

# APPENDIX 10D: MARINE MAMMALS

## OUTPUTS FROM IPCOD POPULATION MODELLING

### Demographic Parameters

#### *Bottlenose Dolphins*

Table 10.1 Demographic parameters for bottlenose dolphins used in the population assessment.

Parameter	Bottlenose Dolphin
MU	Coastal East Scotland
Population Size	195
Growth rate	1.018
Vulnerable subpopulation	Yes, 0.5
Calf/pup survival	0.9
Juvenile survival	0.94
Adult survival	0.945
Fecundity rate	0.3
Age at independence	2
Age at first breeding	9
Density dependence	no

#### *Grey Seals*

Table 10.2 Demographic parameters for grey seals as used in the population assessment.

Parameter	Grey Seal
MU	East Scotland + Northeast England
Population Size	30743
Growth rate	1.01
Vulnerable subpopulation	0.5
Calf/pup survival	0.21
Juvenile survival	0.94
Adult survival	0.94
Fecundity rate	0.84
Age at independence	1
Age at first breeding	5
Density dependence	No

## Bottlenose Dolphin: Projects Alpha and Project Bravo Combined

### Disturbance Impacts from Piling Noise Sequential Construction

Table 10.3 Results of the iPCoD modelling for bottlenose dolphins under three sequential scenarios: monopiles at Alpha followed by pin piles at Bravo (MP\_A\_PP\_B\_Seq), concurrent piling of monopiles and pin piles at Alpha, followed by concurrent piling of monopiles and pin piles at Bravo (MPPP\_A\_B\_Seq), and pin piles at Alpha followed by pin piles at Bravo (PP\_A\_B\_Seq). Red text denotes which of the three scenarios had the worst case result for each output metric.

Scenario	Result Parameter	MP_A_PP_B_Seq	MPPP_A_B_Seq	PP_A_B_Seq
Population Size	Baseline median pop size year 24	274	274	272
	Impacted median pop size year 24	272	274	270
	Impacted as % of baseline	99.3%	100.0%	99.3%
Additional Risk of a 1% Decline	Yr 1	0.057	0.053	0.046
	Yr 6	0.035	0.046	0.039
	Yr 12	0.007	0.008	0.01
	Yr 18	0.004	0.005	0.006
	Yr 24	-0.001	0.002	0.001
Ratio of the impacted to un-impacted population size	Yr 1 Min	0.9091	0.9149	0.8667
	Yr 6 Min	0.8476	0.8593	0.8375
	Yr 12 Min	0.8421	0.8488	0.8353
	Yr 18 Min	0.8381	0.8289	0.8235
	Yr 24 Min	0.8056	0.84	0.811
	Yr 1 Median	1	1	1
	Yr 6 Median	0.9917	1	0.9926
	Yr 12 Median	1	1	1
	Yr 18 Median	1	1	1
	Yr 24 Median	1	1	1
	Yr 1 Mean	0.9968	0.9968	0.9961
	Yr 6 Mean	0.9899	0.9925	0.9916
	Yr 12 Mean	0.9912	0.993	0.9928
	Yr 18 Mean	0.9909	0.9931	0.993
Yr 24 Mean	0.9908	0.993	0.9931	
Ratio of the impacted population growth rate to the baseline population growth rate	Yr 1 Min	0.8708	0.9062	0.8872
	Yr 6 Min	0.9573	0.9723	0.9609
	Yr 12 Min	0.9823	0.9771	0.9797
	Yr 18 Min	0.9752	0.9814	0.9766
	Yr 24 Min	0.9758	0.9772	0.9799
	Yr 1 Median	0.9983	0.9997	0.9996

Scenario	Result Parameter	MP_A_PP_B_Seq	MPPP_A_B_Seq	PP_A_B_Seq
	Yr 6 Median	1	1	1
	Yr 12 Median	1	1	1
	Yr 18 Median	1	1	1
	Yr 24 Median	1	1	1
	Yr 1 Mean	0.9923	0.9967	0.9938
	Yr 6 Mean	0.9992	0.9995	0.9991
	Yr 12 Mean	1	1	0.9999
	Yr 18 Mean	1	1	0.9998
	Yr 24 Mean	1	1	0.9998
Centile for un-impacted population which matches the 50th centile for the impacted population	Yr 1	42	42	45
	Yr 6	45	45	43
	Yr 12	47	47	49
	Yr 18	47	47	46
	Yr 24	47	49	47

Plate 10.1 Simulated bottlenose dolphin population sizes for both the baseline and the impacted populations under the MP\_A\_PP\_B\_Seq scenario (monopile installation at Alpha followed by pin pile installation at Bravo).

