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www.awelymor.cymru

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited
Windmill Hill Business Park
Whitehill Way
Swindon

SMRU Consulting

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Information to inform the bottlenose dolphin and grey seal RIAA for Awel y Môr

Authors:	R R Sinclair
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1.1 Introduction

The purpose of this section is to provide context for the assessment of the potential for the Awel y Môr (AyM) offshore wind farm project to impact bottlenose dolphins as a qualifying feature of the Cardigan Bay Special Area of Conservation (SAC) which is presented in the Report to Inform Appropriate Assessment (RIAA) (Document ref 5.1).

While the maximum number of bottlenose dolphins predicted to be disturbed was 23 individuals (from the maximum design scenario piling of a monopile at the NW modelling location, see ES Volume 2, Chapter 7: Marine Mammals), the RIAA should consider the fact that this level of disturbance is not expected at each WTG location within the array. In addition, the RIAA should consider the movement of bottlenose dolphins and connectivity between the AyM site and the Cardigan Bay SAC. By taking these considerations into account, the predicted impact on the Cardigan Bay SAC can be more realistically determined in order to inform the RIAA.

1.2 SAC Population Assessment

When attributing impacts to the “Cardigan Bay SAC Population” it is important to consider that the bottlenose dolphin population estimates in Wales have varied considerably over the years, and population home ranges have expanded. The Cardigan Bay SAC site evaluation for bottlenose dolphins lists a population size of 101 (min) to 250 (max) and was considered to be based on Moderate data quality (based on partial data with some extrapolation) (JNCC 2015a).

There is photo-ID evidence available that shows that the “Cardigan Bay SAC” bottlenose dolphins are not restricted to the SAC, and a portion of them have been sighted further north, towards the Isle of Man and around Liverpool Bay in both summer and winter months (Pesante et al. 2008, Feingold and Evans 2014, Lohrengel et al. 2018). Photo-ID data have shown that home range varies considerably by individual, with some individuals showing a degree of site fidelity and small home ranges within the Cardigan Bay SAC, while the majority of the population have larger home ranges, encompassing Cardigan Bay SAC, the wider Cardigan Bay area and northern Wales (Lohrengel et al. 2018). Population estimates have been modelled using photo-ID closed population mark-recapture modelling for both the Cardigan Bay SAC and the wider Cardigan Bay area (referring to both Cardigan Bay SAC and northern Cardigan Bay – which includes the majority of the Pen Llyn a’r Sarnau SAC) by Lohrengel et al. (2018) (Figure 1.1). Using a closed population Capture-Recapture Model, in 2016 there were estimated to be a population of 147 bottlenose dolphins in the Cardigan Bay SAC (95% CI: 127 – 194, CV: 0.29) and a population of 174 bottlenose dolphins in the wider Cardigan Bay area (95% CI: 150 – 246, CV: 0.30). Therefore the “Cardigan Bay SAC Population” size used in the RIAA should, if taking a precautionary approach, be 147 bottlenose dolphins.

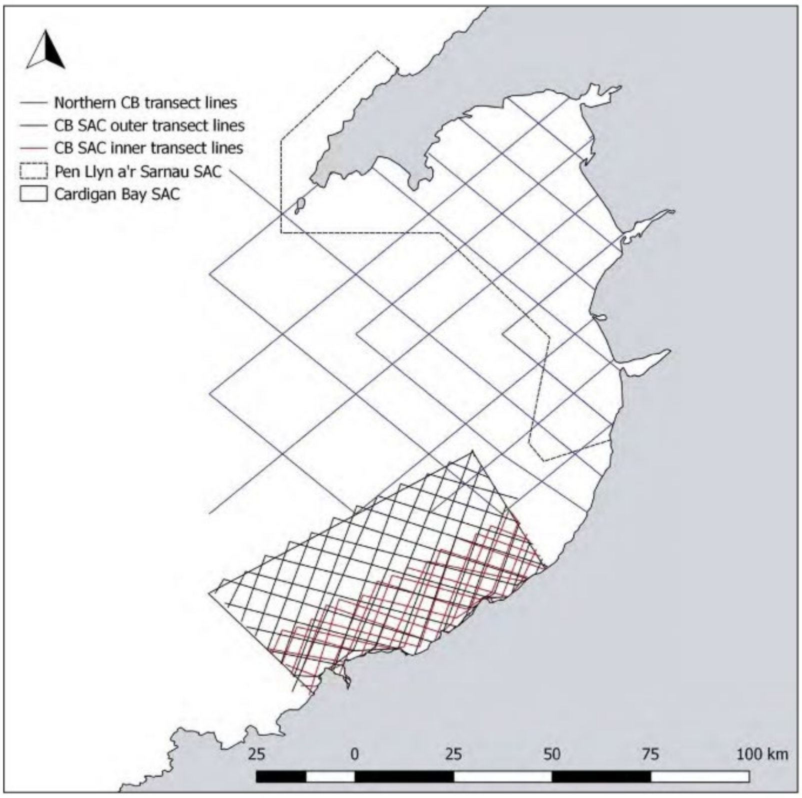


Figure 1.1 Sea Watch Foundation transect routes followed during line transect surveys in Cardigan Bay (Lohrengel et al. 2018).

1.3 Connectivity

There are few data available on the level of connectivity between northern Wales and the Cardigan Bay SAC. Lohrengel et al. (2018) reported that in July 2013 18 bottlenose dolphins were sighted in the Dee Estuary, nine of which (50%) matched the Sea Watch Foundation catalogue, with previous sightings histories showing connectivity between the Dee Estuary, Anglesey, and the Cardigan Bay SAC. Additionally in May 2014 38 individuals were sighted in the Dee Estuary, 12 of which (38%) matched the Sea Watch Foundation catalogue, with previous sightings histories showing connectivity between the Dee Estuary, Anglesey, the Lleyn Peninsular SAC and the Cardigan Bay SAC. Therefore, taking a precautionary approach, it can be assumed that up to 50% of the bottlenose dolphins in north Wales are connected to the Cardigan Bay SAC.

1.4 Assessment of disturbance

1.4.1 Number of dolphins disturbed

While the ES assessment concluded that the maximum design scenario for the northwest modelling location could potentially result in disturbance to up to 23 bottlenose dolphins, this level of disturbance is not representative of the expected disturbance levels at all WTGs across the array area. The modelling for a monopile at the SE location predicted disturbance to 16 bottlenose dolphins, which is only 70% of the predicted number disturbed at the NW location.

The reason for this difference is a combination of:

- differences in proximity of the modelling locations to the coastal waters where bottlenose dolphins are expected to be present, and
- differences in modelled sound propagation between the NW and SE locations, the NW location is in 35.5 m depth while the SE location is in 19.2 m depth – the underwater noise is expected to propagate further in deeper water and as such, WTGs in deeper waters will have larger impact ranges.

It was agreed with stakeholders to conduct underwater noise modelling at two locations, to provide a representative potential impact for the purposes of EIA and HRA. The modelled output sufficiently demonstrates how the predicted number of bottlenose dolphins disturbed is expected to change with respect to both distance from higher density areas and water depth at the modelling location.

1.4.2 Consequences of disturbance

Bottlenose dolphins have been shown to be displaced from an area as a result of the noise produced by offshore construction activities; for example, avoidance behaviour in bottlenose dolphins has been shown in relation to dredging activities (Pirotta et al. 2013). In a recent study on bottlenose dolphins in the Moray Firth (in relation to the construction of the Nigg Energy Park in the Cromarty Firth), small effects of pile driving on dolphin presence have been observed, however, dolphins were not excluded from the vicinity of the piling activities (Graham et al. 2017). In this study the median peak-to-peak source levels recorded during impact piling were estimated to be 240 dB re 1µPa (range 8 dB) with a single pulse source level of 198 dB re 1 $\mu Pa^2 s$. The pile driving resulted in a slight reduction of the presence, detection positive hours and the encounter duration for dolphins within the Cromarty Firth, however, this response was only significant for the encounter durations. Encounter durations decreased within the Cromarty Firth (though only by a few minutes) and increased outside of the Cromarty Firth on days of piling activity. These data highlight a small spatial and temporal scale disturbance to bottlenose dolphins as a result of impact piling activities.

