English Seabird Conservation and Recovery Pathway

Technical report

August 2024

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Report Details

Defra commissioned Natural England to analyse pressures affecting seabirds and marine waterbirds in England and English waters. This technical report sets out the assessment methods and the recommended updates for consideration. These recommended updates form the English Seabird Conservation and Recovery Pathway (ESCaRP), which will support delivery of components within Defra's overarching Environment Improvement Plan (EIP). The recommended updates within the ESCaRP could be considered by Defra and its stakeholders when determining how best to implement and prioritise actions to have the greatest impact for seabird recovery.

This is a Natural England report and should not necessarily be considered Government opinion.

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Keywords

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Executive summary

Many seabird populations are faring poorly in England, with declining abundance and changes in distribution driven by a variety of pressures. As part of the Environment Improvement Plan, and in recognition of the ecological and cultural significance of England's seabirds, Defra commissioned Natural England to undertake a vulnerability assessment for seabirds in light of the pressures they face and develop recommendations which form the ESCaRP, as a guide for Defra and its stakeholders to consider appropriate actions.

Natural England has undertaken a comprehensive review of evidence to inform the most significant pressures negatively affecting seabirds at breeding and non-breeding sites in England and English waters.

The approach included a vulnerability assessment, analysing the spatial overlap between marine birds at sea and 36 human pressures of relevance. Built into this was a renewed understanding of seabird sensitivity to these pressures, such that analysis of vulnerability factored in both exposure and sensitivity to pressures of relevance.

At breeding colonies, an in-depth review of issues affecting nesting birds was carried out. Results from the review were combined with other sources of evidence and existing Site Improvement Plans, where relevant, to provide an expert overview of significant issues.

Where vulnerability at sea or at colonies was assessed as 'high', the sufficiency of existing measures, including legislation and conservation activities, was considered.

Wherever existing measures were found to be insufficient, a recommendation for action was formed. These recommendations factored in relevant considerations relating to climate change. A final set of 19 recommendations was formed, relating to breeding, feeding, surviving and knowledge; each consider timeframes, stakeholders and spatial extent, and are prioritised by perceived urgency and adequacy of existing measures. They include a 'pathway to action', comprised of a series of steps necessary which could be taken to enact the recommendation.

These recommendations, could support delivery of components within Defra's overarching Environment Improvement Plan (EIP). If these recommendations are fully implemented, they could promote effective recovery of England's internationally important seabird populations, contribute to Good Environmental Status under the UK Marine Strategy, and restore these crucial marine predators for the ecological and cultural benefits they bring.

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1. Introduction

The need for a seabird conservation and recovery pathway

At the Coastal Futures conference in 2020, Defra Environment Minister Rebecca Pow announced a commitment to delivering actions to support England's seabird populations. The announcement flagged the ecological and cultural importance of UK's seabirds, many of them nesting in England and using English waters in breeding and non-breeding seasons. Not only are many of these populations internationally important their cultural value is also underlined by the economic and social benefits they can bring to local communities. For example, the RSPB's reserve at Bempton Cliffs generated an estimated tourism income of over £750,000 to the local area during 2009 in addition to local employment provided at the reserve, which was directly attributable to seabirds as iconic features of coastal environments (RSPB 2010). The conservation and recovery actions presented in the ESCaRP, will support delivery of seabird components of Defra's overarching Environment Improvement Plan (EIP).

Actions are required as England's seabird populations are not faring well. There are population declines in many species and, at both international and domestic scale, all indicators point to negative trends that are predicted to worsen (OSPAR environmental status assessment for the Northeast Atlantic 2017[1]; UK Marine Strategy 2019[2]). Without intervention, these internationally important seabird populations will continue to decline, and some populations could even become locally extinct, emphasising the need for urgent action.

Progress has been made through the creation of marine Special Protection Areas (SPAs) in England, however these do not benefit all species and do not cover all areas seabirds may use. Considering new pressures, including recent devastating outbreaks of Highly Pathogenic Avian Influenza, worsening effects of climate change, and the drive to restore seabird populations, additional conservation measures will be required; these will be at the heart of implementing the ESCaRP.

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[1] OSPAR environmental status assessment for the North East Atlantic 2017

[2] UK Marine Strategy 2019

This report aims to detail provide recommendations to help restore seabird and marine waterbird[3] populations and help the UK meet Good Environmental Status (GES) as outlined in the UK Marine Strategy (the term 'seabirds' often refers to the inclusion of marine waterbirds in this report). Taking an evidence-led approach, a technical analysis has identified the key pressures affecting England's seabirds. We also assessed the effectiveness of current measures to address these pressures. Together, the resulting recommendations form the ESCaRP, serving as a guide for Defra and its stakeholders to use in achieving its 'vision for seabird conservation'.

2. Aims and scope

The over-arching aim of Natural England's work on this project was to suggest evidence-led recommendations and pathways to support delivery of components under Defra's EIP. The ESCaRP will aim to optimise the conservation status and prospects of seabirds and waterbirds in England through effective management of the impacts of existing pressures and new occurring threats. The UK devolved administrations are working independently on seabird conservation strategies for Scotland, Wales, and Northern Ireland. Jointly, the recommendations will help restore seabird populations and assist the UK in meeting Good Environmental Status (GES) targets within the UK Marine Strategy. The process underpinning the ESCaRP includes three main steps: vulnerability assessments to identify the key pressures impacting seabirds and waterbirds, an assessment of existing measures determining whether there are gaps or inefficiencies in the current management of key pressures, and the development of recommendations where the current measures could be improved as an aid to identify any further actions required. We have also created a "vision for seabird conservation" in Section 7.

This project considers pressures on seabirds and marine waterbirds in the marine environment and at terrestrial breeding sites (colonies) in England. Different assessment methods were used for the marine and terrestrial environments due to differences in the availability of spatial data for pressures (Figure 1).

Pressures in the marine environment were assessed by a vulnerability assessment that used spatial data for seabird distribution and pressures in English waters. The assessment included:

- an assessment of the sensitivity of each seabird and waterbird species to a range of pressures;
- the identification of human activities emitting these pressures;

[3] Here referring to species typically associated with freshwater habitats in the breeding season, but wholly reliant on marine areas for part of their life cycle, such as divers, seaducks and grebes.

- an assessment of the exposure of the birds to key pressures and activities;
- the determination of the vulnerability of each species to each pressure.

Pressures at breeding sites were assessed using expert judgement, in discussion with colony site managers. An analysis of urban colonies of large gulls and of seabirds in the wider terrestrial environment (eg for gulls inland) were out of scope of the current work.

Based on these assessments, recommendations were developed, taking into consideration how well important pressures are currently being managed, and how climate change affects pressures and their management.

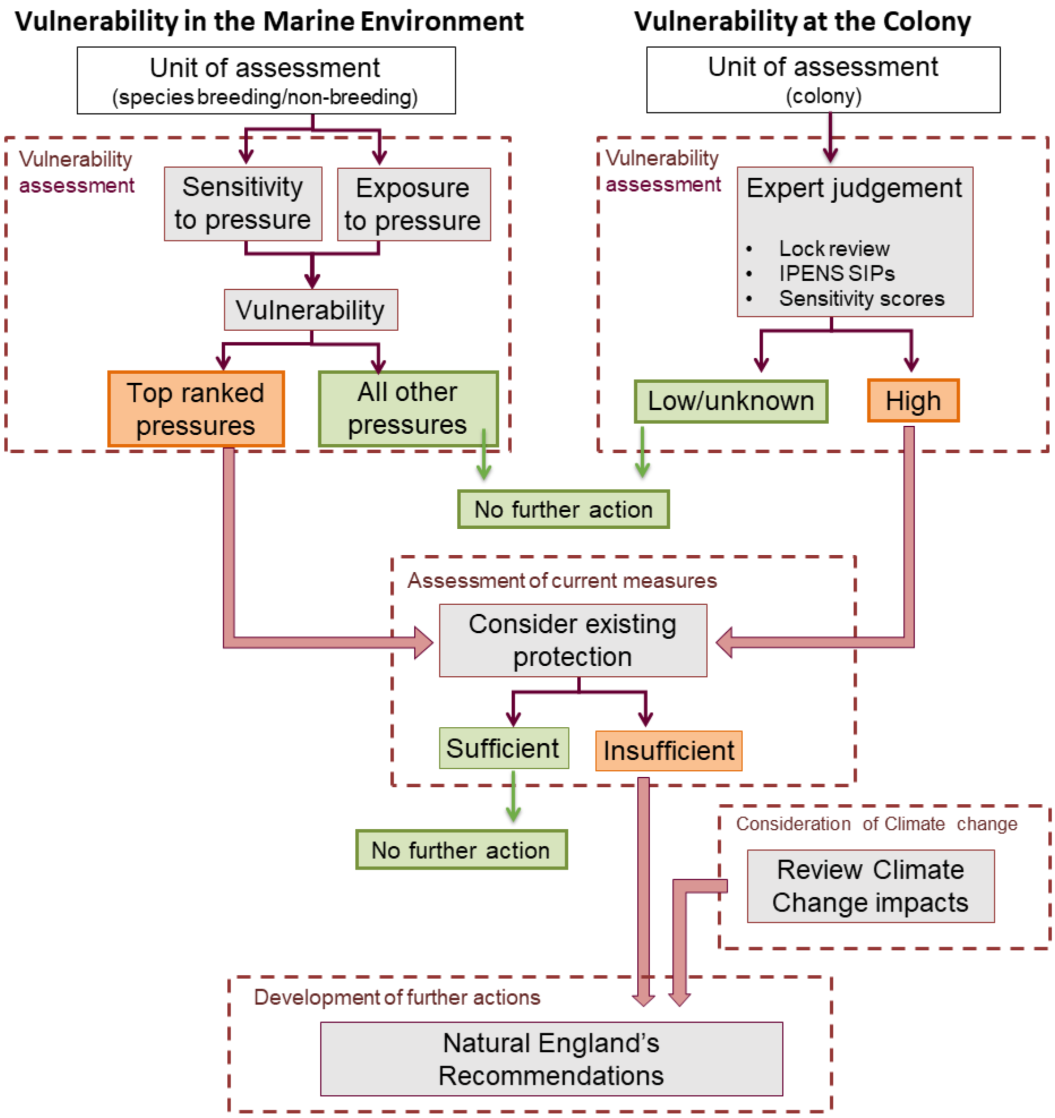


Figure 1. Process to develop recommendations for the ESCaRP.

To inform the scope of the ESCaRP, project objectives were:

1. Update the evidence base to underpin vulnerability assessments of seabirds and waterbirds in England, including sensitivity assessments, species distributions and pressure distributions (Sections 2.1 and 2.2).
2. Assess the vulnerability of the populations of English seabirds and waterbirds to current pressures in English waters and at terrestrial breeding sites in England (Section 2.3).
3. Assess the extent to which important pressures impacting English seabird populations are already managed (Section 5.2)
4. Develop recommendations and advice on future actions to support delivery of components under Defra's EIP (Section 6).

Species in scope

There are 36 species of seabirds and marine waterbirds (divers, grebes, seaducks and waterfowl) in scope of the ESCaRP. Many occur in considerable numbers throughout the year in English waters while a few are mainly present during the breeding season or the non-breeding season (Table 1). Species factsheets with key information are available for each species from the British Trust for Ornithology (BTO) website[4].

The list of species embraces all seabird species breeding in England, any species of marine waterbird which occurs in significant numbers in English (marine) waters at any given time of the year and six species where English conservation efforts add significantly to their wellbeing: Arctic and great skua (during their passage in English waters), red-breasted merganser, Slavonian grebe and black-necked grebe (both with significant non-marine occurrences), and long-tailed duck (which is rare in English waters). Leach's storm petrel was not included in the scope of this iteration of ESCaRP due to no data being available on the non-breeding distribution in English waters.

The 'Birds of Conservation Concern' (BoCC 5) assessments provide the conservation status of bird species considered an established part of the UK's avifauna (Stanbury and others 2021). BoCC 5 Red List species are globally threatened or have declined in range or numbers by 50% or more in the last 25 years (or across a longer timescale dictated by data availability) whilst Amber-listed species occur in the UK in internationally significant numbers, have declined in range or numbers by 25-49% in the last 25 years (or across a longer timescale dictated by data availability, including loss over historic timescales). Green-listed species do not meet these criteria. There are only three species with a green

[4] www.bto.org/understanding-birds/birdfacts

BoCC 5 listing (little gull, great cormorant and red-throated diver), the majority have an amber status (23 species) or are red listed (10 species; Table 1).

The International Union for Conservation of Nature (IUCN) Red List[5] assessments of extinction-risk indicate the Great Britain, European and global extinction risk of bird species, based on geographic range, population size, population trajectory and extinction probability. From the global perspective one species is Critically Endangered (Balearic shearwater), three are Endangered (Atlantic puffin, Arctic skua, common eider) and two species are Vulnerable (black-legged kittiwake and black-necked grebe), but there are important nuances at European and GB scales (Table 1).

[5] www.iucnredlist.org

Table 1. Species listed in taxonomic order (BOU 2022) with seasons present in England.
X indicates if species breeds in England and/or uses English waters in their non-breeding season. Empty cells indicate absence.
Conservation status of the species is shown by BOCC 5[a] and IUCN[b] GB (a), European (b) and global (c) status.

Taxonomic group	Common name	Scientific name	Breeding	Non-breeding	BoCC5 status[a]	IUCN status[b]		
Ducks	Common eider	*Somateria mollissima*	X	X	A	EN	EN	NT
	Common scoter	*Melanitta nigra*		X	R	LC	LC	LC
	Long-tailed duck	*Clangula hyemalis*		X	R	NT	LC	VU
	Red-breasted merganser	*Mergus serrator*	X	X	A	VU	NT	LC
Grebes	Slavonian grebe	*Podiceps auritus*		X	R	VU	NT	VU
	Black-necked grebe	*Podiceps nigricollis*	X	X	A	EN	VU	LC
Gulls	Black-legged kittiwake	*Rissa tridactyla*	X	X	R	CR	VU	VU
	Black-headed gull	*Chroicocephalus ridibundus*	X	X	A	VU	LC	LC
	Little gull	*Hydrocoloeus minutus*		X	G	NE	LC	LC
	Mediterranean gull	*Ichthyaetus melanocephalus*	X	X	A	LC	LC	LC
	Common (Mew) gull	*Larus canus*	X	X	A	LC	LC	LC
	Great black-backed gull	*Larus marinus*	X	X	A	EN	LC	LC
	Herring gull	*Larus argentatus*	X	X	R	EN	LC	LC
	Yellow-legged gull	*Larus michahellis*	X	X	A	EN	LC	LC
	Lesser black-backed gull	*Larus fuscus*	X	X	A	DD	LC	LC
Terns	Sandwich tern	*Thalasseus sandvicensis*	X	X	A	LC	LC	LC
	Little tern	*Sternula albifrons*	X		A	VU	LC	LC
	Roseate tern	*Sterna dougallii*	X		R	EN	LC	LC
	Common tern	*Sterna hirundo*	X		A	NT	LC	LC
	Arctic tern	*Sterna paradisaea*	X		A	VU	LC	LC

Taxonomic group	Common name	Scientific name	Breeding	Non-breeding	BoCC5 status[a]	IUCN status[b]		
Skuas	Great skua	*Stercorarius skua*		X	A	LC	LC	LC
	Arctic skua	*Stercorarius parasiticus*		X	R	CR	EN	LC
Auks	Common guillemot	*Uria aalge*	X	X	A	LC	LC	LC
	Razorbill	*Alca torda*	X	X	A	LC	LC	LC
	Black guillemot	*Cepphus grylle*	X	X	A	LC	LC	LC
	Atlantic puffin	*Fratercula arctica*	X	X	R	LC	EN	VU
Divers	Red-throated diver	*Gavia stellata*		X	G	LC	LC	LC
	Black-throated diver	*Gavia arctica*		X	A	VU	LC	LC
	Great northern diver	*Gavia immer*		X	A	LC	LC	LC
Petrels & Shearwaters	European storm petrel	*Hydrobates pelagicus*	X		A	LC	LC	LC
	Northern fulmar	*Fulmarus glacialis*	X	X	A	LC	VU	LC
	Manx shearwater	*Puffinus puffinus*	X	X	A	LC	LC	LC
	Balearic shearwater	*Puffinus mauretanicus*		X	R	VU	CR	CR
Sulids	Northern gannet	*Morus bassanus*	X	X	A	LC	LC	LC
Cormorants & shags	Great cormorant	*Phalacrocorax carbo*	X	X	G	NT	LC	LC
	European shag	*Gulosus aristotelis*	X	X	R	EN	LC	LC

(a) BoCC 5 status: R = Red, A = Amber, G = Green, (Stanbury and others 2021).

(b) IUCN Red List Status: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC = Least Concern, DD = Data Deficient, NE = Not Evaluated, NT = Near Threatened.

Scope of Spatiotemporal Units

The aims and objectives of the ESCaRP included providing a detailed assessment of the pressures impacting on seabirds both within the marine environment and where relevant at their colonies. For analysis, it was necessary to consider when each species was present and to be considered in-scope of the work and to define these as specific ‘Units of Assessment’ (UoA).

To reflect the requirements of the ESCaRP, assessment of pressures impacting seabirds in both the marine environment and at their colonies at different times of the year used three spatiotemporal variables; colony, breeding and non-breeding (Table 2).

The assessments correspond with species presence or absence in English waters over the course of a year (as indicated in Table 1), and if they breed in colonies in England. For example, common scoter is only present in significant numbers in English waters during the non-breeding season, so it is only assessed during that time. Table 3 indicates which assessments were made for individual species.

Assessments of species vulnerability in the marine environment during breeding, non-breeding and/or passage are described in section 2.

Assessments of vulnerability at colonies are described in section 4, ‘Method to assess vulnerability at breeding sites’.

Table 2. Definition of three spatiotemporal variables applied to each species. (adapted from Spencer and others 2022)

Spatiotemporal variable	Definition	Notes
Colony	Bird during the breeding season at the breeding colony	‘At the breeding colony’ is defined as at or in close proximity to the nesting location of the species during the breeding season. This includes areas away from the immediate nest location, for example, areas where birds rafted adjacent to the colony, or for freshwater breeding birds, the area of the breeding waterbody.

Spatiotemporal variable	Definition	Notes
Breeding	Bird during the breeding season away from the breeding colony	'Away from the breeding colony' is defined as time spent not in close proximity to the breeding colony during the breeding season, generally on foraging trips, but also by wandering non-breeding birds during the breeding season.
Non-breeding	During the non-breeding season for some species there is also a distinct **passage** season defined where a distinction in distribution between non-breeding (ie winter) and passage is possible, depending on the phenology of the species[6]	At all locations and timings outside of the breeding season.

Table 3. Units of Assessment.
X represents an assessment completed for the species during the indicated season and/or at the breeding colony. Empty cells indicate that no assessment was required.

Taxonomic group	Common name	Marine during breeding	Marine during non-breeding	Marine during passage	Colony
Ducks	Common eider	X	X		X
Ducks	Common scoter		X		
Ducks	Long-tailed duck		X		
Ducks	Red-breasted merganser		X		
Grebes	Slavonian grebe		X		
Grebes	Black-necked grebe		X		
Gulls	Black-legged kittiwake	X	X		X
Gulls	Black-headed gull	X	X		X
Gulls	Little gull		X	X	
Gulls	Mediterranean gull	X	X		X
Gulls	Common (Mew) gull	X	X		X
Gulls	Great black-backed gull	X	X		X

[6] In most cases, either the passage or non-breeding (wintering) UoA was used. For three species - common guillemot, little gull and razorbill – assessments were done for both the passage and wintering UoA.

Taxonomic group	Common name	Marine during breeding	Marine during non-breeding	Marine during passage	Colony
Gulls	Herring gull	X	X		X
Gulls	Yellow-legged gull	X			X
Gulls	Lesser black-backed gull	X	X		X
Terns	Sandwich tern	X	X		X
Terns	Little tern	X			X
Terns	Roseate tern	X			X
Terns	Common tern	X			X
Terns	Arctic tern	X			X
Skuas	Great skua	X	X		
Skuas	Arctic skua	X	X		
Auks	Common guillemot	X	X	X	X
Auks	Razorbill	X	X	X	X
Auks	Black guillemot	X	X		X
Auks	Atlantic puffin	X	X		X
Divers	Red-throated diver		X		
Divers	Black-throated diver		X		
Divers	Great northern diver		X		
Petrels & Shearwaters	European storm petrel	X			X
Petrels & Shearwaters	Northern fulmar	X	X		X
Petrels & Shearwaters	Manx shearwater	X	X		X
Petrels & Shearwaters	Balearic shearwater		X		
Sulids	Northern gannet	X	X		X
Cormorants & shags	Great cormorant	X	X		X
Cormorants & shags	European shag	X	X		X

3. Method to assess the vulnerability in the marine environment

Vulnerability is the likelihood that a habitat, community, or individual will be exposed to an external factor to which it is sensitive. It is assessed by combining the sensitivity of a feature to a pressure with the exposure of the feature to that pressure (Natural England and the JNCC 2011). The combination of both will determine how vulnerable the species is to that pressure (Figure 2).

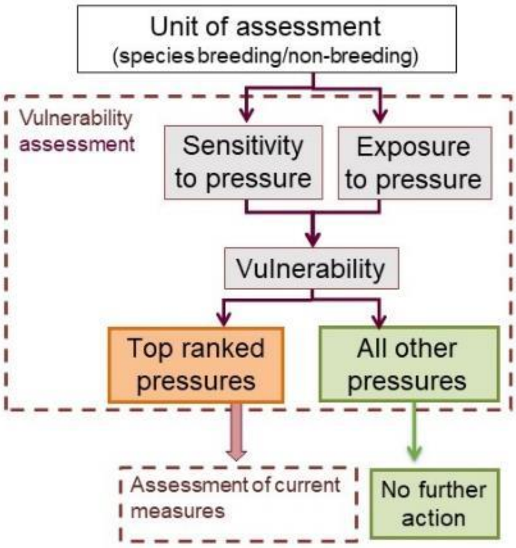


Figure 2. Process to assess vulnerability of birds to pressures in the marine environment.

A light touch Vulnerability Assessment methodology was developed to explore and assess vulnerability in the marine environment, aiming to investigate the vulnerability of seabirds whilst at sea during both their breeding and non-breeding seasons (where applicable). This does not include a vulnerability assessment at the colonies, which is addressed in section 4, 'Vulnerability at breeding sites'.

To assess the vulnerability of the seabird species within scope of the ESCaRP, it was necessary to produce an up-to-date, evidence-based, auditable and transparent series of assessments of each species to a range of pressures. These sensitivity scores would then be used, in combination with assessments of each species' exposure to those pressures and/or the activities which cause them, to assess the vulnerability of each species to those pressures and activities in England. As existing sensitivity assessments did not cover the full list of species within scope of the ESCaRP, an external contract was let to derive new sensitivity assessments. The pressures included within the assessment, and the overall approach of the assessments, are described below, but are presented in more detail in Spencer and others (2022).

Sensitivity assessment

In general terms, sensitivity is the ability of a receptor (habitat or species) to tolerate a pressure (its resistance), or conversely, the degree to which it is affected by the pressure, and secondly, the ability (speed and extent) of the receptor to recover from this pressure (its resilience).

Sensitivity assessment methods

Sensitivity assessments used by Natural England use the following approach of gathering literature to provide evidence pertaining to key characteristics of the habitats and species being assessed (including life-history traits, key characterising species), assessing (scoring) the habitats/species resistance to a pressure, assessing (scoring) the resilience of the habitat/species, combining resistance and resilience scores to produce an overall score of sensitivity, assessing the confidence of the assessment, documenting evidence used to undertake the assessments, and carrying out a quality assurance and peer-review process. To ensure a consistent approach to scoring resistance and resilience, the scoring is performed against an agreed level of pressure (pressure benchmark). This process is laid out in Figure 3.

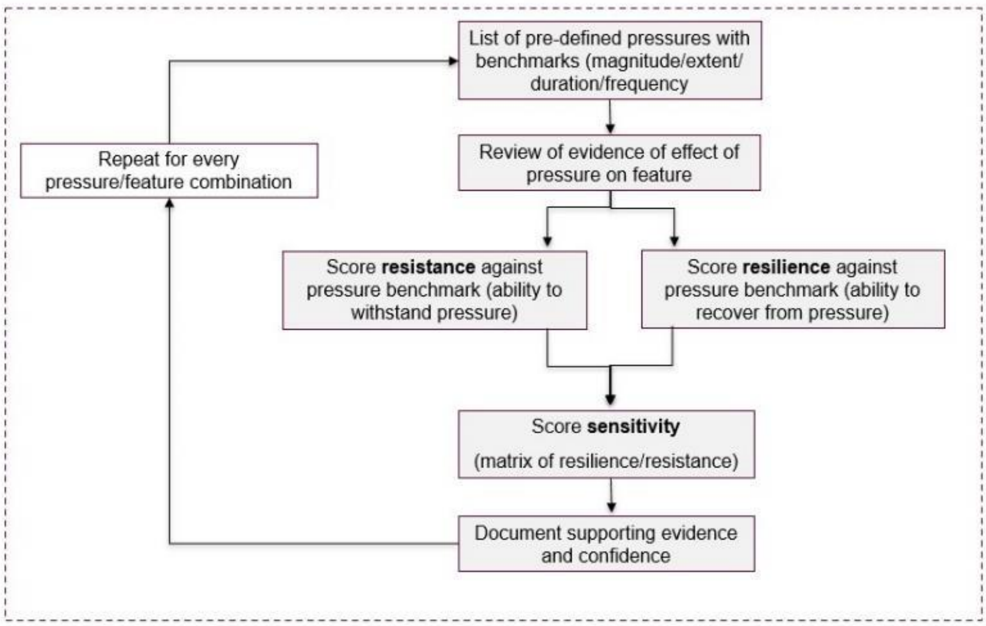


Figure 3. Sensitivity assessment method.

Following these same principles, a method was developed to assess the full suite of species (by Units of Assessment, Table 3) to the pressures (Appendix 1). Sensitivity assessments are carried out at the individual UoA level as sensitivity of the bird species may differ depending on the time of year (breeding/non-breeding seasons) and/or location (at the colony/in the marine environment). The details of the method are reported in Spencer and others (2022).

The resulting output was a sensitivity score of high, medium, low, not sensitive, or insufficient evidence, with a corresponding score for confidence in the assessment, for every unit of assessment against every pressure which could potentially directly impact the species in question. These results were quality assured and stored in a database, along with a brief summary of the evidence used to determine the sensitivity, and the detailed breakdown of the sensitivity score.

In total, sensitivity assessments were completed for 91 species-season UoA and a total of 25 pressures (a further 17 pressures were considered but deemed to not directly impact seabirds, see Appendix 1 for further details). For six of these pressures, two separate assessments were carried out due to the pressures acting on the seabirds via two different pathways of impact – displacement and mortality. To take a precautionary approach, only the higher sensitivity score of the two was used in the vulnerability assessment.

Exposure assessment

In the exposure assessment the spatial overlap between marine bird distributions (during different seasons) and pressure distributions is assessed. In many cases, there are no data on the distribution of individual pressures, however, as pressures can very often be linked to human activities emitting them, activity distributions can be a useful proxy of the distribution of associated pressures. Where possible, it was therefore necessary to obtain data on both species and activity distributions in the marine environment.

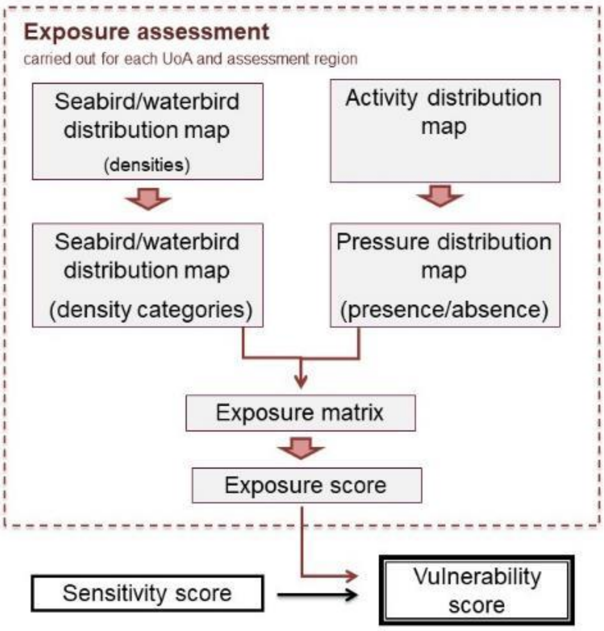


Figure 4. Exposure assessment.

Exposure assessment methods

The exposure assessments were carried out separately for each UoA and each assessment region. The methods underpinning the exposure assessment can be broken down into the following steps (Figure 4):

- Conversion of bird distribution maps into classified maps, based on density categories, for each UoA and assessment region.
- Conversion of activity distribution maps into pressure maps, based on presence/absence of the pressure.
- Determining an exposure score with help of the exposure matrix, based on overlap of the birds density category and presence/absence of a pressure.

Assessment regions

English Waters were divided up into ten assessment regions based on the Charting Progress 2 (CP2) regions (UKMMAS 2010), with each CP2 divided into 'inshore' and 'offshore' using the 12 nautical mile limit. See Figure 12 in Appendix 2.4.

Data used in exposure assessment

Further details of the data used in the exposure assessment, including data sources, data preparation and standardisation can be found in Appendix 2.

Creating classified distribution maps for seabirds and marine waterbirds

For each UoA, a density category was assigned for each assessment region. Using the standardised distribution map for the UoA (for details how these were produced see Appendix 2), the assessment region density category was determined by selecting the highest density category grid cell present within an assessment region. This highest density category method was used in preference to finding the average density category as using an average resulted in a high influence of the source dataset and species over the range of categories assigned. By contrast, using the highest density category method, produced a good spread of regional categories for each UoA. As the vulnerability assessment aimed to assess the relative vulnerability for each species, rather than to compare vulnerability between species, this was deemed appropriate.

For the purposes of the assessment, densities categorised as 'not present' and 'very low' were considered to be non-significant densities of seabirds for the exposure assessment. Therefore, following the assignment of density categories to each assessment region, regional UoA density categories of 'not present' or 'very low' were translated to a category of 'effective or actual zero'.

Where there was no available grid cell data within a region, a density category of ‘unknown’ was assigned to the region.

Creating presence/absence distribution maps for pressures

The presence/absence of each activity (or, where applicable, operation) within each assessment region was determined.

For those activities/operations where spatial data were available, the activity geodatabase was used to determine if the activity/operation was known to be present within each assessment region. If there was no evidence to suggest an activity/operation was present in a region this was recorded as absence with a note of ‘no spatial evidence to indicate present in region’.

It should be noted that the scoring of absence records is not a definitive score and may be incorrect (that is, the activity may be present in the assessment region but not evident in the spatial data). This is a limitation of the activity geodatabase whereby it was only possible to incorporate known and available datasets. The data included cover a wide range of activities including those of likely importance in the subsequent assessment.

For those activities where there was no (or limited) spatial data available (Appendix 2), the presence/absence of each activity/operation was assessed using expert judgement. For the purposes of this assessment, it was decided to screen out many of the activities (across all assessment regions) because these were not considered to be of concern to birds, owing to the spatial separation between the activities and the birds meaning there was no impact pathway (see Appendix 2).

Converting activities to pressures

The presence of an activity within an assessment region was used as a proxy for the pressure’s presence within that assessment region. That is, if one (or more) activities associated with a given pressure were present within an assessment region then it was assumed that the pressure is present within that assessment region.

The activity-pressure interactions (Appendix 2) were used to convert any activity presence records to pressure presence records. As a single pressure may be associated with multiple activities this may have led to pressures being identified multiple times.

All pressures, of relevance to the in-scope species, were found to be present in all assessment regions. This is not surprising given the number of activities occurring within the marine environment and the range of pressures associated with each of these.

Scoring exposure

An exposure score was calculated to indicate how exposed each UoA was to each pressure present within each assessment region. This was calculated using the scoring matrix in Table 4.

The matrix was arranged such that the exposure score mirrored the bird density, assuming the pressure was present. Where the bird density was ‘effective/actual zero’, the exposure was scored as ‘no exposure’ to reflect that the bird density indicates the birds are either not present or are only present in very low numbers. Where the bird density was ‘unknown’, the exposure was scored as ‘unknown exposure’ to reflect the uncertainty relating to whether the bird UoA was present or not. An example of this would be for the Balearic shearwater where the bird distribution data is spatially limited and so for many assessment regions it was not possible to determine the bird density.

Table 4. Scoring matrix using bird density and presence/absence of pressure to calculate exposure.

	High density	**Medium** density	**Low** density	**Effective / actual zero**	**Unknown** density
Pressure **Present**	High exposure	Medium exposure	Low exposure	No exposure	Unknown exposure
Pressure **Absent**	No exposure	No exposure	No exposure	No exposure	Unknown exposure

Vulnerability assessment

Vulnerability assessment methods

Vulnerability was assessed using a scoring matrix to combine the exposure score with the relevant sensitivity assessment score (Table 5).

The matrix was arranged so that high vulnerability scores would only arise if there was evidence of both the UoA being highly sensitive to a pressure, and that the UoA had high exposure to that pressure within a given assessment region. Similarly, the opposite was true for the low vulnerability score only arising where there was low sensitivity and low exposure.

Two vulnerability scores – ‘unknown vulnerability’ and ‘not vulnerable’ – could arise for differing reasons. To ensure transparency about the origin of these vulnerability scores they were further sub-divided, as detailed in Table 6.

Table 5. Scoring matrix used sensitivity assessment score and exposure score to calculate vulnerability.

	High Sensitivity	Medium Sensitivity	Low Sensitivity	Insufficient evidence	Not sensitive	Not relevant / no direct effects
High Exposure	High	High-moderate	Moderate	Unknown – B	Not vulnerable – B	Not vulnerable - C
Medium Exposure	High-moderate	Moderate	Moderate-low	Unknown– B	Not vulnerable – B	Not vulnerable - C
Low Exposure	Moderate	Moderate-low	Low	Unknown – B	Not vulnerable – B	Not vulnerable - C
Unknown Exposure	Unknown - A	Unknown – A	Unknown - A	Unknown– A/B	Not vulnerable – B	Not vulnerable - C
No Exposure	Not vulnerable - A	Not vulnerable - A	Not vulnerable - A	Not vulnerable - A	Not vulnerable – B	Not vulnerable - C

Table 6. Sub-divisions used for the 'unknown vulnerability' and 'not vulnerable' scores.

Vulnerability score	Further detail
Unknown– A	Result of an ‘unknown exposure’. ‘Unknown exposure’ is caused by an ‘unknown’ bird density – where there are lacking the spatial evidence to determine if a bird is present (or not) in the assessment region.
Unknown– B	Result of ‘insufficient evidence’ sensitivity score. Regardless of whether there is an exposure score (or it’s unknown), there was not enough evidence to determine the bird’s sensitivity to the pressure.
Not vulnerable - A	Result of a combination of ‘no exposure’ score but the UoA is either sensitive (H/M/L) or there was insufficient evidence to assess (assume is sensitive). ‘No exposure’ has 2 causes: • Pressure is believed to be ‘absent’ (based on available evidence) • Bird density is ‘effective / actual zero’ These two causes may also interact in combination to give this exposure score.
Not vulnerable – B	Result of ‘not sensitive’ assessment. Regardless of whether there is an exposure score / no exposure / unknown exposure, the bird is considered to be not sensitive to the Pressure (at the benchmark) and thus not vulnerable.
Not Vulnerable - C	Result of either a ‘not relevant’ or ‘no direct effects’ sensitivity assessment. Regardless of whether there is an exposure score / no exposure / unknown exposure, the pressure is considered as either not relevant to birds or have no direct effect on birds.

Results of the vulnerability assessment

A vulnerability assessment score was produced for each UoA, against each pressure, within each assessment region. This resulted in 23,600 result records (59 UoA x 40 pressures x 10 assessment regions). These results are detailed in Appendix 3 including results tables and further explanation.

Most pressures, including all those which are of relevance to seabirds, are present within all ten assessment regions. Therefore, the vulnerability assessment results are being driven by two factors – the density of seabirds within each assessment region and the sensitivity of the seabird to the pressure being assessed.

Important pressures

The assessment of vulnerability in the marine environment included 40 of the 42 pressures (two could not be easily linked to activities and were thus excluded from the vulnerability assessment, see Appendix 1 for further details). Of these 40, 19 pressures resulted in at least one high or high-moderate vulnerability score and were considered further when determining important pressures. The full description of these pressures is provided in Table 23. These remaining nineteen pressures were ranked in three separate ways (Appendix 3, Table 32) – based on the number of high vulnerability scores associated with the pressure; based on the number of high-moderate vulnerability scores associated with the pressure; and finally based on the combined total of high vulnerability and high-moderate vulnerability scores. The same pressures were consistently ranked in the top ten, regardless of ranking method, and are listed in Table 7.

Table 7. Top ten pressures according to ranking method.
Pressures ordered with the pressure associated with the most 'high' and 'high-moderate' vulnerability results (combined) at the top.

Pressure
Removal of target species
Removal of non-target species
Hydrocarbon & PAH contamination
Litter
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)
Introduction of microbial pathogens
Transition elements & organo-metal (eg TBT) contamination
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)
Visual disturbance

4. Method to assess vulnerability at breeding sites

However marine and wide-ranging they are all seabirds must breed on land. During the breeding season their attachment to the nest site means that they must spend a lot of time in one place. Pressures at these breeding sites can affect eggs or chicks, thereby affecting productivity, and they can also affect adults that are more vulnerable whilst attending nests. The sensitivity of seabird species to pressures is therefore likely to be different (usually higher) at breeding sites than elsewhere in a species' range or annual cycle. Most species are also colonial, concentrating large numbers of nests into relatively small areas. Pressures at breeding sites can therefore affect large numbers of birds within a restricted geographical location. Suitable breeding habitat is limited and often sharply defined and seabird colonies tend to remain geographically stable. Most seabirds have a high degree of site fidelity once they have become breeding adults, which means that they will return to the same breeding site year on year and may therefore be exposed to the same pressures for greater periods of time within their lifetime. All of this means that seabirds are likely to have a different vulnerability to pressures at their breeding sites, likely higher. However, given the small geographical areas concerned and the relatively coarse spatial resolution of geographic activity/pressure data, quantitative assessment of species vulnerability at these locations was deemed to be inappropriate for assessing vulnerability at colonies.

A different approach to the assessment of vulnerability in the marine environment was therefore necessary to assess seabird vulnerability at their breeding sites, one in which the expert judgement of site managers played a key role.

Three existing assessments of evidence on the importance of different pressures in colonies were used to underpin an expert judgement identifying the most important pressures for seabirds and waterbirds at breeding colonies in England (Figure 5):

a. a review of England's seabird colonies and pressures affecting them, which surveyed wardens and site managers to identify key pressures at seabird colonies, hereafter 'the Lock review' (Lock and others 2022, see Section 0);
b. the IPENs Site Improvement Plans, which include assessment of the most important issues occurring in Natura 2000 sites across England; and
c. the sensitivity assessments, described already in Section 0, which contain sensitivity assessments relating to pressures acting on birds at colonies, in addition to those assessments of seabird and waterbird sensitivities used in the marine vulnerability assessment (described in Section 2).

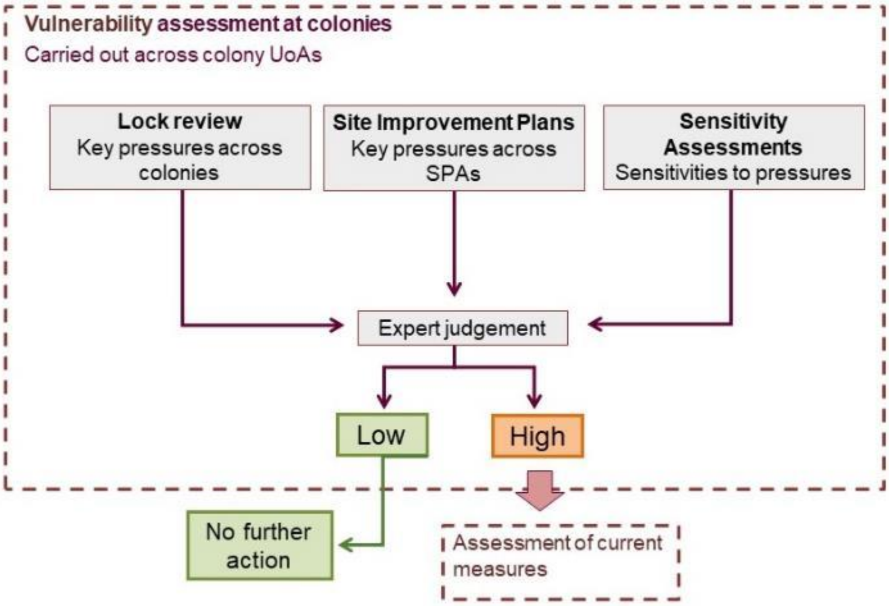


Figure 5. Process to assess vulnerability of birds to pressures at the colony.

The ESCaRP species that breed in England are shown in Table 1. Black-necked grebe and red-breasted merganser only do so in very low numbers, and tend to breed inland, only being associated with marine habitats outside the breeding season. These species are not included within the Seabird Monitoring Programme (SMP) for these reasons. They were therefore not included in this assessment. The remaining 24 species which were assessed at their breeding sites are listed in Table 3.

The assessment did not include urban-breeding populations of herring gull and lesser black-backed gull – only natural-nesting populations of these species were included. This is partly because of the difficulty of establishing the size of the urban populations, although these are substantial. Burnell (2021) estimates that between 75 and 84% of herring gull breeding in England breed in urban environments and that between 65 and 79% of lesser black-backed gull breeding in England breed in urban environments. Given that herring gull are BoCC5 red-listed and lesser black-backed gull are BoCC5 amber-listed in the UK, consideration should be given in future to the pressures faced by these urban populations.

Seabirds breeding on offshore oil and gas structures were also excluded from assessment, largely due to considerable uncertainty about the numbers and locations of breeding birds involved. The decommissioning of such sites could however represent an important loss of breeding habitat for some species. Pressures facing these populations should be considered in future assessments.

Note also that yellow-legged gull has always been an extremely rare breeder in England, has only bred regularly at one site (Poole Harbour) and may not have bred in England since 2018.

Priority sites

The Lock review (see Appendix 4 for methods) estimated that approximately 450,000 pairs of seabirds currently breed in England. Based on the population estimates for breeding seabirds in England, Lock and others (2022) concluded that England supports over 50% of the UK breeding population of six species of seabird: roseate tern (100%), sandwich tern (72%), little tern (78%), lesser black-backed gull (56%), black-headed gull (60%), and Mediterranean gull (96%).

The review identified 22 'priority sites' for breeding seabirds England. Each priority site either supports over 10% of England's breeding population of any seabird species or supports over 10,000 pairs of breeding seabirds. These are shown in Table 8 and Figure 6. In some cases, these sites combine more than one designated site where there is connectivity of breeding bird populations between designated sites. Together, Lock and others (2022) estimated that these priority sites support over 70% of England's breeding seabirds. Conservation actions at these sites would therefore have the greatest impact on England's seabird populations.

Table 8. Priority sites for breeding seabirds in England*.**

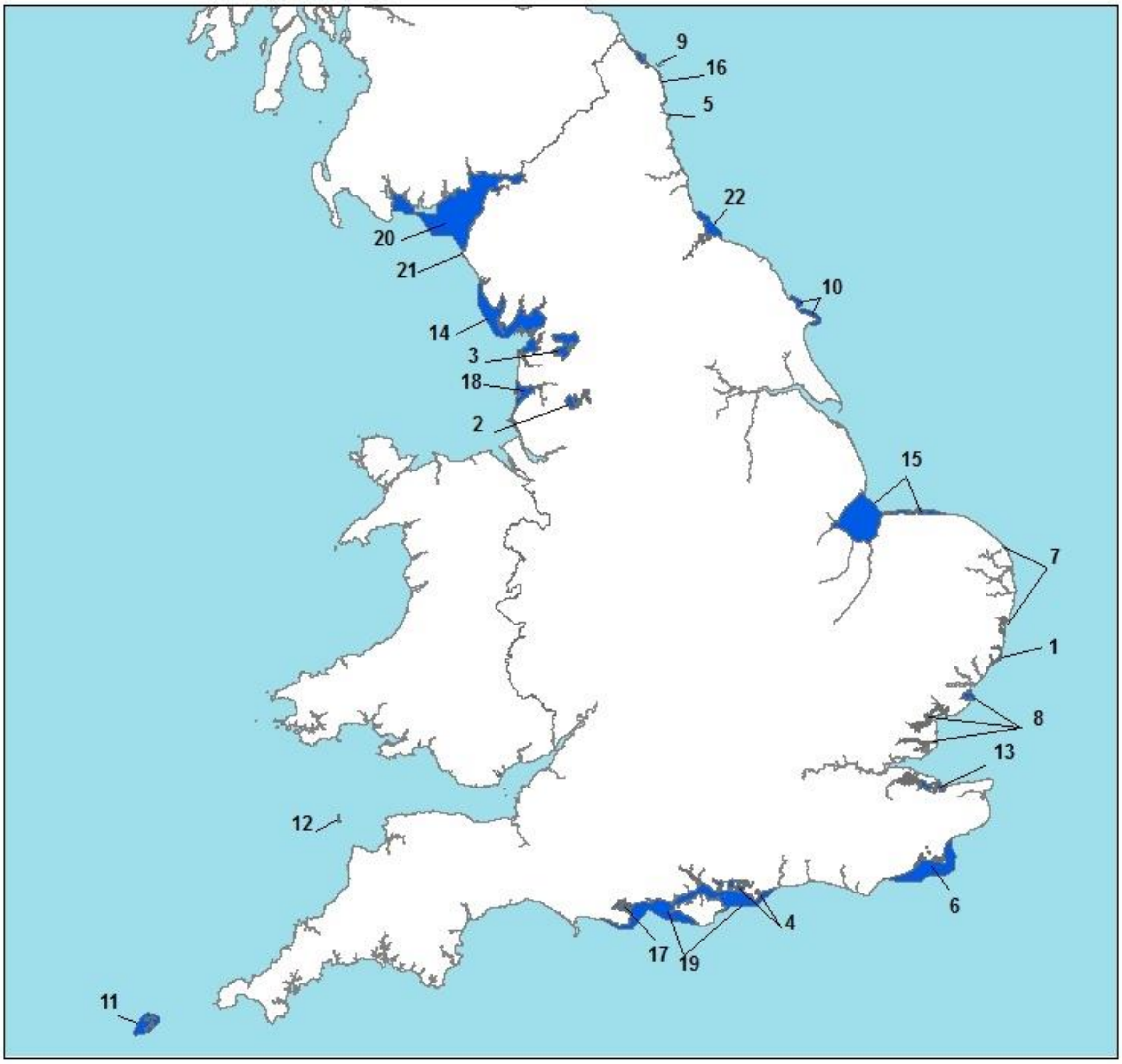
Site	Habitat type	Species with > 10% of England's breeding population at site
Alde-Ore Estuary (SPA)*	Soft coast	Lesser black-backed gull
Belmont Reservoir (West Pennine Moors SSSI) and Stocks Reservoir*	Inland	Black-headed gull
Bowland Fells (SPA)*	Inland	Lesser black-backed gull
Chichester and Langstone Harbours (SPA) and Pagham Harbour (SPA)*	Soft coast	Mediterranean gull**
Coquet Island (SPA)*	Offshore island	Roseate tern** Sandwich tern Common tern Arctic tern Atlantic puffin Common eider
Dungeness, Romney Marsh and Rye Bay (SPA)	Soft coast	Mediterranean gull Common tern
Minsmere - Walberswick (SPA) and Winterton-Horsey Dunes (SSSI)	Soft coast	Little tern

Site	Habitat type	Species with > 10% of England's breeding population at site
Essex estuaries: Hamford Water (SPA), Blackwater Estuary (SPA), Colne Estuary (SPA), and Crouch and Roach Estuaries (SPA)	Soft coast	Mediterranean gull
Farne Islands (SPA)*	Offshore islands	Atlantic puffin** European shag Sandwich tern Arctic tern Common guillemot Common eider
Flamborough and Filey Coast (SPA)*	Mainland cliffs	Northern gannet** Common guillemot** Black-legged kittiwake Atlantic puffin
Isles of Scilly (SPA)*	Offshore islands	European shag** Great black-backed gull** Manx shearwater Lesser black-backed gull
Lundy (SSSI)*	Offshore island	Manx shearwater** Razorbill
Medway Estuary (SPA) and The Swale (SPA)	Soft coast	Mediterranean gull
Morecambe Bay and Duddon Estuary (SPA)*	Soft coast	Common eider
North Norfolk Coast (SPA) and The Wash (SPA)*	Soft coast	Mediterranean gull Sandwich tern Common tern Little tern
Northumbria Coast (SPA) and Lindisfarne (SPA)	Soft coast	Arctic tern**
Poole Harbour (SPA)*	Soft coast	Mediterranean gull Yellow-legged gull**
Ribble and Alt Estuaries (SPA)*	Soft coast	n/a
Solent and Dorset Coast (SPA)*	Soft coast	Common tern
Solway Firth (SPA)*	Soft coast	n/a
St Bees Head (SSSI)*	Mainland cliffs	Black guillemot** Common guillemot
Teesmouth and Cleveland Coast (SPA)	Soft coast	Common tern

*site supporting over 10,000 breeding pairs of seabirds

**site supports over 50% of England's breeding population for this species

***sites are considered priority sites if they support over 10,000 pairs of breeding seabirds and/or over 10% of England's breeding population of any seabird species. Taken from Lock and others (2022). Site designations are given in brackets after site names. Special Protection Areas (SPAs) are assumed to be underpinned by Sites of Special Scientific Interest (SSSIs), so SSSI only stated when site is not an SPA**).**



Legend

1 Alde-Ore Estuary SPA
2 Belmont Reservoir (West Pennine Moors SSSI) and Stocks Reservoir
3 Bowland Fells SPA
4 Chichester and Langstone Harbours (SPA) and Pagham Harbour (SPA)
5 Coquet Island SPA
6 Dungeness Romney Marsh and Rye Bay SPA
7 Minsmere-Walberswick SPA and Winterton - Horsey Dunes SSSI
8 Essex estuaries: Hamford Water SPA, Blackwater Estuary SPA, Colne Estuary, SPA, Crouch & Roach Estuaries SPA
9 Farne Islands SPA
10 Flamborough and Filey Coast SPA
11 Isles of Scilly SPA
12 Lundy SSSI
13 Medway Estuary & Marshes SPA and The Swale SPA
14 Morecambe Bay and Duddon Estuary SPA
15 North Norfolk Coast SPA and The Wash SPA
16 Northumbria Coast SPA and Lindisfarne SPA
17 Poole Harbour SPA
18 Ribble & Alt Estuaries SPA
19 Solent and Dorset Coast SPA
20 Solway Firth SPA
21 St. Bees Head SSSI
22 Teesmouth and Cleveland Coast SPA

Scale (at A4): 1:3,750,000

Map produced on 19/10/2022 by M308130, Natural England.

Figure 6. Priority Sites for breeding seabirds in England. Sites are considered to be priority sites if they support over 10,000 pairs of breeding seabirds and/or over 10% of England's breeding population of any seabird species. Taken from Lock and others (2022).

The majority of these priority sites are on England's east and south coasts (14 out of 22, Figure 6), and most are soft coast sites (also 14 out of the 22, Table 8). It should be noted that several of these sites are of international importance for breeding seabirds, eg Bowland Fells may be the largest lesser black-backed gull colony in the world, and the Flamborough and Filey Coast SPA supports the largest colony of kittiwakes in the North Atlantic.

SPA Protection

SMP colony data on breeding populations (see Appendix 6 for methods) were mapped together with SPA boundaries to determine which colonies fall within the boundaries of a SPA (see Appendix 12, 'Protected Areas' for further details on SPA protection). The SMP-derived population sizes were then used to estimate the proportions of the breeding populations of each species supported by SPAs. Table 9 shows several species for which less than 75% of the breeding population in England is protected within a SPA (black-headed gull, great black-backed gull, herring gull, common gull, northern fulmar, European shag, great cormorant, Manx shearwater and black guillemot). There are very few black guillemot breeding in England (fewer than ten breeding pairs), at only one breeding site (St Bees Head) which is not a SPA. However, just 8% of England's breeding population of Manx shearwater (estimated at 6,087 pairs) currently breed at sites within SPAs (the Isles of Scilly SPA). Less than half of England's breeding population of common gull and great cormorant are estimated to currently breed at sites within SPAs.

Between 75 and 100% of the English breeding population of common tern, little tern, black-legged kittiwake, Mediterranean gull, razorbill and common guillemot are estimated to be protected by SPAs.

One hundred percent of the English breeding population of roseate tern, Sandwich tern, Arctic tern, yellow-legged gull, common eider, and northern gannet are estimated to breed at sites contained within SPAs, along with close to 100 % of the English breeding population of Atlantic puffin, European storm petrel, and lesser black-backed gull (excepting urban breeders).

Table 9. Percentage of England's breeding populations of seabirds estimated to be protected by SPAs, based on SMP data.

	Number of breeding sites in England	% English breeding population within SPA (*smallest to largest*)
Black guillemot	1	0
Manx shearwater	11	8
Common gull	11	41
Great cormorant	117	42
Northern fulmar	215	51
Herring gull*	387	51
European shag	118	68
Great black-backed gull	129	70
Black-headed gull	154	72
Common tern	190	79
Common guillemot	54	85
Black-legged kittiwake	68	85
Razorbill	81	87
Little tern	27	90
Mediterranean gull	41	93
Lesser black-backed gull*	132	97
European storm petrel	15	99
Atlantic puffin	19	99
Arctic tern	12	100
Northern gannet	1	100
Roseate tern	2	100
Yellow-legged gull	1	100
Sandwich tern	18	100
Common eider	4	100

*These species also have large breeding populations in urban areas that are not within SPAs

It is important to note that two species of gull, herring gull and lesser black-backed gull, also have substantial breeding populations in urban areas in England, which are not within SPAs. Table 9 does not include these urban colonies. The percentages of these two species breeding in SPAs in England are therefore likely to be considerably lower than those shown in Table 9.

Lock review

As part of the Action for Birds in England (AfBiE) partnership programme between Natural England and the RSPB, Lock and others (2022) conducted a review of England's seabird colonies and the pressures affecting them. This review included all 24 species listed in Table 3 and all sites where these species are known to regularly breed. This included SPAs with breeding seabirds as qualifying features, SSSIs with breeding seabirds as designated features, other sites of regional significance for breeding seabirds and sites which are known to have held significant numbers of breeding seabirds in the past (1960-2000). In total, 123 sites were included. These were further divided into 222 subsites, based on differences in land ownership and management. With the exception of herring gull and lesser black-backed gull (due to exclusion of urban sites), the sites included are thought to support the majority of England's breeding seabird populations for all species.

Data

Information on breeding seabird population sizes and pressures affecting breeding seabird populations was collected from site managers, wardens, and conservation officers involved with the management of the sites. The information gathered is necessarily subjective but can be considered to be qualitative data based on expert judgement given the unique familiarity of these contacts with the sites being reviewed. It is considered to be the best available evidence on pressures affecting England's breeding seabirds at their breeding sites.

Methods

For each of the 123 seabird breeding sites in England, information was gathered directly from site managers on the sizes of the breeding populations of each seabird species breeding at these sites, the dominant habitat type of each site, and the issues they believed to be negatively impacting breeding seabird populations at the site. The issues identified were categorised according to defined pressures based on the definitions of pressures used by Natural England. The numbers of sites affected by each of the pressures were calculated, and the proportions of England's breeding populations of each species affected by each pressure was calculated based on the estimated population sizes supported by affected sites. For more detailed information on the methods used by the Lock review see a summary in Appendix 4, or the publication Lock and others (2022).

Results of the Lock review

The Lock review identified the four most important pressures affecting England's breeding seabirds as: disturbance, predation and competition, invasive predators, and reduction in habitat (see Table 10). These results are presented in more detail in Appendix 5.

Table 10. The four most important pressures affecting England's breeding seabirds. Also shown are percentage of sites affected, number of species affected, and species for which over 50% of England's breeding population was estimated to be affected for each pressure.

Pressure	% of sites affected	Number of species affected	Species with >50% of breeding population affected
Disturbance	76%	18	Lesser black-backed gull Black-headed gull Mediterranean gull Roseate tern Little tern Sandwich tern Common tern Arctic tern Northern Gannet European shag Common guillemot Razorbill Black guillemot Atlantic puffin Common eider Northern fulmar
Predation and competition	56%	12	Mediterranean gull Black-headed gull Common gull Lesser black-backed gull Herring gull Sandwich tern Roseate tern Common tern Arctic tern Little tern Black guillemot Common eider
Invasive predators	6.5%	7	Manx shearwater European storm petrel European shag Roseate tern Atlantic puffin Arctic tern Razorbill
Reduction in habitat	52%	10	Mediterranean gull Black-headed gull Common gull

Pressure	% of sites affected	Number of species affected	Species with >50% of breeding population affected
			Lesser black-backed gull Sandwich tern Roseate tern Common tern Arctic tern Little tern Herring gull

IPENS SPA Site Improvement Plans review

Improvement Programme for England's Natura 2000 Sites (IPENS) was an EU LIFE funded project that ran between 2013 and 2015 led by Natural England in partnership with the Environment Agency. The aim was to develop understanding of the issues affecting the condition of Natura 2000 sites (SPAs and SACs) in England and what actions were required to improve the condition of these sites.

SIP data

As part of the IPENS project, Site Improvement Plans (SIPs) were developed for each of the Natura 2000 sites in England[7]. Each SIP aimed to provide a high-level overview of the priority issues (both current and predicted) affecting the condition of the features on the sites. The SIPs were developed by Natural England's Area Teams, based on evidence and knowledge at the time, with input from key local delivery bodies and staff working at the sites. The resulting information can therefore be considered to be a vulnerability assessment through expert judgement, but includes assessment of all features of the site, not just seabird features.

Most of the SIPs were drafted in 2014 and 2015. This was the first time that this information had been comprehensively and consistently collated for all of England's Natura 2000 sites, and to date remains the only such exercise. SIPs are still used by Natural England to inform delivery work relating to Natura 2000 sites.

To inform the recommendations for the ESCaRP, the SIP database was interrogated to identify priority issues for Special Protection Areas in England that have breeding seabird species as qualifying features.

[7] Improvement programme for England's Natura 2000 sites (IPENS) - GOV.UK (www.gov.uk) and Natural England Access to Evidence - Improvement Programme for England's Natura 2000 Sites (IPENS)

Method

A total of 28 SIPs were reviewed, covering 36 SPAs in England with ESCaRP species as a qualifying breeding feature. Each SIP recorded a list of 'issues' affecting the respective SPAs. The 'issues' listed were categorised according to wider 'pressure' definitions that correspond to the pressure definitions used for the rest of the ESCaRP (Appendix 1). It was then calculated how many of the SPAs were affected by individual pressures. For more details on the methods refer to Appendix 7

Results of the review of Site Improvement Plans

The numbers of English SPAs with breeding seabird features affected by each pressure according to a review of the SIPs are shown in Table 11. Disturbance was recorded as affecting all of the SPAs (100%). Reduction in availability, extent, or quality of supporting habitat was recorded as affecting 35 SPAs (97.2%), with coastal squeeze recorded as being a cause of the reduction at 25 SPAs (69.4%). Pollution was recorded as affecting 34 SPAs (94.4%). Reduction in availability or quality of food resources was recorded as affecting 33 SPAs (91.7%) for 32 of these (88.9%), commercial fisheries were recorded as a cause. Invasive species were recorded as affecting 27 SPAs (75%). Predation was recorded as affecting 17 SPAs (47.2%). Removal of target species was recorded for 14% of breeding SPAs and usually referred to deliberate taking of birds' eggs (especially gulls) and culling of large gull species. There was only one example of removal of non-target species, which was caused by bird strike.

Table 11. Number and percentage of English SPAs with breeding seabird features in England affected by each pressure according to review of SIPs

Pressure	Number of SPAs affected	Percentage of SPAs affected
Disturbance	36	100.0
Reduction in availability, extent, or quality of supporting habitat	35	97.2
Pollution	34	94.4
Reduction in availability or quality of food resources	33	91.7
Invasive Species	27	75.0
Predation	17	47.2
Removal of target species	5	13.9
Removal of non-target species	1	2.8

Sensitivity assessment

For details on the Sensitivity Assessments, including the methods, see Section 2. The methods are also published in Spencer and others (2022). This work includes sensitivity assessments with particular focus on pressures affecting breeding colonies. As with the other sensitivity assessments, the resulting output for each pressure, bird and season combination (the UoAs) was a sensitivity score of high, medium, low, not sensitive, or insufficient evidence, with a corresponding score for confidence in the assessment.

Sensitivity assessment results

The numbers of species scored as 'highly sensitive' at colony to each pressure are shown in Table 12.

Table 12. Numbers of species scored as 'highly sensitive' to pressures at colony

Pressure	Number of species scored as highly sensitive to pressure at colony
Introduction or spread of invasive non-indigenous species (INIS)	19
Removal of target species	17
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	11
Introduction of microbial pathogens	11
Litter	10
Increase of native competitor/predatory species	9
Removal of non-target species	7
Visual disturbance	7
Hydrocarbon & PAH contamination	7
Reduction in availability, extent, or quality of supporting habitat	7
Transition elements & organo-metal (eg TBT) contamination	5
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	4
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	3
Introduction of light	2

Pressure	Number of species scored as highly sensitive to pressure at colony
Above water noise	1
Introduction of other substances (solid, liquid or gas)	1

Vulnerability assessment

The results of the Lock review and the review of SIPs broadly support each other in identifying the key pressures affecting England's breeding seabirds as disturbance, predation, and reduction in the extent and quality of habitat. There were differences in the results when it came to reduction of food resources – this is discussed below (see 'other pressures'). Any discrepancies are likely due to the differences in the number of sites reviewed, methods, and focus of the reviews. As well as being more recent, the Lock review included a wider range of sites and focused on impacts to breeding seabird populations. The SIPs were produced in 2014 and 2015, only included Natura 2000 sites, and considered impacts to all features of those sites. The SIPs review therefore only included SPAs where breeding seabirds were qualifying features, while the Lock review also included sites for breeding seabirds that are not in SPAs.

While the sensitivity scores do not factor in the actual exposure of species to pressures, they do provide an indication of how vulnerable species could be if exposed to certain pressures. These scores were therefore considered and also broadly support the results from the Lock review and the review of SIPs. Of interest were the high number of 'highly sensitive' scores attributed to 'introduction of microbial pathogens'. The sensitivity scoring, Lock review and SIPs review were all undertaken before the summer of 2022, when highly pathogenic avian influenza (HPAI) caused mass mortality of seabirds at breeding colonies in England. Due to these impacts, and using expert judgement, disease is now included as one of the key pressures affecting England's breeding seabirds. This is discussed in the section 'Other pressures'.

Important pressures affecting England's breeding seabirds

The results of the three assessment methods are summarised in. For more detail, Appendix 8

Table 13. Important pressures identified as affecting England's breeding seabirds through each assessment method. X represents the pressure was identified as important in the assessments. Empty cells indicate that the pressure was not identified as important.

Pressure	Lock review	IPENS SIP	Sensitivity Assessment
Disturbance	X	X	X
Predation	X	X	X
Invasive species	X	X	X
Reduction in habitat	X	X	X
Reduction in food resources		X	X
Pollution/litter		X	X
Removal of target species			X
Introduction of microbial pathogens			X

5. Impacts of climate change on England's seabird populations

Climate change is considered to be one of the main drivers of decline in seabird populations, both in the UK and globally (Daunt & Mitchell 2013, Dias and others 2019, MCCIP 2020). The effects of climate change on the UK's marine and coastal environments are already evident, and these impacts are predicted to continue and increase for the foreseeable future, regardless of the success of attempts to reduce emissions – although the severity of future impacts may be lessened if emissions are reduced (MCCIP 2020, Pearce-Higgins 2021, IPCC 2022b). Further declines in UK seabird populations have been forecast due to these predicted future impacts (Russell and others 2015, Pearce-Higgins 2021).

This section summarises the key mechanisms by which climate change affects marine ecosystems in general and seabird and marine waterbird populations in particular. It includes the effects of climate change on seabirds via prey availability, extreme weather events, sea level rise, spread of invasive non-native species (INNS), and disease outbreaks. This information is used to understand which species will be most impacted, and to take into consideration climate change effects in the development of ESCaRP recommendations (Figure 7). Full details of the review is presented in Appendix 9.

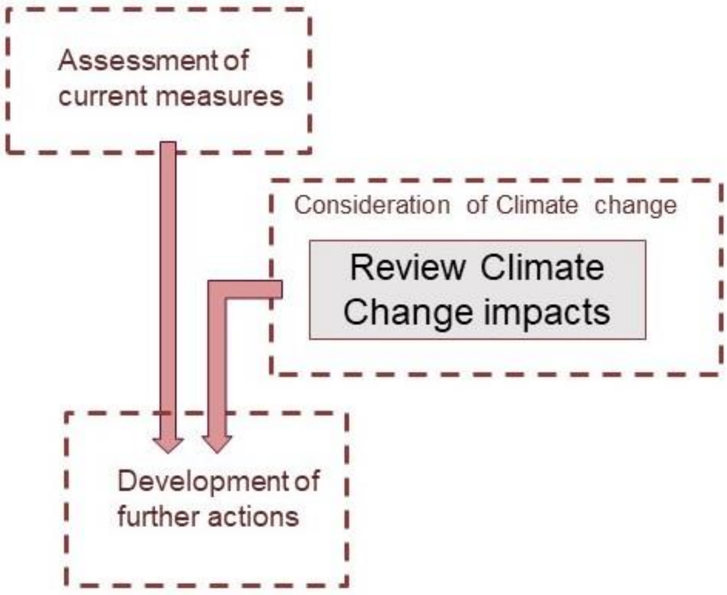


Figure 7. Process to take impacts of climate change into consideration.

Climate change review methods

References were searched for using Google Scholar and search terms included: “species name (ESCaRP species, common name or scientific name) + climate change”, “genus (scientific genus of each of the ESCaRP species + climate change”, “seabirds + climate change” and “sandeels + climate change”. Additional references were suggested by colleagues and fellow researchers. References were included when they related to climate change impacts on ESCaRP species or species closely related to ESCaRP, whatever the geographic location of the study.

The impacts on seabird species caused by human reactions to climate change (eg changes in fishing activity or recreational activity, renewable developments) were not included.

Impacts of climate change on seabirds

Climate change affects seabirds and waterbirds in England in a large number of ways, but the key mechanisms impacting marine ecosystems are: increased air and water temperatures; increased frequency and severity of extreme weather events; sea level rise; increased stratification of the water column; changes in ocean circulation; ocean deoxygenation, and ocean acidification. More detail is provided about each of these in Appendix 9.

Impacts of climate change on seabirds via impacts on marine ecosystems

One key climate impact pathway for seabirds is through changes to their food supply (Grémillet & Boulinier 2009, Daunt & Mitchell 2013, Furness 2016, Dias and others 2019, Mitchell and others 2020, Johnston and others 2021). This is the result of climate-driven physical changes impacting marine organisms at every trophic level, including the abundance and distribution of phytoplankton, the primary producer of marine ecosystems (Grémillet & Boulinier 2009, IPCC 2022b, Johnston and others 2021) and copepods, an important prey species for many fish (Frederiksen and others 2007, Elliot and others 2015, MCCIP 2020). Fish are affected by these changes at lower trophic levels, with trophic mismatches between fish and plankton abundance leading to fish recruitment (Capuzzo and others 2017, IPCC 2022b). In addition, increases in predatory species, such as jellyfish, add to pressures on lower trophic organisms (Daunt & Mitchell 2013, IPCC 2022b). Extreme temperature events like marine heatwaves (MHW) can cause mass mortalities of marine organisms and have been associated with the harmful algal blooms (HABs, Jones and others 2017, IPCC 2022b). MHW can cause massive reductions in phytoplankton productivity, leading to reductions in quality and quantity of forage fish, thereby causing mass mortality events in seabirds (Jones and others 2018, Piatt and others 2020).

The effects of climate change at lower trophic levels amplify up marine food webs and result in changes to the distribution, abundance, availability and quality of the forage fish species relied upon by seabirds as prey (Barrett and others 2012, Furness 2016, Pearce-Higgins 2021, IPCC 2022b). Survival and reproductive success of seabirds is affected by these changes to prey (Sandvik and others 2012, Furness 2016, Pearce-Higgins 2021). If peaks in prey abundance change in their timing, trophic mismatches can have disastrous effects (Grémillet & Boulinier 2009, Daunt & Mitchell 2013, Mitchell and others 2020).

A more thorough review of the impacts of climate change on marine ecosystems and seabird food supply, including sandeels in the North Sea, is provided in Appendix 9.