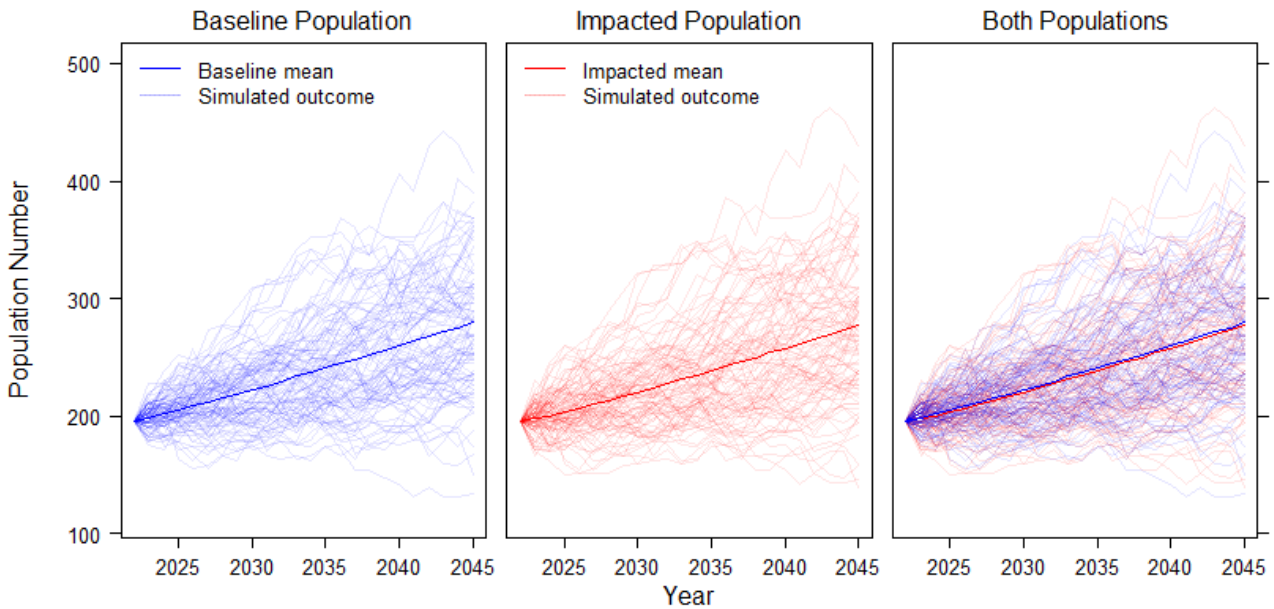


Table 10.4 Additional risk of a 1, 2 and 5% decline across years for the bottlenose dolphin population simulations resulting from the simulated disturbance predicted under the MP\_A\_PP\_B\_Seq scenario (monopile installation at Alpha followed by pin pile installation at Bravo).

Year	Prob. 1% decline	Prob. 2% decline	Prob. 5% decline
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1	0.057	0.049	0.052
6	0.035	0.02	0.005
12	0.007	0.003	0
18	0.004	0.001	0
24	-0.001	0.001	0

*Disturbance Impacts from Piling Noise: Concurrent Construction*

Table 10.5 Additional risk of a 1, 2 and 5% decline across years for the bottlenose dolphin population simulations resulting from the simulated disturbance predicted during the concurrent pin pile scenario.

Year	Prob. 1% decline	Prob. 2% decline	Prob. 5% decline
1	0.061	0.065	0.07
6	0.045	0.022	0.004
12	0.017	0.003	0
18	0.008	0.001	0
24	0.002	0	0

Plate 10.2 Simulated bottlenose dolphin population sizes for both the baseline and the impacted populations under the concurrent pin pile scenario.