The opinions of the experts involved in the 2013 expert elicitation for iPCoD (Harwood et al. 2014) highlighted the following in relation to the potential effects of disturbance on bottlenose dolphins:

- **Adults:** *Disturbance could result in reduced foraging efficiency and displacement from critical foraging area that would place a severe strain on a female's energy budget; this might affect fertility or result in pregnancy failure. Experts also highlighted that "elevated stress levels as a result of being displaced from a known location may impact fecundity". There was wide variation in the number of days of disturbance that experts believed a female could tolerate before it would have any effect on fertility.*
- **Juveniles:** *Disturbance in excess of 50 days could affect juvenile survival due to reduced foraging efficiency and increased stress levels, leading to reduced body condition. One expert said disturbance may disrupt a juvenile learning foraging behaviours and will disrupt social interactions. Most experts believed that the maximum effect of disturbance would be to reduce survival by less than 10%.*
- **Calves:** *Disturbance could affect calf survival if it exceeded 30-50 days, because it could result in mothers becoming separated from their calves and this could affect the amount of milk transferred from the mother to her calf. One expert said "in instances where masking or a threshold shift may also occur, the reuniting of a separated mother-calf pair may be impeded". Opinions were divided on the maximum effect of disturbance on survival.*

1.5 Population modelling

In order to assess whether the predicted level of disturbance would be sufficient to cause a population level effect, the interim PCoD model[1] (version 5.2) was run[2]. Conservative input values were used in the model, such that 23 bottlenose dolphins were predicted to be disturbed on every piling day. The model assumed the absolute worst case scenario, that there could be a total of up to 201 days on which piling might occur (where it was precautionarily assumed that it could take up to three days to install each monopile, resulting in 150 piling days for 50 WTGs, 48 piling days for the two OSPs and 3 piling days for one met mast). An indicative piling schedule was not available for use, and therefore the piling days were randomly spread throughout the 12 month construction period.

Two scenarios were considered:

- assuming all bottlenose dolphins in the Irish Sea MU are functionally linked to the SAC, and thus the "SAC population" is effectively considered to be the MU population (293 animals)
- assuming that not all bottlenose dolphins in the Irish Sea MU are linked to the SAC, and thus the impact is allocated to the SAC designated population (147 animals)

Table 1.1 outlines the parameters that were input into the iPCoD model.

Table 1.1 Bottlenose dolphin population modelling inputs

Inputs		MU	SAC
Number of simulations run	nboot	1000	1000
Species (BND = bottlenose dolphin)	spec	BND	BND
Proportion of population that is female	propfemale	0.5	0.5
Population size at the start of simulations	pmean	**293**	**147**

[1] http://www.smruconsulting.com/products-tools/pcod/ipcod/

[2] Note: there is very little information available on the effects of disturbance from pile driving on bottlenose dolphins, and as such, the 2018 expert elicitation to update the iPCoD transfer functions between disturbance and effects on vital rates did not include bottlenose dolphins.

Pup survival rate	Surv[1]	0.86	0.86
Juvenile survival rate	Surv[7]	0.94	0.94
Adult survival rate	Surv[13]	0.94	0.94
Fecundity rate	Fertility	0.25	0.25
Age at independence	age1	2	2
Age at first birth	age2	9	9
Number of piling years	pile_years	1	1
Proportion of animals in vulnerable component	vulnmean	c(1.0)	c(1.0)
Days of "residual" disturbance	days	0	0
Proportion of disturbed experiencing “days”	prop_days_dist	1	1
Number of piling Operations	pilesx1	1	1
Seasonal variation (1=no variation)	seasons	1	1
Number of animals predicted to experience disturbance during 1 day of piling	numDt[1,]	23	23
Years for simulation	years	25	25
Density dependence (0= no density dependence)	z	0	0
Piling schedule		201 days	201 days

1.5.1 Precaution in the iPCoD modelling

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 to over-estimate the true population level impacts. These are:

- The assumption that 23 bottlenose dolphins are impacted on every day of piling,
- The assumption that it will take up to a maximum of three days to install a monopile,
- The fact that the model assumes a dolphin will not forage for 24 hours after being disturbed,
- 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.

Each of these points are outlined in detail below.

1.5.1.1 Number of dolphins disturbed per day

The scenario modelled here assumes, conservatively, that 23 bottlenose dolphins will be disturbed on every piling day. The impact assessment found that in reality, the number of bottlenose dolphins impacted per day will depend on the piling location as a result of differing depths and proximity to the coast (where densities are higher). The ES modelling found that while 23 bottlenose dolphins are predicted to be impacted for the installation of a monopile at the NW location, only 16 bottlenose dolphins are predicted to be impacted for the installation of a monopile at the SE location. Therefore the assumption that 23 bottlenose dolphins are disturbed on every piling day is precautionary and will over-estimate the true disturbance levels expected at AyM.

1.5.1.2 Number of piling days

In consultation with the project engineers, a worst case scenario was assumed, whereby each monopile foundation may require the drive/drill/drive sequence, which may, at a worst case, result in pile driving occurring on up to three days for each monopile. It is important to note that this is the worst possible scenario, and in reality, based on data collected at recent UK offshore windfarms (Table 2), it will likely take only one day of piling to install a single monopile. Since the impact of disturbance is expected to increase with increasing number of repeated disturbance days (Booth et al. 2019), assuming three piling days for every monopile is likely to over-estimate the true disturbance levels expected at AyM.

Table 2 Piling information for recently installed monopiles at UK offshore windfarms

Project	# piles monitored	Monopile diameter	Piling days per monopile	Duration of piling	Source
Hornsea Project Two	5	9.5 m	1	Max 192.3 min	(Verfuss 2020)
Triton Knoll	4	8.5 m	1	Max 171 min	(Banda et al. 2020)
Hornsea Project One	6	8.1 m	1	Max 120 mins	(Verfuss et al. 2018)
Galloper	4	7.5 m	1	< 140 min	(OSC 2017)
Race Bank	4	Not stated	1	Max 84 min	(NIRAS Consulting Ltd 2017)

1.5.1.3 Duration of disturbance

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 for bottlenose dolphins. This is considered to be 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 in the iPCoD model is significantly beyond that which is considered to be an extreme response and is therefore considered to be unrealistic and will over-estimate the true disturbance levels expected at AyM.

1.5.1.4 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 scenario run for bottlenose dolphins assumes no density dependence, since there is insufficient data to parameterise this relationship. Essentially, what this means is that there is no ability for the modelled impacted population to increase in size back up to carrying capacity following disturbance. At a recent expert elicitation on bottlenose dolphins, 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's 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.

1.5.1.5 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 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 evident in the outputs of iPCoD where the un-impacted (baseline) population size varies massively between iterations, not as a result of disturbance but simply as a result on environmental and demographic stochasticity. In the example provided in Figure 1.2, 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.

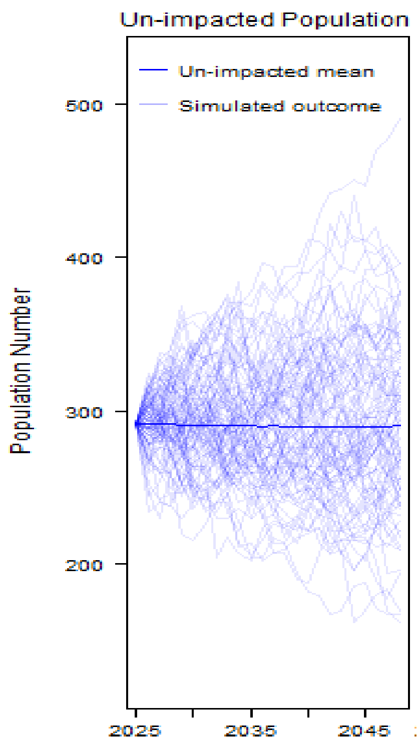


Figure 1.2 Simulated un-impacted (baseline) population size over the 25 years modelled.

1.5.1.6 Summary

All of the precautions built into the iPCoD model and this specific scenario (especially for bottlenose dolphins) that mean that the results are considered to be highly precautionary and likely to over-estimate the true population level impacts.

1.5.2 iPCoD results: MU population

The results of the modelling showed that there was some predicted impact on the MU population as a result of the piling activity at AyM (Table 1.3 and Figure 1.3). The median ratio of the impacted:un-impacted population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was 1 and the impacted mean population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was only 5 individuals smaller than the un-impacted mean population size (such that the impacted population size is expected to be 98.3% of the un-impacted population size). The population size remained the same after 12 years of simulation (1 year of impact followed by 11 years with no impact) and thus the population trajectory of both the impacted and un-impacted populations are expected to be stable in the long term.

