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# Briefing note

**To:** Aquaculture Licences Appeals Board

**Date:** 19 May 2021

**From:** MERC Consultants

Further to submissions received in response to the public consultation phase in relation to Appropriate Assessment of the proposed Shot Head salmon farm, the following represents the response to issues raised by stakeholder submissions, based on best available scientific evidence and expertise. The response addresses:

- All points raised by the Submissions relating to the issue of lacunae or gaps in the ***Report for the purposes of the Aquaculture Licences Appeals Board's Appropriate Assessment of a proposed salmon farm at Shot Head, Bantry Bay, Co Cork,*** (MERC, 2020).
- Concerns raised in the Submissions relating to the issue of bird entanglement and mortality and how this may impact on the SPA species as considered in the report.
- How the conclusion to the Report was formed regarding lacunae/gaps.

## A. The following points of concern were raised by An Taisce with regards to the report supporting AA prepared by MERC.

### 1. An Taisce Concern: Screening

An Taisce raised concerns regarding potential impacts on Storm Petrel. Impacts on Storm Petrel were outside of the scope of the AA report prepared by MERC.

The scope of the report supporting AA commissioned by ALAB from MERC is as follows:

- Fulmar (Beara Peninsula SPA, Iveragh Peninsula SPA, Deenish Island and Scariff Island SPA)
- Gannet (The Bull and The Cow Rocks SPA and Skelligs SPA)
- Guillemot (Iveragh Peninsula SPA)

### 2. An Taisce Concern: Lacunae in the Report supporting AA

An Taisce note that the report supporting AA describes that there is a lack information with regards to seabird interactions with caged fish farms and specifically a lack of evidence with regards to Gannet mortality at fish farms owing to entanglement.

In this regard, An Taisce makes the following points:

- That the lack of evidence points to a lack of data on the likely effects of the proposed development.
- That despite the lack of evidence with regards to effects, MERC has concluded that effects are unlikely to lead to significant population decline.
- That this conclusion lacks scientific rigour.

An Taisce point out further, that:

The Board must be satisfied that on the basis of scientific information without gaps or lacunae that there will be no adverse effects on the integrity of protected sites. Reference is made to Kelly V An Bord Pleanála & Ors and the following points are made:

- The competent authority must carry out an AA for a plan or project in light of the best scientific knowledge in the field and that the final determination must include complete, precise and definitive findings.
- The AA "cannot have lacunae and must contain complete, precise and definitive findings and conclusions capable of removing all reasonable scientific doubt".

An Taisce reiterates:

- Where there are lacunae, the AA is incomplete
- Where an effect is considered to be unlikely, or highly unlikely, this cannot be the basis for a finding that it will not occur. Proof is required beyond reasonable scientific doubt.
- The lack of evidence of impact, does not mean that the impact does not occur.

## 2.1 MERC Response

**2.1.1 The key concerns of An Taisce may be covered by the following:**

- There is a lack of data and information with regards to Gannet and fish farm interactions and the impact of any interaction (injury and/or mortality).
- This lack of data and information cannot lead to a conclusion of no effect.
- An effect is considered to be likely and the impact of this effect cannot be measured in the absence of data.
- This leads to reasonable scientific doubt in the Report supporting AA.
- Where reasonable scientific doubt arises, the AA is incomplete.

**2.1.2 The following is a response these concerns:**

The report supporting AA was informed in part by a review of literature regarding interactions between seabirds and caged salmon farms. This approach is standard within the scientific community as an approach to informing impact and other assessments. This review found that there is an absence of research into the interaction between caged salmon farms and seabirds. That this interaction could and occasionally does occur was acknowledged in the Report supporting AA. The Report supporting AA was also part-authored by a fisheries and aquaculture environmental specialist who has extensive experience and detailed knowledge of commercial pen rearing salmonids at sea in Ireland.

In completing the report, the absence of relevant research was considered a likely indication of the absence of a significant level of interaction. The reasons for this are:

- High mortality between caged salmon farms and seabirds is likely to have been noted by the industry (gannet predation at salmon cages will affect stock and cage maintenance) and was not known to occur based on the experience and knowledge of a contributing author
- High levels of interaction between seabirds and salmon cages is certain to have been noted by the statutory monitoring agencies as well as interested stakeholders, the general public and local interests. No concerns have been raised by monitoring authorities in relation to gannet mortality on salmon farms and no evidence of such interaction is provided in the submission by An Taisce. Wildlife stakeholders and the public generally engage with wildlife that they can see, particularly in relation to iconic species, such as gannets. It is highly likely that injured or dead gannets would be observed and recorded by the public, monitoring agencies, interested stakeholders as well as salmon farm operators at or close to cage farms in Ireland or other jurisdictions that share cage farming industries and gannet populations (e.g. Norway, Scotland). No such evidence has been provided at any stage in any submissions and desk research and specific knowledge and experience confirms that gannet mortality is a rare event on a salmon cage installation.
- Some accounts of wildlife and cage fish farm interactions were available in the literature review. From these accounts those species which interacted frequently with cage farms in the north east Atlantic were seals and cormorants.

However, in preparing the report supporting AA, the conclusion that significant effects in relation to Gannet populations were unlikely was also informed by the following:

- The Gannet population of the Bull and Cow Rocks SPA is increasing, as is the Gannet population nationally and in the UK. This suggests that additional mortality (from any interaction) is not causing sufficient death in the Gannet population to cause a population decline.
- The Gannet population of the Bull and Cow Rock SPA is increasing in the presence of existing and long-established salmon farming operations both within Bantry Bay and the surrounding area (Deenish Island and Inishfarnard in Kenmare River). Any possible fatal interactions between gannets and established salmon farms in the area is not causing sufficient additional mortality to cause a population decline. In the case of a declining population the reasons for a decline are likely to be complex and fatal interactions between gannets and salmon farms are very unlikely to be the principal cause of gannet population decline.
- As stated previously, the population is not in decline and there is no evidence that current salmon farming activity is having a negative impact on the population parameters of growth and population size for Bull and Cow Rocks SPA gannet population.
- Well-developed understanding of the levels of interaction with wildlife in general within the salmon industry gained during extensive commercial marine salmon farming husbandry experience in Ireland.

Based on the above and as detailed in the report supporting AA, the conclusion that significant mortality is unlikely to arise from the proposed salmon farm is supported by sufficient scientific and empirical evidence, which is considered sufficient to remove any reasonable scientific doubt concerning impacts. The Report supporting AA does not suggest that fatal/injurious interactions between gannets and salmon cages never occurs, however it does conclude on the basis of reasonable scientific and empirical evidence that the level of mortality will not be significant to the extent that it would adversely affect the Bull and Cow Rock SPA gannet population.

Notwithstanding the above, further analysis of the issue of Gannet mortality and population level effects on the Bull and Cow Rocks SPA, has been sought, to address the concerns raised by An Taisce. This analysis has been undertaken by DMP Statistics. DMP carried out statistical modelling called Population Viability Analysis to estimate the impact of additional Gannet mortality on the Bull and Cow Rock SPA. The results of this analysis are discussed in more detail in section 3.1.2 of this Response and are presented in full in the report (DMP, 2021).

## 3. An Taisce Concern: Entanglement – Absence of Evidence, Admission of Lacunae

An Taisce make the following points:

- The Report supporting AA acknowledges that there is a risk of entanglement causing mortality owing to caged salmon farming.
- The Report supporting AA acknowledges what An Taisce describes as "*an admission of possible impact, with non-routine mortality and injury*".
- There is a reliance on the fact that other farms have not reported mortality as a result of entanglement, yet there is no requirement for the independent verification of mortality monitoring.
- The lack of recorded mortality cannot inform a conclusion of low risk. An Taisce point out that gannets may forage at the caged farm sites before staff arrive and even if on site they may not see an injured or dying bird. The absence of evidence it is reiterated does not mean the impact does not occur.