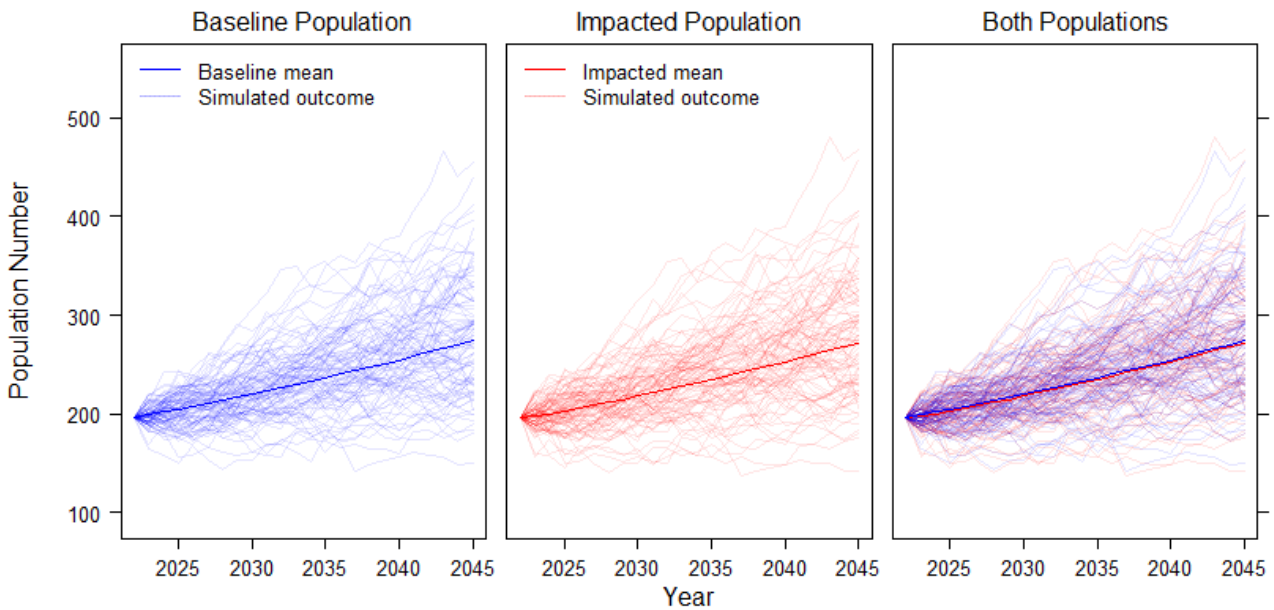


Table 10.6 Results of the iPCoD modelling for bottlenose dolphins under the concurrent pin pile scenario.

Scenario	Result Parameter	PP_AB_Conc
Population Size	baseline median pop size yr 24	272
	impacted median pop size year 24	271

	<b>impacted as % of baseline</b>	99.6%
<b>Ratio of the impacted to un-impacted</b>	Yr 1 Min	0.9022
	Yr 6 Min	0.84
	Yr 12 Min	0.8391
	Yr 18 Min	0.8293
	Yr 24 Min	0.8222
	Yr 1 Median	1
	Yr 6 Median	0.9911
	Yr 12 Median	0.9928
	Yr 18 Median	1
	Yr 24 Median	1
	Yr 1 Mean	0.9954
	Yr 6 Mean	0.99
	Yr 12 Mean	0.9911
	Yr 18 Mean	0.9908
	Yr 24 Mean	0.991
<b>Ratio of the impacted population growth rate to the baseline population growth rate</b>	Yr 1 Min	0.8916
	Yr 6 Min	0.9715
	Yr 12 Min	0.9775
	Yr 18 Min	0.972
	Yr 24 Min	0.9782
	Yr 1 Median	0.9969
	Yr 6 Median	1
	Yr 12 Median	1
	Yr 18 Median	1
	Yr 24 Median	1
	Yr 1 Mean	0.992
	Yr 6 Mean	0.9992
	Yr 12 Mean	1
	Yr 18 Mean	1
	Yr 24 Mean	1
<b>Centile for un-impacted population which matches the 50th centile for the impacted population</b>	Yr 1	42
	Yr 6	46
	Yr 12	48
	Yr 18	47
	Yr 24	49

### Grey Seal: Cumulative Impact Assessment

Plate 10.3 Simulated grey seal sizes for both the baseline and the impacted populations under the cumulative scenario.

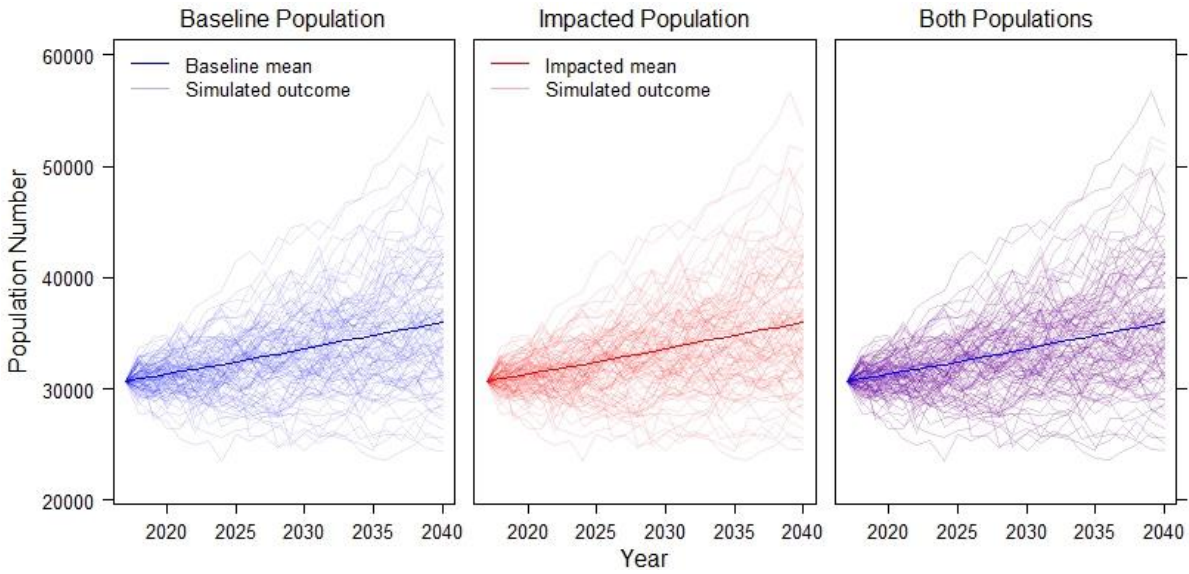


Table 10.7 Results of the iPCoD modelling for grey seals under the cumulative scenario.