Effects of extreme weather on seabirds

High winds have been shown to affect seabird ability to forage effectively and to negatively affect breeding success, leading to widespread breeding failures (Furness 2016, Mitchell and others 2020, Johnston and others 2021). They can blow cliff-nesting adults off their nests, exposing eggs and chicks, and lead to storm swells washing nests off cliff faces or flooding low lying colonies (Johnston and others 2021, Pearce-Higgins 2021). Winter storms have been shown to increase adult mortality, body condition and reproductive success (Clairbaux and others 2020, Mitchell and others 2020), and they can lead to mass mortality events (Louzao and others 2019).

Heavy rainfall during the breeding season can lead to flooding of nesting burrows for species such as Atlantic puffin and Manx shearwater, reducing breeding success (Furness 2016, Johnston and others 2021). It can also chill eggs and chicks, leading to breeding failures (Mitchell and others 2020). In some cases it might lead to cliff erosion which could affect breeding habitats of cliff nesting species (Morecroft & Speakman 2015, Natural England & RSPB 2020). Drought conditions, on the other hand, can reduce freshwater inflow to estuaries, which can lead to eutrophication and HABs.

Heatwaves can lead to overheating of individuals while attending nests (Furness 2016, Johnston and others 2021, Pearce-Higgins 2021).

A more thorough review of the effects of extreme weather events on seabirds is provided in Appendix 9.

Effects of sea-level rise

Low lying coastal habitats, such as sand and shingle beaches, are vulnerable to habitat loss and increased flooding through sea level rise (Miles & Richardson 2018, Natural England & RSPB 2020, IPCC 2022b). Ground-nesting seabirds such as terns and gulls are therefore increasingly vulnerable to reduced breeding success through flooding and complete loss of breeding habitat (Dias and others 2019, Johnston and others 2021, Pearce-Higgins 2021).

A more thorough review of the impacts of sea level rise on seabirds in provided in Appendix 9.

Effects of invasive non-native species, pathogens and parasites on seabirds

Although not primarily a climate change issue, the spread and establishment of invasive non-native species (INNS; also known as invasive non-indigenous species (INIS) and invasive alien species (IAS)) is a growing problem worldwide and climate change is thought to facilitate the spread and establishment of INNS by creating more favourable habitat conditions (Ziska & Dukes 2014, Cuthbert & Briski 2021). Similarly, risks of wildlife disease are exacerbated by climate change by altering ranges and enhancing the growth and persistence of pathogens, parasites, vectors, and hosts (Elliot and others 2015, Dennis & Fisher 2018, Dias and others 2019, Hofmeister & Van Hemert 2018, Mitchell and others 2020, Hakkinen and others 2022). Higher temperatures and other environmental stressors may also make individuals more susceptible to disease and parasitism (Mitchell and others 2020, IPCC 2022b). Recent increases in the incidence and severity of highly pathogenic avian influenza (HPAI) outbreaks in wild birds, with devasting effect, have also been linked to climate change (Mu and others 2014, Lee and others 2020).

A more thorough review of the effects of climate change on the spread and establishment of INNS and pathogens is provided in Appendix 9.

Vulnerability of England's seabird species to climate change impacts

The impacts of climate change on individual species are very difficult to assess or predict. Climate change impacts may be direct or indirect, may interact with each other in complex fashion, and are difficult to disentangle from other pressures on populations (Mitchell and others 2020, Hakkinen and others 2022, IPCC 2022b). In addition, despite seabirds being a relatively well-studied group of organisms, there is still a shortage of comprehensive long-term datasets that allow detailed interpretation of drivers of population change (Furness 2016, Fayet and others 2021, Johnson and others 2021, see Section 4). For many species, data are lacking to make an informed assessment of vulnerability to climate change impacts. Most predictions for seabirds have been done using climate envelope modelling, which are subject to certain caveats, assumptions, and uncertainties (Russell and others 2015). These predictions are limited by evidence gaps and do not generally factor in impacts such as habitat loss due to sea level rise. There is more information available for some species than for others.

Certain factors are generally considered to increase risk, which include aspects of foraging behaviour, foraging range, and extent of migratory behaviour (Johnston and others 2021, Pearce-Higgins 2021). Surface-feeders, such as black-legged kittiwakes, are thought to be more affected by indirect impacts on the abundance and availability of prey (Mitchell and others 2020, Johnston and others 2021, IPCC 2022b), while diving species may be more severely affected by stormy weather (Johnston and others 2021). Specialist feeders are more vulnerable than those with a more generalist diet that may find it easier to shift to other prey items (Furness 2016). Long-distance migrants may be more vulnerable as they are exposed to impacts of climate change throughout their range (Johnston and others 2021). The extent to which a species is capable of dispersing to adapt its range to changing conditions is likely to be key to its climate change resilience, but unfortunately very little is known about this aspect of most species' biology (Russell and others 2015, Johnston and others 2021). Impacts are also likely to vary by geographical region, in ways that are not fully understood. For example, climate change impacts on prey appear to be greater in the North Sea than in other UK waters, while seabirds breeding on Britain's western coasts may be more vulnerable to stormy weather (MCCIP 2020, Newell and others 2015). Appendix 10 sets out species accounts bringing together best available information.

Measures to address the impacts of climate change on England's seabirds

The first and most obvious measure is to reduce carbon emissions. Even small reductions in carbon emissions and global temperature increases could have large benefits for seabird conservation (Russell and others 2015, IPCC 2022). The government has obligations to reduce carbon emissions under the UK Climate Change Act (2008), but current national and international commitments fall far short of requirements to achieve net zero by 2050 (UN Net Zero Coalition 2022). As this widespread issue is covered more than adequately elsewhere (eg UN Net Zero Coalition 2022), no further detail on the need for reduction in carbon emissions or ways of achieving this is provided here.

Based on current evidence, impacts of climate change on seabirds in the UK appear to be varied, but potentially severe and likely to increase Appendix 9 and Appendix 10. While benefits of climate change are predicted for some species (especially marine waterbirds in winter) and a mixture of risk and benefit for others, the majority of England's seabirds are predicted to decline in response to future climate changes. Furthermore, there are still major evidence gaps relating to our understanding of these impacts and thus our ability to predict and mitigate against them. Climate change impacts will therefore need to be factored into all conservation actions, research, and impact assessments relating to seabirds. The impacts of climate change also add to, and may exacerbate, the impacts of other pressures on seabird populations. Reducing the impacts of these other pressures may be the most viable option for mitigating climate change impacts on seabirds.

Suggested measures are presented within the recommendations (section 7), focused mainly on mitigating and improving understanding of the impacts of climate change (current and predicted) on England's seabird populations.

6. Existing species protection and assessment of existing measures

An overview of existing measures, drivers for species protection, relevant legislation and site protection (with associated processes and safeguards) is provided in Appendix 11 and Appendix 12.

Method to assess existing measures

The top-ranked pressures from the vulnerability assessment (Table 7), together with those from the colony assessment (Section 0) were analysed for adequacy and sufficiency of existing measures (Table 14). Pressures to which seabirds and marine waterbirds have a high vulnerability are considered further in this section, and the sufficiency of existing measures to address these pressures is assessed (Figure 8).

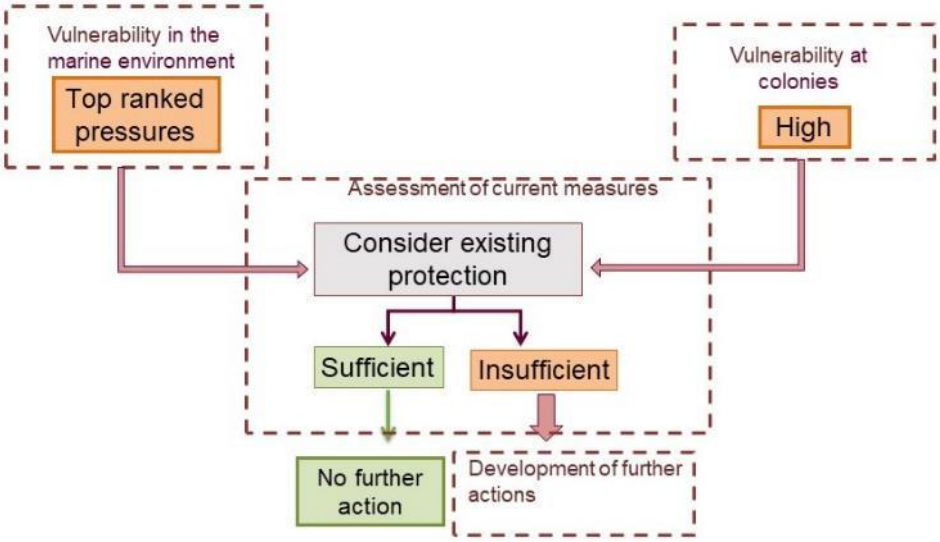


Figure 8. Process to consider existing protection for pressures where birds have a high vulnerability.

The reviews of existing measures for the key pressures are listed in order of the pressure's considered level of importance in, negatively affecting seabirds based on ranking of vulnerability scores for marine pressures (Table 7), key pressures at terrestrial breeding locations (Section 3) and expert judgement.

Table 14. Most important pressures from marine vulnerability assessment and breeding site vulnerability assessment, ordered by pressure importance from expert judgement.

Key pressures	Ranking from marine vulnerability assessment	Ranking from vulnerability at breeding sites assessment
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	5	4
Removal of non-target species	2	
Visual Disturbance	10	1
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	6	
Introduction or spread of invasive non-indigenous species (INIS)		2
Removal of target species	1	
Litter	4	5
Introduction of microbial pathogens	7	
Hydrocarbon & PAH contamination	3	5
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	9	5
Transition elements & organometal (eg TBT) contamination	8	
Permanent and/or irreversible change in the extent or quality of available supporting habitat		3

A list of the key legislation associated with protecting seabirds and marine waterbirds from each pressure's related impacts and threats was created, along with the mechanisms through which the legislation works to protect the birds Appendix 11 The lists of legislation and mechanisms has been drawn from the UK Marine Strategy (UKMS) Part 3 (Defra 2015). Any missing legislation or mechanisms deemed relevant has been identified and added through expert judgement informed largely by Natural England's response to the 2021 consultation on the UKMS Part 3.

The effectiveness of the legislation and associated mechanisms (including their monitoring) has been assessed using expert judgement. Our judgement of effectiveness has been informed largely by Natural England's response to the Marine Strategy Phase 3 consultation, as well as expert input from Natural England specialists.

The review of existing measures for each pressure follows a comprehensive structure to ensure the review is clear (Table 15). Each pressure is given a score for the effectiveness of the existing measures and for the certainty of the effectiveness score (Table 16).

Table 15. Structure of reviews of existing measures for key pressures

Sub-heading	Description
Impact/threat	Route of effect of pressure on seabirds
Key species	Key species vulnerable to the pressure (from vulnerability assessment where applicable, or based on published evidence)
Relevant activities	List of anthropogenic activities causing the pressure
UKMS and OSPAR indicators	Relevant indicators for the pressure
Existing measures	List of existing measures and comments on effectiveness where this can be assessed
Proposed measures	List of proposed measures that are guaranteed to be implemented
Relevant legislation and frameworks	Reference numbers of legislation relevant to the pressure (□)
Conclusion of measures' effectiveness	Conclusion of effectiveness and certainty for the measures related to the pressure

Table 16. Scores of effectiveness and certainty for existing measures

Attribute	Score	Definition
Effectiveness	Red	Measures are considered insufficient and/or not working or applied correctly
Effectiveness	Amber	Measures are in place but not considered appropriate in all respects/not applied sufficiently
Effectiveness	Green	Measures in place and are working or applied appropriately/correctly
Certainty	Certain	Confident in the Effectiveness score due to suitable available data/monitoring
Certainty	Uncertain	Not confident in the Effectiveness score due to lack of suitable available data/monitoring.

Review of existing measures for important pressures

A summary of the outcomes of the review of existing measures for the important pressures identified by the vulnerability assessments is provided in Table 17. The full assessment is provided in Appendix 13 following the structure in Table 15.

Table 17. Summary of the review of existing measures for important pressures.

Key pressures	Measures	Effectiveness (confidence)	Conclusion
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	Existing measures: • Fisheries Act 2020 and Joint Fisheries Statement (2022) [8] • UK Marine Strategy • Spatial closures of forage fish fisheries • Marine Protected Areas (MPAs) Network • Annual bilateral and multilateral fisheries negotiations: The Common Fisheries Policy, The Trade and Co-operation Agreement and Fisheries Negotiations, Fisheries framework Agreements (with Norway and Faroe Islands), UK membership of Regional Fisheries Management Organisations (RFMOs) • Technological innovation and implementation Proposed: • Highly Protected Marine Areas (HPMAs, pilot stage) • No legal mechanism for Remote Electronic Monitoring (REM) but used as a research and evidence tool. • Plans for a real-time closure system across the UK, that can put in place fishing restrictions to reduce impact on unwanted catches or sensitive species including real time closures, live closed areas, commercial impact zones, seasonal closed areas, juvenile real time closures.	**Red** **(certain)**	Although certain measures may mitigate impact at local level, collectively measures are considered inadequate to fully mitigate the pressure for seabirds.
Removal of non-target species	Existing measures: • Marine Protected Areas (MPAs) Network • Planning consents (aquaculture)	**Red** **(uncertain)**	Limited evidence on understanding of bycatch mortality for seabirds. Collectively measures are

[8] Joint_Fisheries_Statement_JFS_2022_Final.pdf (publishing.service.gov.uk)

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	• Fisheries Act (2020) • UK Marine Strategy • Local byelaws by MMO, EA, IFCAs • UK Protected Species Bycatch Monitoring Programme • OSPAR Candidate Indicator on seabird bycatch Proposed: • Implementation of the Marine Wildlife Bycatch Mitigation Initiative • Future MPAs • Highly Protected Marine Areas (HPMAs, pilot stage)		considered inadequate to fully mitigate the pressure.
Visual Disturbance	Existing measures: • Wildlife and Countryside Act 1981 (as amended) - Schedule 1 species protected from disturbance • Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA). • Marine Protected Areas (MPAs) Network • Local partnerships to reduce disturbance, Marine Wildlife Watching Code (Thanet Coast Project) • European Marine Site (EMS) Management Schemes. • Operation Seabird (RSPCA, MMO, relevant Police forces, 2021) • Voluntary schemes/codes to reduce disturbance. Proposed: • Highly Protected Marine Areas (HPMAs, pilot stage)	**Amber** **(certain)**	There are regulatory protections from anthropogenic disturbance activities, though many measures are voluntary and therefore the measures are not considered sufficient to fully mitigate the pressure on land and at sea.
Collision ABOVE water with static	Existing measures: • Marine Protected Areas (MPAs) Network	**Amber**	Due to the uncertainty around suitable

Key pressures	Measures	Effectiveness (confidence)	Conclusion
or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	• Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA). • Offshore Wind Leasing Round 4 plan-level HRAs • Strategic research: Offshore Wind Enabling Actions Programme (OWEA) and Offshore Wind Evidence and Change (OWEC) programme • Provision of discretionary and statutory advice on Marine Renewables development by Natural England • OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations • Marine Plans (10 across England) • UK Marine Policy Statement • Offshore Wind Sector Deal • Regional Advisory Groups Proposed: • Implementation of Net Zero Strategy: Build Back Greener (2021) and British Energy Security Strategy (BESS, 2022) • Highly Protected Marine Areas (HPMAs, pilot stage)	**(certain)**	compensation measures for collision mortality, the measures do not fully mitigate the pressure.
Introduction or spread of invasive non-indigenous species (INIS)	Existing measures: • Marine Protected Areas (MPAs) Network • LIFE Island Biosecurity Project (Biosecurity for Life) • The UK Marine Strategy • Invasive Species Action Plans • Non-native species risk assessments • Pathway Action Plans • Great Britain Non-native Species Strategy	**Red** **(certain)**	Current measures are voluntary and not enforceable. The measures are not considered able to fully mitigate the pressure.

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	• Wildlife and Countryside Act 1981 (as amended) - England & Wales Species Control Agreements and Species Control Orders s14(4A) and Variation of schedule 9 (2010) • Marine biosecurity plans • Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA) and SSSI consents. • Marine Plans (10 across England) • National Islands Plan (and Implementation Strategy) • Water Framework Directive (WFD) Proposed: -		
Removal of target species	Existing measures: • Wildlife and Countryside Act 1981 (Section 16(1)) - General licencing scheme for the removal of protected bird species • Environmental assessments leading to a licence (conditioned as deemed appropriate): Habitat Regulations Assessment (HRA). • Marine Protected Areas (MPAs) Network Proposed: -	**Green** **(certain)**	Current measures are sufficient to mitigate the pressure.
Litter	Existing measures: • The UK Marine Strategy • OSPAR Indicators and Regional Action Plans on Marine Litter 2 (2022) • Industry voluntary schemes: Operation Clean Sweep (Industry's voluntary pellet reduction scheme); Industry Code of Practice on Sky Lanterns (2014); Responsible Fishing Vessel Standard	**Red** **(uncertain)**	Majority of measures are voluntary or rely on the end-user to recycle, where legislation does exist enforcement is often minimal due to lack of funding or lack of evidence, eg for general littering and fishing gear / waste disposal. Therefore

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	• General public voluntary schemes: Great British Spring Clean, Great British Beach Clean and local beach clean schemes and volunteers; Ecoschool programmes on litter, marine litter and plastic pollution. • Schemes to remove litter at sea • Waste Prevention Programmes for England (2013) including: Keep Britain Tidy, Litter Prevention Commitment in England; National Fly-tipping Partnership Framework • Litter Strategy for England 2017; Code of Practice on Litter and Refuse (CoPLAR) (England, updated 2019) • The Resources and Waste Strategy for England (2018) (25 Year Environment Plan) • IMO Action Plan for marine Litter from Ships (2018) • London Convention 1972 (Convention on the Prevention of Maritime Pollution by Dumping of Wastes and Other matter) and 1996 London Protocol • Plastic packaging tax (April 2022) • G20 Osaka Blue Ocean Vision: G20 Implementation Framework for Actions on Marine Plastic Litter • Plastic incorporated in nests monitored in UK seabirds, coordinated by Environmental Research Institute, University of Highlands and Islands. • Plastic particles in fulmar stomachs in the North Sea are monitored for OSPAR Plastic Particles in Fulmars by BTO and Defra. • Beachwatch project has been collecting data on marine litter on beaches since 1994 (organised by Marine Conservation Society). • Marine litter monitoring: collecting data on seabed macro-litter, microplastic on the sea surface and in sub-tidal marine sediment has been undertaken, collated and analysed by Cefas and Defra • Monitoring of impacts on seabirds through Beached bird survey. (RSPB Beached Bird Surveys, North-East Beached Bird Surveys). Proposed:		measures do not fully mitigate the pressure.

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	• Extended Producer Responsibility and Deposit Return Scheme • UK signatory to the United Nations Environment Program (UNEP) on Global Plastic Pollution Treaty		
Introduction of microbial pathogens	Existing measures: • Notifiable avian disease (NAD) control strategy • Quarterly GB avian disease surveillance and emerging threats reports • Register of captive birds • Protection and Surveillance Zones around captive birds or commercial property infected with Avian Flu. • Avian Influenza Prevention Zone (AIPZ) across Great Britain. • Import of Captive Birds, Import Information Note (IIN) CBTC/2 Proposed: -	**Red** **(uncertain)**	No measures currently monitor disease outbreaks in wild bird populations, therefore measures are not sufficient to fully mitigate the pressure.
Hydrocarbon & PAH contamination	Existing measures: • The UK Marine Strategy • Environmental Impact Assessment Regulations • OSPAR's HASEC (Hazardous Substances and Eutrophication Committee) • OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA) • UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020) • Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF) • Manual on Oil Pollution (Section 1) from IMO • OSPAR Guidelines for Dredged Materials • RSPCA rehabilitation centres	**Amber** **(uncertain)**	Monitoring cannot conclude that current measures adequately mitigate the pressure.

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	• Industry standards on oil spill (including Oil Pollution Emergency Plans (OPEPs)) • Monitoring for UKMS and OSPAR Indicators on contaminants covers a wide range of organisms, habitats and contaminants • Monitoring of impacts on seabirds through Beached bird survey. (RSPB Beached Bird Surveys, North-East Beached Bird Surveys). Proposed: -		
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	Existing measures: • The UK Marine Strategy • Environmental Impact Assessment Regulations • Environmental Permitting Regime • OSPAR's HASEC (Hazardous Substances and Eutrophication Committee) • OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA) • UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020) • Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF) • OSPAR Guidelines for Dredged Materials Proposed: -	**Amber** **(uncertain)**	Monitoring for GES is limited in geographical range and no monitoring or targets for pharmaceuticals exist. Therefore, it is uncertain that measures for synthetic contaminants are adequate to fully mitigate the pressure.
Transition elements & organometal (eg	Existing measures: • The UK Marine Strategy • Environmental Impact Assessment Regulations	**Amber** **(uncertain)**	The sampling points for some contaminants in biota are too sparsely distributed to be sure of the

Key pressures	Measures	Effectiveness (confidence)	Conclusion
TBT) contamination	• Environmental Impact regulations • OSPAR's HASEC (Hazardous Substances and Eutrophication Committee) • OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA) • UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020) • Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF) • OSPAR Guidelines for Dredged Materials • Monitoring for UKMS and OSPAR Indicators on contaminants covers a wide range of organisms, habitats and contaminants Proposed: -		effectiveness of the measures.
Permanent and/or irreversible change in the extent or quality of available supporting habitat	Existing measures: • Marine Plans (10 across England) • UK Marine Policy Statement • Local Development Plans • Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Strategic Environmental Assessment, Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA). • Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites, Special Areas of Conservation (SACs). • Shoreline Management Plans • UN Decade of Ecosystem Restoration	**Amber** **(uncertain)**	There is uncertainty around suitable compensation measures for loss of habitat, particularly in the marine environment, the measures do not fully mitigate the pressure.

Key pressures	Measures	Effectiveness (confidence)	Conclusion
	Proposed: • Marine Biodiversity Net Gain • Highly Protected Marine Areas (HPMAs, pilot stage)		

7. ESCaRP vision for seabird conservation

The vision of the ESCaRP is that England supports thriving seabird colonies free of significant disturbance and predation, where habitats offer sufficient flexibility in nest site choice and biosecurity efforts limit the impact of pathogens. Breeding seabirds can find plentiful high-quality food within foraging range of their colonies, and seabirds and marine waterbirds in the non-breeding season can find the same feeding opportunities away from the nest. In breeding and non-breeding seasons, the impact of human activity will be ecologically minimal. Underpinning all this will be a well-funded, secure system of knowledge gathering that allows evidence-led decision making.

Recommendations for seabird recovery can be divided into four categories: **feeding**; **breeding**; **surviving**; and **knowledge**.

Feeding

Seabirds (hereafter taken to include marine waterbirds where relevant) require plentiful available high-quality food within foraging range of nest sites, and in the wider seas when not breeding, to avoid starvation for themselves and their offspring. Seabird recovery is therefore highly dependent on food availability. Most seabirds rely upon small 'forage' fish (such as gadoids, sandeels, clupeids, etc), although others also consume invertebrates (such as shellfish, crustaceans, cephalopods and various species of worms). Implementing recommendations relating to **ecosystem approaches to fisheries management** and **ensuring sensitive management and restoration of benthic habitats within MPAs** would ensure seabirds are able to find and consume sufficient food to survive and produce enough young to reverse negative trends.

Breeding

Seabird colonies in England have huge importance for both the globally significant populations they support, and for people who are drawn to the spectacle of 'seabird cities' and the sights and sounds they bring. Producing more chicks that survive to adulthood is a crucial part of seabird recovery and pressures on seabird nest sites must be lifted. Ensuring **islands are free of invasive predators** is a proven method of allowing burrow- and cliff-nesting seabird populations to recover over relatively short timeframes, but **habitats must also be restored** where appropriate, especially for species (including terns) nesting on soft coasts that are prone to coastal squeeze and coastal erosion. Sites must also be resourced to carefully **manage and limit disturbance and predation** from native predators so that seabirds can nest, breed and rear their young. Finally, measures to **reduce the emergence, spread and impacts from pathogens and parasites** are increasingly important given the devastating and rapid impact diseases like HPAI can have on seabird populations of many species.

Surviving

The reproductive strategy of most seabirds is to produce few (1 – 3) eggs each year over a comparatively long lifespan (for instance, northern gannets live on average for about 17 years, but some can reach 37). For seabird populations to recover, it is important that human activities driving mortality are managed so that seabirds can survive to breed for their full lifespan. There are various mechanisms and initiatives that can achieve this, largely through spatial management or mitigation measures. **Minimising and, where possible, eliminating bycatch from fisheries** is one such measure, as seabirds can drown in nets (eg, auks, European shags) or on long-lines (eg, northern fulmars). **Strengthening use of the mitigation hierarchy** so that all activities consider how best to avoid and reduce impact is vital. Sometimes this may mean support to develop mitigation measures. **Reducing marine litter** and **contaminants** would benefit seabirds and marine ecosystems more generally. Finally, where crucial sea areas are not managed in line with seabird recovery, **reducing pressures to drive marine habitat restoration** may be necessary, and increased site protection could even be required where evidence suggests this is necessary for seabird recovery.

Knowledge

The implementation of the ESCaRP should continue to be informed by the best scientific information available. There is therefore a need to gather data on various evidence gaps, and to monitor and evaluate the success of interventions implemented through the recovery pathway. We must **better understand relationships between seabirds and their prey**, and how they interact with the marine ecosystem, especially as the climate changes. At breeding colonies, we need to ensure **England has long-term monitoring secured at key colonies**, so that decision-making is not solely based on data from other UK countries which may not represent English trends. We also urgently need to **improve our understanding of disease transmission and impact** so that we can minimise the often drastic and upsetting seabird mass mortality events witnessed with HPAI. Away from nest sites, **a system of quantifying cumulative impact** from different sectors would enable better spatial management of activities and could be informed by **improved knowledge of bycatch** rates and distribution, and **improved understanding of other mass mortality impacts**, such as seabird wrecks. Finally, enabling **strategic data collection for baseline and impact monitoring** would promote efficient use of resources and targeted, question-focused knowledge gathering. Of course, all these activities require **co-ordinated and secure funding** to be of long-term benefit.

A different future for England’s seabirds

This report has highlighted the growing pressures facing seabird and marine waterbird populations in England and has identified a series of measures for urgent implementation to reduce them. Our seabird populations are amongst the crown jewels of our wildlife, of international significance, providing essential roles in marine and terrestrial ecosystems, and providing enjoyment and wonder to millions of people. The health of our seabird populations can reveal much about the marine ecosystem. Restoring them will make a crucial contribution to legislative targets (eg Good Environmental Status in the UK Marine Strategy; potentially species targets within the Environment Act 2021; potentially Net Gain as part of sustainable development), conservation targets (eg within protected sites or as part of wider biodiversity recovery and international obligations) and people’s engagement with nature.

Implementing the recommendations from the ESCaRP could point to a different, more resilient future for seabirds in England. This is urgently needed to allow our globally significant populations to recover and be buffered against the increasing pressures they experience, including disease and climate change effects. ESCaRP recommendations offer a way to realise this vision.

8. Recommendations

Process of forming recommendations

Recommendations were created for pressures that had the greatest number of high to medium vulnerability scores across species and seasons in the marine environment, high vulnerability at terrestrial breeding sites and insufficient existing measures to mitigate the pressure for seabirds in England and English waters (
Figure 9).

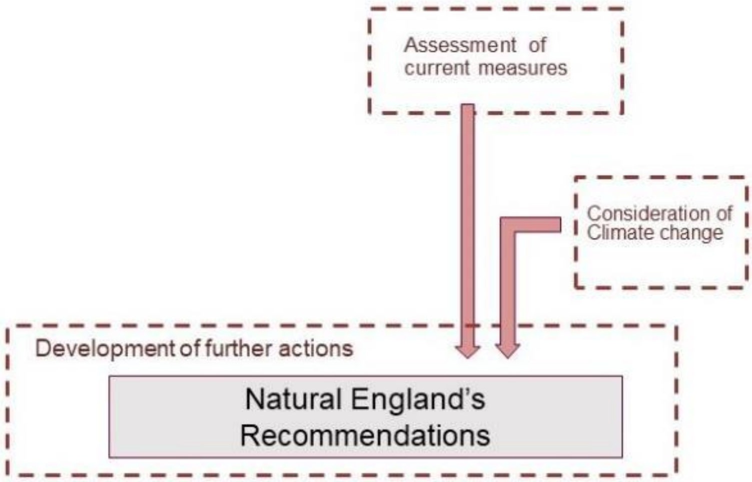


Figure 9. Process to develop recommendations.

Pressures were ranked separately for the marine and breeding site assessments (Table 18). Equal ranked pressures were given a tied rank.

Table 18. Most important pressures from marine vulnerability assessment, breeding site vulnerability assessment and review of existing measures, ordered by pressure importance from expert judgement. Empty cells indicate the pressure was not the most important in the assessment.

Key pressures	Ranking from marine vulnerability assessment	Ranking from vulnerability at breeding sites assessment	Insufficient existing measures (Red/Amber)
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	5	4	Red
Removal of non-target species	2		Red
Visual Disturbance	10	1	Amber
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	6		Amber
Introduction or spread of invasive non-indigenous species (INIS)		2	Red
Litter	4	5	Red
Introduction of microbial pathogens	7		Red
Hydrocarbon & PAH contamination	3	5	Amber
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	9	5	Amber
Transition elements & organometal (eg TBT) contamination	8		Amber
Permanent and/or irreversible change in the extent or quality of available supporting habitat		3	Amber

A weight of evidence approach has been used to form the recommendations included in the ESCaRP (Figure 10). The evidence used comprised of five key sources:

- Scores for pressures and species from the vulnerability assessment at sea (section 3).

- Assessment of pressures that have detrimental impacts at seabird colonies in England (section 4).
- Review of impacts of climate change on seabirds in English waters (section 5).
- Review of efficacy of existing measures and legislation that protect seabirds from the detrimental impacts of anthropogenic pressures in the marine environment (section 5).
- Review of peer-reviewed literature to support requirement and scope of recommendations.

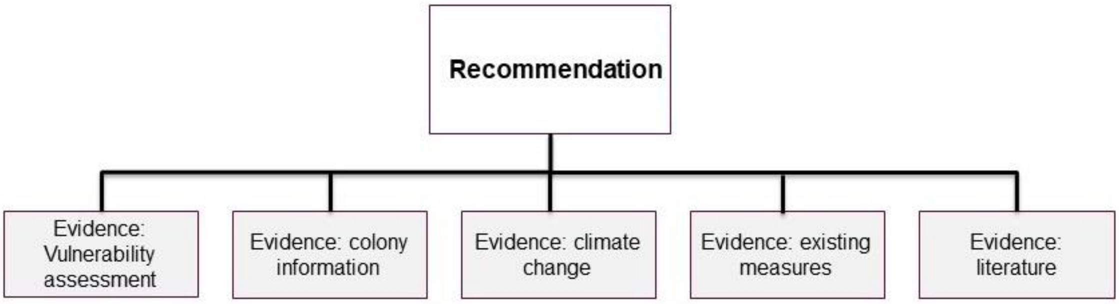


Figure 10. Evidence sources informing recommendations.

The recommendations follow a comprehensive structure to ensure all aspects of the advice is clear to stakeholders (Table 19). For each recommendation there are six sub-headings following the themes of: what, why, how, where, when and who. A seventh sub-heading has been added to ensure the climate change consideration for the recommendation has been considered.

Table 19. Structure for recommendations with worked example.

Headings	Theme	Example
Recommendation	What	Develop forage fish policy for ecosystem approach to fisheries management to safeguard prey
Links to other recommendations	n/a	Effective protection, conservation and restoration of seabird marine habitats
Impact / threat	How	Increased mortality or reduced breeding success due to reduced food
Key species	Who	Key species vulnerable to the pressure (from vulnerability assessment where applicable, or based on published evidence), eg black-legged kittiwake

Headings	Theme	Example
Relevant activities	How	Key activities associated with pressure (from vulnerability assessment where applicable, or based on published evidence), eg
Spatial extent	Where	English Exclusive Economic Zone (EEZ; with links to UK EEZ)
Timeframe	When	Timeframe of implementing measurements: short-, medium- and long-term actions - eg quotas and MSY (Maximum Sustainable Yield), predator reference points, forage fish policy
Status	How	Recommendation is in scoping, in development, ongoing or not started
Other stakeholders	Who	Stakeholders other than Natural England and Defra (assumed to be relevant to all recommendations) who are likely to be involved (eg International Council for the Exploration of the Seas (ICES), Inshore Fisheries and Conservation Authorities (IFCAs), Centre for Environment, Fisheries and Aquaculture Science (Cefas), Marine Management Organisation (MMO), The Royal Society for the Protection of Birds (RSPB) etc.)
Pathway	How	Ecosystem approach to fisheries management
Evidence-based reason[9]	Why	Strong evidence for link between seabird productivity and fish stocks
Climate change[10]	How	Eg changes to prey distribution

The timeframe of the recommendations has been defined as short, medium, and long term (

[9] See Appendix 17

[10] See Appendix 9

Table 20). This is the timeframe for when the pathway to the recommendation, ie the required actions, need to be undertaken to ensure the threats and detrimental impacts on birds are reduced as required.

Table 20. Definitions of timeframes

Timeframe	Definition
Short term	0-2 years
Medium term	3-5 years
Long term	5+ years

The recommendations underwent a strict quality assurance (QA) process within Natural England. The process involved QA from ornithologists as well as other specialists within Natural England. These specialists included experts on fisheries, offshore wind, disease, monitoring, marine contaminants and marine litter.

Recommendations were prioritised via a combination of evidence (eg vulnerability assessment) and expert judgement; for instance, emerging, significant issues such as the outbreak of Highly Pathogenic Avian Influenza (HPAI) in seabirds were prioritised. Once complete, 19 recommendations were formed (Table 21).

It was possible to group recommendations into four categories, so that recommendations and associated actions have clear links to aspects of seabird conservation. The four categories are: **feeding**; **breeding**; **surviving**; and **knowledge**. One recommendation spans two categories and is repeated in the table below to represent this (F2 and S3).

Recommendations were ordered by priority of the actions required, three categories were used (in order of priority): urgent (U; recommendations that should be implemented quickly and will have large benefits for seabird populations), less urgent (LU; recommendations that are important but could be implemented after the Urgent recommendations) and watching brief (WB; recommendations with important steps but fewer direct benefits to seabird populations in the immediate future; Table 21). No priority was given to the recommendations within the knowledge category as they all need to be considered to improve seabird conservation in England. The urgency of addressing knowledge actions should be tied to conservation actions, so that effective monitoring and evaluation of the success of measures is possible. Similarly, prioritisation of knowledge actions should align with the greatest need for evidence for example, where pressures are exerting greatest impacts. Implementing some recommendations, such as K1, will have relevance for multiple linked conservation actions and could deliver wider benefits. In addition, each recommendation has been given a code of a letter and number, the letter is based on the category it falls into eg F = feeding, B = breeding, etc. The number is based on the order of the recommendation within the category, eg 1, 2, etc. Within each recommendation the actions suggested to implement the recommendations have been numbered with the same code: eg F1.1, F1.2, F1.3, etc.

Table 21. Summary of recommendations and their priority. (U: Urgent, LU: Less Urgent and WB: Watching Brief)

Category and Code	Status	Recommendation title
Feeding F1	U	Develop a Forage Fish Policy (or similar mechanism) to implement an ecosystem approach to fisheries management decisions that consider the importance of prey for seabirds
Feeding F2	LU	Effective protection, conservation and restoration of seabird marine habitats
Breeding B1	U	Conservation, restoration and creation of seabird breeding habitats at colonies
Breeding B2	U	Increased site management to help safeguard breeding seabirds against disturbance and predation
Breeding B3	U	Improve and increase efforts to reduce the emergence, spread and impacts of pathogens and parasites in seabirds
Breeding B4	LU	Eradication of invasive terrestrial mammalian predators from existing (and potentially suitable) breeding seabird islands and implementation of associated island biosecurity measures
Surviving S1	U	Develop mitigation and monitoring best practice for key seabird bycatch risk areas (identified through improved understanding)
Surviving S2	U	Strengthen the use of mitigation hierarchy to reduce impacts to seabirds and promote recovery through strategic sustainable development (especially from offshore wind farms)
Surviving S3	LU	Effective protection, conservation and restoration of seabird marine habitats
SurvivingS4	WB	Reduce marine litter and its impacts on seabirds
Surviving S5	WB	Continue to work towards GES for contaminants and reduce the impacts of contaminants on seabirds
Knowledge K1	n/a	Fund long-term monitoring of key seabird colonies in England to ensure representative picture
Knowledge K2	n/a	Increase funding of bird monitoring schemes to inform seabird conservation requirements
Knowledge K3	n/a	Implement a system of recording and investigating seabird mass mortality events (“wrecks”)
Knowledge K4	n/a	Improve the evidence base relating to the causes, prevalence, and impacts of disease in seabirds
Knowledge K5	n/a	Increase and improve long-term monitoring of seabird prey and marine ecosystem health
Knowledge K6	n/a	Improve understanding of scale and spatio-temporal distribution of seabird bycatch to drive targeted action where and when required
Knowledge K7	n/a	Develop an up-to-date, live database to describe cumulative anthropogenic impacts on seabird populations and prioritise action
Knowledge K8	n/a	Promote and enable strategic baseline and impact monitoring of seabirds in relation to marine infrastructure (especially offshore wind farms)

Feeding

Recommendation F1	***Develop a Forage Fish Policy (or similar mechanism) to implement an ecosystem approach to fisheries management decisions that consider the importance of prey for seabirds***
Linked to other recommendations	S1, K5
Impact/threat	Increased mortality or reduced breeding success because of a reduction in food resources
Key species	Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities: Arctic skua, Arctic tern, Balearic shearwater, black-headed gull, black-legged kittiwake, common guillemot, common tern, European shag, great cormorant, little tern, razorbill, Sandwich tern
Relevant activities	Fisheries, eg anchored nets/lines, pelagic fishing, demersal trawls and seines
Spatial extent	English EEZ (with links to UK EEZ), with initial focus on the English North Sea
Timeframe	• Short term: further consideration of management of sandeel fisheries in UK EEZ to increase resilience of sandeel stock; develop working group; align forage fish quota with MSY or proxies. • Short to medium term: review knowledge; establish predator reference points; consider other impacts; monitor fish and predators. • Medium to long term: development of an ecosystem-based approach through a Forage Fish Policy, incorporating predator reference points, wider environmental considerations and management options as identified.
Status	Scoping / Not started
Other stakeholders	ICES, OSPAR, Cefas, JNCC, MMO, IFCAs, fishing industry including processors, fishmeal and fish oil consumers, RSPB, Pew, Wildlife Trusts, academia
Pathway to recommendation	An ecosystem approach for the management of forage fish should consider the direct and indirect impacts of management strategies on seabirds and the wider ecosystem. Such management could include: • **F1.1: Develop a cross-cutting working group.** This group should define the term 'forage fish' and identify the ecosystem objectives (including improving the status of seabird populations) of a forage fish policy. Members of the group should include Defra and its Arms-Length Bodies, ornithologists, fisheries specialists, GES specialists, marine planning specialists, etc. • **F1.2: Consider further reductions of the North Sea sandeel fishery.** Although there may be some uncertainties, the link between seabird productivity and food availability has been demonstrated

Recommendation F1	***Develop a Forage Fish Policy (or similar mechanism) to implement an ecosystem approach to fisheries management decisions that consider the importance of prey for seabirds***
	repeatedly, and sandeels are important prey items for several seabird species of concern. • **F1.3: Strive to set quotas for forage fish species which align with scientific advice for reaching existing MSY targets or proxies.** This may include suspending fisheries when zero Total Allowable Catch (TAC) is advised, depending on mixed fishery considerations. Where quotas are set as part of bi, tri or multi-lateral negotiations, the UK's negotiating position should seek to align quotas with scientific advice. An assessment of possible displacement risk and potential management measures to mitigate these risks should be integral to this work. • **F1.4: Current MSY proxies should be re-calibrated to include predator reference points.** Current fisheries management accounts for predation-driven natural mortality in the reference points of some stocks (eg, $B_{escapement}$ for short-lived species) but fails to explicitly consider the state of predator populations or adjust advice to support predator recovery. To move towards an ecosystem approach which could support recovered seabird populations, forage fish reference points should define safe ecological limits for seabirds, allowing management to adjust fishing activities in response to estimates of the state of seabird and other predator populations. • **F1.5: Review of knowledge and data gaps.** Before such reference points can be implemented, a review of knowledge and data gaps should inform investment in research which will allow the derivation of such reference points. Quotas should then be set in line with the resulting scientific advice. • **F1.6: Strategic monitoring of the status of forage fish and dependent predators should be implemented.** Improved knowledge base of food-web interactions and the role of forage fish in English waters outside the North Sea are also required. Consideration of how this monitoring could be drawn together with the monitoring requirements under other key pieces of legislation (eg GES under the UK Marine Strategy; UKMS) may allow for effective and efficient use of limited time and resources. • **F1.7: Consider the potential for other industries to impact forage fish.** This is so that the cumulative impacts of different activities would allow for a fully ecosystem-based approach to the management of forage fish.

Recommendation F2	***Effective protection, conservation and restoration of seabird marine habitats***
Linked to other recommendations	S3, K5
Impact/threat	Increased mortality or reduced breeding success because of a reduction in habitat suitability and/or availability
Key species	All ESCaRP species
Relevant activities	Fisheries and other extractive activities, marine renewables
Spatial extent	English EEZ - possibly wider for strategic elements and to incorporate extent of species distributions
Timeframe	• Short term: all actions
Status	Ongoing but currently inadequate
Other stakeholders	Statutory Nature Conservation Bodies (SNCBs), MMO, Crown Estate, RSPB, BTO, JNCC, offshore wind industry, Local authorities
Pathway to recommendation	• **F2.1: Protected Site Strategies for marine protected areas with seabird features**: Protected Site Strategies (PSS), as set out in the Environment Act 2021, will include packages of measures designed to address the multiple pressures faced by protected sites. A PSS will be most effective when there are multiple issues influencing site condition and the solutions need to involve multiple stakeholders. PSSs will be ambitious and focus on addressing nature recovery rather than just minimising harm to sites. There are five pilot PSSs, not currently including seabirds or Marine Protected Areas (MPAs); evidence-led PSSs should be formed for all MPAs with seabird features, detailing pressures and necessary remedies. Funding could be provided to deliver this. • **F2.2: Effective management of existing seabird MPAs**: Following formation of PSSs, requisite actions to recover seabird populations within MPAs can be undertaken, ideally informed by spatial management tools which could be developed in parallel. This can include marine use policy that benefits seabirds in multiple locations; for example, a commitment to avoid offshore wind farm (OWF) development within 10 km of MPAs used by diver species, known to be the most sensitive seabirds to development of this type (Allen and others 2019). It could additionally consider the use of by-laws or the creation of Highly Protected Marine Areas (HPMAs). • **F2.3: Review ecological sufficiency of MPA network for seabirds and act accordingly**: Using the same or similar method employed for the ecological sufficiency review of terrestrial SPAs, assess the extent to which seabird needs

Recommendation F2	***Effective protection, conservation and restoration of seabird marine habitats***
	(especially when foraging / aggregating outside the breeding season) are met by the MPA network. Where insufficiencies are identified, take an evidence-led approach to designate suitable additional marine areas, factoring in what the '30 x 30' targets (30% of area protected by 2030) mean for mobile species like seabirds. • **F2.4: Improve wider, ecosystem-based management for marine ecosystems**: An ecosystem approach should be taken to the wider management of marine habitats used by seabirds, with reference to drivers such as GES under the UKMS.

Breeding

Recommendation B1	***Conservation, restoration and creation of seabird breeding habitats at colonies***
Linked to other recommendations	B2, B3, B4
Impact/threat	Physical habitat loss
Key species	All species breeding in England, but particularly those associated with soft coasts including terns and gulls.
Relevant activities	Protected site management, coastal defence management, managed realignment, flood defences, coastal development
Spatial extent	All of England's existing seabird colonies should be considered for restoration potential. Opportunities to create new nesting habitat exist around England, especially on soft coast in the east and south-east; inland, through rafts and freshwater islands; and offshore, where artificial structures may be beneficial where conditions allow.
Timeframe	• Short term: conservation of existing habitats; small-scale habitat creation projects (rafts and small islands); wider strategic considerations. Most protection and restoration work could be done immediately to complement existing initiatives. • Medium term: restoration of existing habitats; offshore structures • Long term: Large-scale soft coast habitat creation projects involving managed realignments
Status	Ongoing but currently inadequate
Other stakeholders	Environment Agency (EA; National Habitat Compensation Programme; NHCP), RSPB, Wildlife Trusts, National Trust, local councils, private landowners, Crown Estate, MMO, industry.

Recommendation B1	*Conservation, restoration and creation of seabird breeding habitats at colonies*
Pathway to recommendation	• **B1.1: Conservation of existing seabird breeding habitats:** Existing seabird habitats should be protected from further habitat loss or degradation. Vegetation should be managed to ensure sufficient suitable nesting habitat for ground-nesting birds is maintained. Water levels and drainage should be managed (where possible) to prevent flooding of nest sites. Colonies of cliff-nesting seabirds should be protected from the impacts of erosion by ensuring that cliff tops are protected from development and intensive agriculture as natural and semi-natural cliff-top habitats minimise erosion (Morecroft & Speakman 2015). • **B1.2: Restoration of existing seabird breeding habitats**: Existing seabird breeding habitats, at coastal and inland sites, can be restored and enhanced by recharging islands and banks to ensure ground-nesting habitat is not flooded, and by managing vegetation to maintain or create suitable nesting habitat for ground-nesting birds. Former tern and gull colonies that have been abandoned can sometimes be restored by identifying and rectifying the problems that led to abandonment, eg managing vegetation, flooding, disturbance, or predation. Decoys and lures can be used to attract birds back to safe breeding habitats. • **B1.3: Creation of new soft-coast habitats for ground-nesting seabirds:** New soft-coast habitats, above the reach of the highest tides and safe from disturbance and predation, should be created to replace habitat lost or predicted to be lost to sea level rise. This can be achieved by creating and recharging islands and banks (Ausden and others 2018, Manning and others 2021) or new islands in well-designed managed realignment schemes. Islands can be designed to be resistant to the impacts of disturbance and predation, such as at Wallasea Island, Essex and Medmerry, Sussex, which have provided safe nesting habitat for gulls and terns. Various reports have identified potentially suitable locations, mainly in East Anglia and the south-east (Miles & Richardson 2018, MMO 2019, MMO 2020). Large-scale projects of this type should be incorporated into wider coastal management schemes, such as Shoreline Management Plans (ShMPs). • **B1.4: Creation of new islands and rafts for inland-nesting seabirds:** The creation of nesting islands and rafts as safe breeding habitat for inland-nesting seabirds such as common tern and black-headed gull should be encouraged. Several projects have been successful (Scarton 2008, Coccon and others 2018, Manikowska-Slepowronska and others 2022). More, well-designed

Recommendation B1	***Conservation, restoration and creation of seabird breeding habitats at colonies***
	rafts and wetland islands would provide much-needed nesting habitat for these species and could even facilitate the (re)colonisation of species such as black tern and little gull. Decoys and lures can be used to attract birds to safe new breeding habitats. Ongoing management and protection should be built into habitat creation plans. • **B1.5: Creation of new offshore structures as breeding habitat for cliff-nesting seabird species:** It may be possible to create new / manage existing offshore structures that would provide breeding habitat for cliff-nesting seabirds such as black-legged kittiwakes and auks, that will readily colonise oil and gas structures. Breeding success may even be higher on offshore man-made structures than at natural sites (Christensen-Dalsgaard and others 2019). Further research will be required to identify suitable locations in areas where lack of nesting space is a limiting factor, and to determine optimal designs for artificial nesting structures. Offshore breeding sites could be created close to foraging areas that are beyond seabird foraging ranges at natural sites, thereby adding new colonies to existing seabird populations. Research should underpin design and location considerations, to maximise successful colonisation and productivity. • **B1.6: Wider strategic inclusion of seabird breeding habitat needs:** Past and predicted losses of seabird breeding habitat in England should be factored into multi-stakeholder strategic management plans (such as ShMPs, the NHCP, Nature Recovery Networks (NRNs), Local Nature Recovery Strategies (LNRS)) and the implementation of the government's 25-year Environment Plan (HM Government 2018). Breeding seabirds should be considered comprehensively as part of these different plans and programmes, seeking alignment and complementarity to ensure that existing breeding sites are adequately managed, and new breeding habitat is created and maintained. Plans should be long-term and adaptive to ensure full implementation and ongoing adaptive management.

Recommendation B2	***Increased site management to safeguard breeding seabirds against disturbance and predation***
Linked to other recommendations	B1, B3, B4
Impact/threat	Disturbance and displacement due to recreational activities (eg tourism) or commercial activities

Recommendation B2	***Increased site management to safeguard breeding seabirds against disturbance and predation***
	Habitat loss and mortality from predatory species
Key species	All ESCaRP breeding species
Relevant activities	Protected site management, coastal development, coastal recreational activities (on land and at sea), dog walking.
Spatial extent	All seabird breeding sites in England. The recent review of England's seabird colonies (Lock and others 2022) identified 22 'priority sites' (Table 8). Actions taken at these priority sites will have the greatest conservation impact. Actions such as awareness and enforcement, byelaws, and zonation should be tackled strategically, at regional and national level, to ensure key areas are prioritised. Reviewing Schedule 1 species is at national scale.
Timeframe	• Short term: Increasing numbers of staff; installing fencing; predator control; public awareness and educational activities • Medium term: regulation; zonation of activities
Status	Ongoing but currently inadequate
Other stakeholders	Site owners and managers of seabird breeding colonies (eg RSPB, National Trust, Wildlife Trusts, local councils, private landowners), regional wildlife crime units, groups/people that use the sites.
Pathway to recommendation	• **B2.1: Increase numbers of site-based staff (wardens/rangers):** Site-based staff are key to reducing impacts of disturbance and predation at colonies (Booker and others 2014, Babcock & Booth 2020, Lock and others 2022). The presence of wardens is probably the most effective way to reduce recreational disturbance, providing engagement and education for the public (Booker and others 2014, Babcock & Booth 2020), as well as deterring (and controlling) predators, deterring egg-collectors, managing habitat and fencing, and informing action through site monitoring. Seasonal wardening at little tern colonies is effective in increasing productivity, and wardens can also be effective at gull colonies (Babcock & Booth 2020, Natural England & RSPB 2020, Lock and others 2022). Many seabird breeding sites in England do not currently have enough site staff to adequately protect breeding seabirds. Provision should be increased. • **B2.2: Install fencing:** Predator-proof fencing is an effective way of reducing the impacts of disturbance and predation. Fencing reduces disturbance from the public in the area around nesting birds and increases public awareness of the need for protection (Babcock & Booth 2020). Predator-proof fencing excludes predators (as well as animals that may cause disturbance such as deer or dogs off leads)

Recommendation B2	***Increased site management to safeguard breeding seabirds against disturbance and predation***
	and has been shown to consistently increase the productivity of vulnerable ground-nesting birds (Smith and others 2010, Babcock & Booth 2020). The fencing requirements at seabird breeding colonies should be reviewed and funding made available were necessary. • **B2.3: Predator control:** Lethal control of predators is likely to be required in some cases. It may not be feasible to fence or otherwise exclude predators from every nest site. Individual predators may also learn to breach fences and these individuals may need to be targeted for lethal control (Kennerley 2008, Pacioni and others 2020). The likelihood of predators breaching fencing is also higher when predator densities are higher, so reducing predator densities in the area surrounding breeding colonies and maintaining these low densities through sustained long-term control may be necessary (Smith and others 2010, Porteus and others 2018). Lethal control should only be carried out under the appropriate licences, by competent staff or specialised contractors. Predators can also be controlled by non-lethal methods, such as diversionary feeding or the use of deterrents such as lasers (Smart & Amar 2018). Tern chicks can be given added protection from avian predators by providing chick shelters (Babcock & Booth 2020). Placing canes amongst tern colonies has also been shown to reduce the incidence of predation by gulls (Boothby and others 2018). • **B2.4: Education and stakeholder engagement:** Increasing public awareness of the need to protect breeding seabirds is key to reducing the impacts of disturbance. Site-based staff can engage with and educate visitors, and fencing helps to raise public awareness of the issue. Well-designed and well-placed signage and interpretation may also be effective at increasing awareness and reducing disturbance. Site-based staff can also work to engage with local stakeholder groups, such as dogwalkers, anglers, yacht clubs, etc to raise awareness and to develop guidance and codes of practice (eg Green Wildlife Guide for Boaters). Citizen science initiatives to monitor and report disturbance, such as Operation Seabird in Yorkshire, are useful for engagement as well as monitoring. Educational activities could also be organised at the wider regional, or even national scale. • **B2.5: Regulation and enforcement:** Protection of breeding seabirds from disturbance will be most effective if supported by policies and laws which are enforced. Byelaws may be necessary in some cases to guide public access and activities and a review of Wildlife & Countryside Act Schedule 1 species is required to reflect recent changes in seabird conservation status. More robust

Recommendation B2	***Increased site management to safeguard breeding seabirds against disturbance and predation***
	enforcement is required of the legal protections of nesting birds from disturbance, particularly for Schedule 1 species; 'Operation Seabird' is an award-winning, multi-agency partnership led by Humberside Police that aims to protect breeding seabirds from disturbance. Similar initiatives have started to be rolled out in other regions, and this model could be developed to include all of England's seabird colonies. • **B2.6: Zonation of human activities:** Strategic zonation of human activities around England's coasts would help to reduce disturbance pressure at seabird colonies. There is a need to create areas for dog walking and recreational activities as alternatives to sites with sensitive breeding birds, and to make the distinctions between these areas clear to the public. Examples include the SANG (Suitable Alternative Natural Greenspace) created to alleviate disturbance pressures on the Thames Basin Heaths SPA.

Recommendation B3	***Improve and increase efforts to reduce the emergence, spread and impacts of pathogens and parasites in seabirds***
Linked to other recommendations	B4, K3, K4
Impact/threat	Mortality and/or reduced breeding success due to pathogens and parasites
Key species	All species
Relevant activities	Biosecurity, monitoring, research, collaboration (note: links to all other recommendations as building resilience of populations is key)
Spatial extent	England, neighbouring UK countries, and other countries with migratory linkages with seabirds facing similar pressures
Timeframe	• Short-term: all actions
Status	Ongoing but currently inadequate
Other stakeholders	APHA (Animal and Plant Health Agency), SNCBs, JNCC, BTO, RSPB, National Trust, Wildlife Trusts, Ecotourism operators, CEH (Centre for Ecology and Hydrology), Cefas
Pathway to recommendation	• **B3.1: Improve biosecurity at seabird colonies:** Effective biosecurity measures should be developed and implemented for all seabird colonies to reduce the spread of pathogens and parasites between colonies. Biosecurity measures should be put in place for all activities occurring at seabird colonies, including ecotourism, monitoring and ringing activities. These disease prevention

Recommendation B3	*Improve and increase efforts to reduce the emergence, spread and impacts of pathogens and parasites in seabirds*
	biosecurity measures could be tied in with biosecurity measures already developed for reducing the spread of invasive non-native species to seabird islands (see recommendation B4) but would be equally necessary at mainland colonies and for activities taking place outside the breeding season. Clear, consistent and up-to-date guidance should be provided for all stakeholders involved in such activities, including site managers and wardens, tour operators, ringers, and other volunteers involved in seabird monitoring activities. • **B3.2: Investigate the effects of removing dead and dying birds on spread and persistence of pathogens:** There is conflicting anecdotal information regarding the effects of removing infected birds and carcasses on the spread of the disease. The impacts may depend on the species and the characteristics of the site involved. Research and document the impacts of carcass removal and use the resultant information to provide informed guidance to colony managers. • **B3.3: Investigate specific interventions aimed at reducing the spread and impacts of pathogens and parasites in seabirds:** Investigate potential options for reducing the spread and impacts of pathogens and parasites in seabirds. Epidemiological research into spread of disease (see Recommendation K4). Investigate environmental persistence of HPAI viruses to inform management measures at colonies (eg, disinfection options). Options include developing and administering vaccines for pathogens (eg, HPAI, avian cholera), administering treatments for ectoparasites to reduce pathogen vectors, and captive breeding and/or head-starting vulnerable species or populations. Conduct research into effective HPAI vaccines for poultry and wild bird species. Investigate the feasibility of administering vaccines effectively and safely in wild seabird populations. Develop emergency protocols, expertise, and facilities to enable the rapid instigation of captive breeding/head-starting programmes that could be implemented when situations of extreme risk to vulnerable species occur suddenly. Investigate options for site management to reduce the inter-annual spread of disease and parasites at seabird colonies, informed by research into the environmental persistence of pathogens and parasites. • **B3.4: Facilitate exchange of information relating to the effectiveness of mitigation measures between different stakeholders and different countries:** Ensure that the effectiveness of intervention measures for reducing the spread and

Recommendation B3	*Improve and increase efforts to reduce the emergence, spread and impacts of pathogens and parasites in seabirds*
	impact of disease in seabirds is documented and the information made available to all stakeholders, including those in other countries. Networks of researchers and colony managers would be particularly useful around distinct oceanic regions, eg, the North Sea. • **B3.5: Improve control of pathogens and parasites in captive birds and limit interactions between captive and wild bird populations:** Implement strict biosecurity and disease control measures (eg, vaccination) for captive bird populations (eg, poultry, game birds) and avoid contact between captive bird and wild bird populations to reduce the spread of parasites and pathogens and the emergence of novel pathogens. • **B3.6: Increase resilience of seabird populations to buffer against disease impacts:** In the face of increasing pressure from pathogens and parasites, it is increasingly important to ensure the abundance and distribution of seabirds in England is sufficient to enable populations to withstand mortality of this type. Increasing resilience, through removal of pressures leading to lethal and sub-lethal effects that increase the vulnerability of seabird populations to disease outbreaks, is critical.

Recommendation B4	*Eradication of invasive mammalian predators from existing (and potentially suitable) breeding seabird islands and implementation of associated island biosecurity measures*
Linked to other recommendations	B1, B2, B3
Impact/threat	Mortality, reduced productivity, and reduction in habitat due to invasive predatory mammals
Key species	All ESCaRP breeding species, but particularly Atlantic puffin, Manx shearwater, European storm petrel, roseate tern
Relevant activities	Rodent eradication, biosecurity
Spatial extent	Eradication of rats: the Isles of Scilly. Biosecurity measures and rapid response: all of England's offshore islands that support breeding seabird populations. Monitoring impacts and investigating feasibility of eradication of all mammalian invasive predators, where a problem: all of England's offshore islands that support (or could support) breeding seabird populations.
Timeframe	• Short term: Further rat eradication of Isles of Scilly; continuation of Biosecurity for LIFE measures

Recommendation B4	*Eradication of invasive mammalian predators from existing (and potentially suitable) breeding seabird islands and implementation of associated island biosecurity measures*
	• Long term: Monitoring of impacts and investigating feasibility of eradication of all mammalian invasive predators from all seabird islands
Status	Eradication: not started. Biosecurity: ongoing but must be continued
Other stakeholders	RSPB, Duchy of Cornwall, Isles of Scilly Wildlife Trust, other regional Wildlife Trusts, National Trust, Landmark Trust, private landowners
Pathway to recommendation	• **B4.1: Eradicate brown rats from the Isles of Scilly:** The eradication of brown rats from as many of the Isles of Scilly as possible could have considerable positive impacts on England's breeding seabird populations, providing safe nesting opportunities on a range of islands, and allowing some range-restricted species (eg, Manx shearwater, European storm petrel and possibly roseate tern) to expand their range. A feasibility study conducted by the RSPB in 2018 concluded that eradicating rats from the remaining islands is feasible (Bell 2011, Varnham & St Pierre 2017), with the exception of the large and heavily populated St Mary's Island. An archipelago-scale rat eradication would be most effective as it would reduce the likelihood of reinvasion between islands, which is a regular occurrence (Stanbury and others 2017, BBC (British Broadcasting Corporation) 2022). The islands of Bryher, Tresco and St Martin's would need to be targeted together due to their close proximity (Bell 2011, Varnham & St Pierre 2017). Eradication needs to be followed by robust biosecurity measures to prevent reinvasion (Bell and others 2019). • **B4.2: Biosecurity measures and rapid response for all seabird islands:** Ongoing and robust biosecurity measures are required for all of England's seabird islands, to prevent invasion/reinvasion by invasive mammalian predators such as rats, which could have severe negative impacts on breeding seabird populations. Rapid response systems also need to be in place to detect and deal with any incursions before they have the chance to spread. The current 'Biosecurity for LIFE' project has been working to develop a coordinated biosecurity and rapid response programme for all the UK's seabird islands. This includes the Isles of Scilly, the Farne Islands, Coquet Island, and Lundy Island in England. This programme should be supported to continue long-term, beyond the currently funded time period. • **B4.3: Investigate presence and impacts of invasive mammalian predators on all of England's offshore islands, and feasibility of eradication:** The presence and impacts of invasive mammalian predators should be monitored for all England's offshore islands, and where issues are detected, the

Recommendation B4	***Eradication of invasive mammalian predators from existing (and potentially suitable) breeding seabird islands and implementation of associated island biosecurity measures***
	feasibility of eradication should be explored. Rats are not the only invasive species that can have detrimental effects on breeding seabird populations. Feral cats and hedgehogs may be impacting populations by predating breeding seabirds on islands. Eradication methods are constantly improving and becoming more ambitious, and it may become possible to remove more invasive mammalian predators from more islands, including larger and more populated ones.

Surviving

Recommendation S1	***Develop mitigation and monitoring best practice for key seabird bycatch risk areas (identified through improved understanding)***
Linked to other recommendations	S4, K6
Impact/threat	Mortality from incidental bycatch
Key species	Removal of non-target species: Arctic skua, Arctic tern, Atlantic puffin, Balearic shearwater, black guillemot, black-throated diver, common guillemot, common scoter, common tern, common eider, European shag, great cormorant, great northern diver, black-legged kittiwake, little gull, long-tailed duck, Manx shearwater, Mediterranean gull, northern fulmar, northern gannet, razorbill, red-breasted merganser, red-throated diver, roseate tern
Relevant activities	Fishing – static nets (gillnets), demersal longlines, purse seines, pelagic trawls, ghost fishing gear
Spatial extent	Should focus on areas where key risk seabird species and longline or gillnet fisheries overlap – informed by mapping work eg, Cleasby and others (2022), Bradbury and others (2017). For the <10 m static net fleet (gillnets), areas to prioritise monitoring and mitigation trials will likely include the southern coast of Devon and Cornwall and the north-east and south-east coasts of England (Coram and others 2015, Miles and others 2020, Northridge and others 2020 For the offshore demersal longline fleet, potential focal areas are likely to be outside of English EEZ waters in the north-west of Scotland and off the Shetland Islands (Northridge and others 2020). Although some demersal long-lining does occur in the far south-west of English EEZ no bycatch was reported

Recommendation S1	***Develop mitigation and monitoring best practice for key seabird bycatch risk areas (identified through improved understanding)***
	there by Miles and others (2020), although a very poorly monitored purse-seine fishery also operates here.
Timeframe	• Short term: improve knowledge of static net usage and bycatch risk in the purse-seine and gillnet fisheries; identification of pilot areas; development of mitigation measures and monitoring as well as support for fishers • Medium term: mitigation and monitoring trials; explore potential use of remote electronic monitoring (REM), ghost gear measures • Long term: mitigation implemented at fleet scale with effective oversight and bycatch monitoring.
Status	Ongoing – UK Bycatch Mitigation Initiative and other trials for bycatch mitigation. Results of these should feed into best practice mitigation
Other stakeholders	MMO, IFCAs, RSPB/Birdlife, fisheries, Clean Catch UK initiative.
Pathway to recommendation	• **S1.1: In collaboration with stakeholders, identify possible pilot area(s) for more focussed development of mitigation trials and monitoring.** This should be informed by studies such as Cleasby and others (2022) that identified bycatch risk hotspots in the UK, Evans and others (2021) that carried out risk mapping of bycatch of protected species (including seabirds) in the North East Atlantic region, and Bradbury and others (2017) that created a Geographic Information System (GIS) tool showing relative risk of UK seabird species to bycatch from fisheries operating in UK waters. This should also be informed by the results of forthcoming research on bycatch hotspots in UK waters, commissioned by Defra under the Bycatch Mitigation Initiative. • **S1.2: Development of best practice mitigation.** This should build on the consideration of gillnet and longline mitigation measures as part of the UK Bycatch Mitigation Initiative. This should also consider existing examples of best practice in English waters, guided by the latest research eg Rouxel and others 2022, but also utilising examples from other nations that reduce bycatch, to encourage wider adoption and refinement of techniques. If purse seining and pelagic trawls are identified as being high risk fisheries for seabird bycatch, then further investigation would be necessary to determine what mitigation measures are appropriate and feasible. This should consider whether mitigation measures used in other countries (eg, the

Recommendation S1	***Develop mitigation and monitoring best practice for key seabird bycatch risk areas (identified through improved understanding)***
	Chilean purse seining fleet which minimise the amount of netting material to reduce the 'ceiling effect' created by excess netting floating on the water's surface as the 'purse' is drawn together) could be adapted for use on UK fleets (Anderson and others 2021). • **S1.3: Trials of potential mitigation.** Consideration should be given to trialling modified gear (including gear switching for gill nets) and fishing practices, such as high contrast netting, net illumination and coloured floats as well as net attendance, night setting and reducing soak times (some of which Defra are already progressing). Fishers should be able to access training to safely extricate, handle and release caught birds. New technologies should be piloted, eg, 'Looming Eye' Buoys (LEBs) and predator shaped kites, as is being trialled by the RSPB/BirdLife/CIFCA/NE Cornwall Bycatch Project, launched in winter 2020 and Ørsted, launched in winter 2021-22 (GoBe 2022). Results of such studies should feed into best practice mitigation updates. Trials must be tailored to each local fishery's context. It is likely that tackling specific bycatch issues will require a 'toolbox' of measures to be employed including alternative gear and innovative technologies in addition to spatial and temporal restrictions or other fishery adaptations, all of which must fully consider socioeconomic and ecological factors. • **S1.4: Development of measures to reduce and remove abandoned, lost and discarded fishing gear in the marine environment.** Incentives enabling fishers to minimise seabird bycatch through abandoned, lost and discarded fishing gear should be considered as part of the commitment in the UK Bycatch Mitigation Initiative. Encourage other user groups to get involved in helping to locate and remove abandoned, lost and discarded fishing nets eg volunteer 'ghost divers'.

Recommendation S2	***Strengthen the use of mitigation hierarchy to reduce impacts to seabirds and promote recovery through strategic sustainable development (especially from offshore wind farms)***
Linked to other recommendations	n/a
Impact/threat	Mortality caused by collision with offshore structures and displacement from valued areas/resources due to placement of offshore structures

Recommendation S2	***Strengthen the use of mitigation hierarchy to reduce impacts to seabirds and promote recovery through strategic sustainable development (especially from offshore wind farms)***
Key species	Visual disturbance: Arctic tern, black guillemot, common tern, razorbill, common guillemot, Atlantic puffin, northern fulmar, northern gannet, red-throated diver, common scoter, common eider Collision above water: common gull, great black-backed gull, herring gull, lesser black-backed gull, Mediterranean gull, northern gannet, black-legged kittiwake, roseate tern, Sandwich tern, Arctic tern, little tern, common tern Collision below water: great cormorant
Relevant activities	Marine renewables: Offshore wind (construction, operation, maintenance and decommissioning), wave (decommissioning, during construction, operation and maintenance), tidal lagoon/impoundment (construction, operation and maintenance and decommissioning), tidal stream (construction, operation and maintenance and decommissioning), cable route construction, grid connection construction
Spatial extent	England EEZ (with links to UK EEZ) and possibly wider for some elements, eg, marine planning and strategic compensation
Timeframe	• Short term: avoidance of impact at project scale; drive strategic compensation; policy steer; best practice • Medium term: avoidance of impact at plan scale; design mitigation options • Long term: enhancement of seabird populations and habitats
Status	Ongoing
Other stakeholders	The Crown Estate, Department for Business, Energy & Industrial Strategy (BEIS), MMO, Offshore Wind Farm (OWF) industry (including renewable energy companies and manufacturers of infrastructure), environmental Non-Governmental Organisations (NGOs)
Pathway to recommendation	Specifically, the recommendation should seek (through measures such as the emerging Environmental Improvement Plan) to: • **S2.1: Promote avoidance of impact at plan level** through enhanced marine spatial planning and marine spatial prioritisation, recognising the wide-ranging nature of seabirds, and utilising emerging tools such as POSEIDON (Planning Offshore wind Strategic Environmental DecisiONs) to take an evidence-led approach to siting of new developments away from 'hard constraint' areas of greatest ecological importance (including SPAs and suitable buffers). • **S2.2: Promote avoidance of impact at project level** through strategic design of infrastructure layout, for instance driven by

Recommendation S2	***Strengthen the use of mitigation hierarchy to reduce impacts to seabirds and promote recovery through strategic sustainable development (especially from offshore wind farms)***
	data on areas of key sensitivity, including parameters such as minimum hub height to reduce seabird collisions. • **S2.3: Ensure mitigation options[11] are designed, tested and available** to reduce impact in areas that cannot be avoided, with early awareness of likely needs so that developers can plan accordingly. Adaptive monitoring could be undertaken for novel mitigation measures; this would ensure that ineffective measures would be determined quickly and rapidly improved upon. • **S2.4: Ensure best practice advice is available and current** (eg for design, data collection, impact assessment, construction, maintenance and operation) and is evidence-based, clear and targeted at reduction of impact. • **S2.5: Drive strategic compensation** so that available options are delivered at scale, are likely to succeed, and effectively offset impacts to seabirds[12]. Long-term and adaptive monitoring of the compensation options is required to ensure the expected outcome is achieved. • **S2.6: Drive enhancement of seabird populations, their habitats and food sources** through mechanisms of nature improvement, including Net Gain and 'Nature Positive' actions relating to development of marine energy (RSPB 2022). • **S2.7: Strong policy steer from Government** would bring renewed focus to these elements and could see them adopted across marine industry sectors.

