Application of precaution in ornithology impact assessments for offshore wind project applications

Evaluation of current approaches

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Executive Summary

The precautionary principle is designed to assist with decision-making under uncertainty and is defined as, "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*." The precautionary principle can be invoked when there is a good reason to believe that serious or irreversible environmental damage could occur and scientific uncertainty is high.

Scottish Government's Marine Directorate and NatureScot advise that precaution (i.e. taking a cautious interpretation of the scientific evidence) should be applied to ornithology impact assessments. NatureScot advises that precaution should be applied at multiple points in the impact assessment process. The consideration of whether or not the precautionary principle should be applied to offshore wind project impact assessments and determinations was beyond the scope of this report. This report focuses on evaluating how and where precautionary approaches are currently being applied by NatureScot and Scottish Government, in offshore wind ornithology impact assessments and consent determinations.

This evaluation identified multiple significant issues with how precaution is currently applied to ornithology impact assessments:

- Applying precaution at multiple points in the impact assessment process means precaution is compounded through the assessment, resulting in potentially large amounts of precaution in outputs;
- Current approaches produce precautionary estimated impacts that are very likely to be larger than true impacts that could occur if a proposed project became operational;
- The extent of precaution in these precautionary estimated impacts (i.e. the extent to which precautionary estimated impacts are greater than true impacts), is not transparent, the likelihood of these estimated impacts occurring is not considered and scientific uncertainty is not fully taken into account;
- SNCB-advised approaches lack transparency and consistency in how scientific evidence is evaluated and used to inform the precautionary approach presented in SNCB guidance and advice;
- The regulator is not being provided with the full range of possible impacts that a proposed offshore wind project could have and the likelihood of each of these possible impacts occurring;
- The precautionary principle requires a risk-based approach to decision-making which is precluded by current SNCB-recommended approaches to ornithology impact assessment.

The regulator can be confident that impacts predicted under current approaches are greater than true impacts that would be caused by an operational project. However, it is not known whether these precautionary estimated impacts represent a realistic worst-case scenario or are a substantial overestimate of true impacts and are biologically implausible, with a very low likelihood of ever occurring.

These precautionary estimated impacts are used to inform the amount of seabird compensation that some proposed offshore wind projects need to secure. If these precautionary estimated impacts are a substantial overestimate, projects are striving to secure more compensation than is actually needed. Securing sufficient seabird compensation is one of the biggest challenges facing proposed offshore wind projects at present.

Consideration by NatureScot and Scottish Government, of the issues with current approaches as described above, is urgently needed. Instead of applying precaution to individual inputs used in ornithology impact assessments, as is currently done, it is recommended that precaution should be applied to outputs, informed by the extent of scientific uncertainty. This means undertaking a robust scientific evaluation of available evidence to inform the impact assessment and then applying a precautionary approach to risk-based decision-making, as described in guidance on the application of the precautionary principle.

Moving to a risk-based approach would provide the regulator with a comprehensive understanding of the full range of potential impacts that a proposed development could have and the likelihood of them occurring. The regulator could adopt a precautionary approach to consent determinations, informed by the full picture of the risk of damage to protected seabird populations, thereby fulfilling the requirements of the precautionary principle. This would also provide transparency around the magnitude of impacts that require seabird compensation, helping to alleviate the current challenges posed by the need to secure sufficient seabird compensation.

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Acronyms and Abbreviations

Acronym	Abbreviation
AEoSI	Adverse effect on site integrity
AssESs	An ORJIP project: Assessing the extent and significance of uncertainty in offshore wind assessment
CEF	Cumulative Effects Framework
CP2030	UK Government's Clean Power 2030 Action Plan
EIA	Environmental Impact Assessment
GSAT	Globally Averaged Surface Air Temperature
GW	Gigawatts
HRA	Habitats Regulation Appraisal
INTOG	Innovation and Targeted Oil & Gas
IROPI	Imperative Reasons of Overriding Public Interest
MD-LOT	Scottish Government's Marine Directorate - Licensing Operations Team
MD-SEDD	Scottish Government's Marine Directorate - Science, Evidence, Data and Digital
ORJIP	Offshore Renewables Joint Industry Programme
OWF	Offshore wind farm
PVA	Population Viability Analysis
SAC	Special Area of Conservation
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area

Definitions

Term	Definition
Apportioning	The process by which estimated seabird mortalities in an OWF development area are allocated to individual SPA colonies, dependent on the probability that an individual seabird in the development area is from a particular seabird colony
Appropriate Assessment	A detailed evaluation of the potential impacts from a plan or project on a European site's qualifying interests and conservation objectives, as part of the Habitats Regulations Appraisal (HRA)
Barrier effects	The additional energy expenditure and associated effects arising from birds needing to divert from their intended path in order to reach their original destination due to flying around an offshore wind farm
Collision risk modelling	The approach used to quantify the risk of seabirds colliding with offshore wind turbine blades
Cumulative assessment	Assessment of the effects from multiple plans or projects, along with the project's effects, as part of an EIA

Term	Definition
Displacement	A reduced number of birds occurring within or immediately adjacent to an offshore wind farm, following construction and operation of an offshore wind farm. Displacement mortality can arise through reduced energy intake or increased energetic costs associated with birds being displaced
Displacement matrix tool	A simple approach recommended by SNCBs for estimating displacement mortality (SNCBs, 2022)
European protected sites	A network of protected sites comprising SACs (Special Area of Conservation) and SPAs (Special Protection Area)
In-combination assessment	Assessment of the effects from multiple plans or projects, along with the project's effects, on European protected sites, as part of an HRA
Impact	The number of seabirds which could die annually as a consequence of operating an offshore wind farm and/or the relative decrease in population size and/or growth rate caused by additional OWF mortality
Likelihood of occurrence	The chance that a specific event will happen. A term used in risk assessment. Note, in this report, 'likelihood' is not used in the statistical sense
Mortality	Seabird mortality is the number of seabirds dying annually
Most likely impact	The impact that has the highest likelihood of occurring
Precaution	The extent to which a value is larger as a consequence of taking a more cautious approach. Inputs to impact assessments can include precaution, i.e. a more cautious value is selected from the evidence. Outputs can also include precaution, i.e. the extent to which an output has been increased in value as a consequence of precaution in inputs
Precautionary approach	A more cautious approach to interpreting evidence or decision-making
Precautionary estimated impacts	Impacts estimated under current approaches to ornithology impact assessment in which precaution is applied to inputs, leading to precautionary estimated impacts
Probability	A statistical term describing the chance that a particular outcome occurs based on the values of parameters in a model
Project-alone assessment	Estimation of the effects from a proposed project, without inclusion of effects from other plans or projects, i.e. not an in-combination or cumulative approach
s36 consent	section 36 consent under the Electricity Act (1989)
Severity	The expected harm or adverse effect that may occur due to exposure to a risk, measuring how serious the consequences could be if the risk materialises
Uncertainty	The inherent limitations in knowledge and the variability in measurements, reflecting the range of possible values within which the true value of a measurement lies

1.0 Current approaches to assessing potential impacts of a planned offshore wind development on protected seabird populations

1. Globally, offshore wind deployment is growing rapidly. Offshore wind is playing a key role in reductions in greenhouse gas emissions and improves energy security within the UK, as well as delivering socio-economic benefits. The UK and Scottish governments have targets for the capacity of offshore wind energy required, e.g. recently the Scottish Government proposed an ambition of an increase in capacity to 40 GW of offshore wind in Scottish waters by 2040 and large scale offshore wind deployment is a key component of the UK Government's Clean Power 2030 Action Plan (CP2030) (Scottish Government, 2025a; UK Government, 2024). Following Crown Estate Scotland's ScotWind and INTOG leasing rounds, there are now many offshore wind farm (OWF) projects in Scotland's planning system (Scottish Government, 2025b).

2. Before being able to construct an OWF, a range of permits and marine licences must be acquired[1]. For example, a section 36 (s36) consent is required to be able to construct and operate an OWF, under the Electricity Act (1989)[2]. Licences are also required under the Marine (Scotland) Act 2008 and Marine and Coastal Access Act 2009. In support of the s36 consent and marine licence applications, an Environmental Impact Assessment (EIA)[3] will usually be required under the Environmental Regulations[4]. Where significant effects to a Special Protection Area (SPA) or a Special Area of Conservation (SAC) cannot be discounted, a Habitats Regulation Appraisal (HRA)[5] is also required, under the Habitats Regulations. Scottish Ministers, as the competent authority or regulator, determine whether to consent a planned OWF. Scottish Government's Marine Directorate – Licensing Operations Team (MD-LOT) administer marine licensing and consenting, on behalf of Scottish Ministers. MD-SEDD (Scottish Government's Marine Directorate - Science, Evidence, Data and Digital) provide advice and support to MD-LOT on technical issues, such as offshore ornithology.