Table 1.3 Bottlenose dolphin population modelling results assuming impact to the MU population

Results	MU
Un-impacted pop mean (after 1 year)	292
Impacted pop mean (after 1 year)	289
Impacted pop as % of un-impacted pop (after 1 year)	99.0%
Median impacted:un-impacted population size (after 1 year)	1
Un-impacted pop mean (after 6 years)	292

Impacted pop mean (after 6 years)	287
Impacted pop as % of un-impacted pop (after 6 years)	98.3%
Median impacted:un-impacted population size (after 6 years)	1
Un-impacted pop mean (after 12 years)	293
Impacted pop mean (after 12 years)	288
Impacted pop as % of un-impacted pop (after 12 years)	98.3%
Median impacted:un-impacted population size (after 12 years)	1

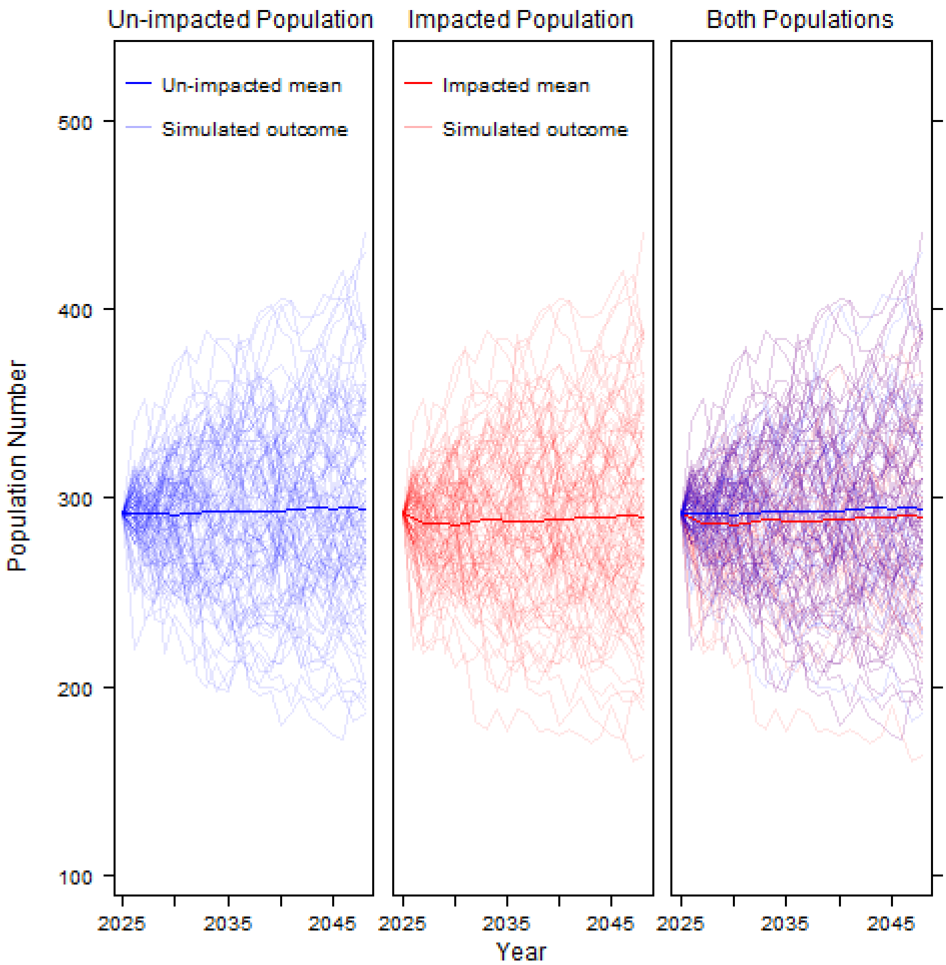


Figure 1.3 Population trajectories of the impacted and unimpacted populations (assuming impact to the MU population).

The results from this precautionary worst case scenario (assuming 23 dolphins were disturbed on every piling day and that it would take three days to install each monopile) is considered to be representative of a medium magnitude, whereby temporary changes in behaviour of individuals is at a scale that would result in potential reductions to lifetime reproductive success to some individuals although the population trajectory is not altered over a generation scale. As highlighted in ES Volume 2, Chapter 7: Marine Mammals, the sensitivity of bottlenose dolphins to disturbance from pile driving is expected to be low, since while there remains the potential for disturbance and displacement to affect individual behaviour and therefore vital rates and population level changes, bottlenose dolphins do have some capability to adapt their behaviour and tolerate certain levels of temporary disturbance

(New et al. 2013). This results in a minor overall impact, which is not significant with respect to the EIA Regulations.

However, as outlined in the previous sections, the iPCoD modelling conducted here is considered to be highly precautionary and likely to over-estimate the population level impacts of disturbance. If the model were to be run to include more realistic parameters (e.g. fewer piling days, inclusion of density dependence and different numbers of animals impacted from different piling location) then the population level results would more than likely be classified as a low magnitude.

To illustrate this, the iPCoD model was also run assuming a total of 67 piling days (one day to install each monopile) and changing the disturbance effect to last for only 8 hours rather than 24. As expected, this resulted in less of a population level impact, with the impacted population size being 100% of the un-impacted population size after 6 years (1 year of impact followed by 5 years with no impact) (Table 1.4) compared to 98.3% under the scenario with 201 piling days (Table 1.3). Therefore, this more realistic example shows that there is expected to be no impact to the MU population as a result of disturbance from pile driving at AyM.

Table 1.4 Bottlenose dolphin population modelling results assuming only 67 piling days and only 8 hours of disturbance effect

Results	MU
Un-impacted pop mean (after 1 year)	292
Impacted pop mean (after 1 year)	292
Impacted pop as % of un-impacted pop (after 1 year)	100%
Median impacted:un-impacted population size (after 1 year)	1
Un-impacted pop mean (after 6 years)	293
Impacted pop mean (after 6 years)	293
Impacted pop as % of un-impacted pop (after 6 years)	100%
Median impacted:un-impacted population size (after 6 years)	1

1.5.3 iPCoD results: SAC population

The results of the modelling showed that there was some predicted impact on the “SAC population” as a result of the piling activity at AyM (Table 1.5 and Figure 1.4). The median ratio of the impacted:un-impacted population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was 1 and the impacted mean population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was only 3 individuals smaller than the un-impacted mean population size (such that the impacted population size is expected to be 97.9% of the un-impacted population size). The population size remained the same after 12 years of simulation (1 year of impact followed by 11 years with no impact) and thus the population trajectory of both the impacted and un-impacted populations are expected to be stable in the long term.

The results from this precautionary worst case scenario (assuming 23 dolphins were disturbed on every piling day, that all impact is attributed to the “SAC population” and that it would take three days to install each monopile) is considered to be representative of a medium magnitude. The sensitivity of bottlenose dolphins to disturbance from pile driving is expected to be low, therefore this results in a minor overall impact, which is not significant with respect to the EIA Regulations.

However, as outlined in the previous sections, the iPCoD modelling conducted here is considered to be highly precautionary and likely to over-estimate the population level impacts of disturbance.

Table 1.5 Bottlenose dolphin population modelling results assuming the SAC population

Results	SAC
Un-impacted pop mean (after 1 year)	148
Impacted pop mean (after 1 year)	146
Impacted pop as % of un-impacted pop (after 1 year)	98.6%
Median impacted:un-impacted population size (after 1 year)	1
Un-impacted pop mean (after 6 years)	148
Impacted pop mean (after 6 years)	145
Impacted pop as % of un-impacted pop (after 6 years)	98.0%
Median impacted:un-impacted population size (after 6 years)	1
Un-impacted pop mean (after 12 years)	149
Impacted pop mean (after 12 years)	145
Impacted pop as % of un-impacted pop (after 12 years)	97.3%
Median impacted:un-impacted population size (after 12 years)	1

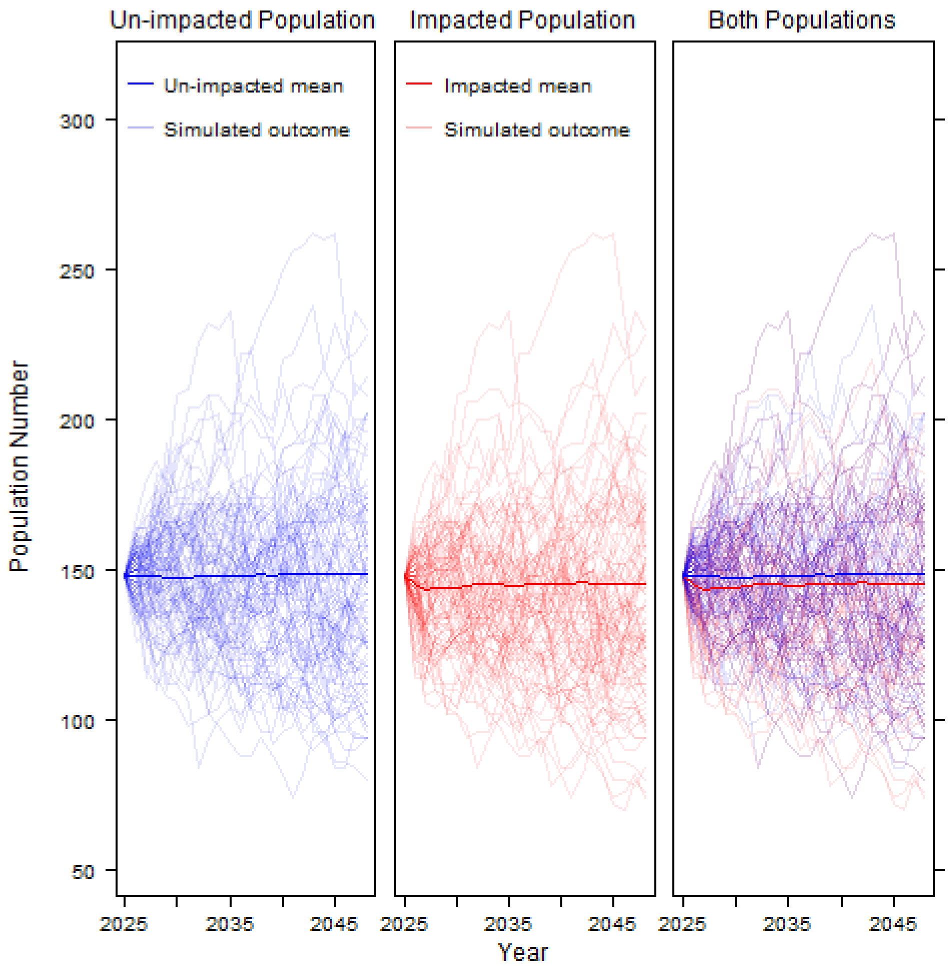


Figure 1.4 Population trajectories of the impacted and unimpacted populations (assuming impact to the SAC population).