Further points are made with regards to the increasing Gannet population in SPA's:

- That the report supporting AA relies on the fact the gannet population in SPA's in proximity to salmon farms is increasing.
- That the report supporting AA notes that while the Gannet population is increasing it will not do so indefinitely.
- That the report supporting AA concludes that in the context of population decline an annual harvest or mortality rate owing to entanglement will be required.
- An Taisce suggest this is a chilling conclusion where mortality impacts are accepted and points to the Gittings 2018 report where 1.7 Gannets lost per SPA would be significant.
- An Taisce suggest that the report supporting AA is suggesting to wait until numbers begin to fall in order to obtain any hard data.
- An Taisce describe the need for prevention and precuaiton within the context of the Habitats Directive, the need for science and verifiable hard data and that even the loss of 1.7 Gannets per year from any SPA would be significant, with a small risk constituting a potential adverse risk on the integrity of the SPA.

### 3.1 MERC Response

**3.1.1 The key concerns of An Taisce may be covered by the following:**

- The absence of data on Gannet mortality should not lead to a conclusion that injury or mortality as a result of entanglement is a rare event. Mortality and injury may be overlooked by salmon farm operators either in their recording system or owing to the fact that staff may not see injured or dead birds.
- That the Report supporting AA is proposing to wait until the Gannet population is in decline before gaining scientific data to ascertain actual mortality levels at salmon farms.

- That 1.7 Gannet mortalities per year at an SPA would be significant, with effects on site integrity.

**3.1.2 The following is a response these concerns:**

The absence of data on Gannet mortality and the conclusion that the risk of injury and mortality is low is based on objective scientific review as described in 2.1.2. It is the case that staff may not notice mortality events outside of working hours. It is also the case that were such events to occur with any frequency they would be noticed by staff during working hours and also by stakeholders, local interests, farm staff, farm managers and/or the public. There is an absence of data from a research project or published research findings to spatially and temporally quantify seabird and cage farm interactions. Because of this, a review of the scientific literature was completed as part of the report supporting AA. This review did not find that Gannet mortality at salmon farms was recorded or reported with any frequency. If the literature review found a higher level of concern regarding Gannet entanglement and death, the need for data to be collected before the report supporting AA could be concluded would have been an explicit recommendation. However, the available information did not indicate this as being necessary. The conclusion of the report supporting AA in this regard is also informed by technical knowledge and experience of a fisheries and aquaculture environmental impact specialist with more than 30 years of relevant experience.

The AA Screening Report does not suggest that it is good practice to wait until there is a population decline before gathering scientific data on a risky interaction. It is acknowledged that mortality owing to entanglement of seabirds is likely to occur occasionally at fish farms. A review of available literature strongly indicates that such events are at worst occasional and in this context population level effects are considered highly unlikely to result. The Gannet populations in nearby SPA's are increasing, suggesting that if mortality does occur (at existing fish farms), it is not having a population level effect.

In a declining population, even low levels of mortality can become significant. The scientific literature reports that it is likely that the Gannet population cannot sustain current growth levels and that in the future pressures such as lack of foraging resources and climate change may begin to affect Gannet survival or productivity and lead to reduced growth or even decline. Before this occurs, it is important to understand the various and cumulative pressures on a population. It is within this context that the monitoring of seabird interactions at fish farms is proposed. It is suggested that the industry has a responsibility to undertake this monitoring at existing sites and under any new licenses. Monitoring is not proposed as a mitigation, it is proposed as a measure to inform wildlife managers, monitoring agencies as well as the collective salmon farming industry as to the extent and nature of all seabird-fish farm interactions.

The Gittings (2018) report described that 10 additional Gannet mortalities per year or 1.7 Gannet mortalities per caged farm per year could lead to a 1% increase in mortality at the Bull and Cow Rocks SPA. Gittings states that in the assessment of collision risk from wind farm developments, a precautionary threshold of a 1% increase in the annual mortality rate is widely used to assess the potential significance of collision mortalities. Gittings also stated that without further information on likely Gannet mortality rates at fish farm sites, and/or more detailed analysis of Gannet population dynamics, it is not possible to assess whether the combined effect of all the fish farm sites in Bantry Bay would result in a significant level of mortality to the Gannet colony in the Bull and the Cow Rocks SPA. Since preparation of the report for the purposes of AA by MERC, Population Viability Analyses (PVA) was conducted for the breeding colony of Gannets in the Bull and Cow Rocks SPA, with the purpose of investigating impacts on population parameters of mortalities associated with

entanglement of Gannets in a proposed fish farm the Bantry Bay (DMP, 2021). The PVA modelling focuses only on the Bull and Cow Rocks SPA, and as such can be considered precautionary as it is unlikely that Gannet mortality associated with the proposed farm would be exclusively linked to this population (there are other colonies in nearby SPAs e.g., the Skelligs SPA) (DMP, 2021).

Modelling results show the effects and significance of impact scenarios in terms of population, for two considered time-periods: the end of the license period (2031) and after a 10-year recovery period (2041). Based on these time periods the results show:

In terms of population growth rate, and:

- by the end of the license period (2031):
  - Results suggest **10** additional annual adult mortalities due to entanglement would likely cause **a low significant impact** in the population's growth rate (0.09% reduction from unimpacted levels)
  - Impacts **between 100 and 500** additional annual adult mortalities may lead to **potentially significant reductions** in growth rate.
  - Impacts causing **over 500** additional annual adult mortalities would cause **highly significant reductions** in growth rate.

- after a 10-year recovery period (2041):
  - **10** additional annual adult mortalities due to entanglement are likely to cause a **low significant impact** in the population's growth rate.
  - Impacts **between 200 and 1000** additional annual adult mortalities may lead to **potentially significant reductions** in growth rate.
  - Impacts **over 1000** additional annual adult mortalities may cause **highly significant reductions** in growth rate.

In terms of population size, by the end of the license period (2031) and after a 10-year recovery period (2041):

- **10** additional annual adult mortalities due to entanglement may cause a **low significant impact** in population numbers (0.99% drop from unimpacted levels)
- Impacts **between 20 and 50** additional annual adult mortalities may lead to **potentially significant drops** in population numbers.
- Impacts causing **over 50** additional annual mortalities would likely cause **highly significant drops** in population numbers.

Following the criteria of Percival (2003; cited in DMP, 2021) effects of low significance would not normally be of concern within the context of AA being regarded as a very slight change in baseline conditions with <1% reduction in population.

Based on the literature, direct knowledge of salmon husbandry at sea, as well as well-developed understanding of management of risks to wildlife on salmon farms, it is considered that Gannet mortality owing to net entanglement is highly likely to be a rare event. Results of the PVA analyses show that with a low level of mortality annually ie <10 Gannets, the effects on the Bull and Cow Rock Gannet populations is of low significance. Between 20 and 50 additional mortalities are estimated to lead to potentially significant drops in population numbers. Levels of mortality in excess of 20 Gannets per year (where each of these Gannets comes from the Bull and Cow Rock SPA) are considered to be highly unlikely and as such significant effects on the Bull and Cow Rock SPA population as a result of this effect are considered unlikely.

## 4. An Taisce Concern: Moderate disturbance.

An Taisce make the following points:

The Report supporting AA describes moderate disturbance to Guillemots causing displacement (as a result of the proposed salmon farm) is evidence pointing towards an adverse effect.