[11] Eg temporal mitigations, such as avoiding disturbing activities at sensitive times of year or managing cumulative simultaneous disturbance across an area; and / or permanent mitigations, such as changing designs to reduce collisions.

[12] A recent study of possible compensation measures for seabirds across SPAs in England highlighted that there could be confidence in a number of suitable measures (MacArthur Green 2022), some requiring co-ordinated and / or Government intervention.

Recommendation S3: *Effective protection, conservation and restoration of seabird marine habitats*
See recommendation F2.

Recommendation S4	*Reduce marine litter and its impacts on seabirds*
Linked to other recommendations	S1, K1, K2, K3
Impact/threat	Lethal and sub-lethal impacts from marine litter and plastic pollution
Key species	Black-headed gull, black-legged kittiwake, European storm petrel, great black-backed gull, great cormorant, lesser black-backed gull, little tern, northern fulmar, northern gannet
Relevant activities	Litter from human lifestyles and terrestrial activities; Litter from marine activities, including: fishing (eg anchored nets/lines, demersal trawl, demersal seines, pelagic fishing), aquaculture (eg shellfish aquaculture: suspended rope/net culture, bottom culture and trestle culture), offshore wind (construction, operation, maintenance and decommissioning), oil and gas (exploration and installation, production, decommissioning), vessels (movement, shipping of cargo, transport, anchorages, discharges/emissions, moorings).
Spatial extent	English EEZ
Timeframe	• Short-term: Improvement of understanding impacts; interactions • Medium-term: Creation of policies and initiatives to reduce marine litter; and abandoned, lost and discarded fishing gear
Status	Ongoing
Other stakeholders	BEIS, IFCAs, JNCC, Cefas, UK ports & harbours, fisheries, OWF developers, Oil and Gas developers
Pathway to recommendation	• **S4.1: Improve understanding of impacts of litter on seabirds.** Increased monitoring of the impacts of marine litter on seabirds is required to ensure that the full impacts on populations are understood. Monitoring of nest incorporation, entanglement and ingestion are required with a standardised method to ensure comparisons are possible. Robust, reproducible methods as part of a nationwide monitoring scheme would be required alongside opportunistic observations (O'Hanlon and others 2021) (see recommendations S1, K1, K2). Engaging with a diverse range of stakeholders would allow for data to be collected in multiple situations, for example, entanglement at colony or sea. It is important to understand the fitness costs or mortality rates

Recommendation S4	*Reduce marine litter and its impacts on seabirds*
	associated with ingesting litter and plastic; this would need to include potential differences between adults and chicks. • **S4.2: Improve understanding of interactions between seabirds and marine litter.** To be able to study the spatiotemporal variation in seabird encounters and impacts from marine litter, data should be available in an accessible online database such as LITTERBASE. This would allow comparisons of impacts across colonies and species. • **S4.3: Develop further policies and initiatives to reduce marine litter.** The current measures implemented (legislative and policy) to protect seabirds from marine litter are not adequate for GES indicators relating to litter, including Northern fulmar ingestion of plastics (UK marine monitoring programmes (publishing.service.gov.uk)), despite positive measures such as legislation listed in the Existing Measures section (□). It is crucial that policies focus on preventing litter entering the marine environment and should move the focus from end-user recycling to corporate requirements for recycling and reducing use at production stages. More initiatives with a focus on a circular economy in England would greatly enhance the ability to stop litter entering the environment. • **S4.4: Seek to reduce and restrict abandoned, lost and discarded gear.** Abandoned, lost and discarded gear and litter from the fishing industry can present issues for seabirds, particularly relating to entanglement at the nest (O'Hanlon and others 2019) (see recommendation S1). There is legal requirement for fishing vessels to retrieve their lost fishing gear, but targeted campaigns, supported by enforcement could remove the litter already in the coastal and marine environment, especially where it coincides with seabird hotspots, as well as preventing it entering the environment at source.

Recommendation S5	*Continue to work towards GES for contaminants and reduce the impacts of contaminants on seabirds*
Linked to other recommendations	K3
Impact/threat	Lethal and sub-lethal impacts of contaminants and pollution
Key species	Hydrocarbon contamination: Atlantic puffin, Balearic shearwater, black-throated diver, black guillemot, common guillemot, European

Recommendation S5	***Continue to work towards GES for contaminants and reduce the impacts of contaminants on seabirds***
	shag, little gull, Manx shearwater, northern fulmar, northern gannet, razorbill, roseate tern Synthetic compound contamination: Balearic shearwater, lesser black-backed gull, little gull, Mediterranean gull, northern fulmar, Sandwich tern Transition elements & organo-metal contamination: Arctic tern, Balearic shearwater, black-legged kittiwake, common gull, roseate tern
Relevant activities	Pollution events from activities eg: shore-based activities, vessels (movement, anchorages, discharges/emissions, moorings), outfalls/intake pipes, oil and gas (exploration and installation, production, decommissioning), recreational activities (eg, powerboating or sailing with an engine, hovercraft), operation of port and harbours, vessel maintenance.
Spatial extent	English EEZ
Timeframe	• Short-term: Starting the programme for monitoring beached birds and starting to build connections between the Water Framework Directive (WFD) and UKMS.
Status	Not started
Other stakeholders	SNCBs, APHA, BTO, RSPB, CEH, Cefas, OSPAR, EA, UK Ports and Harbours, RYA
Pathway to recommendation	• **S5.1: Develop an England-wide programme of regular surveys for beached birds.** *See recommendation K3*. Seek to align and engage with devolved nations for these surveys. This will allow birds killed by or suffering severely from the effects of pollution, most notably crude oil spills, to be found quickly and causes investigated. • **S5.2: Develop connections between Water Framework Directive and UK Marine Strategy.** This would help to solve issues around point-source and upstream pollution and could reduce contamination and pollution entering the marine environment to benefit seabirds and other marine wildlife.

Knowledge

Recommendation K1	***Fund long-term monitoring of key seabird colonies in England to ensure representative picture***
Linked to other recommendations	S4, K2, K4
Impact/threat	All

Recommendation K1	*Fund long-term monitoring of key seabird colonies in England to ensure representative picture*
Key species	All seabirds breeding in England
Relevant activities	Monitoring, research
Spatial extent	English seabird colonies, especially Flamborough and Filey Coast SPA and Isles of Scilly SPA
Timeframe	• Short term: all actions
Status	Not started
Other stakeholders	SNCBs, JNCC, Seabird Monitoring Programme, BTO, RSPB, Isles of Scilly Wildlife Trust
Pathway to recommendation	• **K1.1: Fund the Seabird Monitoring Programme over the long-term to include key sites for England:** The Seabird Monitoring Programme (SMP) is administered by BTO, having recently assumed leadership from JNCC, but key site monitoring in Scotland and Wales is usually led by research bodies or land managers. A similar arrangement could be set up for sites in England, for instance through RSPB (Flamborough Head & Bempton Cliffs) and / or Isles of Scilly Wildlife Trust.

Recommendation K2	*Increase funding of bird monitoring schemes to inform seabird conservation requirements*
Linked to other recommendations	S4, K1, K4
Impact/threat	All
Key species	All ESCaRP species
Relevant activities	Monitoring, research
Spatial extent	English seabird colonies, following recommendations of eg, Cook & Robinson 2010 and Cook and others 2019. All England for The Winter Gull Roost Survey (WinGS), following previous survey methods (Banks and others 2007). All England EEZ waters for at-sea surveys.
Timeframe	• Short term: all actions
Status	Ongoing, current inadequate
Other stakeholders	SNCBs, JNCC, Seabird Monitoring Programme, BTO, CEH, universities, offshore wind industry, RSPB
Pathway to recommendation	• **K2.1: Increase and improve long-term monitoring of abundance, demographic parameters and diet at multiple seabird breeding colonies:** Increase the number

Recommendation K2	*Increase funding of bird monitoring schemes to inform seabird conservation requirements*
	of sites and the number of species for which monitoring of multiple seabird demographic parameters is undertaken (abundance, productivity, survival rates, phenology). JNCC have led several reviews of the SMP, as well as leading design of UK marine monitoring options, meaning templates exist to improve seabird monitoring in England (eg, Cook & Robinson 2010). The SMP should be financially supported to continue its current work, and to improve and expand to cover more sites and more species regularly and routinely, as per recommendations of Cook and others 2019. Funding should also drive improvements to methodology (including innovation), Citizen Science, standardisation and communications. See also recommendation K1. • **K2.2: Support innovation in data collection:** new technologies offer cheaper and reliable opportunities for long-term monitoring, but they require funding to test, develop and implement. • **K2.3: Increase and improve monitoring of wintering gulls:** Fund regular surveys of winter gull populations (eg, the Winter Gull Roost Survey) to allow for accurate and up-to-date estimates of wintering gull populations (Banks and others 2007, Frost and others 2019) to inform conservation assessments and requirements. • **K2.4: Increase and improve at-sea seabird surveys:** Conduct regular, strategic and systematic wide-scale marine surveys of seabird distributions at sea, improving geographic and seasonal coverage as well as added value through supplementary monitoring (eg, simultaneous collection of environmental data). Support Citizen Science survey work as part of wide-scale strategic programmes. Collaborate with existing initiatives like the marine Natural Capital and Ecosystem Assessment (mNCEA) and POSEIDON to ensure data feed into strategic initiatives. • **K2.5: Increase and improve seabird tracking:** Increase the numbers of birds tracked, and the number of colonies birds are tracked from, including supporting long term projects such as 'Motus' and the use of novel techniques such as stable isotope analysis to add value to data. Many of these

Recommendation K2	*Increase funding of bird monitoring schemes to inform seabird conservation requirements*
	actions rely upon the recruitment, training and retention of volunteers.

Recommendation K3	*Implement a system of recording and investigating seabird mass mortality events ("wrecks")*
Linked to other recommendations	S4, S5, K4
Impact/threat	Disease, pollution, litter, climate change (extreme weather, Harmful Algal Blooms (HABs))
Key species	All ESCaRP species
Relevant activities	Monitoring, surveillance, research
Spatial extent	England, with links to wider UK and neighbouring countries
Timeframe	• Short term: all actions
Status	Not started
Other stakeholders	SNCBS, APHA, BTO, RSPB, National Trust, Wildlife Trusts, private landowners, CEH, Cefas, AEWA, CMS (Convention on the Conservation of Migratory Species of Wild Animals), OSPAR
Pathway to recommendation	• **K3.1: Develop an England-wide programme of regular surveys for beached birds:** The current survey programme for beached birds in the UK is spatially and temporally limited. A programme of regular, standardised surveys for beached birds should be developed that covers the whole of England (and ideally the whole of the UK). An alert system should be set up within this programme to report mass mortality events. This will allow the early detection of mass mortality events and enable rapid response in terms of recording data and collecting carcasses for testing. In addition, surveyors conducting at-sea surveys for seabirds or cetaceans could be requested to record instances of seabird mortality at sea. The need for the general public to report mass mortality events (on land or at sea) could also be more widely publicised. See also recommendation K4.2. • **K3.2: Develop an England-wide system for reporting and documenting mass mortality events of seabirds:** When a mass mortality event is detected, there is an urgent need to record large amounts of data from multiple locations. Ideally, this system would already be in place when the mass mortality event is detected, and there would be an easy and standardised way of recording numbers, species, dates, and locations of

Recommendation K3	*Implement a system of recording and investigating seabird mass mortality events ("wrecks")*
	dead birds so that this information is collated in place. The system should be England (and, ideally, UK) wide to facilitate the collation of data and analysis and interpretation of events, as many mass mortality events of seabirds involve more than one country. Recording the numbers of dead and dying birds is vital to understanding the extent of the event and the potential impacts on populations. Such a system would allow the spatial and temporal extent of the event to be determined and the extent of mortality in the affected species to be estimated. See also recommendation K4.2. • **K3.3: Develop an England-wide system for investigating the causes of seabird mass mortality events:** A system should be developed for investigating the causes of seabird mass mortality events. This would benefit from baseline information gathered by regular surveys of beached birds and data gathered on the extent of species mortality affected by the mass mortality events being investigated. Sufficient samples of carcasses from affected species and affected locations should be analysed by qualified staff to determine cause of death. See also recommendation K4.2. • **K3.4: Facilitate the rapid analysis of data and publication of results:** A review by Glencross and others (2021) found that the results of investigations into seabird mass mortality events were often not published until several years after the event took place. Given that mass mortality events may occur in rapid succession due to related causes, it is important that information on the causes of such events becomes publicly available in full as soon as possible after an event. Researchers involved should be supported to be able to publish their findings in scientific journals and used to in formal future policy. • **K3.5: Facilitate exchange of information and collaboration with researchers investigating seabird mass mortality events on other countries:** Seabird populations range over multiple countries borders and mortality events often affect several countries at once. The seabird wreck in the North Sea in autumn of 2021 led to large numbers of dead and dying birds being found along the coasts of many continental European countries as well as the UK (SEAbird POPulations (SEAPOP) 2022, Daunt & Andrews *in prep*). The summer 2022 outbreak of avian influenza caused mass mortality of breeding seabirds in many countries. Researchers in different countries may be investigating the causes of these events without being aware of

Recommendation K3	*Implement a system of recording and investigating seabird mass mortality events ("wrecks")*
	developments elsewhere. Furthermore, data and resources may be pooled so that such research may be more comprehensive and cost-effective. A collaboration and information exchange should be facilitated between researchers and organisations in different countries.

Recommendation K4	*Improve the evidence base relating to the causes, prevalence, and impacts of disease in seabirds*
Linked to other recommendations	K1, K2, K3
Impact/threat	Disease
Key species	All ESCaRP species
Relevant activities	Surveillance, monitoring, research
Spatial extent	England, with links to wider UK and neighbouring countries
Timeframe	• Short term: all actions
Status	Ongoing but currently inadequate
Other stakeholders	SNCBs, JNCC, SMP, APHA, BTO, RSPB, National Trust, Wildlife Trusts, private landowners, CEH, Cefas, AEWA, CMS, OSPAR, Food and Agriculture Organisation of the United Nations (FAO), Scientific Task Force on Avian Influenza and Wild Birds
Pathway to recommendation	• **K4.1: Increase and improve disease surveillance in seabirds and other wild bird populations:** UK-wide disease surveillance programmes should be developed to monitor the evolution and spread of key diseases affecting seabirds, particularly HPAI viruses. Investigate methods of improving virus detection and characterisation in wild birds and in the environment and standardise methods (see recommendation K3 for collection). Whole genome sequencing of viruses should be undertaken to further understanding of HPAI epidemiology (Verhagen and others 2021). Investigate environmental persistence of HPAI viruses to inform management measures. Develop a pooled DNA microarray to enable testing for multiple pathogens and to allow results to be cross-referenced against information on known pathogens in other species. Increasing disease testing in apparently healthy seabirds could be incorporated into existing monitoring activities such as ringing and tagging activities. Regularly collate and analyse data collected from these programmes and make information readily

Recommendation K4	*Improve the evidence base relating to the causes, prevalence, and impacts of disease in seabirds*
	available to stakeholders, including when disease testing is negative. • **K4.2: Increase and improve surveys and reporting of mortality events in seabirds:** See recommendations K3.1, K3.2 and K3.3. Such a system would allow the spatial and temporal extent of the event to be determined and the impacts on the affected species to be estimated. • **K4.3: Increase and improve long-term monitoring of seabird populations to assess impacts of disease:** Increase and improve long-term monitoring of demographic parameters at multiple seabird breeding colonies in order to assess the impacts of disease on populations (see recommendations K1 and K2). Understanding the impact that disease outbreaks have on populations of different seabird species, both in terms of adult mortality and reduced breeding success, will be vital to inform conservation efforts. • **K4.4: Integrate data on seabird pathogens and parasites with long-term seabird monitoring data and data on impacts of other pressures:** Integrating datasets on the epidemiology of seabird pathogens and parasites and extent of mortality with long-term data from demographic monitoring of seabird populations would help to understand the impacts of pathogens and parasites on seabird populations as well as cumulative impacts of pathogens and parasites combined with the impacts of other pressures. See recommendation K7. • **K4.5: Facilitate exchange of information relating to disease in seabirds between different stakeholders and different countries:** Collaboration and information exchange should be facilitated between researchers and organisations in different countries, such as the Scientific Task Force of Avian Influenza and Wild Birds (AEWA 2022).

Recommendation K5	*Increase and improve long-term monitoring of seabird prey and marine ecosystem health*
Linked to other recommendations	F1, F2, S4, S5, K2
Impact/threat	Reduction in prey, reduction in extent and quality of marine habitats, pollution, litter, climate change
Key species	All ESCaRP species

Recommendation K5	***Increase and improve long-term monitoring of seabird prey and marine ecosystem health***
Relevant activities	Monitoring, research, fisheries, marine renewables
Spatial extent	England EEZ, with links to wider North Sea and North-East Atlantic region
Timeframe	Short-term: all actions
Status	Ongoing but currently inadequate
Other stakeholders	SNCBs, MMO, Marine Scotland, Cefas, ICES, OSPAR, Universities, European Union
Pathway to recommendation	• **K5.1: Increase and improve marine monitoring at all trophic levels:** Increase and improve marine monitoring of multiple stressors at all trophic levels. Ensure the geographic and spatial extent and frequency of sampling is sufficient to detect change. Ensure that populations of key seabird prey, such as sandeels, are adequately monitored to inform sustainable fisheries management and seabird conservation. • **K5.2: Strategically coordinate marine monitoring and combine datasets:** Strategically coordinate marine monitoring schemes, including monitoring undertaken by different stakeholders (eg, industry, NGOs), to ensure that greater coverage can be obtained in a cost-effective manner. Ensure standardisation of monitoring methods and data formats between schemes to allow for the collation and simultaneous analysis of multiple datasets. Ensure that datasets collected on different organisms, in different geographic locations, and on different stressors are made available to share so that datasets can be combined to gain a greater understanding of marine ecology and the drivers of change in marine ecosystems. Such monitoring schemes should be England-wide and align and engage with schemes in the devolved administrations. • **K5.3: Facilitate coordination, collaboration and data sharing between countries:** Strategic coordination of marine monitoring schemes and sharing of datasets should be encouraged and facilitated between different countries, particularly those sharing access to the same oceanic basins (eg, the North Sea). This ensures greater coverage and greater statistical power of datasets and reduces duplication of effort and associated costs. Combining resources and datasets allows a greater understanding of marine ecology and the drivers of change in marine ecosystems.

Recommendation K6	***Improve understanding of scale and spatio-temporal distribution of seabird bycatch to drive targeted action where and when required***
Linked to other recommendations	S1
Impact/threat	Mortality from incidental bycatch
Key species	Removal of non-target species: Arctic skua, Arctic tern, Atlantic puffin, Balearic shearwater, common tern, European shag, great cormorant, little gull, Manx shearwater, Mediterranean gull, northern fulmar, northern gannet, razorbill, common guillemot, black guillemot, roseate tern, common eider, common scoter, red-breasted merganser, long-tailed duck, red-throated diver, black-throated diver, great northern diver
Relevant activities	Fishing – static nets (gillnets), demersal longlines, purse seines, pelagic trawls
Spatial extent	England EEZ (with links to UK EEZ) and further afield to NE Atlantic waters
Timeframe	• Short term: all actions
Status	Ongoing. A new contract for the UK Bycatch Monitoring Programme (UKBMP) started in June 2022 so there is already a potential mechanism for how recommendations could be enacted.
Other stakeholders	SNCBs, MMO, IFCAs, fisheries
Pathway to recommendation	• **K6.1: Improve understanding of seabird bycatch through data collection:** Short-term improvements to achieve greater certainty in bycatch estimates would result from a more systematic approach to data collection, particularly in inshore fisheries. This approach would also generate better understanding of the temporal and spatial patterns of bycatch estimates, and demographic information about which individuals are bycaught. This information could then be used to highlight species and areas most at risk and enable possible pilot area(s) for more focussed development of mitigation trials and monitoring to be identified with stakeholders. Additionally, a risk-based prioritisation of Remote Electronic Monitoring (REM) (French and others 2022) could prioritise seabirds for a set number of years to improve data collection. • **K6.2: Support international efforts to monitor seabird bycatch by non-UK fleet / in international waters:** Given that seabirds often travel vast distances across the ocean between breeding and wintering grounds and hence cross the borders of

Recommendation K6	*Improve understanding of scale and spatio-temporal distribution of seabird bycatch to drive targeted action where and when required*
	many nations, they therefore encounter fisheries in different territories. The assessment by Northridge and others (2020) does not consider bird bycatch by non-UK fleets operating in UK or adjacent waters (though effort by those fleets is known to be significant in some areas) mainly because data on bird bycatch rates in those fleets are either unavailable or considered unreliable. However, international efforts (via ICES and OSPAR) are beginning to assess bycatch levels and possible population impacts from all fishing fleets operating in North-east Atlantic waters. Therefore, there is a need to contribute to international efforts (eg, through OSPAR) to share information on bycatch, to better understand population-level processes and deliver common goals.

Recommendation K7	*Develop an up-to-date, live database to describe cumulative anthropogenic impacts on seabird populations and prioritise action*
Linked to other recommendations	K1 – K6
Impact/threat	Mortality due to anthropogenic activities
Key species	All ESCaRP species
Relevant activities	Marine renewables, licensed activities (eg, culling), shipping, marine aggregates, oil and gas
Spatial extent	England EEZ (with links to UK EEZ and potentially further afield to north-east Atlantic waters)
Timeframe	• Medium term: Development of the Cumulative Effects Framework (CEF) for cumulative / in-combination collision and displacement predicted impacts from OWFs is underway. Follow-up activity could develop a wider cumulative database.
Status	Ongoing – a cumulative database of marine renewable impacts (collision and displacement) is being developed, but this will not cover all sources of anthropogenic mortality
Other stakeholders	BEIS, Crown Estate, SNCBs, MMO, IFCAs, OWF industry, fisheries, marine aggregates industry, oil/gas industry, local councils, local groups
Pathway to recommendation	• **K7.1: Expand the CEF to incorporate impacts from other sources.** Once the CEF is developed, the opportunity exists to expand the understanding of cumulative impacts that it covers.

Recommendation K7	*Develop an up-to-date, live database to describe cumulative anthropogenic impacts on seabird populations and prioritise action*
	This could include factoring in mortality to relevant species from licensed culling, non-offshore wind marine industry, bycatch and other human-induced pressures where relevant. This requires effort to quantify and estimate impact from these various sources but would provide invaluable insight into the potential for seabird recovery and perhaps inform natural capital accounting. Such a cumulative impact database could be widened to include other UK countries so that combined effect across borders and seasons can be incorporated, building upon OSPAR initiatives in this area. A Government-led approach could ensure that such a database is maintained appropriately. The database would complement other recommendations relating to monitoring seabird populations and ecosystem health (K2 and K5).

Recommendation K8	*Promote and enable strategic baseline and impact monitoring of seabirds in relation to marine infrastructure (especially offshore wind farms)*
Linked to other recommendations:	S2
Impact/threat	Mortality and displacement from offshore structures
Key species	Visual disturbance: Arctic tern, black guillemot, common tern, Atlantic puffin, razorbill, red-throated diver. Collision above water: common gull, great black-backed gull, herring gull, kittiwake, lesser black-backed gull, Mediterranean gull, northern gannet
Relevant activities	Marine renewables: Offshore wind (construction, operation, maintenance and decommissioning), wave (decommissioning, during construction, operation and maintenance), tidal lagoon/impoundment (construction, operation and maintenance and decommissioning), tidal stream (construction, operation and maintenance and decommissioning)
Spatial extent	England EEZ and wider UK EEZ
Timeframe	• Short term: Cross-sector partner relationships are mainly strong, and development of these ideas is already taking place. There is an immediate short-term action to connect OWF-driven initiatives with ESCaRP actions to ensure that they align and deliver for the aims of both offshore wind development and seabird conservation
Status	Ongoing

Recommendation K8	***Promote and enable strategic baseline and impact monitoring of seabirds in relation to marine infrastructure (especially offshore wind farms)***
Other stakeholders	Crown Estate, BEIS, MMO, offshore wind industry
Pathway to recommendation	• **K8.1: Develop partnership approach to shift to strategic baseline monitoring:** Government should initiate and engage in a partnership approach with the offshore renewables energy sector (including the Crown Estate) to address specific evidence gaps in seabird distribution and abundance at sea through a joint-funded, strategic programme of work. This should collect consistent and accurate data on at-sea baseline distribution of seabirds across UK waters at all times of year, to feed into planning tools like POSEIDON and drive better project-level data collection. • **K8.2: Develop partnership approach to shift to strategic impact monitoring:** Government could jointly fund key pieces of strategic research, with partners such as the Crown Estate, academia and OWF developers. A model is provided by WOZEP (the Offshore Wind Ecological Programme) operating in the Netherlands, and by the Offshore Wind Evidence and Change (OWEC) Programme in the UK. This strategic, public-private partnership approach to research could help accelerate and de-risk the assessment and consenting of OWFs and drive mitigation (and compensation) planning. Key projects could include understanding the flight height of seabirds to inform mitigation design for collisions and increasing the use of post-consent monitoring devices to inform rates of collision at constructed turbines; the Offshore Wind Environmental Evidence Register is a useful reference. • **K8.3: Establish data standards and sharing:** Strategic collection of data should be coupled with a common set of data standards and agreements with key stakeholders to share data in a timely and open fashion. Making distribution and abundance data sharing smoother, standardised and obligatory for developers would enable tools like POSEIDON to become increasingly powerful and useful over time.

9. Implementing the ESCaRP

Seabirds are wide-ranging animals, crossing various domestic and international boundaries in the regular movements made during their life cycles. Most of the species covered in this recovery pathway spend a large proportion of their lives within the jurisdiction of the other devolved UK nations and other neighbouring European countries and will often recruit into colonies across borders. Many are also fully migratory species, spending part of the year as far away as the coast of West Africa or South America. They are also entirely dependent on other parts of both coastal and marine ecosystems, meaning implementation of the ESCaRP recommendations must make links across spatial scales and across ecosystems to succeed.

This should include legislative and policy drivers such as Good Environmental Status goals in the UK Marine Strategy, targets in the EIP, as well as individual species and habitat targets defined by Favourable Conservation Status statements.

In implementing the ESCaRP, Defra will seek to collaborate with Devolved Administrations to, where possible, explore overlaps between the ESCaRP and seabird strategies from the other UK countries so actions may become comprehensive, holistic and efficient. International collaboration is also required where possible (eg OSPAR, AEWA, United Nations), particularly for those more wide-ranging species, to deliver better conservation outcomes in a more cost-effective manner (see Appendix 14).

Opportunities for implementation

Implementation of the recommendations within this ESCaRP will need resources to enable it to be delivered in full. Opportunities may arise from ongoing initiatives, and new opportunities may arise (for instance, through marine Net Gain, if policy allows). Defra could consider a National Seabird Recovery Fund that could become a source of funding for seabird-specific projects linked to ESCaRP delivery, potentially bringing together other sources of revenue that may become available to allow strategic project planning and delivery.

Linked to this could be a Register of Seabird Recovery Projects, with clear delivery outcomes. RSPB have compiled a roughly costed five-year plan for remedies required at breeding colonies, which could form the basis of such a register. This register could act as a guide to decision-making and speed the process of complex discussions around nature recovery.

Next steps

Critical to the success of the ESCaRP will be a robust evaluation framework for how effectively it has been implemented and whether this has successfully supported recovery of England’s seabirds. Monitoring and measuring which measures are successful and which need adapting will be key to finding the best solutions for seabird recovery.

In addition, consideration should be given to the EIP review period and how this applies to the ESCaRP. ESCaRP was developed prior to publication of the seabird census and should be considered alongside the census when implementing recommendations. The impacts of the recent HPAI outbreaks on seabird populations have also yet to be fully assessed. These HPAI outbreaks, and other recent seabird mass mortality have demonstrated how swiftly unforeseen pressures on seabirds can act, meaning a periodic review of these pressures and recommended actions to address them is necessary. Any review should be on a frequent basis, preferably every three-years and align with other assessments eg GES evaluating the success of implemented measures and look for emerging threats. This could also include a re-analysis of sensitivity and spatial information, so that Vulnerability Assessments are kept current.

Furthermore, there are pressures not addressed which could be included in future reviews. Pressures on seabirds outside of English waters, for example, have not been assessed, although they are likely to contribute substantially to population trends in English seabirds (see Appendix 14Urban-nesting gull populations, which make up substantial proportions of the breeding populations of herring and lesser black-backed gull in England, have not been considered in depth. Further work mapping sea level rise and predicted impacts on seabird colonies in England would also be helpful to prioritise action on habitat restoration and creation.

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11. Appendices

• Appendix 1. Consideration of pressures for vulnerability assessment

Pressures have been defined as the "*mechanism through which an activity has an effect on any part of the ecosystem*" (Robinson and others 2008) and may be hydrological, physical, chemical or biological (Sinclair and others 2020).

Natural England uses a standard list of 39 pressures across its marine work, developed over several years and derived from an internationally recognised list provided by OSPAR (2011). This initial list of pressures was reviewed – fifteen pressures were deemed out of scope for the sensitivity assessments, as they would only indirectly affect seabird and marine waterbird species (shown in Table 22 as 'no direct effects'), and a further two were deemed not relevant for birds (shown in Table 22 as 'not relevant).

Multiple pressures that act indirectly upon birds will do so by affecting the supporting habitat, or availability of prey, or by other means. It is often not possible to relate the resulting impacts on bird species back to the specific initial pressure, or multiple pressures, that may have indirectly caused that impact. These include pressures such as 'physical change (to another sediment type)', which affects the supporting habitat of the bird species rather than the birds themselves. In recognition of the fact that some of these indirect pressures are likely to be of significance for the conservation status of seabirds and marine waterbirds, two additional pressures were included for assessment: 'Reduction in availability, extent, or quality of supporting habitat' and 'Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities'. A further pressure was included for assessment, in recognition that seabirds and marine waterbirds may be adversely affected not just by non-native species (included in the pressure 'Introduction or spread of invasive non-indigenous species (INIS)') but also by native species such as badgers *Meles meles*, foxes *Vulpes vulpes* and carrion crows *Corvus corone*.

The list of 42 pressures is summarised in Table 22. Pressures classed as 'no direct effects' or 'not relevant' were not included in the sensitivity assessments, however they were included in the vulnerability assessment, although these would result in a score of 'not vulnerable – C' (see Table 5). A full description of the 19 pressures that resulted in at least one vulnerability score of moderate or higher can be found in Table 23.

Table 22. List of pressures within and out of scope.

Pressure Name	Sensitivity Assessment
Above water noise	assessed
Abrasion/disturbance of the substrate on the surface of the seabed	*no direct effects*
Barrier to species movement	assessed
Changes in suspended solids (water clarity)	assessed
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	assessed
Collision BELOW water with static or moving objects not naturally found in the marine environment	assessed
Deoxygenation	*no direct effects*
Electromagnetic changes	*not relevant*
Emergence regime changes, including tidal level change considerations	assessed
Genetic modification & translocation of indigenous species	*not relevant*
Habitat structure changes - removal of substratum (extraction)	*no direct effects*
Hydrocarbon & PAH contamination	assessed
Increase of native competitor/predatory species	assessed
Introduction of light	assessed
Introduction of microbial pathogens	assessed
Introduction of other substances (solid, liquid or gas)	assessed
Introduction or spread of invasive non-indigenous species (INIS)	assessed
Litter	assessed
Nutrient enrichment	*no direct effects*
Organic enrichment	*no direct effects*
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	*no direct effects*
Physical change (to another seabed type)	*no direct effects*
Physical change (to another sediment type)	*no direct effects*
Physical loss (to land or freshwater habitat)	*no direct effects*
Radionuclide contamination	assessed
Reduction in availability, extent, or quality of supporting habitat	assessed
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	assessed
Removal of non-target species	assessed
Removal of target species	assessed
Salinity decrease	*no direct effects*
Salinity increase	*no direct effects*

Pressure Name	Sensitivity Assessment
Smothering and siltation rate changes (Heavy)	*no direct effects*
Smothering and siltation rate changes (Light)	*no direct effects*
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	assessed
Temperature decrease	*no direct effects*
Temperature increase	*no direct effects*
Transition elements & organo-metal (eg TBT) contamination	assessed
Underwater noise changes	assessed
Vibration	assessed
Visual disturbance	assessed
Water flow (tidal current) changes, including sediment transport considerations	assessed
Wave exposure changes	assessed

Table 23. Detailed pressure description for the nineteens pressures resulting in at least one vulnerability score of moderate or higher.
Note that where possible original pressure descriptions (as agreed in OSPAR 2011) were retained and amended only to increase applicability to birds. Thus, descriptions include references to other marine species and habitats outside the scope of ESCaRP.

Pressure	Pressure Description
Visual disturbance	Disturbance by visual stimuli associated with anthropogenic activities. Examples of such activities include: recreational activities; personnel movements; moving wind turbine blades; vehicle or vessel movements (eg, during construction or maintenance of infrastructure such as bridges, cranes, port buildings, offshore platforms, offshore wind farms etc). Visual stimuli from all such activities may disturb bird breeding areas, roosting areas, rafting areas, feeding areas, etc.
Introduction or spread of invasive non-indigenous species (INIS)	The direct or indirect introduction or spread of non-indigenous species (INIS), also known as invasive non-native species (INNS) or invasive alien species (IAS), including but not limited to the introduction of predators such as mink, weasels, rats, hedgehogs and domestic cats which can result in predation of nesting birds.
Introduction of microbial pathogens	The introduction or increase in levels of pathogens, disease vectors or parasites due to anthropogenic activities. Sources of disease, viruses and parasites could include untreated or insufficiently treated effluent discharges & run-off from terrestrial sources & vessels, including ballast water releases or aquaculture at sea or agricultural sources on land.
Removal of target species	Direct, deliberate (targeted) removal or harvesting of the species by humans, eg, hunting or culling, including the removal/destruction of nests/eggs.

Pressure	Pressure Description
Removal of non-target species	Direct but unintentional removal/harvesting of the species by humans eg, bycatch (including entrapment in fishing gear, ropes, lines, anti-predator nets or any other form of netting); accidental hunting/culling/egg or nest removal or destruction of misidentified species. Note: mortality through entanglement from litter or 'ghost gear' (lost or discarded fishing nets/creels etc) is not included as it is considered under the 'litter' pressure. Mortality through collision with infrastructure is also excluded as considered under the 'collision' pressures.
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	Anthropogenic changes in the quantity or quality of food available to birds caused by the direct removal of food resources (intentional or unintentional) eg, fishing activities, shellfish removal, bait-digging. May be affected by management of fisheries and shellfisheries, discards management, waste management, agricultural practices, etc. This pressure can impact through multiple effects causing increased time and energy expenditure, reduced body condition of all age classes, reduced chick growth rates, reduced productivity and survival of young or adults and ultimately decline of populations.
Changes in suspended solids (water clarity)	Changes in water clarity due to changes in sediment and organic particulate matter concentrations, caused by anthropogenic activities that that disturb sediment and/or organic particulate matter, thereby mobilising it into the water column. These anthropogenic activities include: all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, river management, flood defences, breakwaters, poor soil and livestock management practices in agricultural settings. Particle size, hydrological energy (current speed and direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources are mostly short-lived and occur over relatively small spatial extents but could affect species that rely on underwater vision for hunting.
Wave exposure changes	This pressure refers to local changes in wavelength, height and frequency. Exposure on an open shore is dependent upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, and wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, eg, a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.
Litter	Litter is any manufactured or processed solid material from anthropogenic activities that are discarded, disposed of or abandoned once entering the natural environment including: plastics, metals, timber, rope, fishing gear etc and their degraded components, eg, microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).

Pressure	Pressure Description
Introduction of light	Direct inputs of light from anthropogenic activities, ie lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, eg promenade or pier lighting; lighting on oil and gas facilities, urban street and building lighting etc. Ecological effects may include the diversion of bird species from migration routes if they become disorientated by or attracted to the lights. Attraction to light sources can result in birds directly colliding with structures.
Barrier to species movement	Physical obstruction of species' movements through either air or water including local movements (within and between roosting, breeding, feeding areas) and regional/global migrations. Includes obstruction of movements over/on land, sea, or rivers caused by built structures (eg, buildings, offshore platforms, wind turbines, tidal barrages, wave or tidal array devices), as well as obstruction of movements below water caused by eg, mariculture infrastructure or fixed fishing gear.
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	Injury or mortality from collisions with static and/or moving structures above water or land eg, rigs, buildings, lighthouses, wind turbines, cables, tidal devices, vehicles/vessels
Collision BELOW water with static or moving objects not naturally found in the marine environment	Injury or mortality from collisions with static and/or moving structures below water eg, infrastructure, rigs, wind turbines, cables, tidal devices, vehicles/vessels.
Above water noise	Any loud noise made onshore or offshore by construction, vehicles, vessels, tourism, mining etc. that may disturb birds and reduce time spent in any supporting habitat, eg, feeding, breeding, or roosting area.
Transition elements & organo-metal (eg TBT) contamination	The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are: Arsenic, Cadmium, Chromium, Copper, Mercury and organic mercury compounds, Nickel and its compounds, Lead and organic lead compounds, and Zinc. However, the following may also be released into the marine environment: Aluminium, Barium, Cobalt, Iron, Molybdenum, Selenium, Tin, Tungsten, and Vanadium. Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, eg, Imposex in molluscs. The use of other organo-metalloids, such as organo-copper and organo-zinc compounds, has increased due to the ban on organo-tins.
Hydrocarbon & PAH contamination	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, or

Pressure	Pressure Description
	complex mixtures of two basic molecular structures: straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation), and multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation). These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): biogenic hydrocarbons (from plants & animals); petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off); and = pyrogenic hydrocarbons (from combustion of coal, woods and petroleum). Ecological 'chemical' consequences include taint, acutely toxicity, carcinomas, and/or growth defects. In addition, hydrocarbons may have 'physical' as well as 'chemical' (toxic) effects on marine species. Physical effects include smothering, suffocation, and clogging of feathers, breathing apparatus, or the digestive tracts of species at the air/water boundary, on rocks or in the sediment they inhabit.
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	Increases in the levels of these compounds compared with background concentrations. Synthetic compounds are manufactured for a variety of industrial processes and commercial applications. Chlorinated compounds and other organohalogens are often persistent and often toxic; includes: Polychlorinated biphenols (PCBs), Brominated flame-retardants, Chemical precursors and solvents, sticides vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms, many of which are also organohalogens or organophosphates; includes: insecticides, herbicides, rodenticides, fungicides, parasiticides, antifoulants. Pharmaceuticals and 'personal care products' originate from veterinary and human applications compiling a variety of products including: over the counter medications, fungicides, chemotherapy drugs and animal (eg fin-fish) therapeutics, such as growth hormones and oestrogens. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments, pharmaceuticals have become an emerging concern. Ecological consequences include physiological changes (eg, growth defects, carcinomas). Dispersants (used to disperse oils spills) are often mixtures of distillates, surfactants, and other ingredients. This category also includes: Other synthetic and organic esters, Phthalate esters, and Synthetic musks which may also be PBTs (persistent, bioaccumulative, or toxic substances).
Introduction of other substances (solid, liquid or gas)	The 'systematic or intentional release of solids, liquids, or gases …' (from MSFD Annex III Table 2) is considered eg, in relation to produced water from the oil industry. It should therefore be considered in parallel with the other contaminants' pressures.

Pressure	Pressure Description
	This pressure includes compounds released as operational discharges, produced waters or spills from maritime (offshore/ inshore) installations (eg, oil & gas, renewables), mariculture, shipping and harbours etc that are not assessed elsewhere. This pressure includes inorganic chemicals that vary in their physical or chemical effects, eg, Chemicals transported in bulk that may be spilt (eg acetic acid, phosphoric acid, sulphuric acid, sodium hydroxide); Chemicals in drilling waste or produced waters (eg barite, calcium carbonate, potash, zinc oxide); Inorganic antifoulants (eg Chromium trioxide, copper thiocyanate); Natural products with varied uses (eg molasses transported in bulk but also glycerins, formalin etc); Fin-fish food supplements (eg carotenoids, copper sulphate); Releases from munitions dumps; Chemical warfare agents; Explosives/propellants
Radionuclide contamination	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (eg, oil platforms, medical sources). Regulations on the disposal of radioactive waste differ on land and at sea. Radioactive waste disposal on land must be authorised by the Environment Agency and follow their guidance. The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ship's crew is 10 μSv or less in a year; (ii) the collective effective dose to the public or ship's crew is not more than 1 man Sv per annum, then the material is deemed to contain de minimis levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (ie very low), given that the average background dose to the UK population is ~2,700 μSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.

- # Appendix 2. Exposure Assessment Data and Methods

Appendix 2.1 Ornithological Data

Appendix 2.1.1 Data products used to generate marine seabird distributions maps

The vulnerability assessment required information on the distribution of seabirds in the marine environment. There are a number of possible suitable map products which have been assessed before with regards to their quality and suitability for assessments of offshore wind developments (Johnston and others 2020). These maps vary in species covered, temporal resolution (ie monthly or seasonal maps), and in data sources and methods used to produce them, and no single map product meets the data requirements of the vulnerability analysis across all species. The choice of seabird distribution data product therefore differs between UoAs to ensure that in each case the best available data were used.

The map products providing readily available seabird distribution maps, and the preferential order for their use in the assessment, are outlined below. For details on which maps were used for each UoA, see Table 24.

MERP seabird distribution maps[13]

The seabird distributions maps provided by the Marine Ecosystems Research Programme (MERP) cover the monthly distributions of 12 seabird species and at a 10km spatial resolution over large parts of the northeast Atlantic, including UK waters (Waggitt and others 2020). They were produced with help of Generalized Linear Models and General Estimating Equations (GLM-GEE) and, for UK waters, these maps are considered as being produced by the most sophisticated method and most recent data currently available at this geographic scale and temporal resolution. The data underpinning the MERP maps incorporates also the most comprehensive collection of data, including the most recent available datasets as well as the data used for the European Seabirds at Sea (ESAS) seabird distribution maps, and data used for the Seabird Mapping and Sensitivity Tool (SeaMaST) seabird distribution maps. Where possible, MERP maps were used for the vulnerability analysis, however, they were not available for all species covered by this project.

SeaMaST seabird distribution maps

[13] https://marine-ecosystems.org.uk/

If no MERP seabird distribution maps were available, Natural England's Seabird Mapping & Sensitivity Tool (SeaMaST) seabird distribution maps were used instead where available. SeaMaST provides seasonal seabird distribution maps for 22 species, produced with help of Density Surface Models (Bradbury and others 2014). In an early version of the SeaMaST maps, the 'summer period' and the 'winter period' were defined generically and applied to all species covered by this first analysis. In a later version, the generic seasons were substituted by species-specific seasons. If SeaMaST maps were used in the vulnerability assessments, preference was given to those maps based on species-specific seasons, and only where those were not available, SeaMaST maps with generic seasons were used.

ESAS seabird distribution maps

The European Seabirds at Sea (ESAS) database is the data source underpinning the seabird distribution maps by Kober and others (2010). These seasonal maps were produced for 31 species using Poisson Kriging modelling and are based on older data than used by SeaMaST or in the MERP distribution maps. However, for Mediterranean gull during winter, and for little gull and Sandwich tern during autumn migration, ESAS maps were the only available data source and were used in the vulnerability analysis.

BTO Bird Atlas 2007-11 distribution maps

MERP, SeaMaST and ESAS seabird distribution maps have limitations with regards to their accuracy close inshore, as the underlaying data sets were primarily collected further offshore. Species with a near-shore coastal presence and distribution, such as common eider, grebes and divers, were therefore deemed to be more accurately depicted by data and mapping available from the BTO Bird Atlas 2007-11 (Balmer and others 2013). The BTO distribution maps are seasonal maps, provided for a wide range of species, including *inter alia* seabirds and waterbirds[14]. The methods to produce these maps differed between species, depending on the available data. BTO maps of most of the inshore species had a spatial resolution of 2x2km and a spatial extent of 8km around the UK coast.

Data for the black-necked grebe were only available with a 10x10km resolution, and both a relative abundance and presence-only distribution dataset were combined following guidance from the BTO to produce a more comprehensive dataset. The two datasets (relative abundance and distribution) follow the same polygon grid layout and were superimposed on each other. Where a relative abundance grid cell value was available this was used. For grid cells where a relative abundance was not available

[14] Available in the BTO Mapstore: https://app.bto.org/mapstore/StoreServlet

and a distribution ‘presence’ cell was present, a value one order of magnitude smaller than the lowest relative abundance was assigned to the cell.

Phillips and others (2021) Balearic shearwater distribution maps

Balearic shearwater is the only species not covered by any of the above-mentioned sources of seabird distributions maps. However, Phillips and others (2021) have investigated the probability of this species across the western English Channel and southern Celtic Sea. Even though the data is limited to the southwest of Britain, the area of the suspected greatest abundance of this species, it can be assumed that this is the best information currently available on the distribution of this species in UK waters.

Additionally, because of the limitations of the MERP, SeaMaST and ESAS seabird distribution maps close to the coast, for breeding terns, some gulls, and black guillemot a bespoke approach involving the modelling and projection of at sea distributions of individuals from their known colonies was deemed most appropriate. The approach used information about the location of coastal colonies from the Seabird Monitoring Programme (SMP) database in combination with projected seaward distributions based on estimated foraging ranges (Woodward and others 2019). For details on the methods used see Appendix 6.

Table 24. Data sources and seasonal range of data used for seabird distribution maps. Data for the correct months for each UoA season were used where possible, however data was not always available at this temporal resolution. The 'months of data used' column outlines the actual months of the data used for each distribution map.

Taxonomic Group	Unit of Assessment (UoA)	Data source	Months of data used
Ducks	Common eider - Breeding	BTO Bird Atlas 2007-2011	BTO breeding
	Common eider - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Common scoter - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Long-tailed duck - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Red-breasted merganser - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
Grebes	Slavonian grebe - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Black-necked grebe - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
Gulls	Black-legged kittiwake - Breeding	MERP	May - Sept
	Black-legged kittiwake - Non-breeding	MERP	Oct - Apr
	Black-headed gull - Breeding	SeaMaST	Apr - Sep
	Black-headed gull - Non-breeding	SeaMaST	Oct - Mar
	Little gull - Non-breeding, Wintering	SeaMaST	Oct - Mar
	Little gull - Non-breeding, Passage	ESAS	Aug - Nov
	Mediterranean gull - Breeding	SMP and foraging radii	May - Jun
	Mediterranean gull - Non-breeding	ESAS	All year
	Common gull - Breeding	SeaMaST	Apr - Sep
	Common gull - Non-breeding	SeaMaST	Oct - Mar

Taxonomic Group	Unit of Assessment (UoA)	Data source	Months of data used
	Great black-backed gull - Breeding	SeaMaST	Mar – Aug
	Great black-backed gull - Non-breeding	SeaMaST	Sep - Mar
	Herring gull - Breeding	MERP	Apr - Aug
	Herring gull - Non-breeding	MERP	Sept - Mar
	Yellow-legged gull - Breeding	SMP and foraging radii	May - Jun
	Lesser black-backed gull - Breeding	MERP	May - Aug
	Lesser black-backed gull - Non-breeding	MERP	Sept - Apr
Terns	Sandwich tern - Breeding	SeaMaST	Apr - Aug
	Sandwich tern - Non-breeding, Passage	ESAS	Sep - Oct
	Little tern - Breeding	SMP and foraging radii	May - Jun
	Roseate tern - Breeding	SMP and foraging radii	May - Jun
	Common tern - Breeding	SMP and foraging radii	May - Jun
	Arctic tern - Breeding	SMP and foraging radii	May - Jun
Skuas	Great skua - Breeding	MERP	May - Aug
	Great skua - Non-breeding	MERP	Sep - Aug
	Arctic skua - Breeding	SeaMaST	Apr - Sep
	Arctic skua - Non-breeding, Passage	SeaMaST	Aug - Apr
Auks	Common guillemot - Breeding	MERP	May - Jul
	Common guillemot - Non-breeding, Passage	MERP	Aug - Sep
	Common guillemot - Non-breeding, Wintering	MERP	Oct - Apr
	Razorbill - Breeding	MERP	May - Jul
	Razorbill - Non-breeding, Passage	MERP	Aug - Sep

Taxonomic Group	Unit of Assessment (UoA)	Data source	Months of data used
	Razorbill - Non-breeding, Wintering	MERP	Oct - Apr
	Black guillemot - Breeding	SMP and foraging radii	Mar - May
	Black guillemot - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Atlantic puffin - Breeding	MERP	Apr - Jul
	Atlantic puffin) - Non-breeding	MERP	Aug - Mar
Divers	Red-throated diver - Non-breeding	SeaMaST	Sep - Feb
	Black-throated diver - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
	Great northern diver - Non-breeding	BTO Bird Atlas 2007-2011	BTO winter
Petrels & Shearwaters	European storm petrel - Breeding	MERP	Jun - Oct
	Northern fulmar - Breeding	MERP	Mar - Jul
	Northern fulmar - Non-breeding	MERP	Aug - Feb
	Manx shearwater - Breeding	MERP	May - Sep
	Manx shearwater - Non-breeding, Passage	MERP	Oct - Nov
	Balearic shearwater - Non-breeding, Passage	Phillips and others 2021	All year
Sulids	Northern gannet - Breeding	MERP	May - Sep
	Northern gannet - Non-breeding	MERP	Oct - Apr
Cormorants & Shags	Great cormorant - Breeding	SeaMaST	Apr - Aug
	Great cormorant - Non-breeding	SeaMaST	Sep - Mar
	European shag - Breeding	MERP	Mar - Sep
	European shag - Non-breeding	MERP	Oct - Feb

Appendix 2.1.2 Marine seabird distributions – Preparation of different data sources.

Data Standardisation

In total, seven different data sources were used for the bird distribution data input into the vulnerability assessment in the marine environment. A process of data standardisation was therefore developed to produce comparable inputs and outputs for the Vulnerability Assessment.

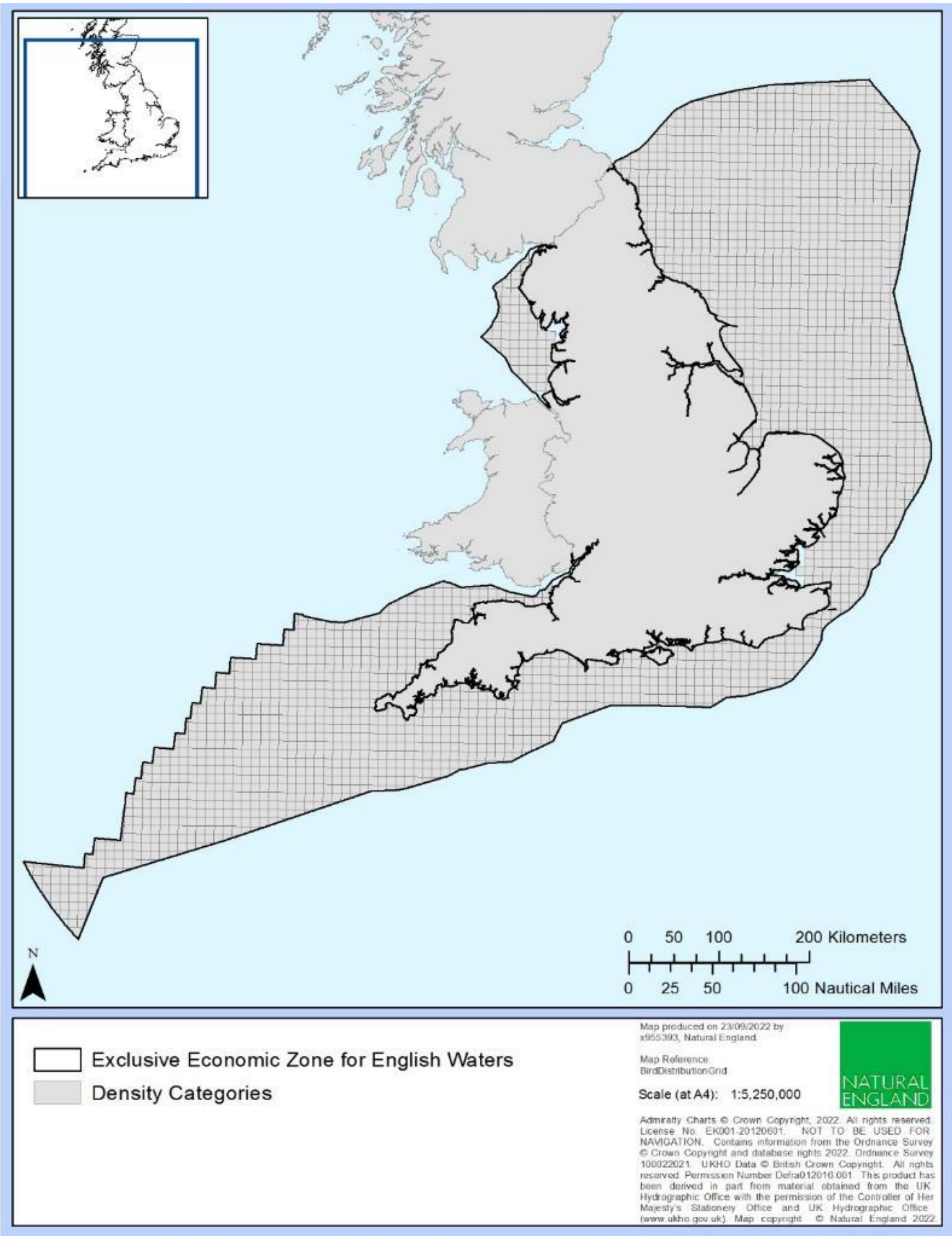


Figure 11. Distribution map with polygon grid clipped to the EEZ for English Waters

Format and Geographic Extent

All bird distribution datasets were converted into an ESRI shapefile format, projected into ETRS 1989 and re-formatted into a standard table structure. The maps were clipped to the English waters exclusive economic zone (EEZ) to produce polygon grids with absolute bird density values for each grid cell (Figure 11). All maps produced using colony locations and foraging radii reflected the shape of the foraging radii (which also used density values, but were not based on a cell distribution, and were not gridded).

Density Categorisation

The maps were transformed into relative density distribution maps by classifying the densities for each map into five categories. For this, the grid cells were sorted in order of their bird density values and assigned one of five density categories, ranging from high to not present (Table 25).

Table 25. Seabird density categories in the marine environment.

Bird density category	Qualifying grid cells
High	highest density grid cells, adding up to 33% of the map population
Medium	next highest density grid cells, adding up to the next 33% of the map population
Low	next highest densities, adding up to 33% of the map population
Very low	lowest density grid cells, adding up to 1% of the map population
Not present	all grid cells with a zero-density value

Population level statistics were completed for each UoA distribution map to assign each density value a density category, using the following method:

- A pseudo 'total population' value was calculated using the sum of all individual density values
- Density values were sorted into ascending numerical order and a cumulative percentage of the total population was calculated at each density value
- The lowest densities which comprised 1% of the 'total population' were assigned to the 'very low' density category.
- The next lowest densities which comprised 33% of the 'total population' were assigned to the 'low' density category, the next 33% to the 'medium' category, and the final 33% to the 'high' density category.
- Actual zero values were assigned a category of 'not present'. This category was included for clarity, however there were only a small number of datasets with any cells assigned to this category, due to the model-based nature of the data sources.

For distribution maps using the BTO 10x10 km data source (black-necked grebe) and the Seabird Monitoring Programme (SMP) foraging radii, the ‘very low’ category was not used, as the spatial extent of the data was limited, and the lowest densities were therefore assumed to be outside the spatial extent of the data.

The distribution maps for black guillemot, roseate tern and yellow-legged gull did not contain enough differing density values to be categorised effectively using the above method. In these cases, an expert judgement approach was used to assign density categories. The distribution maps for all species are presented in Appendix 15.

Appendix 2.2 Activity data

Human activities occur throughout the marine environment including along the coast, inshore and offshore. Natural England's 'Marine and Coastal Operations and Activities' dataset was used as the initial list of activities considered to be in-scope for this work. The dataset includes over 100 marine and coastal activities which are grouped into broader operations. Note that the dataset is not an exhaustive list of all activities which might impact upon birds in the marine environment but does include a broad range.

In addition to those activities included within the dataset, a 'future scenarios' operation was added with a single new activity for 'Offshore wind'. This activity represents all current, known about and potential future offshore wind installations. It was included to ensure that the potentially future extent (spatial footprint) of offshore windfarms was considered during the subsequent assessment of vulnerability in the marine environment. Note that activities associated with current offshore wind were already included within the existing activity list.

For details on the marine activity data, the data sources used and how they were prepared for the analysis, see Appendix 2.2.1 Marine Activity Spatial Data.

There are some activities which cannot easily be mapped. These activities were still included in the assessment of vulnerability in the marine environment, but the spatial presence/absence information used in the exposure assessment was determined using expert judgement. For more details on these activities see Appendix 2.2.2 Marine activity distribution - activities without spatial data**.**.

Appendix 2.2.1 Marine Activity Spatial Data

Marine activity spatial data were collated from a range of sources. All GIS datasets were re-projected into a consistent projection (ETRS89 LAEA). Each data record was then re-formatted into a standard table structure and allocated an activity code describing the activity, creating a single marine activity dataset of collated activities for point, line and polygon data. The fields in the standard table structure used for each data set are listed in Table 28.

Some datasets present spatial data at the operation level – that is, they may not specify which activity they relate to. Where this is the case the spatial data are allocated the relevant operation code. For example, some data from the UKHO Vector dataset is for the activity 'Marine farm/culture', which falls under the operation 'Aquaculture' (Z9) but is not fine enough detail to assign an activity code and therefore remains as 'Aquaculture' (Z9).

Some datasets alternatively present spatial data for multiple activities. For these data, multiple activity codes are assigned. For example, RYA general boating areas data was assigned the activities Z11.1 (Powerboating or sailing with an engine: launching and recovery, participation), Z11.2 (Powerboating or sailing with an engine: mooring and/or anchoring), Z11.3 (Sailing without an engine: launching and recovery, participation) and Z11.4 (Sailing without an engine: mooring and/or anchoring) as any of these may occur within the polygons.

For the additional 'Offshore wind' activity (under the 'Future scenarios' Operation), spatial data for existing and potential future offshore wind were combined. This included the Round 4 preferred projects, offshore wind test and demonstration sites, government support on offer, pre-planning application, consented, in construction, in planning, active/in operation, inactive/decommissioned.

The collated activity data was then quality assured by specialists to ensure the correct activity code was assigned and that all available activity data were included.

As more than one listed activity dataset could have the same activity code, the activity data was dissolved on activity code, resulting in an activity geodatabase containing spatial data (points, lines, polygons) for each activity where spatial evidence was available. For example, line data from KIS-ORCA and UKHO for the activity Z3.2 (Power cable: operation and maintenance) were dissolved creating a single feature for the activity Z3.2 within the line feature class in the activity geodatabase.

The resulting Activity geodatabase was used to determine presence of activities in the in the exposure assessment (see section Exposure assessment methods 0). The different marine activity data sources are listed in Table 26. The field schema used for these data to enter the analysis is provided in Table 27 and Table 28.

Data caveats:

- Anchoring
    - Anchorage areas/general boating areas (recreational) used as a proxy for where anchoring may occur
- Recreation data
    - Used a combination of modelled data for whole English coastline and data for within MPAs (best available). Means that there is more data available within MPAs.
- Fishing data
    - Used a range of fishing datasets, however FisherMap was the main dataset used for inshore fishing activity which is dated now (2010) but still the best available evidence

Table 26. Marine activity data sources.
Note data collation/download happened between May 2021 and April 2022 so datasets outlined below may have been updated since.

Dataset	Source	Notes
UKHO Vector (S-57)	UK Hydrographic Office	UKHO Data © British Crown Copyright. All rights reserved. Permission Number Defra012018.001. This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk).
KIS-ORCA: Cables	KIS-ORCA	ESCA approved use for the project.
KIS-ORCA: Renewables	KIS-ORCA	ESCA approved use for the project.
KIS-ORCA: Oil and Gas	KIS-ORCA	ESCA approved use for the project.
FisherMap	Marine Management Organisation	Available to download from: https://environment.data.gov.uk/arcgis/rest/services/MMO/FisherMap/MapServer
MB0117	Cefas	Available to download from: https://data.cefas.co.uk/view/3277
Protected Wrecks	Historic England	Available to download from: https://historicengland.org.uk/listing/the-list/data-downloads
Offshore Wind Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-wind-site-agreements-england-wales-ni-the-crown-estate/explore?location=52.790200%2C-1.251504%2C6.71
Offshore Wind Cable Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-wind-cable-agreements-england-wales-ni-the-crown-estate/explore?location=52.698964%2C-1.244512%2C6.69
Offshore Wave Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-wave-site-agreements-england-wales-ni-the-crown-estate/explore?location=50.777918%2C-5.092345%2C8.63
Offshore Wave Cable Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-wave-cable-agreements-england-wales-ni-the-crown-estate/explore?location=0.000000%2C0.000000%2C0.00

Dataset	Source	Notes
Offshore Tidal Stream Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-tidal-stream-site-agreements-england-wales-ni-the-crown-estate/explore?location=52.888850%2C-3.683844%2C6.76
Offshore Tidal Stream Cable Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-tidal-stream-cable-agreements-england-wales-ni-the-crown-estate/explore?location=51.877184%2C-5.315998%2C16.46
Offshore Wind Test and Demonstration Sites	The Crown Estate	Available to download from: TCEWebMap_OffshoreWindTestAndDemonstrationSites_August2021 - Overview (arcgis.com) Permission to use data for the project granted by The Crown Estate.
Offshore Natural Gas Storage Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-natural-gas-storage-site-agreements-england-wales-ni-the-crown-estate/explore?location=54.831774%2C-5.773132%2C14.03
Offshore Natural Gas Storage Pipeline Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-natural-gas-storage-pipeline-agreements-england-wales-ni-the-crown-estate/explore?location=54.375602%2C-4.489024%2C8.94
Offshore Meteorological and Oceanographic Equipment Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-meteorological-and-oceanographic-equipment-agreements-england-wales-ni-the-crown-estate/explore?location=53.313182%2C-0.435773%2C7.05
Offshore Carbon Capture and Storage Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-carbon-capture-and-storage-site-agreements-england-wales-ni-the-crown-estate/explore?location=54.211389%2C1.022361%2C10.54
Offshore Minerals Aggregates Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-minerals-aggregates-site-agreements-england-wales-ni-

Dataset	Source	Notes
		the-crown-estate/explore?location=52.033181%2C-1.121135%2C7.19
Offshore Minerals Mining Site Agreements	The Crown Estate	Available to download from: https://opendata-thecrownestate.opendata.arcgis.com/datasets/offshore-minerals-mining-site-agreements-england-wales-ni-the-crown-estate/explore?location=52.383544%2C-2.818598%2C6.77
Marine Aggregate Current Working Areas	The Crown Estate	Obtained from The Crown Estate 2021
Offshore Wells	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/offshore-wells-etrs89/explore?location=55.590350%2C-3.246350%2C4.99
Well Bottom Hole	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/well-bottom-hole-etrs89/explore?location=55.590350%2C-3.246350%2C4.99
Top Hole - Bottom Hole Straight Line Connection	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/top-hole-bottom-hole-straight-line-connection-etrs89/explore?location=55.590350%2C-3.246350%2C4.99
Offshore Fields	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/oga-offshore-fields-etrs89/explore?location=56.172800%2C-0.567550%2C5.41
Licenses	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/oga-licences-etrs89-1/explore?location=56.616000%2C-5.050750%2C5.23
Licensed Blocks	Oil and Gas Authority	Available to download from: https://data-ogauthority.opendata.arcgis.com/datasets/oga-licensed-blocks-etrs89/explore?location=56.616000%2C-5.050750%2C5.23
Marine License Exclusion Zones	Marine Management Organisation	Available to download from: https://environment.data.gov.uk/DefraDataDownload/?mapService=MMO/MarineLicenceExclusionZones&Mode=spatial

Dataset	Source	Notes
MMO1064 Modelling marine recreation potential in England	Marine Management Organisation	Includes data layers for: beach activities, boat angling, motorboat, paddle sports, personal watercraft, sailing, scuba diving, shore angling, surfing, wildlife watching by boat, wildlife watching on land, windsurfing. Available to download from: https://environment.data.gov.uk/portalstg/home/item.html?id=14ac59f006494c2ebaf62b9aa13247ef
MMO1136 Non-Licensable Activities in MPAs	Marine Management Organisation	Available to download from: https://environment.data.gov.uk/DefraDataDownload/?mapService=MMO/NonLicensableActivitiesinMPAsMMO1136&Mode=spatial
MMO1243 High Priority Non-Licensable Activities in MPAs	Marine Management Organisation	Includes data layers for: recreational scuba diving, motorised personal watercraft, non-motorised personal watercraft, powerboating and sailing: launch and recovery, powerboating and sailing: participation, powerboating and sailing: mooring, powerboating and sailing: anchorages. Obtained from Marine Management Organisation 2021
RYA UK Coastal Atlas of Recreational Boating 2.1	Royal Yachting Association	Includes data layers for: RYA Clubs, RYA Training Centres, Marinas, Offshore Routes, General Boating Areas, AIS Intensity.

Table 27. Standardise field schema of pressure distribution data for input into the vulnerability assessment process.

Field	Description	Example
OBJECTID	Automatically generated field to uniquely identify record	1
Shape	Automatically generated description of geometry type	Polygon
Density	Density value for each cell.	1.078345
FC_Name	Feature class name carried forward from individual species feature classes to maintain data traceability	
Source_dataset	Source dataset for species-season distribution data	MERP
Species_name	Common species name	Fulmar
Distribution_code	Code to uniquely identify distribution map for each species season combination in format: 'Novak code'_'season'_'location'. This reflects the metadata of the distribution data used to create the map.	A009_b_m
Feature_code	Code used to associated assessment unit with each distribution code. In the format: 'Novak code'_'season', where season is breeding (b) or non-breeding (nb) This is used for	A009_b

	mapping to other elements of assessment in the vulnerability assessment tool	
Shape_Length	Length of Shape	n/a
Shape_Area	Area of Shape	n/a

Table 28. Standardised field schema of marine activity data for input into the vulnerability assessment process.

Field name	Notes	Example	Relevant category
Dataset_UID	Unique identifier for each dataset added	2021A056	All
Dataset_Source_ID	Unique identifier for polygon/line/point	2021A056___11	All
Date_year	Just the year identifier for the date	2014	All
Source_dataset	High level description of source dataset	Marine Management Organisation	All
Use_feature	Yes/No (null or empty field considered 'No')	Yes	All
Original_Activity_Name	The original activity name from the data source	Beach_Activities_Model_from_MMO1064	All
Operation_Name	The operation name	RECREATION	All
Operation_Z_Code	The operation Z code	Z11	All
Activity_Name	The activity name	Leisure (eg swimming, rock pooling)	All
Activity_Code	The activity Z code	Z11.17	All
Extended_Activity_Code	The activity Z code prefixed with the intensity category	LZ11.17	Where relevant
Intensity	Numerical info from any activity dataset (e.g fishing or anchoring heat maps)	11	Where relevant
Intensity_Category	If the activity dataset contains binning ranges of the intensity value into categories like H,M,L this should be populated here	L	Where relevant
Additional_information	Included any additional information of importance	Modelled dataset. Intensity = tscore. tscore is generated by the model which indicates suitability/potential for the activity. A higher tscore = higher potential/intensity.	All

Appendix 2.2.2 Marine activity distribution - activities without spatial data.

It was not possible to include all Activities in the geodatabase because not all activities are easily mapped.

For example, 'horse riding & dog walking', might occur anywhere on land and along the coast (including the intertidal). Whilst it would be possible to map footpaths, bridleways, and carparks as a proxy these could be anywhere, and the activity is likely to occur outside of the available data layers. Therefore, the decision was made to not attempt to map the activity.

For activities where there was either no or limited spatial data available the decision was made to not determine presence/absence of each activity within each assessment region using spatial analysis (Table 29). These activities were still included in the assessment of vulnerability in the marine environment (see section 3) but the presence/absence information used in the exposure assessment was determined using expert judgement.

Table 29. Activities where spatial data were not used to determine presence/absence. Notes: * indicates that the activity was expertly judged as not being present in any assessment regions and thus was not included in the assessment of vulnerability in the marine environment (no impact pathway).

