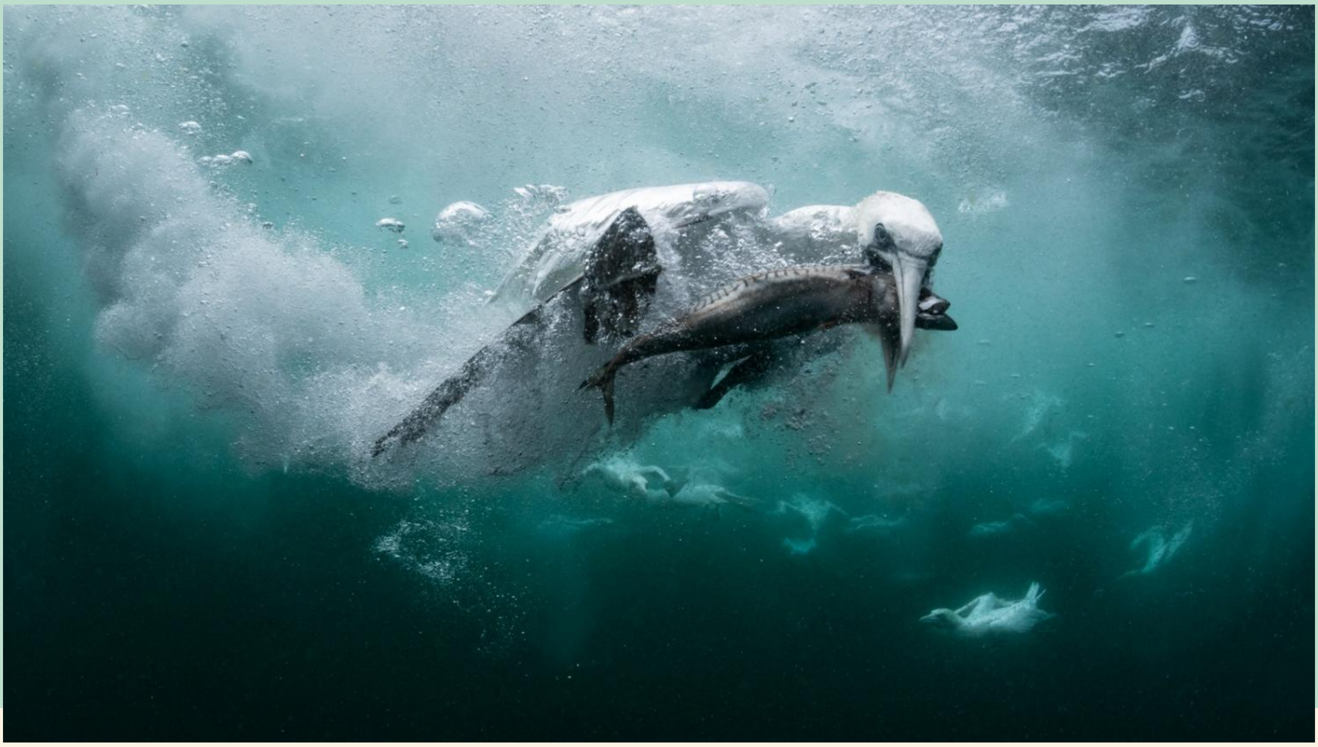

REPORT

Enhancing breeding success of shortlisted North Sea birds breeding outside the Netherlands

Client:	Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur (LVVN)
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Executive Summary

This study provides Nature Regeneration North Sea (NN) with a strategic overview of international measures to enhance the breeding success of seabirds that depend on the North Sea but breed largely outside the Netherlands. Improving breeding success is identified as a key lever to strengthen population resilience in the face of multiple pressures such as offshore wind development, reduced food availability, climate change, predation, disturbance and disease.

Key findings show that breeding success is often limited by a combination of local pressures at colonies (e.g. predation, disturbance, biosecurity) and broader ecosystem drivers (e.g. food availability and climate impacts). Effective measures therefore range from site-based interventions—such as predator eradication, disturbance reduction and artificial nesting structures—to ecosystem-based actions like habitat restoration (e.g. seagrass), to litter removal. The effectiveness and scalability of these measures vary strongly by species and context.

Across species, two types of measures stand out as most promising and actionable for NN:

- Eradication of introduced mammalian predators and biosecurity programmes on breeding islands, particularly for species such as common guillemot and razorbill, where evidence shows substantial improvements in breeding populations and breeding success following predator removal.
- Seagrass cultivation and restoration projects, which have the potential to support a wide range of seabird and waterbird species by enhancing ecosystem functioning, nursery habitat for fish, food availability, and coastal resilience.

The study also highlights that international cooperation is essential, as most relevant breeding colonies lie outside Dutch jurisdiction. A wide range of NGOs, research institutes, governments and private sector actors are already active, providing clear opportunities for NN to align with, co-fund, or scale existing initiatives rather than acting independently.

Main conclusions are that:

- The conservation needs of North Sea seabirds are highly species-specific, requiring tailored approaches rather than a single generic measure.
- Predator eradication and island biosecurity currently provide the strongest evidence for measurable improvements in breeding success for several seabird species.
- Seagrass restoration offers a broader ecosystem-based approach with potential benefits for multiple species and trophic levels.
- Many important pressures on seabirds, including fisheries impacts, climate change, disease outbreaks, and offshore wind development, operate at regional or international scales and cannot be addressed through local measures alone.

International cooperation is essential because most breeding populations occur outside Dutch jurisdiction. Based on these findings, NN is recommended to:

- Prioritize support for predator eradication and biosecurity initiatives on breeding islands.
- Invest in seagrass restoration projects where ecological benefits for seabirds and their prey base can be demonstrated.
- Engage with existing international conservation programs and organizations rather than developing standalone initiatives.
- Undertake detailed feasibility studies before implementation, including site selection, governance arrangements, and opportunities for pilot projects.

- Integrate robust monitoring programs into all measures to evaluate effects on breeding success, population trends, and survival.

By combining evidence-based interventions with international collaboration and long-term monitoring, NN can contribute meaningfully to improving the resilience and conservation status of vulnerable North Sea seabird populations.

1 Introduction

1.1 Background and context

Nature Regeneration North Sea (NN) aims to contribute to a healthy, resilient and biodiverse North Sea, capable of supporting both ecological recovery and sustainable use. Within this ambition, seabirds, coastal, and migratory birds represent a critical ecosystem component and an internationally shared responsibility. Many seabird species that depend on the North Sea for foraging, migration or overwintering breed predominantly outside the Netherlands, while several migratory wader species rely on the North Sea's coastal and intertidal habitats as key stopover and wintering areas along international flyways (Jongbloed et al. 2025). The pressures affecting their populations increasingly operate at the scale of the entire North Sea basin.

Recent analyses, including *Enhancing threatened seabird populations in the North Sea* (van der Have, T.M. 2025), demonstrate that declines in several seabird populations are driven by a combination of factors such as reduced food availability, predation at breeding sites, disturbance, climate change and cumulative impacts of offshore activities. These pressures cannot be effectively addressed through national measures alone. Instead, improving breeding success for internationally breeding seabirds requires coordinated, cross-border action and a strategic understanding of which measures are most effective and feasible at the international level.

Within the NN programme and its annual plans for 2025–2026, increasing attention is therefore given to international cooperation, alignment with existing initiatives, and identifying opportunities where NN can add value beyond the Dutch Continental Shelf. NN seeks to focus on measures that can realistically improve breeding success of seabirds that are ecologically connected to the North Sea, while remaining consistent with an ecosystem-based approach and existing policy frameworks such as MONS, species protection plans and international agreements.

1.2 Objective and scope

The objective of this report is to support Nature Regeneration North Sea by providing a focused overview of international measures that contribute to improved breeding success of seabirds and migratory waterbirds that depend on the North Sea. The report synthesises available knowledge on potential measures, relevant international actors and recent ongoing or completed projects, with the aim of identifying strategic opportunities for NN to focus, connect and strengthen international efforts.

Building on the species selection used in earlier NN work, including *Enhancing threatened seabird populations in the North Sea* (van der Have, T.M. 2025), this report focuses on seven seabird/waterbird species that breed outside the Netherlands but are strongly dependent on the North Sea's offshore, coastal or intertidal ecosystem for part of their life cycle. The species are important for the development of offshore wind farms in the North Sea, as the potential for significant impacts on them has been identified. The species which are included in this report are:

- Northern gannet *Morus bassanus*
- Great skua *Stercorarius skua*
- Common guillemot *Uria aalge*
- Razorbill *Alca torda*
- Red knot *Calidris canutus*
- Bar-tailed godwit *Limosa lapponica*
- Great Black-backed Gull *Larus marinus*

For these species, the report examines:

- key pressures affecting breeding success,
- measures that have been implemented internationally to address these pressures,
- the effectiveness and cost range of these measures, and
- opportunities for international cooperation relevant to NN.

There are three additional species where this report highlights the potential applicability of existing interventions, thus indicating how these measures could be positive across a broader range of seabird species. These three additional species are:

- Black-legged kittiwake *Rissa tridactyla*
- Arctic Skua *Stercorarius parasiticus*
- Herring gull *Larus argentatus*

The report does not aim to provide a comprehensive ecological assessment per species, but rather a decision-supporting synthesis that can inform strategic choices, prioritisation and follow-up actions within the NN programme. The report focuses on physical and spatial measures that are feasible within the current legislative and policy framework applicable during the 2025–2030 implementation period of NN.

2 Approach

This study applies a structured, problem-oriented approach to identify effective and feasible international measures that can improve the breeding success and population resilience of seabirds and migratory waterbirds connected to the North Sea ecosystem. The primary focus is on species whose breeding populations occur within the wider North Sea region and are therefore directly influenced by ecological conditions and human activities in the North Sea basin.

However, not all selected species breed within the North Sea region itself (Bar-tailed godwit and Red Knot). For these species, the assessment focused on those parts of the annual cycle during which they depend on North Sea habitats, particularly wintering, migration and foraging periods. Measures were therefore evaluated based on their relevance within the ecological context of the North Sea rather than strictly within national boundaries.

The approach combines existing knowledge, expert input and comparative assessment and is intended to support strategic decision-making within Nature Regeneration North Sea (NN).

The work was organised in a series of consecutive phases:

1. Baseline information
2. Targeted problem analysis
3. Measures and effectiveness
4. Cooperation and implementation context

These phases were followed in sequence, with intermediate consultation within the project team.

2.1 Phase 1 – Baseline information

A concise baseline is established for the critical seabird species from the NN report: *Enhancing threatened seabird populations in the North Sea*, which consists of species breeding inside and outside the Netherlands that are ecologically linked to the North Sea. For each species, available information is synthesised on:

- population status and trends,
- key breeding areas,
- main pressure factors affecting breeding success (e.g. disturbance, predation, food availability, habitat loss, climate change),
- current levels of breeding success and known drivers of reproductive performance.

The aim is not to provide full ecological descriptions, but to create a comparable overview that highlights vulnerabilities and patterns across species.

2.2 Phase 2 – Targeted problem analysis

Following Phase 1, which included a broader selection of seabird species, the focus of the study was narrowed to seven target species. These species were selected due to their ecological relevance to the North Sea, breeding outside the Netherlands, and their key role in the context of offshore wind farm expansion in the Netherlands.

For these target species, the key causes of low breeding success were analysed in greater detail. This involved distinguishing between:

- pressure factors that directly affect breeding success at breeding sites (e.g. predation, flooding, disturbance), and
- indirect drivers that influence breeding success through effects on adult condition, behaviour or survival (e.g. food availability, Highly Pathogenic Avian Influenza (HPAI)).

2.3 Phase 3 – Measures and effectiveness

Existing international measures/projects are reviewed, with a focus on practical, hands-on interventions such as predator management, artificial nesting structures, habitat management and disturbance reduction. For each measure, available evidence on effectiveness, scalability and limitations is assessed. Ongoing research, pilot projects and remaining knowledge gaps are identified to highlight promising leads and potential investment priorities for NN.

For all seven species, priority measures were selected for further focus. This also involved evaluating whether concentrating on measures aimed at improving breeding productivity represents the most appropriate and effective approach for each species.

2.4 Phase 4 – Cooperation and implementation context

The final phase mapped relevant international actors, initiatives and cooperation opportunities. This included:

- NGOs, research institutes and governmental bodies active in seabird conservation,
- ongoing or completed international projects, and
- potential opportunities for NN to connect, align or add value.

This phase aimed to place the identified measures within their broader governance and cooperation context, supporting strategic decision-making on where NN could most effectively contribute.

2.5 Excel overview

Throughout the project, an Excel-based overview was used as a central working tool. This overview compiled:

- species-specific information,
- identified pressures,
- potential measures and their characteristics, and
- relevant organisations and initiatives.

The Excel overview functioned as a central database throughout the project. It was used to systematically organise species-specific information, pressures, measures and stakeholders, thereby ensuring consistency and comparability across species during the analysis process.

3 Species-specific context

3.1 Northern Gannet

3.1.1 Species' Biology

Northern gannet breed on coasts and islands of the Atlantic Ocean in the sub-Arctic and northern temperate regions of western Europe and eastern North America, and spend the non-breeding season in the wider continental shelf regions as far south as the Gulf of Mexico and the western coast of Africa. The key breeding area is western Europe, and the key breeding habitats are sea cliffs and rocky offshore islands (BirdLife International 2026).

North Sea colonies of gannet (in territories of Norway, UK and Germany) constitute approximately 35% of the European breeding population (Furness 2015). The European population is estimated in turn to represent 75 to 94% of the global breeding population (BirdLife International 2026). Therefore, the North Sea constitutes 26 to 33% of the global population. The North Sea is also the location of the Bass Rock (island/rock on the North Berwick coast in the Firth of Forth, east Scotland) where the population slightly exceeded 75,000 pairs in 2014 (Seabird Monitoring Programme 2026), rendering it the largest gannet colony in the world at that time. More recently, however, numbers of gannets at the Bass Rock colony have declined following the HPAI outbreak at the colony in 2022, with the population estimated to be approximately 52,000 pairs in 2025 (Burton et al. 2025). Key breeding areas in Europe for gannet as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, European Bird Census Council (EBCC) 2026) show several prominent colonies on the UK North Sea coasts[1].