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[1] Licensing and consenting requirements for offshore renewable energy - Marine licensing and consenting: offshore renewable energy projects - gov.scot

[2] Electricity Act 1989

[3] Marine licensing and consenting - Environmental Impact Assessment: overview - gov.scot

[4] For example, the Electricity Works (EIA) (Scotland) Regulations 2017

[5] Habitats Regulations Appraisal (HRA) | NatureScot

3. When determining whether to consent a planned OWF, Scottish Ministers and MD-LOT need to balance a range of potentially competing interests. Scottish Ministers and MD-LOT use information provided in the OWF developer's application and representations received from those with an interest in the development, when determining whether to consent a planned OWF development, e.g. in relation to the environment, commercial fisheries, shipping and navigation, etc. including from the Scottish Government's statutory nature conservation advisor, NatureScot. Additionally, Scottish Ministers and MD-LOT also need to consider government policies, such as the Scottish Government's ambition for 40GW of offshore wind power by 2040 and the Scottish Biodiversity Strategy to 2045 (Scottish Government, 2024; Scottish Government, 2025a).

4. Scotland holds nationally and internationally important numbers of breeding seabirds many of which are associated with and protected by Special Protection Areas or SPAs[6] (Burnell *et al.,* 2023). Under the EIA and HRA regulations, Scottish Ministers and MD-LOT have a responsibility to ensure that the risk of environmental damage to protected seabird populations is fully considered, when determining a planned OWF.

5. In Scotland, NatureScot, as the relevant Scottish Statutory Nature Conservation Body (SNCB), advises MD-LOT, as the regulator, on environmental assessments of plans and projects, including HRA and EIA assessments[7]. Within the Marine Directorate, MD-SEDD (Marine Directorate – Science Evidence Data and Digital) provide specialist technical advice to MD-LOT, e.g. assisting with drafting ornithology sections of Appropriate Assessments. Under the Habitats Regulations[8], NatureScot provides advice to MD-LOT on the potential for a proposed development to have a likely significant effect on the qualifying interests of an SPA or SAC, as well as advice to assist MD-LOT with producing an Appropriate Assessment[9]. To ensure that applications have all the information that NatureScot requires be able to fully advise MD-LOT, NatureScot provides guidance and advice to applicants on how to undertake an HRA and EIA[10]. This includes a set of online guidance notes on how to assess potential impacts of proposed OWF projects on marine birds (NatureScot, 2025), supplemented by project-specific

[6] Special Protection Areas | Advisor to Government on Nature Conservation | JNCC
[7] Environmental assessment | NatureScot
[8] The Conservation (Natural Habitats, &c.) Regulations 1994
[9] Habitats Regulations Appraisal (HRA) | NatureScot
[10] Environmental assessment | NatureScot

advice where SNCBs identify local or project-specific issues that should be considered in addition to or instead of the generic online guidance.

1.1 Current processes for assessing potential impacts from a proposed offshore wind farm project on protected seabird populations

6. NatureScot's eleven guidance notes describe the recommended approach for applicants to follow, when undertaking an HRA or EIA for marine bird species (NatureScot, 2025). Applicants are advised by the regulator (MD-LOT) to follow this process, and to present the predicted impacts on protected seabird populations resulting from following NatureScot's guidance, as part of their consent application.

7. In the EIA and HRA of an OWF project consent application, potential impacts on seabirds arising from collision and displacement mortality that could occur during the operational phase of a project are usually assessed using a quantitative approach, which is described in more detail below. Other impacts arising at different stages of project development and through other impact pathways are usually assessed qualitatively. This report focusses on the recommended process for undertaking quantitative assessments but the same considerations also apply to the qualitative assessments.

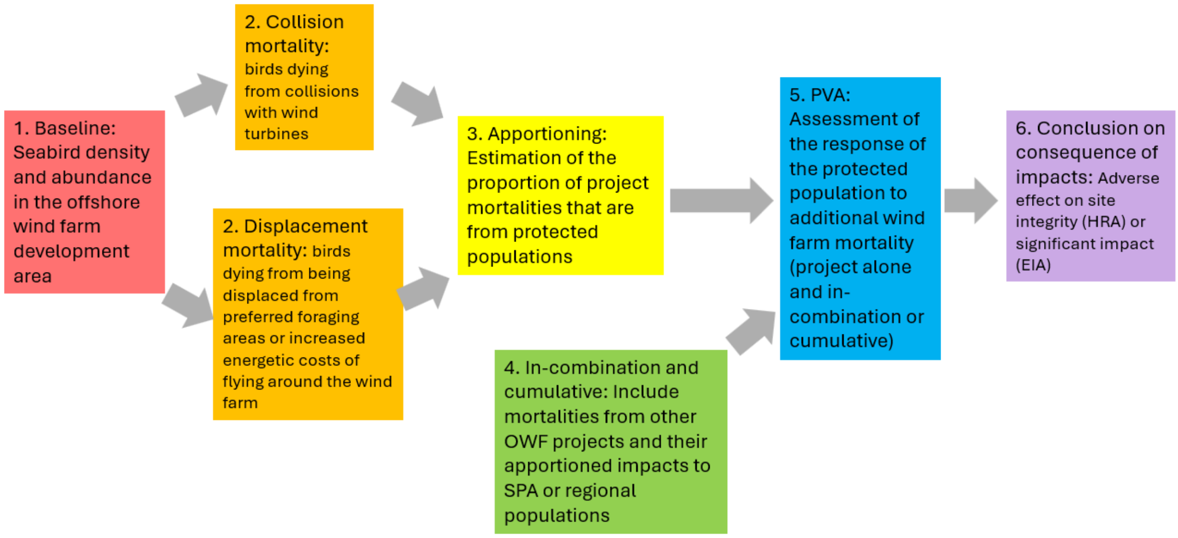

Figure 1. Schematic diagram illustrating the steps of the SNCB-recommended ornithology impact assessment approach to assessing collision and displacement impacts that could arise during OWF project operation (adapted from Searle *et al.*, 2023)

8. Figure 1 shows a schematic diagram of the quantitative elements of the SNCB-recommended ornithology impact assessment process. Briefly, the advised process for assessing impacts for marine birds is:

1) Establish a baseline estimate of the density and abundance of seabirds using the OWF development area;
2) Estimate the potential seabird mortality that could arise through collisions with wind turbines or displacement from preferred foraging areas by the presence of an OWF, including barrier effects caused by birds needing to fly around wind farms, and the consequent reduced energy intake/increased energy expenditure;
3) Apportion mortality estimates to protected populations (SPA populations for HRA or regional populations for EIA), informed by the probability that an individual seabird from that population could be using the development area;
4) Estimate mortality from other plans and projects which are also impacting the same protected seabird populations for an in-combination (HRA) or cumulative (EIA) impact assessment;
5) Assess, using a population model, the response of the protected seabird population to the predicted collision and displacement mortality from the project alone and cumulatively (EIA) or in-combination (HRA) with other OWFs' predicted mortalities;

6) Conclude whether the proposed development, alone or in-combination/cumulatively with other OWFs, could have an Adverse Effect on Site Integrity (AEoSI for SPA populations) and/or a significant impact (for EIA populations).

9. NatureScot's guidance notes provide detailed recommendations on how to undertake steps 1-5, including what information to present in applications (NatureScot, 2025). These steps are substantially more complicated than presented here, as can be seen in the offshore ornithology components of any Scottish offshore wind farm consent application. Step 6 is undertaken by NatureScot, as the statutory advisor to the regulator, MD-LOT. NatureScot's guidance and advice results in an impact assessment process that is highly complex, comprising many parameters which sit within components of multiple models. These guidance notes are updated by NatureScot, as new evidence becomes available or processes are adjusted.

1.2 Scientific uncertainty around how seabirds respond to offshore wind development

10. Whilst the UK's seabirds have been relatively well studied, compared with populations elsewhere in the world, there remain large uncertainties about how seabirds use the marine environment (e.g. Wakefield *et al.,* 2017), their population dynamics and what drives these (e.g. Matthiopoulos *et al.,* 2025), and their non-breeding season distributions (e.g. Buckingham *et al.,* 2022). Studying marine birds is challenging due to them spending most of their lives at sea, where obtaining direct observations of their diet, behaviour, causes of mortality, etc. is very difficult. This is further compounded by shifting baselines in ecology and behaviour driven by ongoing environmental change due to global climate change and other anthropogenic behaviour, e.g. fisheries (e.g. Burnell *et al.*, 2023; Johnston *et al.,* 2025; Mitchell *et al.*, 2020). Consequently, there is high uncertainty about how seabirds use the existing marine environment, how this could change following construction and operation of an OWF, and how this may affect their population dynamics (O'Hanlon *et al.*, 2024).