Activity code	Activity Name	Notes
Z1.3	Beach sand extraction	*
Z11.10	Horse riding & dog walking	*
Z11.14	Wildfowling	*
Z11.7	Firework displays	*
Z12.1	Herbicide spraying & vegetation removal	*
Z12.2	Strandline clearance	*
Z12.3	Sand raking	*
Z13.1	Slipway (maintenance/construction)	*
Z14.1	Licensed intentional and unavoidable consequential taking/killing	*
Z14.3	Licensed scientific sampling	*
Z14.4	Licensed poisoning; stupefying baiting and despatch	*
Z14.5	Licensed taking and immediate releasing or minor scale relocating within same site	*
Z14.6	Licensed taking for translocation and introductions and major scale relocations	*

Activity code	Activity Name	Notes
Z14.7	Licensed disturbing (only) of highly protected species	*
Z14.8	Licensed netting, fitting one-way excluders, fish-refuges	
Z3.4	Telecommunication cable: Laying, burial and protection	
Z3.7	Cables: Horizontal Directional Drilling (HDD)	*
Z4.1	Capital dredging	
Z4.14	Clearance slipways, similar structures and water ways	*
Z4.4	Anchorages/moorings	
Z4.5	Piling	
Z4.6	Capital dredging disposal	
Z4.7	Habitat creation	
Z5.1	Reclaim and land take (eg the footprint of coastal defences)	
Z5.11	Operation of coastal flood and erosion risk management schemes	
Z5.4	Construction of coastal flood and erosion risk management schemes	
Z5.5	Intertidal recharge	
Z5.7	Managed realignment	
Z6.2	Vessel anchorages	
Z6.4	Vessel moorings	
Z6.6	Commercial hovercraft	
Z7.1	Tidal stream: during construction	
Z7.10	Tidal lagoon/impoundment: during construction	*
Z7.12	Tidal lagoon/impoundment: decommissioning	*
Z7.15	Wave: decommissioning	*
Z7.3	Tidal stream: decommissioning	*
Z8.6	Beach	*
Z9.5	Seaweed aquaculture: suspended rope/net culture	

Appendix 2.3 Activity-Pressure Interaction

Each activity is associated with a range of pressures which it may result in, and each pressure might be caused by a number of activities. Data on activity-pressure interactions, created for use in the Advice on Operations component of conservation advice packages, were used in the current analyses. These data were created by Natural England's marine industry specialists, linking activities and pressures (taking a precautionary approach) using a combination of peer-reviewed, grey literature and specialist expert judgement (Millard and others, in prep).

As the ESCaRP scoped in both an additional activity (see Appendix 2.2) and three additional pressures it was necessary to supplement the existing data. Where possible this was done using existing data as a proxy – for example, for the new future scenarios offshore wind activity, activity-pressure linkages were created by copying the most precautionary of the three already existing offshore wind activities.

For the new pressure 'Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities', expert judgement was used to determine which activities this was relevant to.

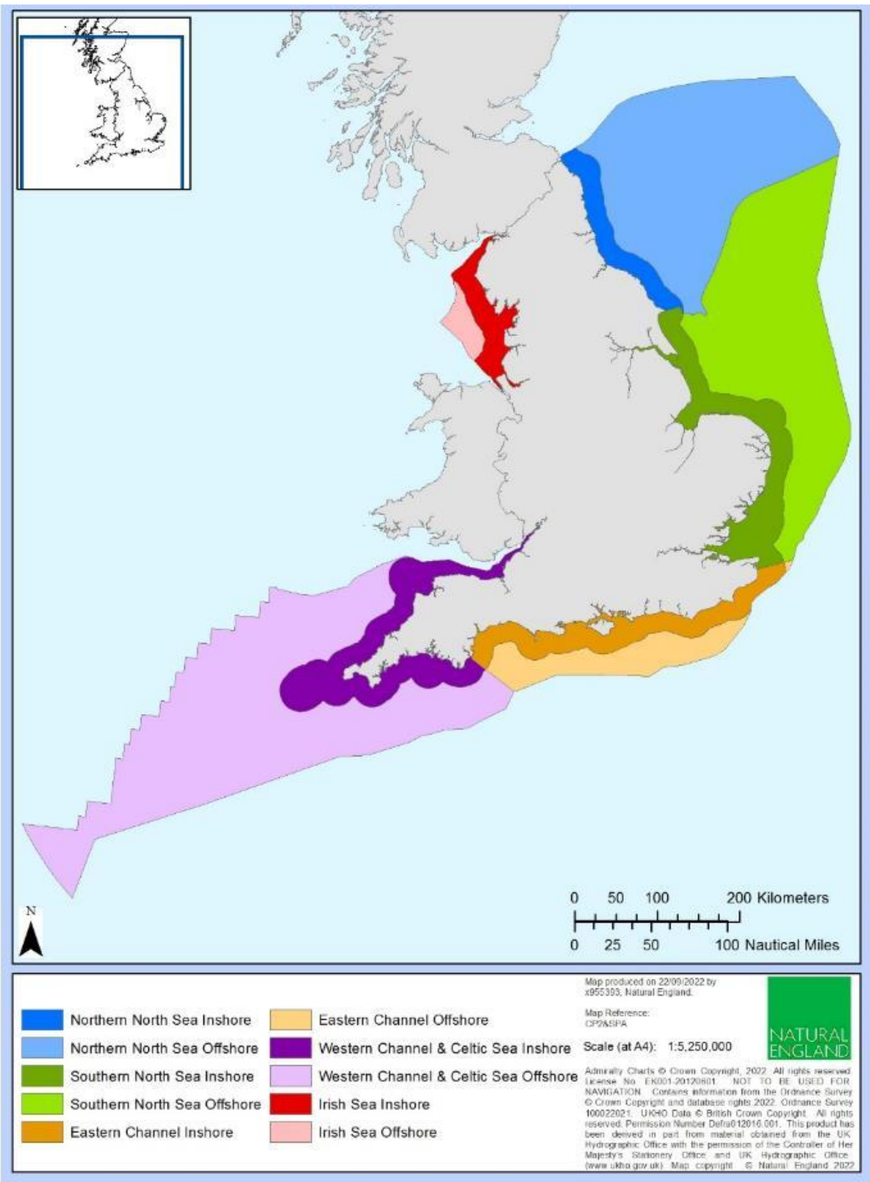
For the other new pressures – 'Increase of native competitor/predatory species' and 'reduction in availability, extent, or quality of supporting habitat' – it was decided that these could not be associated with specific activities thus excluding them from use in the assessment of vulnerability in the marine environment. These pressures were therefore considered using existing information and expert judgement in forming the recommendations.

As a result, only 40 of the 42 pressures outlined in Appendix 1 were included in the activity-pressure interaction data and subsequently in the exposure and the vulnerability assessments.

The resulting activity-pressure interaction data are used in the exposure assessment to convert the presence of (ie exposure of seabirds to) activities to the exposure of seabirds to pressures.

Appendix 2.4 Assessment regions

The use of CP2 regions was selected as they are based on physical and biological features used to define biogeographic regions around the UK (Figure 12). Additionally, the split into inshore and offshore means the assessment regions align well with Marine Plan Areas[15] used to inform decision-making by the MMO for marine activities. Additionally, division of the Assessment Regions into inshore and offshore generally aligned well with the different seabird distribution datasets.



15 Marine plan areas in England - GOV.UK (www.gov.uk) (accessed 11 November 2022)

Figure 12. Assessment regions for the exposure analysis.

• Appendix 3. Vulnerability Assessment Further Details

Appendix 3.1 Results

Appendix 3.1.1 Results by vulnerability assessment score

The results, by vulnerability score, are summarised in Table 30 and can be grouped into three broad categories.

Vulnerability score ranging between ‘high’ and ‘low’ account for 5,962 result records (approximately 25%). This broad category can be further broken down to the five vulnerability assessment scores. Only 573 result records are for ‘high vulnerability’ – that is where both the exposure and sensitivity assessment scores are ‘high’. There are similar number of result records (529) for ‘low vulnerability’ – which was determined based on both ‘low’ exposure and sensitivity assessment scores. The middle band of scores (‘high-moderate vulnerability’; ‘moderate vulnerability’; ‘moderate-low vulnerability’) all had higher number of result records (1,674; 1,741; 1,445 respectively).

A comparable amount of the scores are ‘unknown vulnerability’ scores. They account for 6,145 result records (approximately 26%) and are used where there is uncertainty either in the exposure score or with the sensitivity assessment or with both. ‘unknown vulnerability – A’, where the uncertainty originates from an unknown exposure score, accounts for 1,698; ‘unknown vulnerability – B’, where the uncertainty originates in the sensitivity assessment, accounts for 3,299; and ‘unknown vulnerability - A/B’, where the uncertainty is due to both factors, accounts for 1,148 records.

The biggest group of scores are the ‘not vulnerable’ scores, accounting for 11,493 result records (approximately 48%). ‘Not vulnerable – A’ accounts for 723 records where there is no exposure score (because the pressure is absent from the assessment region; because the bird density is ‘effective / actual zero’; or because of a combination of both). ‘Not vulnerable – B’ accounts for 740 result records where the sensitivity assessment is scored as ‘not sensitive’ (note this is scored as at the benchmark and so should not be assumed that the UoA is always not vulnerable). ‘Not vulnerable – C’ accounts for a large number of result records (10,030) where the pressure being assessed is considered as either ‘not relevant’ or having ‘no direct effects’.

Table 30. Summary results of vulnerability assessment showing the number of result records associated with each broad score category and each vulnerability assessment score.

Broad category	# result records	Vulnerability Assessment Score	# result records
Vulnerability score between High and Low	5,962	High Vulnerability	573
		High-Moderate Vulnerability	1,674
		Moderate Vulnerability	1,741
		Moderate-Low Vulnerability	1,445
		Low Vulnerability	529
Unknown vulnerability	6,145	Unknown Vulnerability - A	1,698
		Unknown Vulnerability - A/B	1,148
		Unknown Vulnerability - B	3,299
Not vulnerable	11,493	Not Vulnerable - A	723
		Not Vulnerable - B	740
		Not Vulnerable - C	10,030
TOTAL	**23,600**	**TOTAL**	**23,600**

Appendix 3.1.2 Results by species and season (UoA)

The assessment of vulnerability in the marine environment scored the vulnerability of each of 59 species-season (or UoA) combinations, against each pressure within each assessment region. These are summarised below in Table 31.

The majority of UoAs were assessed as being ‘high vulnerability’ to at least one pressure in one assessment region, with only eleven UoA (out of 59) having no associated ‘high vulnerability’ results. All UoA were associated with ’high-moderate vulnerability’ and ‘moderate vulnerability’ results in at least one region. All but five UoA were associated with ‘moderate-low vulnerability’ scores, and only fourteen UoA did not have at least one associated ‘low vulnerability’ score.

28 (out of 59) UoA were associated with scores of ‘unknown vulnerability – A’ and ‘unknown vulnerability – A/B’, in all cases this was resultant from an unknown exposure to the pressure and, for the latter, combined with unknown sensitivity to pressure(s) (at the benchmark). All 59 UoA were associated results of ‘unknown vulnerability – B’ the result of unknown sensitivity to pressure(s) (at the benchmark).

Only 15 (out of 59) UoA were associated with scores of ‘not vulnerable – A’, the result of ‘no exposure’. Many UoA (42 out of 59) were associated with ‘not vulnerable – B’ results, due to the UoA being assessed as ‘not sensitive’ (at the benchmark) to the pressure.

All UoA were associated with 170 records of ‘not vulnerable – C’ – associated with the 17 pressures that are ‘not relevant’ or of ‘no direct effects’ across all ten assessment regions.

Table 31. Summary of vulnerability assessment results.
Numbers refer to counts of UoA*pressure*region combinations that fall into each vulnerability category.

Pressure	High Vulnerability	High-Moderate Vulnerability	Moderate Vulnerability	Moderate-Low Vulnerability	Low Vulnerability	Unknown Vulnerability - A	Unknown Vulnerability - A/B	Unknown Vulnerability - B	Not Vulnerable - A	Not Vulnerable - B	Not Vulnerable - C
Visual disturbance	16	88	153	131	41	128			33		
Genetic modification & translocation of indigenous species											590
Introduction or spread of invasive non-indigenous species (INIS)	15	70	135	103	72	104	24	34	33		
Introduction of microbial pathogens	45	136	78	116		96	32	54	33		
Removal of target species	122	117	114	49	6	103	25	21	33		
Removal of non-target species	79	149	109	79		125	3	13	33		
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	65	123	100	67	15	107	21	59	33		
Habitat structure changes - removal of substratum (extraction)											590
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion											590

Pressure	High Vulnerability	High-Moderate Vulnerability	Moderate Vulnerability	Moderate-Low Vulnerability	Low Vulnerability	Unknown Vulnerability - A	Unknown Vulnerability - A/B	Unknown Vulnerability - B	Not Vulnerable - A	Not Vulnerable - B	Not Vulnerable - C
Changes in suspended solids (water clarity)		16	64	32	36	64	21	45	22	290	
Smothering and siltation rate changes (Heavy)											590
Smothering and siltation rate changes (Light)											590
Abrasion/disturbance of the substrate on the surface of the seabed											590
Temperature decrease											590
Temperature increase											590
Salinity decrease											590
Salinity increase											590
Water flow (tidal current) changes, including sediment transport considerations							128	429	33		
Emergence regime changes, including tidal level change considerations							128	429	33		
Wave exposure changes		24	80	43	47	48	80	235	33		
Physical loss (to land or freshwater habitat)											590
Physical change (to another seabed type)											590
Physical change (to another sediment type)											590
Litter	51	145	103	89	15	109	19	26	33		

Pressure	High Vulnerability	High-Moderate Vulnerability	Moderate Vulnerability	Moderate-Low Vulnerability	Low Vulnerability	Unknown Vulnerability - A	Unknown Vulnerability - A/B	Unknown Vulnerability - B	Not Vulnerable - A	Not Vulnerable - B	Not Vulnerable - C
Electromagnetic changes											590
Underwater noise changes			62	21	53	61	42	110	21	220	
Introduction of light		76	83	93	22	62	66	155	33		
Barrier to species movement		60	87	85	57	95	3	23	20	160	
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	50	134	93	119	26	115	13	7	33		
Collision BELOW water with static or moving objects not naturally found in the marine environment	4	76	145	116	76	103	25	12	33		
Above water noise		35	60	51	50	70	58	163	33	70	
Vibration							128	429	33		
Transition elements & organo-metal (eg TBT) contamination	18	154	81	96		96	32	80	33		
Hydrocarbon & PAH contamination	74	139	121	82	1	115	13	12	33		
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	34	127	71	71	11	82	46	115	33		
Introduction of other substances (solid, liquid or gas)		2				8	120	427	33		

Pressure	High Vulnerability	High-Moderate Vulnerability	Moderate Vulnerability	Moderate-Low Vulnerability	Low Vulnerability	Unknown Vulnerability - A	Unknown Vulnerability - A/B	Unknown Vulnerability - B	Not Vulnerable - A	Not Vulnerable - B	Not Vulnerable - C
Radionuclide contamination		3	2	2	1	7	121	421	33		
Nutrient enrichment											590
Organic enrichment											590
Deoxygenation											590
TOTAL	573	1,674	1,741	1,445	529	1,698	1,148	3,299	723	740	10,030

Appendix 3.1.3 Important Pressures

Results of the vulnerability assessment (Table 31) were used to rank pressures associated with high and high-moderate vulnerability scores (Table 32). These were then used to identify the top ten ranking pressures (see Section 0).

Table 32. Pressures resulting in ‘high’ and ‘high-moderate’ vulnerability assessment results.
Data presented including the number of results associated with each score, a combined total and ranking based on the three individual number of scores.

Pressure	# "High Vulnerability"		# "High-Moderate Vulnerability"		#"High" and "High-Moderate" Vulnerability	
	n total	Rank	n total	rank	n total	Rank
Visual disturbance	16	10	88	10	104	10
Introduction or spread of invasive non-indigenous species (INIS)	15	11	70	13	85	11
Introduction of microbial pathogens	45	7	136	5	181	7
Removal of target species	122	1	117	9	239	1
Removal of non-target species	79	2	149	2	228	2
Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities	65	4	123	8	188	5

Pressure	# "High Vulnerability"		# "High-Moderate Vulnerability"		#"High" and "High-Moderate" Vulnerability	
	n total	Rank	n total	rank	n total	Rank
Changes in suspended solids (water clarity)		n/a	16	17	16	17
Wave exposure changes		n/a	24	16	24	16
Litter	51	5	145	3	196	4
Introduction of light		n/a	76	11	76	13
Barrier to species movement		n/a	60	14	60	14
Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)	50	6	134	6	184	6
Collision BELOW water with static or moving objects not naturally found in the marine environment	4	12	76	11	80	12
Above water noise		n/a	35	15	35	15
Transition elements & organo-metal (eg TBT) contamination	18	9	154	1	172	8
Hydrocarbon & PAH contamination	74	3	139	4	213	3
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	34	8	127	7	161	9
Introduction of other substances (solid, liquid or gas)		n/a	2	19	2	19
Radionuclide contamination		n/a	3	18	3	18

Appendix 3.2 Caveats and limitations

There are a number of limitations associated with this type of assessment – the individual input datasets each have their own limitations, as do the end results. Below is a summary of some of these limitations for consideration.

The **bird distribution maps** were created using data from several different sources (see Appendix 2.1.1). Whilst the best available data was used to create each individual map, each dataset will have its own limitations. There are also differences between the source data sets – primarily the units and resolution of the data – and whilst a data standardisation process was developed these differences should still be considered when viewing the results.

The **activity geodatabase** used for this work contains a collation of data from a range of sources. However, only known, and available datasets are included – it is possible that further source data exists but were not included in the geodatabase for various reasons. Moreover, it was not possible to locate spatial data, with complete coverage, for all activities and so some were expertly judged.

The **activity-pressure interactions** were expertly judged, taking a precautionary approach, and using available supporting literature. These data have been used in other Natural England products, but irregularities may still exist.

Sensitivity assessments are a desk-based study and whilst best available evidence is used there is a subjective nature to it how the evidence base is interpreted and in how the scoring is carried out. Additionally, the scoring is based on benchmarks which may not reflect real world scenarios.

The **assessment regions** used are large and used the Charting Progress 2 regions which were split at the 12 nautical mile boundary producing inshore and offshore regions. This boundary is anthropogenic and does not reflect a particular environmental, physical, or biological boundary. The use of such large assessment regions meant it was not possible to pinpoint specific areas of exposure, and thus vulnerability. This is something that could be improved upon.

Bird distribution thresholds were determined for each assessment region by taking the highest density category present within the assessment region and assigning it to the whole region – thus smoothing the score across the whole region. This method was used as it followed a precautionary approach to assigning the density threshold. The resultant density thresholds should not be used to infer that bird density is even across the whole assessment region.

Activity / operation presence / absence within each assessment region was determined using either the available spatial evidence (from the geodatabase) or expert judgement. Given the light touch method it was decided to not look at determining the amount or intensity of an Activity / Operation within an assessment region. The activity/operation presence/absence was then converted to **pressure presence / absence** using the interaction data. The result is a list of pressures present within each assessment region. This assumes that a pressure is present within and evenly distributed across the whole assessment region.

When **scoring exposure,** the matrix in Table 4 was used as it was considered most applicable for the ESCaRP and provided balanced results. Different scoring matrices would yield different results. The use of pressure presence/absence, rather than a more granular scoring system, is a limitation of this method and means that the resulting exposure score is predominantly driven by the seabird density. Development of an alternative approach to scoring pressure – for example by intensity, or number of instances of pressure, or spatial footprint of a pressure – may be possible for future iterations of this work.

When **scoring vulnerability**, the matrix in Table 5 was used as it was balanced and allowed for further interrogation of ‘unknown vulnerability’ and ‘not vulnerable’ scores. Again, different scoring matrices would yield different results. The use of smaller assessment regions would produce results at a finer resolution and help to mitigate some of these levels of uncertainty.

The resulting vulnerability assessment scores should be considered alongside the above limitations.

Appendix 3.3 Examples

Three examples are presented below to indicate the scoring and some of the limitations.

European storm petrel

The distribution data for the storm petrel during the breeding season varies (see Map 10 in Appendix 15) and the density category map (Figure 13 panel a) has a range of densities – high in the western channel and Celtic Sea offshore; medium in the western channel and Celtic Sea inshore and low in all other assessment regions.

Assuming that a pressure is present across all the assessment regions, the exposure score for the European storm-petrel (to that pressure in each assessment region) is based on the density threshold. In turn, the vulnerability assessment results for European storm-petrel, to that pressure across all the assessment regions, is the direct result of, and dependent upon, the exposure score (which is resultant from the density threshold). That is, the sensitivity of the UoA to the pressure is uniform across all assessment regions and does not influence the difference in vulnerability score between assessment regions.

For example, storm petrel is assessed as having ‘medium’ sensitivity (at the benchmark) to the pressures ‘above water collision,’ ‘visual disturbance’ and ‘removal of non-target species’. In assessment regions where the density is high (eg western channel and Celtic sea offshore) and thus the exposure score is high, this combines with the medium sensitivity to give an overall ‘high-moderate vulnerability’. This is the same for all three example pressures as they have the same sensitivity assessment score (see Figure 13 panels a-c).

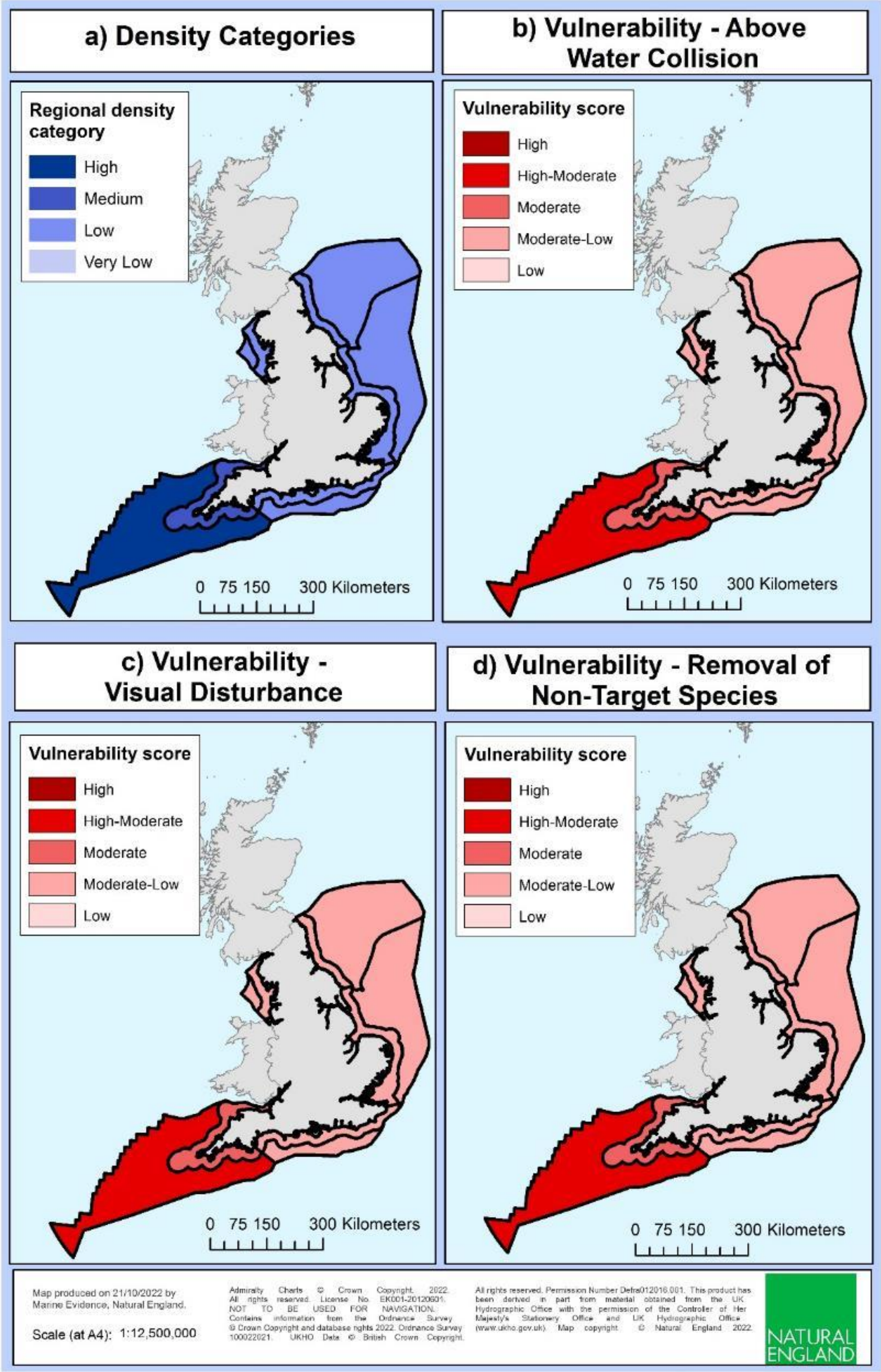


Figure 13. European storm petrel – Breeding UoA - density map (panel a) and vulnerability assessment results for above water collision pressure (panel b), visual disturbance pressure (panel c) and removal of non-target species pressure (panel d).

Northern fulmar

Northern fulmar distribution varies across marine space during the non-breeding season varies (see Map 20 in Appendix 15). The resulting converted density category map (Figure 14, panel a) has a range of densities – high in the northern North Sea inshore, northern North Sea offshore and southern North Sea offshore; medium in the western channel and Celtic Sea inshore, western channel and Celtic sea offshore and southern North Sea inshore; and low in all other assessment regions.

For a pressure such as ‘underwater noise’, where Northern fulmar is considered to be ‘not sensitive’ (at the benchmark) the resulting vulnerability across assessment regions is ‘not vulnerable – B’ (Figure 14 panel b). This is because, regardless of the density score, the sensitivity score influences the results to consistently be the same across all assessment regions.

Whereas, for ‘visual disturbance’, which Northern fulmar is considered to have ‘low’ sensitivity to the vulnerability (at the benchmark) the result varies across the assessment regions (Figure 14, panel c). In assessment regions where the density is high (eg the northern North Sea inshore) and thus exposure is high, this combines with the low sensitivity (at the benchmark) to produce a ‘moderate vulnerability’. Comparatively, in an assessment region with low density (eg Irish sea offshore) and thus low exposure, this combines with the low sensitivity (at the benchmark) to produce a ‘low vulnerability’.

For the pressure ‘removal of non-target species’, Northern fulmar is considered to have a ‘high’ sensitivity (at the benchmark) and so the vulnerability result varies across the assessment regions (Figure 14, panel d). In assessment regions where the density is high (eg the northern North Sea inshore) and thus exposure is high, this combines with the high sensitivity (at the benchmark) to produce a ‘high vulnerability’. Comparatively, in an assessment region with low density (eg Irish sea offshore) and thus low exposure, this combines with the high sensitivity (at the benchmark) to produce a ‘moderate vulnerability’.

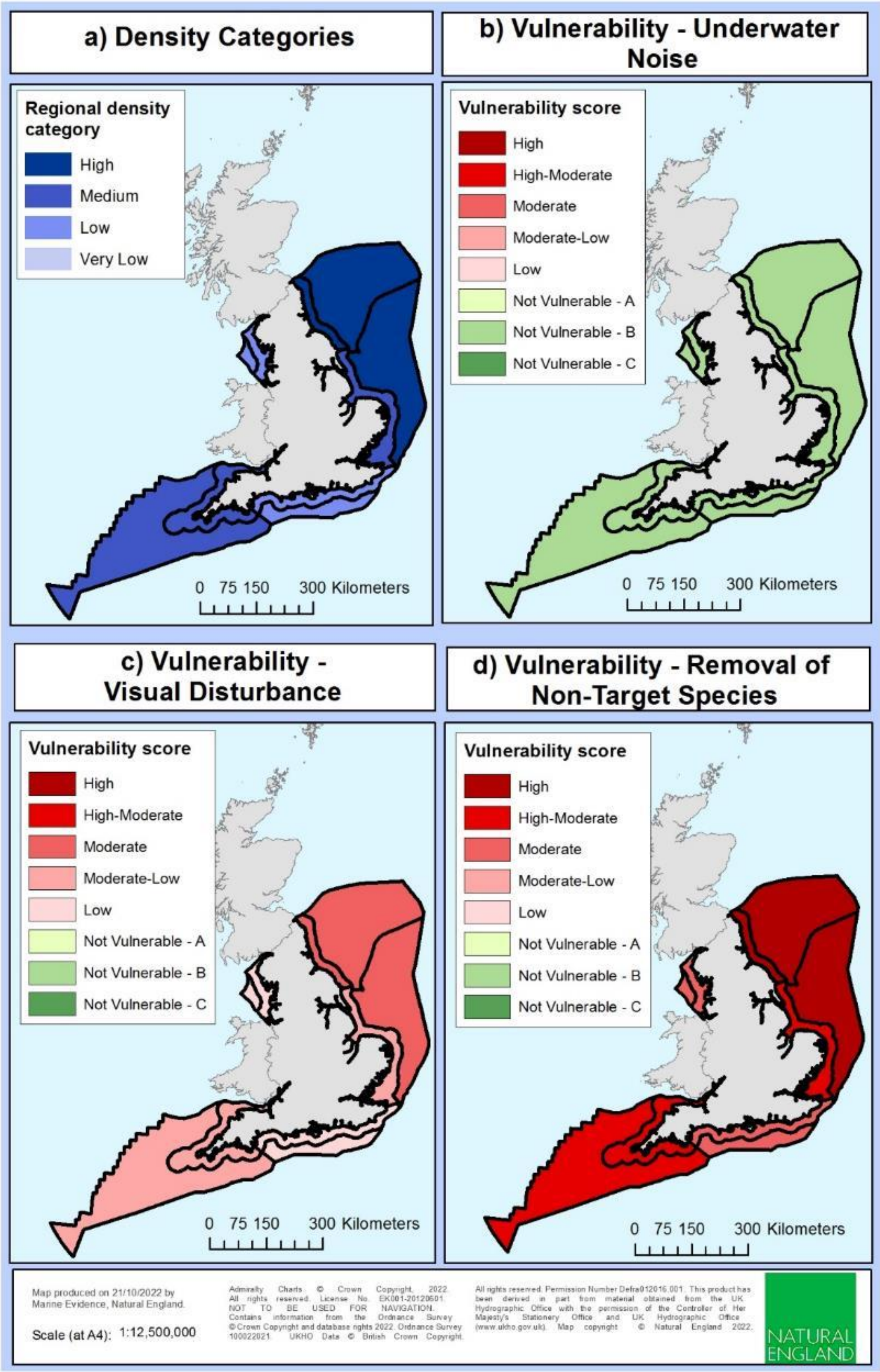


Figure 14. Northern fulmar - Non-breeding UoA - density map (panel a) and vulnerability assessment results for underwater noise pressure (panel b), visual disturbance pressure (panel c) and removal of non-target species pressure (panel d)

Balearic shearwater

Limited distribution data were available for the Balearic shearwater during passage as reflected in the distribution map (see Map 58 in Appendix 15). In the density category map, six of the 10 assessment regions are ‘unknown density’ (Figure 15 panel a), resulting in ‘unknown exposure’ scores for these six assessment regions.

For the pressure ‘removal of non-target species’ (see Figure 15 panel b), Balearic shearwater has a ‘high’ sensitivity (at the benchmark). As a result, in assessment regions where there is a high density (eg western channel and Celtic sea offshore) and thus high exposure, this combines with the high sensitivity (at the benchmark) to produce a ‘high vulnerability’. Whereas, in areas of unknown density and thus unknown exposure, the resulting vulnerability is ‘unknown vulnerability – A’.

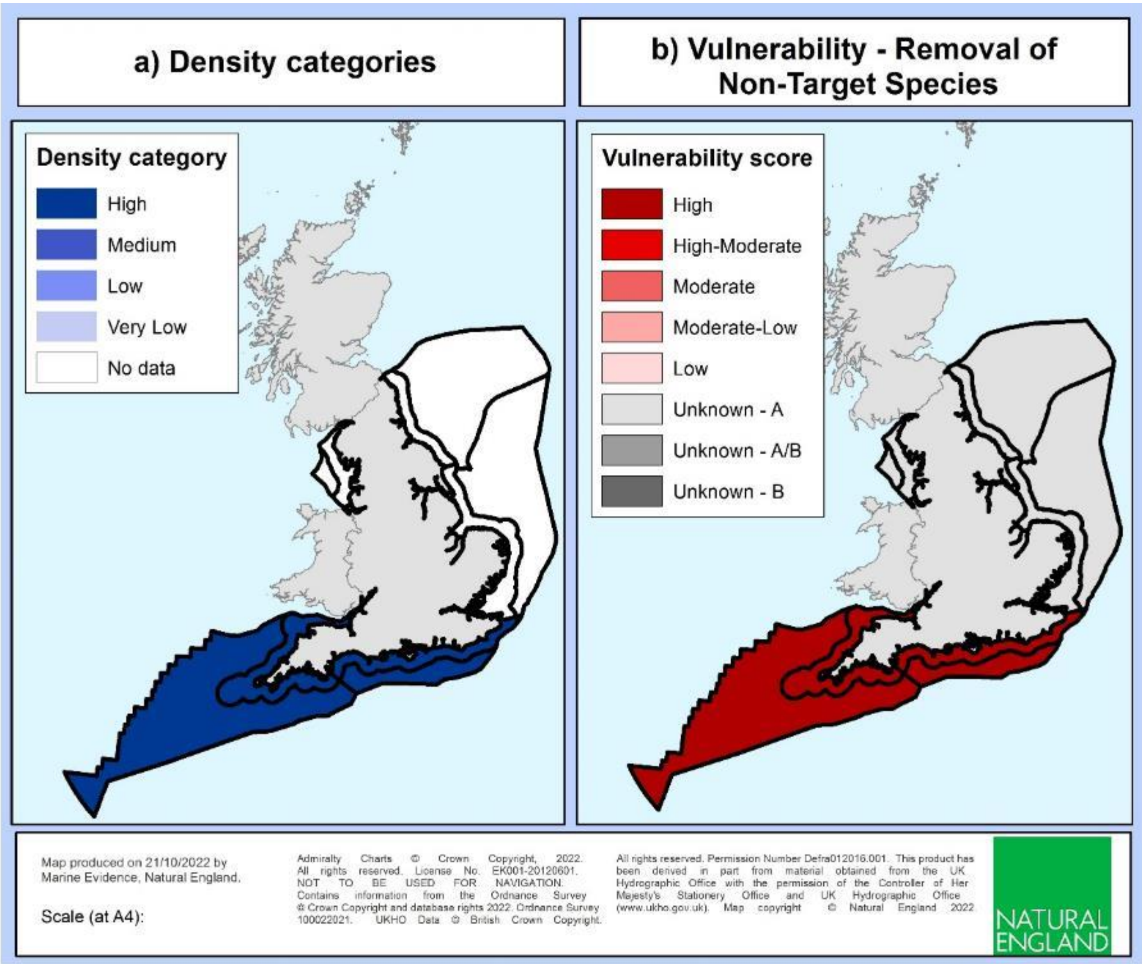


Figure 15. Balearic shearwater - Non-breeding, Passage UoA - density map (panel a) and vulnerability assessment results for removal of non-target species pressure (panel b).

- # Appendix 4. Lock review - Methods

For each of the 123 seabird breeding sites in England, information was gathered directly from site managers (including wardens and conservation officers involved in the management of the site). This included staff from a variety of organisations, such as the RSPB, the National Trust, Natural England, and the Wildlife Trusts. These people can be considered to be the best possible sources of information on the specific issues affecting each site, because of their familiarity with the site, the breeding seabird populations at the site, and the management of the site.

Information was gathered about the sizes of the breeding populations of each seabird species breeding at these sites, to identify 'Priority Sites' for conservation intervention, based on the sizes of the populations of breeding seabirds these sites support. This resulted in a range of population estimates, some of which date back to Seabird 2000 (Michell and others 2004) but most are more recent. It is important to note that the site definitions and sources of site population sizes are different to those calculated using the SMP data (Appendix 6). It is also important to note that the most recent full seabird census data, collected as part of the 'Seabirds Count' census (JNCC in prep) was not yet available at the time of writing.

Site managers were also asked for information about the dominant habitat type of each site, and the issues they believed to be negatively impacting breeding seabird populations at the site. Their responses therefore include consideration of the presence of the pressure, as well as the sensitivity of the breeding population to that pressure and the overall vulnerability of the breeding population to that pressure at that site. The information provided is necessarily subjective and qualitative, but quantitative data on these pressures is largely lacking at meaningful spatial scales. The resulting information can therefore be considered to be a vulnerability assessment through expert judgement, and likely constitutes the best available evidence on pressures affecting England's breeding seabirds at their breeding colonies.

The issues identified by site managers as negatively impacting on breeding seabird populations at sites were then categorised according to defined pressures. These were based on the definitions of pressures used by Natural England but were adapted to reflect the reality reported by site managers. For example, disturbance caused by noise and visual disturbance were not considered separately, but were combined into one 'disturbance' pressure, because these often occur simultaneously. In addition, some site managers reported concerns about the effects of climate change, which were not included in the original list of pressures. To capture these, two additional pressures were added: 'sea level rise' and 'increased frequency and severity of storms'. The pressure definitions used are shown in Table 33.

Table 33. Definitions of pressures used to categorise responses of site managers describing issues negatively impacting on populations of breeding seabirds at breeding colonies.
Taken from Lock and others (2022).

Pressure	Definition
Disturbance	Any disturbance caused by anthropogenic activities that results in displacement or impacts on breeding success. This generally refers to visual disturbance, although noise disturbance is an issue at some sites (eg, personalised motorised watercraft at the Flamborough and Filey Coast SPA).
Removal	Deliberate, targeted removal of the species through human activities. This includes illegal activity such as killing of adults and egg collection as well as licenced activities such as egg harvesting, and species control (eg, control of large gulls)
Predation and competition	Impacts of predation by, or competition from, native species. Competition was included here because impacts on breeding seabirds from native species can sometimes include impacts of both competition and predation that are difficult to separate (eg large gull species on breeding terns).
Invasive species	Presence of invasive species. This mainly refers to the impacts of invasive mammalian predators (such as rats, cats, and mink) on offshore islands where they are not native.
Reduction in habitat	Includes both reduction in extent of habitat (eg, as a consequence of erosion or regular inundation of nesting habitat linked to sea level rise) and reduction in quality of habitat (eg, as a consequence of extensive unmanaged vegetation growth).
Reduction in food	Reduced availability of food during the breeding season evident at the breeding site.
Sea level rise	Sea level rise caused by climate change (linked to habitat loss – see above
Increased frequency and severity of storms	Increased frequency and severity of storms related to climate change
Pathogens	Impacts of disease (eg, botulism or avian influenza).

The percentage of sites affected by each pressure was then calculated. The proportions of England’s breeding populations of each species affected by each pressure was calculated based on the estimated population sizes supported by affected sites. It was assumed that the entire breeding population of each species breeding on the site was affected by the pressure if that pressure was recorded at that site.

- # Appendix 5. Lock review - Results

Important pressures

Disturbance

The most prevalent pressure reported was disturbance, which was assessed to be negatively impacting breeding seabird populations in 76% of sites. Coastal sites were more affected by disturbance than inland sites, and if only coastal sites are considered, then the percentage affected rises to 89% of sites. Soft coasts were the most affected habitat type, with 96% of sites affected.

Based on the estimated populations supported by the sites affected, disturbance was assessed to be potentially negatively impacting over 75% of England's breeding populations of 15 species: roseate tern, little tern, Sandwich tern, common tern, Arctic tern, (non-urban nesting) lesser black-backed gull, black-headed gull, Mediterranean gull, northern gannet, European shag, common guillemot, black guillemot, Atlantic puffin, and common eider. Between 50 and 75% of England's breeding population of northern fulmar were also assessed to be affected, as were between 25 and 50% of England's breeding populations of black-legged kittiwake and great cormorant. These results are shown in Table 34.

Site managers also expressed concerns that disturbance was a growing problem and that impacts could be more significant in future without intervention.

Table 34. Species assessed to be most affected by disturbance. Taken from Lock and others (2022).

Proportion of England's breeding population affected	Species
> 75%	Lesser black-backed gull
	Black-headed gull
	Mediterranean gull
	Roseate tern
	Little tern
	Sandwich tern
	Common tern
	Arctic tern
	Northern gannet
	European shag
	Common guillemot

	Razorbill
	Black guillemot
	Atlantic puffin
	Common eider
50-75%	Northern fulmar
25-50%	Great cormorant
	Black-legged kittiwake

Predation and competition

Predation/competition was assessed to be negatively impacting breeding seabird populations at 56% of sites. Soft coasts were the most affected habitat type, with 96% of sites affected.

Based on the estimated populations supported by the sites affected, predation/competition was assessed to be potentially negatively impacting over 75% of England's breeding populations of twelve species: roseate tern, Sandwich tern, common tern, Arctic tern, little tern, (non-urban nesting) lesser black-backed gull, (non-urban nesting) herring gull, black-headed gull, common gull, Mediterranean gull, black guillemot and common eider (Table 35).

Table 35. Species assessed to be most affected by predation/competition. Taken from Lock and others (2022).

Proportion of England's breeding population affected	Species
>75%	Mediterranean gull
	Black-headed gull
	Common gull
	Lesser black-backed gull
	Herring gull
	Sandwich tern
	Roseate tern
	Common tern
	Artic tern
	Little tern
	Black guillemot
	Common eider

Predation specifically by invasive species was assessed to be impacting breeding seabird populations at only 6.5% of sites but offshore islands were clearly the most affected, with 40% of offshore island sites affected. Based on the estimated populations supported by the sites affected, predation by invasive species was assessed to be potentially negatively impacting over 75% of England's breeding populations of Manx shearwater, European storm petrel, roseate tern, Atlantic puffin, and European shag, with 100% of England's breeding populations of Manx shearwater and European storm petrel assessed as impacted. Predation by invasive species was also estimated to be impacting between 50 and 75% of England's breeding populations on Arctic tern and razorbill (Table 36).

Table 36. Species assessed to be most affected by predation by invasive species. Taken from Lock and others (2022).

Proportion of England's breeding population affected	Species
>75%	Manx shearwater
	European storm petrel
	Shag
	Roseate tern
	Atlantic puffin
50-75%	Arctic tern
	Razorbill

Reduction in habitat

Reduction in extent or quality of breeding habitat was assessed to be negatively impacting breeding seabird populations at 52% of sites. Soft coasts were the most affected habitat type, with 98% of sites affected.

Based on the estimated populations supported by the sites affected, reduction in habitat was assessed to be potentially negatively impacting over 75% of England's breeding populations of nine species: roseate tern, Sandwich tern, common tern, Arctic tern, little tern, (non-urban nesting) lesser black-backed gull, black-headed gull, common gull and Mediterranean gull (Table 37). Reduction in habitat was also assessed to be potentially impacting between 50 and 75% of England's breeding population of (non-urban nesting) herring gulls and between 25 and 50% of England's breeding population of great cormorant.

Table 37. Species assessed to be most affected by reduction in habitat. Taken from Lock and others (2022).

Proportion of England's breeding population affected	Species

>75%	Mediterranean gull
	Black-headed gull
	Common gull
	Lesser black-backed gull
	Sandwich tern
	Roseate tern
	Common tern
	Arctic tern
	Little tern
50-75%	Herring gull
25-50%	Great cormorant

Other pressures

'Reduction in food' was reported to be negatively impacting on breeding populations of seabirds at 12.2% of sites, almost exclusively relating to black-legged kittiwake. It was estimated that over 75% of the breeding population of black-legged kittiwake is being negatively impacted by reduction in food.

'Sea level rise' was reported to be affecting breeding populations at 29% of sites, with this percentage increasing to 64.2% for soft coast sites. It was estimated that over 75% of the breeding population of little tern is being negatively impacted by sea level rise.

'Increased frequency and severity of storms' was reported to be affecting breeding populations at only 3% of sites, but it was estimated that over 75% of the breeding population of European shag is being negatively impacted by increased frequency and severity of storms.

'Pathogens' were reported to be negatively impacting on breeding populations of seabirds at 0.8% of sites, almost exclusively in relation to botulism in herring and lesser black-backed gull populations in the southwest. It should be noted, however, that this review was conducted before the HPAI outbreak in summer 2022 – see section 3.5.1).

- # Appendix 6. Seabird Monitoring Programme data preparation Methods

Appendix 6.1 Colony data preparation

Colony data was provided by the JNCC from the Seabird Monitoring Programme[16] (SMP), which included data on confidential species, not available in the main SMP data available for download. The Seabird monitoring handbook[17] outlines the methods used for data collection to feed into the SMP. Not all species included in the strategy were assessed as part of the colony mapping, either because they don't breed in England, or because no data were available. Species listed as being assessed at colony are shown in Table 3. For these species, Figure 16 outlines the considerations and steps taken during the colony mapping, which were applied for every combination of site / species in the input data (over 20000 individual records, and 3600 combinations). Additional data for common Eider breeding sites was obtained from Lock (2022). See Appendix 4 for further details.

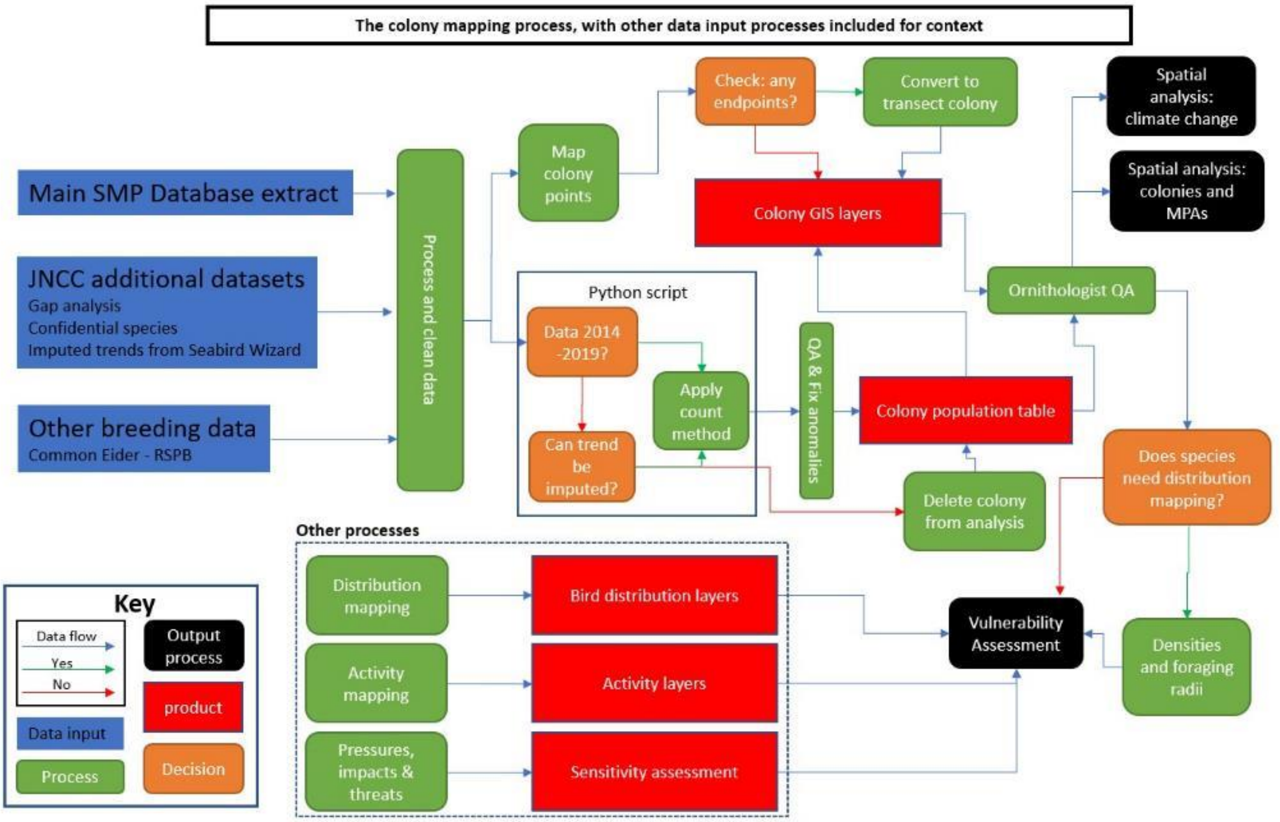


Figure 16. The colony mapping process, with other data input processes included for context.

[16] Seabird Monitoring | JNCC - Adviser to Government on Nature Conservation (accessed 23/08/2022)
[17] Seabird Monitoring Programme | BTO - British Trust for Ornithology (accessed 23/08/2022)

The Seabird Monitoring Programme (SMP) dataset contains data going back to 1960, but the initial task was to pare down the data to obtain a single population value per species at each colony. A colony was considered as a location with an individual ‘Site ID’ in the database, of which there are 1505.

2 rules were used as a starting point to do this:

- **a.** Use the most recent count from the last 5 years
- **b.** Use the average count from the last 5 years.

Rule (a) was to cover all species which were predominantly cliff nesting, and there is site fidelity (ie they return to the same site each year). Therefore the most recent count is the best representative abundance estimate we have for that species at that colony.

Rule (b) covers species which typically move between individual sites and where population fluctuations are more the norm (eg tern species). This was judged to give a better population estimate than the application of rule (a), given that the most recent count for different sites will not always be from the same year, and therefore applying rule (a) would not account for possible movement of individuals between colonies over subsequent years.

The timescale ‘last 5 years’ was applied as it correlated with the time window of the seabirds count census, which ran from 2015-2020. Any data collected in 2020 (the last year records were available from when the SMP extract was taken) were omitted from the analysis. Due to coronavirus many colonies did not get counted, and data which was collected hadn’t undergone the full QA process. 2019 was the last year that the JNCC ran a trend analysis, so 2015-2019 represented a 5-year window of standardised data which was as complete as possible.

The values used were taken from the database in the standard count units reported (eg, apparently occupied nests (AON), apparently occupied territories (AOT), Individual (IND) etc). No conversion factors were used for example to change figures from AON to individuals, or vice-versa. Common guillemot are generally reported as IND. There is a caveat here that some species such as Atlantic puffin have a variety of recording units used ie, individuals at sea are recorded in some locations (SEA) and at other locations by recording apparently occupied burrows (AOB), sometimes recording units vary for the same species at the same site over different years. Therefore, an over/under estimation may be occurring. During data cleaning, occasionally there were two different units recorded for the same species at the same site, in the same year, eg, an IND and an AON count. In this case, for consistency the count associated with the most commonly used unit for recording that species in that location was taken.

In the rare instance (two examples) that counts were given with different unit types for the same species, date (within a week of each other) and site these were added together to give a final population estimate for the site, as per the guidance in the SMP database help guide[18].

An initial scan of the dataset showed that weather conditions recorded as being adverse and possibly impacting the count did not impact significantly on the records contributing to the count figures. It was also considered better to have a record than not, so environmental data in the SMP was not considered.

Colonies located inland were retained, as depending on their foraging range, certain species may still utilise marine areas. The SMP database only holds data on 'natural breeding sites' and for gulls, the urban gull census was not used, as this is a completely different dataset. It was considered that for the purposes of this work, terrestrial vulnerability was out of scope and therefore urban gull colony data was not required.

Sensitive species (eg, Roseate tern) are not included in the SMP, so where additional data existed, this was provided by JNCC separately.

Counts of '0' were included in the data analysis as a survey had taken place for a species at a site, but no units had been recorded. This would contribute when the rule was applied to the past 5 years of data (ie, when calculating averages). If this meant that the result was '0' for a species at a colony, this was recorded, but not mapped as a colony point or entered into any of the subsequent spatial analysis or vulnerability work. Using this method omitted historic colony sites, only considered relatively recent records, and ensured that an up-to-date representation of the species' population and distribution were considered.

A 'gap analysis' was carried out by JNCC to initially screen the data, providing at a colony and species level the most recent year of data available, and whether this was between 2015-19 or not. This highlighted gaps in the data, which were then addressed if possible using the JNCC 'wizard' tool[19]. The wizard is a tool that can generate an estimated count for a location, based on the populations at neighbouring colonies, and return an estimated count for those years without actual values. It must have at least three count values from different years to generate an imputed trend. For any species and colonies with too few observations for a trend to be imputed, the rules were just applied to the actual data available.

Due to the rules developed, actual count data was only used when available from the last 5 years. Any older data was discounted. However, for those species where there was

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[18] Section 4.2.4 – accuracy codes. https://app.bto.org/static/seabirds/app_guide.pdf (accessed 26/08/2022)

[19] For information on how the 'wizard' works, see https://data.jncc.gov.uk/data/701c338f-ed54-43da-a61c-254cb79698b8/Analysis-methods.pdf.

enough data pre-2014 to use the seabird wizard and establish a trend (applies to some colonies of Mediterranean gull, Little tern, Atlantic puffin, Arctic tern and Fulmar) the estimated population values for 2015-2019 were used for analysis, irrespective of how old the last actual data was. This skews the results towards certain species where data is available and no consideration of confidence in the seabird wizard model has been made.

A python script was then used to pull the data from the various sources available (actual count data, imputed trends, gap analysis) and apply the agreed rules to generate a population count value per species and site. Where the value was imputed, it also returned the year of the most recent actual count, for QA purposes. A small number of anomalies raised were investigated and manually processed.

The colonies were mapped using the grid reference provided in the SMP export. Where only the starting grid reference was given, the colony was treated as a point location. If 'start' and 'end' were populated, both were plotted and then the points turned into a line in GIS to represent a transect colony. Some transects, especially along coastal sections were a few km long, so a manual QA at a scale of 1:100,000 was undertaken to align very roughly the transect more closely to the coastline shape (for example around headlands where the straight line between start and end was an unsuitable representation). It was decided that for the purposes of the subsequent dataset use and analysis, a transect exactly matching the shape of the coastline and requiring further GI processing was not required.

Finally, the population count was joined to the point or transect colony in GIS to produce a map of colonies for each species, along with population information. These maps (See Appendix 16) were then sense checked by ornithologists. The method used for each species are shown in Table 38.

Caveats and limitations

The Seabird Monitoring Programme (SMP) is an annual sample, and not a complete seabird census. Therefore, any analysis carried out can only generate population estimates, with a consideration of the inherent caveats, limitations and gaps in the data. The foraging radii density maps were generated for a specific purpose (spatial analysis) and due to the methods used, it is not possible to backwards engineer the population densities back to a population estimate at a specific colony, so this should not be attempted.

Table 38. Summary of colony mapping and foraging radii processing methods.
Rule applied: A is 'Use the most recent count from the last 5 years', B is 'Use the average count from the last 5 years'.

Species	Rule applied	Foraging radius applied Mean Max / Mean max +1sd (km)	Count unit (in majority of times)
Northern fulmar	A		AOS
European storm petrel	A		AOS
Manx shearwater	A		AOB
Black-legged kittiwake	A		AON
Black-headed gull	B		AON
Mediterranean gull	B	20 / n/a	AON
Common (Mew) gull	B		AON
Lesser black-backed gull	A		AON
Herring gull	A		AON
Yellow-legged gull	B	59 / 86	AON
Great black-backed gull	A		AON
Little tern	B	5 / n/a	AON / AOT
Sandwich tern	B		AON / AOT
Common tern	B	18 / 27	AON / AOT
Arctic tern	B	26 / 41	AON / AOT
Roseate tern	B	13 / 23	AON
Northern gannet	A		AON
European shag	A		AON
Great cormorant	A		AON
Common guillemot	A		IND
Razorbill	A		IND
Black guillemot	A		IND
Atlantic puffin	A		Various
Common eider	A		Pairs

Appendix 6.2 Generating seabird distributions in the marine environment using colony locations from the Seabird Monitoring Programme and known Foraging radii

For seven of the species being assessed spatially for the vulnerability assessment, there were not already existing marine distribution maps for English waters available. For these species, ‘foraging radii’ around known colony locations were created to represent the at sea distribution of these species and assess overlap with activities. In GIS, the colony locations (point or line) were buffered using the foraging ranges given in Woodward and others (2019). This step was done with the mean/maximum and then repeated with the mean/max +1 standard deviation (if available), giving 2 concentric circles for each colony.

For those species which don’t forage inland, these circles were then clipped to the coastline to represent the true foraging area. A density value was then applied to each polygon [colony population / area (km^2)]. The density of the outer polygon was calculated based on the whole area of the outer polygon, including that overlapping with the inner polygon. This was to ensure that the density was not artificially increased by only spreading the population over a smaller area furthest away from the colony. The density of the inner polygon was calculated similarly by simply dividing the colony population by the area of the inner circle. This led to a higher density area in the circle closest to the colony, and a lower density in the polygon further away from the colony, as would be expected. Where foraging radii from different colonies overlapped, a Python script was used to calculate a combined (sum) density value for each unique area of overlap. These densities were then categorised as described in Appendix 2.1.2. A graphical example of this process is shown in Figure 17.

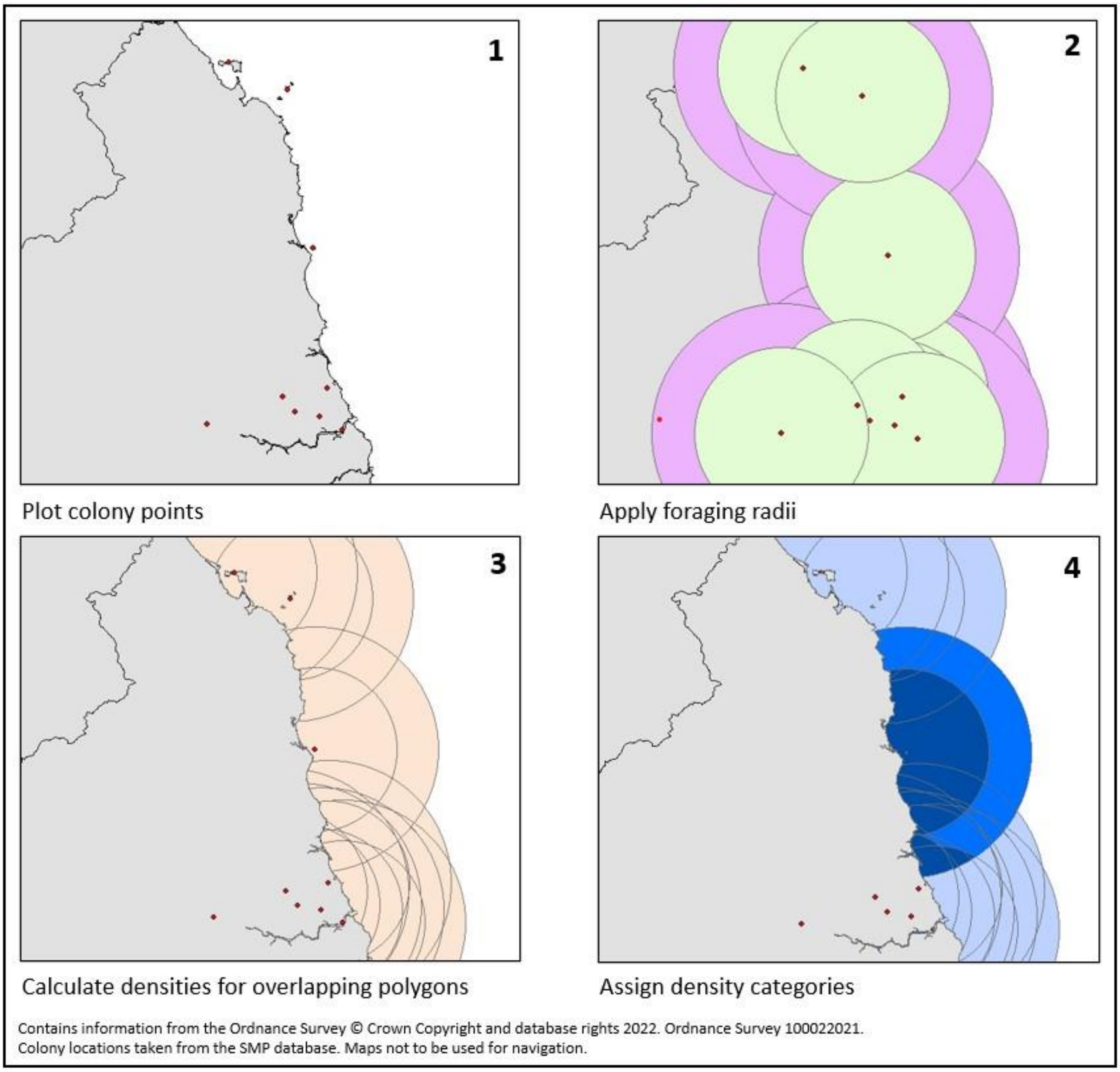

Figure 17. Example process for creation of foraging radii.

• Appendix 7. Methods of review of SPA Site Improvement Plans

The review of Site Improvement Plans (SIPs) first identified 38 SPAs in England with ESCaRP species as a qualifying breeding feature (Table 39).

The SIPs for these SPAs were then identified and reviewed, where possible. Three of these SPAs did not have SIPs, because they were designated after the completion of the IPENS project. These were the Greater Wash SPA, Northumberland Marine SPA, and Solent and Dorset Coast SPA. All three of these SPAs encompass offshore areas surrounding existing terrestrial SPAs. The relevant terrestrial breeding sites are therefore covered by the SIPs for those terrestrial SPAs.

Some SIPS cover multiple SPAs with seabird qualifying features (eg the Essex Estuaries SIP covers Blackwater Estuary SPA, Colne Estuary SPA, and Foulness SPA). Where this is the case, the details from the SIP have been applied to each of the SPAs. In addition, Morecambe Bay Estuary SPA and Duddon Estuary SPA, each of which had their own SIPs, have now been combined to form Morecambe Bay and Duddon Estuary SPA. The details of each SIP have been combined in this case. There were thus 28 SIPs reviewed in total, for 36 SPAs.

Table 39. English SPAs with qualifying breeding seabird features. Marine SPAs that did not have SIPs are shaded.

SPA	Qualifying Features (Breeding)
Abberton Reservoir	Great cormorant
Alde-Ore Estuaries	Lesser black-backed gull, Sandwich tern, little tern
Benacre to Easton Bavents	Little tern
Blackwater Estuary	Little tern
Bowland Fells	Lesser black-backed gull
Breydon Water	Common tern
Chesil Beach & The Fleet	Little tern
Chichester and Langstone Harbours	Common tern, little tern, Sandwich tern
Colne Estuary	Little tern
Coquet Island	Arctic tern, common tern, Sandwich tern, roseate tern, seabird assemblage
Dee Estuary	Common tern, little tern

SPA	Qualifying Features (Breeding)
Dungeness, Romney Marsh, and Rye Bay	Common tern, little tern, Sandwich tern, Mediterranean gull
Farne Islands	Common guillemot, Arctic tern, common tern, roseate tern, Sandwich tern, seabird assemblage
Flamborough and Filey Coast	Northern gannet, common guillemot, razorbill, black-legged kittiwake, seabird assemblage
Foulness	Common tern, little tern, Sandwich tern
Gibraltar Point	Little tern
Great Yarmouth North Denes	Little tern
Greater Wash	Little tern, common tern, Sandwich tern
Hamford Water	Little tern
Humber Estuary	Little tern
Isles of Scilly	European shag, European storm petrel, great black-backed gull, lesser black-backed gull, seabird assemblage
Lindisfarne	Little tern, roseate tern
Liverpool Bay	Common tern, little tern
Medway Estuary	Little tern
Mersey Narrows and North Wirral Foreshore	Common tern
Minsmere-Walberswick	Little tern
Morecambe Bay and Duddon Estuary	Common tern, little tern, Sandwich tern, herring gull, lesser black-backed gull, seabird assemblage
North Norfolk Coast	Common tern, little tern, Sandwich tern
Northumberland Marine	Arctic tern, common tern, Sandwich tern, roseate tern, little tern, common guillemot, Atlantic puffin, seabird assemblage
Northumbria Coast	Arctic tern, little tern
Outer Thames Estuary	Little tern, common tern
Pagham Harbour	Little tern, common tern

SPA	Qualifying Features (Breeding)
Poole Harbour	Common tern, Sandwich tern, Mediterranean gull
Ribble and Alt Estuaries	Common tern, lesser black-backed gull, seabird assemblage
Solent and Dorset Coast	Common tern, little tern, Sandwich tern
Solent and Southampton Water	Common tern, little tern, Sandwich tern, roseate tern, Mediterranean gull
Teesmouth & Cleveland Coast	Common tern, little tern
Thanet Coast and Sandwich Bay	Little tern
The Wash	Common tern, little tern

SIPs recorded a list of 'issues' affecting SPAs and defined these as either 'pressures' (current issues) or 'threats' (future anticipated issues). However, these definitions did not appear to be applied consistently. All issues were therefore included for this review, whether recorded in SIPs as 'pressures' or 'threats'. The list of issues recorded by SIPs is quite long and many are interrelated. For this reason, and to make the results of this review more comparable with the results of other ESCaRP workstreams, the 'issues' listed were categorised according to wider 'pressure' definitions that correspond to the pressure definitions used for the rest of the ESCaRP. These pressures are listed in Table 43. Where insufficient detail was provided to be able to categorise issues according to pressure categories, they were classified as 'other' and left out of this review.

Table 40. Pressure descriptions used to categorise 'issues' reported in SIPs for SPAs with breeding seabird features in England

Pressures	Definition
Disturbance	Any disturbance caused by anthropogenic activities that results in displacement or impacts on breeding success. This generally refers to visual disturbance, although noise disturbance is an issue at some sites.
Predation	Impacts of predation.
Invasive species	Presence of invasive species.
Pollution	Any type of pollution.
Reduction in availability, extent, or quality of supporting habitat	Where it was possible, SPAs that were referred to in SIPs as being affected by coastal squeeze, rising sea levels, or inadequate

	coastal defences were also categorised as being affected by the sub-pressure ‘coastal squeeze’
Reduction in availability or quality of food resources	Where it was possible, those SPAs where food availability was stated to be affected by commercial fisheries in SIPs were also categorised as being affected by the sub-pressure ‘commercial fisheries’
Removal of target species	Deliberate, targeted removal of the adults, eggs, or chicks of the species through human activities. This includes illegal activity such as killing of adults and egg collection as well as licenced activities.
Removal of non-target species	Unintentional removal of the adults, eggs, or chicks of the species through human activities.

Appendix 8. Vulnerability assessments for breeding sites.

Details of the results of the assessments, summarised in Table 11, are provided below.

Disturbance

The review of SIPs showed that 100% of SPAs in England with breeding seabird features listed disturbance as an issue. Lock and others (2022) found that disturbance was the most widely reported pressure negatively impacting England's breeding seabird populations, affecting 76% of all sites, 89% of coastal sites, and 96% of soft coast sites. Based on these results and the estimated population sizes at the affected sites, Lock and others (2022) estimated disturbance to be negatively impacting on over 75% of England's breeding populations of 15 seabird species (see Appendix 5, Table 34).

Disturbance is mostly caused by recreational activities such as beach recreation, dog walking, climbing and angling on land, and recreational watercraft at sea (Lock and others 2022). Coastal sites are popular recreational destinations for people, so breeding seabirds in coastal sites experience higher levels of disturbance. Soft coasts (eg beaches) are particularly attractive and accessible to people and seabirds breeding in these locations therefore experience the highest levels of disturbance. The majority of England's seabird colonies are associated with soft coast habitats. Disturbance was reported by many site managers to be a growing issue (Lock and others 2022), which may be in part linked to climate change. The climate change adaptation manual (Natural England & RSPB 2020) predicted future increases in recreational disturbance at coastal sites.

Disturbance of nesting seabirds can have significant negative impacts on breeding success as disturbed adults leave eggs and young exposed to the elements and the risk of predation (Hunt 1972, Robert & Ralph 1975). High levels of disturbance can also lead to the abandonment of nest sites and even of entire colonies (Hunt 1972, Robert & Ralph 1975, Burger 1981, Hockin and others 1992, Ross-Smith and others 2014). Smaller seabird colonies are likely to be more vulnerable to the impacts of predation than larger ones (Ross-Smith and others 2014, Miles and Richardson 2018).

Wardening, fencing, and awareness-raising initiatives have been shown to be effective at reducing disturbance and increasing productivity at seabird colonies (Booker and others 2014, Babcock & Booth 2020, Natural England & RSPB 2020), but many seabird colonies in England do not have enough resources to adequately protect breeding seabirds (Lock and others 2022). Other solutions include strategic zonation of human activities, and better regulation and enforcement.

Predation and competition

Native predators and competitors

Lock and others (2022) estimated that predation/competition was negatively impacting breeding seabirds at 56% of all sites, and 96% of soft coast sites. Based on the population estimates for affected sites, Lock and others (2022) estimated predation/competition to be negatively impacting on over 75% of England's breeding populations of 12 species (Appendix 5). The review of SIPs showed that 47% of English SPAs with breeding seabirds as qualifying features listed predation as an issue and 75% listed invasive species as an issue.