In the non-breeding seasons, as defined by Furness (2015), the North Sea (along with the English Channel) hosts the majority of individuals from North Sea colonies, which are estimated to make up over 80% of individuals present in the North Sea these seasons, but also substantial proportions of the Faeroe Islands and Iceland breeding populations, making the North Sea important for these breeding populations too.

Breeding success of gannet colonies is generally high with little variation between colonies and years, and Furness et al. (2014) concluded there was therefore little scope for increasing breeding success of gannet. Causes of colony-level reduction or failure in productivity outlined by the Furness et al. (2014) review are generally isolated or unseasonal natural events including extreme cold (snow and ice), landslide, and severe storms. One colony, Sula Sgeir (a remote and uninhabited Scottish island located in the North Atlantic), is subject to a licenced annual harvest of large nestlings (order of magnitude thousands of individuals) on traditional grounds. A threat to breeding success identified by BirdLife International (2026) in its species account for gannet is solid plastic pollution in the marine environment, qualified as 'unknown' in severity and as a growing or 'future' factor as this pollution type is expected to accumulate. By-catch of adults in demersal longline fishing, plus set-nets and purse-seines fisheries, is cited as affecting breeding success via mortality of actively breeding adults (among other demographic factors) at the scope of the majority of the world population by BirdLife International (2026). However, impact on the population is assessed to be low (Anderson et al. 2022, Kingston et al. 2023, BirdLife International 2026).

The gannet population in the North Sea has increased substantially over the last few decades (Murray et al. 2015, Burnell et al. 2023, Burton et al. 2025). However, gannet populations in North Sea colonies in the UK were severely reduced by mortality associated with HPAI in 2022; UK-wide, the population is estimated to have declined by 16% (Tremlett et al. 2024). Much of this decline occurred on the Bass Rock (see above), where numbers fell by more than 30% (Burton et al. 2025). Gannet populations show some evidence that

[1] https://ebba2.info/maps/species/Morus-bassanus/ebba2/abundance/

they are now recovering from their sharp 2022 decline, but this recovery is likely to take many years (Burton et al. 2025). The Northern gannet is currently classified as “least concern” by the IUCN.

3.1.2 Possible Measures

3.1.2.1 Artificial Nesting Structures/Social attraction to colonise vacant sites

The nesting ecology of Northern gannet and the wider genus *Morus* indicates possible suitability for new colonies to establish on artificial nesting structures (ANS). Three colonies of Australasian gannet *Morus serrator* have bred on existing artificial structures, and northern gannet has bred successfully in single pairs or very small colonies on existing artificial structures, such as concrete harbour jetties (as reviewed by NIRAS 2021). Non-breeding individuals at a UK colony readily rest on a concrete helipad (Wanless et al. 2005) which may indicate this surface is sufficiently naturalistic for the birds. Purpose-built (floating) structures for nesting northern gannet have been deployed in two French inshore breeding populations with successful breeding by two pairs in 2013 at one site (NIRAS 2021). An offshore nesting structure was researched and designed from first principles as a potential compensation measure for the species by a UK offshore wind project (Orsted 2021a). An important note regarding small colonies and new colonies is that they typically have lower than average breeding success due to likely higher attendance by less experienced breeding pairs (Mavor et al. 2008). High rates of depredation of nests and eggs by species such as great black-backed gull, has also been reported at such colonies (Mavor et al. 2004).

The costs of an artificial nesting structure for gannet would depend substantially upon the site selected and the design to be deployed. Deployment of free-standing artificial nesting structures at sea are high, due to requirement of offshore engineering, foundation and topside installation. Costs may be lower if the site selected is on the coast rather than offshore. Costs could be raised further (conceivably to over a million Euro for a structure designed to support tens of gannets) if there is a requirement for:

- natural or naturalistic materials for nesting substrate (e.g. granite),
- sound attractants (power supply),
- in-person monitoring (labour, personnel transport/transfer, access, safety and evac features) or
- remote monitoring (camera arrays, storage or transmission of data, power supply, maintenance, drone use).

As an alternative to the creation of artificial nesting structures, nesting habitat for gannet could be created through the modification of existing areas of land on the coast or on islands to expose suitable substrate. Gannet typically nest on dirt or exposed rock, and so clearance of vegetation and / or loose soil could produce suitable nesting habitat. While this approach would be suitable in theory, and may be lower cost than the deployment of artificial nesting structures, it is also less well evidenced than the use of artificial nesting structures for gannet.

Gannets may be responsive to social attraction techniques to colonise ANS, or existing sites which are former colonies or are otherwise suitable for the species. As reviewed by Jones and Kress (2012) and summarised by Furness et al. (2014), “an attempt to start a new Australasian gannet colony at Young Nick’s Head, in New Zealand by social attraction (Sayer & Fogle 2013) was successful, but attempts using the same method with Australasian gannets at Mana Island, New Zealand, and with northern gannets in Nova Scotia and in Quebec failed. Jones and Kress (2012) suggest that the key feature affecting the outcomes at these sites was that the Young Nick’s Head site was in an area frequented by large numbers of potential colonists from a nearby colony, while the unsuccessful attempts were at sites far from source colonies.”

Key considerations regarding ANS or attempts to attract recolonisation of a vacant site include the low probability of success in attracting birds, especially within a three year or similar timeframe. Another critical consideration is whether the population in the locality or wider region is limited by nesting space. (Prior to the HPAI outbreak, some UK colonies were considered to be at carrying capacity with occupancy of all available nesting space e.g. at Bass Rock, supported by the establishment of new breeding pairs at nearby mainland seabird colonies such as St Abb's Head. However, since HPAI it is expected this will no longer be the case at the Bass Rock and other UK colonies that have seen declines, and the potential for benefits to arise from ANS is expected to be lower, at least until populations have recovered to pre-HPAI levels.) Projects should also consider whether the attracted birds are entering from the younger or non-breeding component of the population or are merely relocating from existing colonies.

3.1.2.2 Direct intervention with plastic litter mortality of adults and young

Gannets readily incorporate plastic debris from the marine environment into the composition of their nest, and this regularly leads to a small number of adults and young becoming ensnared and trapped at colonies, and death by starvation of birds which are not released. There is effort at many wardened colonies, such as Bass Rock, to actively seek out and release gannets which have become entangled and also scope for this activity to be carried out at more colonies and with more frequency (e.g. increase from sub-annual to annual, or from once to twice per season). Intervening in plastic-based mortality at colonies would be very likely to have a positive effect on productivity (a potential negative being disturbance of other breeding gannets and other birds which may be avoided through appropriate timing). However, it is not clear that the effect of disentangling birds from plastic litter would result in significant benefits, as productivity at colonies is reported to be generally high and the number of young produced by a colony can be several orders of magnitude higher than the number ensnared. For example, Votier et al. (2011) found that plastic at the nest resulted in an average entanglement of 63 gannets (mostly nestlings) per year at Grassholm: a colony of 40,000 breeding pairs.

The costs of intervening at multiple affected colonies are medium (order of magnitude tens of thousands of Euro) due to costs of labour, offshore transportation of personnel, and any necessary training, all potentially over a large geographic scale, dependent on the spatial scale required or attempted.

3.1.2.3 Indirect intervention with plastic litter using seaweed aquaculture

Gannets incorporate plastic into their nests because they construct their nests predominantly from scraps of material found floating on the sea surface. In the absence of plastic litter, the dominant component of gannet nests would be seaweed and wood. On that basis, it would be possible to reduce gannet entanglement within plastic litter either by removing plastic litter from nests or from the wider environment, or by increasing the abundance of organic nesting material in the environment so that a smaller proportion of plastic litter is used in nest construction.

Co-locating seaweed aquaculture with gannet colonies has been identified as a potential method of increasing the availability of organic debris for gannet nest construction and, therefore, reducing gannet deaths within colonies attributable to entanglement with plastic debris (Furness and Furness 2025). Such measures would also have potential carbon sequestration and commercial benefits (Pessarrodona et al. 2024) and could also increase food availability for gannet. However, no results have yet been published describing the effectiveness of this measure in practice.

Depending on how it was conducted, establishment of seaweed aquaculture near gannet colonies could potentially be profitable in the long term, although this would depend upon the value of the cultivated seaweed (van den Burg et al. 2016). However, short-term costs associated with the active deployment of aquaculture would likely be considerable (order of magnitude hundreds of thousands to millions of Euro depending on the scale required to deliver effective compensation) because of the cost of labour, leases and equipment, and van den Burg et al. (2016) estimated the cost of seaweed aquaculture in the North Sea at $37,062 per hectare per year after set-up. Lower costs could be achieved if no harvesting was conducted, although this would also reduce the potential for profit (except where profit is associated with carbon or biodiversity effects). Creation of new areas of natural seaweed ecosystem, such as kelp forest, can also be relatively expensive, although costs vary considerably depending on the local conditions (Eger et al. 2022a), and if natural seaweed regeneration is being suppressed by human activities, then passive regeneration can be achieved at whatever cost is associated with halting those activities (Eger et al. 2022b). If seaweed growth was being promoted purely for the benefit of gannet (rather than for harvesting or regeneration of natural ecosystems), then cheaper methods may be available that would not otherwise be suitable, such as the deployment of relatively inaccessible artificial structures near the surface which serve as substrate for seaweed growth. The untested nature of the measure would make the magnitude and timescale of any impacts on gannet breeding success uncertain.

3.1.2.4 Limiting disturbance at colonies

While management of disturbance at northern gannet colonies has not been a focus of existing proposals to benefit North Sea gannet populations (such as in compensation measure packages for offshore wind projects), it is a potential measure for improving gannet breeding success. Ecological evidence of recreation-based disturbance of seabirds was reviewed by GoBe Consultants (2024a-d). The most immediate mechanism for disturbance to reduce breeding success is when adults at the colony flush from the nest location, which has been observed in multiple species to result in eggs or chicks being exposed to predators such as gulls, as well as to the elements. Seabird eggs or young have been observed to fall from the nesting ledge during flushing responses, and seabirds nesting at high density on ledges (as with gannet) are more vulnerable to crushing of eggs or young chicks during flushing events.

However, even non-escape behaviours in disturbed seabirds are indicative of distress or discomfort. Non-escape responses are likely to be indicators of physiological, or otherwise non-visible, stress responses with the potential to ultimately affect breeding success via reduced fitness or increased adult investment in their own survival over reproduction. Seabird body temperature, heart rate, levels of the stress hormone corticosterone and time spent being vigilant to threats have all shown changes in response to disturbance when measured in the field (as reviewed by GoBe Consultants 2024a).

North Sea colonies where reduction in disturbance could be applied as a viable measure for improving breeding success are those which i) are likely to experience human disturbance or ii) are otherwise close to built-up areas and/or existing tourism (as modified from GoBe Consultants 2024a for which the aim was downstream recruitment of additional breeding adults c.f. increased breeding success alone). Reducing disturbance is more likely to have an impact on breeding success when this is not significantly limited by another factor such as food supply. Gannet breeding success is not indicated to be limited by food supply (Furness et al. 2014), and records were found of potentially manageable disturbance to North Sea colonies, such as close approach by kayaks at the Bempton Cliffs colony in the UK.

Specific means of limiting disturbance include signage, wardens (either on land or boat-based), visitor access statements (wherein more detailed text, guidance code of conduct is posted in the form of signage, handout/leaflet or on a website), restricting visiting hours or seasons, and restricting visitor approach distance on land or on water (GoBe Consultants 2024a). All are generally low cost (thousands of Euros or less) with the exception of wardens. Of the above, advising visitor approach distance through signage has been reported to have materially limited disturbance (number of instances of birds flushing from nests) at a gannet colony (Great Saltee, Ireland) (Allbrook & Quinn 2020), while restricting visitor approach distance with fences has been shown to result in i) no difference in egg loss between edge and more distant pairs (i.e., minimising edge-related higher failure rate) ii) lower flushing distances (i.e., higher resilience) than in pairs at sites with high visitation rate (GoBe Consultants 2024a). Although higher in cost due to the greater resource requirement, wardens “increase the success of management measures, as they provide a mechanism of enforcement to any statutory or voluntary management measures. Furthermore, wardens have been shown to increase visitors’ environmental knowledge and promote better behavioural practices” (GoBe Consultants 2024a). Restriction of visitor hours at Saltee Islands, Ireland successfully reduced disturbance (The Saltee Islands, 2001). Visitor access statements have been deployed at seabird colonies and may have similar impact to signage in reducing disturbance. The downstream effect of reducing disturbance on breeding success is challenging to measure due, in part, to other underlying factors which may confound data analysis and direct evidence for beneficial effects is scarce or absent, with little known about the potential scale of any potential benefits that might arise.

3.1.2.5 Biosecurity of nesting islands

As a colonial-breeding seabird with high nesting densities, gannets are highly vulnerable to diseases such as HPAI (highly pathogenic avian influenza); the 2021-22 HPAI outbreak in the UK resulted in an approximately 16% decline in gannet populations from which the population is not likely to recover for some years (Tremlett et al. 2024). Limiting of disease transmission to gannet colonies through biosecurity is not considered possible due to possibility of gannets themselves transmitting diseases between colonies during dispersal and relocation. Gannets are also potentially vulnerable to introduced mammalian predators. Existing evidence suggests that gannets are less impacted by mammalian predators than some other seabird species such as puffins and shearwaters (Tapia-Harris and Evans 2024), likely at least in part because of their nesting ecology. However, reports do exist of invasive mammalian predators feeding on gannets at colonies and so at least some impact does exist; Montevecchi et al. (2019) reported red fox *Vulpes vulpes* feeding on gannet within a colony in Newfoundland, Canada, and American mink *Neogale vison* have occasionally been observed attacking gannet chicks at colonies in Scotland.