Scenario	Result Parameter	Grey Seal CIA
Population Size	Baseline median pop size year 24	35548
	Impacted median pop size year 24	35545
	Impacted as % of baseline	99.99%
Additional Risk of a 1% Decline	Yr 1	0
	Yr 6	-0.001
	Yr 12	0
	Yr 18	0
	Yr 24	0
Ratio of the impacted to un-impacted population size	Yr 1 Min	0.9996
	Yr 6 Min	0.9877
	Yr 12 Min	0.9865
	Yr 18 Min	0.9866
	Yr 24 Min	0.9864
	Yr 1 Median	1
	Yr 6 Median	1
	Yr 12 Median	1
	Yr 18 Median	1
	Yr 24 Median	1
	Yr 1 Mean	1
	Yr 6 Mean	0.9999
	Yr 12 Mean	0.9999
Yr 18 Mean	0.9999	

Scenario	Result Parameter	Grey Seal CIA
Ratio of the impacted population growth rate to the baseline population growth rate	Yr 24 Mean	0.9999
	Yr 1 Min	0.9996
	Yr 6 Min	0.9995
	Yr 12 Min	0.9998
	Yr 18 Min	0.9998
	Yr 24 Min	0.9998
	Yr 1 Median	1
	Yr 6 Median	1
	Yr 12 Median	1
	Yr 18 Median	1
	Yr 24 Median	1
	Yr 1 Mean	1
	Yr 6 Mean	1
	Yr 12 Mean	1
	Yr 18 Mean	1
Yr 24 Mean	1	
Centile for un-impacted population which matches the 50th centile for the impacted population	Yr 1	50
	Yr 6	50
	Yr 12	50
	Yr 18	50
	Yr 24	50

### Bottlenose Dolphin: Cumulative Impact Assessment

Table 10.8 Results of the iPCoD modelling for bottlenose dolphins under 3 cumulative scenarios: Concurrent piling (shortest duration) with PTS, single piling (longest duration) with PTS and single piling (longest duration) without PTS. Red text denotes which of the 2 scenarios with PTS had the worst case result for each results parameter. Shaded cells highlight the median counterfactual values.

Result Parameter		Shortest Duration (with PTS at Inch Cape)	Longest Duration (with PTS at Inch Cape)	Shortest Duration (no PTS)	Longest Duration (no PTS)
Median Population Size Year 24	Baseline	274	274	272	272
	Impacted	142	130	260	256
	# animals difference	132	144	12	16
	Impacted as % of baseline	51.8%	47.4%	95.6%	94.1%
Additional Risk of a 1% Decline	Yr 1	0	0	0	0
	Yr 6	0.463	0.481	0.137	0.171
	Yr 12	0.618	0.636	0.048	0.082

	Yr 18	0.614	0.648	0.021	0.037
	Yr 24	0.55	0.589	0.004	0.018
Ratio of the impacted to un-impacted population size	Yr 1 Min	1	1	1	1
	Yr 6 Min	0.3084	0.2712	0.6667	0.6638
	Yr 12 Min	0.1383	0.06977	0.6897	0.6471
	Yr 18 Min	0.09091	0.07246	0.6667	0.5918
	Yr 24 Min	0.1045	0.06034	0.656	0.54
	Yr 1 Median	1	1	1	1
	Yr 6 Median	0.8439	0.84	1	0.9912
	Yr 12 Median	0.6489	0.627	1	0.9917
	Yr 18 Median	0.5559	0.5296	1	0.9932
	Yr 24 Median	0.5167	0.4922	1	1
	Yr 1 Mean	1	1	1	1
	Yr 6 Mean	0.8236	0.8187	0.958	0.946
	Yr 12 Mean	0.6319	0.6121	0.9619	0.9479
	Yr 18 Mean	0.5523	0.5277	0.9589	0.9446
	Yr 24 Mean	0.5246	0.4988	0.9593	0.9456
Ratio of impacted to un-impacted annual growth rate	Yr 1 Min	0.964	0.9608	0.9712	0.9688
	Yr 6 Min	0.9395	0.9529	0.9194	0.9612
	Yr 12 Min	0.7179	0.7065	0.9712	0.9688
	Yr 18 Min	0.8136	0.785	0.9706	0.9674
	Yr 24 Min	0.8891	0.8412	0.9667	0.9595
	Yr 1 Median	1	1	1	1
	Yr 6 Median	1.064	1.076	1	1
	Yr 12 Median	0.9668	0.9654	1	1
	Yr 18 Median	0.9896	0.9865	1	1
	Yr 24 Median	1.006	1.008	1	1
	Yr 1 Mean	0.9995	0.9994	0.9997	0.9995
	Yr 6 Mean	1.083	1.097	1.011	1.021
	Yr 12 Mean	0.9613	0.9571	1	1
	Yr 18 Mean	0.9878	0.9844	1	1
	Yr 24 Mean	1.006	1.009	0.9999	1
Centile for un-impacted population which matches the 50th centile for the impacted population	Yr 1	43	50	48	50
	Yr 6	12	8	38	36
	Yr 12	1	1	39	36
	Yr 18	1	1	40	38
	Yr 24	1	1	41	39