Eggs and young birds are defenceless against predators unless protected by parent birds, and the ability of the parents to defend their nests depends on the seabird species as well as the type and size of predator. Predation of adult birds is also sometimes an issue. Breeding seabirds often nest in large numbers at high densities in colonies, which makes them attractive targets for predators. Predation of eggs and young negatively impacts seabird breeding success and high levels of predation can lead to total reproductive failure in gull and tern colonies (Southern & Southern 1979, Southern and others 1985, Ross-Smith and others 2014, Babcock & Booth 2020). High levels of predation can also lead to the abandonment of nest sites or even entire colonies, effectively amounting to loss of breeding habitat (Ross-Smith and others 2014, Babcock & Booth 2020).

Predation by other avian species (such as large gulls, corvids or birds of prey) can be a significant issue for some colonies, and sometimes occurs in tandem with competition for breeding habitat (eg large gulls competing for breeding habitat with breeding tern species whilst also predating tern chicks and young). However, it is mammalian predators, such as foxes, badgers, otters, and rats, that generally have the greatest impacts on breeding seabirds (Smith and others 2010, Lavers and others 2010, Roos and others 2018, Babcock & Booth 2020, Lock and others 2022). Population densities of many generalist mammalian predators have increased in the UK and are now amongst the highest in Europe (Roos and others 2018). Soft coast sites are more accessible to mammalian predators, which is why the highest levels of predation are recorded at soft coast sites. Soft coasts also experience the highest levels of disturbance, and the impacts of disturbance and predation reinforce each other: disturbance increases the risk of predation, while the presence of predators causes disturbance (Hockin and others 1992, Hunt 1972). The impacts of disturbance and predation should be tackled in tandem, and can often have joint solutions, eg increased wardening and fencing. Reductions in available breeding habitat can lead to smaller, denser colonies, which are more vulnerable to the impacts of predation.

Invasive predators

Breeding seabirds are also vulnerable to predation by non-native invasive mammalian predators, such as American mink *Neogale vison* or domestic cats *Felis catus*, neither of which are native to the UK. Brown rats *Rattus norvegicus* and European hedgehogs *Erinaceus europaeus* are not native to the UK's offshore islands, where they can cause devastation in seabird colonies (Jones and others 2008, Thomas and others 2017. Dias

(2019) identified predation by invasive species as one of the top three threats to global seabird populations. England does not have many offshore islands, but those that it does have support substantial proportions of its breeding seabird populations, particularly for certain species (eg Manx shearwater, European storm petrel). Lock and others (2022) estimated that over 75% of England’s breeding populations of Manx shearwater, European storm petrel, Atlantic puffin, European shag and Roseate tern are being negatively impacted by predation from invasive species, along with between 50 and 75% of England’s breeding populations of Razorbill and Arctic tern. The most vulnerable species to this type of predation are burrow-nesters, already mostly confined to offshore islands (eg Manx shearwater and European storm petrel). The presence of invasive predators has likely reduced the available breeding habitat for these most vulnerable species and restricted their breeding range (Lock and others 2022).

Brown rats have been successfully eradicated from the islands of St Agnes and Gugh in the Scilly Islands but remain on many of the other islands in the Scilly archipelago, where they are negatively impacting breeding seabirds (Lock and others 2022) and from which they present the threat of reinvasion to the eradicated islands (Stanbury and others 2017, Varnham & St Pierre 2017). Feral cats are also thought to be having negative impacts on breeding seabirds in the Scillies (Lock and others 2022). The eradication of rats and other invasives from the remaining Scilly Isles could have considerable benefits for breeding seabirds.

Biosecurity measures to prevent invasive species from reaching invasive-free islands (eg Coquet Island, Farne Islands, St Agnes and Gugh in the Scillies, Lundy) are important, alongside monitoring and rapid response to detect and deal with any incursions (Stanbury and others 2017, Thomas and others 2017, Bell and others 2019, Booker and others 2019).

Reduction in extent and quality of breeding habitat

Lock and others (2022) estimated that reduction in habitat was negatively impacting breeding seabirds at 52% of all sites, and 98% of soft coast sites. The review of SIPs showed that 97% of English SPAs with breeding seabirds as qualifying features listed the reduction in availability, extent, or quality of supporting habitat as an issue, with 69% citing coastal squeeze as a factor. Lock and others (2022) estimated reduction in habitat to be negatively impacting over 75% of England’s breeding populations of Sandwich tern, roseate tern. common tern, little tern and Arctic tern, lesser black-backed gull, common gull, black-headed gull and Mediterranean gull, as well as between 50 and 75% of England’s breeding population of herring gull. Unsurprisingly, these are all ground-nesting species associated with soft coasts, where reported levels of habitat reduction are highest.

Miles and Richardson (2018) estimated that England had lost 50% of shingle habitat, 18% of sand dunes, and 15% of saltmarsh since the second world war, largely because of development and land claim. However, the biggest future threat to coastal habitats is from sea level rise caused by climate change, and the related problem of coastal squeeze (Miles & Richardson 2018, MCCIP 2020). Mean sea levels in the UK have already risen by approximately 17 cm since the start of the 20th century and climate predictions show that they will continue to rise under all emissions scenarios until at least the year 2100 (Lawton and others 2010, Fung and others 2018, Met Office 2021). Future increases in sea level are likely to be greatest in southern and eastern England (MCCIP 2020), where the majority of England's soft coast seabird breeding colonies are located. Miles and Richardson (2018) predicted that, without intervention, 5,000 ha of protected coastal habitat in England could be lost by 2060, with even larger areas being functionally lost as suitable breeding habitat.

The Lock review found that 64% of soft coast sites (supporting over 75% of England's breeding population of little tern) are reportedly already being affected by sea level rise. The SIPs review found that coastal squeeze was reported as a cause of habitat reduction at 69% of English SPAs with breeding seabirds as a qualifying feature. However, the impacts of sea level rise and coastal squeeze are difficult to disentangle from impacts such as flooding due to storm surges, heavy rainfall or drainage issues, and the impacts may be greater than reported. The future impacts of sea level rise are difficult to predict, and beyond the scope of the assessments conducted here. A detailed and informed mapping exercise could be undertaken to determine which of England's breeding seabird sites are most at risk and to prioritise interventions.

Ground-nesting species that nest in sand and shingle coastal habitats (such as terns and gulls) are particularly at risk, since even minor increases in sea level can lead to large areas of habitat being rapidly lost (Johnston and others 2021). Many current breeding sites for terns and gulls on beaches and low-lying near-shore islands are likely to become unsuitable or be lost entirely within the next 10 years (Ross-Smith and others 2014, Ausden and others 2015, Miles & Richardson 2018, Dias and others 2019, Babcock & Booth 2020, Lock and others 2022). Little terns are likely to be the most vulnerable species, as they tend to nest just above the tideline and (Miles & Richardson 2018). In recent years, high proportions of England's little tern nests have been flooded out, leading to breeding failure (Lock and others 2020). The risk of flooding is further increased by storm surges and heavy rainfall, which are also linked to climate change and predicted to increase (MCCIP 2020, IPCC 2022a). The increased risk of intermittent flooding of nesting areas affects seabird breeding success and could lead to the abandonment of nesting areas and thus their effective loss as breeding habitat (Natural England 2015b, Babcock & Booth 2020, Pearce-Higgins 2021, IPCC 2022b, Lock and others 2022).

Degraded coastal habitats are also more vulnerable to flooding, so reduction in quality of habitat is also a contributing factor (Natural England 2015b, Miles & Richardson 2018, IPCC 2022a). Natural England's IPENS Coastal Management Theme Plan (Natural England 2015c) concluded that the overall status of England's intertidal habitats was 'bad-deteriorating'.

The effects of habitat reduction also compound the impacts of disturbance and predation, particularly at soft coast sites, where levels of disturbance and predation were found to be highest. The loss of suitable breeding habitat forces seabirds to breed in less suitable areas where they may be at higher risk of disturbance and predation (Miles & Richardson 2018) and also leads to smaller colonies which are more vulnerable to the effects of disturbance and predation (Ross-Smith and others 2014). Higher concentrations of individual birds in fewer suitable locations also facilitates the spread of disease (Hofmeister & Van Hemert 2018). Further loss of breeding habitat could have severe consequences for England's seabird populations, particularly those already in decline (Newell and others 2015, Furness 2016, Johnston and others 2021, Lock and others*2022*).

Disease

The Lock review, SIPs review, and sensitivity scoring exercise were all undertaken before the summer of 2022, which saw Highly Pathogenic Avian Influenza (HPAI) cause mass mortality at England's seabird colonies. The impacts caused by this disease on England's seabirds are unprecedented, so it is not surprising that neither the Lock review nor the SIPs review highlighted disease as a key pressure. However, eleven species were scored as being 'highly sensitive' to the pressure 'introduction of microbial pathogens' during the sensitivity scoring. This reflects the fact that there has been growing concern about the potential for disease and parasitism to pose serious threats to seabird populations in recent years should outbreaks occur (Mitchell and others 2020, Hakkinen and others 2022). Seabirds can be affected by a wide range of parasites and pathogens, ranging from ectoparasites such as ticks to microbial pathogens such as viruses and bacteria (Khan and others 2019). As long-lived, wide-ranging species, seabirds may be more exposed to pathogens and parasites than other taxa and may act as vectors (Mallory and others 2010, Khan and others 2019). High concentrations of individuals at breeding colonies, combined with high site fidelity, may increase the risk of exposure and transmission amongst seabird species (Bourret and others 2018, Stidworthy & Denk 2018, Mitchell and others 2020). Habitat loss and degradation may lead to higher concentrations of individuals in fewer suitable locations, which further facilitates the spread of disease and potentially exacerbates population-level impacts (Hofmeister & Van Hemert 2018, IPCC 2022b).

The outbreaks of HPAI in seabird populations across Europe and North America during the summer of 2022 proved that these concerns were not unfounded. The unprecedented scale of mortality means that disease, and HPAI in particular, is now considered a very real threat to seabird populations, as well as populations of other wild bird species (AEWA 2022, RSPB 2022, Walton 2022). Mass mortality of adults and chicks of many seabird species due to HPAI was recorded at breeding colonies during the summer of 2022 (Falchieri and others 2022). While mortality records likely underestimate the true scale of mortality (Falchieri and others 2022), mortality data collected by colony managers and shared with Natural England (which likely under-represents impacts), collated and analysed in October 2022, indicates that England lost at least 30% of the adult breeding population of the red-listed roseate tern, approximately 10% of the breeding adult population of Sandwich tern, and approximately 10% of the breeding adult population of common tern. The loss of such a high proportion of England's breeding roseate tern population is particularly of concern, as this is a red-listed species with only one breeding colony in the UK (Coquet Island) and very few colonies in the northeast Atlantic region. The potential population-level impacts are exacerbated by having so few breeding colonies.

Other species affected by HPAI in England in 2022 include Arctic tern, northern gannet, black-legged kittiwake, herring gull, black-headed gull, common guillemot, Atlantic puffin, razorbill, European shag, lesser black-backed gull, great black-backed gull, Mediterranean gull, great cormorant, and common eider. The true impacts of these outbreaks on survival and productivity in England's seabird populations will not be understood without further monitoring in future years (Anker-Nilssen and others 2017, Glencross and others 2021, Banyard and others 2022, Miller 2022, Falchieri and others 2022). There are also concerns that HPAI could continue to cause high levels of mortality in these and potentially other seabird species in breeding seasons to come.

Other pathogens known to have caused significant levels of mortality in seabirds include avian cholera (Bourret and others 2018, Khan and others 2019), botulism (Ortiz & Smith 1994, Rock 2005, Malik and others 2021), Bisgaard taxon bacteria (Duff and others 2021, Niedringhaus and others 2021) and viral duck enteritis *Anatid alphaherpesvirus 1* (Duff and others 2021, C. Raven *pers comm.*).

There is growing evidence that climate change exacerbates the risks of wildlife disease, and climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future (Elliot and others 2015, Dennis & Fisher 2018, Dias and others 2019, Hofmeister & Van Hemert 2018, Johnston and others 2021, Hakkinen and others 2022, IPCC 2022b). The recent increases in the incidence and severity of avian influenza (AI) outbreaks in wild birds have been linked to climate change, and future increases in AI outbreaks caused by climate change have been predicted (Mu and others 2014, Lee and others 2020). The impacts of disease are likely to be greater on birds that are already suffering from nutritional stress or from the presence of toxins (Stidworthy & Denk 2018, Khan and others 2019, Sebastiano and others 2022). Reducing the impacts of other pressures on seabirds could therefore help to reduce the impacts of disease.

The England Wildlife Health Strategy (Defra 2009) states that government has a responsibility to intervene in wildlife disease issues when the impact of a disease is significant enough to cause a decline in the population viability of a species officially recognised as of conservation concern, or where the impact could lead to a species becoming threatened.

Our understanding of seabird disease ecology and parasitology is limited (Khan and others 2019, Hakkinen and others 2022) and there are major evidence gaps concerning the prevalence of pathogens and parasites, transmission pathways, and population-level impacts (Khan and others 2019, Pearce-Higgins 2021, Falchieri 2022). Options for mitigating the spread and impacts of disease in seabird populations should be investigated, especially at colonies where transmission risk appears to be highest (Bourret and others 2018, Khan and others 2019, AEWA 2022, Banyard and others 2022, RSPB 2022).

Other pressures

Reduction in food

The review of SIPs showed that 92% of SPAs in England with breeding seabirds as qualifying features listed reduction in availability or quality of food resources as an issue, with commercial fisheries cited as a cause of reduction in food for 89% of SPAs. The Lock review, however, only found that 12.2% of seabird breeding sites reported reduction in food as an issue, mostly sites supporting black-legged kittiwake, with over 75% of the English breeding population of black-legged kittiwake estimated to be negatively impacted. However, the Lock review did not include assessment for this pressure at all sites and for all species consistently, because this pressure was judged to be a marine pressure rather than one acting directly at the breeding site. This pressure was therefore only included where the information was volunteered and is likely to be an underestimate of true impacts.

The availability of sufficient quality food is known to be a critical factor affecting both seabird productivity and survival (Frederiksen and others 2004, Wanless and others 2005, Mitchell and others 2020, Pearce-Higgins 2021). The relationship between seabird populations and the availability and quality of food is, however, difficult to determine and requires long term monitoring of seabird populations and prey populations, along with diet studies at colonies (Lewison and others 2012, Elliot and others 2015, Ceia and others 2022, IPCC 2022b, Lock and others 2022). While sufficient food is critical to breeding success at colonies, foraging activities take place away from the breeding site, and this pressure is therefore not considered in full as part of the colony assessment.

Litter and pollution

The SIPs review found that 94% of SPAs in England with breeding seabirds as qualifying features listed pollution as an issue. The Lock review, however, did not find that either pollution or litter were reported as important pressures negatively impacting breeding seabird populations in England. The disparity in results may be due to the fact that SIPs were recording issues that were affecting any features of the site. However, the sensitivity scoring (Appendix 3) scored a relatively high number of species as ‘highly sensitive’ at colonies to different types of pollution (‘litter’, ‘hydrocarbon & PAH contamination’, ‘Transition elements & organo-metal (eg TBT) contamination’, ‘Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)' and 'introduction of other substances (solid, liquid or gas)', indicating that breeding seabirds are likely to be negatively impacted by pollution and litter should they be exposed to it at their breeding colonies.

Some seabird species (eg northern gannet) can incorporate plastic litter into their nests and this can lead to problems with entanglement (O'Hanlon and others 2021). High levels of contaminants or crude oil at or near to seabird colonies could have severe impacts of large numbers of adults and chicks due to the high concentrations of individuals at these locations. These risks can be reduced by achieving Good Environmental Status for contaminants and reducing levels of plastic litter, but increasing the number and size of seabird colonies will also help seabird populations to be more resilient to localised events.

Other impacts of climate change

The Lock review found that 'increased frequency and severity of storms' was reported to be having a negative impact at 3% of sites that support over 75% of England's breeding population of European shag. Increases in storms and heavy rainfall can lead to eggs and chicks becoming chilled, reducing breeding success (Mitchell and others 2020). The fact that the plumage of European shags is only partially waterproof may mean they are more vulnerable to the effects of heavy rainfall (Johnston and others 2021). Winter storms have been linked to decreased winter survival in European shag (Frederiksen and others 2008).

The frequency and severity of extreme weather events is predicted to increase due to climate change (IPCC 2022b). Future increases in the frequency and severity of high winds and heavy rainfall could also lead to higher rates of cliff erosion, affecting the availability of suitable breeding habitat for cliff-nesting seabird species (Morecroft & Speakman 2015, Natural England & RSPB 2020). Increases in the frequency and severity of summer storms could also effectively reduce the available breeding habitat for cliff-nesting species if more exposed locations become unsuitable (Newell and others 2015, Johnston and others 2021). Heavy rainfall during the breeding season can lead to flooding of nesting burrows of species such as Atlantic puffin and Manx shearwater, reducing breeding success and effectively reducing breeding habitat (Furness 2016, Johnston and others 2021). Heatwaves can also have negative impacts on breeding seabirds (Furness 2016, Pearce-Higgins 2021, Quintana and others 2022).

Removal

The SIPs review found that 'removal of target species' was reported as an issue at 14% of English SPAs with breeding seabirds as qualifying features. This generally referred to the deliberate taking of eggs (usually gulls) and occasional culling of large gull species under licence. The Lock review found that removal was reported to be negatively impacting breeding seabird populations at 11.4% of England's seabird breeding sites. Again, this mostly referred to the taking of eggs or culling of adults of large gulls under licence. It is worth noting that both reviews used data collected prior to the recent changes to General Licensing for gull species, and that these changes may affect these results. It is also worth noting that urban populations of herring and lesser black-backed gull, which may be exposed to higher levels of removal, were not assessed.

The fact that disturbance, predation, and habitat reduction are reported to be affecting breeding seabird populations at so many of England's breeding seabird sites indicates that current work to protect breeding seabird populations at these sites is insufficient. There is therefore an urgent need to address these issues at seabird breeding sites and to ensure the conservation objectives of those within protected sites are met.

Sea level rise is clearly a threat to seabird breeding habitat in England, particularly to soft coast habitats on the south and east coasts. Large-scale habitat creation is likely to be necessary to offset losses. Created habitats could be designed to be less accessible to predators and people to further protect breeding seabirds.

The impacts of the HPAI outbreaks in 2022 show how quickly a severe threat to our seabird breeding populations can emerge and have devastating impacts, and highlighted the risk of having so many of our breeding seabirds concentrated in such a small number of locations. This outbreak also demonstrated how unprepared conservation bodies were to be able to deal with and document such a severe and sudden threat. Improved monitoring systems are required to detect and document mass mortality events and to understand their impacts on populations (Anker-Nilssen and others 2017, Glencross and others 2021, Banyard and others 2022). Emergency protocols should also be developed to deal with sudden and severe threats to vulnerable populations.

The Lock review resulted in the creation of a register of all of England's seabird colonies, identifying the specific issues at each site and the interventions that site managers believe are necessary to address those issues. This register should be maintained and updated as and when new information becomes available (for example the results of the most recent seabird census) and can be used to inform conservation actions. The Lock review also identified 22 Priority Sites (Table 8) that together are estimated to support over 70% of England's breeding seabirds, where conservation interventions would have the greatest impacts.

Appendix 9. Climate change impacts and potential mitigation measures.

Climate change affects seabirds and waterbirds in England in a number of ways. The key mechanisms through which climate change impacts marine ecosystem are briefly summarised below, before providing more details on how these changes to the ecosystem affect seabird and waterbird species further up the food chain.

Increased air and water temperatures

Increases in air temperatures drive increases in ocean temperatures, generally measured as sea surface temperature (SST) (Grémillet & Boulinier 2009, MCCIP 2020, IPCC 2022b). Globally, average SSTs increased by 0.88°C between 1850-1900 and 2011-2020 (IPCC 2022b). The UK's seas have shown a warming trend overall, with the greatest increases in the north of Scotland and the North Sea (MCCIP 2020, Johnston and others 2021). In the North Sea, average winter SST has increased by approximately 1°C since the early 1980s (Mitchell and others 2020).

Increases in SST are predicted to continue. The most recent IPCC models predict that the average global ocean temperatures will increase by between 1 and 4°C by the end of this century (IPCC 2022a). Annual mean temperatures in Europe are predicted to increase more than the global mean (Elliot and others 2015, IPCC 2022c). In UK waters, the greatest increases are predicted in the North Sea and the Channel (MCCIP 2020).

Marine heatwaves (MHW) are periods of elevated sea surface temperatures relative to the long-term mean (IPCC 2022b). The frequency, intensity, duration, and extent of MHW have increased since the 1980s due to climate change and are predicted to increase further during the 21st century (Smale and others 2019, Piatt and others 2020, IPCC 2022b). Terrestrial heatwaves are also increasing and can have negative impacts on breeding seabirds (Natural England & RSPB 2020, Pearce-Higgins 2021, Quintana and others 2022).

Increased frequency and severity of extreme weather events

Global warming and other climate changes have led to a global increase in the frequency and severity of extreme weather events, including strong winds (storms), heatwaves (including marine heatwaves), droughts and heavy rainfall events (IPCC 2022a, IPCC 2022b). While difficult to predict, these increases are predicted to continue throughout the 21st century (IPCC 2022a, IPCC 2022b).

Sea level rise

Due to a combination of climate change drivers, including ocean warming and melting ice, global mean sea levels (GMSLs) are rising (Grémillet & Boulinier 2009, IPCC 2022b).

GMSLs have risen by approximately 20 cm since 1901 and the rate of sea level rise is accelerating (IPCC 2022b). It is very difficult to predict future sea levels due to their dependence on future emissions and uncertainty around ice sheet processes, as well as geographic variation in erosion rates, but GMSL may increase by more than 1m by 2100 (IPCC 2022b).

Increased stratification of the water column

Rising sea surface temperatures lead to an increase in stratification (reduced vertical mixing), since warmer surface water doesn't mix as well with the cooler water below (Grémillet & Boulinier 2009, MCCIP 2020). The transfer of nutrients and oxygen between water layers is therefore reduced, with implications for marine food webs (MCCIP 2020, IPCC 2022c). Ocean stratification has increased globally since 1970 and is expected to increase further by the end of this century (IPCC 2022b). Thermal stratification has already affected UK waters, with stratification now beginning earlier in the year, and this trend is likely to continue (MCCIP 2020, IPCC 2022c).

Changes in ocean circulation

Ocean circulation is key to the movement of salt, nutrients, oxygen and carbon, and therefore for marine ecosystems (IPCC 2022b). Changes in circulation can be caused by changes to atmospheric pressure, including climate change-induced changes to the North Atlantic Oscillation (NAO) and the Atlantic Meridional Overturning Circulation (AMOC) (Grémillet & Boulinier 2009, Elliot and others 2015, MCCIP 2020). Decreasing ice cover and increasing meltwater in the Arctic may also affect circulation (Grémillet & Boulinier 2009, MCCIP 2020). UK shelf seas are predicted to decrease in salinity due to circulation changes (MCCIP 2020). Changes in circulation may reduce the flow of oceanic water from the Atlantic into the North Sea, resulting in the North Sea becoming more enclosed by the end of the 21st century (MCCIP 2020). Increased enclosure could lead to further increases in temperature and stratification (MCCIP 2020).

Changes to rainfall also cause changes to river catchment run-off into the sea, affecting the amount of freshwater, nutrients, and contaminants entering the sea. For enclosed and semi-enclosed seas and shallow seas (such as the North Sea), this may have greater impacts, leading to changes in salinity and sediment, pollution and eutrophication (Elliot and others 2015, MCCIP 2020, IPCC 2022b)

Ocean deoxygenation

Increased stratification and decreased oxygen solubility lead to lower concentrations of dissolved oxygen in sea water (MCCIP 2020). Globally, dissolved oxygen concentrations have declined by 2% since 1960 and unprecedented declines in subsurface oxygen content are predicted by the end of this century (MCCIP 2020, IPCC 2022c). In the North Sea, oxygen concentrations appear to have already decreased, and oxygen concentrations in UK waters are predicted to decline faster than the global average, particularly in the North Sea (MCCIP 2020).

Ocean acidification

Increased atmospheric levels of CO_2 lead to more CO_2 being absorbed by the oceans, which in turn leads to ocean acidification (Mitchell and others 2020, IPCC 2022b). Globally, ocean surface pH has already declined over the past forty years, and this trend is predicted to continue (IPCC 2022b). The impacts of acidification are poorly understood, but it is already known to be affecting calcifying plankton at the base of marine food chains (Grémillet & Boulinier 2009, Mitchell and others 2020, MCCIP 2020) and may increase the toxicity of contaminated sediments (Elliot and others 2015).

Effects of changes to marine ecosystems and food supply on seabirds

One of the key pathways through which climate change affects seabirds is through impacts on their food supply (Grémillet & Boulinier 2009, Daunt & Mitchell 2013, Furness 2016, Dias and others 2019, Mitchell and others 2020, Johnston and others 2021). The many physical impacts of climate change are affecting the distributions, abundance, and phenology of marine organisms at every trophic level (IPCC 2022b, IPCC 2022c). Different organisms at different trophic levels may react to climate change in very different ways and at different rates, resulting in spatial and temporal mismatches between predator and prey, known as ‘trophic mismatches’, with repercussions for entire food webs (Daunt & Mitchell 2013, IPCC 2022b). In their position at the top of marine food chains, seabirds are particularly vulnerable to the compounded effects of these changes at lower trophic levels (Furness 2016, Pearce-Higgins 2021).

Impacts of climate change on marine ecosystems

Phytoplankton are the primary producers of marine ecosystems (Capuzzo and others 2017). Warming temperatures, changes in salinity, increased stratification and acidification are leading to phytoplankton declines and changes in phytoplankton species composition that have repercussions for the entire ecosystem (Elliot and others 2015, Capuzzo and others 2017, Johnston and others 2021, IPCC 2022b). Global marine primary productivity has declined significantly since 1999 due to decreased phytoplankton biomass caused by climate change (Grémillet & Boulinier 2009, IPCC 2022b). These declines are projected to continue, and to lead to even greater declines in total marine animal biomass as the effects are amplified up food chains (IPCC 2022b). Distributions of phytoplankton are also likely to be affected by warming temperatures (Johnston and others 2021, IPCC 2022b). Changes to the timing of phytoplankton blooms have knock-on effects on food webs through trophic mismatches (Elliot and others 2015, Johnston and others 2021, IPCC 2022b). Climate change also affects the distributions, abundance, size and species composition of zooplankton communities, with global declines in zooplankton biomass predicted (Furness 2016, IPCC 2022b).

Copepods (a group of zooplankton species that are important in marine food webs) have declined in biomass and altered in species composition in the North-East Atlantic and in the North Sea (Frederiksen and others 2013, Elliot and others 2015, Capuzzo and others 2017, MCCIP 2020, IPCC 2022b). Calanoid copepods are key prey species for many fish, including the lesser sandeel (*Ammodytes marinus*) (Lindegren and others 2018). Total calanoid copepod biomass in the northern North Sea has declined by 70% in the last 50 years due to climate change (Frederiksen and others 2007, Elliot and others 2015, MCCIP 2020). Copepod distributions have also shifted northwards, and the timing of peak abundance has changed (Frederiksen and others 2007, Elliot and others 2015, Mitchell and others 2020).

Fish are affected by these changes at lower trophic levels, with trophic mismatches between fish and plankton abundance leading to fish recruitment failures that are predicted to increase, particularly at higher latitudes (Capuzzo and others 2017, IPCC 2022b). Fish are also affected directly by climate change. Temperature changes affect fish growth, survival, and reproduction (Grémillet & Boulinier 2009, MCCIP 2020). Higher temperatures in the North Sea have led to earlier spawning in mackerel and earlier maturation in herring and sole. Fish also change their distributions in response to climate change (Barrett and others 2012, Elliot and others 2015, Lima and others 2022). Fish communities in UK waters have already changed substantially, with declines in cold-water species such as cod and eelpout and increases in warm-water species such as European anchovy (Elliot and others 2015, MCCIP 2020, IPCC 2022b).

Less mobile marine species that are not capable of altering their distributions to cope with climate change are predicted to experience high mortality (IPCC 2022b). These include key habitat-forming species such as corals, kelps, and seagrasses, and the consequent habitat loss could therefore have considerable impacts on marine and coastal ecosystems (IPCC 2022b).

Climate change can also affect marine food webs through top-down impacts, where increases in predatory species add to pressures on lower trophic organisms (Furness 2016, Johnston and others 2021). Jellyfish have increased worldwide due to climate change and add to predation pressure on zooplankton and fish larvae (Daunt & Mitchell 2013, IPCC 2022b). Bottom-up and top-down impacts occurring simultaneously compound negative impacts and further destabilise marine food webs (Johnston and others 2021, IPCC 2022b). Rapid changes in marine ecosystems caused by climate change could lead to food web collapses, mass mortality events and ecological ‘tipping points’ that result in permanent changes (IPCC 2022b).

Marine heatwaves (MHW) are periods of elevated sea surface temperatures relative to the long-term mean (IPCC 2022b). The frequency, intensity, duration, and extent of MHW have increased since the 1980s due to climate change and are predicted to increase further during the 21st century (Smale and others 2019, Piatt and others 2020, IPCC 2022b). MHW can cause mass mortality of marine organisms and increases in MHW could lead to unprecedented and irreversible changes in marine ecosystems (Jones and others 2018, Smale and others 2019, Piatt and others 2020, IPCC 2022b).

Climate change has also been linked to recent increases in the occurrence of harmful algal blooms (HABs), which are dense concentrations of phytoplankton that produce toxins harmful to marine organisms (Jones and others 2017, IPCC 2022b). The causes of HABs are as yet unclear but they appear to be favoured by MHWs, drought, deoxygenation and increased ocean stratification and acidification caused by climate change (Jones and others 2017, Townhill and others 2018, IPCC 2022b). HABs are becoming more frequent globally and are predicted to increase, with some models predicting increases in the North Sea (Jones and others 2017, Townhill and others 2018, IPCC 2022b).

Impacts of marine ecosystem changes on seabirds

The combined effects of climate change at the lower trophic levels magnify up marine food webs and are resulting in changes to the distribution, abundance, availability and quality of the forage fish species relied upon by seabirds as prey (Barrett and others 2012, Furness 2016, Pearce-Higgins 2021, IPCC 2022b). Survival and reproductive success of seabirds is affected by these changes to their prey (Sandvik and others 2012, Furness 2016, Pearce-Higgins 2021). Because seabirds are central place foragers during their breeding seasons that have evolved to time their breeding seasons to coincide with peak abundance of food, changes to the distribution and timing of prey can cause trophic mismatches with disastrous consequences for breeding seabirds (Grémillet & Boulinier 2009, Daunt & Mitchell 2013, Mitchell and others 2020). Increased SST has been negatively correlated with breeding success and adult survival in several seabird species, including black-legged kittiwake, Arctic Tern, Atlantic puffin, common guillemot, European shag, northern fulmar, and Manx shearwater, likely acting via changes to food supply (Riou and others 2011, Sandvik and others 2005, Sandvik and others 2014, Mitchell and others 2020, Searle and others 2022).

Changes in sea surface salinity attributed to climate change have also been linked to negative impacts on breeding success of black-legged kittiwake, razorbill, northern gannet and great black-backed gull in the North Sea, likely also via indirect effects on prey (Searle and others 2022).

MHW can lead to mass mortality of seabird prey and subsequent mass mortality of seabirds. A large MHW that occurred in the Northeast Pacific between 2014 and 2016 and extended from California to Alaska (nicknamed ‘the blob’) caused a massive reduction in phytoplankton productivity, declines in important zooplankton species, and reductions in the quantity and quality of forage fish species (Jones and others 2018, Piatt and others 2020).These changes led to several mass mortality events of seabirds through starvation, including thousands of Cassin’s auklets *Ptychoramphus aleuticus* and an estimated one million common guillemot, as well as tufted puffins *Fratercula cirrhata* and crested auklets *Aethia cristatella* (Jones and others 2018, Jones and others 2019, Piatt and others 2020).

A MHW in the northwest Atlantic in the winter of 2012-2013 reduced plankton levels and led to mass mortality of razorbills and Atlantic puffins (Diamond and others 2020).

MHWs have also been linked to HABs (Jones and others 2017, Piatt and others 2020). Toxins produced by HABs can cause mass mortality in seabird prey, affecting seabirds indirectly, and may also cause mortality in seabirds themselves through toxicity or plumage fouling (Jones and others 2017, Gibble & Hoover 2018). HABs have been implicated in mass mortality events of cormorants, terns, auks, waterfowl, shearwaters, pelicans, and black-legged kittiwakes, although the majority of these incidents have not been well documented (Jones and others 2017, Johnston and others 2021). A 'red tide' HAB in the northeast Pacific in 2009 lasted several months and caused mass mortality of surf scoter *Melanitta perspicillata*, white-winged scoter *Melanitta deglandi*, and common guillemot (Jones and others 2017).

Sandeels and seabirds in the North Sea

A relatively well-studied example of the impacts of climate change on seabirds and one that is particularly relevant to seabirds in England is the case of sandeels in the North Sea. The lesser sandeel (*Ammodytes marinus*, hereafter 'sandeel') is a key prey species for many seabird species breeding in the North Sea (Furness 2016, Wanless and others 2018). The abundance of sandeels in the North Sea has declined over the past forty years, and changes in the timing of key life history events have also occurred (Burthe and others 2012, Wanless and others 2018, Mitchell and others 2020). Sandeel health and growth also appears to have been affected, as sandeels have declined in size and been shown to be of lower nutritional value (Wanless and others 2005, Wanless and others 2018, Daunt & Mitchell 2013).

Sandeel recruitment has been shown to be negatively correlated with increasing SSTs in the North Sea (Arnott & Ruxton 2002, Frederiksen and others 2007). Higher SSTs in the North Sea have led to significant changes in the abundance and distribution of the sandeel's preferred prey, the dominant copepod *Calanus finmarchicus* (Frederiksen and others 2013, Lindegren and others 2018, IPCC 2022b). Higher mean annual SSTs have been shown to be negatively associated with the occurrence of *C. finmarchicus* (Frederiksen and others 2013), and the recruitment of sandeels in the North Sea has been shown to be positively correlated with the abundance of *C. finmarchicus* (van Deurs and others 2009). Frederiksen and others (2013) predicted that future changes in climate would result in decreasing environmental suitability for the dominant copepod *Calanus finmarchicus* in the Northeast Atlantic during the 21st century and consequent declines in seabird breeding success.

Increases in jellyfish and larger predatory fish such as mackerel caused by warming may also affect sandeels by competing with them for copepod prey and by predating on sandeel larvae (Frederiksen and others 2013, Daunt & Mitchell 2013). Changes in wind and currents may also affect spawning and movements of larval sandeels, affecting their availability as prey for seabirds during the breeding season (Wright & Bailey 1993, Saetre and others 2002, Frederiksen and others 2013).

Seabird breeding success in the North Sea has been shown to be negatively impacted by declines in sandeels as a key prey item, and therefore indirectly impacted by increased SSTs (Furness 2016, Johnston and others 2021, Pearce-Higgins 2021). Wanless and others (2018) showed that the proportion of sandeels in chick diets of black-legged kittiwake, razorbill, common guillemot and European shag breeding on the Isle of May in the North Sea had declined over the past thirty years, and that this decline was linked to increasing SSTs. Wanless and others (2005) showed that widespread seabird breeding failures on Britain's east coast in 2004 was caused by reduced energetic content of sandeels and sprats *Sprattus sprattus* taken as prey, and linked this to climate change. Reed and others (2015) found that increased SSTs led to increased instances of skipped breeding in common guillemots on the Isle of May and suggested that this could be due to the negative impacts of increased SSTs on sandeels in the North Sea. Searle and others (2022) found negative links between sea surface temperature and breeding success in Atlantic puffin and common guillemot at North Sea colonies, likely due to indirect impacts on sandeels.

Black-legged kittiwakes are specialist feeders that are particularly reliant on sandeels during breeding in the North Sea, and black-legged kittiwake breeding productivity has been shown to be linked to the abundance of sandeels within foraging range (Frederiksen and others 2007, Mitchell and others 2020, Johnston and others 2021). Black-legged kittiwakes have also experienced widespread declines in recent decades (Frederiksen and others 2007, Sandvik and others 2014). Frederiksen and others (2004 and 2007) showed that adult survival and breeding productivity of black-legged kittiwakes was negatively correlated with higher winter SSTs and suggested this was due to the negative impacts of higher SSTs on sandeel populations. Black-legged kittiwakes are also surface-feeders, and increased stratification caused by climate change may affect the surface availability of prey such as sandeels (Carroll and others 2015). Carroll and others (2015) showed that increased stratification has been negatively correlated with black-legged kittiwake breeding success in UK waters, likely due to the reduced availability of sandeels as prey caused by increased stratification. Searle and others (2022) also found negative links between changes in sea surface salinity attributed to climate change and breeding success in black-legged kittiwake, common guillemot, razorbill, great black-backed gull, and northern gannet, also likely due to indirect impacts on sandeel prey.

Sandeel stocks are also negatively affected by sandeel fisheries in the North Sea, and the combined impacts of climate change and fisheries on sandeel stocks and on seabirds are likely to be additive (Frederiksen and others 2007, Frederiksen and others 2013, Lindegren and others 2018, Mitchell and others 2020).

Predicting seabird and waterbird responses to changes of marine ecosystems

There are three ways in which seabirds might, in theory, be able to adapt to climate change-induced changes to their food supply. They could shift to different prey species, they could change the timing of their breeding to coincide with peak prey abundance, or they could change their own distribution to match that of their prey (Johnston and others 2021, Pearce-Higgins 2021).

With changing fish distributions, populations of warm water fish species may grow in UK waters that could act as alternatives to sandeels as seabird prey (Frederiksen and others 2103, Russell and others 2015, Mitchell and others 2020). These include anchovies *Engraulis encrasicolus* and sardines *Sardina pilchardus*, both of which are predicted to shift their ranges northwards (Russell and others 2015, Lima and others 2022). Anchovies have increased in abundance in the North Sea, but although they are taken as prey by seabirds, it is unclear whether increases in the abundance of anchovies would be able to support the current sizes of seabird breeding populations in the Northeast Atlantic (Frederiksen and others 2013). Sprats *Sprattus sprattus* are another important prey species for seabirds around UK waters that may present an alternative to sandeels (Frederiksen and others 2013, Wanless and others 2018), but the effects of climate change on sprats is unclear (Frederiksen and others 2013). Wanless and others (2005) showed that the nutritional quality of sprats had declined with increased SSTs. Declines in key zooplankton species could affect populations of other seabird forage fish species (Frederiksen and others 2013). Trophic mismatch also remains a threat for all forage fish species (Mitchell and others 2020).

Furthermore, not all small fish species are suitable as seabird prey. A decline in sandeels in the mid-2000s saw many seabirds breeding in the North Sea switch to snake pipe fish *Entelurus aequoreus*, but these were not suitable as food for chicks (Harris and others 2008) and chick survival was adversely affected (Mitchell and others 2020). The complexity of marine food webs and climate change drivers makes predicting the future distributions, timings, and abundances of potential forage fish species extremely difficult (IPCC 2022b).

Seabird breeding seasons in the North Sea have not changed to adapt to the changes in the timing of sandeel abundance (Burthe and others 2012, Mitchell and others 2020). Comprehensive global meta-analyses by Keogan and others (2018 & 2022) found that seabirds in general have not sufficiently altered their phenology to compensate for changes in the timing of peak abundance of prey. Whelan and others (2022) found that black-legged kittiwakes and Brünnich's guillemots *Uria lomvia* in the Arctic altered their breeding phenology in response to climate, but that these changes were probably insufficient to mitigate against the negative impacts of climate change. The risk of trophic mismatch between breeding seabirds and their prey is therefore likely to increase in future (Johnston and others 2021)

Climate change is causing species distributions in the northern hemisphere to shift northwards (Elliot and others 2015, Pearce-Higgins 2021, IPCC 2022b). Seabird species may also shift their range northwards to follow their prey, particularly outside the breeding season when their movements aren't so constrained (Furness 2016, Mitchell and others 2020). At higher latitudes, the options for redistribution are obviously more limited (Furness 2016). Studies at seabird colonies on Svalbard in the Arctic found that Arctic seabird species such as little auk *Alle alle* and Brünnich's guillemot had declined, while boreal species such as black-legged kittiwake and common guillemot had increased, indicating that the latter species had shifted their distributions northwards (Descamps & Strøm 2021). Many seabird species breeding in the UK are at the southern end of their range in the North-East Atlantic, which may mean that some species will experience population declines or local extinctions as habitat suitability declines and shifts northwards (Mitchell and others 2020). Species currently at the southern edge of their range may be lost as breeding species from the British Isles. These include Arctic terns, Arctic skuas, and great skuas (Furness 2016). Russell and others (2015) used climate envelope modelling to predict the future distributions of 23 seabird species breeding in the British Isles. They predicted that over 65% of species would experience range reductions, assuming that species were capable of dispersing to new areas. If species were not able to disperse, all 23 species were predicted to experience range reductions (Russell and others 2015).

The ability of seabird species to disperse to new areas in response to change is unknown but may be limited because seabirds are long-lived and often exhibit strong breeding site fidelity (adults returning to the same breeding site year on year) and natal philopatry (individuals recruiting to breed in colonies in which they were raised) (Russell and others 2015, Furness 2016, Mitchell and others 2020). The formation of new seabird colonies can therefore be a very slow process, as it relies on recruitment by first-time breeders to non-natal colonies, the propensity for which varies by species and is likely to be affected by multiple factors (Russell and others 2015, Mitchell and others 2020). Searle and others (2022) also showed that breeding seabirds are unlikely to be able to extend their foraging ranges to cope with changes to prey availability.

Overall, it is therefore likely that the predicted impacts of climate change in UK waters will lead to further reductions in survival and breeding success for seabirds that feed on small shoaling fish (Daunt & Mitchell 2013, Mitchell and others 2020, Searle and others 2022).

Seabird populations that breed further north than the British Isles are likely to experience even greater declines due to climate change, which could affect British-breeding populations connected by meta-population dynamics (eg black-legged kittiwake, Arctic tern) as well as populations wintering in UK waters (eg long-tailed duck, common scoter) (Drever and others 2012, Håland 2014, Sandvik and others 2014, Pearce-Higgins 2021, IPCC 2022b, MWCAT 2022). Increases in ice-free conditions further north may also mean that seaduck species such as common eider and long-tailed duck may not need to migrate as far south in winter and wintering populations in the UK would therefore decrease (Elliot and others 2015, MWCAT 2022).

Effects of extreme weather on seabirds

Increased frequency and severity of strong winds

Globally, oceanic wind intensity has increased in recent decades (Louzao and others 2019). While storm trends vary by region and are difficult to predict, the frequency and severity of high energy storm events are predicted to increase and this is likely to affect UK seabirds (Louzao and others 2019, IPCC 2022b).

Strong winds can lead to widespread breeding failure for seabirds (Mitchell and others 2020, Johnston and others 2021). Strong winds affect the ability of seabirds to forage effectively, by making both flight and diving behaviours more energetically costly (Mitchell and others 2020, Johnston and others 2021). Higher wind speeds have been shown to negatively affect foraging ability and breeding success in tern species and in black-legged kittiwake (Furness 2016). While for procellariform seabird species, such as northern fulmar and Manx shearwater, increased wind speeds may reduce flight costs, high onshore winds have been associated with increased incidences of ‘groundings’ of these species (Johnston and others 2021). High winds can blow adult cliff-nesting birds from their nests, exposing eggs and chicks, and can lead to storm swells that wash nests off cliff faces or flood low lying colonies (Johnston and others 2021, Pearce-Higgins 2021). Increases in the frequency and severity of summer storms have been shown to reduce breeding success in razorbill, common guillemot, European shag and black-legged kittiwake, with effects particularly strong for razorbill and at more exposed locations (Newell and others 2015). Given that the orientation of storms is likely to be important, seabird colonies on Britain’s west coast may be more severely affected than those on the east coast (Newell and others 2015, Johnston and others 2021). Increases in the frequency and severity of summer storms could effectively reduce the available breeding habitat if more exposed locations become unsuitable and could have negative consequences for seabird populations, particularly those already in decline (Newell and others 2015, Furness 2016, Johnston and others 2021).

Storms can also directly cause adult mortality of seabirds, which has more severe implications for population dynamics given that seabirds are usually long-lived, slow-reproducing species (Clairbaux and others 2021, Johnston and others 2021, Pearce-Higgins 2021). Winter storms in particular have been shown to increase adult mortality and also affect body condition and future reproductive success in surviving adults (Clairbaux and others 2021, Mitchell and others 2020). A study by Clairbaux and others (2021) found that winter storms most likely affect seabirds due to their inability to forage during storm events. Frederiksen and others (2008) found that the winter survival of European shags breeding on the Isle of May was negatively affected by strong onshore winds and heavy rainfall. Severe storms along Europe’s Atlantic coast during the winter of 2013-2014 led to a mass mortality event (‘wreck’) of seabirds, over half of which were Atlantic puffins (Louzao and others 2019). Several severe storms in the winter of 2015-2016 led to a wreck of Atlantic puffins in SW Norway (Anker-Nilssen and others 2017). Most of these birds were thought to be breeders at colonies on the East Coast of Britain, and overwinter survival was shown to have been affected at the Isle of May that year (Anker-Nilssen and others 2017). The ‘Beast from the East’ storm in early 2018 substantially delayed seabird breeding at colonies on the east coast of Britain (Mitchell and others 2020). Louzao and others (2019) showed that winter mortality of adult common guillemots was correlated with higher numbers of extreme wind events and hypothesised that this was due to the negative effects of storms on guillemot foraging efficiency.

Rainfall changes

Extreme weather changes are predicted to lead to increased rainfall in some areas and decreased rainfall in others (IPCC 2022b). The frequency of both droughts and heavy rainfall events are increasing in the UK (Natural England & RSPB 2020). Drought conditions reduce freshwater inflow to estuaries, which can lead to eutrophication and HABs (see 2.2). Heavy rainfall during the breeding season can lead to flooding of nesting burrows for burrow-nesting species such as Atlantic puffin and Manx shearwater, reducing breeding success (Furness 2016, Johnston and others 2021). Manx shearwaters have been shown to abandon burrows that flood in subsequent years, so increased incidences of flooding effectively lead to loss of breeding habitat (Furness 2016). Heavy rainfall can also chill eggs and chicks of other species, leading to widespread breeding failure (Mitchell and others 2020). Increases in rainfall could lead to higher rates of cliff erosion, affecting breeding habitat for cliff-nesting species (Morecroft & Speakma 2015, Natural England & RSPB 2020). Adult winter mortality of European shags breeding on the Isle of May was shown to be linked to high onshore winds and higher rainfall, likely due to the poor waterproofing of European shag feathers and the inability of adults to dry off (Frederiksen and others 2008).

Heatwaves

The frequency, severity, and duration of heatwaves are increasing and are predicted to increase further in future (IPCC 2022a). Marine heatwaves can have drastic effects on seabird prey and can lead to HABs, but heatwaves can also have direct negative impacts on breeding seabirds (Natural England & RSPB 2020, Pearce-Higgins 2021, Quintana and others 2022). Some seabird species have been shown to show signs of physiological stress through overheating while incubating eggs or brooding young on nests (Furness 2016, Johnston and others 2021, Pearce-Higgins 2021). Extreme temperatures can also cause direct mortality of chicks and/or eggs. In 2016, a heatwave caused mass mortality of chicks of imperial cormorant (*Leucocarbo atriceps)* at a colony in Argentina (Quintana and others 2022)

Causes of seabird wrecks

While seabird wrecks (mass mortality events) have always occurred, usually in response to severe winter weather, it does appear that they are becoming both more common and more severe, and that these increases are related to climate change (Anker-Nilssen and others 2017, Jones and others 2020, Diamond and others 2020, Glencross and others 2021). Mass mortality events can have severe and long-lasting impacts on seabird populations, particularly those that are already in decline (Anker-Nilssen and others 2017, Jones and others 2019, Mitchell and others 2020, Piatt and others 2020). Unfortunately, the causes of seabird wrecks are not always fully investigated or understood (Clairbaux and others 2021, Glencross and others 2021). Only a small proportion of the birds that die are typically washed ashore, so it can be difficult to estimate the full extent of the mortality, as well as the geographic origin of carcasses (Anker-Nilssen and others 2017, Louzao and others 2019, Piatt and others 2020). Of those carcasses that are washed ashore in accessible locations, only a small proportion are usually subjected to post-mortem tests to investigate cause of death (Jones and others 2019, Daunt & Andrews, *in prep*). The paucity of long-term seabird colony studies also makes it difficult to understand the effects wrecks have on seabird demographics (Anker-Nilssen and others 2017). In autumn 2021 and winter 2021/2022, a seabird wreck occurred in the North Sea that was unprecedented in magnitude and geographic scale given the time of year and lack of association with severe weather (Fullick and others 2022, Daunt & Andrews *in prep*). The birds, mostly common guillemot and razorbill, appear to have starved, but the reasons for such sudden and serious changes to the food chain remain unclear at this time (Daunt & Andrews, *in prep*). Understanding the causes of mass mortality events in seabirds could provide important information about changes in the marine ecosystems on which they depend (Diamond and others 2020).

Effects of sea level rise on seabirds

Global mean sea level has risen by approximately 20cm since 1901, and the rate of sea level rise is increasing (IPCC 2022b). Sea levels are predicted to continue to rise throughout the 21st century and may increase by as much as 1m by 2100 (IPCC 2022b). The coastal regions of the North Sea are expected to be particularly vulnerable to increases in sea levels due to strong tidal regimes and the effects of storm surges (IPCC 2022c). In the UK, sea levels are rising faster in the south and east of England, where the land is also sinking slightly (Morecroft & Speakma 2015, MCCIP 2020). In addition to mean sea level rise, the risks of extreme sea levels and flooding are compounded by increases in the frequency and severity of storm swells and heavy rainfall events (MCCIP 2020, IPCC 2022a).

Low lying coastal habitats, such as sand and shingle beaches, are vulnerable to habitat loss and increased flooding through sea level rise (Miles & Richardson 2018, Natural England & RSPB 2020, IPCC 2022b). Large areas of these habitats may be lost with only minor increases in sea level (Johnston and others 2021). Habitat loss is compounded by the effects of coastal squeeze – human developments along coastlines that limit the ability of coastal habitats inland (Natural England 2015a). Ground-nesting seabird species that breed on sand and shingle beaches, such as terns and gulls, are therefore increasingly vulnerable to reduced breeding success through flooding and complete loss of breeding habitat (Dias and others 2019, Johnston and others 2021, Pearce-Higgins 2021).

The majority of England's seabird colonies are associated with these low-lying soft coast habitats that are increasingly at risk from sea level rise (Lock and others 2022). What's more, these habitats have already experienced massive habitat loss and degradation, and seabird colonies in these habitats are already threatened by high levels of disturbance and predation (Miles & Richardson 2018, Lock and others 2022). Species breeding in these habitats include little tern, Sandwich tern, common tern, Arctic tern, black-headed gull, Mediterranean gull, lesser black-backed gull, herring gull and common gull (Lock and others 2022). Tern species, particularly little terns, are especially vulnerable as they tend to nest very close to the high-water mark (Ausden and others 2015, Miles & Richardson 2018, Mitchell and others 2020, Natural England & RSPB 2020).

Cliff erosion, particularly of soft cliffs, may also be affected by sea level rise, especially when combined with the effects of extreme weather, resulting in habitat loss or degradation for cliff-nesting seabirds (Morecroft & Speakma 2015, Natural England & RSPB 2020).

Effects of invasive non-native species, pathogens and parasites on seabirds

Invasive non-native species

Invasive non-native species (INNS, also known as invasive alien species) are one of the greatest threats to seabird populations worldwide (Croxall and others 2012, Burthe and others 2014, Dias and others 2019, Mitchell and others 2020). The majority of the threats to seabirds posed by INNS act on land at breeding sites and are caused by invasive predatory species such as rats, cats, and mice (Croxall and others 2012, Dias and others 2019). However, a wider range of INNS also threaten seabird populations by causing habitat loss and degradation (Sydeman and others 2012). The spread and establishment of INNS is a growing problem worldwide, and climate change is likely to exacerbate this problem by facilitating the spread and establishment of non-native species (Ziska & Dukes 2014, Cuthbert & Briski 2021).

Marine INNS are a growing concern and can cause severe negative impacts to marine ecosystems, which are already facing many other pressures (Chan and others 2018, Cuthbert & Briski 2021). Climate change may increase the risks posed by marine INNS as conditions such as temperature and salinity change to make habitats more favourable to non-native species whilst simultaneously less favourable to native ones (Chan and others 2018, Cuthbert & Briski 2021). These changes may facilitate the establishment of INNS as well as increasing their ecological impact (MCCIP 2020, Cuthbert & Briski 2021). Negative impacts to marine ecosystems caused by INNS could add to negative impacts on seabird populations through changes to their prey supply.

Pathogens and parasites

Although our understanding of seabird disease ecology and parasitology is limited, there is increasing concern amongst seabird ecologists that disease and parasitism may pose serious threats to seabird populations (Mitchell and others 2020, Hakkinen and others 2022). Concentrations of individuals at breeding colonies and high site fidelity may increase the risk of exposure to seabird species (Mitchell and others 2020). There is growing evidence that climate change exacerbates the risks of wildlife disease by altering ranges and enhancing the growth and persistence of pathogens, parasites, vectors, and hosts (Elliot and others 2015, Dennis & Fisher 2018, Dias and others 2019, Hofmeister & Van Hemert 2018, Mitchell and others 2020, Hakkinen and others 2022). Changes in geographical ranges brings species that were previously separated geographically together and increases the risk of disease transmission (Dennis & Fisher 2018, Hofmeister & Van Hemert 2018, Carlson and others 2022). Increasing temperatures and precipitation are also linked to increased risk of transmission and higher levels of parasitism (Hofmeister & Van Hemert 2018, Mitchell and others 2020, Johnston and others 2021). Habitat loss or degradation may lead to higher concentrations of individuals which further facilitates the spread of disease (Hofmeister & Van Hemert 2018, IPCC 2022b). Higher temperatures and other environmental stressors may also make individuals more susceptible to disease and parasitism (Mitchell and others 2020, IPCC 2022b). Climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future (Dennis & Fisher 2018, Dias and others 2019, Johnston and others 2021, IPCC 2022b).

Recent increases in the incidence and severity of highly pathogenic avian influenza (HPAI) outbreaks in wild birds have been linked to climate change and future increases have been predicted (Mu and others 2014, Lee and others 2020). Outbreaks of HPAI in wild birds have increased in Europe and in the UK in recent years and there is growing concern around the population-level impacts of HPAI on the UK's seabirds (Verhagen and others 2021, Banyard and others 2022). HPAI was confirmed as the cause of a mass mortality event in great skuas breeding in Scotland in the summer of 2021 which also appeared to affect breeding success (Banyard and others 2022). In late 2021, HPAI killed approximately 10% of the Svalbard-breeding population of barnacle geese (*Branta leucopsis*) wintering in the UK, demonstrating that it is possible for the virus to have severe population-level impacts on wild bird species (Miller 2022). The summer 2022 HPAI outbreak in seabirds was unprecedented in seasonality, species affected, and extent of mortality, and there are concerns that it may be having severe population-level impacts on species of conservation concern (AEWA 2022, CMS 2022, Miller 2022, RSPB 2022). Species that have tested positive for HPAI in the UK during 2022 include great skua, common eider, northern gannet, Atlantic puffin, common guillemot, great black-backed gull, herring gull, black-headed gull, Arctic tern, common tern, Sandwich tern, and roseate tern (HM Government 2022). While mortality records likely underestimate the true scale of mortality (Falchieri and others 2022), mortality data collected by colony managers and shared with Natural England (which likely under-represents impacts) indicates that England lost at least 30% of the adult breeding population of the red-listed roseate tern, approximately 10% of the breeding adult population of Sandwich tern, and approximately 10% of the breeding adult population of common tern, as well as widespread breeding failure in these and several other species. It is also clear that species not previously affected by HPAI could become affected by new strains in future. The true extent of this outbreak on populations of seabirds in the UK remains to be seen, but it is clear that disease (particularly HPAI) now poses a serious threat to the UK's seabird populations, and conservation gains could be lost due to disease within a short period of time (AEWA 2022, RSPB 2022, Walton 2022).

Potential mitigation measures

Improving the resilience of seabird populations to climate change by reducing the impacts of other pressures

Even if carbon emissions can be successfully reduced, the impacts of climate change on seabird populations are already apparent and are likely to increase. These impacts are not going to be reversible in the short to medium term (years to decades). While it may be difficult to address the impacts of climate change on seabirds directly, measures can be taken that will increase the resilience of seabird populations to climate change, by reducing the cumulative impacts of other pressures. Climate change impacts may also be exacerbated by interactions with non-climate drivers such as habitat loss or resource overexploitation (IPCC 2022b). Reducing the impacts of non-climate pressures will therefore be vital to enable seabird populations to cope with the impacts of climate change (Furness 2016, Alderman & Hobday 2016, IPCC 2022b).

Reducing the impacts of pressures at sea

The availability of sufficient, quality food is necessary for healthy seabird populations, so the impacts of climate change on seabird prey are concerning, particularly given these impacts are predicted to increase (0). The impacts of anthropogenic overexploitation of seabird prey and climate change are likely to be additive (IPCC 2022b). It is therefore even more important that fisheries involving seabird prey are managed in a sustainable way, with sufficient set-aside for seabird needs (Capuzzo and others 2017, Lindegren and others 2018, IPCC 2022b). This is especially important for fisheries of key forage species, such as sandeels (Dunn 2021).

Marine protected areas (MPAs), ideally highly protected marine areas (HPMAs) are a potential mechanism for protecting key seabird foraging areas and other ecologically important areas such as moulting areas. Strategically implemented and well-managed MPAs also have the potential to contribute substantially towards climate change mitigation by ensuring healthy marine ecosystems (IPCC 2022b). Healthy habitats are more resilient to the impacts of climate change and are also capable of sequestering large amounts of 'blue carbon'. This capacity is reduced by heavy trawling and dredging activities, which also release carbon, contributing to rising carbon dioxide (CO_2) levels (Stephenson &

Johnson 2021). MPAs deliver the greatest climate change mitigation benefits when they are large and prohibit extractive activities (IPCC 2022c). The management and monitoring of MPAs will need to accommodate 'shifting baselines' caused by climate change, and potentially flexible boundaries given potential changes in distribution of mobile species such as fish and seabirds (Elliot and others 2015, IPCC 2022b). It will also be important to take a wider, ecosystem-based approach to achieve the healthy marine food webs on which seabirds depend.

The resilience of seabird populations to climate change could further be improved by reducing the impacts of seabird bycatch and entanglement, marine litter, pollution, and offshore renewable developments.

Reducing the impacts of pressures at breeding sites

The terrestrial habitats used by breeding seabirds have experienced widescale habitat loss and degradation, and this habitat loss is predicted to increase with rising sea levels and the effects of extreme weather (see section 3.5.1). This is particularly an issue for low-lying soft coast sites where even small increases in sea level could result in dramatic habitat loss. Degraded habitats are also more vulnerable to the risk of flooding. This habitat loss would reduce available breeding habitat for seabirds such as terns and gulls, and result in fewer, smaller colonies, which would also be more vulnerable to the impacts of disturbance and predation (Ross-Smith and others2014). Higher concentrations of individual birds in fewer suitable locations also facilitates the spread of disease (Hofmeister & Van Hemert 2018). There are also concerns that climate change may increase levels of recreational disturbance at coastal sites, increasing the need to provide disturbance-free habitats for nesting birds (Natural England & RSPB 2020).

It is therefore vital to protect and restore seabird breeding habitats to improve the resilience of seabird populations as well as the resilience of those habitats to the impacts of climate change. Habitat creation for soft coast-nesting species is also likely to be required on a large scale to offset past losses and to mitigate against predicted future losses due to sea level rise. This type of large-scale habitat creation (eg managed realignments) can also help to protect coasts from the impacts of flooding and rising sea levels, and could be integrated into Shoreline Management Plans and other programmes such as the National Habitat Compensation Programme (NHCP).

Seabird breeding habitats are also effectively reduced through the impacts of disturbance and predation (see Section 4). These impacts could be reduced by increasing protection from disturbance and predation, and by eradicating invasive mammalian predators on islands and maintaining effective biosecurity. This would result in improved availability of suitable nesting habitat, as well as increased breeding success, contributing to healthier seabird populations and greater resilience to the impacts of climate change.

More seabird colonies would also reduce the potential impacts of stochastic events such as extreme weather events or disease outbreaks. Climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future and has been linked to recent outbreaks of HPAI (Mu and others 2014 Dennis & Fisher 2018, Dias and others 2019, Lee and others 2020, Hakkinen and others 2022). Efforts should be made to reduce the incidence and impacts of disease on seabird populations.

Improving the evidence base

Impacts of climate change on seabirds

There are still considerable evidence gaps relating to the impacts of climate change on seabirds and on marine ecosystems in general. Improved understanding of these impacts would help to inform more effective conservation action and to construct more accurate PVA models. Monitoring is also important for evaluating the effectiveness of conservation actions. Seabirds are also useful ecological indicators of the health of marine ecosystems due to their visibility and their position at or near the top of marine food chains. Monitoring the impacts of climate change on seabirds therefore provides a useful contribution towards improving our understanding of the impacts of climate change on wider marine ecosystems.

Climate change has been shown to affect seabird abundance, distribution, diet, breeding success, survival, and phenology (Mitchell and others 2020, Johnston and others 2021), but there are still questions about the extent of these impacts, the contribution of the different climate variables, and how these may vary geographically and between species (Searle and others 2022). Being able to understand and quantify these impacts, and distinguish them from the impacts of other pressures or natural fluctuations, requires long-term monitoring of seabird abundance, productivity, survival, phenology, metapopulation dynamics, diet, and distribution (Johnston and others 2021, Pearce-Higgins 2021, Orgeret and others 2022).

Currently, monitoring at seabird colonies under the Seabird Monitoring Programme is considered to be insufficient to deliver reliable abundance and productivity trend information or to detect impacts on populations for several species (Dunn 2021, Edmonds and others 2021, Pearce-Higgins 2021). Most papers published on the impacts of climate change on UK seabirds are from studies conducted on the Isle of May in Scotland, thanks to the long-running and detailed monitoring data that are collected there as an SMP 'key site'. However, given regional variation in climate variables and seabird demographics, these may not accurately represent the situation in England, where there are currently no SMP key sites. In order to understand and quantify the impacts of climate change on England's seabirds, we therefore need to increase and improve monitoring of seabird abundance, demography, and diet at England's seabird colonies, and to develop SMP key sites in England.

Climate change may also lead to changes in seabird distributions, foraging ranges and key foraging areas at sea, and these changes may affect the degree to which seabirds are exposed to other pressures such as bycatch or offshore renewables (Pearce-Higgins 2021). Long-term, wide-scale data is therefore needed on seabird distributions and habitat use of seabirds at sea, through at-sea surveys and tracking studies, to inform our understanding of these potential changes.

There are also key evidence gaps around the causes and extent of mass mortality events, which can have severe impacts on seabird populations. Mass mortality events can be caused by extreme weather events, HABs, changes to prey availability or disease outbreaks, all of which have been linked to climate change and predicted to increase (see Sections 3 and 5). Unfortunately, the extent of seabird mass mortality events (or 'wrecks') are not always fully documented, and the causes are not always fully investigated (Anker-Nilssen and others 2017, Clairbaux and others 2021, Glencross and others 2021). Improved surveillance and reporting of mass mortality events, and further research into the causes of these events, is required to improve our understanding of climate change impacts on seabird populations and to inform seabird conservation (Louzao and others 2019, Clairbaux and others 2021, Glencross and others 2021).

Recent HPAI outbreaks have had major impacts on England's breeding seabird colonies. There is growing evidence that disease outbreaks of this kind are linked to changes in climate variables, and future increases in incidence and severity of disease have been predicted (Mu and others 2014, Hofmeister & Van Hemert 2018, Carlson and others 2022; See Section 5.2). However, our understanding of the way climate change interacts with parasitism and disease in seabirds is currently limited (Khan and others 2019, Hakkinen and others 2022). We therefore need to improve disease surveillance and research to improve our understanding of epidemiology and transmission dynamics and how these may relate to climate change impacts.

Impacts of climate change on seabird prey and marine ecosystems

There are also considerable evidence gaps relating to the impacts of climate change on seabird prey and the marine ecosystems that support seabird populations. Filling these evidence gaps will improve our understanding of impact pathways and help us to implement effective mitigation and conservation actions for seabirds. The impacts of climate change at lower trophic levels amplify up marine food webs and result in changes to seabird prey that can have major impacts on seabird survival, breeding success, and distribution (Appendix 12). There are many different climate change variables affecting marine ecosystems, including changes to temperature, oxygen levels, salinity, stratification and acidification. How different species respond to each of these parameters varies depending on their capacity to adapt or disperse. The result is a destabilising effect on marine ecosystems, through 'trophic mismatches'. Rapid changes to marine ecosystems caused by climate change could lead to ecological 'tipping points' that result in severe and irreversible changes (IPCC 2022b). There are key knowledge gaps with respect to the differing responses of marine organisms to the different climate variables, and the combined, cascading, and interacting impacts of climate change on marine ecosystems and how these vary geographically (IPCC 2022b, IPCC 2022c). Current marine monitoring systems are not thought to be sufficient to be able to detect and study these combined impacts (Elliot and others 2015, IPCC 2022b, IPCC 2022c). Increased and improved marine monitoring at all trophic levels will be necessary to understand these impacts. It will be particularly important to monitor key seabird prey species, such as sandeels, and how these may be affected by climate change (Dunn 2021, Edmonds and others 2021, Olin and others 2022).

Adaptive approaches

The need to improve the evidence base shouldn't be seen as a reason to delay action on climate change. There is an urgent need to act given the impacts that are already being seen and the pace of change. A balance needs to be struck between obtaining the necessary information and taking timely action. It will be necessary to take an adaptive approach - improving the evidence base whilst also taking action and monitoring the effectiveness of that action (Alderman & Hobday 2016).

Impacts of climate change on seabirds outside of England

Seabirds are wide-ranging animals and most of England's seabirds will spend a large proportion of their lives within the jurisdiction of the other UK nations and other countries (Jodice & Suryan 2010, Wernham and others 2002). Foraging trips may take seabirds breeding in England into the waters of neighbouring countries, particularly the Republic of Ireland and other UK countries, but also other countries around the North Sea basin. Individuals will often recruit into breeding colonies across borders, so that most seabird populations in England can be viewed as part of larger, international meta-populations (Jodice & Suryan 2010). Many are also long-distance migrants that spend part of the year in the Southern Hemisphere. For example, most of England's breeding terns winter off the coasts of western and southern Africa, while England's breeding Manx shearwaters winter off the coast of South America (Wernham and others 2002).

England's seabird populations are therefore affected by pressures outside, as well as within, England's borders. The impacts of these pressures also need to be considered when addressing the conservation of England's seabird populations. Climate change is a global problem, the impacts of which vary geographically, and a combination of local and global solutions is required to address climate change impacts (IPCC 2022b). Long-distance migrants may be particularly vulnerable as they are exposed to multiple impacts of climate change throughout their range (Johnston and others 2021, Nagy and others 2022).

International collaboration is therefore likely to play a key role in the success of efforts to increase the resilience of seabird populations to the impacts of climate change, and efforts to improve our understanding of those impacts. Cross-border collaboration typically results in better outcomes and greater cost-effectiveness when it comes to bird research and conservation, particularly for migratory species (Kirby and others 2008, Kark and others 2009, Nevins and others 2009, Jodice & Suryan 2010, Levin and others 2013, Hobday and others 2017, Nagy and others 2022). This can be achieved through working with organisations such as OSPAR, AEWA, ICES and the UN. Furthermore, threats to seabirds in international waters can only be tackled with international collaboration (O'Leary and others 2020, Davies and others 2021).

• Appendix 10. Climate change species accounts.

Below are accounts for the species included in the ESCaRP, summarising the available information on climate change-related threats to these species, with a focus on threats in the UK, but with some evidence from elsewhere within the species' range. Pearce-Higgins (2021) looked at long-term population trends and summarised the results of different climate change vulnerability assessments to evaluate the risks of climate change on bird species in the UK. These risk assessment scores are included in the species accounts (where available), along with the most recent species conservation status in the UK according to Stanbury and others (2021). Species are ordered according to the risk scores given by Pearce-Higgins (2021) (starting with the highest) and BoCC5 conservation status (starting with the highest category of concern). It is important to remember that while these species accounts and risk assessments (where available) are based on the best available evidence, there remain considerable evidence gaps and these should not be considered full assessments of species vulnerability. Where benefits are flagged, these generally apply to non-breeding populations of marine waterbirds, predicted to experience warmer winters which may increase their survival.

Species that have breeding populations in England

Atlantic puffin

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Breeding Atlantic puffins are heavily reliant on small shoaling fish, particularly sandeels in the North Sea, where declines in the abundance, availability, and quality of sandeels due to climate change have been shown to negatively affect breeding success (Wanless and others 2005, Barrett and others 2012, Mitchell and others 2020, Fayet and others 2021, Johnston and others 2021, Pearce-Higgins 2021). Frederiksen and others (2013) found that breeding success of Atlantic puffins on the Isle of May was positively correlated with environmental suitability of the copepod *C. finmarchicus*, a key prey species for sandeels that has been shown to decline with increasing SSTs (sea surface temperatures).