11. Technological advances in approaches to monitoring bird behaviour at sea (e.g. new developments in bird biologging; camera and radar systems on OWFs to observe bird avoidance behaviour) are helping to build the evidence base on how seabirds respond to offshore wind development, improving our understanding of potential consequences of offshore wind development on seabird populations (Skov *et al.*, 2018; Tjørnløv *et al.*, 2023). However, logistical and financial challenges prevent large scale deployment of these technologies and so these methods tend to produce only small sample sizes from

a very limited number of locations. Even the most comprehensive studies frequently reveal considerable variation in behaviour and response to the environment, driven in many cases by specific local factors (O'Hanlon *et al.*, 2024). All of this can limit the generalisation of these new insights to specific seabird colonies and individual OWF project applications.

12. As a consequence, there is high scientific uncertainty around evidence used to inform ornithological impact assessments for offshore wind applications.

1.3 The Precautionary Principle

13. The precautionary principle is defined in the UN Rio Declaration on Environment and Development 1992 as, "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UNEP, 1992). The precautionary principle is enshrined in EU environmental law[11]. Following the UK's withdrawal from the EU, the precautionary principle, along with other environmental principles, has been adopted by both the Scottish Government and the UK Government for policy development (Scottish Government, 2023; UK Government, 2023).

1.4 Application of the precautionary principle in ornithology impact assessments

14. NatureScot and MD-LOT advise applicants to follow a precautionary approach to EIA and HRA ornithology impact assessments. They advise that this is required under the precautionary principle, because of the high uncertainty around potential impacts that a proposed OWF could have on protected seabird populations. SNCB's guidance adopts a precautionary approach to impact assessment, i.e. informed by a more cautious interpretation of scientific evidence when uncertainty is high around the evidence supporting a particular parameter, component or model used in the impact assessment process.

15. SNCB guidance recommends that precaution is applied in various ways across most stages of the impact assessment process, described above (see Figure 1). A full review of where and how precaution is applied is beyond the scope of this report but the ORJIP

[11] EUR-Lex - 12008E191 - EN - EUR-Lex

AssESs[12] project WP1 report (Furness *et al.*, 2025) presents values that SNCBs advise using for ornithology impact assessments, as recommended in their online guidance notes. Alongside these, the Furness *et al.* (2025) report also presents a comprehensive review of the evidence base and literature, suggesting alternative values that could be used in impact assessments, informed by current evidence.

16. Box 1 presents an example of a NatureScot-advised precautionary value being adopted for a parameter in the displacement matrix model, used to estimate displacement mortality, to illustrate how precaution is currently applied at some points in the impact assessment process. Note, precaution is not consistently applied throughout the assessment process and some recommended inputs to assessments are not precautionary (Furness *et al.*, 2025). By applying a precautionary approach to some inputs to impact assessments, SNCBs have taken steps to ensure that outputs are also precautionary. This is done with the aim of giving both SNCBs and the regulators the reassurance that assessment outputs are sufficiently precautionary such that advice based on these outputs will fulfil the requirements of the precautionary principle.

Box 1. Example of a precautionary approach

This example illustrates how precaution is applied to one input to the ornithology impact assessment process.

NatureScot advise use of an auk displacement rate of 60% (NatureScot, 2023). Furness *et al.* (2025) reviewed reported displacement rates for common guillemot (*Uria aalge*) in the North Sea and, from the ten studies from 12 different OWFs, found a wide range of values, from no displacement up to 91% of birds being displaced. At most OWFs, displacement rate was less than 52%, with exceptions from studies in the German Bight and one Dutch OWF (Heinänen and Skov, 2018, Peschko *et al*., 2020a; Peschko *et al*., 2020b and Peschko *et al*., 2024). Evidence from three studies at two Scottish OWFs found no compelling evidence for any displacement of common guillemots in the breeding season (Vallejo *et al.*, 2017; Leopold, 2018; Trinder *et al.*,2024).

Adopting a value of 60% displacement is a judgement that NatureScot advise under a precautionary approach. There is a wide range of reported displacement rates and evidence from only two Scottish OWFs, one of which (Robin Rigg) is unlikely to be representative of Scottish OWFs currently in the planning process. Due to uncertainty in the evidence for auk displacement rates, NatureScot do not advise use of a displacement rate derived from all available evidence (e.g. a mean or median) but instead advise use of a higher displacement rate.

[12] ORJIP AssESs project: Assessing the extent and significance of uncertainty in offshore wind assessment: ORJIP: Assessing the extent and significance of uncertainty in offshore wind assessments (AssESs) | The Carbon Trust

17. SNCBs advise that, as new evidence becomes available through monitoring at operational OWF and other research studies, uncertainty around the potential impact of a planned offshore wind farm development will decrease and consequently a less cautious interpretation of the evidence base can be taken. This would mean less precautionary inputs to impact assessments could be adopted instead, in the future.

18. OWF projects produce applications that largely follow NatureScot's guidance (NatureScot, 2025) when producing HRA and EIA ornithology impact assessments. Typically, impact assessment outputs for a particular seabird population (e.g. an SPA feature) comprise a single precautionary estimate of mortality (or a higher and lower estimate in the case of species at risk of displacement mortality), along with a precautionary estimate of relative change in population size and population growth rate in the presence of predicted OWF mortality. NatureScot use these values presented in applications to inform their advice to MD-LOT. This is then used by the Marine Directorate and Scottish Ministers to draw a conclusion on whether a proposed project is likely to have an AEoSI.

2.0 Issues with the current approach to applying precaution in ornithology impact assessments

19. Currently, while the precautionary principle is embedded in UK and Scottish policy documentation (e.g. Scottish Government, 2023; UK Government, 2023), there are no published guidelines on how the precautionary principle should be applied in the context of offshore wind development. Advice provided by NatureScot and the Marine Directorate (i.e. MD-LOT and MD-SEDD) is generally precautionary but there is no guidance or policy from Scottish Government on how precaution should be applied by NatureScot and the Marine Directorate in their advice.

20. The evaluation presented in this report, of how precaution is applied in ornithology offshore wind impact assessments, has identified nine inter-related issues:

1) Precaution is applied to inputs to ornithology impact assessments in an inconsistent and non-transparent manner;
2) Precaution is applied at the incorrect points in ornithology impact assessments. A precautionary approach can be applied in decision making but should not be applied in the scientific evaluation of evidence. Precaution should be applied to outputs, not inputs of impact assessments;
3) Scientific uncertainty is not fully quantified and propagated through the impact assessment process to outputs;
4) The likelihood[13] of a particular impact occurring is not estimated or considered;
5) The precautionary principle requires that a risk-based approach should be used, where possible, to inform decision-making. Current ornithology impact assessment approaches do not enable use of a risk-based approach to decision-making;
6) Precaution accumulates through the impact assessment process in a non-transparent manner. Outputs from impact assessments are high, i.e. are ‘precautionary’, but the extent of precaution in these outputs is not known;
7) In-combination and cumulative precautionary estimated impacts will also be high but have no likelihood of occurrence estimated, meaning they may be biologically implausible and have a very low likelihood of ever occurring. As more projects are included in cumulative and in-combination assessments, the probability of all projects simultaneously having these high impacts becomes ever smaller;
8) Impact assessment outputs are a precautionary overestimate of impacts that are most likely to occur, yet these overestimated impacts still require to be fully compensated. Securing sufficient seabird compensatory measures is one of the biggest challenges facing many planned offshore wind projects in Scotland;

[13] ‘likelihood’ in this report is used to mean the chance of an event occurring. It is not used in the statistical sense.

9) Without knowledge of scientific uncertainty and likelihood of occurrence associated with predicted ornithology impacts, the regulator is not provided with the full set of necessary information on which to base an informed consent decision.

21. Each of these issues is described in detail below.

2.1 Lack of transparency in application of precaution to inputs

22. Precaution is not applied to all parameter values and model components in a consistent way. The ORJIP AssESs project provides a comprehensive review of SNCB guidance and advice in relation to available evidence, identifying apparent inconsistencies in how available evidence has been used to inform a precautionary approach (Furness *et al.*, 2025). Below are three examples to illustrate the issue of inconsistency and a lack of transparency in SNCBs advice on how precaution should be applied to inputs to impact assessments.