2 Information for the grey seal RIAA

2.1 Introduction

The purpose of this section is to provide context for the assessment of the potential for the Awel y Môr (AyM) offshore wind farm project to impact grey seals as a qualifying feature of the Lleyn Peninsula and the Sarnau/ Pen Llyn a`r Sarnau Special Area of Conservation (SAC) which is presented in the Report to Inform Appropriate Assessment (RIAA) (Document ref 5.1).

While the maximum number of grey seals predicted to be disturbed was 81 grey seals (from the maximum design scenario piling of a monopile at the NW modelling location, see ES Volume 2, Chapter 7: Marine Mammals), the RIAA should consider the fact that this level of disturbance is not expected at each WTG location within the array. In addition, the RIAA should consider the movement of grey seals and connectivity between the AyM site and various SACs along the Welsh coastline. Finally, it is also important to note that the numbers of grey seals using the SAC to haul out and breed is now higher than the population size at the time of SAC designation (and therefore published in the SAC citation). By taking these considerations into account, the predicted impact on the Lleyn Peninsula and the Sarnau SAC can be more realistically determined in order to inform the RIAA.

2.2 Connectivity assessment

Grey seals are a wide ranging species and frequently travel over 100 km between haul-out sites and across MUs (e.g. Thompson et al. 1996, Cronin et al. 2013, SCOS 2019). Therefore, it is important to understand that grey seals are not resident at one specific haul-out site, and as such, there is no such thing as a “Lleyn Peninsula and the Sarnau SAC grey seal”. Instead, grey seals have associations with SACs (i.e. they have recorded telemetry positions within an SAC) and may associate with multiple SACs. Here, the SMRU seal telemetry database was examined to investigate the connectivity between the AyM and all SACs in the area.

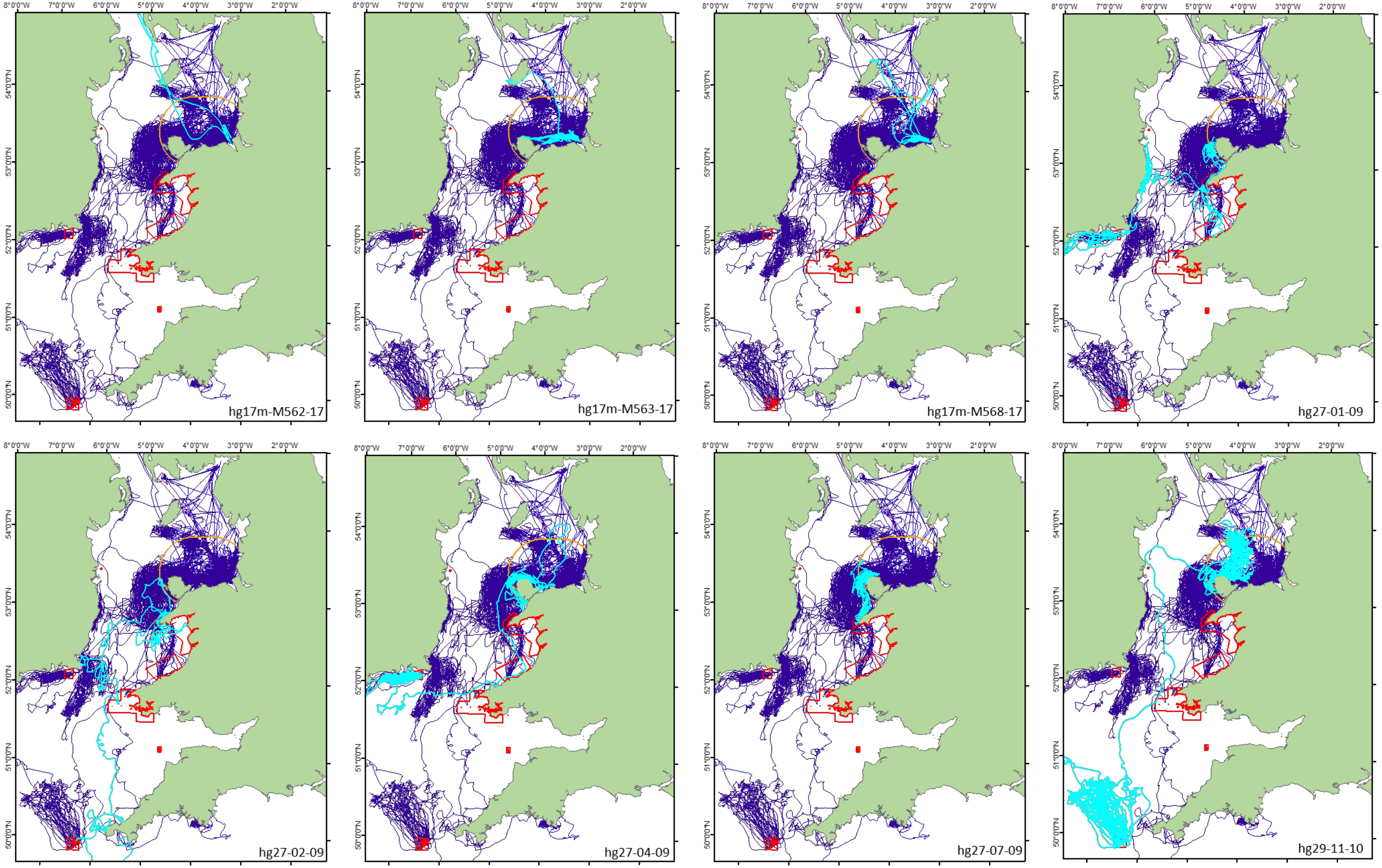
A buffer of 50 km was placed around the AyM array area. All tagged seals which had telemetry locations recorded within this AyM buffer were extracted from the SMRU telemetry database. This process identified a total of 34 grey seals within the AyM buffer, 33 of which were tagged in the West England and Wales MU, and one of which was tagged in the West Scotland MU (Table 2.1). The 34 grey seals within the 50 km buffer of the AyM array area showed connectivity with the following grey seal SACs (Table 2.1 and Figure 2.1):

- Lleyn Peninsula and the Sarnau/ Pen Llyn a`r Sarnau (Wales)
- Pembrokeshire Marine/ Sir Benfro Forol (Wales)
- Cardigan Bay/ Bae Ceredigion (Wales)
- Saltee Islands (Ireland)
- Isles of Scilly Complex (England).

Table 2.1 Summary information on the 34 grey seals with telemetry data within the 50 km buffer of AyM, including which SACs they associated with.