Changes to sea surface salinity attributed to climate change have also been linked to reduced breeding success in the North Sea (Searle and others 2022). Trophic mismatch is also likely to be affecting this species (Johnston and others 2021). Climate change has also been linked to reductions in adult survival rates (Sandvik and others 2005, Pearce-Higgins 2021). Sudden changes to prey abundance and quality caused by marine heatwaves have led to mass mortality in this species (Diamond and others 2020).

Atlantic puffin breeding burrows are vulnerable to flooding during heavy rainfall events (Furness 2016). Atlantic puffins are also vulnerable to adult mortality caused by adverse weather, which can lead to mass mortality (Anker-Nilssen and others 2017, Louzao and others 2019).

Atlantic puffins in the UK tested positive for HPAI during the summer 2022 outbreak. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The extent of the Atlantic puffin's European range is predicted to decrease substantially in response to climate change, and much of the southern parts of its range within the UK are predicted to become unsuitable (Russell and others 2015, Johnston and others 2021). Pearce-Higgins (2021) predicted an 89% decline in the abundance of the breeding Atlantic puffin population in Britain and Ireland by 2050 under a high climate change scenario, and Searle and others (2022) also predicted a decline in breeding success according to current climate predictions.

Black-legged kittiwake

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Black-legged kittiwakes are specialist surface-feeders and therefore particularly vulnerable to climate change impacts on prey (Mitchell and others 2020). Black-legged kittiwake breeding in the North Sea are heavily reliant on sandeels, where declines in the abundance, availability and quality of sandeels due to increasing SSTs have negatively affected breeding success (Frederiksen and others 2004, Wanless and others 2005, Frederiksen and others 2007, Wanless and others 2018, Pearce-Higgins 2021). Frederiksen and others (2013) found that breeding success of black-legged kittiwakes on the Isle of May was positively correlated with environmental suitability of the copepod *C. finmarchicus*, a key prey species for sandeels that has been shown to decline with increasing SSTs.

Adult survival and population size have also been negatively correlated with increased SSTs, likely also due to indirect impacts of increased temperatures on prey (Sandvik and others 2014, Mitchell and others 2020, Appendix 12). As a surface feeder, black-legged kittiwake is also likely affected by the increased stratification of the water column, which has been negatively correlated with breeding success (Carroll and others 2015). Searle and others (2022) showed that changes to sea surface salinity associated with climate change were negatively correlated with black-legged kittiwake breeding success in the North Sea, and predicted that these negative effects are likely to increase with future changes. Terrestrial temperatures were also shown to negatively affect breeding success in the North Sea (Searle and others 2022).

Black-legged kittiwake have high foraging costs and are therefore vulnerable to adverse weather conditions affecting their foraging ability (Frederiksen and others 2007, Newell and others 2015, Johnston and others 2021). Increases in the frequency and severity of summer storms have been shown to negatively affect breeding success (Newell and others 2015).

Black-legged kittiwakes in the UK tested positive for HPAI during the summer 2022 outbreak Falchieri and others 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The extent of the Black-legged kittiwake’s European range is predicted to decrease in response to climate change, with colonies in the south of the UK predicted to become less suitable (Russell and others 2015, Johnston and others 2021). There is evidence that the species’ range is already shifting northwards (Descamps & Strøm 2021). Carroll and others (2015) predicted substantial declines in black-legged kittiwake productivity at UK colonies due to climate change, as a result of future increases in SSTs and stratification. They predicted that the greatest productivity declines would be at Flamborough Head, which supports by far the largest breeding population of black-legged kittiwake in England (Carroll and others 2015). Pearce-Higgins (2021) predicted a 54% decline in breeding black-legged kittiwake populations in Britain and Ireland by 2050 under a high climate change scenario. Searle and others (2022) also predicted declines in black-legged kittiwake breeding success under current climate predictions.

Herring gull

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Herring gulls nesting and foraging in natural (non-urban) habitats may be affected by the availability of marine prey, particularly as surface feeders (Mitchell and others 2020, Johnston and others 2021). However, the species’ generalist foraging behaviour may buffer it from impacts on prey as they are able to switch to other food sources (Furness 2016, Johnston and others 2021). The species has already successfully colonised urban environments in the UK for nesting and foraging, and there is potential for its urban range to expand (Johnston and others 2021).

Foraging at sea is also likely to be negatively affected by adverse weather conditions, which have been shown to negatively affect breeding success in natural-nesting herring gulls (Johnston and others 2021). Low-lying ground nests in coastal areas are also vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022).

Herring gulls in the UK tested positive for HPAI during the summer 2022 outbreak (Falchieri and others 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The extent of the herring gull's European range has been predicted to decrease in response to climate change, with much of the southern part of its range becoming unsuitable (Russell and others 2015, Johnston and others 2021). While some studies suggest there may be benefits from climate change for this species in the UK, Pearce-Higgins (2021) assessed breeding populations to be at high risk.

European shag

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Risk (breeding populations)

Increased SSTs have been shown to negatively affect breeding success and adult survival in European shags, likely via changes in the abundance and quality of prey (Wanless and others 2005, Wanless and others 2018, Mitchell and others 2020, Johnston and others 2021). Howells and others (2018) found that the frequency of sandeels being taken as prey by European shags on the Isle of May had decreased dramatically over the past three decades, likely linked to impacts on sandeels of increased SSTs in the North Sea.

Increases in summer storms have been shown to negatively affect breeding success in European shags (Newell and others 2015). Storms affect the ability of birds to forage effectively and may also flood or otherwise destroy nests (Newell and others 2015, Johnston and others 2021). High winds and heavy rainfall have also been shown to negatively affect adult winter survival and first year survival rates (Frederiksen and others 2008, Furness 2016, Johnston and others 2021). High levels of mortality in European shags in Shetland in 2011 and 2014 were associated with prolonged gales (Heubeck and others 2015). The fact that European shag feathers are only partially waterproof may mean this species is more vulnerable to waterlogging, hypothermia and reduced foraging ability caused by storms (Frederiksen and others 2008, Johnston and others 2021).

Predictions of European range extent vary but the range is likely to shift northwards and most predictions agree some level of risk to the species due to climate change impacts in the UK (Russell and others 2015, Johnston and others 2021, Pearce-Higgins and others 2021).

Roseate tern

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Roseate terns are surface feeders and therefore vulnerable to climate change impacts on availability of prey (Mitchell and others 2020). They may also be vulnerable as long-distance migrants due to being exposed to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

High winds have been shown to negatively affect foraging ability in common tern and Sandwich tern and this may also apply to roseate tern (Furness 2016, Johnston and others 2021). Rainfall has been shown to affect common tern breeding success and may equally affect other tern species (Johnston and others 2021).

Low-lying tern colonies are vulnerable to sea level rise and flooding (Miles & Richardson 2018, Johnston and others 2021, Lock and others 2022). Tern species have a high potential to disperse to new breeding areas, but successful dispersal will depend on the availability of suitable alternative habitats which may need to be artificially created (Miles & Richardson 2018, Johnston and others 2021).

Roseate terns breeding on Coquet Island (the UK's only breeding colony of this species) tested positive for HPAI during the summer 2022 outbreak, and high levels of mortality were observed in adults and chicks. It is estimated that at least 30% of Coquet Island's (and thus the UK's) breeding adults have died during the course of this outbreak (Ibrahim Alfarwi, *pers. comm*.). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a major threat to this species.

European range predictions for roseate tern vary, but the breeding range is likely to shift northwards in response to climate change (Russell and others 2015, Johnston and others 2021). Some studies predict benefits from climate change for this species in the UK, but benefits will likely be dependent on habitat creation and management actions (Miles & Richardson 2018, Miles and others 2018, Johnston and others 2021).

Slavonian grebe

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Benefit (wintering populations), Not assessed (breeding populations)

For Slavonian grebes, very little information on climate change impacts is available. Pearce-Higgins (2021) predicted high benefits of climate change for wintering populations in the UK.

Arctic tern

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk

Arctic terns are surface feeders and are therefore vulnerable to the impacts of climate change on prey abundance and availability (Mitchell and others 2020). Breeding success has been negatively correlated with increasing SSTs, likely impacting via changes to food supply (Mitchell and others 2020, Pearce-Higgins 2021).

High wind speeds have been shown to negatively affect foraging success in terns (Furness 2016, Johnston and others 2021). Heavy rainfall has also been shown to affect breeding success in common terns and this may apply equally to other tern species (Johnston and others 2021). The Arctic Tern’s lengthy migration may also expose it to multiple climate change impacts throughout its range (Wernham and others 2002, Johnston and others 2021).

Low-lying tern colonies are vulnerable to sea level rise and flooding (Miles & Richardson 2018, Johnston and others 2021, Lock and others 2022). Tern species have high potential to disperse to new breeding areas, but successful dispersal will depend on the availability of suitable alternative habitats which may need to be artificially created (Miles & Richardson 2018, Johnston and others 2021).

Arctic terns in the UK tested positive for HPAI during the summer 2022 outbreak. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The extent of the Arctic tern’s European range is predicted to decrease considerably in response to climate change (Russell and others 2015, Johnston and others 2021). Arctic terns breeding in the UK, particularly in England, are already at the southern edge of their range, and Arctic terns are therefore likely to be lost as a breeding species in the UK, with English colonies being lost first (Russell and others 2015, Furness 2016, Johnston and others 2021).

Little tern

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk

Little terns are surface feeders and therefore vulnerable to climate change impacts on the abundance and availability of food (Mitchell and others 2020). They are also vulnerable due to having a relatively small foraging range.

High wind speeds have been shown to negatively affect foraging success in terns (Furness 2016, Johnston and others 2021). Heavy rainfall has also been shown to affect breeding success in common terns and this may apply equally to other tern species (Johnston and others 2021). Little terns may also be vulnerable as a migratory species exposed to multiple climate change impacts throughout its range (Wernham and others 2002, Johnston and others 2021).

Breeding little terns are particularly vulnerable to sea level rise and flooding because they nest on beaches just above the high tide mark (Ausden and others 2015, Miles & Richardson 2018, Natural England & RSPB 2020, Mitchell and others 2020, Johnston and others 2021, Lock and others 2022). Nests of little tern breeding in the UK are frequently flooded by tidal surges and this has contributed to population declines (Mitchell and others 2020). Tern species have high potential to disperse to new breeding areas, but successful dispersal will depend on the availability of suitable alternative habitats which may need to be artificially created (Miles & Richardson 2018, Johnston and others 2021). The species is also particularly vulnerable to impacts of recreational disturbance, which has been predicted to increase at breeding sites due to climate change (Natural England & RSPB 2020).

The extent of the little tern's European range has been predicted to decline due to climate change (Russell and others 2015, Johnston and others 2021). Predictions for the species in the UK vary, but most studies predict negative impacts. Both the Climate Change Adaptation Manual (Natural England & RSPB 2020) and Pearce-Higgins (2021) assessed this species to be at high risk from climate change impacts.

Black guillemot

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Black guillemots have a relatively limited breeding distribution in England and a relatively small foraging range, which makes this population vulnerable to climate change impacts. Studies have shown that breeding success in black guillemot may be negatively impacted by adverse weather (Johnston and others 2021).

Greenwood (2007) found that increased SSTs were correlated with earlier laying by black guillemots, but found no relationship with breeding success. Black guillemots breeding in the UK are at the southern limit of their range and most of their current UK distribution is predicted to become climatically unsuitable (Russell and others 2015, Johnston and others 2021). This species is therefore likely to be lost as a breeding species in the UK, with the very small English colonies being lost first (Russell and others 2015, Johnston and others 2021). Pearce-Higgins (2021) assessed the species as being at high risk from climate change impacts.

Northern fulmar

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Northern fulmar productivity has been shown to be negatively impacted by reductions in prey availability caused by climate change (Mitchell and others 2020, Pearce-Higgins 2021). Northern fulmars may be particularly vulnerable to changes in prey availability and abundance as a surface-feeder (Mitchell and others 2020).

While strong winds may reduce energetic costs of foraging for northern fulmar, increases in the frequency and severity of storms have been shown to negatively affect breeding success (Johnston and others 2021). Survival and breeding success of northern fulmars have been shown to be negatively correlated with climate change-related increases in winter North Atlantic Oscillation (WNAO) (Grosbois & Thompson 2005, Lewis and others 2009). High onshore winds may also increase the incidence of 'groundings', particularly where there is also artificial light pollution (Johnston and others 2021).

Predictions of the future European range vary but most studies agree that this species is at high risk from climate change impacts in the UK (Johnston and others 2021, Pearce-Higgins 2021).

Great black-backed gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

The great black-backed gull's generalist diet and foraging behaviour may buffer it from climate change impacts to prey, as it may be able to switch to other food sources (Furness 2016, Johnston and others 2021). This species may have potential to increase its use of urban environments, as herring and lesser black-backed gulls have already done (Johnston and others 2021). However, changes to the availability of marine prey may negatively affect this species, particularly as it is a surface feeder at sea (Mitchell and others 2020, Johnston and others 2021). Searle and others (2022) showed that changes in terrestrial temperatures and in sea surface salinity attributed to climate change are associated with reduced breeding success in great black-backed gulls in the North Sea, with these impacts predicted to increase under current climate predictions.

Adverse weather conditions may affect their ability to forage at sea as in herring gulls (Johnston and others 2021). Low-lying nests are vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022).

Great black-backed gulls in the UK tested positive for HPAI during the summer 2022 outbreak (Gov.uk 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The European range of the great black-backed gull is predicted to decrease in response to climate change, with large areas predicted to become climatically unsuitable within the 21st century (Russell and others 2015, Johnston and others 2021). Predictions for the UK vary, with some studies suggesting climate change may provide benefits for this species (Johnston and others 2021). However, Pearce-Higgins (2021) assessed the species to be at high risk from climate change impacts in the UK.

European storm petrel

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk

There have been very few studies of climate change impacts on European storm petrels (Johnston and others 2021). As surface-feeders they may be particularly vulnerable to climate change impacts on prey availability (Mitchell and others 2020). Impacts of climate change on prey have been suggested (Johnston and others 2021). Soldatini and others (2016) suggested that European storm petrels may have limited resilience to climate change impacts due to their high level of philopatry, but that warmer winters may benefit the species. As long-distance migrants, they may also be vulnerable through being exposed to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

The European storm petrel's European range is predicted to increase overall in response to climate change, but areas at the southern edge of its range are predicted to become climatically unsuitable (Johnston and others 2021). While some studies have predicted benefits in the UK, Pearce-Higgins (2021) assessed the species as being at high risk from climate change impacts in the UK.

Common guillemot

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Risk (breeding populations)

Increased SSTs have been negatively linked to common guillemot breeding success and the incidence of skipped breeding, due to decreasing availability and quality of prey (Wanless and others 2005, Reed and others 2015, Wanless and others 2018, Mitchell and others 2020, Johnston and others 2021, Searle and others 2022). Frederiksen and others (2013) found that breeding success of common guillemot on the Isle of May was positively correlated with environmental suitability of the copepod *C. finmarchicus*, a key prey species for sandeels that has been shown to decline with increasing SSTs. Climate change has also been linked to reduced adult survival rates (Sandvik and others 2005). Searle and others (2022) showed that changes to terrestrial rainfall associated with climate change affected breeding success in common guillemots in the North Sea. Irons and others (2008) found that changes in SSTs were associated with reduced colony sizes of common guillemot throughout the Arctic and sub-Arctic, likely due to impacts on marine food webs.

Increases in summer storms have been shown to negatively impact breeding success (Newell and others 2015). Finney and others (1999) showed that common guillemots brought smaller sandeels to chicks during stormy weather. Common guillemots are also vulnerable to winter mortality and occasionally mass mortality events due to winter storms (Louzao and others 2019).

Common guillemots in the UK tested positive for HPAI during the summer 2022 outbreak (Gov.uk 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

Future predictions of European range extent vary but most agree that the range is likely to decline, particularly at its southern edge, which includes breeding areas in England (Russell and others 2015, Johnston and others 2021). There is evidence that the breeding range is already shifting northwards (Descamps & Strøm 2021). Predictions for the UK vary, but most suggest the species is at risk form climate change impacts in the UK (Johnston and others 2021, Pearce-Higgins 2021).

Razorbill

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Risk (breeding populations)

Increased SSTs have been negatively linked to razorbill breeding success, due to decreasing availability and quality of prey (Wanless and others 2005, Wanless and others 2018). Searle and others (2022) also noted a negative link between changes in sea surface salinity attributed to climate change and breeding success in razorbill. Razorbills have also been shown to be vulnerable to mass mortality caused by sudden changes in food supply caused by marine heatwaves (Diamond and others 2020).

Newell and others (2015) showed that, out of four seabird species on the Isle of May, razorbill was the species most negatively impacted by summer storms. Sandvik and others (2005) linked climate change to reduced adult survival rates. The species is vulnerable to winter mortality caused by adverse weather (Louzao and others 2019).

The extent of the razorbill’s European range is predicted to decrease due to climate change, and breeding areas in southern England are predicted to become climatically unsuitable (Russell and others 2015, Johnston and others 2021). Predictions for the species in the UK vary, but most suggest the species is at some level of risk due to climate change impacts (Pearce-Higgins 2021).

Sandwich tern

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Risk

As surface feeders, Sandwich terns are likely to be vulnerable to climate change impacts on the abundance and availability of prey (Mitchell and others 2020). They may also be vulnerable as long-distance migrants due to being exposed to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Adverse weather has been shown to negatively affect foraging ability in Sandwich terns (Furness 2016, Johnston and others 2021). Rainfall has been shown to affect common tern breeding success and may equally affect other tern species (Johnston and others 2021).

Low-lying tern colonies are vulnerable to sea level rise and flooding (Miles & Richardson 2018, Johnston and others 2021, Lock and others 2022). Tern species have high potential to disperse to new breeding areas, but successful dispersal will depend on the availability of suitable alternative habitats which may need to be artificially created (Miles & Richardson 2018, Johnston and others 2021).

Sandwich terns in the UK tested positive for HPAI during the summer 2022 outbreak, with high levels of mortality observed alongside mass breeding failure (Falchieri and others 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a threat to this species.

Predictions of European range extent for Sandwich tern vary but breeding range is likely to shift north in response to climate change (Russell and others 2015, Johnston and others 2021). Predictions for the future of this species in the UK vary but Pearce-Higgins (2021) suggests the species faces medium risk due to impacts of climate change in the UK.

Common eider

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Risk & Benefit (breeding populations), High Risk (wintering populations)

Pearce-Higgins (2021) predicted a mixture of risks and benefits from climate change for populations of common eider breeding in the UK, and assessed UK wintering populations as being at high risk. Negative impacts of climate change on breeding grounds further north than the UK may be reflected in decreases in wintering populations in the UK (Furness 2016, Pearce-Higgins 2021). The increasing extent of favourable ice-free wintering habitat further north may also reduce numbers wintering in UK waters (Elliot and others 2015).

Common eider in the UK tested positive for HPAI during the summer 2022 outbreak. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

Red-breasted merganser

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Risk (breeding populations), Medium Benefit (wintering populations)

Pearce-Higgins (2021) predicted medium risk for breeding populations in the UK, and medium benefit for wintering populations. The increasing extent of favourable ice-free wintering habitat further north may reduce numbers wintering in UK waters (Elliot and others 2015).

Northern gannet

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Limited Impact

Northern gannets have a large foraging range, flexible foraging behaviour and the ability to take a wide variety of species as prey, and it is suggested that they are therefore buffered to some extent from climate change impacts (Johnston and others 2021). Increases in mackerel in UK waters in recent years linked to rising temperatures appear to have favoured increases in northern gannet populations (Davies and others 2013, Johnston and others 2021). However, recent increases in the duration of foraging trips by breeding northern gannets in the Celtic and Irish Seas suggest that foraging conditions have become less suitable for gannets in these areas (Davies and others 2013). Searle and others (2022) found a negative link between changes in sea surface salinity associated with climate change and breeding success in northern gannet in the North Sea. As long-distance migrants, northern gannets may be vulnerable through exposure to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Northern gannets in the UK tested positive for HPAI during the summer 2022 outbreak (Falchieri and others 2022), with high levels of mortality observed. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a threat to this species.

The northern gannet's European range is predicted to decrease overall in response to climate change but is unlikely to change much in the UK during the 21st century (Johnston and others 2021). A variety of studies have predicted some benefits to this species from climate change (Russell and others 2015, Johnston and others 2021, Pearce-Higgins

2021). Pearce-Higgins (2021) predicted limited impacts of climate change on this species in the UK.

Common gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Medium Benefit (breeding populations)

Common gulls may be vulnerable to climate change impacts on prey as surface-feeders, although they do display some flexibility in their foraging behaviour and have adapted to some extent to urban environments (Mitchell and others 2020). Individuals that are long-distance migrants may be vulnerable through exposure to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Adverse weather conditions have been shown to negatively affect breeding success in natural-nesting herring gulls and this may also apply to common gulls (Johnston and others 2021). Low-lying ground nests are vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022). Common gulls may be vulnerable to increases in avian influenza outbreaks.

The common gull's European range is predicted to decline with the southern parts of range becoming climatically unsuitable (Johnston and others 2021). Predictions for the UK vary, with some studies suggesting risks and others suggesting climate change could provide benefits for this species (Johnston and others 2021, Pearce-Higgins 2021). Benefits are likely to depend to some extent on habitat creation and management actions (Miles & Richardson 2018, Lock and others 2022).

Common tern

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Benefit

Common terns are surface feeders and therefore vulnerable to climate change impacts on availability of prey (Mitchell and others 2020). They may also be vulnerable as long-distance migrants due to being exposed to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

High winds have been shown to negatively affect foraging ability in common tern (Furness 2016, Johnston and others 2021). Rainfall has been shown to affect common tern breeding success (Johnston and others 2021).

Low-lying tern colonies are vulnerable to sea level rise and flooding (Miles & Richardson 2018, Johnston and others 2021, Lock and others 2022). Tern species have high potential to disperse to new breeding areas, but successful dispersal will depend on the availability of suitable alternative habitats which may need to be artificially created (Miles & Richardson 2018, Johnston and others 2021).

Common terns in the UK tested positive for HPAI during the summer 2022 outbreak, with high levels of mortality observed. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The European range of the common tern is predicted to decrease overall, but the species' UK range has been predicted to increase in response to climate change (Russell and others 2015, Johnston and others 2021). Many studies predict benefits from climate change for this species, but benefits will likely be dependent on habitat creation and management actions (Miles & Richardson 2018, Miles and others 2018, Johnston and others 2021).

Black-headed gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Benefit (breeding populations)

Black-headed gulls may be vulnerable to climate change impacts on prey as surface-feeders, although they do display some flexibility in their foraging behaviour and have adapted to some extent to urban environments (Mitchell and others 2020). Individuals that are long-distance migrants may be vulnerable through exposure to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Adverse weather has been shown to affect breeding success in black-headed gulls (Johnston and others 2021). Foraging ability may be affected by adverse weather conditions as is the case with other small gulls and terns (Frederiksen and others 2007, Johnston and others 2021). Low-lying ground nests are also vulnerable to flooding and sea level rise (Johnston and others 2021, Lock and others 2022).

Black-headed gulls in the UK tested positive for HPAI during the summer 2022 outbreak (Gov.uk 2022). The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

The black-headed gull's European range is predicted to decline, with the more southerly areas becoming climatically unsuitable due to climate change (Johnston and others 2021). Predictions for the UK vary, with some studies suggesting risks and others suggesting climate change could provide benefits for this species (Johnston and others 2021, Pearce-Higgins 2021). Benefits are likely to depend to some extent on habitat creation and management actions (Miles & Richardson 2018, Lock and others 2022).

Lesser black-backed gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High Benefit (breeding populations)

Lesser black-backed gulls nesting and foraging in natural (non-urban) habitats may be affected by the availability of marine prey, particularly as surface feeders (Mitchell and others 2020, Johnston and others 2021). However, the species' generalist foraging behaviour may buffer it from impacts on prey as they are able to switch to other food sources (Furness 2016, Johnston and others 2021). The species has already successfully colonised urban environments in the UK for nesting and foraging, and there is potential for its urban range to expand (Johnston and others 2021).

Foraging at sea is likely to be negatively affected by adverse weather conditions, as has been shown to be the case for herring and great black-backed gulls (Johnston and others 2021). Adverse weather conditions have been shown to negatively affect breeding success in natural-nesting herring gulls and this may also apply to lesser black-backed gulls (Johnston and others 2021). Individuals that are long-distance migrants may be vulnerable through exposure to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Low-lying ground nests in coastal areas are vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022).

Lesser black-backed gulls may be vulnerable to increases in avian influenza outbreaks.

The lesser black-backed gull's European range is predicted to decrease in response to climate change with over 60% of the species' European range predicted to become climatically unsuitable (Russell and others 2015, Johnston and others 2021). However, predictions for the UK suggest that climate change may provide benefits for the species here (Johnston and others 2021, Pearce-Higgins 2021). Wintering numbers in the UK have increased in recent years, possibly due to warmer winters (Johnston and others 2021). Pearce-Higgins (2021) predicted high benefits for this species from climate change in the UK.

Manx shearwater

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Riou and others (2011) found that higher SSTs were correlated with reduced prey quality, later breeding, and lower fledging masses in Manx shearwater. Manx shearwater may be vulnerable to changes in prey availability as a surface-feeder, although they are also capable of diving (Mitchell and others 2020). Guilford and others (2008) suggested that the foraging ranges of Manx shearwater breeding in Wales may have shifted North in recent decades in response to climate change.

The species' lengthy migratory journey may mean it is exposed to multiple climate change impacts throughout its range (Wernham and others 2002, Johnston and others 2021).

Heavy rainfall can lead to Manx shearwater burrows flooding and being abandoned, thereby affecting breeding success and leading to loss of breeding habitat (Furness 2016, Johnston and others 2021). High winds may reduce energetic costs of foraging but may also lead to increased incidence of 'groundings', especially where there is artificial light pollution (Johnston and others 2021).

Predictions of European range extent for Manx shearwater vary, and some studies suggesting there may be climate change benefits for this species in the UK (Russell and others 2015, Johnston and others 2021). However, Russell and others (2015) predicted the species would be at high risk from climate change impacts unless it shows high dispersal ability.

Mediterranean gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Mediterranean gulls may be affected by the availability of marine prey, as surface feeders (Mitchell and others 2020, Johnston and others 2021). Adverse weather conditions have been shown to negatively affect breeding success in other gull species and this may also apply to Mediterranean gulls (Johnston and others 2021). Individuals that are long-distance migrants may be vulnerable through exposure to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Low-lying ground nests are vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022)

Most studies predict that the European range of the Mediterranean gull will increase due to climate change (Russell and others 2015, Johnston and others 2021). Predictions for the UK vary with some studies suggesting climate change may provide benefits for this species (Johnston and others 2021). The size of the breeding population in England is currently increasing (JNCC 2022).

Black-necked grebe

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Very little information on climate change impacts on this species is available.

Yellow-legged gull

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

There is very little information on climate change impacts on this species. Yellow-legged gulls have a generalist diet and flexible foraging behaviour, which may buffer the species against impacts of climate change, although they may be vulnerable as a surface feeder (Mitchell and others 2020, Johnston and others 2021). Yellow-legged gulls have also shown that they have an ability to adapt to urban environments in other parts of their range (Benussi & Fraissinet 2020). Ability to forage at sea and breeding success are likely to be affected by adverse weather conditions, as they are in herring gulls (Johnston and others 2021).

Low-lying ground nests are vulnerable to sea level rise and increased flooding (Johnston and others 2021, Lock and others 2022).

Yellow-legged gulls currently only breed in England in very low numbers (Lock and others 2022).

Great cormorant

BoCC5 status: Green

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk (breeding populations)

Very little information exists on climate change impacts to great cormorant (Johnston and others 2021). The negative impacts of storms and heavy rainfall that have been shown to negatively affect breeding success and survival in European shags may also apply to great cormorant, as the latter also have only partially waterproof feathers (Furness 2016, Frederiksen and others 2008, Johnston and others 2021).

Great cormorants in the UK tested positive for HPAI during the summer 2022 outbreak. The population-level impact of this outbreak has not yet been fully assessed, but HPAI should be considered a potential threat to this species.

European and UK range predictions for great cormorant vary but the range is likely to shift northwards (Johnston and others 2021). Pearce-Higgins (2021) assessed the species to be at high risk from climate change impacts in the UK.

Species with only wintering or passage populations in England

Long-tailed duck

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk

There is limited information available on the impacts of climate change on long-tailed duck in the UK. However, negative impacts of climate change on the species' breeding grounds in the Arctic may be reflected in decreases in wintering populations in the UK (Furness 2016, Dever and others 2012, Håland 2014, MWCAT 2022). The increasing extent of favourable ice-free wintering habitat further North may also reduce numbers wintering in UK waters (Elliot and others 2015).

Pearce-Higgins (2021) assessed wintering populations of long-tailed duck in the UK to be at high risk from climate change impacts.

Arctic skua

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: High Risk

Pearce-Higgins (2021) assessed breeding populations of Arctic skua in the UK (all in Scotland) to be at high risk from climate change impacts. Substantial declines in productivity and population size of Arctic skua in Scotland have been linked to climate change-related changes in marine food webs (Perkins and others 2018, Pearce-Higgins 2021). As a long-distance migrant, the Arctic skua may also be vulnerable through being exposed to multiple climate change impacts throughout its range (Wernham and others 2002, Johnston and others 2021).

The European range of the Arctic skua is predicted to decline considerably in response to climate change and Arctic skuas are likely to be lost as a breeding species from the UK (Russell and others 2015, Furness 2016, Mitchell and others 2020). The loss of breeding populations in Scotland, combined with declines elsewhere in its breeding range, would likely mean decreases in passage populations through English waters.

Common scoter

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: Risk & Benefit (breeding populations - Scotland), High Benefit (wintering populations)

Pearce-Higgins (2021) predicted a mixture of risks and benefits for common scoter breeding in the UK (Scotland) and high benefits (abundance increases) for wintering UK populations. Negative impacts of climate change on the species' breeding grounds further north than the UK may be reflected in decreases in wintering populations in the UK (Furness 2016, Pearce-Higgins 2021). The increasing extent of favourable ice-free wintering habitat further North may also reduce numbers wintering in UK waters (Elliot and others 2015).

Balearic shearwater

BoCC5 status: Red

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Balearic shearwater do not breed in the UK, but the species has recently expanded its non-breeding range northwards in response to warming sea temperatures, resulting in increasing numbers of non-breeding birds in English waters (Luczak and others 2011). The species may be vulnerable to climate change impacts on prey availability as a surface feeder, although they are also capable of diving (Mitchell and others 2020).

Black-throated diver

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: High benefits (breeding populations), Not assessed (wintering populations)

Very little information exists for climate change impacts on black-throated diver. Pearce-Higgins (2021) predicted high benefits of climate change (abundance increases) for breeding populations in the UK (all of which are in Scotland) but did not assess risks to wintering populations in English waters.

Great northern diver

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Very little information exists for climate change impacts on great northern diver. Negative impacts of climate change on breeding grounds further north may be reflected in decreases in wintering populations in the UK (Furness 2016, Pearce-Higgins 2021). The increasing extent of favourable ice-free wintering habitat further north may also reduce numbers wintering in UK waters (Elliot and others 2015).

Great skua

BoCC5 status: Amber

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

In the UK, great skuas only breed in Scotland. Great skuas have been shown to be vulnerable to the effects of heat stress caused by higher temperatures, with negative effects on breeding success (Oswald and others 2008). Indirect effects of higher temperatures on sandeel stocks may also affect breeding success in great skuas (Oswald and others 2008). The great skua's European range is predicted to decrease in response to climate change, and it is thought likely that it will be lost as a UK breeding species (Russell and others 2015, Furness 2016, Mitchell and others 2020). Great skuas may also be vulnerable as long-distance migrants exposed to multiple climate change impacts throughout their range (Wernham and others 2002, Johnston and others 2021).

Breeding great skuas in Scotland have recently been shown to be vulnerable to mass mortality caused by HPAI (Banyard and others 2022). The population-level impact of the 2021 and 2022 outbreaks have not yet been fully assessed, but HPAI should be considered a threat to this species.

The loss of breeding populations in Scotland, combined with declines elsewhere in its breeding range, would likely mean decreases in passage populations through English waters.

Red-throated diver

BoCC5 status: Green

Pearce-Higgins (2021) UK Climate change risk assessment: High benefit (breeding populations), Not assessed (wintering populations)

Very little information exists for climate change impacts on red-throated diver. There is no evidence to date of any reduction in range for the species (Pearce-Higgins 2021). Pearce-Higgins (2021) predicted high benefits of climate change for breeding populations in the UK (all of which are in Scotland), but did not assess risks to wintering populations in England.

Little gull

BoCC5 status: Green

Pearce-Higgins (2021) UK Climate change risk assessment: Not assessed

Very little information exists for climate change impacts on little gull. As a surface feeder, they may be vulnerable to climate change impacts on the availability of food (Mitchell and others 2020). Foraging ability may be affected by adverse weather conditions, as is the case with other small gulls and terns (Frederiksen and others 2007, Johnston and others 2021). Little gulls may also be vulnerable to multiple climate change impacts throughout their range as they are migrants (Wernham and others 2002, Johnston and others 2021).

- # Appendix 11. Relevant legislation and frameworks.

Legislation and frameworks relevant to key pressures impacting seabirds, the reference numbers for applicable legislation are listed within the reviews in Appendix 13.

Table 41. Legislation relevant to key pressures directly impacting seabirds.

Reference number	Legislation and frameworks
Cross-cutting legislation (legislation and frameworks relevant to multiple pressures)	
1	The Environment Act 2021
2	UK Marine Strategy Regulations 2010 (S.I. 2010/1627)
3	Strategic Environmental Assessment Directive (2001/42/EC) (retained EU law)
4	Environmental Impact Assessment (EIA) Directive (85/337/EEC) (retained EU law)
5	The Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales
6	The Conservation of Offshore Marine Habitats and Species Regulations 2017
7	Marine and Coastal Access Act 2009 (provide for establishment of a network of MPAs)
8	Wildlife & Countryside Act 1981 (as amended)
9	The Countryside and Rights of Way Act 2000
10	The Natural Environment and Rural Communities (NERC) Act 2006 in England and Wales
11	Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA): UK Implementation Plan
12	Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended)
13	River Basin Management Plans (RBMPs) - The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017
14	Convention on Biological Diversity
15	Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)
16	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
Legislation relevant to fisheries (related to prey quantity and quality and removal of non-target species pressures to seabirds)	
17	United Nations Convention on the Law of the Sea (UNCLOS)

Reference number	Legislation and frameworks
18	Fisheries Act 2020 alongside appropriately amended retained EU law under the European Union (Withdrawal) Act 2018.
19	Common Fisheries Policy Regulation Article 15 1380/2013 (retained EU law) - the landing obligation will continue to apply in UK waters until it is replaced [1]
20	Climate Change Act 2008: Sustainable Fisheries Policy
21	UK has joined Regional Fisheries Management Organisations (RFMOs): North-East Atlantic Fisheries Commission (NEAFC), Northwest Atlantic Fisheries Organization (NAFO), International Commission for the Conservation of Atlantic Tunas (ICCAT), Indian Ocean Tuna Commission (IOTC) and North Atlantic Salmon Conservation Organization (NASCO)
22	UK Marine Wildlife Bycatch Mitigation Initiative
23	UN Sustainable Development Goal 14
24	Food and Agricultural Organisation (FAO) of the United Nations Code of Conduct for Responsible Fisheries
Legislation and frameworks relevant to habitats (related to extent or quality of available su26pporting habitat pressure to seabirds)	
25	Town and Country Planning Act 1990
26	OSPAR Recommendations 2011/4-6 (protection of breeding sites and adjacent offshore areas for kittiwake and roseate tern)
Legislation and frameworks relevant to renewable energy (related to above water collision pressure to seabirds)	
27	Ten Point Plan for a Green Industrial Revolution and Powering our Net Zero Future (Energy White Paper)
28	EU Directive 2018/2001 Renewable Energy (retained EU law)
Legislation and frameworks relevant to invasive non-native species (related to introduction or spread of invasive non-indigenous species pressure to seabirds)	
29	The Invasive Non-native Species (Amendment etc) (EU Exit) Regulations 2019
30	Animal Welfare and Invasive Non-native Species (amendment etc) (EU Exit) Regulations 2020
31	Invasive Alien Species (Enforcement and permitting) Order 2019 in England & Wales
Legislation and frameworks relevant to pollution (related to litter, hydrocarbon and PAH contamination, synthetic compound contamination and transition elements and organometal contamination pressures to seabirds)	
32	International Convention for the Prevention of Pollution from Ships (MARPOL)

Reference number	Legislation and frameworks
33	Environmental Protection Act 1990 (as amended) (England, Wales & Scotland)
34	Clean Neighbourhoods and Environmental Act 2005 (England & Wales)
35	The Environmental Protection (Microbeads) (England) Regulations 2017
36	The Environmental Protection (Plastic straws, cotton buds and Stirrers) (England) Regulations 2020
37	Environmental Permitting (England & Wales) Regulations 2010
38	Waste (England & Wales) Regulations 2011
39	Producer Responsibility Obligations (Packaging Waste) Regulations 2007
40	The Packaging (Essential Requirements) Regulations 2015
41	The Merchant Shipping (Prevention of Pollution by Garbage from Ships) Regulations 2020
42	The Merchant Shipping and Fishing Vessels (Post waste Reception Facilities) 2003 (as amended)
43	Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities
44	Food and Agricultural Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries
45	The Environmental Protection (Microbeads) (England) Regulations 2017
46	The Environmental Protection (Plastic Straws, Cotton Buds and Stirrers) (England) Regulations 2020
47	Single Use Carrier Bags Charge Legislation
48	REACH etc. (Amendment) Regulations 2021
49	Merchant Shipping (Ship-to-Ship Transfers) Regulations 2010
50	Merchant Shipping (Prevention of Pollution from Noxious Liquid Substances in Bulk) Regulations 2018
51	Merchant Shipping (Prevention of Oil Pollution) Regulations 2019
52	Industrial Emissions Directive (2010/75/EU) (EU Parliament, 2010) (retained EU law)
53	Marketing and Use Directives (76/769/EEC (European Council, 1976) (retained EU law)
54	Directive on ship-source pollution (2009/123/EC) (European Parliament, 2009) (retained EU law)
55	Bonn Agreement for Co-operation in Dealing with pollution of the North Sea by Oil and Other Harmful Substances

Reference number	Legislation and frameworks
56	Stockholm Convention on Persistent Organic Pollutants (International source control legislation)
57	Biocides Regulations – Control of Pesticides (Amendment) Regulations 1997 (retained EU law) Biocidal Products Regulation (528/2012) (EU Parliament, 2012) (retained EU law)
58	Minamata Convention on Mercury: Control of Mercury (Amendment) (EU Exit) Regulations 2020 and Regulation (EU) 2017/852 (retained EU law)
Legislation relevant to microbial pathogens (related to introduction of microbial pathogens pressure to seabirds)	
59	Animal Health Act 2002
60	The Transport of Animals (Cleansing and Disinfection) (England) (No. 3) Order 2003
61	The Diseases of Animals (Approved Disinfectants) (England) Order 2007
62	The Exotic Disease (Amendment) (England) (EU Exit) Regulations 2018
63	The Exotic Animal Disease (Amendment) (England) Order 2021
64	Commission Implementing Regulation (EU) No 139/2013 (retained EU law)
65	The Aquatic Animal Health (England and Wales) Regulations 2009
66	Legislation concerning Avian Flu: The Avian Influenza of Avian Origin in Mammals (England) (No. 2) Order 2006 The Avian Influenza and Influenza of Avian Origin in Mammals (England) (No.2) Order 2006 The Avian Influenza (H5N1 in Wild Birds) (England) Order 2006 The Avian Influenza (H5N1 in Wild Birds) (England) (Amendment) Order 2021 The Avian Influenza (Preventive Measures) (England) Regulations 2006

• Appendix 12. Overview of Existing Measures.

The scope of the ESCaRP is to help restore seabird populations and assist the UK in meeting Good Environmental Status (GES) targets within the UK Marine Strategy. Here we outline the UK Marine Strategy and other legislation in place to protect seabirds and waterbirds in English waters. We have reviewed the existing legislation and measures in place for important anthropogenic pressures to inform our recommendations (Section 7).

Appendix 12.1 UK Marine Strategy (UKMS)

The UK is legally required to take measures to achieve or maintain Good Environmental Status (GES) for our seas, and to do this through development and implementation of a UK Marine Strategy (UKMS) as set out in the Marine Strategy Regulations 2010. Achieving GES is about protecting the marine environment, preventing its deterioration, and restoring it where practical, while allowing sustainable use of marine resources.

The overall objective of the UK Marine Strategy is consistent with the UK's vision for 'clean, healthy, safe, productive and biologically diverse ocean and seas' and is consistent with our commitments in the 25 Year Environment Plan (25 YEP). The UKMS is also a key tool for achieving the improvements to the marine environment set out in the Environment Act and key international obligations such as the OSPAR North-East Atlantic Environment Strategy and the UN Sustainable Development Goal 14.

GES is defined as the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions. In addition, the use of the marine environment is at a level that is sustainable, thereby safeguarding the potential for uses and activities by current and future generations. To help evaluate progress towards GES the assessment is broken down into 11 qualitative descriptors:

- D1: biological diversity – covers cetaceans, seals, **birds**, fish, pelagic habitats and benthic habitats
- D2: non-indigenous species
- D3: commercially exploited fish and shellfish
- D4: food webs – covers cetaceans, seals, **birds**, fish and pelagic habitats.
- D5: eutrophication
- D6: seafloor integrity
- D7: permanent alteration of hydrographical conditions
- D8: concentrations of contaminants
- D9: contaminants in fish and other seafood
- D10: marine litter
- D11: introduction of energy, including underwater noise

The UK Marine Strategy is made up of three components, Parts One to Three, with each component updated on a 6 yearly cycle, with the 2018-2024 cycle updating progress towards achieving GES in our seas by 2024.

Part One

This is an assessment of marine waters, objectives for GES and targets and indicators to measure progress towards GES (first published in December 2012)[20].

An assessment of progress of Good Environmental Status was undertaken by the UK in 2019[21] as part of the updated UKMS part one, and for birds (D1 and D4) it was concluded that the population and condition of UK seabirds had failed to achieve GES and was predicted to get worse. Birds were the only descriptor assessed as moving away from the GES target. This stark assessment should justify increased ambition for birds in the UK Marine Strategy and lead to urgent implementation of actions to recover the internationally important marine bird populations.

Part Two

This part of the strategy sets out the monitoring programmes to monitor progress against the targets and indicators (first published in August 2014)[22]. Part Two was updated in 2021[23] following public consultation. For birds, these consist of long-term monitoring programme datasets (Seabird Monitoring Programme, SMP; Wetland Bird Survey, WeBS; Breeding Bird Survey; BBS), supplemented by data from periodic surveys to monitor indicators of change in the distribution of seabird breeding colonies, waterbird coastal breeding sites and intertidal wintering or migration sites of shorebirds. Existing monitoring activities ie site-specific monitoring for Special Protection Areas (SPAs) and other marine protected areas (Marine Conservation Zones, MCZs; Sites of Special Scientific Interest, SSSIs and Ramsar sites) will be integrated; and will involve the measurement of the distribution, abundance, and productivity (breeding success) of a range of key seabird and waterbird species in UK coastal and marine waters.

The purpose of the monitoring programmes is to provide sufficient evidence to demonstrate the extent that the revised objectives and targets set out in the updated UK

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[20] Marine Strategy Part One: UK initial assessment and Good Environmental Status (publishing.service.gov.uk) 2012

[21] Marine Strategy Part One: UK updated assessment and Good Environmental Status (publishing.service.gov.uk) 2019

[22] Marine Strategy Part Two: UK marine monitoring programmes (publishing.service.gov.uk)

[23] updated UK Marine Strategy Part Two (publishing.service.gov.uk)

Marine Strategy part one have been met so that a robust assessment of progress towards achieving GES in 2024 within the UK Marine Strategy area can be provided. Information on monitoring programme details, developments since 2014 and issues and opportunities for descriptors including birds (D1 and D4) can be found in the part two update.

Part Three

This part of the strategy sets out a programme of measures for achieving GES (first published in December 2015)[24].

A consultation undertaken in 2021[25] sets out proposals for updating this part of the strategy and shows the programme of measures the UK intends to use to achieve or maintain GES for UK seas at least until the next evaluation of GES in 2024. The consultation provides information on the original 2015 programme of measures and the broad frameworks and specific policies and programmes being introduced in the 2021 programme of measures which will result in additional measures to support the achievement of GES for birds and the other qualitative descriptors. Defra are updating this aspect of the strategy and will soon publish a revised programme of measures, summary of responses to the consultation and government response.

A number of the measures set out in part three of the strategy have an impact on more than one of the ecosystem elements or descriptors – these are known as cross-cutting measures. These are mostly well-established mechanisms or legislation, eg Fisheries Act 2020, Habitats Regulations. The 2021 consultation provides an overview where there has been an update to these cross-cutting measures and a full description of each can be found in 2015 Programme of Measures and progress updates since 2015 can be found in Annex 4 of the consultation document.

The 2021 consultation outlines the measures that have been developed over the current cycle of the UK Marine Strategy or are proposed as completely new measures for each qualitative descriptor. These include both measures that have been introduced since 2015 and those that are planned to take in the coming years for which funding has already been committed.

The consultation also outlines for each descriptor those measures that were included in 2015 Programme of Measures as part of the last UK Marine Strategy cycle, which remain in place and continue to contribute to the achievement or maintenance of GES. It also details where updates or additions to these pre-existing measures have been made since 2015.

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[24] Marine Strategy consultation: UK marine monitoring programmes (publishing.service.gov.uk)

[25] Marine Strategy Part Three: UK Programme of Measures - consultation document (defra.gov.uk)

Measures specifically for birds (D1 and D4) relevant in England include:

e) Broad frameworks, including: conservation regulations; seabird conservation strategies for each devolved administration; Fisheries Act 2020; UK Bycatch Mitigation Initiative; biosecurity; Offshore Wind Enabling Actions Programme; climate change measures).
f) Existing measures adopted in the 2015 programme of measures, including:
– Marine Protected Areas (MPA) network designated and managed through Conservation Regulations (eg Birds Directive, Habitats Directive), Marine and Coastal Access Act 2009
- Fisheries measures that will protect birds, eg relevant byelaws or equivalent statutory controls which have been updated since 2015
- Measures to protect seabirds from non-indigenous species: protection of bird island colonies from the invasion by non-indigenous predatory mammals (eg black/brown rat, fox, American mink) - An audit of the biosecurity measures in place on each of the UKs 42 seabird island Special Protection Areas (SPAs) has been conducted. The results showed that many of our most important seabird islands have no protection against the threat of invasion by non-native mammalian predators. Of the three English island SPAs (Coquet Island, Farne Islands and Isle of Scilly), invasive predatory mammals were absent from the Farne Islands SPA and Coquet Island SPA, although these colonies were considered to have high potential risk without biosecurity measures. At the Isles of Scilly SPA, high-impact invasive mammals are present on some islands, but not on all of its 85 islands: invasive predatory mammals were absent on Annet, St Agnes and Gugh, but were considered to have high potential risk without biosecurity measures; whilst invasive predatory mammals were present at Tresco, St Martin’s, Bryher, Samson, St Helen’s, Northwethel, Men-a-vaur, Tean, Merrick and Round Island, although the level to which risk of further incursion of these islands has been partially minimised by biosecurity measures (for further information see: Invasive mammals (cefas.co.uk).
- Measures to protect seabirds from human activities, including regarding licenses to shoot birds. Defra completed its review of ‘general licenses’ for shooting wild birds resulting in herring gulls and lesser black-backed gulls being taken off the licensable category ‘general licence to kill’ in 2019.
- International measures to protect seabirds: OSPAR Recommendations 2011/4-6; Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)

The UK is applying for an exception for the Birds descriptor (D1, D4) under and Regulation 14(2)(a) and (e) of the Marine Strategy Regulations 2010 for the following reasons:

- action or inaction for which the UK is not responsible
a) natural conditions which do not allow timely improvement in the status of the marine waters concerned

Part one of the Marine Strategy sets out that milder winters have affected where waterbirds forage and that the lower availability of small fish has affected breeding seabirds. Both impacts are partly driven by climate change and are likely to be affecting population size and condition. Additionally, climate change can have other potential effects on seabirds populations including from increased storms, loss of nesting sites due to sea level rise, and algal blooms (Section 4, Appendix 9) The UK is taking strong action to tackle climate change domestically and internationally, including through legislation that commits to a legally binding target of net zero emissions by 2050. However, there is a time lag between mitigation action occurring and positive impacts being seen on natural conditions. This means that climate change will still negatively impacts seabirds and marine waterbirds. While the environmental effects of climate change, such as warming sea temperatures, can be reduced, this cannot be achieved without a global effort. However, it is possible for the UK to take action that will reduce the impacts of the changing environment on marine birds. Whilst we can address some of the impacts of climate change on seabirds directly, we can also increase the resilience of seabirds to climate change by reducing the cumulative impacts of other pressures, thereby aiding the adaptation of marine bird populations in the UK to an inevitably changing climate (see section 0). Nevertheless, due to global prevailing conditions, these measures may not be enough for us to achieve GES as currently defined in the targets in Part One of the UK Marine Strategy.

Appendix 12.2 Legislation

All wild birds in Great Britain are also protected under the Wildlife and Countryside Act 1981 (as amended). The 1981 Act applies to our terrestrial environment and inshore waters (within 12 nautical miles of land). Part 1 of the Act sets out specific offences in relation to protected species of animal, including birds and plants. There are various exceptions to these offences. Defra or Natural England can licence, for certain specific purposes, actions that would otherwise constitute an offence against a protected species. Individual licenses can be issued for the following purposes:

- for the conservation of wild birds
- preserving public health and safety and air safety
- prevent serious damage (to crops, livestock and fisheries)
- photography
- survey, research and ringing
- possession (eggs, chicks and adults)
- to control a predatory species

Post-EU Exit, the Wildlife and Countryside Act 1981 has been amended so that species of wild birds found in or regularly visiting either the UK or the European territory of an EU Member State will continue to be protected.

There are also ‘general licences’ which cover relatively common situations where there’s unlikely to be any significant conservation impact. They preclude the requirement for an individual licence. Defra has completed its review of ‘general licenses’ for shooting wild birds. Herring gulls and lesser black-backed gulls were taken off the licensable category ‘general licence to kill’ in 2019.

Seabirds covered by the ESCaRP that are most frequently subject to licenses include herring gull and lesser black-backed gull through destruction of nests and/or eggs and killing of individuals; black-headed gull primarily from the licensed removal of eggs for the purposes of taking and selling the eggs for human consumption, but also some killing of individuals; and great cormorant for killing/taking of individuals.

Wild birds are protected under the Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds, known as the Birds Directive. The Birds Directive protects all wild birds and their nests, eggs and habitats within the European Union. The requirements of the Birds Directive were transposed into UK legislation through a range of primary and secondary legislation. A wide range of statutory policies and other activities by the UK government, the devolved administrations and their agencies also support the implementation of the Birds Directive. The Conservation of Habitats and Species Regulations (2017) as amended were one of the pieces of UK domestic law that transposed certain elements of the Birds Directive. Post-EU Exit, the 2017 regulations have been amended by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 to ensure that they continued to operate effectively from 1 January 2021.

Seabirds are subject to regional strategic management objectives under the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) ‘*to halt and prevent by 2020 further loss of biodiversity in the OSPAR Maritime Area*’ to achieve good environmental status (GES) in our seas. In the Greater North Sea, the target for GES has not been met for breeding seabirds, with only 59% of species reaching their abundance target indicators. Non-breeding waterbirds in the Greater North Sea are however faring better, with 78% of species meeting abundance target indicators, thereby achieving GES for this group (UKMMAS 2021).

Appendix 12.3 Protected areas

UK seabirds have long been protected by law (Seabirds Preservation Act, 1869; Wildlife and Countryside Act, 1981; Conservation of Habitats and Species Regulations 2017 (as amended) as well as through the network of Special Protection Areas (SPAs), which pre-EU Exit formed part of the Natura 2000 network, and now post-EU Exit form the UK’s national site network.

The UK is a signatory to a range of international agreements, where the UK has international legal obligations to meet under these agreements, including the requirement of the development of an ecologically coherent network of terrestrial and marine protected areas across the UK, Europe, the North-East Atlantic and globally. Maintaining a coherent network of protected sites with overarching conservation objectives through the UK's national site network is still required in order to:

- fulfil the commitment made by government to maintain environmental protections
- continue to meet the UK's international legal obligations, such as the Bern Convention, the Oslo and Paris Conventions (OSPAR), Bonn and Ramsar Conventions.

Protected areas are one of a number of management measures used to help deliver conservation objectives and authorise sustainable use of the seas around the UK. Further details on management measures can be found in Section 6.

Designated sites

Special Protection Areas (SPAs)

The requirements of the Birds Directive have been a major driver of UK bird conservation action. Provisions under the Birds Directive required Member States to contribute to the ecological network of protected sites across Europe by classifying Special Protection Areas (SPAs) to protect birds that are rare or vulnerable in Europe as well as all migratory birds that are regular visitors.

The Conservation of Habitats and Species Regulations (2017) as amended were one of the pieces of UK domestic law that transposed certain elements of the Birds Directive. Post-EU Exit changes ensure that the strict protections afforded to sites, habitats and species, including wild birds, continues. One of the changes is that previously designated SPAs (together with Special Areas of Conservation, SACs) form the UK's 'national site network' along with any further sites designated under these 2017 Regulations in the future. New management objectives for the UK national site network were also inserted as regulation 16A into the Habitats Regulations 2017 in 2021 (see below).

The programme of SPA identification, classification and subsequent management is long established in the terrestrial and estuarine environment. There has been a large increase in the designation of SPAs with 'marine components', especially since 2010. SPAs with 'marine components' protect bird species listed in the Birds Directive as Annex I or as regularly occurring migratory species, that are dependent on the marine environment for all or part of their life cycle, where these species are found in association with intertidal or subtidal habitats within the site. The SPAs on land or at sea form part of the UK's national site network and the UK's contribution to the OSPAR Commission's network of Marine Protected Areas (MPAs) and the Bern Convention's pan-European 'Emerald Network' of Protected Areas.

There are 43 SPAs in England that have ESCaRP seabird species as qualifying features. Some also have 'seabird assemblage' as qualifying features. These include two cross-border sites, one with Wales (Dee Estuary) and one with Scotland (Solway Firth). These SPAs, along with their qualifying features, are shown in Table 42 and in Figure 18.

There are 39 SPAs with breeding seabird species as qualifying features. Thirty-three of these are terrestrial SPAs, of which five have marine extensions to provide protection of the seas immediately surrounding the breeding sites that are used by seabirds for maintenance, socialisation behaviours (such as preening, displaying, rafting, roosting and bathing) and/or foraging: Flamborough and Filey Coast SPA, Hamford Water SPA, Dungeness, Romney Marsh and Rye Bay SPA, Morecambe Bay and Duddon Estuary SPA, and Teesmouth and Cleveland Coast SPA. There are also six wholly marine SPAs that include important areas used by seabirds in both the breeding and non-breeding seasons: Falmouth Bay to St Austell Bay SPA, Greater Wash SPA, Outer Thames Estuary SPA, Liverpool Bay SPA, Northumberland Marine SPA and Solent and Dorset Coast SPA.

Ten SPAs have breeding and non-breeding seabird species as qualifying features. There are also four SPAs with non-breeding seabirds only as qualifying features.

Table 42. All SPAs in England with seabird qualifying features ('seabirds' defined by ESCaRP list) and their qualifying features.

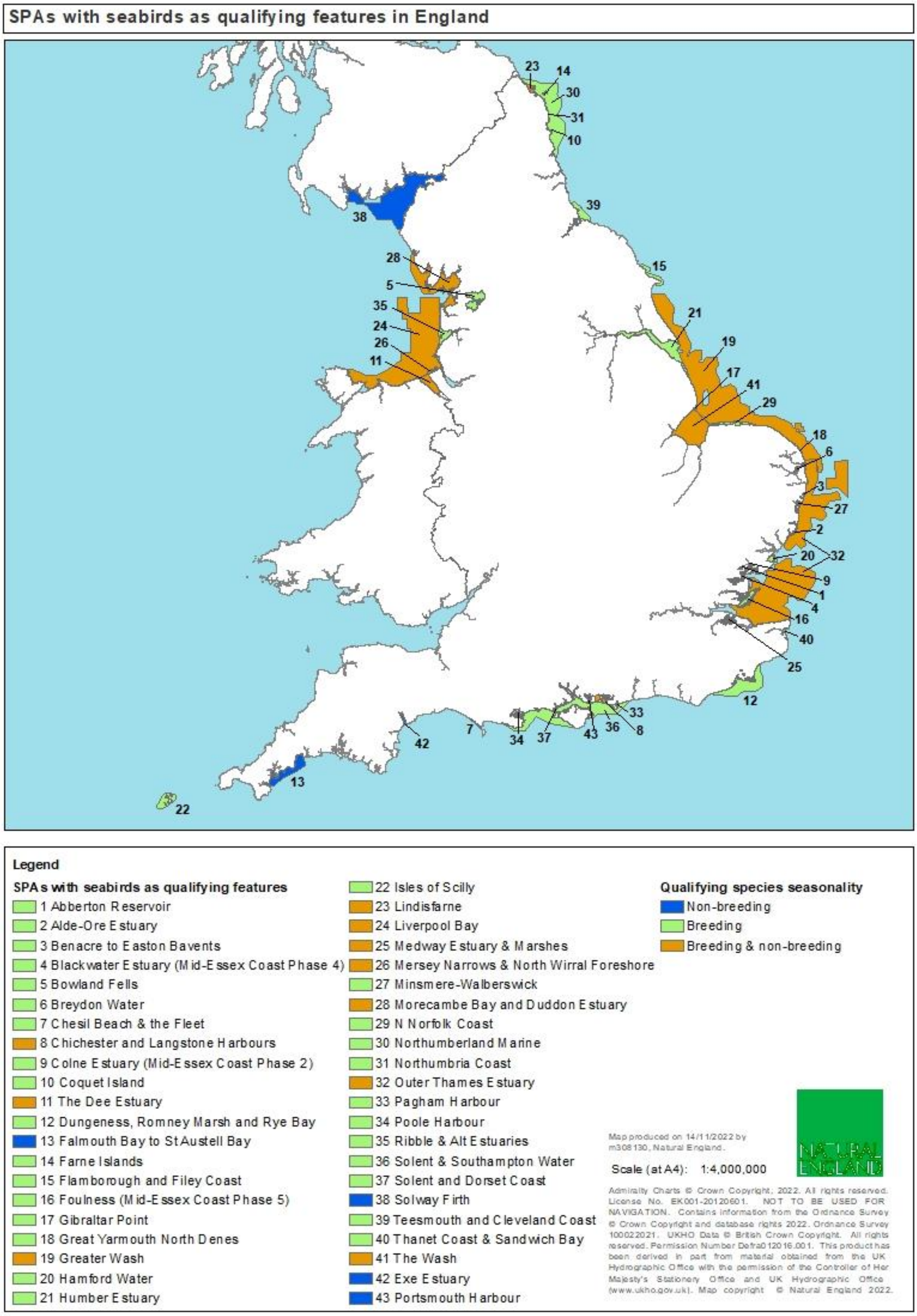
SPA Name	Qualifying Features (Breeding)	Qualifying Features (Non-breeding)
Abberton Reservoir	Great cormorant	
Alde-Ore Estuary	Lesser black-backed gull, Sandwich tern, little tern	
Benacre to Easton Bavents	Little tern	
Blackwater Estuary	Little tern	
Bowland Fells[26]	Lesser black-backed gull	
Breydon Water	Common tern	
Chesil Beach & The Fleet	Little tern	
Chichester and Langstone Harbours	Common tern, little tern, Sandwich tern	Red-breasted merganser
Colne Estuary	Little tern	
Coquet Island	Arctic tern, common tern, Sandwich tern, roseate tern, seabird assemblage	

SPA Name	Qualifying Features (Breeding)	Qualifying Features (Non-breeding)
Dee Estuary	Common tern, little tern	Sandwich tern
Dungeness, Romney Marsh, and Rye Bay*	Common tern, little tern, Sandwich tern, Mediterranean gull	
Exe Estuary		Slavonian grebe
Falmouth Bay to St Austell Bay**		Black-throated diver, great northern diver, Slavonian grebe
Farne Islands	Guillemot, Arctic tern, common tern, roseate tern, Sandwich tern, seabird assemblage	
Flamborough and Filey Coast*	Gannet, guillemot, razorbill, kittiwake, seabird assemblage	
Foulness	Common tern, little tern, Sandwich tern	
Gibraltar Point	Little tern	
Great Yarmouth North Denes	Little tern	
Greater Wash**	Little tern, common tern, Sandwich tern	Common scoter, little gull, red-throated diver
Hamford Water*	Little tern	
Humber Estuary	Little tern	
Isles of Scilly*	European shag, storm petrel, great black-backed gull, lesser black-backed gull, seabird assemblage	
Lindisfarne	Little tern, roseate tern	Common scoter, eider, long-tailed duck, red-breasted merganser
Liverpool Bay**	Common tern, little tern	Common scoter, little gull, red-throated diver
Medway Estuary	Little tern	
Mersey Narrows and North Wirral Foreshore	Common tern	Common tern, little gull

SPA Name	Qualifying Features (Breeding)	Qualifying Features (Non-breeding)
Minsmere-Walberswick	Little tern	
Morecambe Bay and Duddon Estuary*	Common tern, little tern, Sandwich tern, herring gull, lesser black-backed gull, seabird assemblage	Lesser black-backed gull, Mediterranean gull
North Norfolk Coast	Common tern, little tern, Sandwich tern	
Northumberland Marine**	Arctic tern, common tern, Sandwich tern, roseate tern, little tern, guillemot, puffin, seabird assemblage	
Northumbria Coast	Arctic tern, little tern	
Outer Thames Estuary**	Little tern, common tern	Red-throated diver
Pagham Harbour	Little tern, common tern	
Poole Harbour	Common tern, Sandwich tern, Mediterranean gull	
Portsmouth Harbour		Red-breasted merganser
Ribble and Alt Estuaries	Common tern, lesser black-backed gull, seabird assemblage	
Solent and Dorset Coast **	Common tern, little tern, Sandwich tern	
Solent and Southampton Water	Common tern, little tern, Sandwich tern, roseate tern, Mediterranean gull	
Solway Firth*		Red-throated diver
Teesmouth & Cleveland Coast*	Common tern, little tern	Sandwich tern
Thanet Coast and Sandwich Bay	Little tern	
The Wash	Common tern, little tern	Common scoter

*SPA includes marine extension

**wholly marine SPA



SPAs with seabirds as qualifying features in England
Legend
SPAs with seabirds as qualifying features
1 Abberton Reservoir
2 Alde-Ore Estuary
3 Benacre to Easton Bavents
4 Blackwater Estuary (Mid-Essex Coast Phase 4)
5 Bowland Fells
6 Breydon Water
7 Chesil Beach & the Fleet
8 Chichester and Langstone Harbours
9 Colne Estuary (Mid-Essex Coast Phase 2)
10 Coquet Island
11 The Dee Estuary
12 Dungeness, Romney Marsh and Rye Bay
13 Falmouth Bay to St Austell Bay
14 Farne Islands
15 Flamborough and Filey Coast
16 Foulness (Mid-Essex Coast Phase 5)
17 Gibraltar Point
18 Great Yarmouth North Denes
19 Greater Wash
20 Hamford Water
21 Humber Estuary
22 Isles of Scilly
23 Lindisfarne
24 Liverpool Bay
25 Medway Estuary & Marshes
26 Mersey Narrows & North Wirral Foreshore
27 Minsmere-Walberswick
28 Morecambe Bay and Duddon Estuary
29 N Norfolk Coast
30 Northumberland Marine
31 Northumbria Coast
32 Outer Thames Estuary
33 Pagham Harbour
34 Poole Harbour
35 Ribble & Alt Estuaries
36 Solent & Southampton Water
37 Solent and Dorset Coast
38 Solway Firth
39 Teesmouth and Cleveland Coast
40 Thanet Coast & Sandwich Bay
41 The Wash
42 Exe Estuary
43 Portsmouth Harbour
Qualifying species seasonality
Non-breeding
Breeding
Breeding & non-breeding
Map produced on 14/11/2022 by m308130, Natural England.
Scale (at A4): 1:4,000,000
Admiralty Charts © Crown Copyright, 2022. All rights reserved. License No. EK001-20120601. NOT TO BE USED FOR NAVIGATION. Contains information from the Ordnance Survey © Crown Copyright and database rights 2022. Ordnance Survey 100022021. UKHO Data © British Crown Copyright. All rights reserved. Permission Number Defra012016.001. This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). Map copyright © Natural England 2022.

Figure 18. Map of SPAs in England with seabird qualifying features.

Wetlands of International Importance ('Ramsar Sites')

Many English SPAs are also designated as Ramsar sites, although they may be designated for the same or different species (or habitats). Ramsar sites are internationally important wetlands designated under the Convention on Wetlands of International Importance. Ramsar sites do not form part of the national site network. However, Government and the devolved administrations have also issued policy statements relating to Ramsar Sites which extend to them the same protection at a policy level as SPAs (and SACs). In practice, the site assessment provisions of the Habitats Regulations 2017 are applied to them.

In England nine Ramsar sites have the seabird species covered by the English Seabird Conservation and Recovery Plan listed as protected features (common tern, Sandwich tern, roseate tern, little tern, little gull, Mediterranean gull, lesser black-backed gull, red-breasted merganser).

Sites of Special Scientific Interest (SSSIs)

Sites of Special Scientific Interest (SSSIs) are notified by Natural England under the Wildlife and Countryside Act 1981 (as amended). There are 72 SSSIs (out of a total of 4,123) in England with species covered by the ESCaRP as notified features of special interest. Many of these SSSIs overlap and/or form component colonies of the larger seabird colony SPAs.

Nature Reserves

Many of these colonies are also protected and managed at National Nature Reserves (NNRs) (eg Farne Islands NNR and Scolt Head Island NNR) and Nature Reserves (eg Bempton Cliffs Nature Reserve and Coquet Island Nature Reserve).

NNRs are the land declared under the National Parks and Access to the Countryside Act 1949 or Wildlife and Countryside Act (1981) as amended. They were established to protect some of our most important habitats, species and geology, and to provide 'outdoor laboratories' for research. Most NNRs offer great opportunities to schools, specialist interest groups and the public to experience wildlife at first hand and to learn more about nature conservation. Natural England manages about two thirds of England's NNRs. The remaining reserves are managed by organisations approved by Natural England, eg the National Trust, RSPB, Wildlife Trusts and local authorities.

Marine Conservation Zones (MCZs)

Marine Conservation Zones (MCZs) are a type of marine nature reserve in UK waters. They are designated with the aim to protect a range of nationally important, rare or threatened habitats and species. MCZs were established under the Marine and Coastal

Access Act (2009). MCZs can be designated for highly mobile species such as birds. In the North Sea the Berwick to St Mary's MCZ (Northumberland) was designated in 2019 to protect breeding and non-breeding common eider, whilst in the Irish Sea the Cumbria Coast MCZ was designated in 2019 for breeding razorbill.

Site Protection

SPAs

In England, SPAs (terrestrial and marine within 12nm) are given legal protection by the Conservation of Habitats and Species Regulations 2017 as amended most recently by the changes made by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019. The 2017 Regulations are one of the pieces of domestic law that transposed the land and marine aspects of the Habitats Directive (Council Directive 92/43/EEC) and certain elements of the Wild Birds Directive (Directive 2009/147/EC), known as the Nature Directives into UK law. The changes to parts of the 2017 Regulations have been made so that they operate effectively post-EU Exit. Most of these changes involved transferring functions from the European Commission to the appropriate authorities in England (and Wales). All other processes or terms in the 2017 Regulations remain unchanged and existing guidance is still relevant.

For the offshore components (beyond 12nm) of marine SPAs this protection is afforded through the Conservation of Offshore Marine Habitats and Species regulations 2017. Part 4 of the 2019 (Amendment) Regulations applies the changes to the Offshore Marine Habitats and Species Regulations 2017.

The Habitats Regulations require all proposed plans or projects being either undertaken or authorised by a competent or public authority that may cause an impact on a SPA (or SAC) to be formally assessed against the conservation objectives for that site. This process is known as a Habitats Regulations Assessment (HRA) and is a rigorous statutory procedure, based on the precautionary principle, which ensures that only those plans and projects which the assessment has ascertained will have no adverse effects on the site may proceed. The procedure allows exceptions to be made for those plans and projects for which adverse effects cannot be avoided but which must be permitted for imperative reasons of overriding public interest and where there are no feasible alternative solutions.