### 4.1 MERC Response

**4.1.1 The key concerns of An Taisce may be covered by the following:**

Adverse effects on Guillemots have been overlooked in the Report supporting AA

**4.1.2 The following is a response these concerns:**

Guillemots may be displaced from the footprint of the propose fish farm. Guillemots forage over a wide area and their prey is highly mobile. Displacement from the area of Bantry Bay occupied by the salmon farm is not likely to be significant for a species which forages over a wider area and preys on mobile species.

## 5. Significant declines – Favourable Conservation Status.

An Taisce make the following points:

- The Report supporting AA outlines that direct and indirect impacts on SCI species is assessed with a view to the NPWS Conservation Objectives for the Saltee Islands SPA which aim for "no significant decline" in breeding population, abundance, productivity rate, or distribution.
- An Taisce points out that these criteria do not meet the requirements of the Habitats Directive, which are that there is no adverse effect on the integrity of the site if the conservation status is unfavourable, which is the case if numbers are falling – not merely significant, but at all.
- An Taisce state that as such, the Report supporting AA is using a standard of decline that allows for reduction in conservation status and does not meet the requirements for eliminating the risk of adverse effect on the integrity of the site.

### 5.1 MERC Response

**5.1.1 The key concerns of An Taisce may be covered by the following:**

- Any fall in Gannet numbers will results in adverse effects on the integrity of the Bull and Cow Rocks SPA.

**5.1.2 The following is a response these concerns:**

The objective to prevent any reduction in the Gannet population, beyond natural variation, on the Bull and Cow Rocks SPA is an important one.

The Conservation Objectives for the Bull and Cow Rocks SPA is to: To maintain or restore the favourable conservation condition of the bird species listed as Special Conservation Interests for this SPA. In the absence of detailed CO's for this site, those for the Saltee Islands were used. For Gannet the detailed conservation objectives are: To maintain the favourable conservation condition of Gannet in the Saltee Islands SPA, which is **defined by the following list of attributes and targets:**

| Attribute | Measure | Target |
|---|---|---|
| Breeding population abundance: apparently occupied nests (AONs) | Number | No significant decline |
| Productivity rate: fledged young per breeding pair | Mean number | No significant decline |
| Distribution: breeding colonies | Number; location; area (hectares) | No significant decline |
| Prey biomass available | Kilogrammes | No significant decline |
| Barriers to connectivity | Number; location; shape; area (hectares) | No significant increase |
| Disturbance at the breeding site | Level of impact | No significant increase |
| Disturbance to marine areas adjacent to colony | Level of impact | No significant increase |

PVA modelling (DMP, 2021) shows that an impact of between 20 and 50 additional annual adult mortalities may lead to potentially significant drops in population numbers on the Bull and Cow Rock SPA. Thus, the modelling shows that an additional mortality of at least 20 mortalities per year is required before population level effects become significant. It considered highly unlikely that this level of mortality occurs at salmon farms without detection and without concerns being reflected in the literature. A significant decline in the breeding population of the Bull and Cow Rock SPA is therefore not considered likely. It is noted again that the PVA modelling focuses only on the Bull and Cow Rocks SPA, and as such can be considered precautionary as it is unlikely that all Gannet mortality in the proposed farm would be exclusively linked to this population (there are other colonies in nearby SPAs e.g. Skelligs SPA) (DMP, 2021).

Any Gannet mortality owing to anthropogenic pressures should be avoided at salmon farms. On this basis the AA report recommended that monitoring of fish farm and seabird interactions is monitored, so that even occasional mortality owing to salmon cages may be avoided.

## 6. An Taisce Concern: Conclusion: Contradicted by the Evidence

An Taisce make the following points:

- Cumulative impacts arising from the removal of fish are considered in the Report supporting AA.
- The report supporting AA concludes that although the amount of foraging habitat will be reduced by 2% this does not reduce the actual amount of forage fish available.
- An Taisce make the point that the fish farm will reduce the foraging resource available to seabirds owing to increased pressure on fish stocks to feed farmed fish. Concerns are raised with regards to sprat (and juvenile herring as bycatch) which is both foraged by seabirds and fed to farmed salmon.
- The statement that a reduction in foraging habitat in Bantry Bay does not reduce the amount of forage fish available, is considered to be illogical.
- Impacts on the marine ecosystem have not been fully assessed leading to lacunae and incomplete AA

### 6.1 MERC Response

The reduced foraging habitat owing to the footprint of the salmon farm is highly unlikely to lead to reduced foraging as fish prey are mobile. The footprint of the fish farm will lead to a small loss of area available to forage within rather than a reduction in prey.

The potential impact of reduced foraging for seabirds owing to increased pressure on fish stocks to feed farmed fish is a complex interaction. The AA report was required to consider, the potential impact of the Shot Head salmon farm development on the conservation objectives of:

- Fulmar (Beara Peninsula SPA, Iveragh Peninsula SPA, Deenish Island and Scariff Island SPA)
- Gannet (The Bull and The Cow Rocks SPA and Skelligs SPA)
- Guillemot (Iveragh Peninsula SPA)

The AA report assessed potential impacts arising from the proposed Shot Head salmon farm on the basis of evidence presented in the Marine Institute AA-screening matrix, independent AA screening report and Natura Impact Statement processes, along with a subsequent detailed appraisal and validation of the evidence presented.

## B. Response to Save Bantry Bay submission of 13.11.2020

The commentary concerning the desirability of more detailed information on interactions with seabirds is acknowledged and this is recommended in the report supporting AA.

Further comments contained in the submission do not refer to potential gaps around bird mortality data pertaining to fish farms and no further response is provided.

## C. Response to submission from Galway Bay against salmon cages

The submission from GBASC has been reviewed. There is no requirement for a response from MERC as the submission makes no reference to potential gaps around bird mortality data pertaining to fish farms

## D. Response to submission by Friends of the Irish Environment

The submission from FIE has been reviewed. FIE raise concerns regarding the following: Disease and its transmission to native species; Impact of the collection and use of wrasse as cleaner fish; Algae blooms; Lumpfish; The pair trawling for sprat in Bantry Bay for fishmeal production; Pesticides.

The concerns raised by FIE focus on the Habitats Directive Screening completed by the Marine Institute with regards to this application. It is outside of the scope of AA Report prepared by MERC which was required to focus specifically on SPA and bird species of Special Conservation Interest. One concern relates to the indirect impact of pair trawling for sprat species protected under the Birds Directive.

The potential impact of reduced foraging for seabirds owing to increased pressure on fish stocks to feed farmed fish is a complex interaction. The AA report was required to consider, the potential impact of the Shot Head salmon farm development on the conservation objectives of:

- Fulmar (Beara Peninsula SPA, Iveragh Peninsula SPA, Deenish Island and Scariff Island SPA)
- Gannet (The Bull and The Cow Rocks SPA and Skelligs SPA)
- Guillemot (Iveragh Peninsula SPA)

The AA report assessed potential impacts arising from the proposed Shot Head salmon farm on the basis of evidence presented in the Marine Institute AA-screening matrix, independent AA screening report and Natura Impact Statement processes, along with a subsequent detailed appraisal and validation of the evidence presented.

## References

**DMP (2021)** Population Viability analysis of the Impacts of additional mortality due to fish net entanglement in Gannets from Bull and Cow Rocks SPA. Prepared for MERC Consultants Ltd by DMP Statistical Solutions UK Ltd. 27 April 2021. Version 1.0 Draft.