Management of disease transmission to, and predator invasion of, nesting islands through maintained and improved biosecurity is therefore a potential measure for improving gannet breeding success. Island biosecurity is well practiced worldwide and is responsible for the recovery and maintenance of some of the most endangered bird species, with toolkits and manuals readily available for approaching such projects (Matos et al. 2018, Thomas 2025). Exclusion of mammalian predators from gannet colonies through biosecurity would also be likely to have substantial additional benefits for seabird species other than gannet within those colonies (Tapia-Harris and Evans 2024).

3.2 Great Skua

3.2.1 Species' Biology

Great skua breed in Iceland, the Faroe Islands, Norway (including Svalbard) and the UK. The species is fully migratory; many individuals spend the non-breeding period mainly in the Atlantic off western Europe, but others winter off eastern North America and birds may occur as far south as Brazil and Cape Verde.

North Sea colonies of great skua (in territories of Norway and the UK) were estimated to total 17,694 breeding adults (Furness 2015), while the global breeding population (confined to Europe) is 30,000 to 35,000 breeding adults (Birdlife International 2015). North Sea colonies therefore constitute approximately **50 to 59%** of the global/European population. Key breeding areas for great skua as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, EBCC 2026) show concentration of colonies in the Northern Isles (i.e., Shetland and Orkney) of the UK[2]. However, a large number of colonies and individuals in the UK were impacted by HPAI from 2021 and this may have influenced the relative North Sea population.

Threats affecting breeding success cited by BirdLife International (2026) include depletion of food supply in relation to fisheries – both the harvest of sandeels and the curtailment of fisheries discards which are both key food sources – and historical culling of great skuas, although due to increased legal protection this continues only at low levels if at all, and likely with negligible impact on the population. Some North Sea great skua are also killed by fisheries bycatch (Kingston et al. 2023). Prior to 2021-22, populations of great skua colonies at colonies in the UK were broadly stable on average, having increased substantially in the 20th century (MacArthur Green 2021). Where populations were declining, underlying factors driving colony-level declines and failures in productivity are outlined by the Furness et al. (2014) review. These included food shortage and associated intra-specific predation of young by neighbouring adults in the colony. Very wet conditions also negatively impacted breeding success. Great skua saw the most severe decline of all studied UK seabirds following the 2021-22 HPAI outbreak, with counts decreasing by >50% at 79% of previously occupied sites (Tremlett et al. 2024). Great skua are currently classified as "least concern" by the IUCN, although this assessment was last updated prior to the 2021-22 HPAI outbreak.

3.2.2 Possible Measures

3.2.2.1 Supplementary feeding of great skuas

Poor breeding success in great skua is likely to be at least in part a result of decreased availability of natural food (MacArthur Green 2021). Consequently, increasing food availability through supplementary feeding has the potential to increase breeding success in a very targeted manner. A pilot study on Foula in Scotland has demonstrated that supplementary feeding of great skua is an effective measure for increasing their breeding success. Half of breeding pairs in the study were given once-daily supplementary food in the form of fish and octopus, with the quantity of additional food provided increasing over the course of the breeding season to track chick requirements. Pairs that were provided with supplementary food showed a 200% higher breeding success (in terms of number of chicks fledged) on average than control pairs (MacArthur Green 2021). This pilot study suggests that the measure could be extremely effective in increasing great skua population growth. However, the study was conducted over only a single year and included only 20 breeding pairs, and so further study would be appropriate to better quantify the expected return from implementation of this measure.

Supplementary feeding is practical for great skua because of their ecology; birds are easy to access while breeding and their broad diet means that are a range of food items will be accepted. Supplementary feeding has also been shown to have an immediate impact on breeding success in the year in which it is

[2] *https://ebba2.info/maps/species/Catharacta-skua/ebba2/abundance/*

implemented. This measure could be targeted at any colony, but would be most effective if targeted at large colonies where baseline breeding success is relatively low. The efficacy of the measure will depend upon the conditions at the target colony: an experimental study conducted on South Polar Skua (*Catharacta maccormicki*) in the Antarctic showed that, when food availability is not limiting at a site, supplementary feeding of skuas does not increase chick fledging success (Ritz et al. 2005).

The costs of intervening at colonies are medium (order of magnitude tens of thousands of Euro) due to costs of labour, offshore transportation of personnel, and any necessary training, all potentially over a large geographic scale. Supplementary feeding would need to be conducted continuously throughout the breeding season in all years in which it was required.

No routine supplementary feeding of great skua is currently occurring as a conservation measure. Concerns have been raised by expert organisations around the implementation of supplementary feeding on the basis that it could have unintended negative impacts on the behaviour and ecology of both target and non-target species, including top-down effects on prey species, attraction of generalist predators which predate nests or birds in the area, or unbalancing competition between species (Plummer et al. 2021). Although these concerns have been raised in the context of garden birds, they would still need to be addressed if supplementary feeding of great skua was proposed as a prolonged measure to increase their breeding success.

3.2.2.2 Cessation of culling

Human activities resulted in a decline in skua populations in the 1700s and 1800s, much of which was associated with the collection of eggs. However, egg collecting became illegal in the UK in the mid-1900s, and legal culling of great skua in both the UK and Norway can now only be conducted under license. It is likely that illegal persecution of great skua resulted in damage to some colonies in the past (Furness 1987). However. while it is possible that some illegal culling still occurs, such activities are no longer reported at any significant scale. Small-scale culling of great skua under license has been conducted in the past thirty years to mitigate against loss of livestock (Klomp and Furness 1992, Votier et al. 2007), but recent declines in great skua numbers, both prior to and as a result of Highly Pathogenic Avian Influence (HPAI), mean that the issuance of future licenses to cull great skua is now extremely unlikely (Tremlett et al. 2024). Some culling may still be theoretically permissible for the purposes of preventing danger to aircraft, but government records of legal culling currently do not show any evidence that culling of great skua is currently active in the UK or Norway for this reason or any other.

On the basis that no significant legal culling of great skua currently occurs or is likely to occur in the near future, it is considered unlikely that reductions in culling could be implemented as a measure to increase great skua survival or breeding success.

3.3 Common guillemot

3.3.1 Species' Biology

Common guillemot breed across a circumpolar breeding range, on cliffs and islands of the North Atlantic and North Pacific oceans (Birdlife International 2026).

North Sea colonies of common guillemot (in territories of Norway, UK and Germany) were estimated to total 1,385,332 breeding adults (Furness 2015), which is approximately 45 to 59% of the European breeding population (BirdLife International 2015). Most of these birds are part of the UK population (Artsdatabanken 2021a). The global population is historically considered to exceed 18 million individuals including sub-adults (del Hoyo et al. 1996), in which case the European population would constitute up to 12% of the global population, but a more recent and high-confidence estimate of global population is not ventured (BirdLife International 2026). Key breeding areas in Europe for guillemot as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, EBCC 2026) show many large colonies around the west and east coasts of mainland Britain in the UK and in Iceland[3].

Common guillemot populations in the UK are broadly stable, although there is significant variability among colonies (Harris et al. 2024). Factors underlying reduced productivity at guillemot colonies outlined by Furness et al. (2014) were shortage of prey (sandeel and sprat), severe weather, predation by large gulls and predation by rodents (rats). BirdLife International (2026) also cites bycatch in net fisheries, oil pollution and direct harvest of guillemot by humans (outside the North Sea region) as ongoing threats impacting on breeding success although with variously unknown, negligible or low impact on population and in some cases acting indirectly. At some North Sea colonies, HPAI has caused adult and chick mortality which may exceed natural mortality (Butcher et al. 2023). However, unlike some other species, the population size of common guillemot does not seem to have declined at colonies as a result of HPAI (Tremlett et al. 2024). Common guillemot are currently classified as "least concern" by the IUCN.

3.3.2 Possible Measures

3.3.2.1 Eradication of introduced mammalian predators/Biosecurity of nesting islands

Invasive mammalian predators (sometimes captured within the broader term invasive alien vertebrates (IAV)) are one of the greatest threats to seabird species worldwide (Dias et al. 2019). Mammalian predators often have the ability to access seabird breeding colonies. Where this occurs, they can reduce both breeding productivity (via predation of eggs and chicks). The occurrence of invasive mammalian predators on islands is frequently the result of human introductions but in the UK context they also often arise from 'natural' colonisations or re-colonisations because many islands are close to source populations on the mainland or on larger islands (Stanbury et al., 2017). Eradication or exclusion of mammal predators from seabird colonies is an established method of increasing survival and breeding success within seabird colonies (Pizzolla et al. 2024). Key predators include black rat (*Rattus rattus*), brown rat (*Rattus norvegicus*), feral domestic cat *(Felis catus*), American mink (*Neovison vison*) and red fox (*Vulpes vulpes*). Such predators occur on many UK islands, with Stanbury *et al*. (2017) estimating that amongst UK islands larger than 10 ha, mink occur on 22%, brown rat on 21%, cat on 17% and fox on 2% (whilst several other mammalian predators also occur with relatively high frequency). Of these, rats are the most pervasive threat and are the species most commonly targeted by eradication efforts. However, eradication programmes must consider the impact of all of the predators present as removal of a single predator may provide limited benefits if other predators remain present at the colony (Lambert et al. 2021).

[3] EBB https://ebba2.info/maps/species/Uria-aalge/ebba2/abundance/ A2 - Maps

Guillemot are ledge-nesting, and their nesting ecology means that they are generally considered to be less susceptible to mammalian predators than species that nest in more accessible locations such as puffin (burrow-nesting) and, to a lesser extent, razorbill (crevice-nesting). Some previous mammalian predator eradication projects that have been carried out in the UK have demonstrated that mammalian predator eradication can provide substantial benefits to guillemot populations. For example, guillemot populations on Lundy increased substantially following rat eradication in 2004 from 2,348 individuals in 2000 to 12,202 individuals in 2025. Similarly, the guillemot population of Canna increased from 1,350 individuals in 2004 to 2,850 individuals in 2018 following rat eradication in 2005 (Luxmoore et al. 2019), and the guillemot population on Ramsey Island increased from 2,650 individuals in 1997 to 4,774 individuals in 2025 following rat eradication in 1999. Based upon a systematic literature review process (encompassing both UK and international studies), Tapia-Harris and Evans (2024) assessed the ecological efficacy of mammalian predator eradication / management as ‘medium’, which was the highest rank attained amongst the seven measures that were included for consideration and regarded as corresponding to clear conservation actions. Tapia-Harris and Evans (2024) also concluded that the practical feasibility of mammalian predator eradication / management was ‘high’, which again ranked highest amongst the different measures assessed. Thus, at a broad level at least, the findings from Tapia-Harris and Evans (2024) support the position from earlier reviews that predator eradication / management has potential for delivering regional-scale benefits to seabird breeding populations. The findings from Tapia-Harris and Evans (2024) also indicate the importance of seabird nesting ecology in determining the extent to which species may be impacted by mammalian predators. Positive responses to mammalian predator eradication / management were most frequently documented amongst burrow nesting and ground nesting species, whilst responses were more variable amongst crevice and cliff nesters (for which strong beneficial effects were documented in only 64% and 50% of studies, respectively). This will largely result from differences in accessibility to mammalian predators, although for burrow nesting seabirds the association with nesting ecology may be confounded to some extent by the fact that the majority of studies concern eradication of rats (which may be prolific predators of such species – Tapia-Harris and Evans, 2024). The association with nesting ecology supports the conclusions of Pizzolla *et al*. (2024) that the evidence of benefits from predator eradication / management is strongest for puffin (specifically in relation to rat eradication), less consistent for razorbill, less consistent still for guillemot.

It should be noted that, as a systematic review, the responses of seabird populations to mammalian predator eradication collated by Tapia-Harris and Evans (2024) are subject to publication biases. Thus, it is likely that, all else being equal, studies showing no response of a seabird population to mammalian predator eradication are less likely to be published than those that showed a positive response. Furthermore, where certain species are not the focus of such studies because they are not considered *a priori* to be likely to be vulnerable to mammalian predators then this type of bias is likely to be exacerbated. This could affect the reported response rates of crevice and (more particularly) cliff-nesting species, so that the values determined for positive responses by crevice and cliff-nesting species (i.e. 64% and 50%, respectively), may be overestimates. At the same time, the systematic review approach can lead to the omission of some informative examples of population responses to mammalian predator eradication (e.g. via the application of particular criteria for the inclusion of studies which cause some studies to be omitted). For example, Tapia-Harris and Evans (2024) include the positive response of guillemot to rat eradication on Canna (Luxmoore *et al*., 2019) but omit consideration of the guillemot responses on Lundy and Ramsey Island, both of which were stronger than the response documented at Canna (Pizzolla *et al*., 2024).

Note also that monitoring and metrics reported following eradication programmes focus on population or colony size rather than breeding success. While increases in total breeding colony size follow some rodent eradication programmes as seen above, there is little evidence as to how breeding success per pair changes following rodent eradication programmes. More broadly, there is a knowledge gap regarding which factor or combination of i) increased breeding success, ii) recruitment of breeding adults from other colonies and iii) recruitment of previous non-breeders, drives seabird colony growth when this occurs following rodent eradication programmes.

Further mammalian predator eradication schemes are currently ongoing within the UK (e.g. on Rathlin Island), whilst the management or eradication of mammalian predators at seabird breeding colonies is frequently proposed compensatory measure for offshore wind farm projects which are predicted to have an adverse effect on SPA guillemot populations, primarily through displacement from important foraging habitat and associated impacts on population performance. (Orsted 2021b, Outer Dowsing Offshore Wind 2023, MarramWind 2025). Stanbury et al. (2017) lists a top 25 potential UK islands and Crown Dependencies in terms of suitability for invasive alien vertebrate removal programmes. Of these, North Sea entries to the list include several within the Orkney and Shetland archipelagos.