1. Collision risk models use an input of a distribution of bootstrapped estimates of density of birds in flight in the OWF development area for each calendar month, which is an evidence-based best estimate and not a precautionary approach. By contrast, displacement mortality modelling has an input of mean seasonal peak abundance[14], which is a precautionary approach. The same data, monthly digital aerial surveys of the development area, inform both collision and displacement model inputs. The justification for displacement mortality estimation requiring a more precautionary approach than collision mortality estimation has not been published;
2. The way in which evidence on seabird displacement rates has been used to inform the advised displacement rate, to be used in estimation of displacement mortality, is not transparent. A precautionary auk displacement rate of 60% is advised by NatureScot (NatureScot, 2023) but the process by which this value was selected from published studies on displacement rates has not been published. See Box 1 in Section 1.4 for more details;
3. NatureScot advise that kittiwake should be assessed for potential mortality from both displacement and collisions (NatureScot, 2023). By contrast, Natural England advise that kittiwake does not need to be assessed for displacement mortality (Parker *et al.*, 2025; SNCBs, 2022). Natural England and NatureScot appear to have taken a different interpretation of the same underlying evidence on the extent of kittiwake displacement caused by offshore wind development. The reason for these different approaches has not been published.

[14] Mean seasonal peak abundance is calculated as: ([peak abundance estimate from any month within a particular season in year 1] + [peak abundance estimate from any month within that particular season in year 2]) / 2.

23. There appears to be no systematic and/or transparent approach to the application of precaution in impact assessments, in SNCB advice. This could be due to the absence of guidance or policy from Scottish Government on how the precautionary principle should be applied in the context of offshore wind impact assessments. SNCBs appear to have inconsistently made judgements on the extent of precaution to apply in their guidance and advice. These judgements are broadly related to the amount of uncertainty associated with evidence used to inform that component of the assessment, although precaution is not directly related to the extent of scientific uncertainty in the evidence in a transparent, repeatable and quantifiable manner. Butler *et al.* (2025) described this as, "…a nuanced and diverse approach to the interpretation of precaution in relation to uncertainty in inputs".

24. Openness and transparency are a key component of the precautionary principle (Commission, 2000; ILGRA, 2002). The Inter-Departmental Liaison Group on Risk Assessment (ILGRA) advise that, "…where the precautionary principle is invoked and applied, openness becomes critically important in achieving an outcome that stakeholders regard as valid. Openness demands candour in exposing, for example:

- the information on which risk assessment was undertaken;
- the scientific uncertainties and reasoning for invoking the precautionary principle, and any uncertainty factors already built into the risk assessment;
- the assumptions made in establishing credible scenarios;
- the many factors that influence the choice of risk management measures.

25. Transparency and openness also help to ensure proportionate outcomes by exposing where judgements have been made at each stage of the decision-making process," (ILGRA, 2002).

2.2 Precaution is applied at the incorrect points in ornithology impact assessments

26. There are two compelling arguments which show that precaution should not be applied to inputs to ornithology impact assessments. Firstly, the Commission of the European Communities produced a communication on the precautionary principle which makes clear that the precautionary principle should be used by decision makers when making political decisions, and not in the scientific evaluation of the evidence (Commission, 2000). Secondly, a statistical evaluation of current ornithology impact assessments

recommended that precaution should be applied to uncertainty in outputs, and not to uncertainty in inputs (Butler *et al.*, 2025). Each of these two arguments is considered in more detail below.

2.2.1 Invoking and implementing the precautionary principle

27. Prior to invoking the precautionary principle, scientists should undertake a robust evaluation of the available evidence and degree of scientific uncertainty (Commission, 2000; Scottish Government, 2023). Once a political decision has been made to invoke the precautionary principle, scientists should undertake a risk assessment, informed by the severity and likelihood of occurrence of credible scenarios occurring, while ensuring scientific uncertainty is fully considered (ILGRA, 2002; Scottish Government, 2023). Decision makers can then apply a precautionary approach to deciding on which particular course of action to select, informed by the risk assessment (Commission, 2000).

28. The diagram in Figure 2 illustrates the distinct stages of deciding whether to invoke the precautionary principle and then deciding on a course of action, informed by the precautionary principle (Commission, 2000). The process of using the precautionary principle in decision making is:

    1. The precautionary principle can be invoked when there is evidence for both irreversible harmful effects and a high level of scientific uncertainty about the consequences and/or likelihood of environmental harm occurring (Commission, 2000; RPC, 2025; Scottish Government, 2023; UK Government, 2023);
    2. The decision to invoke the precautionary principle is a policy decision but needs to be informed by a scientific evaluation of the available evidence, particularly the scientific uncertainty (Commission, 2000; RPC, 2025; Scottish Government, 2023);
    3. Once the precautionary principle has been invoked, a further scientific evaluation of the potential adverse effects should be undertaken. This is needed to assess the risk of undesirable outcomes occurring. These outcomes can be informed by credible scenarios, as proposed by ILGRA (2002), and need to fully capture scientific uncertainty and confidence in probability of outcomes occurring (RPC, 2005; Science for Environment Policy, 2017; UK Government, 2023).
    4. Lastly, decision makers can then use the risk assessment to make precautionary decisions on the best course of action, informed by both the probability of undesirable outcomes occurring and confidence in the underlying scientific evidence.

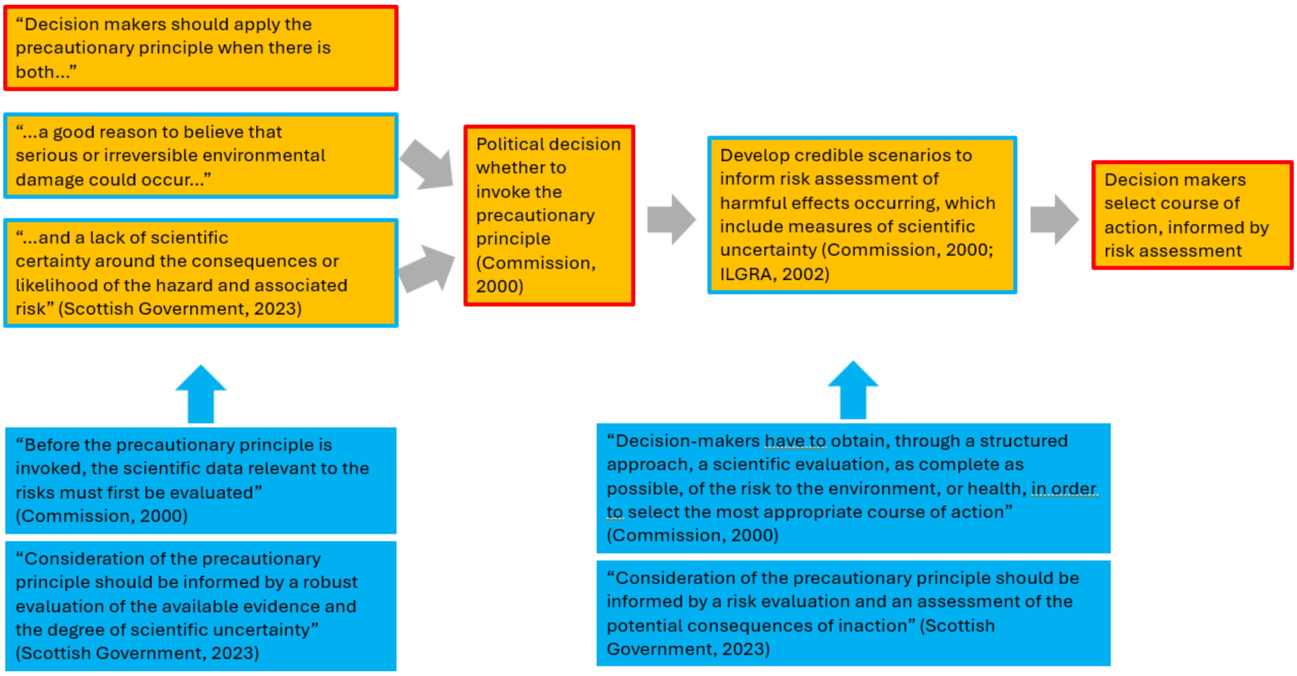

Figure 2. Diagram illustrating the roles of scientists (blue) and decision makers (red) in the process of invoking the precautionary principle and then implementing it to inform decision-making. The scientific contribution to the process is described in the blue boxes, illustrating the role of scientific evaluation of the evidence in the application of the precautionary principle.