**Percival, S.M. (2003).** Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment

# POPULATION VIABILITY ANALYSIS OF THE IMPACTS OF ADDITIONAL MORTALITY DUE TO FISH NET ENTANGLEMENT IN GANNETS FROM BULL AND COW ROCKS SPA

Prepared for MERC Consultants Ltd

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19 May 2021

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| DOCUMENT INFORMATION | |
|---|---|
| VERSION | 2.0 |
| ISSUED DATE | 19 May 2021 |
| AUTHOR | B. Caneco & C. Donovan |
| STATUS | Final |

**REVISION HISTORY**

| VERSION | ISSUED DATE | REASON FOR ISSUE |
|---|---|---|
| 1.0 | 27 April 2021 | Issued for Information & review |
| 1.1 | 28 April 2021 | Minor typo corrections and text editing |
| 2.0 | 19 May 2021 | Finalised following approval |

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## OVERVIEW

This document presents the underpinnings of the Population Viability Analyses (PVAs) conducted for the breeding colony of Gannets in the Bull and Cow Rocks SPA to investigate population-level impacts of mortalities from entanglement in a proposed fish farm the Bantry Bay. Stochastic, density independent, age-structured matrix models were used to simulate population trends over time for a range of speculative impacts, which were subsequently compared pairwise with unimpacted projections. Full details of the analysis, including model specifications and demographic rates used, are provided below.

## EXECUTIVE SUMMARY

The following points summarise the main findings from the PVA of Gannets in the Bull and Cow Rocks SPA[1]:

- 10 additional adult Gannet deaths due to net entanglement in the starting year (2021) corresponds to an increase of 1% in the baseline/unimpacted mortality rate per year.

- In terms of population growth rate:

  - by the end of the license period (2031):

    - Results suggest **10** additional adult deaths due to entanglement would likely cause **an impact of low significance**[2] in the population's growth rate (0.09% reduction from unimpacted levels)

    - Impacts **between 100 and 500** additional adult deaths may lead to **potentially significant reductions** in growth rate.

    - Impacts causing **over 500** additional adult deaths would cause **highly significant reductions** in growth rate.

  - after a 10-year recovery period (2041):

    - **10** additional adult deaths due to entanglement are likely to cause an **impact of low significance** in the population's growth rate.

    - Impacts **between 200 and 1000** additional adult deaths may lead to **potentially significant reductions** in growth rate.

    - Impacts **over 1000** additional adult deaths may cause **highly significant reductions** in growth rate.

- In terms of population size, by the end of the license period (2031) and after a 10-year recovery period (2041):

    - **10** additional adult deaths due to entanglement may cause an **impact of low significance** in population numbers (0.99% drop from unimpacted levels)

    - Impacts **between 20 and 50** additional adult deaths may lead to **potentially significant drops** in population numbers.

    - Impacts causing **over 50** additional deaths would likely cause **highly significant drops** in population numbers.

[1] For ease of reference, impact scenarios are presented in terms of number of additional adult deaths in the starting year – corresponding impacted annual mortality levels can be referred to in Table 4.

[2] Significance here follow the definitions of Percival [-2003]

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# 1 INTRODUCTION

A proposed salmon farm in the Bantry Bay lies within the foraging range of the breeding colony of Gannets in the Bull and Cow Rocks SPA (Grecian et al., 2012). Anecdotal evidence suggests Gannets are only occasional visitors to marine fishing farms, and Gannet mortalities due to fish net entanglement are rare (Gittings, 2018). However, Gannets are a long-lived species and small increases in annual mortality rates could lead to a significant population decline. It is worth noting that the Bull Rock Gannet colony has more than doubled in size over the period during which the existing fish farms in Bantry Bay have been operating.

Based on wind farm impact significance criteria (Percival, 2003), Gittings' (2018) screening assessment suggests that 10 additional adult deaths per year from the proposed fish farm, equating to a 1% increase in the baseline mortality rate, could cause a potentially significant negative impact in the Bull and Cow Rocks SPA Gannet population. However, as the author points out, the 1% change-from-baseline threshold is very precautionary, and further assessments involving population dynamics modelling would be desirable to investigate which level of additional annual mortality would lead to a significant negative impact on the population.

In the present study, investigations of potential population-level impacts from entanglement mortalities are performed via Population Viability Analysis (PVA). PVA provides a robust framework to predict changes in population sizes and growth rates, using demographic parameters and statistical population models to simulate population trajectories under different conditions over a given period. Comparisons are made between 'baseline' conditions, whereby conditions remain unimpacted, and under 'scenario' conditions where speculative impacts are applied to the population by changing the demographic parameters.

By focussing only on the Bull and Cow Rocks SPA, the present analysis can be considered precautionary as it is unlikely that all Gannet mortality in the proposed farm would be exclusively linked to this population (there are other colonies in nearby SPAs e.g., the Skelligs SPA). Modelling covers a 20-year period, representing the expected duration of the fish farm license followed by a 10-year recovery period.

In summary, this analysis aims to provide support for the following issues:

a) With an additional mortality of 10 Gannets per year, would there be population level effects at the Bull and Cow Rocks SPA?
b) What level of Gannet mortality before there are significant population level effects at the SPA?

# 2 METHODS

## 2.1 Modelling specifications and assumptions

The PVA uses an age-structured matrix model (Caswell, 2001) to simulate the population's progress through time in terms of abundance and age distribution, based on species-specific demographic rates and count estimates. The model assumes individuals to be grouped into discrete year age-classes, and all members of an age-class are considered equal with respect to their demographic vital rates (i.e. survival, growth and reproduction). The model dynamics involves predicting the population numbers at age in the next year given its previous year's numbers and vital rates.

The generic population model can be written in compact form as

$$\mathbf{n}_{y+1} = \mathbf{L}\mathbf{n}_y$$

where $\mathbf{n}_y$ is the population vector with elements $n_{a,y}$ denoting the number of individuals at each age-class $a = 1, \dots, A$ at year $y$, $\mathbf{n}_{y+1}$ is the numbers at age-class in the following year, and $\mathbf{L}$ represents the $A \times A$ projection matrix (also known as the Leslie matrix). The projection matrix $\mathbf{L}$ defines the expected contribution to each age-class from the previous year's age-classes.

Models represent an annual post-breeding census over a period of $y = 1, \dots, Y$ year steps. Therefore, the model annual cycle comprises a census immediately after fledging on the first day of the biological year, with the first age-class ($a = 1$) containing newly hatched birds, followed by a 12-month period of survival. Then, on the first day of the subsequent year, surviving animals increment in age, reproduction occurs and resultant new-borns fledge, and the next census is carried out. Reproduction is confined to adult birds, with age of first breeding specifying the age above which all individuals are considered breeding adults. The final age-class $A$ is an aggregated age group, representing $A$ years-old birds and older. This implies the absence of senescence, i.e. the survival and reproductive performances of the oldest animals remain constant over time.

The expanded version of the generic population model can then be expressed as

$$\begin{bmatrix} n_{1,t+1} \\ n_{2,t+1} \\ n_{3,t+1} \\ \vdots \\ n_{A,t+1} \end{bmatrix} = \begin{bmatrix} 0 & \cdots & 0 & 0 & P_A(0.5)S_A \\ S_{1\to2} & 0 & 0 & \cdots & 0 \\ 0 & S_{2\to3} & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & 0 & S_{A-1\to A} & S_A \end{bmatrix} \times \begin{bmatrix} n_{1,t} \\ n_{2,t} \\ n_{3,t} \\ \vdots \\ n_{A,t} \end{bmatrix}$$

where $P_A$ denotes the annual productivity rate of age-class $A$, expressed as the annual average number of fledged young per breeding pair; and $S_{a\to a+1}$ represents the annual survival transition rate of animals of age-class $a$, i.e. the average proportion of birds in age-class $a$ that will survive the whole year and transition to age-class $a + 1$. Elements in the top row of the projection matrix $\mathbf{L}$ (i.e. half of the productivity rate multiplied by the survival rate) reflect the annual fecundity rate per capita of each adult age-class.