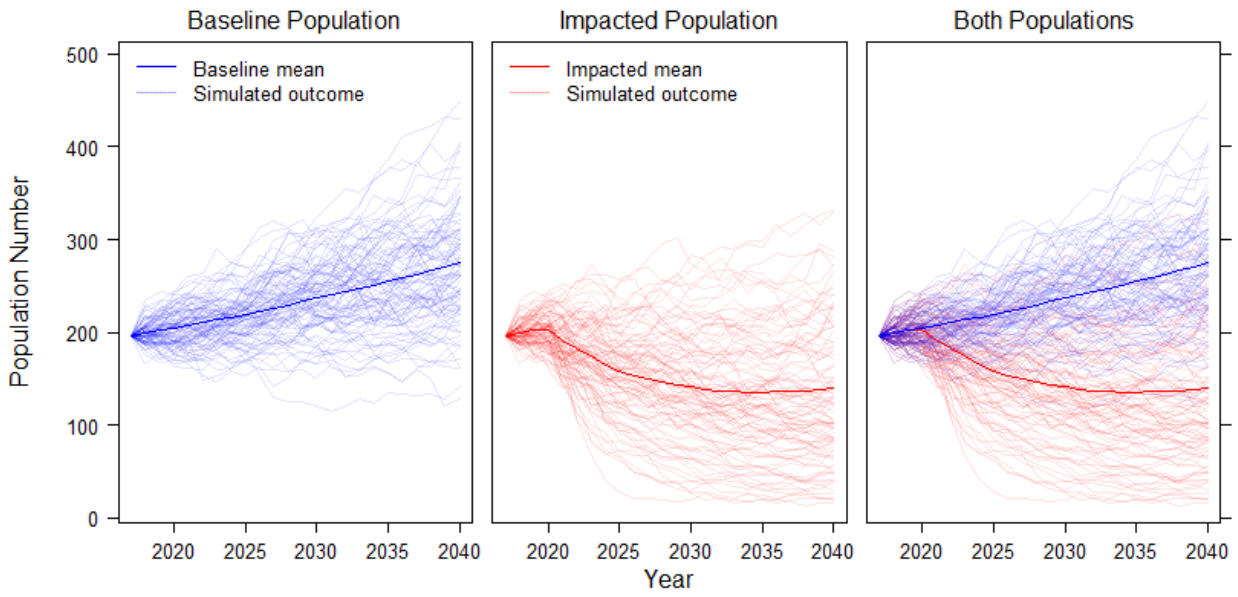
*Bottlenose Dolphin Cumulative Assessment: Single installation vessel (longest duration)  
With PTS at Inch Cape*

- 10.2. Under the longest duration cumulative scenario with PTS, the simulations demonstrated that in probabilistic terms, there was a large increase in the risk of population decline in the impacted population. In the sixth year of simulation there was a maximum of a 48.1% increase in the probability of a 1% population decline and a 40.5% increase in the risk of a 2% decline (Table 10.9). This impact was long term, and by year 24, the increase in the probability of a 1% decline was still high at 58.9%.
- 10.3. After 24 years of simulation, the median baseline population size (across 1,000 simulations) was 274 (95% CI: 174 - 388), and the median impacted population size (across 1,000 simulations) was 130 (95% CI: 30 - 302). This means that after a simulated 24 years the size difference between the median baseline and impacted population was a total of 144 individuals and the impacted population size was only 47% of the baseline population size. Therefore, there was a very significant difference between the predicted baseline (unimpacted) and impacted population sizes as a result of the predicted levels of disturbance and PTS.
- 10.4. The population trajectory for both the baseline and the impacted populations (the mean and each individual of the 1,000 simulated outcomes) are presented in Plate 10.4. This demonstrates that the mean impacted population is predicted to experience a large decline in population size at the end of year 2020 and continues to decline in size from a mean population size of 202 at the start of 2020, to a lowest mean population size of 136 at the start of year 2033, after which it increases slightly to a mean population size of 140 by the start of 2040. This therefore demonstrates a significant long term population effect of the cumulative scenario with PTS on the bottlenose dolphin population.
- 10.5. Across all 1,000 paired simulations, the median ratio of baseline and impacted population sizes was between 0.49 and 0.84, the mean ratio of the impacted to the baseline population was between 0.50 and 0.82 and the 3<sup>rd</sup> quartile ratio was between 0.50 and 0.93 (excluding year 1) which indicates that most of the simulations resulted in impacted populations that were smaller than the paired baseline population in all simulation years (excluding year 1) (Table 10.10). This is also demonstrated in Plate 10.5 which shows that most of the simulations have a ratio of <1 which means that the impacted population size is smaller than the paired baseline population size.