Tag Ref	Seal MU	Location	Tag Date	Days	Location	Tag	Age	Sex	Lleyn	Pembr.	Cardigan	Saltee	Scilly
hg17m_M562_17	W England & Wales	River Dee	27/06/2017	24	ARGOS	GSM/SRDL	Adult	M					
hg17m_M563_17	W England & Wales	River Dee	30/06/2017	92	ARGOS	GSM/SRDL	Adult	F					
hg17m_M568_17	W England & Wales	River Dee	28/06/2017	91	ARGOS	GSM/SRDL	Adult	M					
hg3_Pede_03	W Scotland	Islay	08/09/2003	89	ARGOS	SRDL	Adult	M					
hg56_576_17	W England & Wales	River Dee	03/07/2017	52	GPS	GSM	Adult	F					
hg56_625_17	W England & Wales	River Dee	04/07/2017	34	GPS	GSM	Adult	F					
hg56_626_17	W England & Wales	River Dee	03/07/2017	52	GPS	GSM	Adult	F					
hg56_627_17	W England & Wales	River Dee	03/07/2017	47	GPS	GSM	Adult	F					
hg56_628_17	W England & Wales	River Dee	04/07/2017	30	GPS	GSM	Adult	M					
hg56_630_17	W England & Wales	River Dee	04/07/2017	23	GPS	GSM	Adult	F				Y	
hg56_750_13	W England & Wales	River Dee	04/07/2017	111	GPS	GSM	Adult	M	Y		Y		
hg56_752_13	W England & Wales	River Dee	04/07/2017	76	GPS	GSM	Adult	M					
hg61_738_18	W England & Wales	Bardsey	18/05/2018	239	GPS	GSM	Adult	M	Y				
hg61_811_18	W England & Wales	Bardsey	18/05/2018	93	GPS	GSM	Adult	M	Y				
hg7_114M10_04	W England & Wales	Bardsey	15/06/2004	126	ARGOS	SRDL	Adult	M	Y	Y			
hg7_116F16_04	W England & Wales	River Dee	17/06/2004	135	ARGOS	SRDL	Adult	F					
hg7_122F18_04	W England & Wales	River Dee	18/06/2004	139	ARGOS	SRDL	Adult	F					
hg7_126F6_04	W England & Wales	Ramsey	14/06/2004	168	ARGOS	SRDL	Adult	F	Y	Y			
hg7_140M14_04	W England & Wales	River Dee	17/06/2004	169	ARGOS	SRDL	Adult	M	Y				
hg7_151M13_04	W England & Wales	River Dee	18/06/2004	143	ARGOS	SRDL	Adult	M					
hg7_157F15_04	W England & Wales	River Dee	17/06/2004	126	ARGOS	SRDL	Adult	F					
hg7_158M9_04	W England & Wales	Bardsey	15/06/2004	198	ARGOS	SRDL	Adult	M	Y		Y		
hg7_55F17_04	W England & Wales	River Dee	17/06/2004	194	ARGOS	SRDL	Adult	F					
hg7_56F19_04	W England & Wales	River Dee	18/06/2004	134	ARGOS	SRDL	Adult	F					