Tables 1 – 3 detail the main specifications and assumptions used to build the model and run the simulations for this analysis. Furthermore:

- Environmental stochasticity, which accounts for the variation arising from environmental changes affecting individuals in the same group (e.g. between-year differences in weather conditions), was incorporated at the level of productivity and survival rates. For each simulated year, a value for each demographic rate was randomly generated from a Beta distribution defined by the mean and standard deviation estimates chosen for that specific rate. Beta distributions are considered to generate biologically reasonable values of survival and productivities rates (Morris and Doak, 2002).

- Due to the lack of data on demographic rates of Gannets in Bull and Cow Rocks, preference was given to broader scale estimates based on combined independent studies collated in Horswill and Robinson (2015) (Table 1). National level estimates are believed to generate parameter values that express more accurately the underlying degree of uncertainty in model simulations. However, since demographic estimates are derived from past data, model predictions take no account of impacts of continuing climate change on seabird demography.

- Although density dependence is evident in the natural environment, for seabird populations the mechanisms as to how this operates are largely uncertain. Misspecification of density dependence may lead to unreliable predictions and, for that reason, seabird assessments typically assume density independence (Table 2). As such, models lack mechanisms to restrict projections from either increase to infinity or decrease to extinction. In the context of impact assessments, the latter situation provides a suitable precautionary feature.

- The population was considered a closed system, i.e. age distributions are not affected by migration exchanges between neighbouring colonies.

- Assuming the population was at equilibrium at the starting year, the initial population size in terms of breeding individuals (Table 1) was converted to total size (i.e. number of birds in the whole population) using the proportion of breeders under the population's stable age distribution (i.e. the proportion of individuals per age-class). The stable age distribution was provided by the right eigenvector associated with the dominant eigenvalue of the population projection matrix using the mean of the demographic rates. The initial population vector ( $\mathbf{n_1}$) was then obtained by multiplying the initial total size by the stable age distribution vector.

- Starting with the initial population vector for the first simulated year, new population vectors were calculated by multiplying the previous year's population vector by a new projection matrix generated from sampling each demographic rate (i.e. different projection matrices prevailing in each simulated year).

- The model projects the population forward in one-year steps for a period of 20 years (Table 2), representing the 10-year duration of the fish farm license followed by a 10-year recovery period. Each 20-year simulation was run 5000 times to obtain indicative population trends and estimates of uncertainty surrounding those trends.

**Table 1**: Baseline demographic parameters and other modelling features specified for the PVA of Gannets from Bull and Cow Rocks SPA

| Parameters | PVA assumptions | | | Data source | Comments |
|---|---|---|---|---|---|
| **Initial population size (adult/breeders)** | 12776 | | | SMP (2021) | Based on latest counts available for the SPA, from 2014. Derived from aerial imagery (see Newton et al., 2015). |
| **Age at first breeding** | 6 | | | Horswill and Robinson (2015) | |
| **Maximum eggs/pair** | 1 | | | Snow & Perrins (1998) | |
| **Final age-class (A)** | 6 | | | | |
| **Survival rates** | | **Mean** | **SD** | Horswill and Robinson (2015) | No SPA-specific estimates available. Pooled estimates from UK and Irish colonies, used instead. |
| | $S_{1\to2}$ | 0.424 | 0.007 | | |
| | $S_{2\to3}$ | 0.829 | 0.004 | | |
| | $S_{3\to4}$ | 0.891 | 0.003 | | |
| | $S_{4\to5}$ | 0.895 | 0.003 | | |
| | $S_{5\to6}$ | 0.919 | 0.042 | | |
| | $S_6$ | 0.919 | 0.042 | | |
| **Productivity rate (per pair)** | $P_5$ | 0.700 | 0.082 | Horswill and Robinson (2015) | No SPA-specific nor country-level estimates available. UK national figures used instead. |

- Fish farm impacts from entanglement mortalities were incorporated in the model in terms of additional mortalities. Additional mortalities were assumed to be applied to all age classes in proportion to their presence in the population, based on the stable age distribution. The implicit assumption in apportioning additional mortalities this way is that mortality due to entanglement have constant age selectivity.

- Impact scenarios comprised 3 ranges of additional mortalities per annum (Table 3), expressed as additional adult deaths in the starting year. While impact scenarios are conveyed in terms of absolute deaths, this is not expected to remain constant as population sizes change over time. As such, the absolute number of additional deaths only strictly applies in the first year of simulation. They were converted to per-capita mortality rate (assumed constant over time) so the number of additional deaths in a year changes proportionately to the simulated population size. Table 4 provides the equivalence between additional adult deaths and additional per-capita mortality rates under each impact scenario (computed as "additional adult deaths"/"number of adults in starting year"). Impacted mortality rates and its relative change from the baseline rate are also presented.

- Simulation of impact scenarios followed a matched runs approach (Green, 2014), whereby stochasticity is applied to the population before impacts are applied. Specifically, survival and productivity rates simulated at each time step are the same for the unimpacted and impacted populations, with additional mortalities rates being subsequently deducted from simulated survivals.

**Table 2**: Modelling configurations specified for the PVA of Gannets from Bull and Cow Rocks SPA

| Model options | PVA configuration | Comments |
|---|---|---|
| **Environmental stochasticity** | Included (Beta distribution) | Survival and productivity rates simulated via Beta distributions, parameterized with Mean and SD values provided above. |
| **Density dependence** | Not included | Density independent models ignore regulation mechanisms helping recovery when population is reduced to low numbers. |
| **Demographic stochasticity** | Not included | Demographic stochasticity usually ignored for populations greater than 100 individuals (WWT Consulting, 2012) |
| **Sabbaticals** | Not included | No data available on annual proportion of adult gannets skipping breeding for Bull and Cow Rocks SPA |
| **Starting projection year** | 2020 | Base year, which is required to be one year-step before the impact year, here assumed as 2021. |
| **Final projection Year** | 2041 | 10 years after license termination to investigate recovery period |
| **Number of simulations** | 5000 | |

**Table 3**: Impact scenarios and configuration specified for the PVA of Gannets from Bull and Cow Rocks SPA.

| Model options | PVA configuration | | Comments |
|---|---|---|---|
| **Impacts starting year** | 2021 | | |
| **Impacts ending year** | 2031 | | Assuming a 10-year period fish farm license |
| **Impact scenarios (additional adult deaths in impact starting year)** | Range | Increments | 3 ranges at different increments to provide good scenario coverage while keeping the number of required simulations within reasonable computational demands. |
| | 10 - 50 | 10 | |
| | 100-500 | 50 | |
| | 500-1200 | 100 | |
| **Same level of impact applied to immatures?** | Yes | | All ages equally likely to get trapped on fish nets, i.e. per-capita entanglement mortality assumed to be fixed across ages. |

**Table 4**: Impact scenarios considered for the PVA of Gannets from Bull and Cow Rocks SPA. Correspondence between additional adult deaths in starting year, additional mortality rates (considered fixed across age-classes and over time), impacted mortality rate and relative change from baseline/unimpacted scenario (represented as '0' additional deaths). E.g., 10 additional adult deaths correspond to an increase of 1% in mortality rate from baseline levels.