**Table 10.9 Additional risk of a 1, 2 and 5% decline across years as a result of the simulated disturbance impact resulting from the longest duration cumulative scenario with PTS.**

Year of simulation	Additional probability of a 1% decline	Additional probability of a 2% decline	Additional probability of a 5% decline
1	0	0	0
6	0.481	0.405	0.217
12	0.636	0.548	0.283
18	0.648	0.531	0.232
24	0.589	0.451	0.141

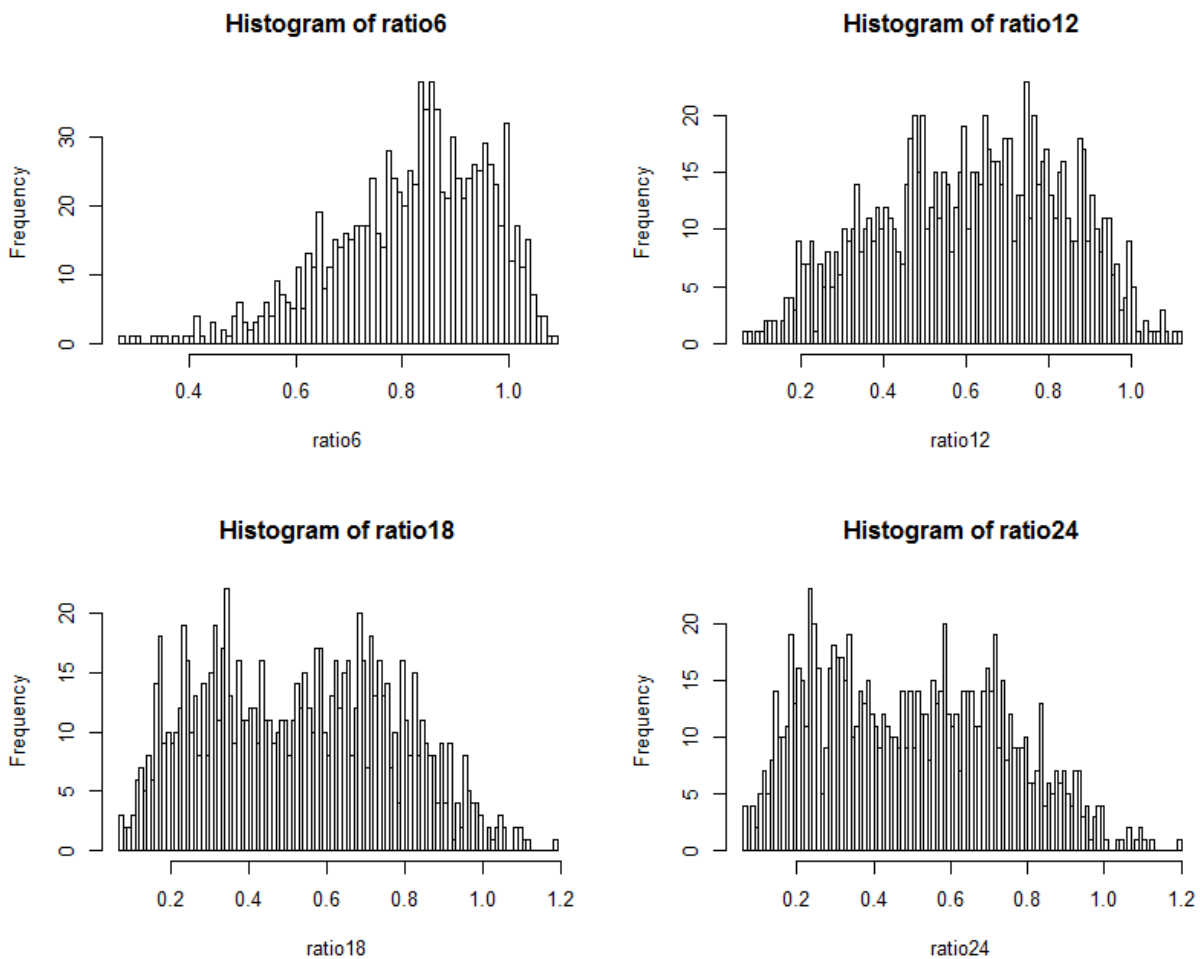
**Plate 10.4 Simulated bottlenose dolphin population sizes for both the baseline and the impacted populations under the longest duration cumulative scenario including disturbance and PTS.**



**Table 10.10 The ratio of impacted to baseline population size in years 1, 6, 12, 18 and 24 across all 1000 paired bottlenose dolphin population simulations for the longest duration cumulative scenario**

Year	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	1	1	1	1	1	1
6	0.2712	0.7299	0.84	0.8187	0.9301	1.083
12	0.06977	0.4531	0.627	0.6121	0.7879	1.11
18	0.07246	0.3247	0.5296	0.5277	0.7184	1.183
24	0.06034	0.2948	0.4922	0.4988	0.6903	1.191

Plate 10.5 The ratio of the impacted population size to the baseline population size for each of the 1,000 paired simulations run for year 6, 12, 18 and 24 under the longest duration cumulative scenario including PTS and disturbance.