Best practice guidance for mammalian predator eradication in the UK has been published by the Royal Society for the Protection of Birds (RSPB) (Thomas et al. 2017). Site selection is of critical importance for implementation of mammalian predator eradication programmes, and, as such, numerous reports have been published ranking potential target sites according to defined criteria (Stanbury et al. 2017, Burnell et al. 2024). Stanbury *et al*. (2017) proposed that the maximum island size on which rat eradication is likely to be feasible is 130 kilometres squared (km^2), and UK rat eradication projects have tended to focus on islands substantially smaller than this theoretical limit, with six of the seven known successful rat eradications being on islands of less than 5 km^2 in area and the largest island on which rats were successfully eradicated being Canna, at approximately 13.1 km^2 (Tapia-Harris and Evans, 2024). (Larger mammalian predators may be eradicated on islands larger than 130 km^2 (Stanbury *et al*., 2017)). Eradication of rats (the most common target species) is usually conducted using poison bait, typically deployed in the winter months when predator populations are at a natural minimum and scarcity of natural food will maximise their consumption of bait. Poison bait has the potential to have negative impacts on non-target species, which must be assessed prior to deployment of the measure. These negative effects can arise either through consumption of the bait or through secondary exposure due to consumption of poisoned individuals of the target species. Reduction of non-target species' exposure to bait can be achieved through enclosure of bait within bait stations, and secondary exposure risks for non-target species can be reduced by deployment of low-persistence toxins such as coumatetralyl and warfarin (SSER 2023). In extreme cases (e.g. non-target species which themselves have vulnerable, rare or endemic status), particularly vulnerable and important non-target species have also been temporarily taken into captivity during rat eradication to prevent exposure (Hall et al. 2014). Physical traps may also be deployed, either as replacement for poison in areas where bait cannot feasibly be deployed, or in addition to poison. Subsequent to completion of the eradication programme, 2-3 years of monitoring is required to determine that eradication has been successful. Guillemot population responses to mammalian predator eradication can be relatively rapid provided that other factors are not limiting to population growth: for example, eradication of rats on Lundy in 2004 preceded a 42% increase in guillemot population over the next four years (Price & Booker 2008).

Not only is mammalian predator eradication beneficial to seabird species only if local environmental conditions at the colony permit population growth in the absence of predators (Luxmoore et al. 2019), but once mammalian predators have been eradicated from an area, continuous monitoring and biosecurity measures must be put in place to prevent them from returning. On islands, biosecurity measures typically consist of establishing rat-exclusion procedures for visiting vessels, island-wide deployment and monitoring of bait and / or wax chew blocks and, when possible, deployment of detection dogs. On peninsulas, predator-exclusion fencing may also be deployed. As with the work undertaken by Pizzolla *et al*. (2024), the (wider) evidence-base on which Tapia-Harris and Evans (2024) rely derives largely from relatively small islands for which approaches to eradicating invasive mammalian predators are relatively well developed, meaning that eradication in such situations is generally feasible (Stanbury *et al*., 2017). Tapia-Harris and Evans (2024) point out that approaches for the control or eradication of mammalian predators on larger islands or on mainland sites are often less well developed, whilst the challenges to achieving the objectives of such management are likely to be greater for several reasons (including issues of scale, the presence of larger human populations and the requirement for control measures (as opposed to eradication) to be ongoing over the long-term). Despite this, and in common with Pizzolla *et al*. (2024), Tapia-Harris and Evans (2024) suggest that mammalian predator eradication / management on larger islands and mainland sites should be considered in relation to the development of compensatory measures.

Mammalian predator eradication programmes typically cost in the order of hundreds of thousands to millions of Euro, with costs being higher for larger islands. A series of estimated costs for mammalian predator eradication were provided by MarramWind Offshore Wind Farm as part of their derogation case, ranging from £150,000 to £70,000,000 (MarramWind 2025). For this reason, mammalian predator eradication is often carried out by groups of organisations drawing funding from a range of sources including public grants, although industry-led eradication programmes have been proposed by large offshore wind developers for the purposes of providing compensation in relation to predicted adverse effects on SPA seabird populations (Orsted 2022, Dogger Bank South Offshore Wind Farms 2024, Outer Dowsing Offshore Wind 2025).

3.3.2.2 Limiting disturbance at colonies

Offshore windfarm projects in UK waters have identified an in-principle potential compensation measure for guillemot of intervening to reduce disturbance to breeding colonies, and there is scope for this measure to be deployed in the North Sea to potentially improve guillemot breeding success. Discussion regarding this measure has focused on recreation-based disturbance to small breeding colonies of guillemot and razorbill in the south-west of England (i.e. the English Channel and Celtic Sea). Recreation-based disturbance is believed to be affecting breeding colonies in this region on the basis that, i) some colonies show local declines against a positive regional population trend in line with national trends between the previous two seabird censuses (Seabird 2000 (1998-2001, Mitchell et al. 2004) and Seabirds Count (2015-2021, Burnell et al. 2023)), ii) the region and the specific habitats and locations of guillemot and razorbill colonies are popular for tourism and associated recreational activities, and iii) recreation-based disturbance is considered to negatively affect one or more demographic factors in cliff-breeding seabirds. These also apply to North Sea colonies of guillemot in that some colonies are in areas with local and seasonal high tourism, while others still are subjected to visitor pressures specifically related to the colonies' presence and characteristics (seabird colonies have many of the same traits as outlined for seal colonies by Curtin et al. (2009) which predispose colonies to recreation-based disturbance). Indeed, disturbance risk posed by birdwatching and photography is indicated to be the highest among recreational activities in terms of the frequency, proximity, intensity and persistence of encounters between breeding seabirds and participants (as reviewed in GoBe Consultants 2024a).

Ecological evidence of recreation-based disturbance of guillemot was reviewed by GoBe Consultants (2024a-d). The most immediate mechanism for disturbance to reduce breeding success is when adults at the colony flush from the nest location, which has been observed in multiple species to result in eggs or chicks being exposed to predators such as gulls, and the elements. Eggs or young have been observed to fall from the nesting ledge during flushing responses, and seabirds nesting at high density on ledges (as with guillemot and razorbill) are more vulnerable to crushing of eggs or young during flushing events. Studies of guillemot breeding colonies in California observed premature departure and presumed mortality of guillemot chicks, loss of all chicks, loss of eggs, and abandonment of a colony due to (fishing) vessels (Rojek et al. 2007). Loss of eggs and chicks occurred "when boats spent extended periods of time close to nesting areas." As cited by Rojek et al. (2007), Harris and Wanless (1984) indicate that disturbance to guillemot chicks can result in vacating the nest at lower body mass with clear implications for survival.

However, disturbed guillemot at colonies may alternatively exhibit non-escape behaviours which are indicative of distress or discomfort such as head-bobbing. Non-escape responses are likely to be indicators of physiological or otherwise non-visible stress responses with the potential to ultimately affect breeding success via reduced fitness or increased adult investment in their own survival over reproduction. Seabird body temperature, heart rate, levels of the stress hormone corticosterone and time spent vigilant for threats have all shown changes in response to disturbance when measured in the field (as reviewed by GoBe Consultants 2024a). A study of nesting guillemots at St Abbs Head in southeast Scotland found a negative correlation between human visitor rate and breeding success (Beale & Monaghan 2004, Beale 2004). This was due to non-escape behaviours as visitors did not flush birds from nests.

North Sea colonies where reduction in disturbance could be applied as a viable measure for improving breeding success are those which i) are likely to experience human disturbance or ii) are otherwise close to built-up areas and/or existing tourism (as modified from GoBe Consultants 2024a for which the aim was downstream recruitment of additional breeding adults c.f. increased breeding success alone). Reducing disturbance is more likely to have an impact on productivity when this is not significantly limited by another factor such as food supply. Guillemot and razorbill populations in the North Sea are reported to be predominantly limited by availability of food (JNCC 2021) rather than nesting sites, but this might no longer be the case if effective closure of the UK North Sea sandeel fishery (Natural England et al. 2025) results in significant recruitment of sandeels of appropriate size to provision to nestling guillemot.

Specific means of limiting disturbance include signage, wardens (on land or boat-based), visitor access statements (wherein more detailed text, guidance code of conduct is posted in the form of signage, handout/leaflet or on a website), restricting visiting hours or seasons, and restricting visitor approach distance (on land or on water) (GoBe Consultants 2024a). Of these, advising visitor approach distance through signage has been reported to have materially limited disturbance (number of instances of birds flushing from nests) at a seabird colony (Great Saltee, Ireland) (Allbrook & Quinn 2020), while restricting visitor approach distance with fences has been shown to result in i) no difference in egg loss between edge and more distant pairs (i.e., minimising edge-related higher failure rate) ii) lower flushing distances (i.e., higher resilience) than in pairs at sites with high visitation rate (GoBe Consultants 2024a). Although higher in cost due to requirement to cover labour, overheads and potentially accommodation, wardens “increase the success of management measures, as they provide a mechanism of enforcement to any statutory or voluntary management measures. Furthermore, wardens have been shown to increase visitors’ environmental knowledge and promote better behavioural practices” (GoBe Consultants 2024a). Restriction of visitor hours at Saltee Islands, Ireland and Isle of May, North Sea successfully reduced disturbance (The Saltee Islands, 2001; NatureScot, 2020). Visitor access statements have been deployed at seabird colonies and may have similar impact to signage above, reducing disturbance in principle. Bans on dogs have been deployed at seabird colonies and are likely to reduce disturbance based on the recorded disturbance or nest destruction events at the same sites prior to the dog ban, but quantitative downstream effects on disturbance are not reported. Similarly, the downstream effect of reducing disturbance on breeding success is challenging to measure due to other underlying factors which may confound both efforts and data analysis.

3.3.2.3 Artificial Nesting Structures/Social attraction to colonise vacant sites

There is evidence that guillemot may nest on artificial nesting structures and are receptive to social attractant techniques to recolonise vacant sites, therefore these two (related) measures have potential to aid breeding success of guillemot in the North Sea. Guillemot have been observed in the order of 100 individuals in head-down nesting posture on offshore platforms in the southern North Sea during a survey of seabird use of existing offshore artificial structures (Niras 2021). Use of concrete ledges to encourage guillemot to redistribute at a colony was suggested by Thibault et al. (2010). However, the Karlsö Murre Lab at Gotland in the Baltic Sea is the only published example of a purpose-built nesting structure for common guillemot (Hentati-Sundberg et al. 2012) consisting of limestone slabs forming six ledges on the outside of a research building built of steel and oak. Guillemot first nested in 2009, and is used by guillemot for nesting despite availability of natural nest sites substrate elsewhere on the island, indicating that individual guillemot will make use of (naturalistic) artificial ledges in preference to genuine natural ledges.

Guillemot have been successfully attracted to re-colonise a vacant historical breeding site in the north Pacific, at Devil's Slide Rock, California (Parker et al. 2007). This project deployed social attraction, including use of decoys (of adults in both standing and incubation posture, and of early-stage young and eggs), mirrors to create impression of greater abundance, and colony sound playback on a sound-system (from a sound-recorded colony numbering thousands of birds with playback focused on female copulation calls). After nine breeding seasons without natural recolonisation, guillemots were present on the site within 24 hours of social attraction equipment installation in January 1996 and six pairs made nesting attempts in June of the same year. Continued use of the attractants in successive years saw colony growth continue with 190 nesting pairs by 2004. Attraction equipment was indicated to be a clear factor in the recolonisation.

Key considerations regarding ANS or attempts to attract recolonisation of a vacant site include the low probability of success in attracting birds, especially within a three year or similar timeframe. Another consideration is whether the population in the locality or wider region is limited by nesting space. Guillemot and razorbill populations are reported to be predominantly limited by availability of food (JNCC 2021) rather than nesting sites, but this might no longer be the case if effective closure of the UK North Sea sandeel fishery (Natural England et al. 2025) results in significant recruitment of sandeels of appropriate size for use by breeding guillemot. There is also a tendency for new colonies to have lower breeding success (i.e., breeding success may relate to colony size) and, related to this, projects should consider whether the attracted birds are entering from the younger or non-breeding component of the population or are merely relocating from existing colonies.

3.3.2.4 Seagrass cultivation/restoration

Seagrass restoration has been shown to have positive impacts on the biomass of small fish, including clupeids, which are a key prey species for a number of seabird species including guillemot. The 3,600 hectare seagrass meadow creation project in Spider Crab Bay, Cobb Bay and South Bay in Virginia has seen local fish biomass increase by orders of magnitude since restoration began in 1999 (Orth et al. 2020). Food availability is significant source of mortality in guillemot (JNCC 2021). Increasing food availability to guillemot is therefore a plausible way of increasing survival and breeding success.

Ongoing seagrass cultivation projects exist in shallow areas of the North Sea in the Netherlands, Germany, Denmark and the UK, all of which demonstrate the feasibility of seagrass meadow creation and expansion. Two of the largest scale projects are Restoration Forth in the Firth of Forth in Scotland (Thomas 2020), run by Project Seagrass and funded by NGOs and industry, and ongoing seagrass restoration work in the Wadden Sea and in Zeeland (Govers et al. 2022), run by The Fieldwork Company and funded by public grants. Both of these projects have successfully created one or more hectares of established seagrass meadow.

Despite the existence of proven methods for seagrass restoration, it may not be suitable as a measure to increase guillemot breeding success: firstly, it only has potential to act indirectly on breeding success, and therefore has low measurability over any timescale; secondly, existing seagrass cultivation and restoration projects have not quantified the benefits to guillemot and so the magnitude of the benefits that could be expected from any project would not just be hard to measure, but also hard to predict; and thirdly, it takes time for mature marine ecosystems to establish within new seagrass beds such that benefits can be accrued by other species, such as guillemot, and it is therefore not clear if effects on guillemot could be expected to occur within a 3-5 year timeframe from measure implementation.

Costs for seagrass restoration are likely to be on the order of hundreds of thousands to millions of Euro per hectare because of the need to secure relevant leases, procure and cultivate seedlings, and deploy them at scale.

3.4 Razorbill

3.4.1 Species' Biology

Razorbill breed across a trans-Atlantic breeding range from eastern North America to north-west Russia. The majority of the global breeding population was historically in Iceland, though the Icelandic population is now approximately 40% of the global population due to increases in other regions.

North Sea colonies of razorbill (in territories of Norway, UK and Germany) were estimated to constitute approximately **15%** of the European breeding population (Furness 2015) - the majority of which is in Iceland. European breeders constitute over 90% of the global population (Birdlife International 2026), therefore the North Sea accounts for approximately 14% of the global population. Key breeding areas in Europe for razorbill as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, EBCC 2026) show the largest colonies are in Iceland but with two major colonies in the Northern Isles of the UK in the North Sea[4].In the migration seasons as defined by Furness (2015), the North Sea additionally hosts a substantial proportion of the large Icelandic breeding population, making the North Sea important for this breeding population too.