hg56_M557_17	W England & Wales	River Dee	04/07/2017	137	GPS	GSM/SRDL	Juv	F					
hg27_01_09	W England & Wales	Anglesey	23/10/2009	176	GPS	GSM	Pup	M	Y			Y	
hg27_02_09	W England & Wales	Bardsey	23/10/2009	57	GPS	GSM	Pup	F	Y	Y			Y
hg27_04_09	W England & Wales	Anglesey	22/10/2009	213	GPS	GSM	Pup	M			Y	Y	
hg27_07_09	W England & Wales	Anglesey	22/10/2009	238	GPS	GSM	Pup	F	Y				
hg29_11_10	W England & Wales	Anglesey	07/11/2010	336	GPS	GSM	Pup	M		Y			Y
hg29_13_10	W England & Wales	Anglesey	22/10/2010	103	GPS	GSM	Pup	F	Y				
hg29_16_10	W England & Wales	Anglesey	22/10/2010	135	GPS	GSM	Pup	F	Y	Y			
hg29_19_10	W England & Wales	Anglesey	07/11/2010	176	GPS	GSM	Pup	F					
hg29_25_10	W England & Wales	Anglesey	07/11/2010	252	GPS	GSM	Pup	F	Y				
							Total #		**13**	**5**	**3**	**3**	**2**
							% of 34 seals		**38%**	**15%**	**9%**	**9%**	**6%**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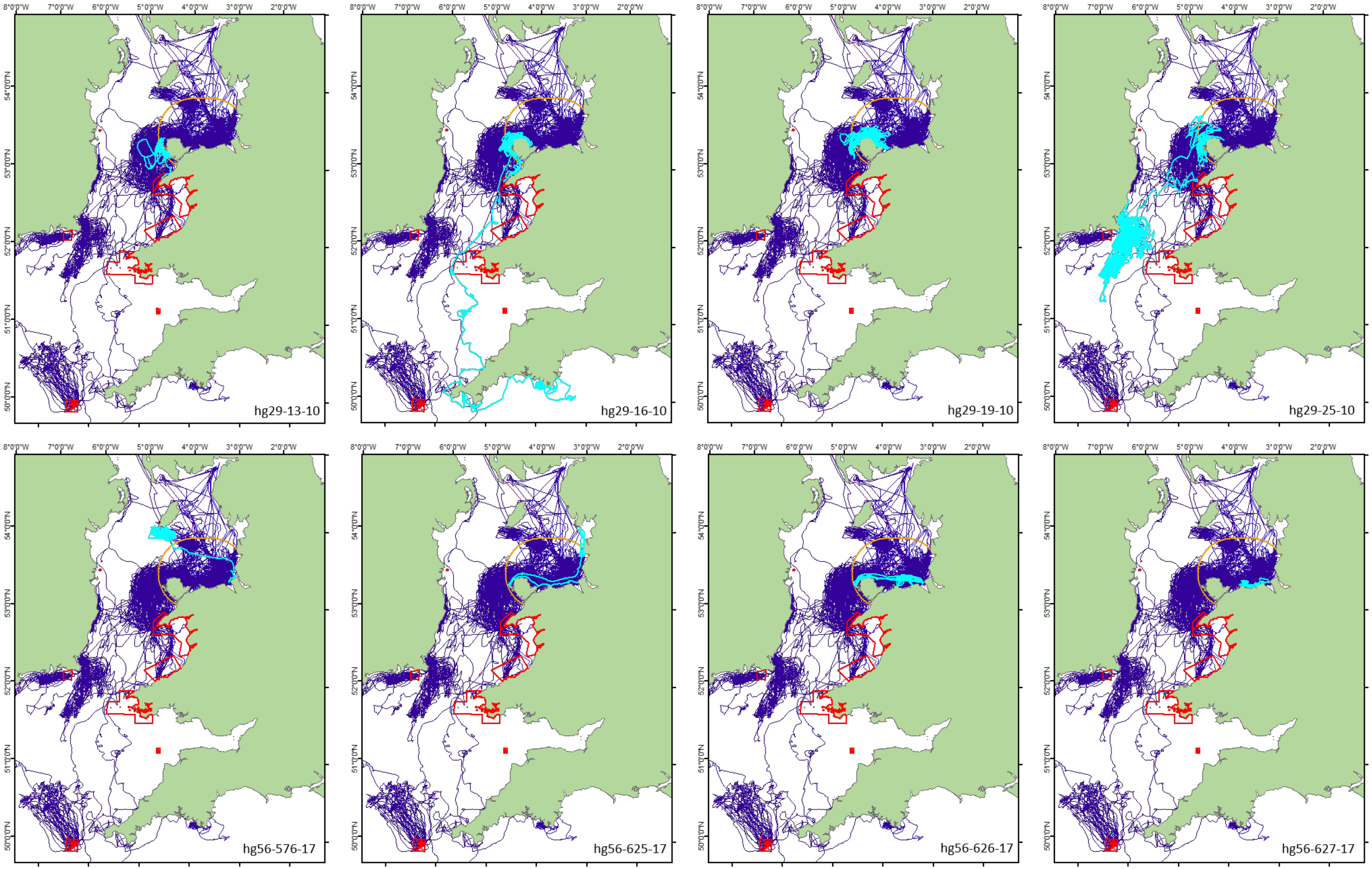
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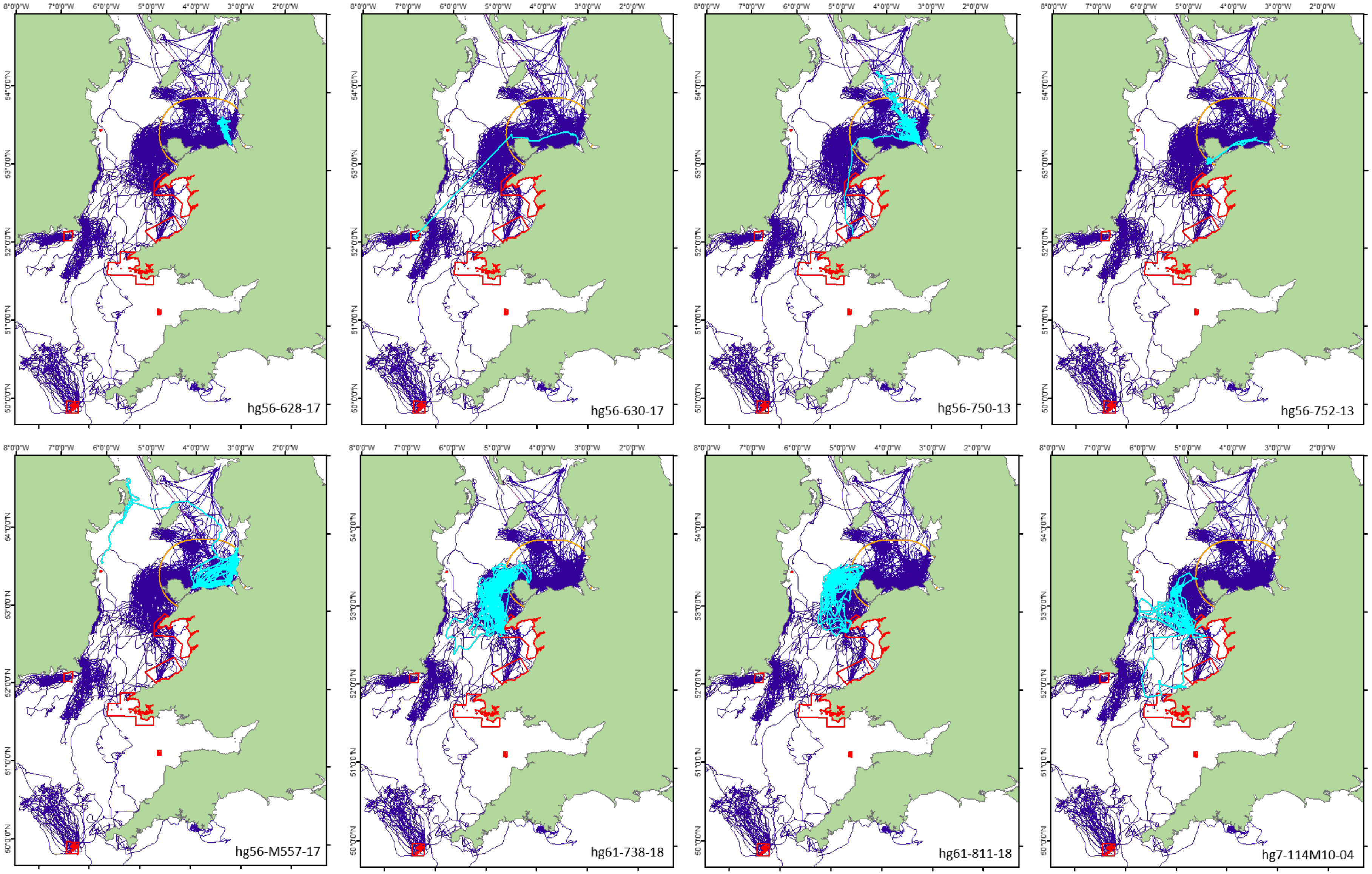
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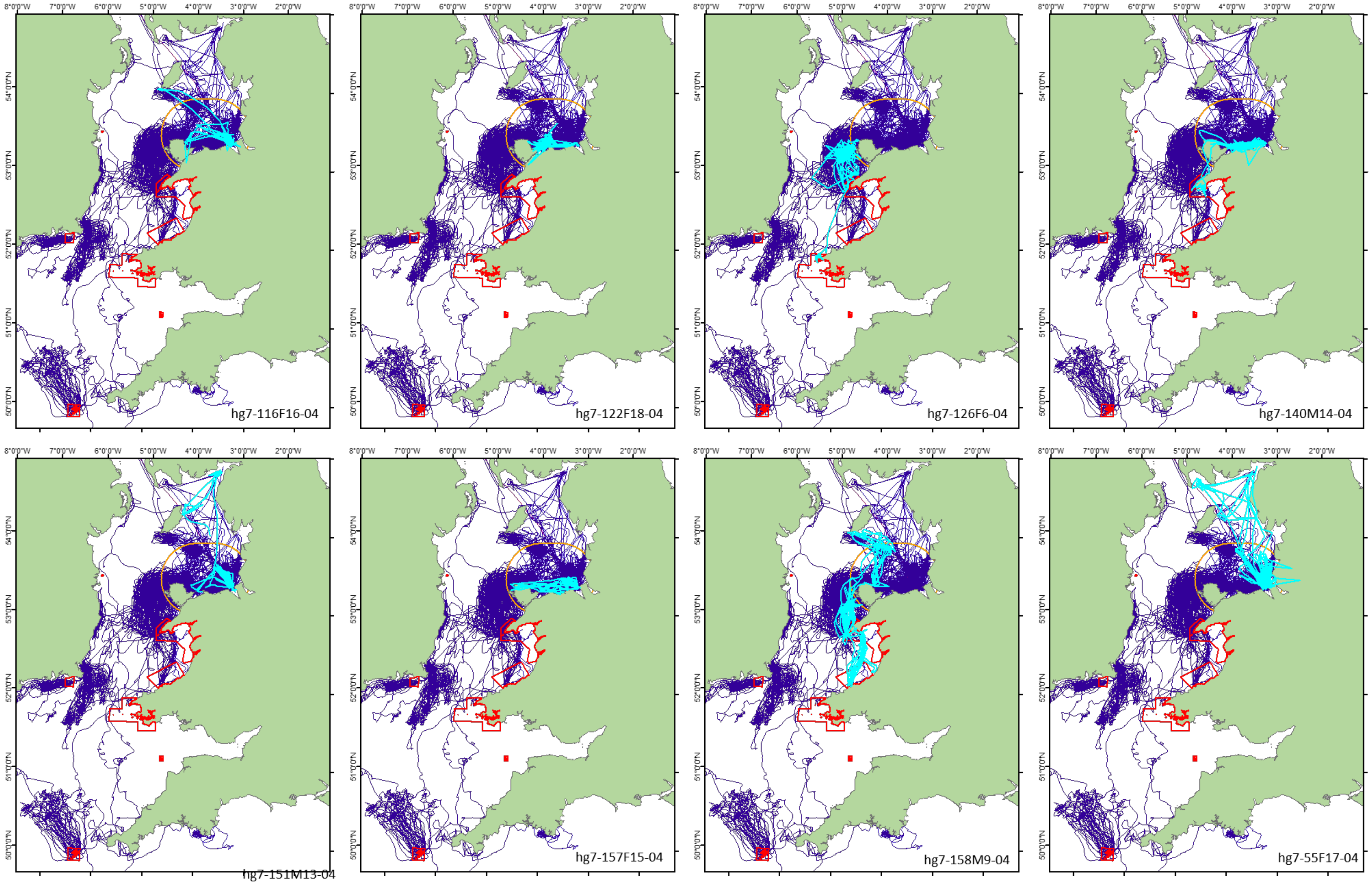
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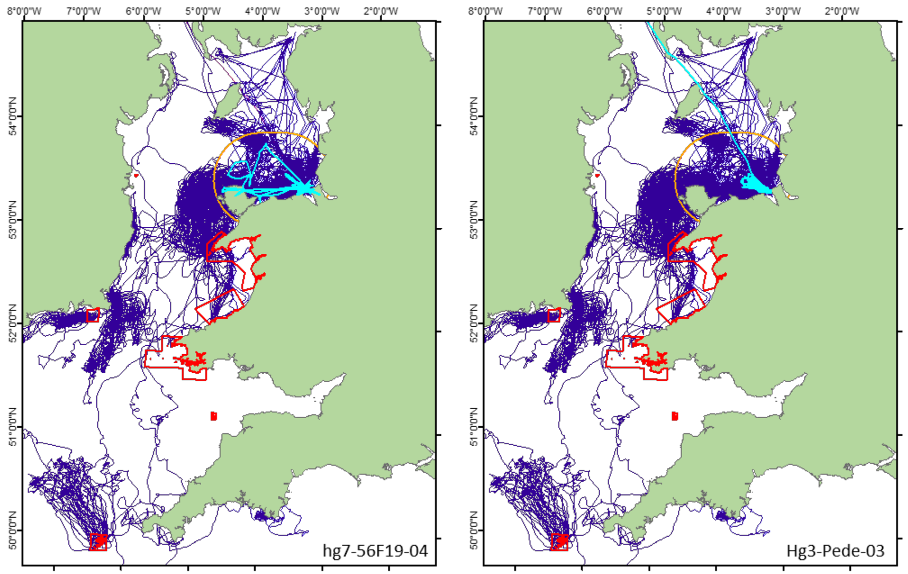

Figure 2.1 Telemetry tracks of the 34 grey seals with data recorded within the 50 buffer of the AyM array area (red lines = grey seal SACs, dark blue = all tracks, bright blue = individual track, orange circle = 50 km buffer)

2.3 Assessment of disturbance

2.3.1 Number of grey seals disturbed

While the ES assessment concluded that the maximum design scenario for the northwest modelling location could potentially result in disturbance to up to 81 grey seals, this level of disturbance is not representative of the expected disturbance levels at all WTGs across the array area. The modelling for a monopile at the SE location predicted disturbance to 62 grey seals, which is 74% of the predicted number disturbed at the NW location. The reason for this difference is a combination of:

- differences in the grey seal density surface, with higher predicted densities in the Liverpool Bay/ Dee Estuary area (SE of the site) compared to the more offshore waters (NW of the site), and
- differences in modelled sound propagation between the NW and SE locations, the NW location is in 35.5 m depth while the SE location is in 19.2 m depth – the underwater noise is expected to propagate further in deeper water and as such, WTGs in deeper waters will have larger impact ranges.

It was not possible to conduct underwater noise modelling for all WTGs across the array area, however, the modelling at two locations sufficiently demonstrates how the predicted number of grey seals disturbed is expected to change with respect to both distance from higher density areas and water depth at the modelling location.