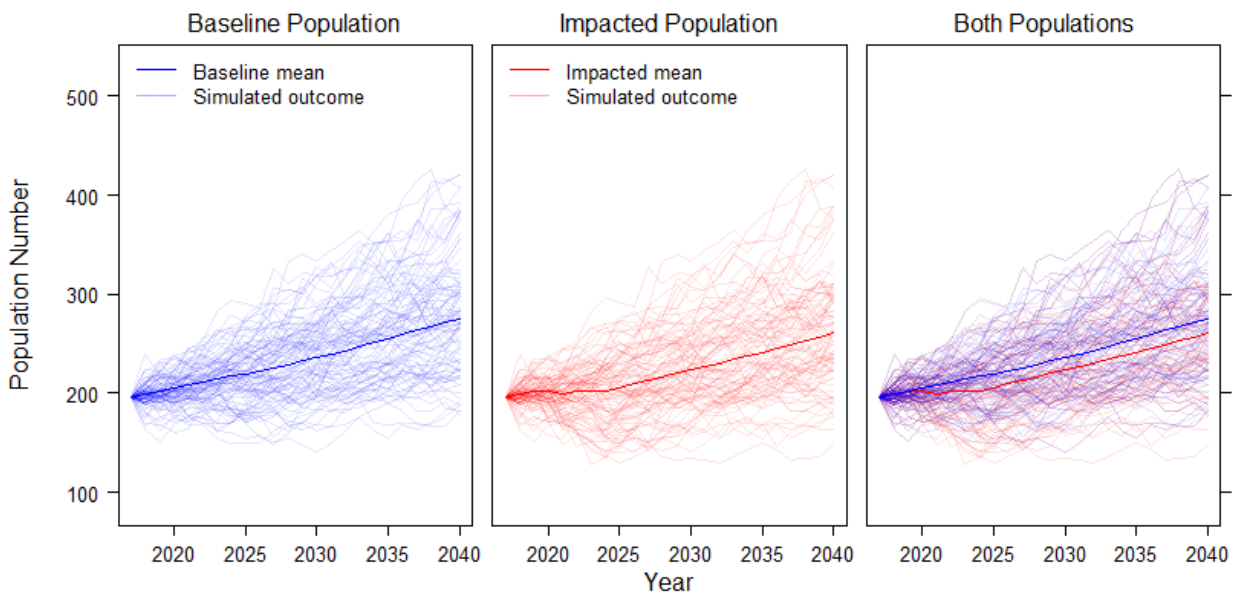
- 10.6. It is unclear exactly why the inclusion of PTS at Inch Cape has such a large effect on the simulated impacted population trajectory but it is linked to the results of the expert elicitation process that was carried out when the iPCoD framework was developed. Given the uncertainty and lack of empirical data on the individual consequences of PTS for individuals, a precautionary approach was taken by some experts who felt that the effect of PTS on survival and fecundity could be quite high. Additional work carried out since then on the magnitude and frequency of PTS as a result of exposure to noise has demonstrated that the amount of PTS that bottlenose dolphins could receive from exposure to piling noise is relatively limited and that it would be likely limited to specific frequency bands largely outside the region of highest hearing sensitivity (Kastelein et al., 2012b, Kastelein et al., 2012a, Finneran, 2015, Kastelein et al., 2017). A recent revisit of the expert elicitation process for the iPCoD framework, as yet unpublished, concluded that the effects of PTS were likely to be far less than specified during the original expert elicitation (C. Booth, SMRU Consulting, pers comm). Nevertheless, regardless of the consequences of PTS, the more realistic scenario is that no bottlenose dolphins are likely to experience PTS as a result of any piling activity in the East Coast Management Unit.

*Bottlenose Dolphin Cumulative Assessment: Single vessel (longest duration) without PTS*

**Table 10.11 Additional risk of a 1, 2 and 5% decline across years as a result of the simulated disturbance impact resulting from the longest duration cumulative scenario without PTS**

Year of simulation	Additional probability of a 1% decline	Additional probability of a 2% decline	Additional probability of a 5% decline
1	0	0	0
6	0.171	0.138	0.025
12	0.082	0.027	0
18	0.037	0.014	0
24	0.018	0.003	0