Razorbill populations in the UK have increased significantly over the past few decades (Harris et al. 2024). Similar trends have been observed in most national populations around the North Sea, although the Norwegian population has declined (Artsdatabanken 2021b). Factors underlying individual years of lower productivity at UK razorbill colonies outlined by Furness et al. (2014) were food (sandeel and sprat) shortage, predation by large gulls, and predation by rodents (rats). BirdLife International (2026) also cites climate change and severe weather (specifically temperature extremes), oil pollution and mink predation as ongoing threats impacting on breeding success although with negligible or low impact on population. At some North Sea colonies, HPAI has caused adult and chick mortality which may exceed natural mortality (Butcher et al. 2023), although razorbill are not believed to have been impacted by the 2021-22 HPAI outbreak as severely as many other seabird species (Tremlett et al. 2024). Razorbill are currently classified as “least concern” by the IUCN.

3.4.2 Possible Measures

3.4.2.1 Artificial Nesting Structures/Social attraction to colonise vacant sites

There is evidence that razorbill may nest on artificial nesting structures and are receptive to social attractant techniques to recolonise vacant sites, therefore these two (related) measures have potential to aid breeding success of razorbill in the North Sea. Thirteen razorbill were observed on one offshore platform in the southern North Sea during a survey of seabird use of existing offshore artificial structures (Niras 2021), and the artificially constructed Karlsö Murre Lab on Gotland in the Baltic Sea hosts ten pairs of razorbill within 67 specially designed nest boxes (Hentati-Sundberg et al. 2025). Razorbill first nested on the structure in 2015, and is used by razorbill for nesting despite availability of natural nest sites substrate elsewhere on the island.

Active colony restoration techniques such as social attraction are relatively effective for auks as a group (Spatz et al. 2023). Social attraction was used to re-establish razorbill colonies on Eastern Brothers Island in Maine following a major oil spill in 2004 (US Fish and Wildlife Service 2010) and had previously been deployed at other colonies in Maine Coastal Islands National Wildlife Refuge for the same purpose (US Fish and Wildlife Service 2005).

[4] *https://ebba2.info/maps/species/Alca-torda/ebba2/abundance/*

Key considerations regarding ANS or attempts to attract recolonisation of a vacant site include the low probability of success in attracting birds, especially within a three year or similar timeframe. Another consideration is whether the population in the locality or wider region is limited by nesting space. Razorbill populations, like guillemot populations, are reported to be predominantly limited by availability of food (JNCC 2021) rather than nesting sites, but this might no longer be the case if effective closure of the UK North Sea sandeel fishery (Natural England et al. 2025) results in significant recruitment of sandeels of appropriate size for use by breeding razorbill. There is also a tendency for new colonies to have lower breeding success (i.e., breeding success may relate to colony size) and, related to this, projects should consider whether the attracted birds are entering from the younger or non-breeding component of the population or are merely relocating from existing colonies.

3.4.2.2 Eradication of introduced mammalian predators/Biosecurity of nesting islands

Razorbill nest both in crevices and on ledges. Their vulnerability to mammalian predators is therefore intermediate, between that of less-impacted ledge-nesting species such as common guillemot and heavily impacted burrow-nesting species such as puffin. An overview of potential application and efficacy of introduced mammalian predator eradication and control, plus associated biosecurity measures, is provided for razorbill within that prepared for guillemot in the above **section 3.3.2.1**.

Eradication of invasive mammalian predators has previously been carried out at a number of razorbill colonies in the UK, and razorbill numbers have sometimes increased markedly following removal of mammalian predators. For example, razorbill populations on Lundy in the UK increased steadily following rat eradication in 2004 from a low of 841 individuals, and reached 4,508 individuals in 2025 (Seabird Monitoring Programme 2026). Similarly, razorbill populations on Ramsey Island have increased since rat eradication was completed in 2000. However, razorbill populations do not always increase following predator eradication: razorbill populations on Canna stabilised following predator eradication in 2006, but have shown relatively little subsequent increase (Luxmoore et al. 2019). As with the work undertaken by Pizzolla *et al*. (2024), the (wider) evidence-base on which Tapia-Harris and Evans (2024) rely in their systematic review of invasive predator eradication and other measures for seabirds, derives largely from relatively small islands for which approaches to eradicating invasive mammalian predators are relatively well developed, meaning that eradication in such situations is generally feasible (Stanbury *et al*., 2017). Tapia-Harris and Evans (2024) point out that approaches for the control or eradication of mammalian predators on larger islands or on mainland sites are often less well developed, whilst the challenges to achieving the objectives of such management are likely to be greater for several reasons (including issues of scale, the presence of larger human populations and the requirement for control measures (as opposed to eradication) to be ongoing over the long-term). Despite this, and in common with Pizzolla *et al*. (2024), Tapia-Harris and Evans (2024) suggest that mammalian predator eradication / management on larger islands and mainland sites should be considered in relation to the development of compensatory measures.

3.4.2.3 Limiting disturbance at colonies

Offshore windfarm projects in UK waters have identified an in-principle potential compensation measure for razorbill of intervening to reduce disturbance to breeding colonies, and there is scope for this measure to be deployed in the North Sea to potentially improve razorbill breeding success. Discussion regarding this measure has focused on recreation-based disturbance to small breeding colonies of guillemot and razorbill in the south-west of England (i.e. the English Channel and Celtic Sea). Recreation-based disturbance is believed to be affecting breeding colonies in this region on the basis that, i) some colonies show local declines against a positive regional population trend in line with national trends between the previous two seabird censuses (Seabird 2000 (1998-2001, Mitchell et al. 2004) and Seabirds Count (2015-2021, Burnell et al. 2023)), ii) the region and the specific habitats and locations of guillemot and razorbill colonies are popular for tourism and associated recreational activities, and iii) recreation-based disturbance is considered to negatively affect one or more demographic factors in cliff-breeding seabirds. These also apply to North Sea colonies of razorbill in that some colonies are in areas with local and seasonal high tourism, while others still are subjected to visitor pressures specifically related to the colonies' presence and characteristics (seabird colonies have many of the same traits as outlined for seal colonies by Curtin et al. (2009) which predispose colonies to recreation-based disturbance). Indeed, disturbance risk posed by birdwatching and photography is indicated to be the highest among recreational activities in terms of the frequency, proximity, intensity and persistence of encounters between breeding seabirds and participants (as reviewed in GoBe Consultants 2024a).

Ecological evidence of recreation-based disturbance of razorbill was reviewed by GoBe Consultants (2024a-d). The most immediate mechanism for disturbance to reduce breeding success is when adults at the colony flush from the nest location, which has been observed in multiple species to result in eggs or chicks being exposed to predators such as gulls, and the elements. Seabird eggs or young have been observed to fall from the nesting ledge during flushing responses, and seabirds nesting at high density on ledges (as with guillemot and razorbill) are more vulnerable to crushing of eggs or young during flushing events.

However, disturbed razorbill at colonies may alternatively exhibit non-escape behaviours which are indicative of distress or discomfort. Non-escape responses are likely to be indicators of physiological or otherwise non-visible stress responses with the potential to ultimately affect breeding success via reduced fitness or increased adult investment in their own survival over reproduction. Seabird body temperature, heart rate, levels of the stress hormone corticosterone and time spent vigilant for threats have all shown changes in response to disturbance when measured in the field (as reviewed by GoBe Consultants 2024a).

North Sea colonies where reduction in disturbance could be applied as a viable measure for improving breeding success are those which i) are likely to experience human disturbance or ii) are otherwise close to built-up areas and/or existing tourism (as modified from GoBe Consultants 2024a for which the aim was downstream recruitment of additional breeding adults c.f. increased breeding success alone). Reducing disturbance is more likely to have an impact on productivity when this is not significantly limited by another factor such as food supply. Guillemot and razorbill populations in the North Sea are reported to be predominantly limited by availability of food (JNCC 2021) rather than nesting sites, but this might no longer be the case if effective closure of the UK North Sea sandeel fishery (Natural England et al. 2025) results in significant recruitment of sandeels of appropriate size to provision to nestling razorbill.

Specific means of limiting disturbance include signage, wardens, visitor access statements (wherein more detailed text, guidance code of conduct is posted in the form of signage, handout/leaflet or on a website), restricting visiting hours or seasons, and restricting visitor approach distance (GoBe Consultants 2024a). Of these, advising visitor approach distance through signage has been reported to have materially limited disturbance (number of instances of birds flushing from nests) at a seabird colony (Great Saltee, Ireland) (Allbrook & Quinn 2020), while restricting visitor approach distance with fences has been shown to result in i) no difference in egg loss between edge and more distant pairs (i.e., minimising edge-related higher failure rate) ii) lower flushing distances (i.e., higher resilience) than in pairs at sites with high visitation rate (GoBe Consultants 2024a). Although higher in cost due to requirement to cover labour, overheads and potentially accommodation, wardens "increase the success of management measures, as they provide a mechanism of enforcement to any statutory or voluntary management measures. Furthermore, wardens have been shown to increase visitors' environmental knowledge and promote better behavioural practices" (GoBe Consultants 2024a). Restriction of visitor hours at Saltee Islands, Ireland and Isle of May, North Sea successfully reduced disturbance. Visitor access statements have been deployed at seabird colonies (e.g. at Skomer in Wales) and may have similar impact to signage above, reducing disturbance in principle. Bans on dogs have been deployed at numerous razorbill colonies (e.g. the Farne Islands in England, Skomer in

Wales and Hornøya Nature Reserve in Norway) and are likely to reduce disturbance based on the recorded disturbance or nest destruction events at the same sites prior to the dog ban, but quantitative downstream effects on disturbance are not reported. Similarly, the downstream effect of reducing disturbance on breeding success is challenging to measure due to other underlying factors which may confound both efforts and data analysis.

3.4.2.4 Seagrass cultivation/restoration

Seagrass restoration has been shown to have positive impacts on the biomass of small fish, including clupeids, which are a key prey species for a number of seabird species including razorbill. The 3,600 hectare seagrass meadow creation project in Spider Crab Bay, Cobb Bay and South Bay in Virginia has seen local fish biomass increase by orders of magnitude since restoration began in 1999 (Orth et al. 2020). Food availability is significant source of mortality in razorbill, with some mass mortality events in the North Sea having been attributed to starvation (Heubeck et al. 2011). Increasing food availability to razorbill is therefore a plausible way of increasing survival and breeding success.

Ongoing seagrass cultivation projects exist in shallow areas of the North Sea in the Netherlands, Germany, Denmark and the UK, all of which demonstrate the feasibility of seagrass meadow creation and expansion. Two of the largest scale projects are Restoration Forth in the Firth of Forth in Scotland (Thomas 2020), run by Project Seagrass and funded by NGOs and industry, and ongoing seagrass restoration work in the Wadden Sea and in Zeeland (Govers et al. 2022), run by The Fieldwork Company and funded by public grants. Both of these projects have successfully created one or more hectares of established seagrass meadow.

Despite the existence of proven methods for seagrass restoration, it may not be suitable as a measure to increase razorbill breeding success: firstly, it only has potential to act indirectly on breeding success, and therefore has low measurability over any timescale; secondly, existing seagrass cultivation and restoration projects have not quantified the benefits to razorbill and so the magnitude of the benefits that could be expected from any project would not just be hard to measure, but also hard to predict; and thirdly, it takes time for mature marine ecosystems to establish within new seagrass beds such that benefits can be accrued by other species, such as razorbill, and it is therefore not clear if effects on razorbill could be expected to occur within a 3-5 year timeframe from measure implementation.

Costs for seagrass restoration are likely to be on the order of hundreds of thousands to millions of Euro per hectare because of the need to secure relevant leases, procure and cultivate seedlings, and deploy them at scale.

3.5 Red Knot

3.5.1 Species' Biology

The entire population of the *islandica* subspecies of red knot (which breeds in high Arctic Canada and northern Greenland) spends the non-breeding season in Western Europe. This includes i) North Sea estuaries and coasts (in northern and eastern Scotland, eastern England, Norway and the Wadden Sea), but also those in ii) Ireland, iii) western Britain, iv) the Baltic region and v) the Atlantic coasts of France, Spain and Portugal. The North Sea coasts may conservatively host **33%** of this non-breeding European population based on relative coastline length. The population of the two subspecies i*slandica* and *rufa* red knot combined is estimated to be 1.2 million, out of a global population of 2 to 3 million mature individuals of all subspecies (Birdlife International 2026). Therefore, Western Europe accounts for potentially up to half of the global population, and the North Sea may as a rough estimate support up to **16%** of the global population, albeit outside the species' breeding season.

A large proportion of the red knot in Europe winter within the Wadden Sea (Kleefstra et al. 2025). European wintering red knot populations within this area have declined over the past few decades, although they are now relatively stable (Kleefstra et al. 2022). Factors potentially affecting breeding success are climate change and severe weather conditions (considered a generic threat affecting breeding success of Arctic waders but with research on this species currently lacking) (BirdLife International 2026). Body condition of birds arriving to the breeding grounds in spring from their spring staging grounds in Iceland, carries over directly to breeding condition (Morrison 2006), therefore foraging intake at the spring staging grounds could be closely associated with breeding success. Red knot suffer an effective reduction in available foraging area during the non-breeding season due to human disturbance and displacement by recreation, tourism, aircraft and development (BirdLife International 2026). Red knot are currently classified as "near threatened" by the IUCN.

3.5.2 Possible Measures

No manageable direct threats or limitations to breeding success on the breeding grounds have been identified, and the breeding grounds are beyond the geographic scope of the NN project. Possible measures are therefore limited to other stages of the migration cycle, in or close to the North Sea region.