SPA classification also brings conservation benefits through implementation of proactive site-based conservation measures to maintain or restore the conservation status of the qualifying species. The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 introduced a new national site network within the UK territory comprising SPAs (and SACs) already designated under the Nature Directives, and any further sites designated under the Regulations. As well as the creation of a national site network, the changes under the 2019 Regulations include:

a. the establishment of management objectives for the national site network (the ‘network objectives’)
b. a duty for appropriate authorities to manage and where necessary adapt the national site network as a whole to achieve the network objectives

The network objectives are to:

- maintain or, where appropriate, restore habitats and species listed in Annexes I and II of the Habitats Directive to a favourable conservation status (FCS)
- contribute to ensuring, in their area of distribution, the survival and reproduction of the species of birds listed in Annex I to the amended Wild Birds Directive which naturally occur in the United Kingdom’s territory, and those regularly occurring migratory species of birds not listed in that Annex which naturally occur in the United Kingdom’s territory; and securing compliance with the overarching aims of the Wild Birds Directive.

The appropriate authorities must also have regard to the:

- importance of protected sites
- coherence of the national site network
- threats of degradation or destruction (including deterioration and disturbance of protected features) on SPAs and SACs

The network objectives contribute to the conservation of UK habitats and species that are also of pan-European importance, and to the achievement of their FCS within the UK.

SSSIs

Terrestrial SPAs (and SACs) are also notified as SSSIs under the Wildlife and Countryside Act 1981 as amended. The legislative protection afforded to SSSIs protects their notified features of sites from development, other damage, and since 2000 in England also from neglect. However, SSSI protection alone is less strict compared to the extra protection afforded to SPAs (and SACs) by the Habitats Regulations.

All public bodies have a general duty given by Section 28G of the Wildlife and Countryside Act to take reasonable steps, consistent with the proper exercise of the authority’s functions, to further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which the site is of special scientific interest. This duty operates through the exercise of existing functions and all other authorisation regimes. It is intended to require public authorities to think more broadly and actively about how they carry out their existing functions and activities and, where feasible, to take positive measures to benefit SSSIs.

The National Planning Policy Framework sets out a general presumption that development on land within or outside a SSSI, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits of the development in the location proposed clearly outweigh both its likely impact on the features of the SSSI, and any broader impacts on the national network of SSSIs. Local planning authorities are therefore required to have policies in their development plans that protect SSSIs and in England they have to consult Natural England over planning applications that could affect the notified features of an SSSI (such a development might not be within or even close to the SSSI itself). The requirement for consultation covers any development that might affect the features and does not apply just to developments within a SSSI itself.

Additionally, the owners and occupiers of SSSIs are required to obtain consent from the relevant nature conservation body (Natural England for England) if they want to carry out, cause or permit to be carried out within the SSSI any of the activities listed in the notification. Public bodies are also required to seek Natural England's assent or advice before carrying out or authorising, in the exercise of its functions, operations where these are likely to damage any of the features for which a SSSI has been notified.

As part of the SSSI notification, the relevant nature conservation body is required to send all SSSI owners/occupiers its views about the management of the SSSI which is a site-specific statement describing the ideal management of the site based on the ecological requirements of its notified features of special interest. Owners/occupiers are encouraged to carry out this management and if an owner/occupier is unwilling or unable to carry out management, ultimately the conservation body may exercise its regulatory powers to require it to be done. Public bodies that own/occupy SSSIs also have a duty to manage them properly.

MCZs

Public bodies have a duty towards MCZs under Section 125 (2) of the Marine and Coastal Access Act, so that a public authority must: 'exercise its functions in the manner which the authority considers best furthers the conservation objectives stated for the MCZ; and where it is not possible to exercise its functions in a manner which furthers those objectives, exercise them in the manner which the authority considers least hinders the achievement of those objectives.'

More specifically, all public authorities are under a duty given by Section 126 of the Marine and Costal Access Act when: 'determining an application (whenever made) for the authorisation of the doing of an act, and the act is capable of affecting (other than insignificantly) the protected features of an MCZ or any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependent.'

This therefore requires a public authority in the process of deciding about such an act to consider whether there is, or there may be, a significant risk of the act hindering the achievement of the conservation objectives stated for the MCZ. If so, the authority must notify the appropriate statutory conservation body of that fact.

Defra guidance has indicated that the duties in relation to the Marine and Coastal Access Act are designed to provide these MCZs with clear, flexible, proportionate and effective protection. The aim is to best achieve the conservation objectives for sites whilst not disproportionately impacting on the functions and efficiency of public authorities or preventing necessary development which is in the public interest from taking place as long as there is compensation of equivalent environmental benefit.

- # Appendix 13. Review of existing measures for important pressures.

A review of existing measures was carried out for the twelve most important pressures that effect seabirds. Note where relevant pressure specific or cross cutting legislation occurs it is linked by number to table 41 in Appendix 12.

Pressure 1	**Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities**
Impact/threat	Increased mortality or reduced breeding success because of a reduction in food resources
Key species	Arctic skua, Arctic tern, Balearic shearwater, black-headed gull, black-legged kittiwake, common guillemot, common tern, European shag, great cormorant, little tern, northern gannet razorbill, Sandwich tern
Relevant activities	Fisheries, eg anchored nets/lines, pelagic fishing, demersal trawls and seines
UKMS and OSPAR indicators	UKMS: Fish - D3 (commercial fish), D4 (food webs) Fish are the main prey of seabirds and detrimental impacts on fish populations and abundance will cascade and impact upon the species covered in this strategy. OSPAR Common indicators: FC2: proportion of large fish (large fish index).
Existing measures A. **The Fisheries Act 2020** The objectives of the Fisheries Act could provide justification for the improved management of forage fish species both from a fish stock and wider environment perspective. However, how those objectives will be implemented through the Joint Fisheries Statement, Fisheries Management Plans and any secondary legislation is not yet clear. The objectives described below could be of particular relevance to the improved management of forage fish. The Fisheries Act 2020 also extends the Marine Management Organisation's (MMO's) marine conservation powers to regulate fishing for the purposes of protecting the marine environment. Previously the MMO's conservation powers were limited to Marine Protected Areas (see Section E). The MMO may now make byelaws outside MPAs relating to the exploitation of sea fisheries resources in England for the purposes of conserving (1) marine flora or fauna, (2) marine	

habitats/types of habitat, or (3) features of geological or geomorphological interest. Restrictions can prohibit exploitation during specific periods, limit how much a vessel may catch within a specified period, or limit how much time a person or vessel may spend fishing over a specified period.

Sustainability and Precautionary Objectives

The sustainability and precautionary objectives pertain to the exploitation of commercially exploited stocks. The sustainability objective aims to ensure fishing activities are sustainable in the long term while maintaining the economic viability of fisheries. The precautionary objective aims to ensure that the biomasses of target species are maintained above levels capable of producing Maximum Sustainable Yield (MSY). While these objectives do not directly aim to maintain predator populations (eg, seabirds), the sustainable and precautionary objectives work to prevent stock overexploitation and thus maintain stock viability which should prevent the deterioration of their ecosystem role. Total Allowable Catch (TAC) is advised by the International Council for the Exploration of the Sea (ICES) through single-species stock assessments. Dynamic predation pressures are more frequently being incorporated into stock assessments and there is growing rhetoric to suggest the management of some forage fish species accounts for the needs of predators. There is limited evidence that this is the case, as current reference points for forage fish fail to acknowledge the status of predators or the prey requirements which may enable their recovery. However, there are rapid and promising developments in this arena: for example, ICES have recently adopted a new ecosystem-based reference point (F_{eco}) which could enable the inclusion of environmental and predator needs in future catch advice.

The Ecosystem Objective

The ecosystem objective states that fisheries should be managed using an ecosystem-based approach to minimise and, where possible, reverse negative impacts on wider marine ecosystems. The ecosystem objective also states that fisheries should minimise and, where possible, eliminate the incidental catches of sensitive species. An ecosystem-based approach has been defined within the Act as an approach that (i) ensures the collective pressures of human activities do not prevent us from achieving Good Environmental Status (GES), and (ii) does not compromise the capacity of marine ecosystems to respond to human induced changes. Fisheries and Fishery Management Plans (FMPs) therefore have an obligation to minimise detriment to the GES targets outlined in the UKMS. For seabirds, the relevant targets are included below under section B: UKMS.

The Bycatch Objective

The bycatch objective should see the reduction or avoidance of catches of fish which are below minimum conservation reference size. Most seabirds eat small fish (eg, sandeels) or the juvenile stages of large fish (eg, cod). Improved selectivity may improve prey availability for seabirds which predate upon the early year classes of commercially exploited fish.

B. The UK Marine Strategy

The UK Marine Strategy (UKMS) outlines the objectives, targets, indicators, and means of monitoring for the UK to achieve or maintain GES. The high-level objective of the UKMS for seabirds outlines that the abundance and demography of marine bird species indicate healthy populations that are not significantly affected by human activities.

The UKMS also provides objectives and targets for fish and food webs which, if achieved, could see an increase in the availability of prey for seabirds. For fish, there is a similarity between UKMS targets and the objectives of the Fisheries Act in that the UKMS: under Descriptor 3 of the UKMS there is a high-level objective for populations of commercially exploited species to be within safe biological limits with targets for the maintenance of stock biomass above levels capable of producing MSY. Under descriptor 4: food webs, the UKMS has targets to which aim to restore or maintain a healthy marine food web as indicated by the abundance, productivity, and species composition of representative feeding guilds, as well as the size structure of fish communities.

C. Spatial closures of forage fish fisheries

The North-east England and Eastern Scotland sandeel fishery closure remains in place. The impact of the closure has been mixed, after some initial increases in sandeel abundance, no long-term increase in sandeel abundance has persisted. For 2022, ICES have advised zero catch for sandeels in Sandeel Areas 4 and 1r as the spawning stock size is below $B_{escapement}$, a biomass reference point below which a stock is considered to have reduced reproductive capacity. Sandeel productivity depends on a combination of drivers, including fishing but also ecosystem condition (eg, temperature and food availability) (Lindegren and others 2018). Area closures may have limited success if forage fish production is driven by diffuse ecosystem change as opposed to direct fishing pressure. Recent changes to smaller scale management of sandeel stocks is a positive move (UKMS Part 3).

National Cod Avoidance Plan (technical and spatial management measures to reduce fishing pressures on cod) The National North Sea Cod Avoidance Plan seeks to support the recovery of North Sea cod as well as the management of the fishing industry. The plan includes seasonal closures (1st Jan to 30th Apr) to protect spawning populations and Real Time Closures (RTCs) to protect high abundances of recruited cod of all ages. RTCs can be responsive to changes in cod distribution and are triggered based on the number of cod caught per hour. Protecting cod during spawning could help to prevent recruitment overfishing, reducing the impact of fishing on the availability of juvenile cod as prey for seabirds. While a recovered cod stock may benefit some seabird species, it is possible that other species could be negatively impacted due to trophic interactions and their prey preferences. For example, guillemots eat some juvenile cod, but their main prey is capelin, a major prey of cod. The availability of capelin could therefore decline under increased predation pressure, reducing the availability for seabird consumption and detrimentally impacting the productivity of guillemots or other species with similar dependencies.

D. **Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.**

Current

The MPA network and the features for which they are designated are afforded legal protection from ‘plans and projects’ under the Habitats Regulations and Marine and Coastal Access Act. This means that developments (including but not limited to aggregates, navigational dredging, offshore wind) require MPA assessments, and must avoid, mitigate, or compensate for significant impacts. Forage fish are not themselves specifically protected by any MPAs in England, although there will be some occasions where direct removal of forage fish could have a significant impact upon a designated feature. For example, where forage fish may be prey items of designated birds within SPAs (Special Protection Areas). This means that forage fish may still have to be considered within some MPA assessments.

Commercial fishing activity is also subject to MPA assessment and management as a matter of policy. In 2012 Defra announced the *revised approach* to the management of commercial fisheries in European Marine Sites (EMS) – ie SPAs & SACs. IFCAs and MMO are the key fisheries regulators who are responsible for implementing the revised approach. IFCAs have made significant progress towards this within their inshore remit. The MMO have made less progress to date, largely due to the need for cooperation from other EU member states in offshore waters. Since leaving the EU however, and with new powers under the Fisheries Act as noted above, the MMO is now able to proceed with implementing MPA fisheries management (ie byelaws) in their jurisdiction (6nm +).

Therefore, there will be some instances where removal of fish species has been considered within MPA assessments, but only in very specific situations. Whilst the regulations require compensation of significant impacts for developments of overriding public interest, compensation in the marine environment is complex and difficult to define and deliver, so there are risks associated with this. For commercial fisheries, there are a number of MPAs that have not yet been assessed and had any management required implemented. This mechanism alone is not adequate to protect forage fish.

Future

Not all MPAs have yet been assessed for impacts caused by commercial fishing activity. However, with the revised approach policy steer from Defra, those remaining sites should be assessed and managed in due course.

E. **Annual bilateral and multilateral fisheries negotiations: The Common Fisheries Policy, The Trade and Co-operation Agreement and Fisheries Negotiations, Fisheries framework Agreements (with Norway and Faroe Islands), UK membership of Regional Fisheries Management Organisations (RFMOs)**

Through the Trade and Cooperation Agreement (TCA), Heading five of Part 2, the UK and EU have agreed to cooperate to ensure that fishing activities for shared stocks are environmentally sustainable in the long term and contribute to achieving economic and social benefits. We have a shared objective to maintain or restore harvested species at biomass levels capable of producing MSY. We have agreed a shared duty to:

A. Apply the precautionary approach to fisheries management
B. Promote the long-term sustainability of shared stocks
C. Use best available scientific advice, principally from ICES
D. Improve selectivity to protect juvenile fish and spawning aggregations and avoid or reduce bycatch
E. Minimise the harmful impacts of fishing on the marine ecosystem and preserve marine biodiversity

Through this agreement and given notification, each party can decide on any measure applicable to its wasters in pursuit of the above objectives, however a party can not apply measures to the vessels of the other party in its waters unless it also applies the same measures to its own vessels.

The TCA established a Specialised Committee on Fisheries which provides a forum for discussion and co-operation in relation to sustainable fisheries management. The Specialised Committee on Fisheries can consider emergency measures and the development of multi-year strategies for conservation and management as the basis for setting TACs and other management measures.

The Common Fisheries Policy (CFP) landing obligations (discard ban) came into force for pelagic fisheries in 2015, for key demersal species (cod, hake, sole) in North Atlantic waters in 2016 and for other commercial species in all waters in 2017. The landings obligation applies to species under TAC with exemptions for some species, damaged goods, and for some fisheries (eg, pots, traps, creels, beam trawls for IVb and IVc brown shrimp). Non-TAC species are still discarded and vessels that process catch at sea discard offal. The impact of the landing obligations is as yet unknown, but it is expected that there will be some reduction in seabird species populations. When the landings obligation came into force, we had a very limited understanding of the importance of discards for the food web. Studies have since helped us to better understand the dependence of seabirds and other species on discards. Sherley and others (2020) estimated that North Sea discards can support ~3.45 million seabirds per annum (a decline from ~5.66 million in 1990) but highlighted that more work is still needed to monitor the response of seabird scavengers to changing fisheries practices. Under an ecosystem approach we should better understand how changes in fisheries policy (eg, the landings obligation), catch restrictions, and displacement (which could reduce or increase energetic-related foraging pressures) impact discard-dependant seabirds.

F. Technological innovation and implementation

VMS and iVMS

Vessel Monitoring Systems (VMS) have been useful for monitoring, control, and surveillance purposes as well as producing evidence for some ecological indicators. However, the usefulness of

VMS limited by the low frequency of reports that are unable to take account of fine scale spatial data clusters and the exclusion of smaller vessels (<12m). Inshore Vessel

Monitoring Systems (I-VMS) for vessels <12m have started rolling out to the English inshore fleet (> 1,000 devices installed so far) and legislation is due to come into force which will make I-VMS a legal requirement for vessels <12m. VMS and I-VMS data will help to provide a more complete picture of fishing activity and enable more efficient decisions on local and national management measures and policies. *CatchApp and electronic reporting* Recent improvements in reporting of catches in the under 10m vessels have been being legally enforced since February 2022 after a phased introduction. Vessels must record what they catch (rather than land) and where the catches took place for the first time, via a mobile phone app called the CatchApp. Alongside other reporting mechanisms already in place for the over 10m vessels (such electronic logbooks), a much fuller baseline of fishing effort will shortly be available.
Proposed measures **A. Joint Fisheries Statement. Secondary legislation and Fisheries Management Plans may be relevant but currently in development. Do not currently have a statuary requirement to include seabirds but could include seabirds by interplay between UK Marine Strategy and ecosystem objective.** The Fisheries Act could make significant differences to seabird populations if Fisheries Management Plans (FMPs) for prey species / forage species are produced as a result of the Act. It is an opportunity that could be missed if FMPs focus solely on Maximum Sustainable Yield (MSY) of commercial species. This is because MSY refers to the sustainability of the fishery rather than the sustainability of the fish population. It doesn't consider the fish populations role as supporting predator species, and bird 'take' wouldn't be factored in to MSY calculations. The Government is developing its fisheries management approach across a range of areas. This includes reviewing our policy on industrial fisheries. Following the recent call for evidence, Defra, working with others, will be developing a policy on a future management strategy for industrial fishing in UK waters over the next few weeks and months. The introduction of any future measures in English waters will be subject to a formal consultation period. **B. Highly Protected Marine Areas (HPMAs, pilot stage)** HPMAs will contribute to protection of fish populations, but this mechanism is only at the pilot stage, so the importance and success of the measure is uncertain. **C. No legal mechanism for Remote Electronic Monitoring (REM) but used as a research and evidence tool. It would improve data gathering and ensure compliance.** **D. Plans for a real-time closure system across the UK, that can put in place fishing restrictions to reduce impact on unwanted catches or sensitive species including real time closures, live closed areas, commercial impact zones, seasonal closed areas, juvenile real time closures.**

Relevant legislation	Cross-cutting legislation: 1, 3, 4, 5, 6, 7, 9, 10, 11, 17 Legislation relevant to fisheries: 18, 19, 20, 21, 22
Conclusion of measures' effectiveness	**Effectiveness** **Red** **Certainty** **Certain** Although certain measures may mitigate impact at local level, collectively measures are considered inadequate to fully mitigate the pressure for seabirds.

Pressure 2	**Removal of non-target species**
Impact/threat	Mortality from accidental by-catch
Key species	Arctic skua, Arctic tern, Atlantic puffin, Balearic shearwater, black guillemot, black-throated diver, common guillemot, common scoter, common tern, common eider, European shag, great cormorant, great northern diver, black-legged kittiwake, little gull, long-tailed duck, Manx shearwater, Mediterranean gull, northern fulmar, northern gannet, razorbill, red-breasted merganser, red-throated diver, roseate tern
Relevant activities	Fishing – static nets (gillnets), demersal longlines, purse seines, potting, demersal and pelagic trawls, ghost fishing gear
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs) OSPAR Common indicators: B1: marine bird abundance.

Existing measures

A. **Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.**
MPAs offer protection to named features only, this will include some of the relevant bird species in some sites. Commercial fishing activity is subject to MPA assessment and management as a matter of policy. In 2012 Defra announced the *revised approach* to the management of commercial fisheries in European Marine Sites (EMS) – ie SPAs & SACs.

IFCAs and MMO are the key fisheries regulators who are responsible for implementing the revised approach. IFCAs have made significant progress towards this within their inshore remit. The MMO has made less progress to date, largely due to the need for cooperation from other EU member states in offshore waters. Since leaving the EU however, and with new powers under the Fisheries Act, the MMO is now able to proceed with implementing MPA fisheries management (ie byelaws) in their jurisdiction (6nm +).

Therefore, there will be some instances where bycatch of relevant bird species from commercial fishing activity has been considered within some MPA assessments. There are several MPAs though that have not yet been assessed and had any management required implemented. This mechanism alone is not adequate to protect bird species from bycatch pressures.

B. Fisheries Act (2020)

Objectives are outlined in the Existing measures for pressure: “Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities” (above).

The ecosystem objective (Section 1(6)) is the one that will apply to seabird bycatch and is that—

(a) fish and aquaculture activities are managed using an ecosystem-based approach so as to ensure that their negative impacts on marine ecosystems are minimised and, where possible, reversed, and

(b) incidental catches of sensitive species are minimised and, where possible, eliminated.

The delivery of this objective will be through various proposed measures.

C. The UK Marine Strategy

Outlined in the Existing measures for pressure: “Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities” (above).

D. Local byelaws by MMO, EA, IFCAs

Byelaw adopted by Environment Agency in 2010 to reduce seabird bycatch deaths in Filey Bay, close to Flamborough & Filey Coast SPA. Measures were introduced, including: regulate set-net activities, special netting, not fishing at night, net attendance, and training for netsmen to safely release caught birds. Over six years there was a decline in seabird bycatch. This project shows that there are measures which can successfully reduce seabird bycatch although data on mitigation is limited.

E. UK Protected Species Bycatch Monitoring Programme

This has not previously been systematically targeted to seabirds. Very limited evidence-base to inform understanding of the scale of by-catch mortality of seabirds in UK waters from vessels of all nationalities or of the impact of that unknown level of mortality on seabird populations.

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F. OSPAR Candidate Indicator on seabird bycatch

Not currently assessed due to lack of data.

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Proposed measures

A. Implementation of the Marine Wildlife Initiative

A new initiative (Defra, 2022) that sets out how the UK government and Devolved Administrations will minimise sensitive marine species bycatch and entanglement in UK fisheries. The UK Seabird bycatch plan of action was integrated into the initiative. This measure is too recent to be able to assess its effectiveness.

B. Future MPAs

Not all MPAs have yet been assessed for impacts caused by commercial fishing activity. However, with the revised approach policy steer from Defra, those remaining sites should be assessed and managed in due course.

C. Highly Protected Marine Areas (HPMAs, pilot stage)

This mechanism is only at the pilot stage, so the importance and success of the measure is uncertain.

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Relevant legislation

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Cross-cutting legislation: 2, 3, 6, 8, 9, 12, 15, 16, 17

Legislation relevant to fisheries: 18, 19, 22, 23, 24, 25

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Conclusion of measures' effectiveness

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Effectiveness **Red**

Certainty **Uncertain**

Limited evidence base for the understanding of bycatch mortality for seabirds and collectively measures are considered inadequate to fully mitigate the pressure.

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Pressure 3	**Visual Disturbance**
Impact/threat	Disturbance and displacement due to recreational activities (eg tourism) or commercial activities (eg vessels)
Key species	Arctic tern, black guillemot, common tern, razorbill, common guillemot, Atlantic puffin, northern fulmar, northern gannet, red-throated diver, common scoter, common eider

Relevant activities	Marine renewables: Offshore wind (construction, operation, maintenance and decommissioning), wave (decommissioning, during construction, operation and maintenance), cable route construction, grid connection construction
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs) OSPAR Common indicators: B1: marine bird abundance, B3: Marine Bird Breeding success/failure

Existing measures

A. Wildlife and Countryside Act 1981 (as amended) - Schedule 1 species protected from disturbance

The Act covers intentional and reckless disturbance of wild birds listed on Schedule 1 while nest building, at a nest with eggs or young, or disturbance to dependent young of the species. The Act does not cover protection from disturbance outside of the breeding season and therefore is not as effective as it could be for wild birds.

Schedule 1 has not been reconsidered and should be reviewed at Defra Policy level. Activities that will intentionally disturb Schedule 1 species (in the breeding season) require a license.

B. Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA).

The HRA process requires all plans/projects for licensable activities to be assessed in relation to Natura 2000 sites and their Conservation Objectives. Where Conservation Objectives include attributes relating to disturbance or maintaining or restoring the population the plans/projects can only be consented/licensed if the regulator is convinced that any disturbance or mortality they might cause will not lead to any adverse effects on site integrity (AEoSI; beyond reasonable scientific doubt).

The assessments are suitable for protecting qualifying features from small projects/plans that may not go ahead or avoid impacts due to the processes. However, if AEoSI cannot be ruled out and consent is provided under the Habitats Regulations, then Article 64 of the Regulations requires compensatory measures to be secured. This is for projects with imperative reasons of overriding public interest (IROPI) for example offshore wind farms and NSIPs. Unfortunately, the effectiveness of compensatory measures is uncertain as evidence of suitability is often limited or missing and few options benefit the impacted site rather than the wider population. No compensatory measures proposed for seabirds have yet been implemented or shown to succeed through monitoring. Compensatory measures are mostly delivered in an ad-hoc way on project-by-project basis, there is no strategic approach to delivery or monitoring of compensatory measures. The “avoid, reduce, mitigate and compensate” hierarchy is broadly adhered to through the offshore wind development consenting process.

Reasons for partial effectiveness of the HRA process includes:

- It is a feature-based approach to protection, therefore only species that are qualifying features of protected sites are assessed within HRAs. Not all species covered by the plan are qualifying features of protected sites. Therefore alone this mechanism is not effective at mitigating the pressure for all species.
- Only relevant for activities that require a licence or consent, so disturbance caused by unlicensed activities is not in scope, for example dog walking or kite surfing. Therefore, HRA is not effective in dealing with the effects of unlicensed activities.
- In the marine environment the focus of impact assessments is almost exclusively on Natura 2000 sites via HRA, and little attention is given to SSSIs (when not also classified as an SPA) which are assessed via EIAs. This impacts small seabird colonies.

The HRA process has proved effective in the Crown Estate's offshore wind leasing Round 4 as to avoid disturbance/displacement of red-throated diver being a problem for future consenting of projects under Round 4, boundaries for leasing rounds were a minimum of 10km to the boundary of the Greater Wash SPA. In addition, the boundaries for the East Anglia One North and East Anglia Two Wind Farms have been reconfigured to lie at least 8 km from the Outer Thames Estuary SPA boundary in order to gain consent and to deliver compensation measures for the remaining disturbance/displacement of red-throated diver. On the other hand, the Crown Estate did not do the same when considering Round 4 leasing areas next to Liverpool Bay SPA.

C. Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.

Over 75% of England's breeding populations for 15 seabird species are estimated to be affected by disturbance. 76.4% of English colony sites (including inland sites) are currently affected by disturbance (Lock and others, 2022). Disturbance is listed as an issue for 100% of Site Improvement Plans (SIPs) for English SPAs with breeding seabirds as a qualifying feature (Natural England, 2015; Lock and others, 2022). There are measures that can be introduced to reduce disturbance; recreational disturbance at breeding seabird colonies has been successfully reduced at little tern colonies by introducing wardens, temporary fencing and raising awareness (Natural England & RSPB 2020, Babcock & Booth 2020; Lock and others, 2022).

Many protected sites have site management plans which can include zonation or temporal restrictions of activities within the site to help reduce levels of the activity and disturbance in the most sensitive areas or times. For example, Poole Harbour Aquatic Management Plan.

D. Local partnerships to reduce disturbance, Marine Wildlife Watching Code (Thanet Coast Project)

Bird Aware Solent Partnership: In the Solent, concerns over AEoSI due to recreational disturbance pressures on features of various SPAs led to the Bird Aware Solent partnership. This consists of 15 Local Planning Authorities and four conservation organisations, including Natural England. Their mitigation strategy is funded by financial contributions from developers of new homes within 5.6km of the Solent SPAs. This is primarily driven by concerns relating to recreational disturbance of non-breeding water birds but there are multiple tern colonies in this area that may benefit from the mitigation measures too.

Other examples include the Bird Aware Essex Coast partnership of 12 Local Planning Authorities, Essex County Council and Natural England, further strengthening recognition of positive messages on recreation management.

E. European Marine Site (EMS) Management Schemes.

For example, Flamborough and Filey SPA: A 5-year management plan (2016-2021) for the activities within the site, including reactional activities on land and at sea. The aims of the scheme include ensuring commercial activities (non-fishing) does not negatively affect the conservation features of the site.

F. Operation Seabird (RSPCA, MMO, relevant Police forces, 2021)

An awareness campaign to educate and inform visitors to the UK coastline to prevent wildlife being disturbed and to prosecute when required. The scheme received two national policing awards.

G. Voluntary schemes/codes to reduce disturbance.

For example: Marine Wildlife Watching Code (Thanet Coast Project) - A local best practice code for watching marine wildlife to reduce disturbance. Wildlife safe Scheme (WiSe) - A voluntary scheme to minimise unintentional disturbance to marine wildlife from wildlife watching operators, includes a code of conduct, training, and accreditation

Proposed measures

A. Highly Protected Marine Areas (HPMAs, pilot stage)

This mechanism is only at the pilot stage, so the importance and success of the measure is uncertain.

Relevant legislation	Cross-cutting legislation: 4, 5, 6, 7, 8, 9, 10, 11, 13, 17
Conclusion of measures' effectiveness	**Effectiveness** Amber **Certainty** Certain

	There are regulatory protections from anthropogenic disturbance activities although many measures are voluntary, therefore the measures are not considered sufficient to fully mitigate the pressure on land and at sea.

Pressure 4	**Collision ABOVE water with static or moving objects not naturally found in the marine environment (eg, boats, machinery, and structures)**
Impact/threat	Mortality from collision with anthropogenic structures, commonly wind turbines.
Key species	Common gull, great black-backed gull, herring gull, lesser black-backed gull, Mediterranean gull, northern gannet, black-legged kittiwake, northern gannet, roseate tern, Sandwich tern, Arctic tern, little tern, common tern
Relevant activities	Marine renewables: Offshore wind (construction, operation, maintenance and decommissioning), wave (decommissioning, during construction, operation and maintenance)
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs) OSPAR Common indicators: B1: marine bird abundance

Existing measures

A. **Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.**

   SPAs in the marine environment or with marine components have been created for a number of seabirds/waterbirds (Appendix 12.3). The benefit of these sites is that they direct developers away from sensitive areas (though environmental assessments, below). Although not all species covered by this strategy are protected by Marine Protected Areas (MPAs).

   However, there is still a lack of data on where important foraging areas for key cliff-nesting seabird colonies such as Flamborough and Filey Coast and the Farne Islands in English waters in the breeding season are located as well as locations of key and non-breeding season foraging areas in English waters. Therefore the areas are not protected through site-based measures.

B. **Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA).**

The HRA process are outlined in existing Measures for “Visual Disturbance” (above).

Offshore wind sector-wide in-combination predicted levels of collision mortality include significant contributions from legacy/operational projects that have the potential to adversely impact the populations of certain seabird species at certain SPAs. Their impacts will not be addressed through the compensatory measures put in place for new developments.

C. Offshore Wind Leasing Round 4 plan-level HRAs

Spatial planning for Round 4 considered the location of sites protecting seabird species and the foraging ranges of breeding seabirds from those sites in constraint mapping. Round 4 leasing areas refined to avoid some of the areas where future developments would pose greatest potential risk to populations of certain seabird species. However, SPAs with qualifying features that are sensitive to pressures from OWF were only ‘soft constraints’, despite AEoSI being advised by Natural England for OWF projects currently in the planning process. Forthcoming Floating Wind leasing round HRA will build on lessons learnt from this approach and take a more iterative approach to site identification and refinement.

D. Strategic research: Offshore Wind Enabling Actions Programme (OWEA) and Offshore Wind Evidence and Change (OWEC) programme

Many government and industry funded research projects eg ORJIP, OWEC. OWEAP etc have been commissioned to improve evidence base and precision of predicted impacts on seabirds.

There are no accurate estimates of the true numbers of birds killed through collision with turbines at any given development or across English waters or of the magnitude and consequences of displacement at individual developments or cumulatively.

There is no monitoring in place to estimate the actual population-level impacts (if any) of either collision mortality.

E. Provision of discretionary and statutory advice on Marine Renewables development by Natural England

Natural England engagement can result in reduced development footprints and turbine heights being raised higher above the sea surface, to reduce predicted impacts on seabird populations from displacement and collision mortality respectively.

Natural England provides input into the post-consent monitoring proposals required at many consented developments, to improve the evidence base regarding collision mortality and validate the conclusions of impact assessments.

F. Marine Plans (10 across England)

Regional marine plans and the Marine Spatial Prioritisation Programme for improved planning of developments in marine environment.
Proposed measures **A. Net Zero Strategy: Build Back Greener (2021), British Energy Security Strategy (BESS, 2022)** The BESS has confirmed the government's ambitious target to deliver up to 50 GW by offshore wind by 2030. The strategy will include a review of relevant legislation (include the Habitats Regulations and associated HRA), strategic compensation, design standards and strategic monitoring. It is expected that strategic compensation for OWF will improve the effectiveness for impacted species (raised above) and improving design standards to ensure available mitigation approaches are included from the beginning of a project (eg increased draught height). **B. Highly Protected Marine Areas (HPMAs, pilot stage)** This mechanism is only at the pilot stage, so the importance and success of the measure is uncertain.

Relevant legislation	Cross-cutting legislation: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 17 Legislation relevant to renewable energy: 28, 29
Conclusion of measures' effectiveness	**Effectiveness** **Amber** **Certainty** **Certain** Due to the uncertainty around suitable compensation measures for collision mortality, the measures do not fully mitigate the pressure.

Pressure 5	**Introduction or spread of invasive non-indigenous species (INIS)**
Impact/threat	Habitat loss and mortality from invasive predatory mammals.
Key species	All ESCaRP breeding species, but particularly Atlantic puffin, Manx shearwater, European storm petrel, roseate tern

Relevant activities	Rodent eradication, biosecurity
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs); D2 (Non-indigenous species) OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure; BB13: Trends in new records of non-indigenous species introduced by human activities.

Existing measures

[Note: Measures and initiatives relating to aquatic INIS (eg, ballast water management and shell fisheries) have not been listed here.]

A. **Protected sites: Special Protection Areas (SPAs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.**

Many seabird colonies in England are on protected sites on the mainland or on low-lying islands very close to shore (eg, saltmarsh islands) and it is impossible or difficult to eradicate and then exclude invasive mammalian predators.

B. **LIFE Island Biosecurity Project (Biosecurity for Life)**

UK Biosecurity for Life project developed a programme of early detection and rapid response on all island groups in English waters containing SPAs that support breeding seabirds ie, Farne Islands, Coquet Island, Lundy Island and the Isles of Scilly. The project has legacy aspects with the continuation of monitoring and ambitions for commitments to be made by stakeholders. However, the commitments would not be legally binding.

UK Marine Strategy Indicator on the presence of invasive predatory mammals on seabird islands – monitors effectiveness of biosecurity on some SPAs as part of the Biosecurity for Life Project.

Many seabirds in England do not breed on islands or in SPAs and so are not covered by the UK Biosecurity for Life project or the UK MSFD monitoring against the invasive mammal target.

There is little monitoring of the usage of guidance and best practice information and how successful they are at reducing risk.

C. **The UK Marine Strategy**

Outlined in the Existing measures for pressure: “Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities” (above).

The UK has not achieved GES for non-indigenous species (descriptor D2). The ability to detect new INISs has improved but no change in number of new records.

D. **Invasive Species Action Plans (in preparation by GB Non-Native Species Secretariat)**
E. **Non-native species risk assessments (reviewed by Non-Native Risk Analysis Panel of the UK Non-Native Species Secretariat)**
F. **Pathway Action Plans (PAPs) to precent or manage risk posed by pathways. Draft PAPs for angling and recreational boating under consultation.**

There is reliance on voluntary measures, eg, Pathway Action Plans, leading to inconsistency in development and delivery, hindering their impact. The draft PAPs under consultation focus on hull fouling. There are no PAPs that cover the potential risk of spreading mammals to islands from vessel movements (recreational or commercial).

G. **Great Britain Non-native Species Strategy (currently under review)**

Successes from the 2015 strategy include eradication of American bullfrog, three PAPs and 11 Generic Contingency Plans.

H. **Wildlife and Countryside Act 1981 (as amended) - England & Wales Species Control Agreements and Species Control Orders s14(4A) and Variation of schedule 9 (2010) – a plan to control or eradicate a species**

Successful invasive predatory mammal eradication programmes: Isles of Scilly (Isles of Scilly Seabird Recovery Project) and Lundy. There remain several islands in English waters, principally within the Isles of Scilly, which do not currently host populations of seabird species that are typically vulnerable to predation by invasive mammals, but which might populate the islands if the predators were removed.

I. **Marine biosecurity plans.**

For example, Tamar Estuaries (in review), North Western IFCA Biosecurity Plan (2014-2019), Marine Operator Biosecurity Toolkits (2019; England)

J. **Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA) and SSSI consents.**

The HRA process are outlined in existing Measures for “Visual Disturbance” (above).

K. **Marine Plans (10 across England)**
L. **National Islands Plan (and Implementation Strategy)**
M. **Water Framework Directive (WFD)**

EA guidance includes encouragement to develop biosecurity management plans as a possible measure for WFD assessments but there is no legal requirement to do so.

Proposed measures None known	
Relevant legislation	Cross-cutting legislation: 1, 2, 3, 6, 9, 11, 12, 13, 14, 17 Legislation relevant to invasive non-indigenous species: 30, 31, 32
Conclusion of measures' effectiveness	**Effectiveness** **Red** **Certainty** **Certain** The current measures are voluntary and not enforceable, the measures are not considered able to fully mitigate the pressure.

Pressure 6	**Removal of target species**
Impact/threat	Intentional taking of adults/eggs (licenced culling, control and harvesting)
Key species	All ESCaRP species
Relevant activities	Licensable activities eg culling, taking eggs.
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs) OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure

Existing measures

A. **Wildlife and Countryside Act 1981 (Section 16(1)) - General licencing scheme for the removal of protected bird species.**

   General licences are granted to kill or take wild birds and destroy eggs or nests of wild birds, for purposes including conserving wild birds and preventing spread of disease. Since 2019, applications to control species included in the ESCS must be made to Natural England specifying the reasons for control and numbers involved. Licensees are required to report the numbers of individuals controlled.

B. **Environmental assessments leading to a licence (conditioned as deemed appropriate): Habitat Regulations Assessment (HRA).**

   The HRA process are outlined in existing Measures for "Visual Disturbance" (above).

Any application for a general licence that could impact seabird populations within SPAs are subject to an HRA. Applications to control large gull species are subject to strategic HRA considering cumulative and in combination mortality from other activities. **C. Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Ramsar sites.** Not all species covered by this strategy are protected by Marine Protected Areas (MPAs).	
Proposed measures None Known	
Relevant legislation	Cross-cutting legislation: 6, 9, 11, 12, 17
Conclusion of measures' effectivenes	**Effectiveness** **Green** **Certainty** **Certain**

Pressure 7	**Litter**
Impact/threat	Mortality and reduced fitness through entanglement or ingestion
Key species	Black-headed gull, black-legged kittiwake, European storm petrel, great black-backed gull, great cormorant, lesser black-backed gull, little tern, northern fulmar, northern gannet
Relevant activities	Litter from human lifestyles and terrestrial activities; Litter from marine activities, including: fishing (eg anchored nets/lines, demersal trawl, demersal seines, pelagic fishing), aquaculture (eg shellfish aquaculture: suspended rope/net culture, bottom culture and trestle culture), offshore wind (construction, operation, maintenance and decommissioning), oil and gas (exploration and installation, production, decommissioning), vessels (movement, shipping of cargo, transport, anchorages, discharges/emissions, moorings).

UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs), D10 (Marine Litter) OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure, BE1: Marine litter on beaches, BE3: Monitoring of plastic particles in stomachs of seabirds, BE2: Marine litter on seafloor.

Existing measures

The measures in place do not stop litter from entering the marine environment. More measures are required to reduce reliance on single-use plastics and the linear economies they are associated with. Circular economies should be supported through legislation.

A. **The UK Marine Strategy**

   Outlined in the Existing measures for pressure: “Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities” (above).

   UK has not achieved GES for marine litter (descriptor D10).

B. **OSPAR Indicators and Regional Action Plan on Marine Litter (RAP ML 2; 2022)**

   The UK target for beach litter (common indicator BE1) has not been met. Floating litter, there is no specific target related to this indicator (common indicator BE3), but the UK has adopted a surveillance indicator to monitor the plastic content found in the stomachs of fulmars (in line with the OSPAR Ecological Quality Objective). OSPAR has a long-term goal that fewer than 10% of fulmars should have no more than 0.1g of plastic in their stomachs. Currently, 60% of fulmars beached in the UK (within NE Atlantic region) have more than 0.1g of plastic in their stomachs. Seafloor litter (common indicator BE2) is widespread across all areas of the UK. More data is required before a trend can be analysed and a full assessment undertaken.

   Monitoring for OSPAR indicators only considers NE Atlantic and is not UK wide. OSPAR only covers the NE Atlantic, it does not cover the Western Channel and Celtic Seas (WCCS) regions. Beach litter monitoring indicates that the WCCS region may have higher litter incidences compared to other areas, however no fulmars are monitored in this area, the area with the highest potential issue.

C. **Industry voluntary schemes: Operation Clean Sweep (Industry’s voluntary pellet reduction scheme); Industry Code of Practice on Sky Lanterns (2014); Responsible Fishing Vessel Standard**

   Measures are voluntary and not enforceable.

D. **General public voluntary schemes: Great British Spring Clean, Great British Beach Clean and local beach clean schemes and volunteers; Ecoschool programmes on litter, marine litter and plastic pollution.**

Measures rely on general public volunteering.

E. Schemes to remove litter at sea

Government funded schemes, for example: CleanAtlantic (EU and UK funded project and research into abandoned, lost and discarded fishing gear (ALDFG)); Fishing for Litter (FFL) scheme (OSPAR Recommendation 2016/1).

Public schemes are increasing, for example: Ocean Recovery Project, Odessey Innovation and Global Ghost gear Initiative and UK Ghost Gear Coalition who collect and retrieve ALDFG. These are volunteer / grass roots led with no regular government funding.

Policies and government commitments: Marine Licensing (Exempted Activities) (Amendment) Order 2019 removed requirement for divers to have a marine licence to remove ghost fishing gear; British-Irish Council Commitment to develop solutions for collection and recycling of end-of-life fishing gear (2019); UK has adopted a surveillance indicator to monitor the plastic content found in the stomachs of fulmars (in line with the OSPAR Ecological Quality Objective).

No legal requirement to retrieve ghost fishing gear from the marine environment.

F. Waste Prevention Programmes for England (2013) including: Keep Britain Tidy, Litter Prevention Commitment in England; National Fly-tipping Partnership Framework

Recycling is reliant on the end-user, not the producer.

G. Litter Strategy for England 2017; Code of Practice on Litter and Refuse (CoPLAR) (England, updated 2019)

H. The Resources and Waste Strategy for England (2018) (25 Year Environment Plan)

I. IMO Action Plan for marine Litter from Ships (2018)

J. London Convention 1972 (Convention on the Prevention of Maritime Pollution by Dumping of Wastes and Other matter) and 1996 London Protocol

K. Plastic packaging tax (April 2022)
A tax applied to plastic packaging manufactured or imported into the UK that contains less than 30% recycled content.

L. Single-use plastic carrier bag charge (2015, 2021)

This charge was introduced in England in 2015, and increased in 2021. Estimates show that use of this type of bag has reduced by >95%.

M. Microbeads ban (2018)

This change made it necessary to remove microbeads from cosmetic and personal care products, ensuring these tiny plastic particles do not enter the marine environment via watercourses. **N. Single-use plastics ban (2020)** Products such as drinking straws, cotton buds and stirrers can no longer be made from plastic, reducing the amount of single-use plastic items entering the marine environment. **O. G20 Osaka Blue Ocean Vision: G20 Implementation Framework for Actions on Marine Plastic Litter** **P. Plastic incorporated in nests monitored in UK seabirds, coordinated by Environmental Research Institute, University of Highlands and Islands** **Q. Plastic particles in fulmar stomachs in the North Sea are monitored for OSPAR Plastic Particles in Fulmars by BTO and Defra** **R. Beachwatch project has been collecting data on marine litter on beaches since 1994 (organised by Marine Conservation Society)** **S. Marine litter monitoring: collecting data on seabed macro-litter, microplastic on the sea surface and in sub-tidal marine sediment has been undertaken, collated and analysed by Cefas and Defra. Methodologies are in line with the guidance from OSPAR** **T. Monitoring of impacts on seabirds through Beached bird survey. (RSPB Beached Bird Surveys, North-East Beached Bird Surveys)** Surveys show the decrease in oil on beaches and dead birds and have continued to highlight the issue of bycatch of seabirds in abandoned, lost and discarded gear (50 years since RSPB Beached Bird Survey began I The RSPB). The current survey programme is spatially and temporally limited.	
Proposed measures **A. Extended Producer Responsibility and Deposit Return Scheme** Policy measures to improve collection and fund recycling but delays to the policies (due to start in 2023/2024)	
Relevant legislation	Cross-cutting legislation: 1, 2, 3 Legislation relevant to marine litter: 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46

Conclusion of measures' effectiveness	**Effectiveness** **Red** **Certainty** **Uncertain** The majority of measures are voluntary or rely on the end-user to recycle and where legislation does exist enforcement is often minimal due to lack of funding or lack of evidence (eg for general littering and fishing gear / waste disposal), so the measures do not fully mitigate the pressure.

Pressure 8	**Introduction of microbial pathogens**
Impact/threat	Mortality from introduced microbial pathogens
Key species	All ESCaRP species
Relevant activities	Biosecurity, monitoring, research, collaboration (note: links to all other recommendations as building resilience of populations is key)
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs) OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure

Existing measures

A. **Notifiable avian disease (NAD) control strategy**

B. **Quarterly GB avian disease surveillance and emerging threats reports**

C. **Register of captive birds**

D. **Protection and Surveillance Zones around captive birds or commercial property infected with Avian Flu**

E. **Avian Influenza Prevention Zone (AIPZ) across Great Britain**

F. **Import of Captive Birds, Import Information Note (IIN) CBTC/2**

The UK has Protection and Surveillance Zones around captive birds or commercial property infected with Avian Flu. There are legal requirements to keep all captive birds indoors and follow strict biosecurity measures to limit the spread of and eradicate the disease. However there are no measures to monitor or manage Avian Flu in wild bird populations.

Proposed measures None known	
Relevant legislation	Legislation relevant to pathogens: 60, 61, 62, 63, 64, 65, 66, 67
Conclusion of measures' effectiveness	**Effectiveness** **Red** **Certainty** **Uncertain** There are no measures monitoring disease outbreaks in wild bird populations, the measures are not sufficient to fully mitigate the pressure.

Pressure 9	**Hydrocarbon & PAH contamination**
Impact/threat	Mortality or sublethal impacts from oil contamination
Key species	Atlantic puffin, Balearic shearwater, black-throated diver, black guillemot, common guillemot, European shag, little gull, Manx shearwater, northern fulmar, northern gannet, razorbill, roseate tern
Relevant activities	Pollution events from activities eg: shore-based activities, vessels (movement, anchorages, discharges/emissions, moorings), outfalls/intake pipes, oil and gas (exploration and installation, production, decommissioning), recreational activities (eg, powerboating or sailing with an engine, hovercraft), operation of port and harbours, vessel maintenance.
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs), D8 Contaminants OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure
Existing measures **A. The UK Marine Strategy** Outlined in the Existing measures for pressure: "Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities" (above).	

The UK has largely achieved its aim of GES for contaminants. Concentration of hazardous substances and their biological effects are generally meeting agreed target thresholds. Highly persistent legacy chemicals are the cause of the few failures, mainly in coastal waters close to polluted sources (Contaminants (cefas.co.uk)). The sampling for PAHs in biota in coastal waters is not sufficient to provide an indication of PAHs in relation to exposure for seabirds. Monitoring occurs in blue mussels and is linked to designated shellfish waters and facilities which may have better water quality than other areas, and spatial coverage across England does not provide enough samples to appropriately inform exposure for seabirds PAHs in biota (cefas.co.uk).

There are still concerns around pollution from point-sources and pollution from upstream sources. There needs to be a stronger connection between the Water Framework Directive and UK Marine Strategy to allow integration between terrestrial, marine and coastal water issues.

- **B. Environmental Impact Assessment Regulations**
- **C. OSPAR's HASEC (Hazardous Substances and Eutrophication Committee)**
- **D. OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA)**
- **E. UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020)**
- **F. Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF)**
- **G. Manual on Oil Pollution (Section 1) from IMO**
- **H. OSPAR Guidelines for Dredged Materials**
- **I. RSPCA rehabilitation centres**
- **J. Industry standards on oil spill (including Oil Pollution Emergency Plans (OPEPs))**

Trends for number of oil/chemical spills is decreasing and trends for polycyclic aromatic hydrocarbons in biota is stable**.**

K. Monitoring for UKMS and OSPAR Indicators on contaminants covers a wide range of organisms, habitats and contaminants.

Monitoring is insufficient; monitoring of PAHs in biota are only from shellfish farms and the spatial distribution of sediment samples for PAH analysis are insufficient to assess the risk for seabird populations.

L. Monitoring of impacts on seabirds through Beached bird survey. (RSPB Beached Bird Surveys, North-East Beached Bird Surveys)

Surveys show the decrease in oil on beaches and dead birds and have continued to highlight the issue of bycatch of seabirds in abandoned, lost and discarded gear (50 years since RSPB Beached Bird Survey began I The RSPB). The current survey programme is spatially and temporally limited.

Proposed measures None Known	
Relevant legislation	Cross-cutting legislation: 1, 2, 3, 4, 8, 12, 13, 14, 16 Legislation relevant to pollution: 33, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56
Conclusion of measures' effectiveness	**Effectiveness** **Amber** **Certainty** **Uncertain** Monitoring is insufficient to conclude that the measures adequate to fully mitigate the pressure.

Pressure 10	**Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals**
Impact/threat	Mortality and sublethal impacts from synthetic compound contaminants
Key species	Balearic shearwater, lesser black-backed gull, little gull, Mediterranean gull, northern fulmar, Sandwich tern
Relevant activities	Pollution events from activities eg: shore-based activities, vessels (movement, anchorages, discharges/emissions, moorings), outfalls/intake pipes, oil and gas (exploration and installation, production, decommissioning), recreational activities (eg, powerboating or sailing with an engine, hovercraft), operation of port and harbours, vessel maintenance.
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs), D8 Contaminants OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure
Existing measures **A. The UK Marine Strategy** Outlined in the Existing measures for pressure: "Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities" (above).	

The UK has largely achieved its aim of GES for contaminants (Defra, 2019). Concentration of hazardous substances and their biological effects are generally meeting agreed target thresholds. Highly persistent legacy chemicals are the cause of the few failures, mainly in coastal waters close to polluted sources (Contaminants (cefas.co.uk)). In particular, in coastal waters the pesticide lindane is present in English coastal waters at levels exceeding the threshold for GES (Coastal waters (cefas.co.uk)). A number of pharmaceutical compounds may not be included within current monitoring, therefore the potential or actual impacts of them are uncertain. An outstanding issue for GES is regarding PCB 118, one of the most toxic polychlorinated biphenyls, which is above the environmental assessment criterion in 4 of the 5 assessed Charting Progress 2 regions (UK Marine Monitoring Assessment Strategy Community (2010); Contaminants (cefas.co.uk)). There are still concerns around pollution from point-sources and pollution from upstream sources. There needs to be a stronger connection between the Water Framework Directive and UK Marine Strategy to allow integration between terrestrial, marine and coastal water issues. The monitoring for UKMS covers a wide range of organisms, habitats and contaminants, however it does not necessarily cover a broad enough geographic range to be used for interpretation for a specific species group. **B. Environmental Impact Assessment Regulations** **C. Environmental Permitting Regime** **D. OSPAR's HASEC (Hazardous Substances and Eutrophication Committee)** **E. OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA)** **F. UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020)** **G. Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF)** **H. OSPAR Guidelines for Dredged Materials**
Proposed measures None known

Relevant legislation	Cross-cutting legislation: 1, 2, 3, 4, 8, 12, 13, 14, 16 Legislation relevant to pollution: 33, 47, 48, 49, 50, 51, 52, 53, 54, 56, 58
Conclusion of measures' effectiveness	**Effectiveness** Amber **Certainty** Uncertain

	Monitoring for GES is limited in geographical range and there is no monitoring or targets for pharmaceuticals, therefore it is uncertain that measures for synthetic contaminants are adequate to fully mitigate the pressure.

Pressure 11	**Transition elements & organometal (eg TBT) contamination**
Impact/threat	Mortality and sublethal impacts of non-synthetic compounds (eg heavy metals)
Key species	Arctic tern, Balearic shearwater, black-legged kittiwake, common gull, roseate tern
Relevant activities	Pollution events from activities eg: shore-based activities, vessels (movement, anchorages, discharges/emissions, moorings), outfalls/intake pipes, oil and gas (exploration and installation, production, decommissioning), recreational activities (eg, powerboating or sailing with an engine, hovercraft), operation of port and harbours, vessel maintenance.
UKMS and OSPAR indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs), D8 Contaminants OSPAR Common indicators: B1: marine bird abundance, B3: Marine bird breeding success/failure
Existing measures **A. The UK Marine Strategy** Outlined in the Existing measures for pressure: "Reduction in the quantity or quality of available food due to direct removal of food resources by anthropogenic activities" (above). The UK has largely achieved its aim of GES for contaminants (Defra, 2019). Concentration of hazardous substances and their biological effects are generally meeting agreed target thresholds. There are no thresholds that are related to seabirds. Highly persistent legacy chemicals are the cause of the few failures, mainly in coastal waters close to polluted sources (Contaminants (cefas.co.uk)). In particular, in coastal waters lindane, TBT and mercury are present in English coastal waters at levels exceeding the threshold for GES (Coastal waters (cefas.co.uk)). It should also be noted that analysis of 'Metals in Biota' in fish and shellfish (Metals in biota (cefas.co.uk)) may not occur in areas where key seabird breeding colonies are present, or key foraging areas which limits the interpretation of data in relation to seabird species if localised contamination is present.	

There are still concerns around pollution from point-sources and pollution from upstream sources. There needs to be a stronger connection between the Water Framework Directive and UK Marine Strategy to allow integration between terrestrial, marine and coastal water issues. **B. Environmental Impact Assessment Regulations** **C. Environmental Impact regulations** **D. OSPAR's HASEC (Hazardous Substances and Eutrophication Committee)** **E. OSPAR List of Substances of Possible Concern (LSPC) and List of Chemicals for Priority Action (LCPA)** **F. UK Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH) (REACH etc. (Amendment etc.) (EU Exit) Regulations 2020)** **G. Ship to ship Transfer Guide (For Petroleum, Chemicals and Liquified Gases) from International Chamber of Shipping (ICS) and the Oil Companies' International Marine Forum (OCIMF)** **H. OSPAR Guidelines for Dredged Materials** **I. Monitoring for UKMS and OSPAR Indicators on contaminants covers a wide range of organisms, habitats and contaminants** The monitoring covers a wide range of organisms, habitats and contaminants, however it does not necessarily cover a broad enough geographic range to be used for interpretation for a specific species groups. **J. OSPAR Harmonised Mandatory Control System (HMCS) (Offshore Chemical Regulations 2002 (as amended))**	
Proposed measures None known	
Relevant legislation	Cross-cutting legislation: 1, 2, 3, 4, 8, 12, 13, 14, 16, Legislation relevant to pollution: 33, 47, 48, 49, 51, 52, 53, 54, 55, 56, 59
Conclusion of measures' effectiveness	**Effectiveness** **Amber** **Certainty** **Uncertain** The sampling points for some contaminants in biota are too sparsely distributed to be sure of the effectiveness of the measures.

Pressure 12	Permanent and/or irreversible change in the extent or quality of available supporting habitat
Impact/threat	Physical habitat loss from infrastructure
Key species	All ESCaRP species
Relevant activities	Fisheries and other extractive activities, marine renewables
UKMS and OSPAR Indicators	UKMS: Birds - D1 (biological diversity), D4 (food webs); OSPAR Common indicators: B1: marine bird abundance, B3: Marine Bird Breeding success/failure

Existing measures

A. **Marine Plans (10 across England)**

   Regional marine plans and the Marine Spatial Prioritisation Programme for improved planning of developments in marine environment.

B. **UK Marine Policy Statement**
C. **Local Development Plans**
D. **Environmental assessments leading to a Marine licence (conditioned as deemed appropriate): Strategic Environmental Assessment, Environmental Impact Assessment (EIA), Habitat Regulations Assessment (HRA).**

   The HRA process are outlined in existing Measures for “Visual Disturbance” (above).

   The compensatory measures required for NSIPs are difficult to determine when the project needs to compensate for the effects of loss of habitat and resulting displacement of bird populations. There is uncertainty of success for any measures. For example, SPAs for wintering red-throated diver are affected by OWF that are close to or within the boundary of the SPA and there are currently no suitable compensation measures available.

   Many operational/legacy projects are within boundaries of SPAs for seabirds or sufficiently close to them to cause indirect loss of habitat through displacement. While some projects in planning are sufficiently close to the boundaries of SPAs for seabirds to cause indirect loss of habitat within the SPA through displacement.

E. **Marine Protected Areas (MPAs) Network: Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), National Nature Reserves (NNRs), Sites of**

Special Scientific Interest (SSSIs), Ramsar sites, Special Areas of Conservation (SACs). Not all species covered by this strategy are protected by Marine Protected Areas (MPAs). **F. Shoreline Management Plans** **G. UN Decade of Ecosystem Restoration**	
Proposed measures **A. Marine Biodiversity Net Gain** This measure is currently under consultation. **B. Highly Protected Marine Areas (HPMAs, pilot stage)** This mechanism is only at the pilot stage so the importance and success of the measure is uncertain.	
Relevant legislation	Cross-cutting legislation: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17 Legislation relevant to habitats: 26, 27
Conclusion of measures' effectiveness	**Effectiveness** **Green** **Certainty** **Uncertain** Despite uncertainty around suitable compensation measures for loss of habitat, particularly in the marine environment, the measures are considered to mitigate the pressure.

- # Appendix 14. Pressures affecting seabirds outside of English waters.

Seabirds are highly mobile animals that do not recognise national boundaries (Jodice & Suryan 2010, Davies and others 2021). While the species included in ESCaRP spend at least part of their life cycle in England or in English waters (see Table 1), the majority will also spend a large proportion of their lives outside of England and English waters, within the jurisdictions of other nations or in international waters. Table 43 summarises information on the potential geographic ranges of these species when they are not in England. This information is mainly based on ringing and tracking data (Wernham and others 2002, Furness 2015, Leopold 2017, Seatrack 2021, Davies and others 2021). There can be considerable variation in distribution within each species, between colonies, life stages, sexes and individuals (Wernham and others 2002, Leopold 2017). The information presented in Table 43 is therefore a summary of the potential range of the species outside of England, not the specific range of individual birds. Our understanding of the movements of seabirds is also continually and rapidly evolving, largely thanks to developments in individual-based tracking, and there may be gaps in this information that have yet to be filled (Cleasby and others 2020, Davies and others 2021, Buckingham and others 2022).

Table 43. Summary of potential geographic range of 'English' seabirds when outside of England or English waters.
Information taken from Wernham and others (2002), Furness (2015), Leopold (2017), Seatrack (2021), Davies and others (2021).

Species name	Geographic range of 'English' birds when not in England or English waters (includes territorial waters of states)
Common eider	Scotland, Sweden, Denmark, Norway, the Netherlands, Germany
Common scoter	Scotland, Finland, Norway, Iceland, Northwest Russia
Long-tailed duck	Scotland, Northern Fennoscandia, Northwest Russia, Iceland, Greenland
Red-breasted merganser	Scotland, Fennoscandia, central Europe, Iceland, Greenland
Slavonian grebe	Scotland, Sweden, Finland, Baltic states
Black-necked grebe	Thought to be relatively sedentary
Black-legged kittiwake	Scotland, Ireland, Wales, Scandinavia, Russia, France, Spain, Portugal, Northwest and West Africa, South Africa, West Atlantic, South Atlantic

Species name	Geographic range of 'English' birds when not in England or English waters (includes territorial waters of states)
Black-headed gull	Belgium, the Netherlands, Germany, Denmark, Fennoscandia, Czech Republic, Poland, Latvia, Lithuania, Russia, Ireland, France, Spain, Portugal, North Africa
Little gull	Scotland, Fennoscandia, Northwest Russia, Baltic states, Western Mediterranean, Irish Sea, Northwest and West Africa
Mediterranean gull	Hungary, Germany, France, Belgium, the Netherlands, former Yugoslavian states
Common (Mew) gull	Scotland, Fennoscandia, Denmark, the Netherlands, Baltic states, Russia
Great black-backed gull	Scotland, Scandinavia, Northwest Russia, Iceland, Faroes, Greenland, Belgium, the Netherlands, France, Spain, Portugal
Herring gull	Scotland, Ireland, Fennoscandia, Iceland, Denmark, Germany, Poland, France, Spain
Yellow-legged gull	France, Spain, Portugal, Western Mediterranean
Lesser black-backed gull	Scotland, Fennoscandia, Faroes, Iceland, Denmark, the Netherlands, Belgium, France, Spain, Portugal, Western Mediterranean, North Africa, West Africa
Sandwich tern	Scotland, Wales, Ireland, the Netherlands, Denmark, France, Spain, Portugal, North Africa, West Africa, South Africa
Little tern	The Netherlands, Denmark, France, Spain, Portugal, Northwest and West Africa
Roseate tern	Ireland, France, Spain, Portugal, Northwest and West Africa, South America
Common tern	Scotland, Ireland, Wales, Fennoscandia, Belgium, the Netherlands, Germany, Poland, Baltic states, France, Spain, Portugal, Northwest and West Africa
Arctic tern	Scotland, Siberia, North America, France, Spain, Portugal, Northwest and West Africa, South Africa, Antarctica, North and South Atlantic
Great skua	Scotland, Fennoscandia, Russia, Iceland, Faroes, France, Spain, Portugal, Western Mediterranean, Northwest and West Africa, North and South Atlantic, North America, South America
Arctic skua	Scotland, Fennoscandia, Greenland, Belgium, the Netherlands, Germany, Denmark, France, Spain, Portugal, Mediterranean, North and South Atlantic North America, South America

Species name	Geographic range of 'English' birds when not in England or English waters (includes territorial waters of states)
Common guillemot	Scotland, Ireland, Wales, Scandinavia, Faroes, Norway, Iceland, Baltic states, North Atlantic, the Netherlands, France, Northern Spain
Razorbill	Scotland, Fennoscandia, Iceland, Greenland, Northwest Russia, the Netherlands, France, Spain, Portugal, North Africa, Western Mediterranean
Black guillemot	Scotland, Ireland, Wales, Scandinavia
Atlantic puffin	Scotland, Ireland, Norway, Denmark, Iceland, Faroes, Greenland, North Atlantic, North America, France, Spain, Portugal, Western Mediterranean
Red-throated diver	Scotland, Fennoscandia, Iceland, Greenland
Black-throated diver	Scotland, Fennoscandia
Great northern diver	Scotland, Iceland, Greenland, Canada
European storm petrel	Scotland, Wales, Ireland, Iceland, Faroes, Fennoscandia, France, Spain, Portugal, Northwest and West Africa, South Africa, North and South Atlantic
Northern fulmar	Scotland, Wales, Ireland, Iceland, Greenland, Canada, Fennoscandia, Denmark, Germany, Barents Sea, North Atlantic, France, Spain
Manx shearwater	Scotland, Wales, Ireland, France, Spain, Portugal, Northwest and West Africa, North America, Caribbean, Brazil, Argentina, North Atlantic, South Atlantic
Balearic shearwater	Mediterranean, Southern North Sea, North Atlantic, Northwest and West Africa
Northern gannet	Scotland, Wales, Ireland, Norway, France, Spain, Portugal, Western Mediterranean, Northwest and West Africa
Great cormorant	Scotland, Ireland, Wales, Fennoscandia, Denmark, the Netherlands, Belgium, France, Spain, Portugal
European shag	Scotland, Ireland, Wales, France, Belgium, the Netherlands, Denmark, Norway, Northern Spain

Key areas of importance for ‘English’ seabirds outside of England and English waters

Seabirds of most of these species will spend time within the jurisdictions of the other devolved nations of the UK, the Republic of Ireland, and neighbouring European countries around the North Sea basin. Seabirds breeding in England may move through multiple jurisdictions within a single foraging trip during the breeding season (Jodice & Suryan 2010, Woodward and others 2019). For many species (eg black-legged kittiwake, roseate tern), birds breeding in England form part of larger metapopulations, with individuals regularly recruiting into breeding colonies that include individuals breeding in the rest of the UK, the Republic of Ireland, and nearby European countries (Ratcliffe and others 2008b, Jodice & Suryan 2010, Horswill and others 2022). Most species will also travel through these neighbouring jurisdictions on passage to and from their English breeding or wintering areas (Wernham and others 2002, Jodice & Suryan 2010).

Many of England’s breeding seabirds are also long-distance migrants that winter off the coasts of Africa or even South America (Wernham and others 2002, Ratcliffe and others 2008). The seas off the west coasts of Africa are key overwintering areas for many of our breeding seabirds, including terns and northern gannet (Wernham and others 2002, Grémillet and others 2015, Piec & Dunn 2021, Wong and others 2021).

Species that winter in English waters usually breed further North, in Scotland, Fennoscandia, Northwest Russia, Iceland, or even Greenland (Wernham and others 2002, Boertmann and others 2004).

More pelagic species such as northern fulmars, black-legged kittiwake and Atlantic puffin will spend large parts of the non-breeding season in international waters in the Atlantic (Davies and others 2021, Horswill and others 2022). Northern fulmars and Manx shearwaters will even travel thousands of kilometres to the mid North Atlantic on foraging trips during the breeding season (Woodward and others 2019).

Pressures affecting seabirds outside of English waters

Migratory seabird species are exposed to cumulative impacts of pressures throughout their range, and this is a contributing factor to global declines in seabird populations (Dias and others 2019, Davies and others 2021). There are still evidence gaps regarding the distributions of many seabird species, particularly outside the breeding season (Davies and others 2021, Buckingham and others 2022). The non-breeding season is also typically the least well-protected period of seabird life cycles and protections at sea are limited (Davies and others 2021). Conditions during the non-breeding season, however, are crucial to survival and to subsequent breeding productivity (Szostek & Becker 2015, Davies and others 2021). Seabirds may experience higher energetic demands during winter and during moulting periods outside the breeding season, and vulnerability to pressures during moult may be exacerbated by reduced mobility (Davies and others 2021, Buckingham and others 2022).

Industrial overfishing and bycatch off the coast of West Africa is likely to be having negative impacts on English breeding populations of seabirds such as roseate tern, little tern and northern gannets (Gremillet and others 2015, Correira and others 2019, Piec & Dunn 2021). In the North Atlantic, seabirds face threats such as bycatch, pollution, and overfishing (Davies and others 2021). The effects of climate change are likely to be impacting species throughout their range and life cycles (Dias and others 2019, Johnston and others 2021, IPCC 2022b, Nagy and others 2022).

A thorough review of the pressures impacting on our seabird populations outside of English waters has not been done for this project. However, we recommend that these pressures be reviewed to inform future iterations of the England Seabird Conservation and Recovery Pathway. Understanding the threats faced by seabirds in different parts of their range and at different stages in their life cycle is crucial to understanding divers of population decline and prioritising conservation action (Jodice & Suryan 2010, Davies and others 2021, Nagy and others 2022).

The importance of international collaboration for seabird conservation

Cross-border collaboration typically results in better outcomes for bird conservation, particularly for migratory species (Kirby and others 2008, Nevins and others 2009, Jodice & Suryan 2010, Levin and others 2013, Hobday and others 2017, Nagy and others 2022) as well as greater cost-effectiveness (Kark and others 2009). International collaboration is therefore likely to play a key role in the successful conservation of our seabird populations (Dias and others 2019, O'Leary and others 2020, BirdLife International 2021, Piec & Dunn 2021, Nagy and others 2022).

The amount of time spent by English seabirds within the jurisdictions of the other UK devolved nations and the interconnectedness of metapopulations means that it makes sense for seabird conservation efforts to be coordinated across the UK. Many relevant systems and monitoring programmes relevant to seabirds (eg National Site Network, Seabird Monitoring Programme (SMP)) operate at the UK level. The UK Marine Strategy covers the extent of the marine waters over which the UK exercises jurisdiction. The alignment of the different UK seabird conservation strategies and plans would therefore increase the potential for their alignment with the UK Marine Strategy.

Given the wide-ranging movements of our seabirds, their effective conservation will also depend on coordination and cooperation at an international level, especially those in the Northeast Atlantic region, African-Eurasian Waterbird Agreement area, and OSPAR regional sea convention. Many of the most significant anthropogenic pressures impacting on England's seabirds are managed at a European or international level (HM Government 2012). Therefore, England cannot achieve its goals for seabirds in isolation.

Climate change is a global problem that will require global, as well as local, solutions (IPCC 2022b). Furthermore, threats to seabirds in international waters can only be tackled with international collaboration (O'Leary and others 2020, Davies and others 2021).