29. It is evident from the diagram and literature on the precautionary principle (e.g. Commission, 2000; ILGRA, 2002; RPC, 2025; Science for Environment Policy, 2017; Scottish Government, 2023; UK Government, 2023), that the scientific evaluations should not use a precautionary approach but instead should be as objective and robust as possible. This was made clear by the Commission's advice on application of the precautionary principle: "The determination of appropriate action including measures based on the precautionary principle should start with a scientific evaluation and, if necessary, the decision to commission scientists to perform an as objective and complete as possible scientific evaluation," (Commission, 2000). Instead of applying precaution to the scientific evaluation, precaution should be applied in decision making, following the full scientific evaluation.

2.2.2 A statistical justification for applying precaution to ornithology impact assessment outputs

30. The current offshore wind ornithology impact assessment process applies precaution at multiple points in the impact assessment process (see Section 1.4 and Furness *et al.*, 2025). The ORJIP AssESs project investigated current approaches of applying

precaution to inputs rather than outputs using a simple illustrative case study (Butler *et al.*, 2025). They found that, within the context of their case study, "…an approach based on applying precaution to inputs, rather than outputs is over-precautionary and, in some cases, highly over-precautionary." They also found that, for their case study, applying precaution to outputs without also propagating uncertainty through to outputs risked being 'under-precautionary'.

31. As a consequence of this they recommended to, "Move to the evaluation of precaution in relation to uncertainty in outputs rather than uncertainty in inputs." Butler *et al.* (2025) acknowledged that their case study used a set of assumptions that do not necessarily apply to ornithology impact assessments but they note that, with respect to the recommendation to apply precaution to uncertainty in outputs, "…the key qualitative conclusions follow from general statistical principles." The findings of Butler *et al.* (2025) are discussed in more detail below, under Section 2.6.

2.3 Impact assessment outputs do not fully quantify uncertainty

32. Uncertainty in ornithology impact assessments can come from multiple sources, including obvious sources such as environmental variability but also, for example, structural uncertainty in models used in assessments and linguistic uncertainty, such as understanding of the term 'precaution' (Masden *et al.*, 2015).

33. Current ornithology impact assessment processes do not quantify the overall uncertainty in a scientifically robust, evidence-based manner (Searle *et al.*, 2023). Some components of the impact assessment process do capture some aspects of uncertainty. For example, the stochastic collision risk model (Caneco, 2022), can propagate uncertainty in most biological inputs through into collision risk modelling outputs. By contrast, the displacement matrix tool (SNCBs, 2022) and apportioning tool (NatureScot, 2018) do not quantify uncertainty and model structural uncertainty is not considered (Butler *et al.*, 2025).

34. The lack of quantification of uncertainty in current approaches to ornithology impact assessments undermines confidence in predicted impacts and potentially contributes to precaution being incorrectly applied (Searle *et al.*, 2023). A key motivation for the ORJIP AssESs project was the urgent need to quantify current levels of uncertainty across the ornithological impact assessment process. Furthermore, the precautionary principle requires quantification of scientific uncertainty. Scottish Government's Guiding Principles

on the Environment (Section 5.11, Scottish Government, 2023) recommends that, "…consideration of the precautionary principle should be informed by a robust evaluation of the available evidence and the degree of scientific uncertainty".

35. Searle *et al.* (2023) reviewed sources of uncertainty in ornithology impact assessments and made recommendations on how best to quantify that uncertainty and propagate it through the impact assessment process. The ORJIP AssESs project report (Butler *et al.*, 2025) offers pragmatic solutions to quantification and propagation of uncertainty in impact assessments, by using the Cumulative Effects Framework (CEF) tool. However, Butler *et al.* (2025) does recognise that not all uncertainty can be quantified and captured in impact assessment outputs. As a consequence of this, applying precaution to outputs of impact assessments will still require careful interpretation and judgement, even with uncertainty quantified and propagated through the assessment process as fully as possible (Butler *et al.*, 2025).

2.4 The likelihood of an impact occurring is not considered

36. The UK Government's risk-based approach to the precautionary principle, under their environmental principles policy statement (UK Government, 2023), "…seeks to manage the likelihood and severity of environmental harm occurring, based on exposure to a specific hazard. This is distinct from an approach that solely considers hazards that can cause environmental harm," (UK Government, 2023). Whilst this UK Government document is intended as guidance for developing new policies, rather than advice on offshore wind impact assessments, the same presumably applies in this latter context. Current approaches to ornithology impact assessments produce an estimate of severity, e.g. estimated mortalities that a proposed project could cause, but without any assessment of the likelihood of harm occurring, e.g. the probability of that mortality occurring.

37. Figure 3 shows an illustrative distribution of the full range of possible impacts (e.g. number of seabird mortalities per annum) that a theoretical OWF project could have on a protected seabird population. A similar distribution could also be produced for other outputs from a stochastic impact assessment process, e.g. PVA outputs such as counterfactual of population size after 30 years of impact. Full quantification and propagation of uncertainty through the impact assessment process would allow a probability distribution of potential impacts, such as shown in Figure 3, to be generated (Butler *et al.*, 2025). Note, this figure has been adapted from figures presented in Butler

et al. (2025), and is based on the assumption that uncertainty in outputs can be fully quantified.

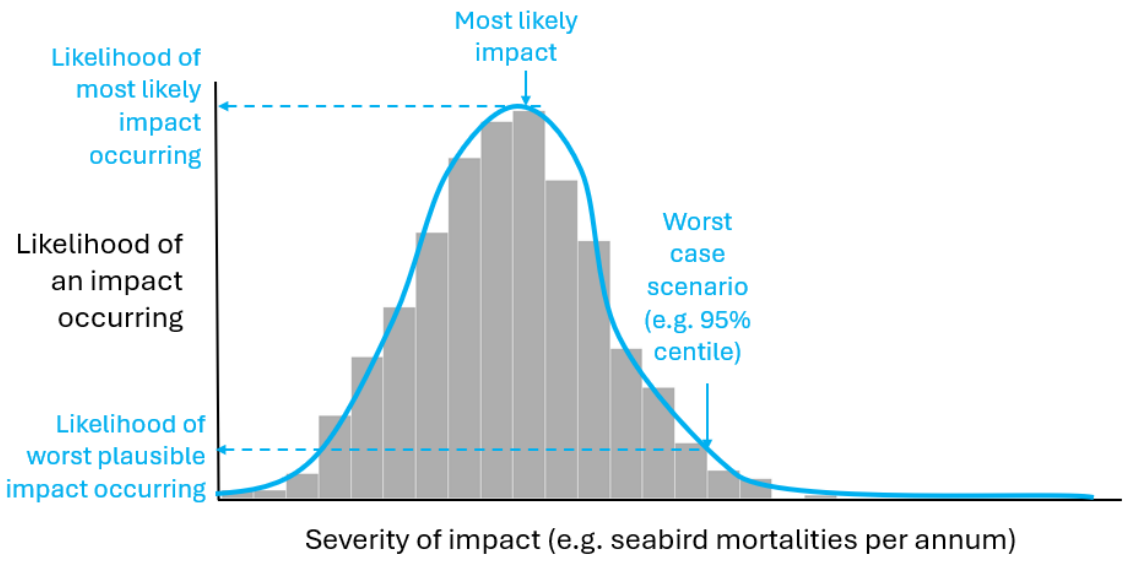

Figure 3. A histogram of simulated theoretical outputs from a stochastic impact assessment process in which the uncertainty from throughout the process is propagated into outputs. The shape of the probability distribution provides information on both the severity of impact and the likelihood of that impact occurring, e.g. the most likely impact (the modal value in this diagram) and a worst-case scenario (the 95th centile in this diagram). (Schematic diagram adapted from a similar diagram presented in Butler *et al.,* 2025).

38. From such a probability distribution of possible impacts, a range of credible scenarios can be selected. Where possible this should include the most likely and worst-case scenarios (ILGRA, 2002). In the illustrative example presented in Figure 3, the most likely scenario is taken to be the estimated seabird mortality and probability of occurrence at the mode of the distribution and the worst-case scenario is the 95% centile but other points on the probability distribution could be selected to represent these and other scenarios.

39. The illustrative example of a probability distribution of possible impacts, presented in Figure 3, is an approximately normal distribution. In reality, the shape of the distribution may not be a normal distribution but it is a reasonable assumption that more severe

impacts will have a lower likelihood of occurrence than less severe impacts, the latter having a greater likelihood of occurring.