2.3.2 Consequences of disturbance

The expert elicitation workshop in Amsterdam in 2018 (Booth et al. 2019) concluded that grey seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores and that the survival of 'weaned of the year' animals and fertility were determined to be the most sensitive parameters to disturbance (i.e. reduced energy intake). However, in general, experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance due to their larger energy stores and more generalist and adaptable foraging strategies. Grey seals are capital breeders and store energy in a thick layer of blubber, which means that, in combination with their large body size, they are tolerant of periods of fasting as part of their normal life history. Grey seals are also highly adaptable to a changing environment and are capable of adjusting their metabolic rate and foraging tactics, to compensate for different periods of energy demand and supply (Beck et al. 2003, Sparling et al. 2006). Grey seals are also very wide ranging and are capable of moving large distances between different haul out and foraging regions (Russell et al. 2013). Therefore, they are unlikely to be particularly sensitive to displacement from foraging grounds during periods of active piling.

The experts agreed that grey seals could tolerate moderate-high levels of repeated disturbance (>100 days, most likely ~180 days, up to 335 days) before there was any effect on adult female fertility rates (Figure 2.2, top left). The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and experts agreed that during this time it might take lower levels of repeated disturbance (>14 days, most likely ~55 days, up to 200 days) before there was any effect on weaned-of-the-year survival (Figure 2.2, top right). The experts also predicted that that same 'weaned of the year' calf would require moderate levels of repeated disturbance (>30 days, most likely ~90 days, up to 330 days) to reduce its survival rate to zero (Figure 4, top right).

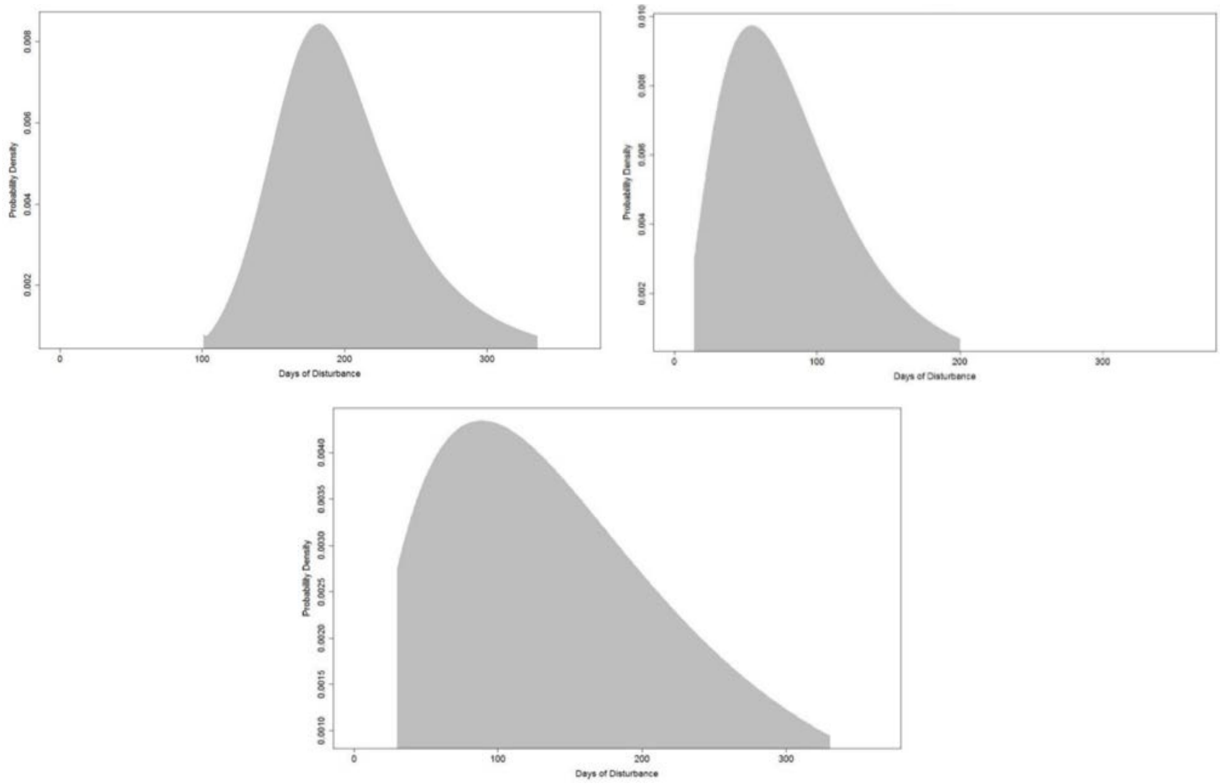

Figure 2.2 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth et al., 2019).

Top left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Top right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' grey seal could 'tolerate' before it has any effect on survival. Bottom left: number of days required to reduce the survival of the same 'weaned of the year' individual to zero.

2.4 SAC Population Assessment

When attributing impacts to the "Lleyn Peninsula and the Sarnau SAC Population" it is important to consider that the grey seal population in the UK has been significantly increasing for several years, and therefore the "SAC population size" at the time of SAC designation (2004) is considerably smaller than that estimated by the current count data (though it should be noted that grey seal haul out count data in Wales are sparse due to the inaccessibility of many of the key haul-out sites, e.g. Stringell et al. 2014). The Lleyn Peninsula and the Sarnau SAC site evaluation for grey seals lists a population size of 101 (min) to 250 (max) but was considered to be based on poor data quality (rough estimation) (JNCC 2015b).

More recent analysis of the photo-ID images within the EIRPHOT database identified 618 individuals at Bardsey Island in 2011 (Langley et al. 2020) (Table 2.2), which is the main breeding site within the Lleyn Peninsula and the Sarnau SAC. This highlights that the SAC designation size is not reflective of the number of grey seals using the SAC. Therefore, using the estimated population size at the time of SAC designation against which to assess potential impacts is considered to be inappropriate as it is not reflective of the current level of grey seal usage within the SAC.

As shown from the telemetry data, the photo-ID data held in the EIRPHOT database found high levels of connectivity between sites along the Welsh coast, within SACs, between different SACs, and between SACs and non-designated areas (Langley et al. 2020). These data further highlight the fact that there is no such thing as a "Lleyn Peninsula SAC grey seal" as there is evidence from both the telemetry and photo-ID data that grey seals move between SACs along the Welsh coastline.

Table 2.2 The number of individuals at Bardsey within the EIRPHOT database identified by left head extracts for each year (from Table S5 of Langley et al. (2020)).

Year	Total identified
2008	61
2009	413
2010	553
2011	618

2.5 Population modelling

In order to assess whether the predicted level of disturbance would be sufficient to cause a population level effect, the interim PCoD model (version 5.2) was run. Conservative input values were used in the model, such that 81 grey seals were predicted to be disturbed on every piling day. The model assumed the absolute worst case scenario, that there could be a total of up to 201 days on which piling might occur (where it was precautionarily assumed that it could take up to three days to install each monopile, resulting in 150 piling days for 50 WTGs, 48 piling days for the two OSPs and 3 piling days for one met mast). An indicative piling schedule was not available for use, and therefore the piling days were randomly spread throughout the 12 month construction period.

Two scenarios were considered:

- assuming all grey seals in the OSPAR Region III MU are functionally linked to the SAC, and thus the "SAC population" is effectively considered to be the MU population (66,100 animals)
- assuming that not all grey seals in the OSPAR Region III MU are linked to the SAC, and thus the impact is allocated to the Lleyn Peninsula and the Sarnau SAC designated population (618 animals)

Table 2.3 outlines the parameters that were input into the iPCoD model.

Table 2.3 Grey seal population modelling inputs

Inputs		MU	SAC
Number of simulations run	nboot	1000	1000
Species (GS=grey seal)	spec	GS	GS
Proportion of population that is female	propfemale	0.5	0.5
Population size at the start of simulations	pmean	**66100**	**618**
Pup survival rate	Surv[1]	0.222	0.222

Juvenile survival rate	Surv[7]	0.94	0.94
Adult survival rate	Surv[13]	0.94	0.94
Fecundity rate	Fertility	0.84	0.84
Age at independence	age1	1	1
Age at first birth	age2	5	5
Number of piling years	pile_years	1	1
Proportion of animals in vulnerable component	vulnmean	c(1.0)	c(1.0)
Days of "residual" disturbance	days	0	0
Proportion of disturbed experiencing “days”	prop_days_dist	1	1
Number of piling Operations	pilesx1	1	1
Seasonal variation (1=no variation)	seasons	1	1
Number of animals predicted to experience disturbance during 1 day of piling	numDt[1,]	81	81
Years for simulation	years	25	25
Density dependence (0=no density dependence)	z	0	0
Piling schedule		201 days	201 days

2.5.1 MU Population

The results of the modelling showed that there was no impact on the MU population as a result of the piling activity at AyM (Table 2.4 and Figure 2.3). The median ratio of the impacted:un-impacted population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was 1 and the impacted mean population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was the same as the un-impacted mean population size.