| Additional adult deaths | Additional Mortality rate | Impacted mortality rate | Change from unimpacted mortality rate (%) |
|---|---|---|---|
| **0** | 0.000 | 0.081 | 0 |
| **10** | 0.001 | 0.082 | 1 |
| **20** | 0.002 | 0.083 | 2 |
| **30** | 0.002 | 0.083 | 3 |
| **40** | 0.003 | 0.084 | 4 |
| **50** | 0.004 | 0.085 | 5 |
| **100** | 0.008 | 0.089 | 10 |
| **150** | 0.012 | 0.093 | 14 |
| **200** | 0.016 | 0.097 | 19 |
| **250** | 0.020 | 0.101 | 24 |
| **300** | 0.023 | 0.104 | 29 |
| **350** | 0.027 | 0.108 | 34 |
| **400** | 0.031 | 0.112 | 39 |
| **450** | 0.035 | 0.116 | 43 |
| **500** | 0.039 | 0.120 | 48 |
| **600** | 0.047 | 0.128 | 58 |
| **700** | 0.055 | 0.136 | 68 |
| **800** | 0.063 | 0.144 | 77 |
| **900** | 0.070 | 0.151 | 87 |
| **1000** | 0.078 | 0.159 | 97 |
| **1100** | 0.086 | 0.167 | 106 |
| **1200** | 0.094 | 0.175 | 116 |

## 2.2 Implementation, key outputs, and Impact significance criteria

The PVA was implemented using the Seabird PVA Tool developed by Natural England (Searle et al. 2019). In particular, the npva R package (v3.6) was employed to set-up the model and run the simulations. Supporting data manipulation and output preparation was also done via the R statistical programming environment v4.0.x (R Core Team, 2021).

PVA outputs shown in this report follow recommendations by Jitlal *et al.* (2017) on suitable metrics to summarise change in populations. Thus, the main PVA metrics presented are:

- The ratio of impacted to unimpacted annual growth rate (i.e. counterfactual of growth rate)
- The ratio of impacted to unimpacted population size (i.e. counterfactual of population size)
- Centile for unimpacted population size that matches the 50th centile for impacted population size.

Criteria to assess the significance of effects of potential impacts in seabird populations described in Percival (2003) was applied to attribute levels of significance to each impact scenario.

Counterfactuals for population growth rate (CGR) and population size (CPS), effectively providing relative changes from baseline conditions under each impact level, were used to determine the magnitude of the impact in terms of growth rate and population size, based on the thresholds presented in Table 5.

Magnitude of effects were then combined with the sensitivity level of the colony to yield the impact significance of scenario. In this instance, the Gannets colony in the Bull and Cow Rocks SPA is considered as a highly sensitive population, as it is listed as Special Conservation Interests for this SPA (National Parks and Wildlife Service, n.d.).

**Table 5**: Assessment criteria and thresholds for classifying levels of magnitude and significance of impacts, as specified in Percival (2003)

| Magnitude | Magnitude description and threshold | Impact significance level for Gannets in Bull and Cow Rocks SPA |
|---|---|---|
| **Very High** | Total loss or very major alteration to key elements/features of the baseline conditions. Post impact composition and attributes will be fundamentally changed and may be lost from the site altogether.<br>**Guide**: >80% reductions in population size / vital rates | **Very High[1]** |
| **High** | Major loss or major alteration to key elements/features of the baseline conditions such that post impact composition and attributes will be fundamentally changed.<br>**Guide**: 20-80% reductions in population size / vital rates | **Very High** |
| **Medium** | Loss or alteration to one or more key elements/features of the baseline conditions such that post impact composition attributes of baseline will be partially changed.<br>**Guide**: 5-10% reductions in population size / vital rates | **Very High** |
| **Low** | Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying attributes of baseline conditions will be similar to post-impact patterns.<br>**Guide**: 1-5% reductions in population size/ vital rates | **Medium[2]** |
| **Negligible** | Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation.<br>**Guide**: < 1% population/ habitat lost | **Low[3]** |

[1] Represents a highly significant impact on bird populations and would warrant refusal of a development proposal.

[2] Potentially significant impact requiring careful assessment. Appropriate mitigation measures might be required to allow development proposal.

[3] Not normally of concern.

## 3 PVA RESULTS

Figures 1 – 4 present the main outputs from the PVA of the Gannets colony in Bull and Cow Rocks SPA. Data underpinning these plots is presented in the Appendix (Table A1).

For ease of reference, impact scenarios are presented in terms of number of additional adult deaths in the starting year – corresponding impacted annual mortality levels can be referred to in Table 4.

Figure 1 shows the simulated trajectories of the populations under the baseline/unimpacted conditions and the range of impact scenarios. The effects of incremental additional mortalities on population trajectories over time are clearly evident, with decays being more pronounced and recovery periods less reactive as the size of the impact increases.

In Figure 2 the medians of impacted population sizes decline rapidly to the lower tails of the distribution of simulated unimpacted population sizes, showing how unlikely impacted levels are expected to occur under baseline conditions once additional annual adult mortalities surpass the 150 deaths. On the other hand, medians of impacts under 50 additional deaths are well within the distribution of simulated unimpacted projections (above the 40$^{th}$ percentile), showing that projected sizes under those impacts are not uncommon under the unimpacted scenario.

Figure 3 displays the effects and significance of impact scenarios in population growth rate, for the two considered time-periods. Specifically:

- by the end of the license period (2031):
    - Results suggest 10 additional adult deaths due to entanglement would likely cause an impact of low significance to the population's growth rate (0.09% reduction from unimpacted levels)
    - Impacts between 100 and 500 additional adult deaths may lead to potentially significant reductions in growth rate.
    - Impacts causing over 500 additional deaths would cause highly significant reductions in growth rate.
- after a 10-year recovery period (2041):
    - 10 additional adult deaths due to entanglement are likely to cause an impact of low significance to the population's growth rate.
    - Impacts between 200 and 1000 additional adult deaths may lead to potentially significant reductions in growth rate.
    - Impacts over 1000 additional adult deaths may cause highly significant reductions in growth rate.

Figure 4 shows the effects and significance of impact scenarios in terms of population size, the two considered time-periods. By the end of the license period (2031) and after a 10-year recovery period (2041):

- 10 additional adult deaths due to entanglement may cause an impact of low significance to population numbers (0.99% drop from unimpacted levels)

- Impacts between 20 and 50 additional adult deaths may lead to potentially significant drops in population numbers.

- Impacts causing over 50 additional deaths would likely cause highly significant drops in population numbers.