40. Current approaches to ornithology impact assessment produce a single[15] precautionary estimate of the severity of impact but no likelihood of occurrence. As uncertainty is not fully quantified under current approaches, there is no distribution of possible impacts to give context to the single precautionary estimated impact. Whilst precautionary estimated impacts are very likely be greater than a most likely impact, e.g. an impact that would be expected to occur most frequently, it is not known whether precautionary estimated impacts represent a plausible worst case scenario or are very unlikely to ever occur, as illustrated in Figure 4.

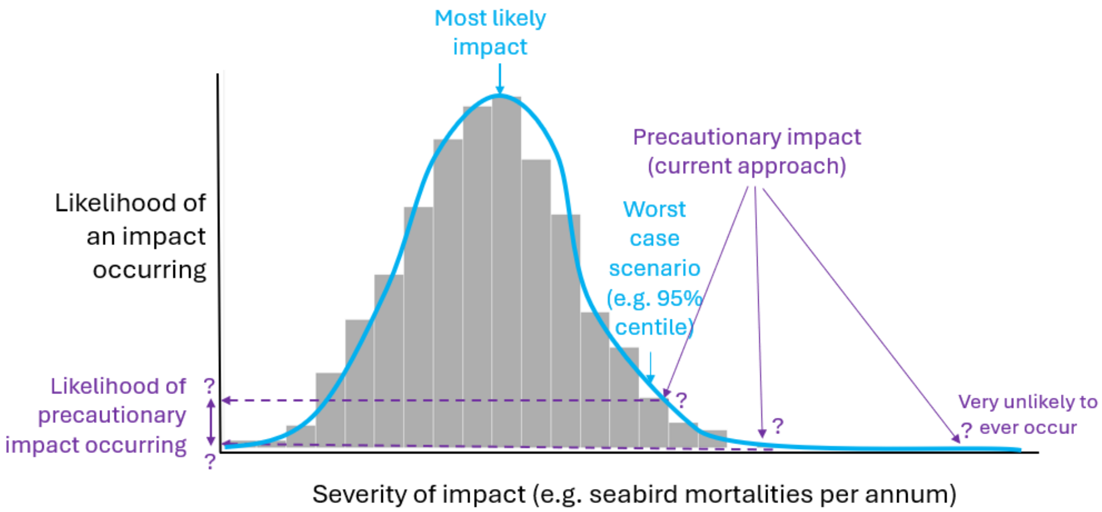

Figure 4. A distribution of simulated theoretical outputs from a stochastic impact assessment process in which the uncertainty from throughout the process is propagated into outputs. The likelihood of occurrence for precautionary estimated impacts (in purple), produced under current impact assessment approaches, is unknown. Schematic diagram adapted from a similar diagram presented in Butler *et al.* (2025).

41. Current approaches to ornithology impact assessments produce a single estimate of seabird mortality along with a relative change in population size and growth rate in the

[15] Two estimates are produced for species assessed for displacement mortality, a ‘high’ and ‘low’ estimate

presence of estimated seabird mortality. Under current approaches it is not known where on a probability distribution the single estimate would sit, i.e. how much greater than a most likely impact the precautionary estimated impact is, nor the likelihood of it occurring. This is illustrated in Figure 4.

2.5 A risk-based approach is not undertaken

42. Risk is usually estimated as the consequences or severity of an adverse event, multiplied by the likelihood of that event occurring. The Commission (2000) defines risk evaluation, with respect to the precautionary principle, as, (1) hazard identification, (2) hazard characterisation consisting of the nature and severity of adverse effects, (3) the probability of exposure, (4) risk characterisation, which corresponds to the probability and severity of adverse environmental effects liable to occur. Taking into account the 'inherent uncertainties' during risk characterisation is also important (Commission, 2000). Box 2 provides definitions for severity, likelihood, uncertainty and risk.

Box 2: Definitions of severity, likelihood, uncertainty and risk

Severity of the consequences of environmental harm, in the case of offshore wind development, could be an estimate of seabird mortality that a proposed development is predicted to have or response of a protected (SPA) seabird population to additional predicted mortality arising from a development, such that high severity equates to predictions of high seabird mortality or large decreases in population size or growth rate.

Likelihood of harm occurring, in the case of offshore wind development, is the probability of a particular mortality occurring if a development becomes operational, or the probability of a particular change in seabird population size or growth rate occurring in response to additional mortality attributable to the development. Note that in this report the term 'likelihood' is used in the context of risk evaluation and not in the statistical sense.

Both severity and likelihood will have uncertainty associated with them. The severity of environmental harm, such as an estimate of seabird mortality that an offshore wind project could cause, and the probability of this occurring, will have large uncertainties associated with them, arising from multiple sources (Masden *et al.*, 2015; Searle *et al.,* 2023).

Risk is the product of the likelihood of environmental harm occurring and the severity of the consequences of environmental harm, taking into account uncertainty in the evidence used to estimate severity and likelihood (Commission, 2000; UK Government, 2023).

43. The Commission (2000), in its guidance on the precautionary principle, recommended that, "… every decision must be preceded by an examination of all the available scientific data and, if possible, a risk evaluation that is as objective and comprehensive as possible." Both the Scottish Government and UK Government, in their advice to policy makers, recommend that a risk-based approach to the precautionary principle should be adopted (Scottish Government, 2023; UK Government, 2023). Scottish Government's Guiding Principles on the Environment

(Section 5.11, Scottish Government, 2023) recommends that, "…consideration of the precautionary principle should be informed by:

- a robust evaluation of the available evidence and the degree of scientific uncertainty;
- a risk evaluation and an assessment of the potential consequences of inaction;
- the participation of all interested parties in the study of precautionary measures, once the results of the scientific evaluation and/or the risk evaluation are available.".

44. Despite these clear recommendations from both the Commission and UK and Scottish Governments, current approaches to ornithology impact assessments for offshore wind applications preclude undertaking a risk assessment. Current approaches generate only a single estimate of severity, e.g. seabird mortality, with no information on the likelihood of that mortality occurring. Since risk is the product of severity and likelihood of occurrence, risk cannot be evaluated if there is no information on likelihood of occurrence.

45. A risk-based approach that considers several credible scenarios, necessitates information on the full range of possible mortalities that could occur and the likelihood of those mortalities occurring. Furthermore, risk-based approaches under the precautionary principle require full assessment of uncertainty, which is also omitted from current approaches (Searle *et al.*, 2023; Butler *et al.,* 2025).

2.6 Lack of transparency in extent of precaution in impact assessment outputs

46. Precautionary estimated impacts, as outputs from ornithology impact assessments undertaken using current SNCB-recommended approaches, are highly likely to be overestimating true impacts. SNCBs seek to produce precautionary estimated impacts, by adding precaution to inputs of impact assessments, under the assumption that these outputs represent a 'worst-case scenario' and are therefore fulfilling the requirements of the precautionary principle. However, the inconsistent and non-transparent approach taken to the application of precaution to inputs means that the extent of precaution in outputs is also lacking in transparency.

47. The ornithology impact assessment process (see Figure 1) uses outputs from one stage of the process as an input to a subsequent stage. See Furness *et al.* (2025) and Section

2.1 for some examples of precaution applied in each step of the impact assessment process. When precaution is applied to inputs to impact assessments at multiple stages, precaution can compound or accumulate through the assessment process. As an analogy, this is similar to the way in which compound interest accumulates over time in a savings account. The consequence of this is that impact assessment outputs could be highly precautionary, i.e. predicted impacts could be a substantial overestimate of plausible impacts, but the extent of precaution in impact assessment outputs is currently unknown. Following the analogy of compound interest, this is equivalent to not knowing how much money has accrued in a savings account, in which compound interest rates are unknown and variable.

48. The EU Commission (2000) recognised the issue of precaution accumulating. “When the available data are inadequate or non-conclusive, a prudent and cautious approach to environmental protection, health or safety could be to opt for the worst-case hypothesis. When such hypotheses are accumulated, this will lead to an exaggeration of the real risk but gives a certain assurance that it will not be underestimated.”

49. The ORJIP AssESs project investigated this issue of precaution accumulating through the impact assessment process (see Appendix 2 of Butler *et al.*, 2025). Butler *et al.* (2025) used an illustrative example of a hypothetical model that explored how the extent of precaution in outputs varied with the number of parameters in a model and whether these parameters were added or multiplied together. The stochastic hypothetical model had 2 parameters, 4 parameters or 6 parameters which were either added together or multiplied together to give a model output.