3.5.2.1 Maximising food intake on Icelandic staging grounds

There may be scope to improve conditions for feeding and accumulation of migratory and breeding resources of birds at the Icelandic spring staging grounds. This is the key stage of the migratory cycle for preparing to enter breeding condition in addition to building fat reserves for the final migration flight (Morrison 2006). Limiting factors which may be manageable at the Icelandic staging grounds may be disturbance or coastal development. Further research would be required regarding whether human activities currently disturb red knot in spring in Iceland, and trends in factors underlying disturbance such as tourism and development. Overall, this measure may not be suitable on account of lying beyond the North Sea geographic scope of NN, acting only indirectly on breeding success and therefore having low measurability over any timescale.

3.5.2.2 Seagrass cultivation/restoration

Seagrass meadow restoration projects identify birds foraging on seagrass beds during low water periods as likely beneficiaries of meadow restoration (Unsworth & Butterworth 2021), and this includes red knot. These projects are generally at the earliest stages of implementation, and it is unknown what effect seagrass bed restoration will have on red knot food resource quantity, quality or energy intake, or carryover effects to population dynamics or breeding success. Projects in the North Sea and English Channel are located in the autumn passage and overwintering locations of red knot, and food intake in these periods is considered to be less influential over breeding condition or success than that during spring staging in Iceland (Morrison 2006). As above, this measure may not be suitable on account of only having potential to act indirectly on breeding success.

3.6 Bar-tailed godwit

3.6.1 Species' Biology

Bar-tailed godwit breed in a disjointed European Arctic breeding range, spanning from north Scandinavia to far-eastern Russia, and also breed in western and northern Alaska. The species is fully migratory and spends the non-breeding season in different overwintering grounds varying from west Africa east to Australasia dependent on breeding population and/or subspecies. Key breeding areas in Europe for bar-tailed godwit as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, EBCC 2026) show the species is most abundant in the highest latitudes of mainland Fennoscandia[5].

Bar-tailed godwit in the North Sea region spend the non-breeding season along Atlantic coasts of Europe and Africa (BirdLife 2026) and originate from breeding grounds in northern Norway and Russia (Wright et al. 2012). A contingent of this non-breeding population remains in the North Sea region through the core winter months, and a possibly larger contingent undertakes spring staging in the Wadden Sea before returning to the breeding grounds. A conservative estimate of **10 to 15%** (based on proportion of total wintering Atlantic coastline as mapped by BirdLife International 2026) remain on the North Sea coasts for the entire overwintering and passage period. The relevant subspecies, nominate *lapponica*, is estimated in turn to constitute 16% of the global population, therefore the North Sea supports conservatively 2% of the global population through the non-breeding period.

European bar-tailed godwit populations within the Wadden Sea have remained relatively stable over the past few decades, although there have been shifts in the population's distribution among regions (Kleefstra et al. 2025). Breeding success of bar-tailed godwit is affected by weather conditions. Additionally, bar-tailed godwit nest in proximity to other nesting species which are more aggressive against generalist predators, including long-tailed skua and whimbrel, which can provide beneficial protection for nesting godwits. However, long-tailed skua can also themselves predate bar-tailed godwit nests, and occurrence of this is associated with periods of lower availability of rodents which are an important prey resource for the skuas. Most threats identified for the species by BirdLife International (2026) are centred on their staging and overwintering range. Bar-tailed godwit suffer an effective reduction in available foraging area during the non-breeding season due to human disturbance and displacement which is considered to have medium, impact causing slow, significant declines (BirdLife International 2026). Bar-tailed godwit are currently classified as "near threatened" by the IUCN.

3.6.2 Possible Measures

3.6.2.1 Diversionary feeding of long-tailed skua

Predation of bar-tailed godwit nests by long-tailed skua is indicated to be linked to population dynamics of other food sources, wherein nests are predated at a higher rate of occurrence when rodents are absent Larsen & Grundetjern 1997, Larsen 2000). Therefore, there is potential for diversionary supplementary feeding of long-tailed skua to maintain a low rate of bar-tailed godwit nest predation by this species and therefore at sufficient scale improve breeding success. Diversionary feeding of hen harrier *Circus cyaneus* is an existing measure to limit their predation of red grouse (willow ptarmigan, *Lagopus lagopus scotticus*) which are argued to be an economically important quarry species (Thompson et al. 2009).

Supplementary feeding of Arctic skua has been trialled as a means of directly benefiting the breeding success and survival rate of the skuas, rather than benefitting a co-occurring bird species. In comparison to supplementary feeding of great skua, Arctic skua supplementary feeding is calculated to be potentially economical and logistically possible in terms of tonnage of required food per season. Arctic skua pairs

[5] *https://ebba2.info/maps/species/Limosa-lapponica/ebba2/abundance/*

required a ‘training’ period wherein supplementary food was initially accepted alongside a more naturalistic bait (domestic hen’s egg with shell already broken) before pairs learned to accept supplementary food alone. Suggested items for supplementary food for Arctic skua were cat food, hen’s eggs, fish or day-old domestic chicks. A key consideration for Arctic skua feeding which is transferrable to long-tailed skua is that provision of food should be targeted to ensure uneaten food does not remain in the area, as this is expected to attract generalist predators and scavengers (such as foxes, ravens) which can predate nests (including of bar-tailed godwit). The approach suggested by those undertaking the Arctic skua trials is to provide food at evening hours when the colony is well attended by the target species, but in the high Arctic summer there may be little opportunity to time provisioning to avoid predators as photoperiod is near to 24 hours. Favourable logistics for Arctic skua provisioning is in part due to many UK SPA colonies already being staffed by wardens (Furness et al. 2014). Feasibility should be researched of existing personnel covering a sufficient scale of the breeding population of bar-tailed godwit and long-tailed skua.

3.6.2.2 Seagrass cultivation/restoration

Seagrass meadow restoration projects identify birds foraging on seagrass beds during low water periods as likely beneficiaries of meadow restoration (Unsworth & Butterworth 2021), and this includes bar-tailed godwit. These projects are generally at the earliest stages of implementation, and it is unknown what effect seagrass bed restoration will have on bar-tailed godwit food resource quantity, quality or energy intake, or carryover effects to population dynamics or breeding success. Projects in the UK North Sea and English Channel are located in autumn passage and overwintering locations of bar-tailed godwit. Projects in the Wadden Sea are in the major spring staging area, where food intake is more influential over breeding condition or success (Wright et al. 2012). However, this measure may not be suitable on account of only having potential to act indirectly on breeding success, and therefore having low measurability over any timescale.

3.7 Great Black-backed Gull

3.7.1 Species' Biology

Great black-backed gull breed over a trans-Atlantic breeding range from the USA Great Lakes and eastern North America to the European coasts of Russia (BirdLife International 2026). Large numbers breed in the Barents Sea (Furness 2015). Populations breeding in severe (polar) conditions migrate south to warmer regions for their non-breeding season (BirdLife International 2026).

North Sea colonies of great black-backed gull (in territories of Norway, UK and Germany) constitute approximately **20%** of the European breeding population (Furness 2015, Fauchald et al. 2015, BirdLife 2026). The European population is estimated in turn to represent less than half of the global breeding population (BirdLife 2026). Therefore, the North Sea constitutes up to 10% of the global population. (In the non-breeding season, the North Sea is estimated to host all individuals from North Sea colonies, but also a substantial proportion of the very large Barents Sea breeding population (Furness 2015), which as a result may be the majority population of origin among individuals present during the non-breeding season.) Key breeding areas in Europe for great black-backed gull as mapped in the most recent European Breeding Bird Atlas (EBBA2, 2013-17, EBCC 2026) show high density of breeding birds along the Norwegian coast, the west coast of Iceland and the west coast of Britain, UK[6].

Great black-backed gull populations have declined substantially in the UK over the last few decades (Harris et al. 2024). This decline has been part of a global trend and has also been observed in other North Sea populations (Lopez et al. 2022), although some colonies have increased (Sovon 2024). The 2021-22 HPAI outbreak had relatively little impact on great black-backed gull population size at UK colonies (Tremlett et al. 2024). Great black-backed gull are currently classified as "least concern" by the IUCN, although this assessment may change as a result of their declining population size (Lopez et al. 2022).

3.7.2 Possible Measures

3.7.2.1 Control of large mammalian predators

Where great black-backed gull colonies are accessible by red fox or American mink, and potentially rats, predation of eggs and young can significantly impact colony-level productivity (Mitchell et al. 2004). Barrier and/or control methods against these larger predators have potential to improve productivity at such colonies. Predator-proof fencing can be effective against both species. Lethal control of mink is the subject of existing programmes as it is a damaging invasive non-native predator of native mammals and birds of conservation concern. Lethal control of red fox is more divisive as it is a native predator, but it is still undertaken for conservation purposes.

3.7.2.2 Cessation of culling

Large gull culls are an ongoing measure at some seabird colonies, as nest predation by these species can have a significant limiting effect on breeding success of other seabird species (Lopez et al. 2023). Culls and other human sources of animal mortality can disproportionately remove individuals which are hunting or otherwise undertaking routine movements, and therefore remove more adults in healthy condition than natural causes of mortality. Cessation of culling great black-backed gulls therefore has potential to improve the survival rate of breeding adults, facilitate larger colony sizes and improve coarse and/or nest-level productivity of great black-backed gulls. Necessarily, a cessation measure can only be implemented at colonies where culling is currently licensed, and licensing is most likely to relate to local status of the gulls as significant predators of other seabird species of conservation concern. Potential negative effects on these seabirds of any cessation in large gull culling would obviously require consideration, with such likely negative

[6] *https://ebba2.info/maps/species/Larus-marinus/ebba2/abundance/*

effects needing to be weighed against the benefits to the gull populations. However, with recent shifts in other factors such as the effective closure of the UK North Sea sandeel fishery, it is possible that the potential benefits to seabird populations and breeding success in these localities could mean that current levels of culling of predatory gulls are not required. Any such effects are, of course, speculative at the current time and would be subject to local monitoring data on populations and/or breeding success.

3.8 Opportunities for additional beneficiary species

This section outlines how the measures described in Chapters 3.1 to 3.7 may also provide benefits to three additional species. Rather than introducing new or species-specific measures, it highlights the potential applicability of existing interventions across a broader range of seabirds.

Given the exploratory nature of this assessment, no detailed evaluation of effectiveness, feasibility or cost is provided for these additional species. Instead, the section identifies where measures developed for the primary target species could plausibly contribute to improved breeding success or survival of other species, based on similarities in ecology, habitat use or pressure factors. These potential benefits should therefore be regarded as indicative and may require further investigation before implementation.

3.8.1 Black-legged kittiwake

Innovations for designs of artificial nesting structures for gannet and auk species could readily incorporate nesting provision for black-legged kittiwake, as the latter readily colonises purpose-built nesting shelves and ledges which can be incorporated above or below the designed structure for the main target seabird species. Where kittiwake, razorbill and guillemot nesting site characteristics are directly compared within mixed-species breeding colonies (Eveillard-Buchoux et al. 2019), guillemot are indicated to occupy a niche most in favour of openness to the air, while kittiwake and razorbill are more likely to use sites with a ‘ceiling’ to them. Kittiwakes occupied the widest height range of the three species, nesting generally higher on cliffs than razorbill or guillemot were recorded – guillemot nests occupied the bottom 57% and razorbill nest the bottom 62% of the vertical range, at study cliff sites of 35 to 80 m above sea level (Eveillard-Buchoux et al. 2019). Where attempting to create nesting provision for the three species simultaneously, there is therefore a requirement for a diversity of available ledge heights and variation in level of enclosure among lower nesting spaces.

As reviewed by GoBe Consultants (2024a-d) seabirds nesting at high density on ledges (as with kittiwake) are more vulnerable to crushing of eggs or young chicks during flushing events, therefore there is potential for kittiwake breeding success to benefit if the species is present at colonies where measures are implemented to reduce disturbance events. In addition to success in actually reducing the levels of disturbance, the magnitude of positive impact of such measures is dependent on the existing baseline level of disturbance events experienced by kittiwake at the colony.

As reviewed by Tapia-Harris and Evans (2024), seabirds which nest on narrow ledges on shear surfaces such as kittiwake are less likely to benefit significantly or at least consistently from introduced mammalian predator eradication efforts as their nests are relatively or entirely inaccessible to mammalian predators. There is little, if any, evidence of responses in kittiwake populations to the eradication of mammalian predators. However, the same review did suggest kittiwake may benefit from diversionary feeding programmes on avian predators, as kittiwake have been documented as being vulnerable to avian predators in some locations and regions.

3.8.2 Arctic Skua

There is initial evidence (from the Baltic Sea) that measures to remove mink from small islands could benefit Arctic skua breeding density (and therefore potentially coarse/colony-level productivity) where the species is present (Nordström et al. 2003). This is an example of Arctic skua potentially benefiting from a generalist measure to improve seabird breeding success as suggested by this review. However, in the North Sea strongholds of the species, large-mammalian predation is not indicated to be important in driving Arctic skua populations or breeding success, as may be the case in the Baltic region. In the UK, Arctic skua declines have been linked to bottom-up effect from collapse of sandeel food supply (via Arctic tern *Sterna paradisaea* on which they klepto-parasitise) and consequently it is indicated that closure or de facto closure of sandeel fisheries would benefit Arctic skua, particularly those breeding in Orkney and Shetland (Furness 2021). A primary measure suggested for improving Arctic skua breeding productivity is supplementary feeding (as discussed in section 3.6.2.1 but this is a targeted rather than generalist measure (necessarily to avoid unintended feeding of opportunistic and generalist predators).

3.8.3 Herring gull

Measures for great black-backed gull are effectively generic measures for large gulls, which will therefore benefit herring gull when they nest in sympatry with great black-backed gull. Herring gull are also reported to have benefitted from efforts to control or eradicate both large mammals (Davis et al. 2008) and rats (Zonfrillo 2001, Luxmoore et al. 2019) in seabird breeding locations, as their ground nests are normally highly accessible to mammalian predators (Tapia-Harris and Evans 2024 Table 30).