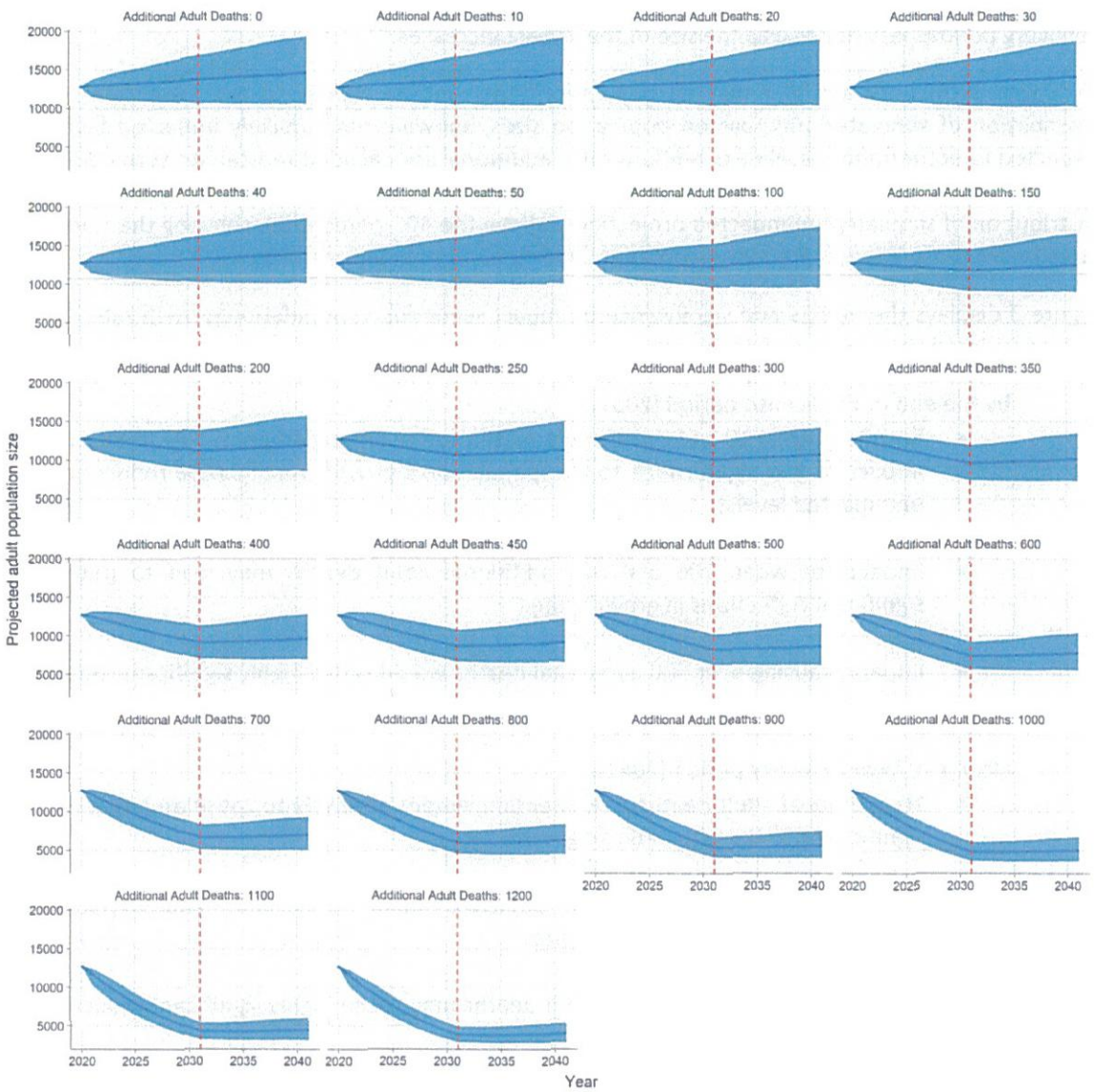


**Figure 1**: Projections of adult population sizes over a 20-year period. Each plot represents an impact scenario in terms of additional adult deaths ('0' deaths for unimpacted scenario). The thick blue line is the median of the simulated projections at each time point, while the blue shaded envelopes comprise the central 95% of simulated values. The red vertical dashed line conveys the end of the license period (i.e., end of impact), after which impact effects are absent.

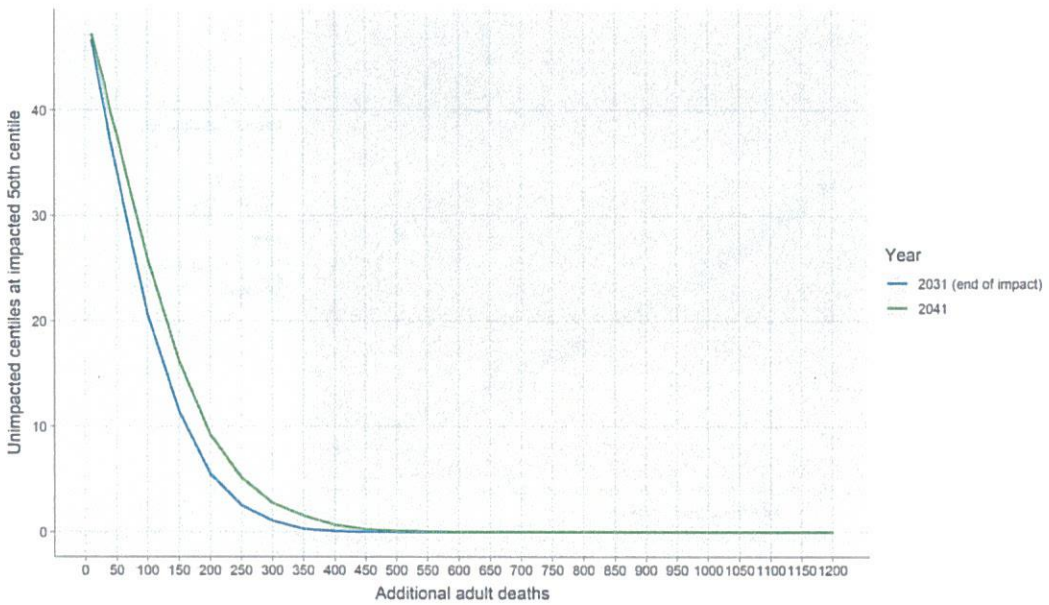


**Figure 2**: The median of the impacted population size as a centile of the unimpacted population size at projected years 2031 and 2041, for a range of impact scenarios (incremental additional adult deaths – x-axis). For example, 30% means the median (50th percentile) of the impacted projections sits at the 30th percentile of the unimpacted projections.

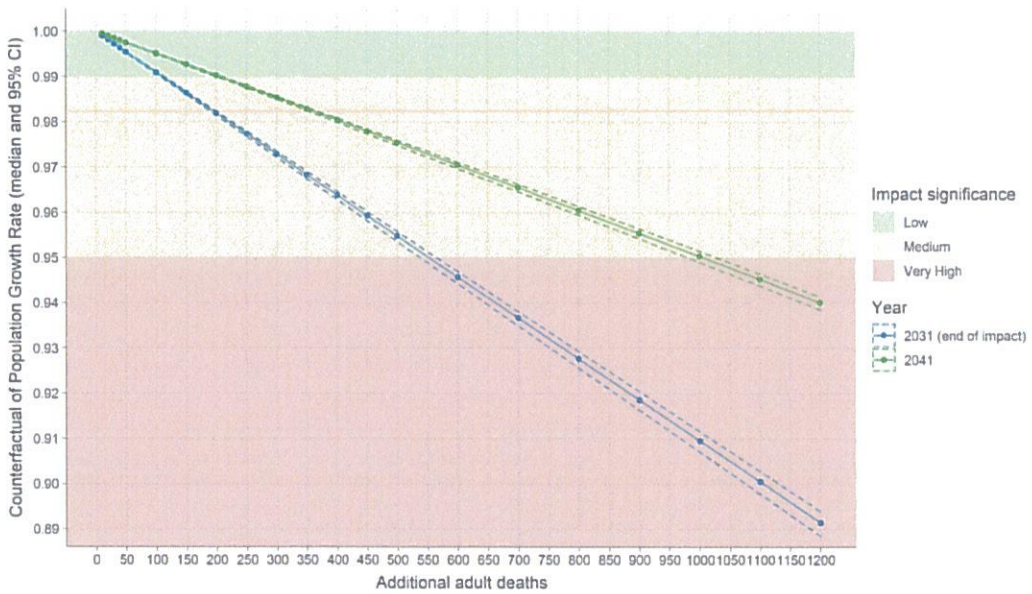


**Figure 3**: Counterfactual of population growth rate at projected years 2031 and 2041, for a range of impact scenarios (incremental additional adults deaths – x-axis). E.g., 0.9 means a 10% reduction in the growth rate under the impact ratio at the projected year. Solid lines represent the 50$^{th}$ percentile (median), dashed lines give the central 95% of simulated values (2.5% and 97.5% reference points). Shaded areas represent levels of impact significance (Table 5) – e.g., an impact causing a 10% reduction in growth rate from unimpacted levels constitutes a medium magnitude impact which, for a very high sensitivity colony, is an impact of very high significance.