Therefore, despite the highly conservative inputs (that 81 grey seals were disturbed on every piling day and that it would take up to three days to install one monopile), there were no significant population level consequences predicted by the modelling. In conclusion, the pile driving activity at AyM is not expected to result in disturbance levels that are sufficient to affect the MU population.

Table 2.4 Grey seal population modelling results assuming the MU population

Results	MU
Un-impacted pop mean (after 1 year)	66,100
Impacted pop mean (after 1 year)	66,100
Impacted pop as % of un-impacted pop (after 1 year)	100%
Median impacted:un-impacted population size (after 1 year)	1
Un-impacted pop mean (after 6 years)	69,689
Impacted pop mean (after 6 years)	69,689

Impacted pop as % of un-impacted pop (after 6 years)	100%
Median impacted:un-impacted population size (after 6 years)	1
Un-impacted pop mean (after 12 years)	73,772
Impacted pop mean (after 12 years)	73,772
Impacted pop as % of un-impacted pop (after 12 years)	100%
Median impacted:un-impacted population size (after 12 years)	1

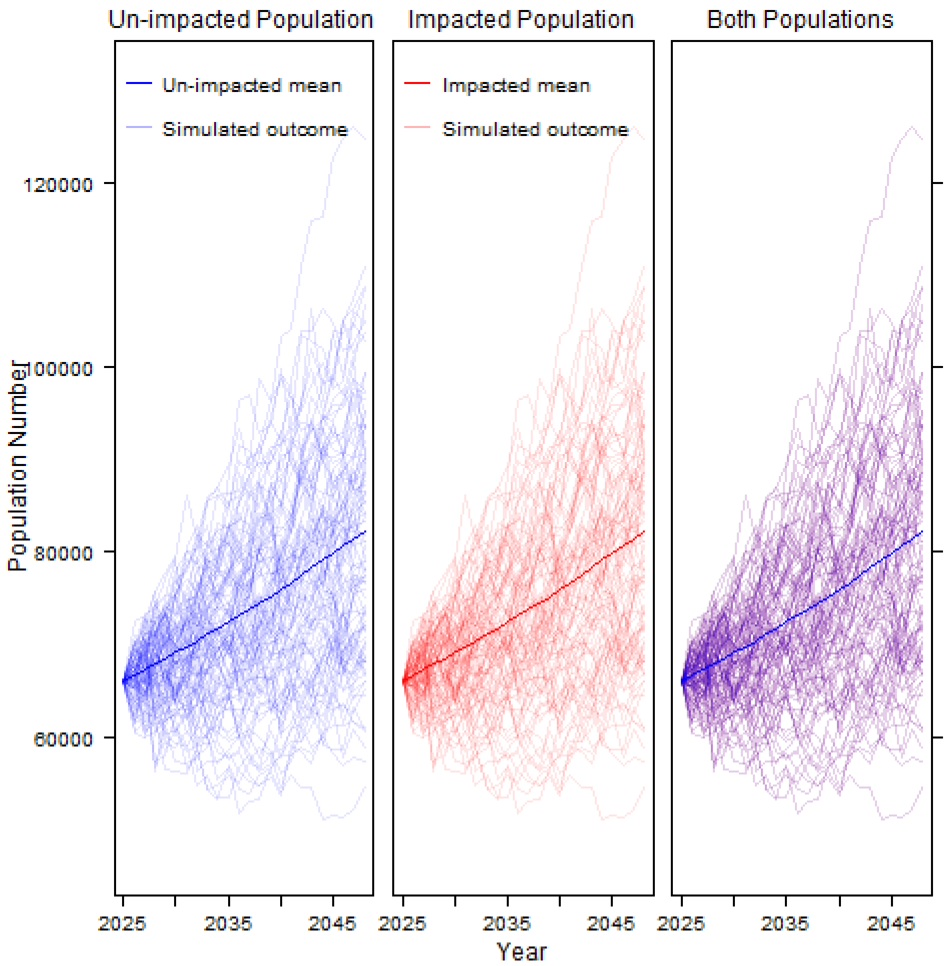

Figure 2.3 Population trajectories of the impacted and unimpacted populations (assuming impact to the MU population).

2.5.2 SAC Population

The results of the modelling showed that there was no impact on the "SAC population" as a result of the piling activity at AyM (Table 2.5 and Figure 2.4). The median ratio of the impacted:un-impacted population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was 1 and the impacted mean population size after 6 years of simulation (1 year of impact followed by 5 years with no impact) was the same as the un-impacted mean population size.

Therefore, despite the highly conservative inputs (that 81 grey seals were disturbed on every piling day, that it would take up to three days to install a monopile, and that all disturbance was attributed to the Lleyn Peninsula and the Sarnau SAC designated population), there were no significant population level consequences predicted by the modelling. In conclusion, the pile driving activity at AyM is not expected to result in disturbance levels that are sufficient to affect the Lleyn Peninsula and the Sarnau SAC designated population.

Table 2.5 Grey seal population modelling results assuming the SAC population

Results	SAC
Un-impacted pop mean (after 1 year)	622
Impacted pop mean (after 1 year)	622
Impacted pop as % of un-impacted pop (after 1 year)	100%
Median impacted:un-impacted population size (after 1 year)	1
Un-impacted pop mean (after 6 years)	652
Impacted pop mean (after 6 years)	652
Impacted pop as % of un-impacted pop (after 6 years)	100%
Median impacted:un-impacted population size (after 6 years)	1
Un-impacted pop mean (after 12 years)	692
Impacted pop mean (after 12 years)	692
Impacted pop as % of un-impacted pop (after 12 years)	100%
Median impacted:un-impacted population size (after 12 years)	1

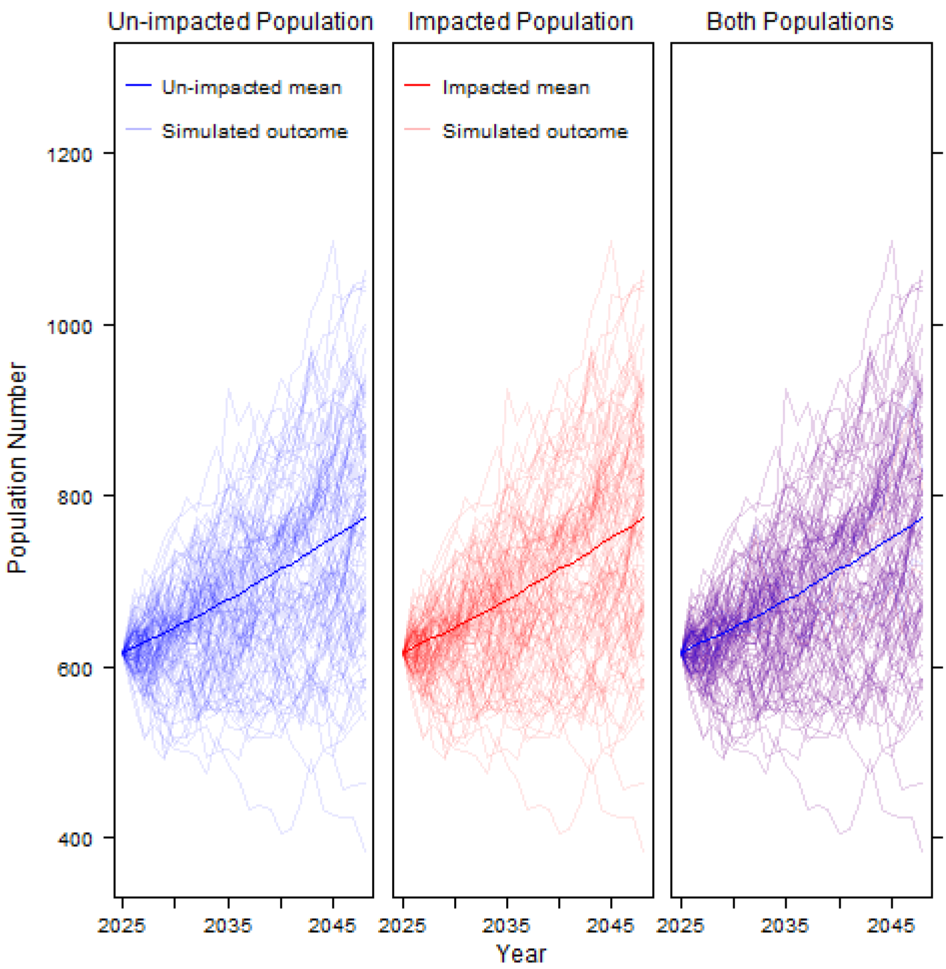

Figure 2.4 Population trajectories of the impacted and unimpacted populations (assuming impact to the SAC population).

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Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited
Windmill Hill Business Park
Whitehill Way
Swindon