4 Key international actors and cooperation opportunities

Restoring seabird and migratory waterbird populations in the North Sea requires collaboration beyond national boundaries. Many seabird species that forage in the Dutch North Sea breed elsewhere in the North Sea basin, particularly in the United Kingdom, Norway and Denmark. Migratory waterbirds using estuarine areas of the North Sea during the non-breeding season include species breeding at high latitudes. Consequently, measures aimed at improving breeding success, food availability or habitat conditions often need to be implemented at an international scale.

To identify opportunities for collaboration, an overview was compiled of relevant international organisations, research institutes, NGOs, governmental bodies and industry actors involved in seabird conservation, monitoring and offshore wind development. The overview is presented in an accompanying spreadsheet and categorises organisations based on their type, geographic scope, activities, relevance for seabirds and potential relation to the Nature Regeneration North Sea (NN) programme.

This chapter distinguishes between two categories:

1. Key organisations involved in seabird research, conservation or offshore wind governance.
2. Ongoing international initiatives and programmes that could provide opportunities for alignment or collaboration with NN.

Together these actors form the institutional landscape within which international seabird conservation and mitigation measures are developed. This chapter does not aim to provide a comprehensive inventory of all organisations and initiatives in the North Sea region. Instead, it presents a selection of key examples that are particularly relevant to the objectives of NN, either due to their role in implementing measures, generating knowledge, or enabling international coordination. The examples illustrate the types of actors and initiatives with which NN could engage.

4.1 Key organisations

The organisations identified in the dataset include NGOs, research institutes, governmental organisations and private-sector actors. These organisations operate at different geographic scales and have varying roles in seabird conservation, from scientific research and monitoring to policy coordination and implementation of mitigation or compensation measures.

The spreadsheet classifies organisations according to:

- organisation type
- geographic scope
- operational capacity (whether the organisation executes projects itself)
- focus on birds and breeding behaviour
- potential funding relevance
- potential relation to NN

Below the most relevant organisational categories are described. This chapter does not aim to provide a comprehensive inventory of all organisations and initiatives in the North Sea region. Instead, it presents a selection of key examples that are particularly relevant to the objectives of NN, either due to their role in implementing measures, generating knowledge, or enabling international coordination. The examples illustrate the types of actors and initiatives with which NN could engage.

4.1.1 NGOs and conservation organisations

Several non-governmental organisations play a central role in seabird conservation in the North Sea region. These organisations are often directly involved in colony management, monitoring of breeding success and implementation of conservation measures.

At the international level, BirdLife International plays an important role in coordinating conservation strategies and monitoring programmes across countries. Birdlife focusses on a global network of conservation organisations that focuses on policy coordination, monitoring and protection of Important Bird Areas (IBAs). Although BirdLife itself does not directly implement projects, it plays an important role in coordinating conservation strategies and monitoring programmes across countries. The BirdLife Marine Task Force provides expertise on seabird conservation and can facilitate international alignment between national initiatives.

In the United Kingdom, the Royal Society for the Protection of Birds (RSPB) is one of the most important organisations involved in seabird conservation. RSPB manages several large seabird colonies in the North Sea region and implements practical conservation measures such as predator control, biosecurity measures, artificial nesting structures and habitat management. Because many North Sea seabird species breed in UK colonies, RSPB has extensive experience with interventions aimed at improving breeding success. RSPB is also actively involved in strategic compensation measures related to offshore wind development. This makes the organisation a highly relevant partner for NN, particularly for projects aimed at improving breeding success of species such as northern gannet, black-legged kittiwake and puffins.

In Scotland, organisations such as the Scottish Seabird Centre contribute to long-term monitoring of seabird colonies and research into breeding success, foraging behaviour and diet composition. While often operating at a smaller scale, these organisations provide valuable long-term datasets and local ecological knowledge that can support conservation and restoration initiatives.

In Norway, BirdLife Norway is actively involved in the monitoring and conservation of seabirds along the Norwegian coast. Through its network of local groups, volunteers and conservation programmes, the organisation contributes to monitoring population trends, breeding success and threats affecting seabird species. BirdLife Norway also participates in policy discussions and conservation initiatives related to marine ecosystems and offshore developments. Given Norway's importance for several North Sea and Northeast Atlantic seabird populations, BirdLife Norway can provide valuable expertise and local knowledge to support conservation and restoration measures.

In Denmark, DOF BirdLife Denmark monitors Danish bird populations, including several North Sea seabird species such as Northern gannet, Black-legged kittiwake, Common guillemot, Razorbill, and Herring gull. Its long-term monitoring data and expertise in coastal and marine bird conservation can support location selection for measures. However, the abundance of breeding colonies in Denmark which are of interest for this study is limited.

In Germany, NABU (Nature and Biodiversity Conservation Union) in Germany carries out monitoring of seabirds in the German North Sea and manages conservation programmes for coastal and migratory bird species. NABU may be a relevant partner for restoration or protection initiatives for species such as black-legged kittiwakes along the German North Sea coast.

4.1.2 Research institutes

Research capacity relevant to seabird ecology, offshore wind impacts and marine ecosystems is distributed across all North Sea countries. While this section highlights a selection of key institutes, it should be noted that additional organisations exist in each country. Additional research institutes can be identified through a review of recent scientific publications on the target species and measures, by examining author affiliations, participation in international programmes.

In the United Kingdom, several institutes play a prominent role. The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) conducts applied research on marine ecosystems and offshore wind impacts, including food web dynamics relevant to seabirds. The Centre for Ecology and Hydrology (UKCEH) also contributes extensive research on seabird ecology, population dynamics and environmental change. In addition, the British Trust for Ornithology (BTO) provides long-term monitoring data and tracking studies for seabirds and migratory species.

In Scotland, research institutes and organisations such as NatureScot, in collaboration with universities and partners, are involved in long-term monitoring and applied research on seabirds. This includes tracking studies, colony monitoring and research linked to offshore wind developments, often in collaboration with programmes such as OWEC. Scotland also hosts major seabird colonies, making it a key region for applied projects on breeding success and mitigation measures.

In Denmark, Aarhus University conducts extensive research on seabird movements and offshore wind interactions, including the use of GPS tracking and radar data to assess collision risk and displacement effects. Danish research has contributed significantly to international methodologies for assessing seabird impacts from offshore wind development.

In Germany, institutions such as the Alfred Wegener Institute (AWI) and Helmholtz-Zentrum Hereon conduct research on marine ecosystems, climate impacts and seabird distribution in the North Sea. The Alfred Wegener Institute (AWI) also conducts research on seabird distribution and habitat use in the North Sea, including aerial and ship-based surveys that support marine spatial planning. In addition, research programmes coordinated through the Federal Maritime and Hydrographic Agency (BSH) include long-term monitoring of seabird distribution in German offshore wind farm areas, providing data on displacement and habitat use.

In Norway, the Norwegian Institute for Nature Research (NINA) and the Institute of Marine Research (IMR) play key roles in seabird monitoring, population assessments and marine ecosystem research. In Norway, the Norwegian Institute for Nature Research (NINA) leads the SEAPOP programme, a long-term national monitoring programme for seabirds that assesses population trends, breeding success and ecological drivers. This programme provides key data for understanding population dynamics and informing conservation measures across the North Sea region.

Together, these institutes provide a scientific foundation for understanding seabird ecology and evaluating the effectiveness of measures. Collaboration with such organisations could support NN in monitoring, modelling and assessing the impact of proposed interventions.

4.1.3 Governmental and advisory organisations

Governmental bodies play an important role in regulating offshore wind development, managing marine ecosystems and coordinating conservation policies. All countries bordering the North Sea have governmental bodies responsible for environmental management, marine spatial planning and nature conservation. The examples below highlight key organisations most directly involved in seabird conservation and offshore wind development.

In the United Kingdom, Natural England and NatureScot act as the government advisers on the natural environment for parts of the North Sea. These organisations provide scientific advice, administer funding programmes and supports the development of conservation policies and environmental management frameworks. Natural England and NatureScot are also involved in advising on the implementation of compensation measures related to offshore wind projects. Similarly, the Joint Nature Conservation Committee (JNCC) provides scientific advice to the UK government and devolved administrations on nature conservation. JNCC contributes to large-scale monitoring programmes and provides scientific evidence for environmental policy and marine spatial planning.

In Scotland, NatureScot plays a key role in advising on seabird conservation and offshore wind development. Government-supported programmes include monitoring of seabird colonies, designation and management of protected areas, and the development of compensation measures for offshore wind impacts. Scotland has also been involved in large-scale initiatives such as the *Seabirds Count* census and ongoing research programmes linked to offshore wind evidence generation.

A key policy framework is the *Scottish Seabird Conservation Action Plan* (Scottish Government, 2025), which places strong emphasis on improving breeding success through targeted interventions at colony level. In particular, the plan highlights the importance of predator management and biosecurity measures on seabird islands, recognising invasive mammals such as rats as a major driver of breeding failure for many species. Actions include eradication of invasive predators, prevention of reintroduction through strict biosecurity protocols, and long-term monitoring of colony recovery following interventions.

These measures are already being implemented in Scotland through projects such as island restoration and biosecurity programmes, which have demonstrated substantial increases in breeding success and population recovery following predator removal. As such, Scotland provides a strong example of how targeted, site-based interventions can deliver measurable improvements in seabird breeding success and could inform similar approaches within the NN programme

In Denmark, government agencies such as the Danish Energy Agency and the Danish Environmental Protection Agency oversee environmental assessments and monitoring related to offshore wind development. This includes requirements for baseline surveys and post-construction monitoring of seabirds, contributing to the evidence base for impact assessment and mitigation.

In Germany, the Federal Maritime and Hydrographic Agency (BSH) coordinates environmental monitoring programmes associated with offshore wind farms, including systematic surveys of seabird distribution and habitat use. These programmes are used to assess impacts such as displacement and inform permitting and mitigation requirements. In parallel, the Federal Agency for Nature Conservation (BfN) supports research and conservation initiatives aimed at protecting marine biodiversity, including seabirds.
In Denmark, the Danish Energy Agency and the Danish Environmental Protection Agency are responsible for offshore wind development and environmental regulation.

In Norway, the SEAPOP programme, supported by the Norwegian Environment Agency and research institutes, is a central national initiative for monitoring seabird populations. The programme combines colony monitoring, demographic studies and ecological research, and is used to inform national conservation policy and international reporting.

These organisations are particularly relevant in the context of offshore wind permitting and compensation frameworks, where they play a role in defining mitigation and conservation requirements. These compensation frameworks could give a basis to find large scale projects on the key species focussed on in Chapter 3.

4.1.4 Private sector actors

Offshore wind developers and energy companies are increasingly involved in seabird monitoring and compensation programmes as part of environmental impact mitigation strategies.

Companies such as SSE Renewables, Ørsted, RWE, Scottish Power Renewables/Iberdrola, Equinor and Vattenfall are involved in research projects and pilot initiatives aimed at reducing ecological impacts of offshore wind farms. These include measures such as collision monitoring systems, bird-safe turbine designs and habitat restoration projects.

For example, RWE and partners have conducted experiments with black-painted turbine blades to assess whether increased visibility reduces bird collisions (Kleyheeg-Hartman, 2025). Another example is, collision monitoring programmes have been implemented at offshore wind farms such as Thanet (UK) and the Aberdeen Offshore Wind Farm (European Offshore Wind Deployment Centre, Scotland) (JNCC, 2022). These projects have generated important empirical data on seabird flight behaviour, avoidance rates and collision risk, contributing to improved impact assessments and mitigation strategies for offshore wind development.

In addition, developers are increasingly involved in compensation and restoration measures, such as predator control, habitat restoration and artificial nesting structures, often in collaboration with conservation organisations and research institutes.

While many of these initiatives are project-specific, collaboration with industry partners could create opportunities for cofinancing or for testing ecological measures within offshore wind developments. Because this study focuses specifically on breeding success, wind farm operators may have a particular interest in contributing to these projects, as improved breeding outcomes are relevant to their compensation requirements. Such collaboration could strengthen both the effectiveness and overall impact of the measures.

4.2 Ongoing international initiatives

In addition to individual organisations, several international initiatives coordinate research, monitoring and policy development related to seabird conservation and offshore wind impacts. These initiatives provide opportunities for NN to align its activities with existing programmes and contribute to a broader North Sea strategy.

4.2.1 Strategic coordination initiatives

Several initiatives operate at the policy or coordination level and aim to align conservation efforts across the North Sea region.

The Regional Action Plan for Seabirds under the OSPAR Convention is one of the most important international frameworks for seabird conservation. The action plan focuses on reducing pressures on seabird populations, protecting breeding areas and harmonising monitoring across OSPAR member states. Many measures currently being developed within the NN programme — such as breeding habitat restoration, predator management and improving food availability — directly align with the priorities of the OSPAR Regional Action Plan.

Another initiative is the Joint Working Group on Seabirds, which supports international collaboration on seabird monitoring, indicator development and data management within the OSPAR and ESAS frameworks. The group provides scientific assessments and methodological guidance but does not implement projects itself.

The Greater North Sea Basin Initiative (GNBSI) represents a political coordination platform between North Sea countries aimed at aligning energy development, nature conservation and maritime spatial planning. Although it does not implement projects directly, it plays an important role in shaping the broader governance context for offshore wind development and marine conservation.

4.2.2 Research and knowledge programmes

A range of international and national research programmes contribute to improving the evidence base on seabird ecology and the impacts of offshore wind development. These programmes typically focus on data collection, modelling and methodological development, rather than the direct implementation of conservation measures. As such, their primary value lies in informing impact assessments, guiding mitigation strategies and reducing uncertainties, rather than delivering immediate improvements in breeding success.