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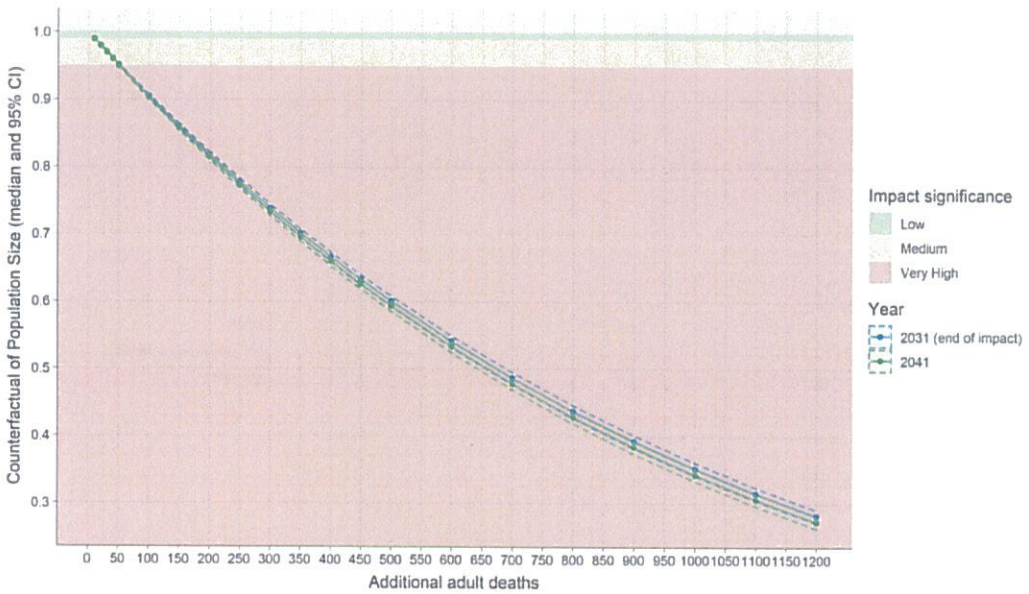


**Figure 4**: Counterfactual of population size at projected years 2031 and 2041, for a range of impact scenarios (incremental additional adults deaths – x-axis). E.g., 0.5 means the impacted population size is one-half of the unimpacted population size at the projected year. Solid lines represent the 50$^{th}$ percentile (median), dashed lines give the central 95% of simulated values (2.5% and 97.5% reference points). Shaded areas represent levels of impact significance (Table 5) – e.g., an impact causing a 50% drop in population size from unimpacted levels is classified as a high magnitude impact which, for a very high sensitivity colony, constitutes an impact of very high significance.

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## 5 APPENDIX

Table A1: Main summary outputs from the PVA of Gannets from Bull and Cow Rocks SPA. Summaries provided for two time periods: (i) from starting year to end of license/impact year (2031) and (ii) from starting year to end of 10-year recovery period (2041)

| Year | Additional adult mortality | Median Population growth rate | 2.5 percentile of simulated growth rates | 97.5 percentile of simulated growth rates | Median of counterfactual of growth rare | Median of counterfactual of population size |
|---|---|---|---|---|---|---|
| 2031 | 0 | 1.0068 | 0.9838 | 1.0258 | | |
| | 10 | 1.0059 | 0.9829 | 1.0249 | 0.9991 | 0.9901 |
| | 20 | 1.0050 | 0.9820 | 1.0240 | 0.9982 | 0.9803 |
| | 30 | 1.0040 | 0.9811 | 1.0231 | 0.9973 | 0.9706 |
| | 40 | 1.0031 | 0.9802 | 1.0222 | 0.9964 | 0.9609 |
| | 50 | 1.0022 | 0.9793 | 1.0213 | 0.9955 | 0.9514 |
| | 100 | 0.9977 | 0.9747 | 1.0168 | 0.9910 | 0.9049 |
| | 150 | 0.9931 | 0.9702 | 1.0122 | 0.9864 | 0.8605 |
| | 200 | 0.9885 | 0.9656 | 1.0077 | 0.9819 | 0.8181 |
| | 250 | 0.9840 | 0.9610 | 1.0032 | 0.9774 | 0.7776 |
| | 300 | 0.9795 | 0.9564 | 0.9986 | 0.9729 | 0.7389 |
| | 350 | 0.9749 | 0.9518 | 0.9940 | 0.9683 | 0.7020 |
| | 400 | 0.9703 | 0.9472 | 0.9895 | 0.9638 | 0.6668 |
| | 450 | 0.9658 | 0.9427 | 0.9849 | 0.9593 | 0.6331 |
| | 500 | 0.9612 | 0.9381 | 0.9804 | 0.9548 | 0.6011 |
| | 600 | 0.9521 | 0.9290 | 0.9713 | 0.9457 | 0.5413 |
| | 700 | 0.9430 | 0.9198 | 0.9622 | 0.9367 | 0.4870 |
| | 800 | 0.9339 | 0.9107 | 0.9531 | 0.9276 | 0.4376 |
| | 900 | 0.9248 | 0.9015 | 0.9440 | 0.9186 | 0.3929 |
| | 1000 | 0.9157 | 0.8923 | 0.9349 | 0.9095 | 0.3523 |
| | 1100 | 0.9065 | 0.8831 | 0.9258 | 0.9005 | 0.3156 |
| | 1200 | 0.8974 | 0.8739 | 0.9167 | 0.8914 | 0.2824 |
| 2041 | 0 | 1.0065 | 0.9913 | 1.0201 | | |
| | 10 | 1.0060 | 0.9908 | 1.0196 | 0.9995 | 0.9899 |
| | 20 | 1.0055 | 0.9904 | 1.0191 | 0.9990 | 0.9798 |
| | 30 | 1.0051 | 0.9899 | 1.0186 | 0.9985 | 0.9699 |
| | 40 | 1.0046 | 0.9894 | 1.0181 | 0.9981 | 0.9600 |
| | 50 | 1.0041 | 0.9889 | 1.0176 | 0.9976 | 0.9503 |
| | 100 | 1.0016 | 0.9864 | 1.0152 | 0.9951 | 0.9028 |
| | 150 | 0.9992 | 0.9840 | 1.0127 | 0.9927 | 0.8574 |
| | 200 | 0.9967 | 0.9815 | 1.0103 | 0.9903 | 0.8142 |
| | 250 | 0.9943 | 0.9790 | 1.0078 | 0.9878 | 0.7729 |
| | 300 | 0.9918 | 0.9766 | 1.0054 | 0.9854 | 0.7336 |
| | 350 | 0.9893 | 0.9741 | 1.0029 | 0.9829 | 0.6961 |
| | 400 | 0.9868 | 0.9716 | 1.0004 | 0.9804 | 0.6603 |
| | 450 | 0.9843 | 0.9691 | 0.9980 | 0.9780 | 0.6262 |
| | 500 | 0.9819 | 0.9666 | 0.9955 | 0.9755 | 0.5937 |
| | 600 | 0.9769 | 0.9616 | 0.9905 | 0.9705 | 0.5332 |
| | 700 | 0.9718 | 0.9566 | 0.9854 | 0.9655 | 0.4784 |
| | 800 | 0.9668 | 0.9515 | 0.9804 | 0.9605 | 0.4288 |
| | 900 | 0.9617 | 0.9465 | 0.9753 | 0.9554 | 0.3839 |
| | 1000 | 0.9566 | 0.9414 | 0.9702 | 0.9504 | 0.3433 |
| | 1100 | 0.9515 | 0.9363 | 0.9651 | 0.9453 | 0.3066 |
| | 1200 | 0.9463 | 0.9311 | 0.9600 | 0.9401 | 0.2735 |

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