50. Firstly, with no precaution applied to the model, a probability distribution of outputs was generated by running 100,000 simulations of the hypothetical model. Values were randomly sampled from each parameter in each simulation. This probability distribution describes the range of possible outputs that the model can produce and the probability of different outputs occurring, in the absence of any precaution.

51. To mimic current approaches to applying precaution in impact assessments, precaution was then applied to inputs to the model by taking the 95% quantile value for each of the 2, 4 or 6 input parameters to give a single precautionary output. This single output can be considered to be equivalent to the precautionary estimated impacts produced by ornithology impact assessments. Note, the AssESs project used the 95% centile as an

arbitrary choice to illustrate the concepts rather than a 95% centile being an agreed definition of a precautionary approach (Butler *et al.*, 2025).

52. Lastly, precaution was then applied to outputs, instead of inputs, by taking the output value at the 95% centile in the probability distribution.

53. As would be expected, model outputs based on applying precaution to inputs (i.e. when using a 95% quantile value for model inputs) were systemically larger than when applying the equivalent level of precaution (i.e. the 95% quantile) to outputs. The difference was substantially larger for models with more model parameters, and when parameters were multiplied together, rather than added together (Butler *et al.*, 2025).

54. To relate this to ornithology impact assessments, assume that the aim of applying precaution in ornithology impact assessments is to estimate a worst case scenario impact for which there is a 1 in 20 chance of true impacts exceeding the worst case scenario, i.e. that 95% of the time, true impacts will be less than the worst case scenario impact. However, due to precaution being applied to inputs of impact assessments, true impacts have a much smaller chance of being greater than the precautionary estimated impact.

55. In the hypothetical model developed by Butler *et al.* (2025), true impacts were less than the precautionary model outputs between 99% and 99.99% of the time, depending on the number of model parameters and whether the model was additive or multiplicative. This means that the true impacts exceeded the precautionary model outputs between 1 in 100 times and 1 in 100,000 times. In other words, precautionary model outputs were extremely unlikely to ever occur, in this hypothetical model.

56. The implication of this is that the outputs of ornithology impact assessments (i.e. precautionary estimated impacts) could include substantially more precaution than is necessarily intended by SNCBs (Butler *et al.*, 2025). This hypothetical model suggests that precautionary estimated impacts generated by current approaches could be extremely unlikely to ever occur in reality.

57. However, this illustration presented by Butler *et al.* (2025) does not directly relate to ornithology impact assessments, as uncertainties in model structure are not considered and the application of precaution to parameter values within assessments does not

typically take a 95% centile value. For example, the 60% displacement rate assumed for auks (see Box 1) is not necessarily the 95% centile of the distribution of auk displacement rates, informed by scientific evidence of empirical displacement rates (see Furness *et al.*, 2025). Instead, it is a precautionary value selected by NatureScot, given uncertainty in the evidence on auk displacement rates and the relevance of that evidence to auk displacement at Scottish OWFs (see Box 1). Also, the Butler *et al.* (2025) hypothetical model illustrates the consequences of adding or multiplying just six parameter values. The ornithology impact assessment process is far more complex than this, with many more parameters and complex interactions among parameters that are not always transparent.

58. Butler *et al.* (2025) advised that, “One of the key advantages of evaluating precaution in relation to uncertainty in outputs, rather than inputs, is that it enables a more explicit and transparent understanding of the overall level of precaution being applied. When precaution is applied across individual inputs at different modelling stages, it becomes inherently difficult to assess its overall impact.”

2.7 Accumulation of precaution in cumulative and in-combination assessments

59. Impact assessments for HRA and EIA require consideration of the impacts that a planned OWF project could have in isolation, and in-combination (for HRA) or cumulatively (for EIA) with other OWFs. Cumulative and in-combination impact assessments sum precautionary estimated impacts from multiple OWF projects, where these impact the same protected seabird populations, e.g. SPA colonies, as the proposed project.

60. Cumulative and in-combination impact assessments have the same issues as project-alone assessments, i.e. precaution is applied to inputs instead of outputs, leading to a lack of transparency in the extent of precaution in estimated impacts and those estimates potentially including substantially more precaution than intended (Butler *et al.*, 2025). As is the case for project-alone impact assessments, there is no assessment of the probability of occurrence for the cumulative/in-combination precautionary estimated mortality. Therefore, predicted cumulative/in-combination mortality estimates could be biologically implausible with a very low probability of occurrence.

61. From a statistical perspective, the probability of true impacts from all projects in an in-combination assessment concurrently exceeding their precautionary estimated impacts becomes increasingly unlikely, as more projects are added to the assessment. For example, if project-alone impacts are likely to exceed the precautionary estimated impacts only 1 in 100 times, the probability of multiple projects' impacts exceeding the in-combination precautionary estimated impact is substantially less likely and becomes vanishingly small as the number of projects increases.

62. As is the case for project-alone assessments, applying precaution to outputs, rather than inputs, would provide transparency to the extent of precaution in cumulative and in-combination impacts.

2.8 Consequences of accumulation of precaution on seabird compensation requirements

63. Under the HRA Regulations, if a proposed development is predicted to have an AEoSI on a European protected site, the development cannot be consented unless Scottish Ministers conclude that certain criteria are met to enable a derogation that allows the project to proceed. In such cases, there must be Imperative Reasons of Overriding Public Interest (IROPI) as to why the development should be allowed to proceed[16]. The developer is required to compensate for the predicted damage to the European protected site, to ensure that the overall coherence of the protected site network is maintained. In the case of offshore wind development, where Scottish Ministers conclude that the proposed development will have an AEoSI for seabird features of SPAs, compensatory measures need to be used to offset the proposed development's predicted seabird mortality[17].

64. Current precautionary approaches to in-combination assessment predict high seabird mortality to seabird populations close to multiple planned and operational offshore wind farms, e.g. along the east coast of Britain. Consequently, Scottish Ministers and the Secretary of State have concluded an AEoSI for many seabird features of these east coast SPAs. However, these high seabird mortality estimates are based on current approaches to impact assessment, with precaution applied to inputs, instead of outputs. As explained above, these precautionary estimated impacts lack transparency in the

[16] Habitats Regulations Appraisal (HRA) | NatureScot
[17] Marine licensing and consenting: Habitats Regulations Appraisal - gov.scot

extent of precaution included in them and may be substantially overestimating impacts. Furthermore, the likelihood of these impacts occurring is unknown. These high in-combination precautionary estimated impacts could represent a substantial overestimate of true impacts and may be biologically implausible.

65. Conclusions by Scottish Ministers of AEoSI for multiple features and SPAs means that all planned offshore wind projects along the east and north-east coast of Scotland need to secure seabird compensation to offset their predicted impacts. A proposed project's seabird compensation requirements will be defined by the project's precautionary estimated impacts, predicted using current SNCB-recommended approaches. Securing sufficient seabird compensation currently represents a substantial challenge to offshore wind development in the UK. The challenge is such that UK and Scottish governments have recently consulted on legislative reform, and changes to policy and guidance to facilitate projects and plans with securing sufficient compensation[18, 19]. Addressing the issues with the approaches to applying precaution in ornithology impact assessments has substantial potential to alleviate current challenges with securing sufficient seabird compensation.

2.9 Decision makers are not receiving the full range of information on a project's potential impacts

66. Offshore wind projects produce applications that largely follow NatureScot's guidance and advice to produce HRA and EIA ornithology impact assessments. Following SNCB guidance results in impact assessment outputs comprising a single precautionary estimate of mortality (or a higher and lower estimate for species at risk of displacement mortality), along with a precautionary estimate of relative change in population size and population growth rate in the presence of predicted OWF mortality. NatureScot uses these values presented in applications to inform their advice to MD-LOT. Scottish Minsters and MD-LOT then use NatureScot's advice to conclude on whether the proposed project will have an AEoSI and hence whether derogation and seabird compensation is required.

67. Scottish Ministers and MD-LOT can be confident that true impacts that a proposed development would have, if it became operational, are very highly likely be less than the

[18] Offshore wind - strategic compensation policy: consultation - gov.scot
[19] Scottish Marine Recovery Fund: consultation - gov.scot

precautionary estimated impacts produced under current NatureScot guidance. However, as explained above, this information precludes taking the risk-based approach to decision-making that is required by the precautionary principle. MD-LOT do not have information on the likelihood of occurrence of precautionary estimated impacts produced following current NatureScot guidance. Additionally, MD-LOT do not have any information on severity and likelihood of occurrence for a range of other scenarios, such as less severe impacts with a higher probability of occurrence. Box 3 provides an analogy, from decision-making to reduce climate change impacts, that illustrates how current approaches to applying precaution in ornithology impact assessments do not provide decision makers with the full range of information they need.