Several research programmes focus specifically on the ecological impacts of offshore wind development.
A major example is the Offshore Wind Evidence and Knowledge Hub (OWEC), funded by The Crown Estate. OWEC supports a portfolio of research programmes investigating ecological impacts of offshore wind farms on marine ecosystems, including seabirds. These programmes include studies on collision risk, habitat displacement, foraging behaviour and cumulative effects of wind energy development.
Specific OWEC-funded programmes include:

- **PrediCtOr**, which aims to improve understanding of seabird collision risk with offshore wind turbines.
- **ReSCUE**, which investigates seabird flight heights to refine collision risk assessments.
- **ECOWind** and **ECOWINGS**, which study broader ecological interactions between offshore wind farms and marine ecosystems.
- **ORJIP**, UK-wide collaborative programme of environmental research with the aim of reducing consenting risks for offshore wind and marine energy projects

Similar research efforts are present in other North Sea countries, which are mentioned in the above presented chapters. In Denmark, research led by Aarhus University and supported by national authorities focuses on seabird movement, behaviour and interactions with offshore wind farms, including tracking studies and collision risk modelling. In Germany, research programmes coordinated through institutions such as the Federal Maritime and Hydrographic Agency (BSH) and research institutes (e.g. AWI) contribute to long-term monitoring of seabird distribution and the assessment of offshore wind impacts. In Norway, national programmes such as SEAPOP provide extensive datasets on seabird populations and ecology, which can be used to understand pressures and inform management decisions at a broader scale.

While these programmes do not typically deliver concrete, site-based conservation measures, they provide essential scientific input for the design, targeting and evaluation of such measures. For NN, maintaining links with these initiatives is therefore valuable to ensure access to up-to-date knowledge, data and methodologies, and to align proposed measures with the latest scientific understanding.

4.2.3 Opportunities for NN collaboration

The analysis indicates several areas where NN could align with existing international initiatives.

1. First, partnerships with conservation organisations such as BirdLife international, RSPB, NABU, DOF, SSC, and Birdlife Norway could support implementation of measures aimed at improving breeding success in major seabird colonies outside the Netherlands. By collaboration with the Birdlife International it could strengthen the relationships within the North Sea countries and increase the inclusion within the program. Besides the practical input the NGO's can deliver, it could possibly also help with co-funding exploration.
2. Second, collaboration with research programmes such as OWEC, ECOWind, and ECOWINGS could strengthen the scientific basis for ecosystem-based measures and provide access to large datasets and modelling frameworks.
3. Third, coordination with policy initiatives such as the OSPAR Regional Action Plan for Seabirds could ensure that NN measures contribute to broader regional conservation goals.

By aligning its activities with existing initiatives, NN could increase the effectiveness and scalability of ecological measures aimed at restoring seabird populations in the North Sea.

5 Conclusions and recommendations

This review has considered a subset of bird species of ecological relevance to the North Sea and with the common trait of breeding outside the Netherlands, but varying significantly in their taxonomy, ecology, the extent of research regarding their ecology, factors limiting their populations, importance of their North Sea population to European or global populations, and the remoteness of their breeding populations. As a result, we have identified a high level of variability between species regarding possible measures and evidence/history of successful deployment, and ultimately in the feasibility of improving each species' breeding success. During the process of reviewing for each species, additional measures have been identified which were discarded on various bases, such as being beyond the assumed jurisdiction or reach of the Program, or their effect on breeding success was not directly measurable, or was not measurable within three years. These include marine plastics cleanup and prevention, reducing frequency of disturbance to overwintering waterbirds, and mitigation measures against seabird bycatch by fisheries. However, these still warrant mention as activities which would almost certainly benefit individual seabirds and waterbirds to some degree. Table 1 summarises the main threats attributed to each of the study species. Table 2 summarises the measures short-listed by this review for each species. Concluded priority actions are outlined in the next section [5.1].

Table 1 Severity and details/mechanisms of ongoing threats assessed as having 'Low' impact or higher for each of the seven target species, as classified by IUCN (International Union on Conservation of Nature) and BirdLife International

Species	Fisheries management	Offshore renewables	Invasive and other problematic species, genes & diseases	Climate change	Human intrusions and disturbance
Northern gannet	Slow, significant declines (bycatch)	Negligible declines (displacement, collision)			
Great skua	Slow, significant declines (decrease in fish stocks, change in discard practices)				
Common guillemot	Slow, significant declines (bycatch, decrease in fish stocks)			Slow, significant declines (temperature extremes)	
Razorbill	Slow, significant declines	Causing/could cause	Slow, significant	Slow, significant declines	

Species	Fisheries management	Offshore renewables	Invasive and other problematic species, genes & diseases	Climate change	Human intrusions and disturbance
	(bycatch, decrease in fish stocks)	fluctuations (displacement)	declines (rat, mink)	(temperature extremes, storms and severe flooding)	
Great black-backed gull	Slow, significant declines (change in discard practices)				
Red knot					Unknown (recreational activities)
Bar-tailed godwit		Unknown (displacement, collision)			Slow, significant declines (recreational activities)

Table 2 Previous success, cost-effectiveness, feasibility and practicality scoring for the shortlisted measures for each of the seven target species, scoring Low to High (plus Unknown) following approach taken by Furness et al. (2014). Confidence (C, 'High' 'Moderate' or 'Low') is also assigned to each cell value, based on amount and consistency of evidence, following approach taken by Furness et al. (2014).

Species	Measure	Previous success in the species	Previous success in similar species	Cost-effectiveness	Feasibility	Practicality
Northern gannet	Artificial Nesting Structures / Social attraction to colonise vacant sites	Low to Moderate C = Low*	Low to Moderate C = Low	Low C = Mod	Low C = Mod	Low C = Mod
	Direct intervention with plastic litter mortality at colony	Low C = Low	Unknown C = Low	Low C = Mod	Low C = Mod	Low C = Mod

Species	Measure	Previous success in the species	Previous success in similar species	Cost-effectiveness	Feasibility	Practicality
	Indirect intervention with plastic litter mortality	Low C = Low	Unknown C = Low	Low C = Mod	Mod C = Mod	Mod C = Mod
	Limiting disturbance at colonies	Moderate C = Low	Moderate C = Low	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod
	Biosecurity of nesting islands	Unknown C = Low	High C = High	Moderate C = High	Moderate C = High	Moderate C = High
Great skua	Supplementary feeding	High C = Mod	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod	Low C = Mod
	Cessation of culling	High C = High	High C = High	High C = High	Moderate C = High	High C = High
Common guillemot	Eradication of introduced mammalian predators / Biosecurity of nesting islands	Moderate C = High	Moderate to High C = High	Moderate C = High	High C = High	Moderate C = High
	Limiting disturbance at colonies	Unknown C = Low	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod
	Artificial Nesting Structures / Social attraction to colonise vacant sites	Moderate C = Low	Moderate C = Low	Low C = Mod	Low C = Mod	Low C = Mod
	Seagrass cultivation / restoration	Unknown C = Low	Unknown C = Low	Low C = Low	Moderate C = Low	Moderate C = Low
Razorbill	Eradication of introduced mammalian predators / Biosecurity of nesting islands	Moderate C = High	Moderate to High C = High	Moderate C = High	High C = High	Moderate C = High

Species	Measure	Previous success in the species	Previous success in similar species	Cost-effectiveness	Feasibility	Practicality
	Limiting disturbance at colonies	Unknown C = Low	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod
	Artificial Nesting Structures / Social attraction to colonise vacant sites	Low C = Low	Moderate C = Low	Low C = Mod	Low C = Mod	Low C = Mod
	Seagrass cultivation / restoration	Unknown C = Low	Unknown C = Low	Low C = Low	Moderate C = Low	Moderate C = Low
Great black-backed gull	Control of large mammalian predators (fencing, trapping)	Moderate to High C = Low	Moderate to High C = Mod	Moderate C = Mod	Moderate C = Mod	Moderate C = Mod
	Cessation of culling	High C = Low	High C = High	High C = Mod	High C = Mod	High C = Mod
Red knot	Maximising food intake (on Icelandic staging grounds)	Unknown C = Low	Unknown C = Low	Moderate C = Low	Low C = Mod	Moderate C = Mod
	Seagrass cultivation / restoration	Unknown C = Low	Unknown C = Low	Low C = Low	Moderate C = Low	Moderate C = Low
Bar-tailed godwit	Diversionary feeding of long-tailed skuas	Unknown C = Low/None	Moderate C = Low	Low C = Mod	Low C = Mod	Low C = Mod
	Seagrass cultivation / restoration	Unknown C = Low	Unknown C = Low	Low C = Low	Moderate C = Low	Moderate C = Low

5.1 Recommended priorities for NN

5.1.1 Eradication of introduced mammalian predators of seabirds / Biosecurity for nesting islands

This measure has proved effective in increasing colony populations of some seabird species, including guillemot and razorbill for which there is evidence of a moderate level of efficacy in terms of population response, with examples from some colonies in the UK showing very marked increases in numbers following the implementation of this measure. Evidence of the full extent to which such responses in guillemot and razorbill are due to increases in breeding success or direct increase in numbers of adults (due to occupation of predator-accessible nesting sites) is lacking, but in some instances much of the initial increase, at least, must arise from the latter effect (due to the short time period over which it occurs). However, even if much of the increase in numbers results from such immigration to the colony, the overall breeding productivity at the colony is expected to increase due to the greater number of breeding pairs. It is a high-cost and labour-intensive measure but is the subject of published methods, guidance and toolkits. NN may benefit existing projects through funding or lead a new project at additional sites. Where such eradications are undertaken, subsequent biosecurity measures need to be implemented to ensure that the benefits are maintained, whilst there may be potential for NN to help facilitate and contribute to existing biosecurity programmes on islands on which these species breed, as well as to island breeding sites for gannet.

5.1.2 Seagrass cultivation projects

Seagrass cultivation projects are already underway in key areas of the North Sea including the Wadden Sea, and NN may benefit existing projects through funding or provision of personnel or lead a new project at additional sites. Seagrass cultivation has a particularly wide range of potential benefitting taxa of organisms, including amongst the priority seabirds and priority waterbirds that are the focus of this report.

5.2 Suggested next steps

Following this review, the recommended next steps are:

- Consultation with existing and new partners and stakeholders on the outcomes of the review
  - Initially focus on organisations such as BirdLife International and the RSPB, given their established networks, experience with seabird conservation initiatives for the focus species, and potential role in supporting implementation and identifying additional collaborators.
  - Engage directly with organisations and stakeholders responsible for, or experienced in, implementing the proposed measures, as these parties may provide practical insights into feasibility, delivery, and scaling opportunities.
  - Engage directly with organisations and stakeholders linked to the proposed measures, including conservation bodies, research institutes, offshore wind farm (OWF) developers, and other parties involved in compensatory measures programmes.
  - Expand engagement over time to include governmental departments and regulatory agencies that may support or coordinate strategic, regional-scale implementation initiatives.
- Undertake in-depth feasibility studies for the implementation of measures, including:
  - opportunities for pilot studies to establish efficacy of the selected measure (e.g. by monitoring the responses of implementation (or trial implementation) against trends at sites where the measures are not implemented).;
  - site selection;
  - international coordination requirements; and

- governance and delivery mechanisms.

- Ensure that robust monitoring programmes are implemented alongside measures to improve understanding of their efficacy and seabird responses. Monitoring should, where appropriate, assess changes in breeding success, breeding population size, survival, and other relevant ecological indicators for target species.
- Develop implementation roadmaps outlining responsibilities, timelines, funding mechanisms, and coordination pathways between stakeholders.
- Strengthen coordination with governmental stakeholders and agencies to support policy alignment, strategic planning, and potential regional-scale deployment of measures.

5.3 Knowledge gaps and uncertainties

This study is primarily based on a review of available literature, policy documents and technical reports, supplemented by expert consultation. Given this approach and considering the large geographical scope (North Sea basin) and ecological complexity of the selected species, several knowledge gaps and uncertainties remain.

First, it is important to acknowledge that not all relevant measures, pilot projects or local initiatives may have been captured. Many initiatives are ongoing, unpublished, or documented in grey literature. In particular, information on the effectiveness, costs and feasibility of measures is often incomplete or based on site-specific case studies. Therefore, the overview presented here should be regarded as indicative rather than exhaustive. It is recommended to follow up directly with the organisations mentioned in this report to validate costing, feasibility and potential co-financing opportunities for specific measures.

Ecological uncertainties
A number of ecological uncertainties limit the ability to predict the effectiveness of measures:

- **Food availability and demographic response**:
  Although several studies demonstrate links between prey abundance (e.g. sandeel, sprat, herring) and breeding productivity in species such as kittiwake and guillemot, quantitative relationships remain poorly defined for many species. It is often unclear what level of prey recovery is required to achieve measurable improvements in survival or reproductive success at the population level.
- **Spatial mismatch between pressures and measures**:
  Many of the focal species use Dutch waters outside the breeding season but breed elsewhere (e.g. UK, Scandinavia, Arctic regions). The extent to which measures implemented in one part of the flyway (e.g. predation control at colonies, fishery closures at sea) compensate for impacts occurring elsewhere remains uncertain.
- **Displacement and behavioural responses**:
  For offshore wind impacts and other spatial pressures, uncertainty remains around the magnitude of displacement, barrier effects and cumulative impacts. Similarly, behavioural flexibility in diet and foraging strategies may buffer or amplify impacts, but this is species-specific and not always well understood.
- **Climate change interactions**:
  Climate-driven shifts in prey distribution and quality (e.g. changes in sandeel availability, phenological mismatch) interact with fisheries and spatial developments. These cumulative and interacting pressures are difficult to disentangle and project into the future.

Effectiveness and scalability of measures
For many proposed measures (e.g. predator control, creation of artificial breeding habitat, disturbance reduction), the evidence base varies considerably:

- Some measures have strong empirical support at local scale (e.g. predator eradication on islands, fishery closures benefiting sandeel-dependent species).
- Others are supported mainly by predictive modelling studies or expert judgement.
- Long-term monitoring data to demonstrate sustained population-level effects are often lacking.

In addition, scalability is uncertain. Measures that are effective at colony level may not be sufficient to compensate for large-scale mortality or displacement effects at sea. Conversely, ecosystem-based measures (e.g. forage fish management, habitat restoration) may have more broad benefits but require international coordination and long implementation timelines.

- **Economic and governance uncertainties**
- **Cost estimates** are often based on single-case examples and may not translate directly to other regions.
- **Feasibility** depends strongly on governance context, stakeholder acceptance, and legal constraints.
- **International coordination** is essential for many species but remains politically and institutionally complex.

Given these uncertainties, an adaptive approach is recommended: combining implementation of promising measures with robust monitoring, iterative evaluation and adjustment over time.

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