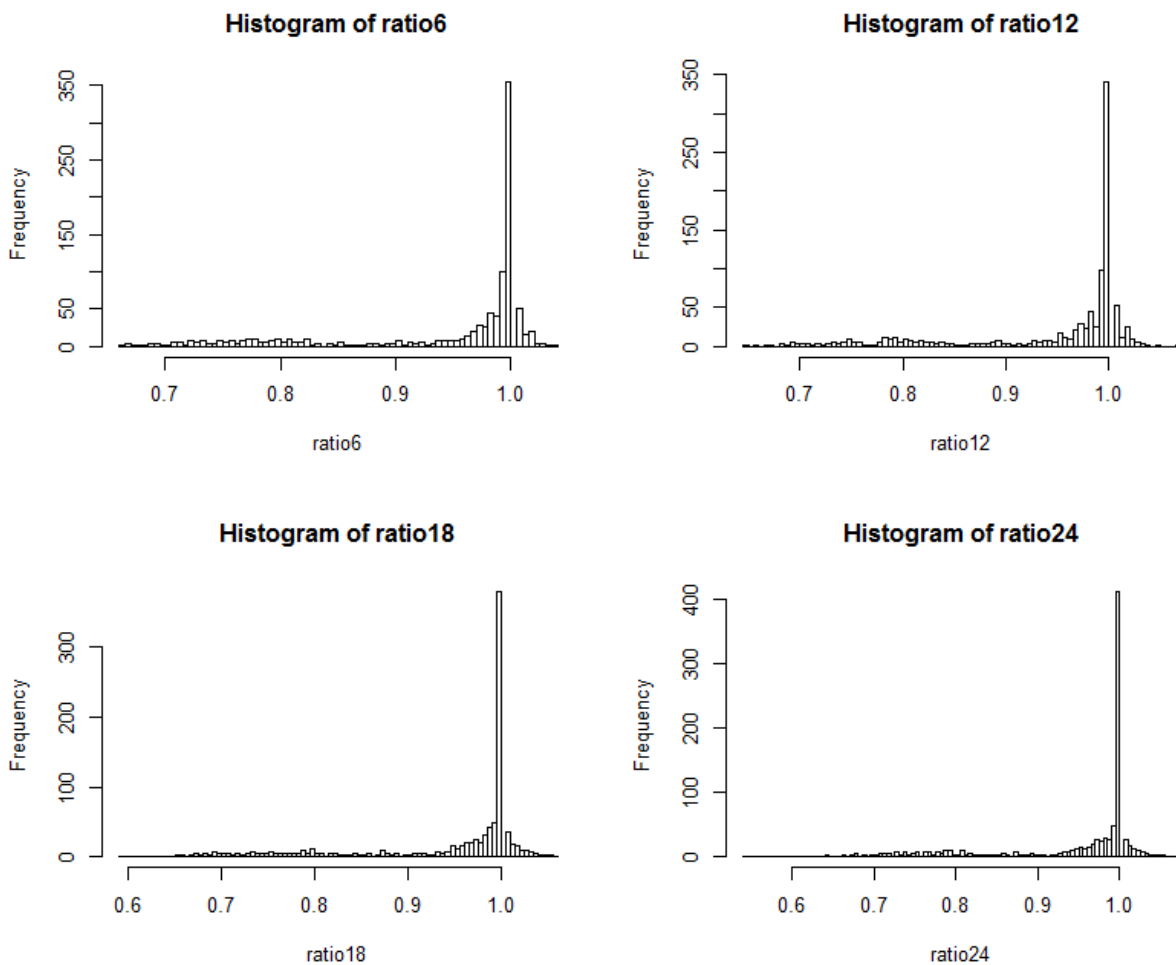
**Plate 10.6 Simulated bottlenose dolphin population sizes for both the baseline and the impacted populations under the longest duration cumulative scenario without PTS.**



**Table 10.12 The ratio of impacted to baseline population size in years 1, 6, 12, 18 and 24 across all 1000 paired bottlenose dolphin population simulations for the longest duration cumulative scenario without PTS**

Year	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	1	1	1	1	1	1
6	0.6638	0.9444	0.9912	0.946	1	1.039
12	0.6471	0.94	0.9917	0.9479	1	1.067
18	0.5918	0.9393	0.9932	0.9446	1	1.059
24	0.54	0.9405	1	0.9456	1	1.074

Plate 10.7 The ratio of the impacted population size to the baseline population size for each of the 1,000 paired simulations run for year 6, 12, 18 and 24 under the longest duration cumulative scenario without PTS.



- FINNERAN, J. J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *The Journal of the Acoustical Society of America*, 138, 1702-1726.
- KASTELEIN, R. A., GRANSIER, R., HOEK, L., MACLEOD, A. & TERHUNE, J. M. 2012a. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. *Journal of the Acoustical Society of America*, 132, 2745-2761.
- KASTELEIN, R. A., GRANSIER, R., HOEK, L. & OLTHUIS, J. 2012b. Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4kHz. *Journal of the Acoustical Society of America*, 132, 3525-3537.
- KASTELEIN, R. A., HELDER-HOEK, L., VAN DE VOORDE, S., VON BENDA-BECKMANN, A. M., LAM, F.-P. A., JANSEN, E., DE JONG, C. A. & AINSLIE, M. A. 2017. Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) after exposure to multiple airgun sounds. *The Journal of the Acoustical Society of America*, 142, 2430-2442.