Box 3. An analogy: Climate change science to inform decision making

The use of science to inform decision making to minimise the extent of climate change presents a useful analogy to illustrate the issues with applying precaution to inputs, rather than outputs, of ornithology impact assessments.

Decision makers need to understand the potential consequences of climate change, informed by predictions of future emissions and associated changes to global temperatures and climate. Climate scientists use the best available evidence and advanced mathematical approaches to produce estimates of future climate change under a range of scenarios (Lee *et al.,* 2021). Uncertainty and confidence in different scenarios are conveyed using agreed language (Mastrandrea *et al.*, 2010). For example, "In the near term (2021–2040), a 1.5°C increase in the 20-year average of globally averaged surface air temperature (GSAT), relative to the average over the period 1850–1900, is *very likely* to occur in scenario SSP5-8.5, *likely* to occur in scenarios SSP2-4.5 and SSP3-7.0, and *more likely than not* to occur in scenarios SSP1-1.9 and SSP1-2.6," (see Lee *et al.*, 2021 Chapter 4: Future Global Climate: Scenario-based Projections and Near-term Information for explanation of scenarios).

If climate scientists were to use the precautionary approach that SNCBs recommend for ornithology impact assessments, for estimating near term GSAT, climate scientists would need to use precautionary values for some of the inputs to their models. These models would consequently produce a high estimate of GSAT in 2040, but with no estimate of the probability of that temperature occurring nor of the uncertainty or confidence in that estimate. Decision makers would know that the GSAT estimate was high, and that true global temperature rises would be very likely to be smaller than the predicted GSAT in 2040 but would have no knowledge of how much smaller the temperature rises could be nor of the probability of those smaller temperature rises occurring. Decision makers would not have the full range of information required to be able to identify the best management actions to minimise risk of unfavourable outcomes from climate change.

This analogy also illustrates the problem of scientists applying precaution to the scientific evidence they provide rather than decision makers applying precaution in their decision making. The precautionary principle relies on scientists presenting the best available evidence as clearly and transparently as possible to decision makers, capturing and communicating uncertainty around that evidence effectively. Decision makers can then adopt a precautionary approach to decision making if required, to reduce the risk of certain scenarios occurring. If precaution is applied in the process of generating the scientific evidence, decision makers do not have a robust assessment of the evidence with which to make an informed judgement on the best approach to managing risks of adverse outcomes occurring.

68. Recommendations are provided below on the information that MD-LOT and Scottish Ministers would need in order to have a full understanding of the likelihood of various impacts occurring, enabling them to balance the risk of environmental damage against other benefits of offshore wind development, while adhering to the precautionary principle.

3.0 Recommendations

69. Nine inter-related issues with the way in which precaution is currently applied in ornithology impact assessments are described in detail above. These are:

1) Precaution is applied to inputs to ornithology impact assessments in an inconsistent and non-transparent manner;
2) Precaution is applied at the incorrect points in ornithology impact assessments. A precautionary approach can be applied in decision making but should not be applied in the scientific evaluation of evidence. Precaution should be applied to outputs, not inputs of impact assessments;
3) Scientific uncertainty is not fully quantified and propagated through the impact assessment process to outputs;
4) The likelihood of a particular impact occurring is not estimated or considered;
5) The precautionary principle requires that a risk-based approach should be used, where possible, to inform decision-making. Current ornithology impact assessment approaches do not enable use of a risk-based approach to decision-making;
6) Precaution accumulates through the impact assessment process in a non-transparent manner. Outputs from impact assessments are high, i.e. are 'precautionary', but the extent of precaution in these outputs is not known;
7) In-combination and cumulative precautionary estimated impacts will also be high but have no likelihood of occurrence estimated, meaning they may be biologically implausible and have a very low likelihood of ever occurring. As more projects are included in cumulative and in-combination assessments, the probability of all projects simultaneously having these high impacts becomes ever smaller;
8) Impact assessment outputs are a precautionary overestimate of impacts that are most likely to occur, yet these overestimated impacts still require to be fully compensated. Securing sufficient seabird compensatory measures is one of the biggest challenges facing many proposed offshore wind projects in Scotland;
9) Without knowledge of scientific uncertainty and likelihood of occurrence associated with predicted ornithology impacts, the regulator is not provided with the full set of necessary information on which to base an informed consent decision.

70. It is for NatureScot and Scottish Government to advise offshore wind applicants on how to undertake ornithology impact assessments as part of their consent applications. Consequently, it is recommended that Scottish Government and NatureScot urgently consider the issues identified in this evaluation, including the scientific and mathematical robustness of current and alternative approaches, as well as legal and policy positions on application of the precautionary principle to offshore wind development. The critical issue identified in this evaluation is the need for transparency in precaution in impact assessments, by moving the application of precaution to outputs rather than inputs. This means adopting a precautionary approach to decision making and not to the scientific

evaluation of the evidence. This needs to be undertaken in a transparent and open manner, in line with the Commission's guidance on applying the precautionary principle (Commission, 2000).

71. The ORJIP AssESs project (Butler *et al.*, 2025) makes multiple recommendations on addressing many of the issues identified in this evaluation of how precaution is applied in ornithology impact assessments. Consequently, this report supports the recommendations presented by the ORJIP AssESs project.

72. The precautionary principle requires an evaluation of risk (Commission, 2000; Scottish Government, 2023; UK Government, 2023). Use of credible scenarios enable risk assessment when there is high uncertainty about the severity and/or likelihood of occurrence of a hazard or threat, as proposed by the Inter-Departmental Liaison Group on Risk Assessment's advice on the application of the precautionary principle (ILGRA, 2002). It is recommended to move to a risk-based approach for determining OWF project consents.

73. There are multiple examples of scientific uncertainty being considered in a risk-based approach to inform decision-making, under the precautionary principle, where a risk of environmental harm exists. One such example is the form of scientific advice used to communicate the risk of climate change to decision-makers. Mastrandrea *et al*. (2010) define language for communicating scientific uncertainty to decision-makers which would be helpful for presenting information to assist with decision making with respect to OWF consenting. The benefits of using the Mastrandrea *et al.* (2010) terminology were also noted by the Chief Scientific Advisor Marine of the Scottish Government when reviewing MD-SEDD's advice on Berwick Bank's proposed compensatory measures (Chief Scientific Advisor Marine, 2024).

4.0 Conclusions

74. Decision makers need to be able to make an informed decision when considering whether to consent a proposed offshore wind project, weighing up the risks of environmental damage against many other considerations, such as socio-economic benefits and ambition to meet offshore wind capacity targets. Decision makers therefore need to understand risks in terms of potential environmental damage from consenting a proposed development. To do so they need information on the full range of possible outcomes, including the likelihood of occurrence and severity (e.g. magnitude of seabird mortality), as well as uncertainty associated with these.

75. In this report, the way in which precaution is applied in ornithology EIA and HRA impact assessments for offshore wind consent applications has been evaluated. The consideration of whether or not the precautionary principle should be applied to offshore wind project assessments and determinations was beyond the scope of this report.

76. NatureScot and the Marine Directorate advise that a precautionary approach should be followed when considering ornithology impacts arising from proposed offshore wind developments. This involves applying precaution to inputs to ornithology impact assessments, at multiple points throughout the assessment process. Under current approaches, the regulator can be confident that true impacts to protected seabird populations that would arise should a proposed development become operational, are very likely to be lower than the precautionary estimated impacts currently presented in applications. However, the evaluation presented in this report has identified multiple significant issues with current approaches.

77. To address these issues, instead of applying precaution to individual inputs used in ornithology impact assessments, as is currently done, it is recommended that precaution should be applied to outputs, informed by the extent of scientific uncertainty. This means undertaking a robust scientific evaluation of available evidence to inform the impact assessment and then applying a precautionary approach to risk-based decision-making, as described in guidance on the application of the precautionary principle.

78. Consideration, by NatureScot and Scottish Government, of the issues with current approaches identified in this evaluation is urgently needed. Moving to a risk-based approach to OWF determinations would provide the regulator with a comprehensive

understanding of the full range of potential impacts that a proposed development could have and the likelihood of them occurring. The regulator could adopt a precautionary approach to consent determinations, informed by the full picture of the risk of damage to protected seabird populations, thereby fulfilling the requirements of the precautionary principle. This would also provide transparency around the magnitude of impacts that require seabird compensation, helping to alleviate the current challenges posed by the need to secure sufficient seabird compensation.

5.0 Basis of Report

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