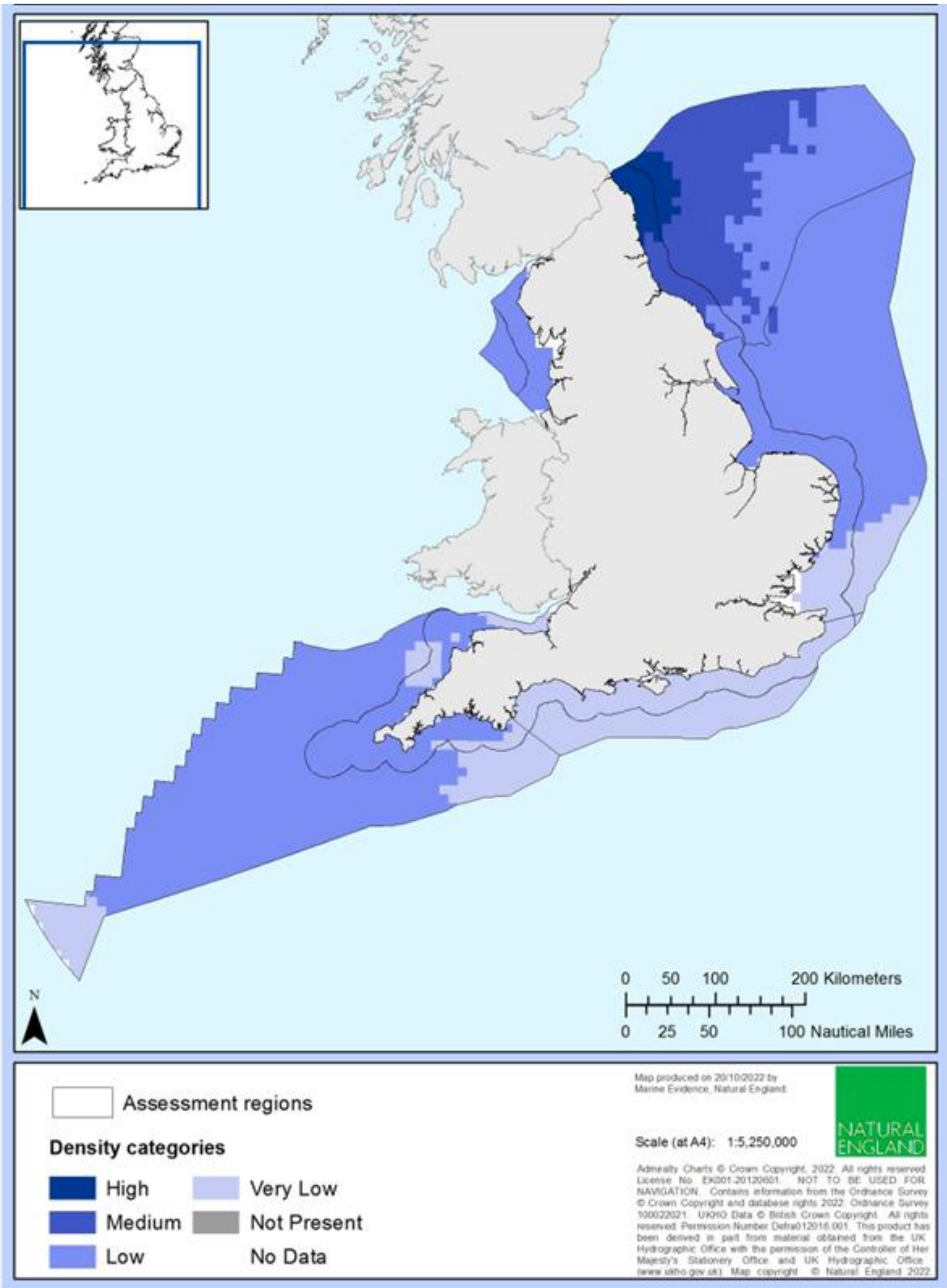
We therefore recommend that efforts be made to work in collaboration with other nations to monitor and conserve seabird populations.

• Appendix 15. Distribution maps

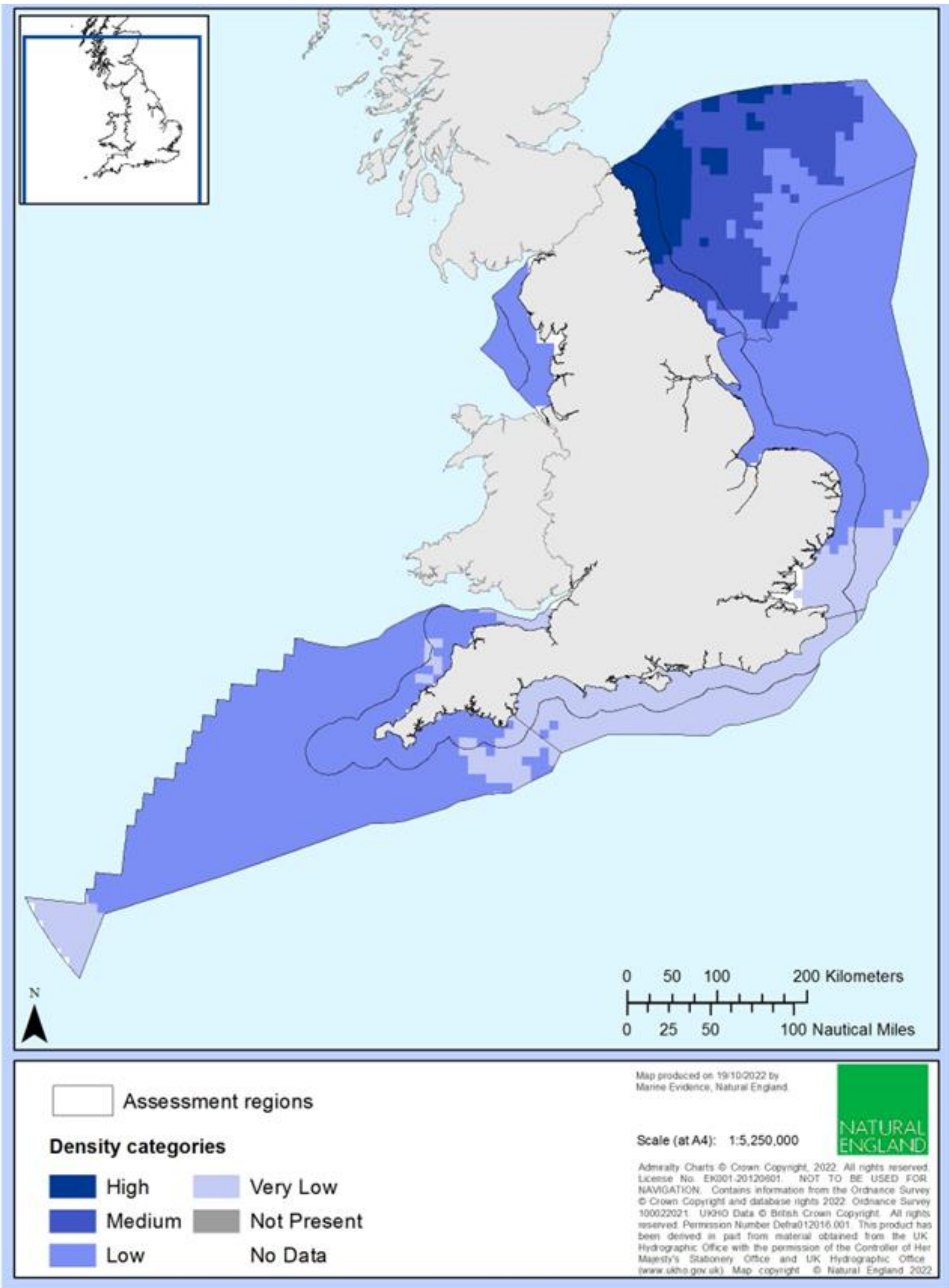
Distribution maps with categorised densities which were produced for the Vulnerability in the Marine Environment assessment.

Marine Ecosystems Research Programme (MERP) categorised density distribution maps

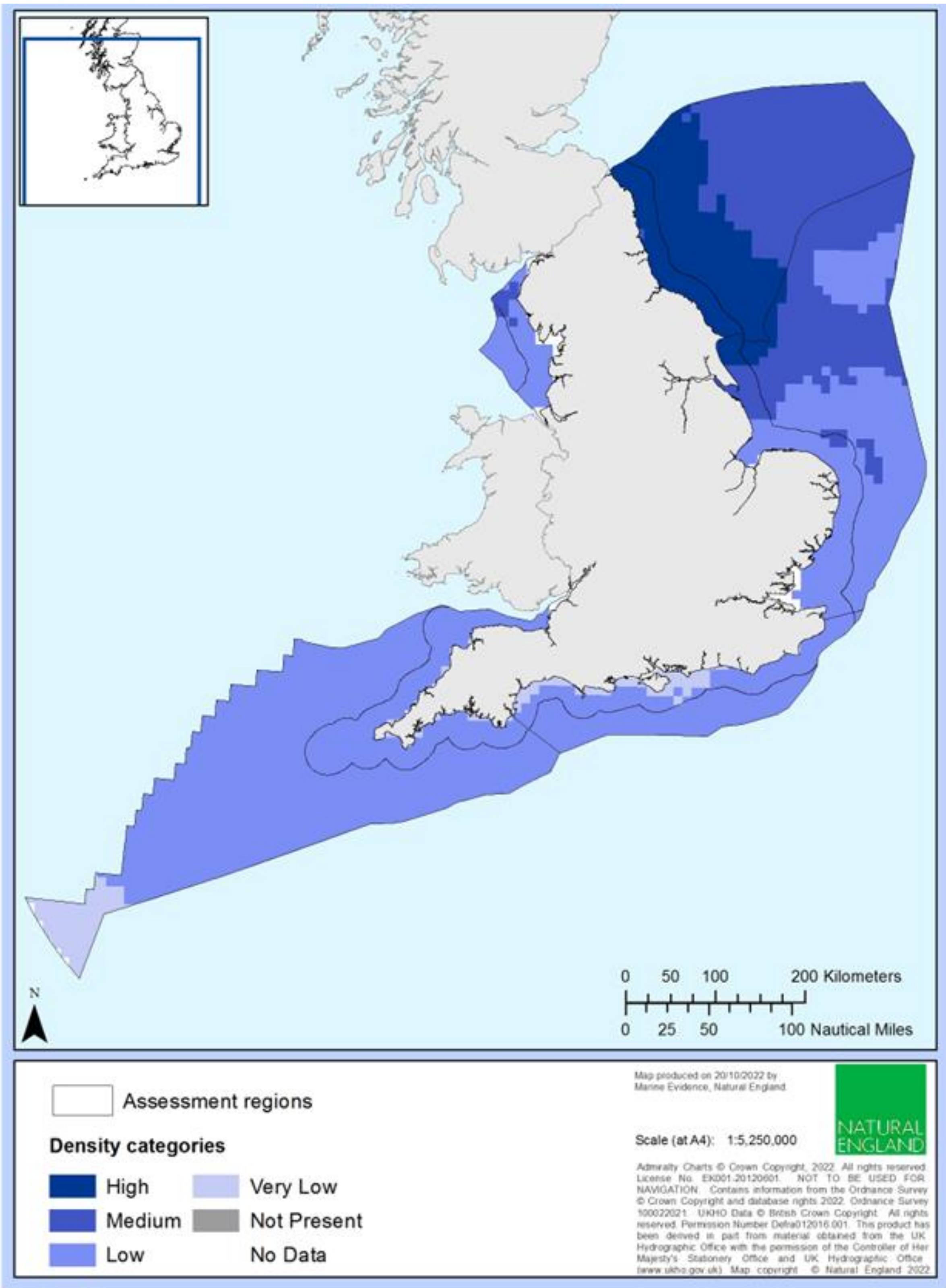
Map 1: Atlantic puffin - breeding



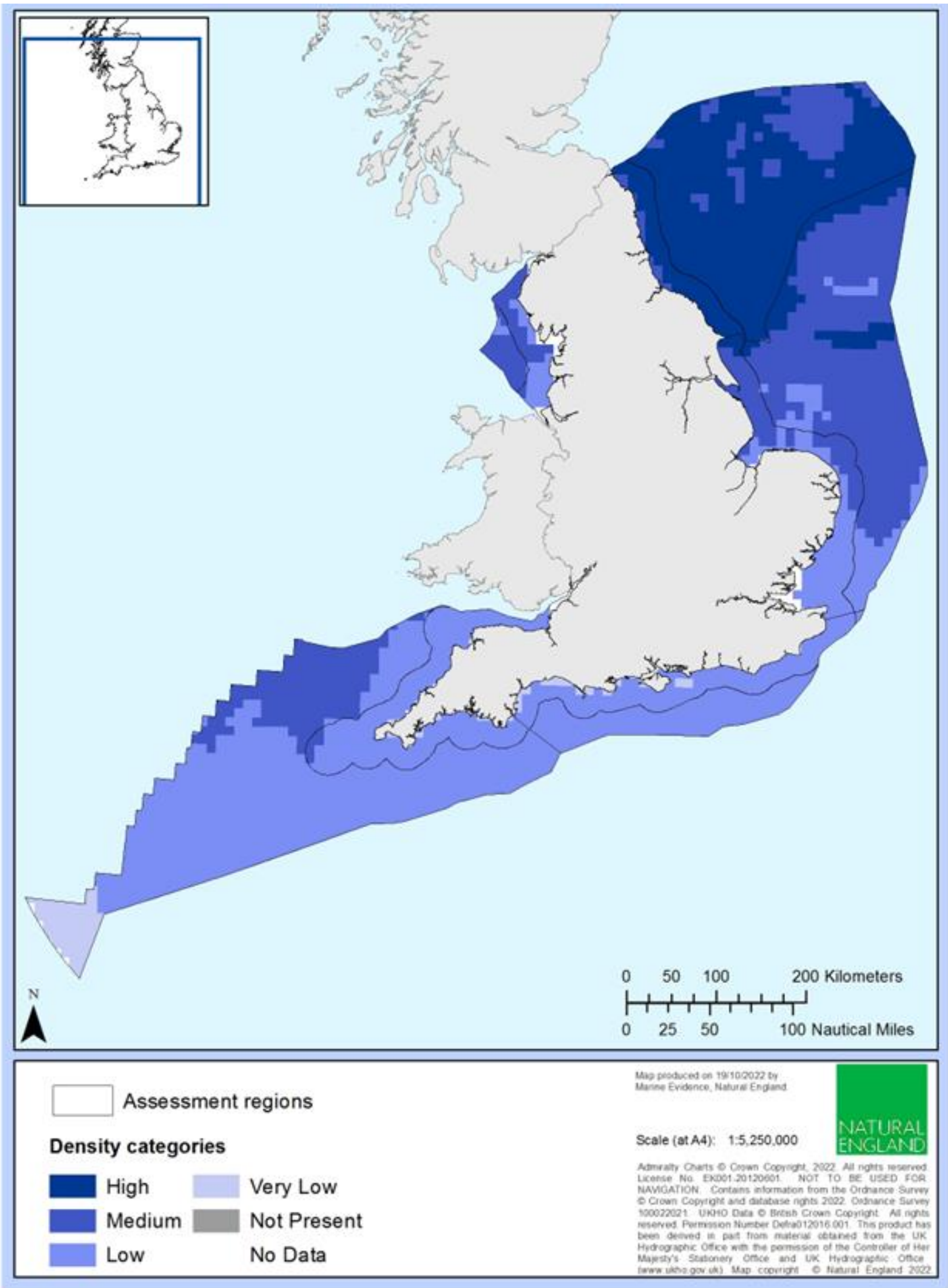
Map 2: Atlantic puffin – non-breeding



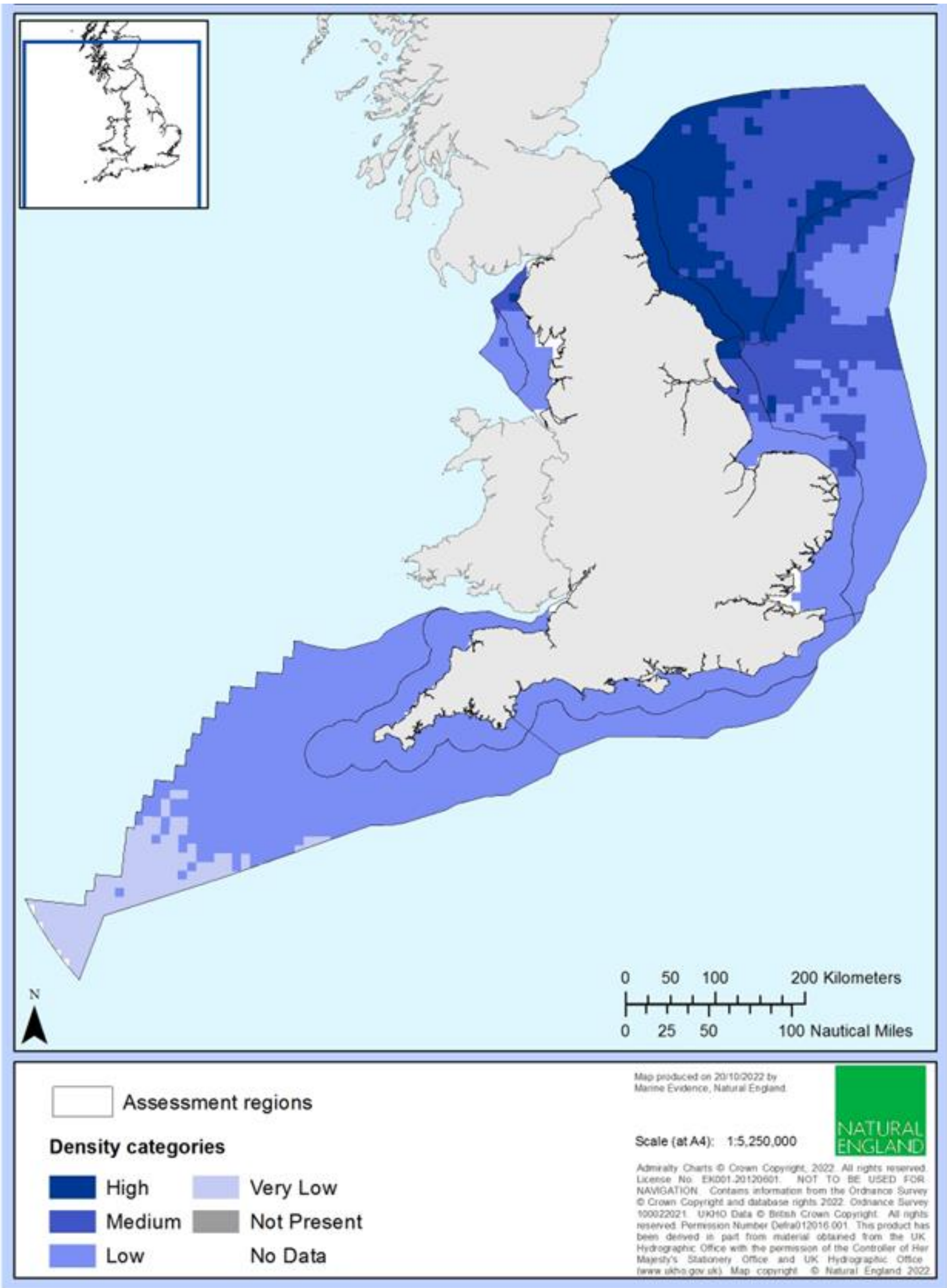
Map 3: Black-legged kittiwake - breeding


N
0 50 100 200 Kilometers
0 25 50 100 Nautical Miles
Assessment regions
Density categories
High
Medium
Low
Very Low
Not Present
No Data
Map produced on 20/10/2022 by Marine Evidence, Natural England
Scale (at A4): 1:5,250,000
Admiralty Charts © Crown Copyright, 2022. All rights reserved. License No. EK001-20120601. NOT TO BE USED FOR NAVIGATION. Contains information from the Ordnance Survey © Crown Copyright and database rights 2022. Ordnance Survey 100022021. UKHO Data © British Crown Copyright. All rights reserved. Permission Number Defra012016.001. This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). Map copyright © Natural England 2022

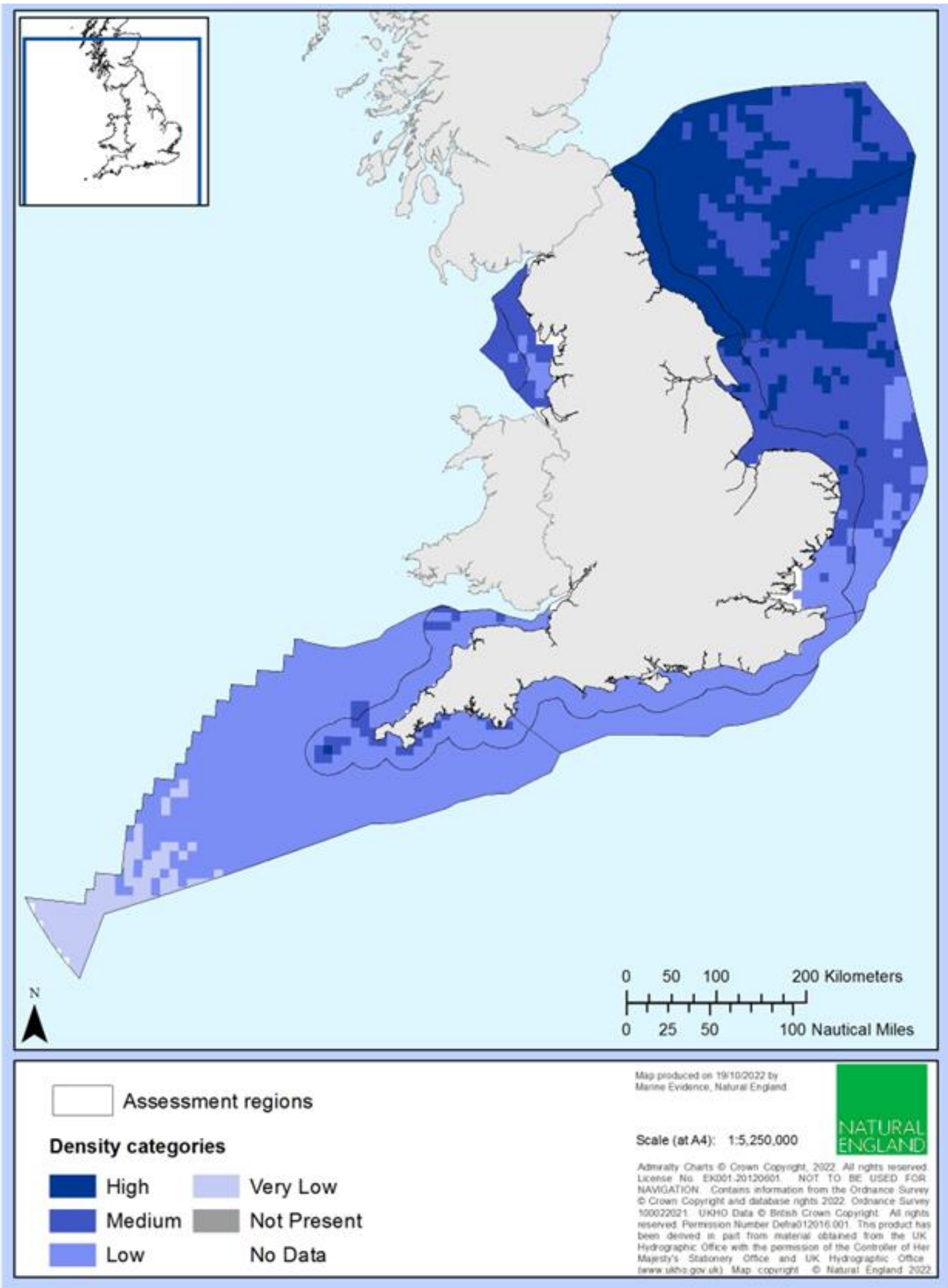
Map 4: Black-legged kittiwake - non-breeding



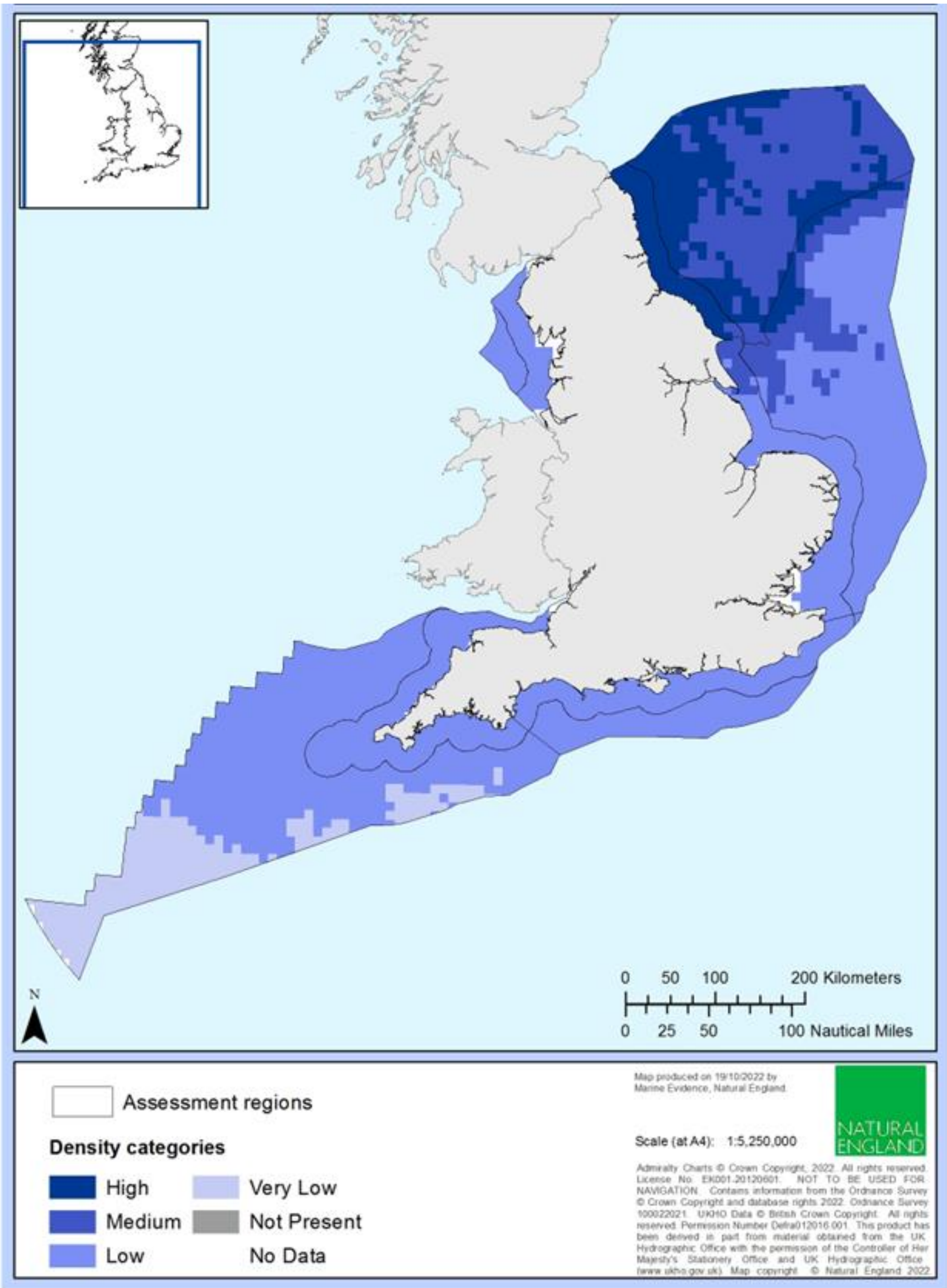
Map 5: Common guillemot - breeding



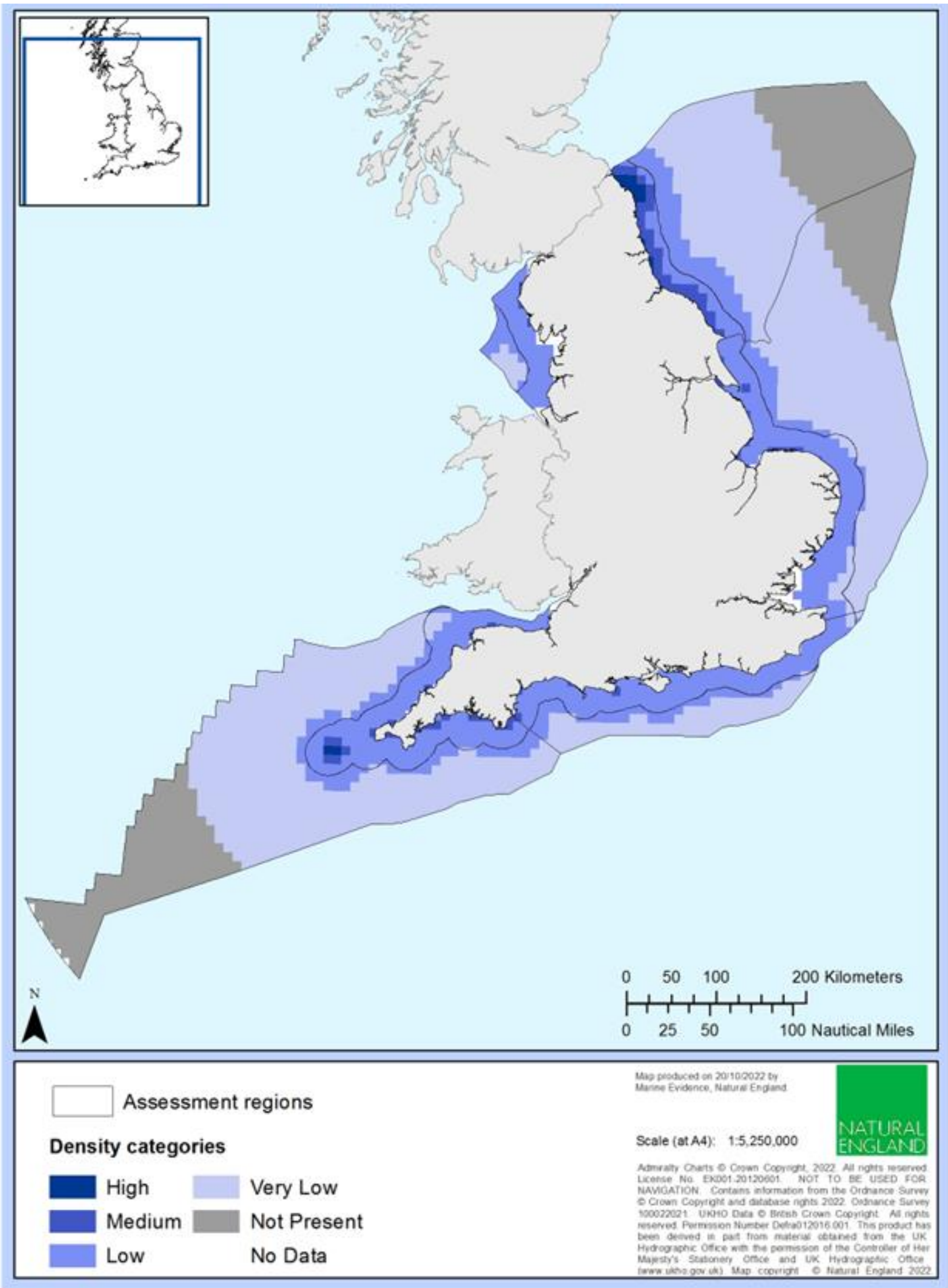
Map 6: Common guillemot - non-breeding



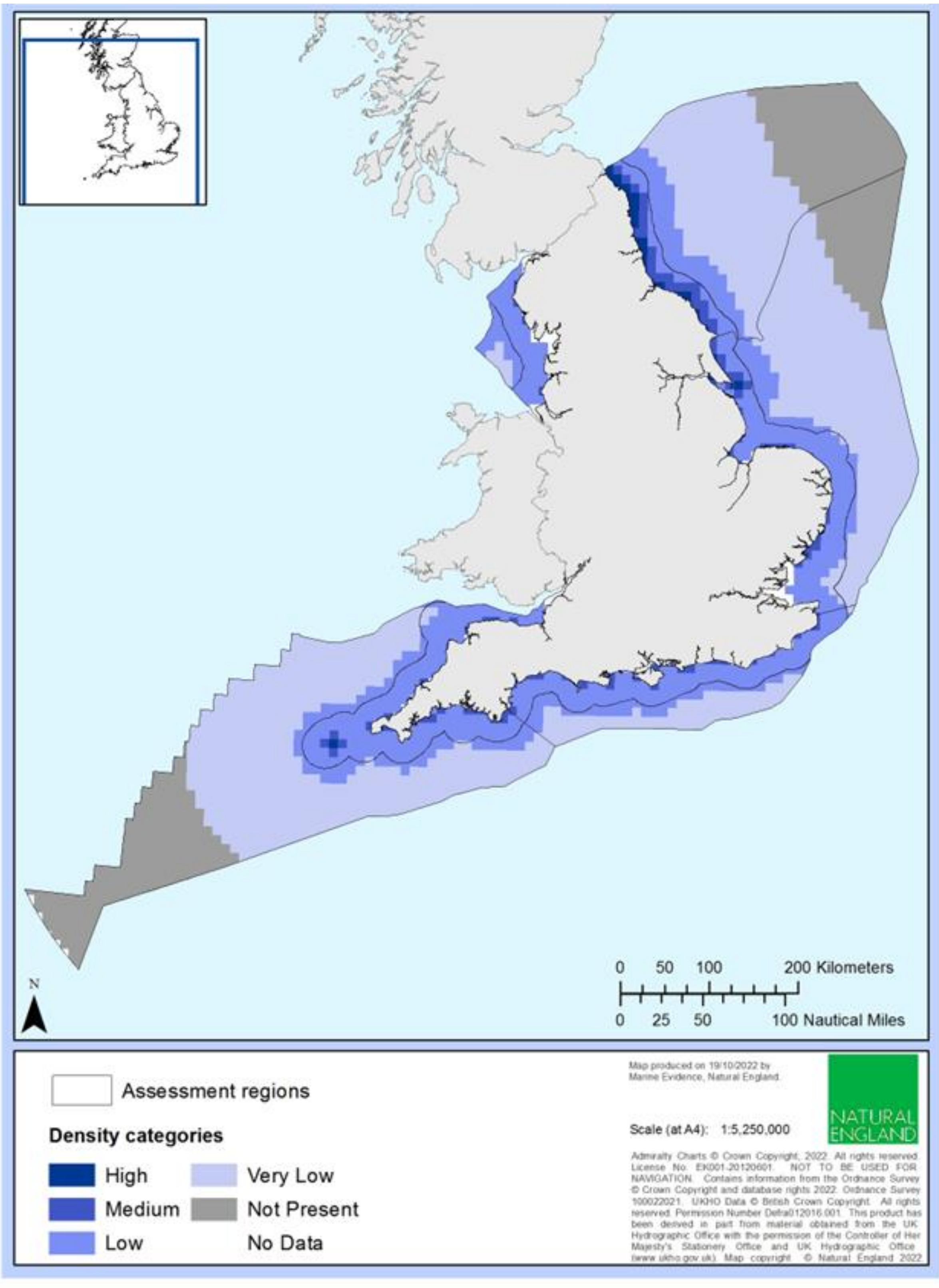
Map 7: Common guillemot - non-breeding, passage



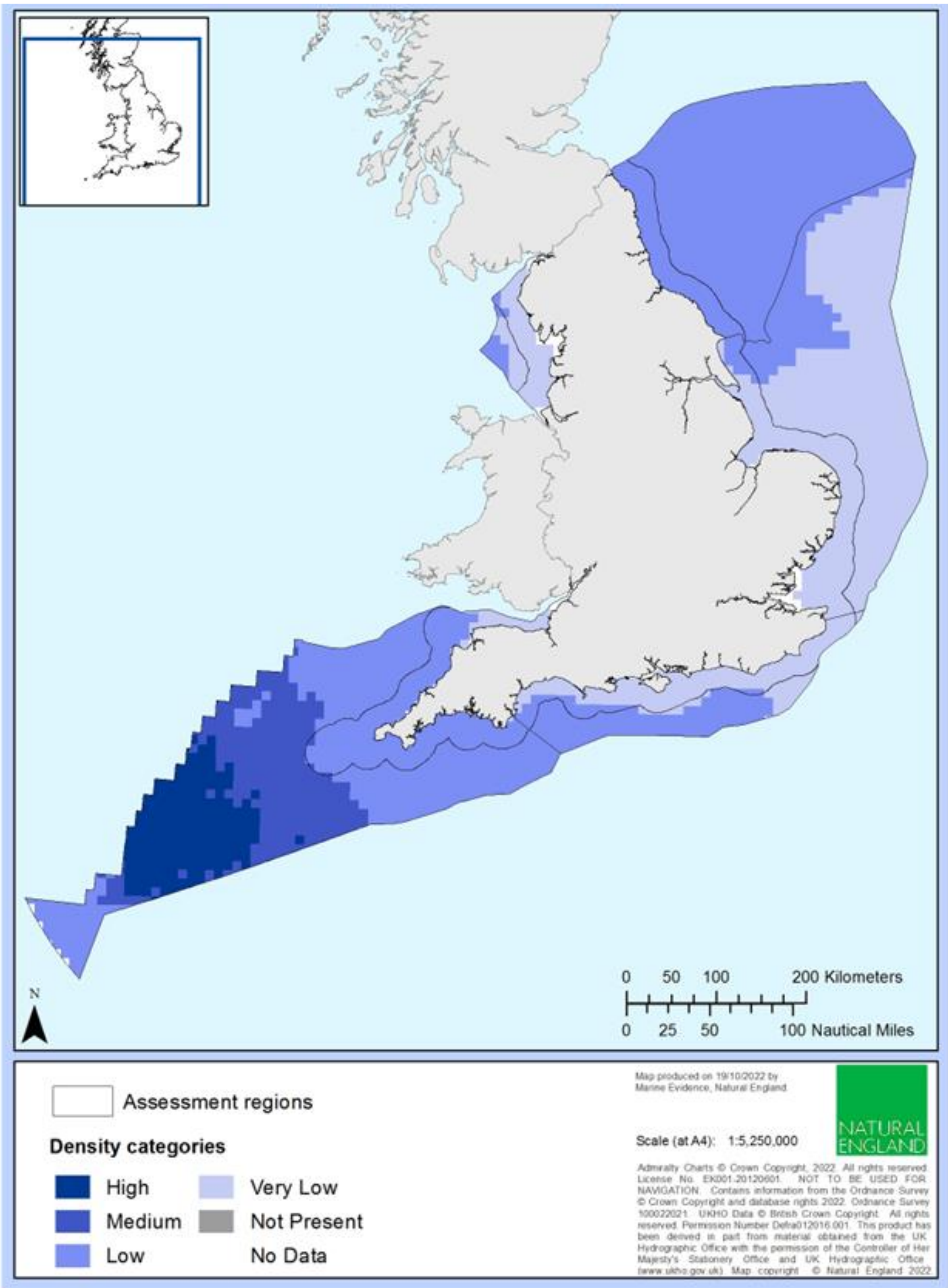
Map 8: European shag - breeding



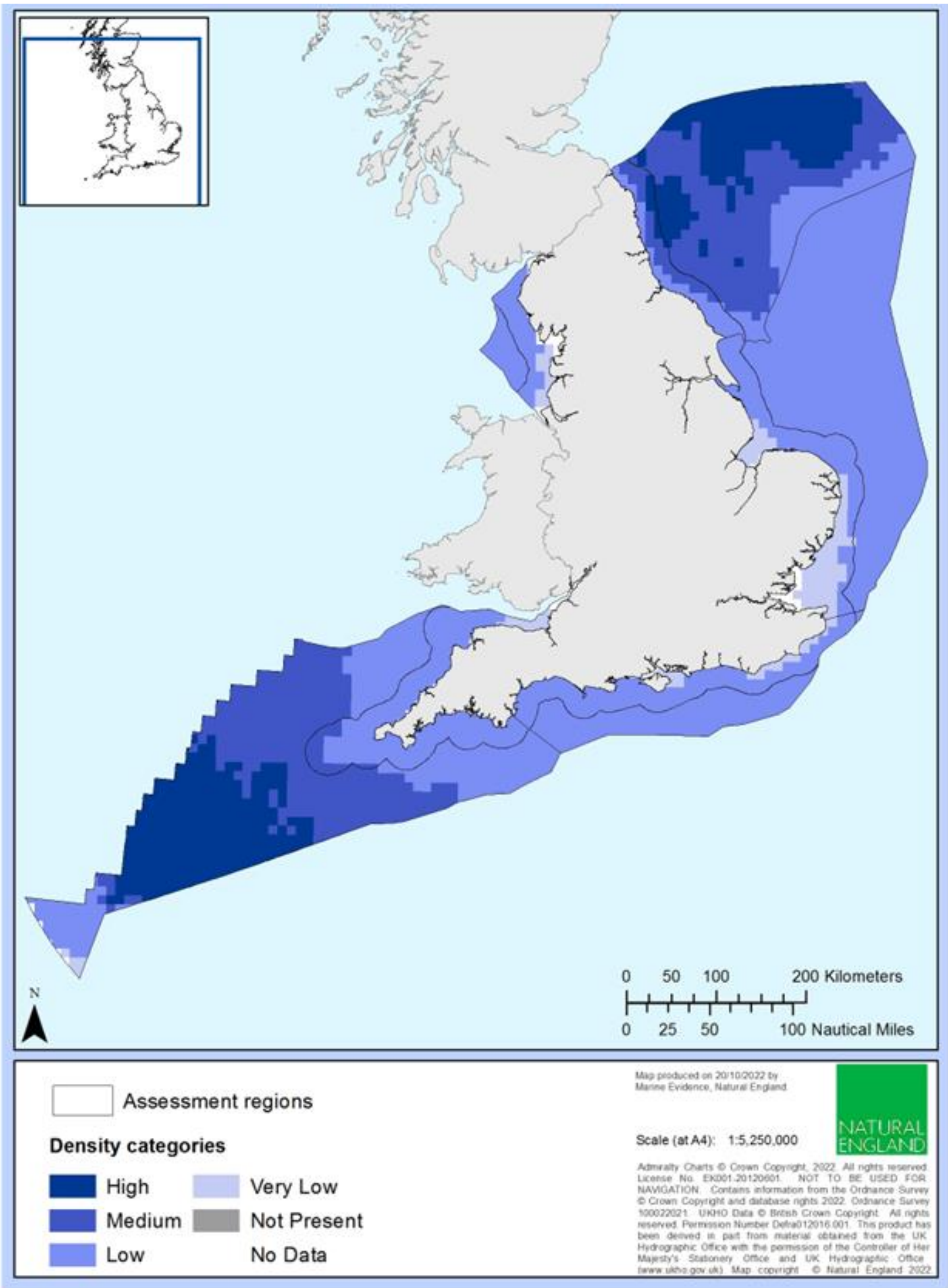
Map 9: European shag - non-breeding



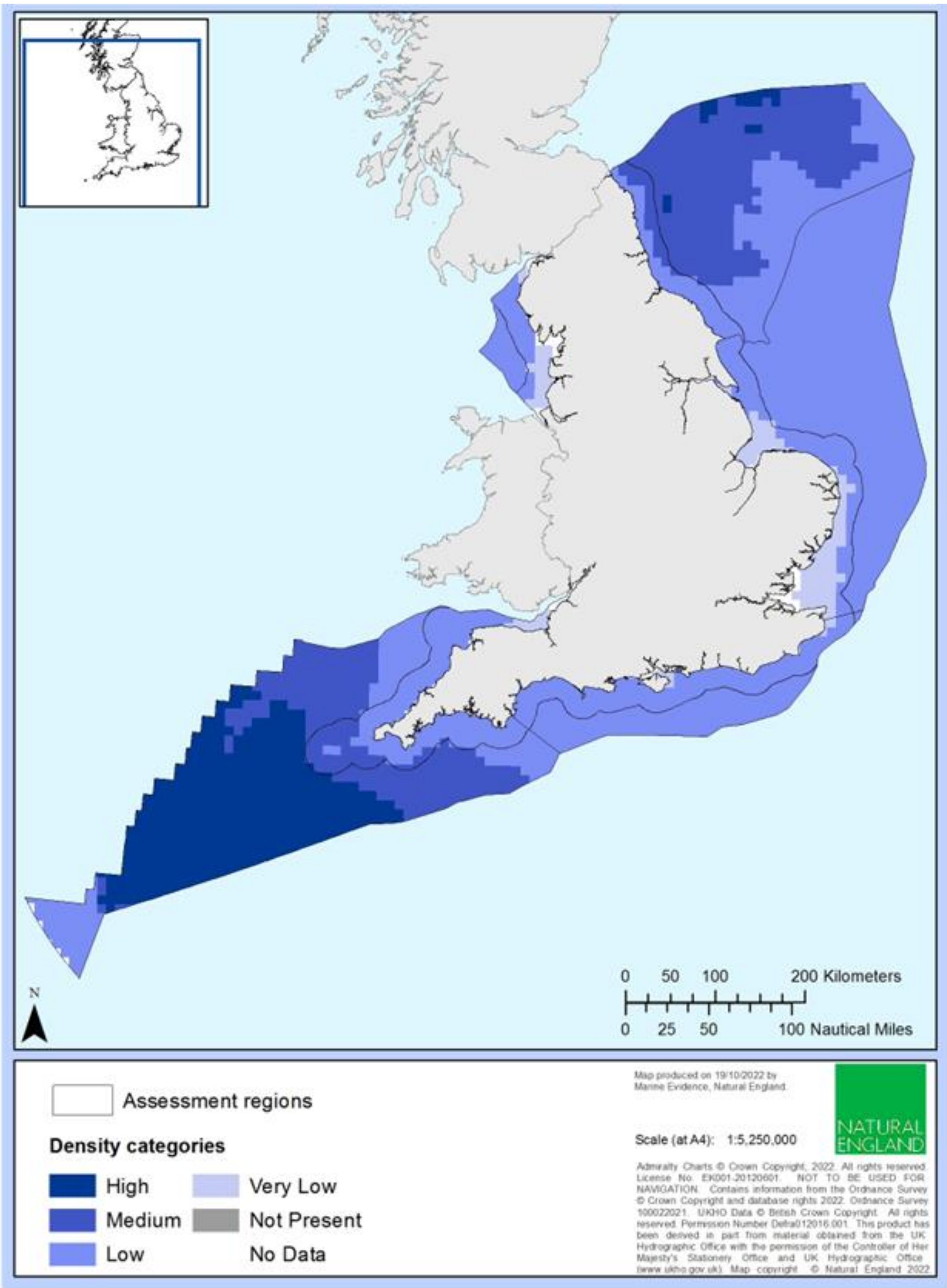
Map 10: European storm petrel - breeding



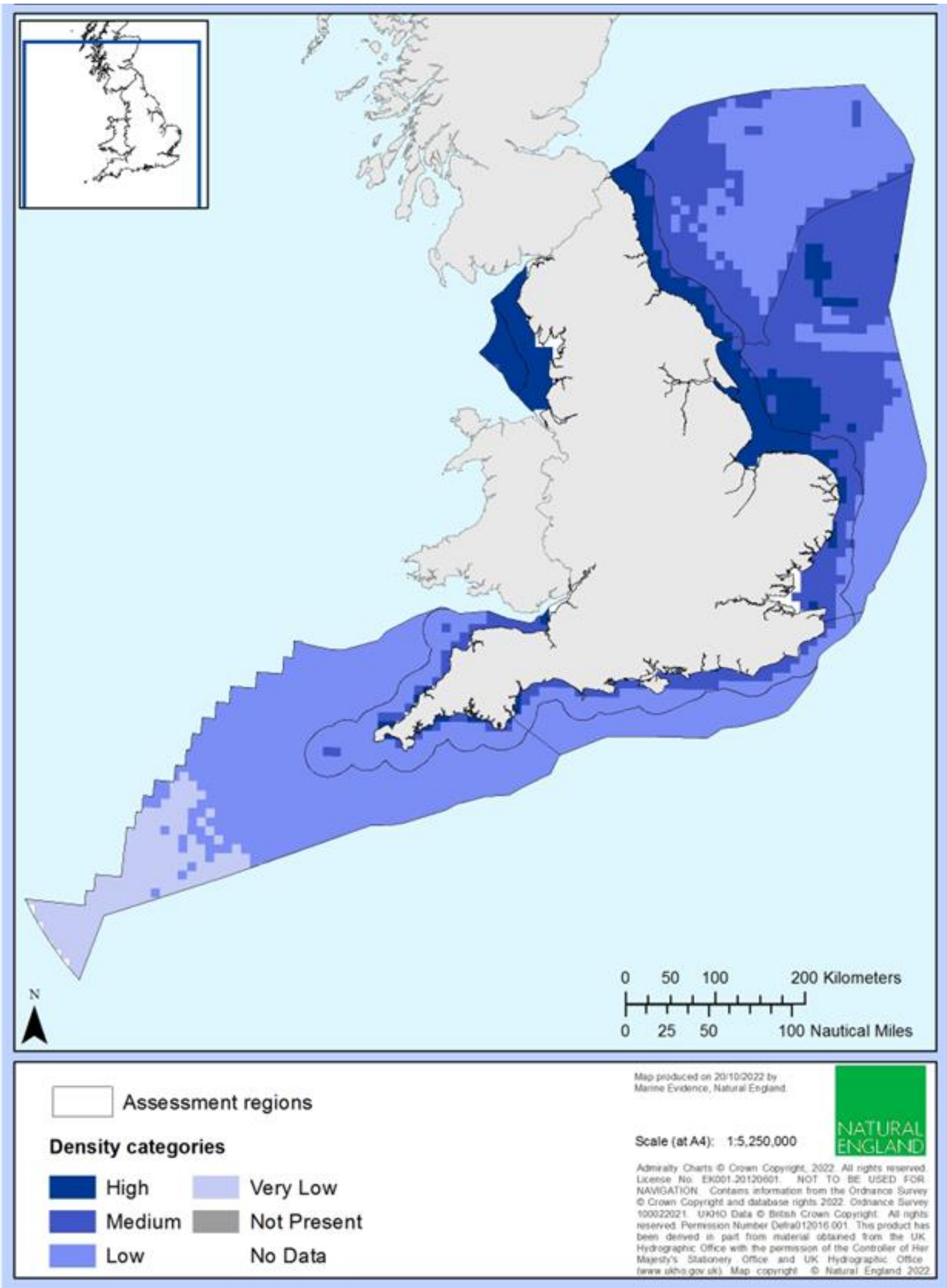
Map 11: Great skua - breeding



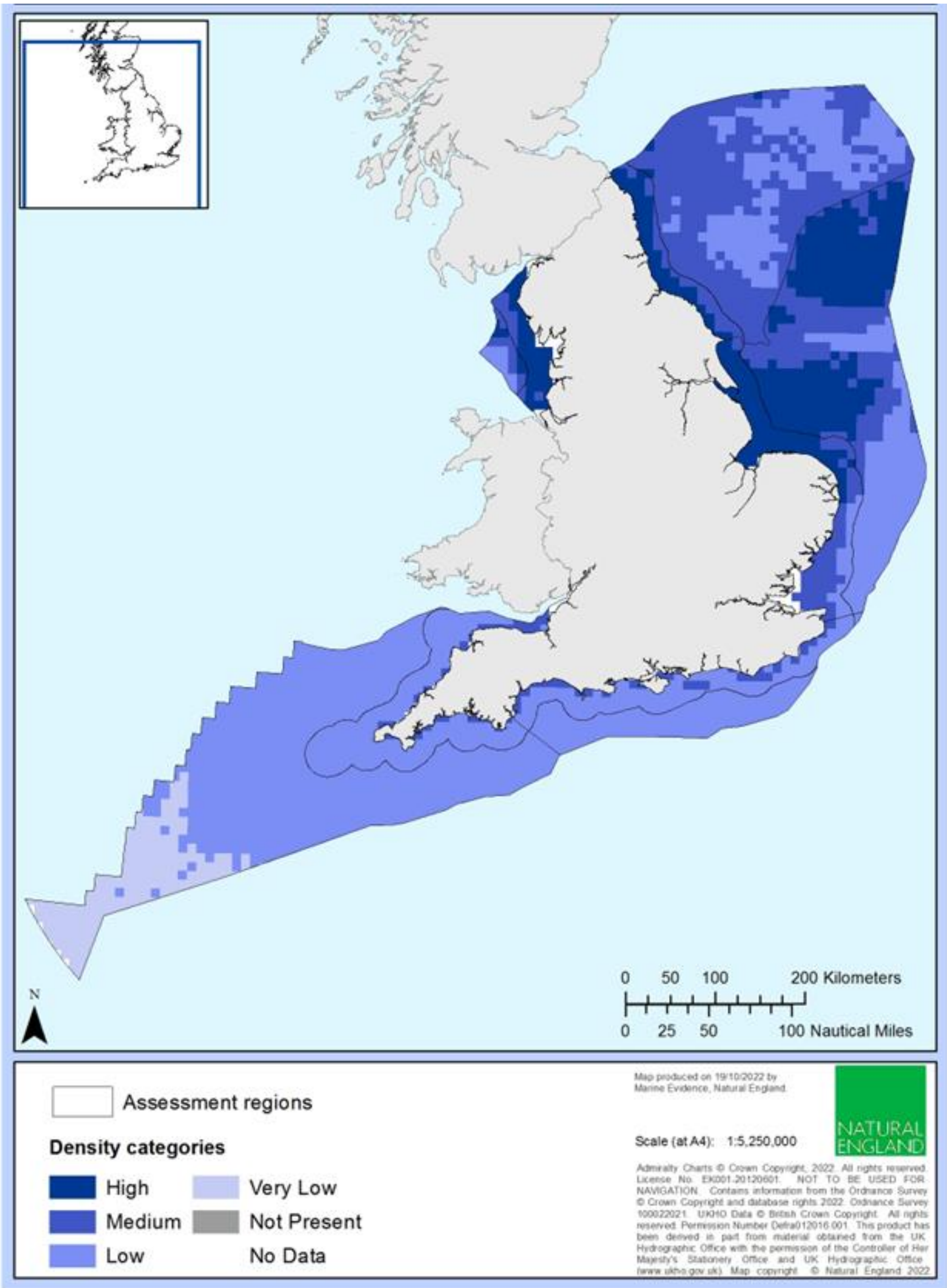
Map 12: Great skua - non-breeding



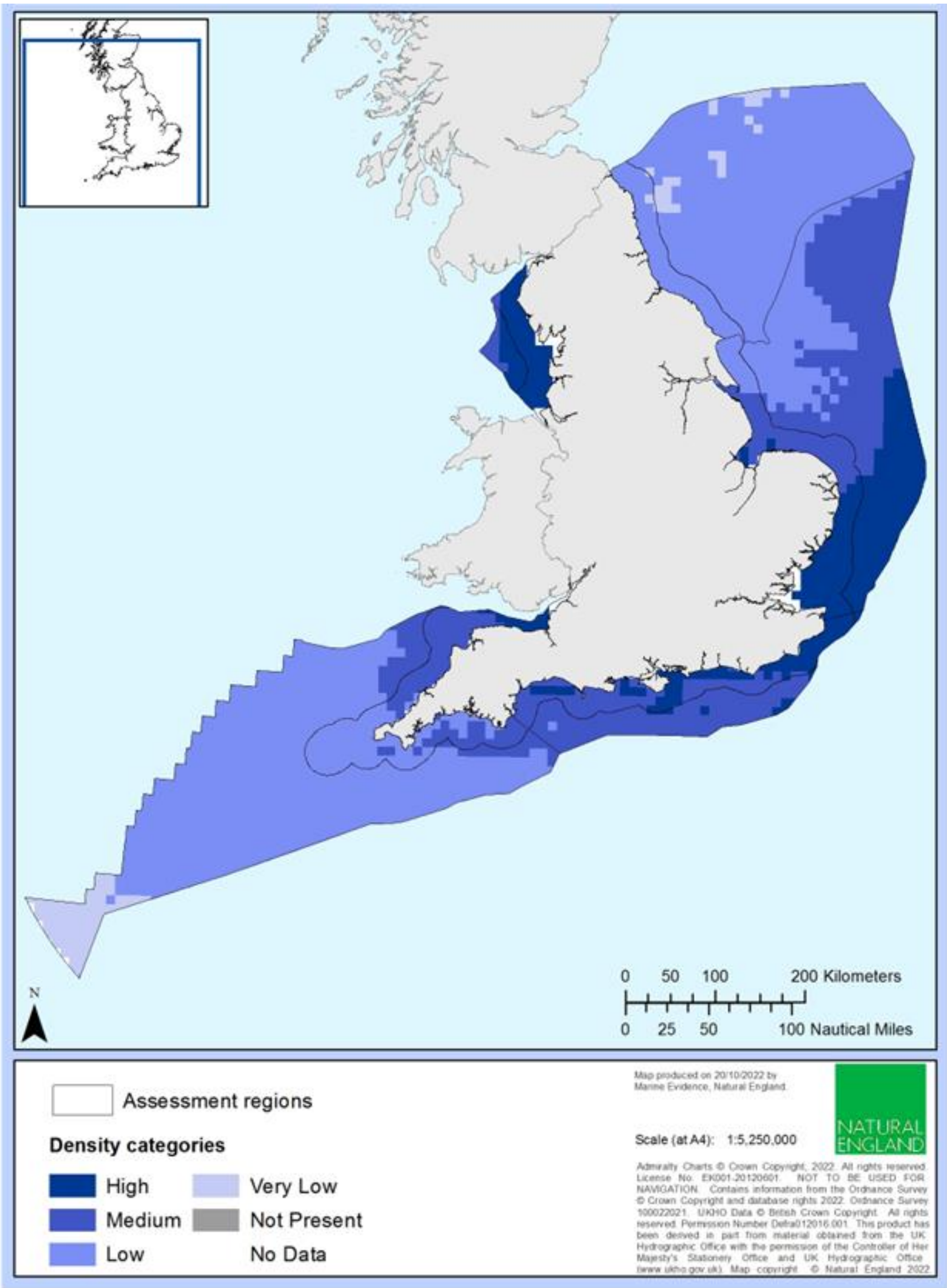
Map 13: Herring gull - breeding



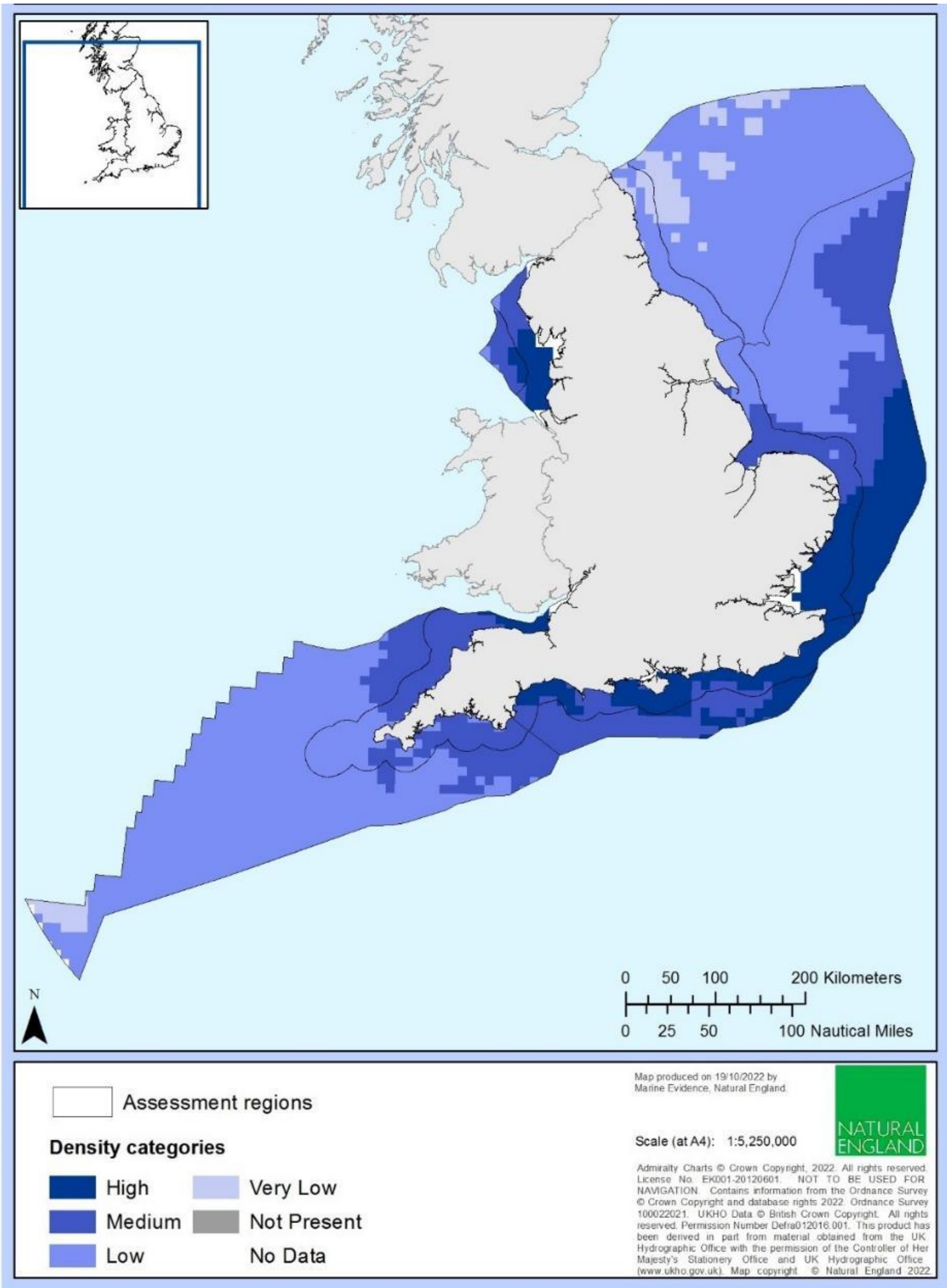
Map 14: Herring gull - non-breeding



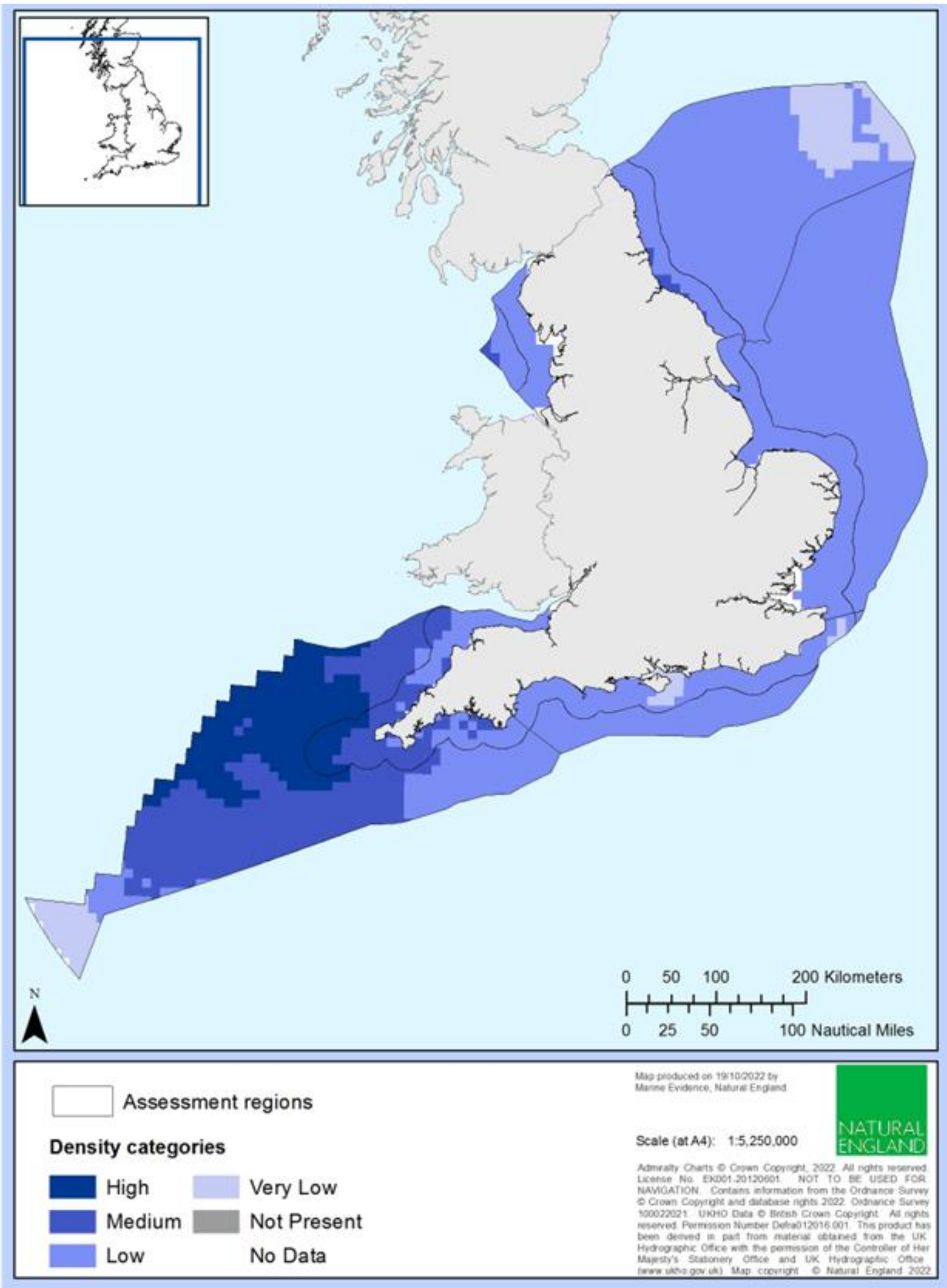
Map 15: Lesser black-backed gull - breeding



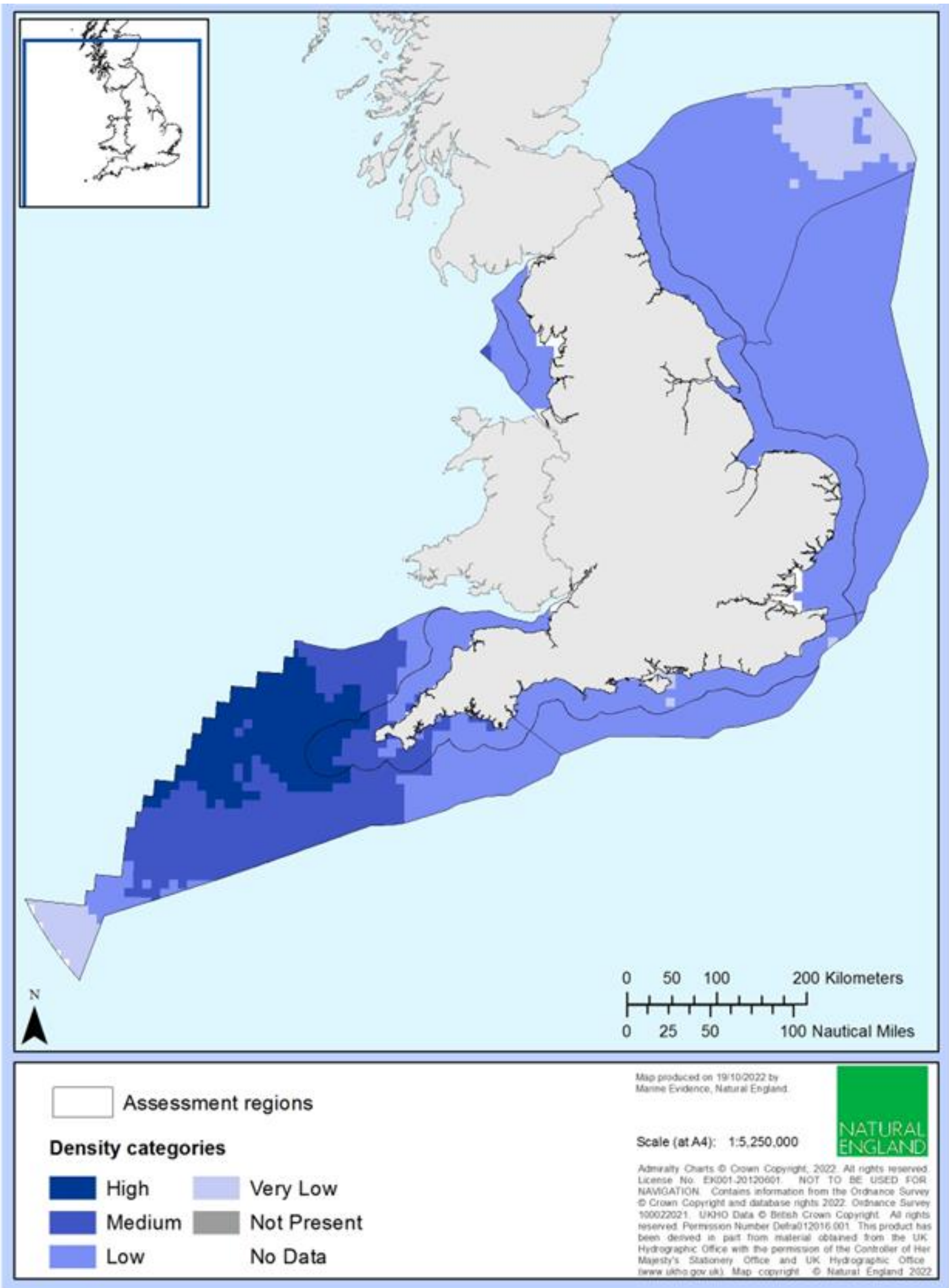
Map 16: Lesser black-backed gull - non-breeding



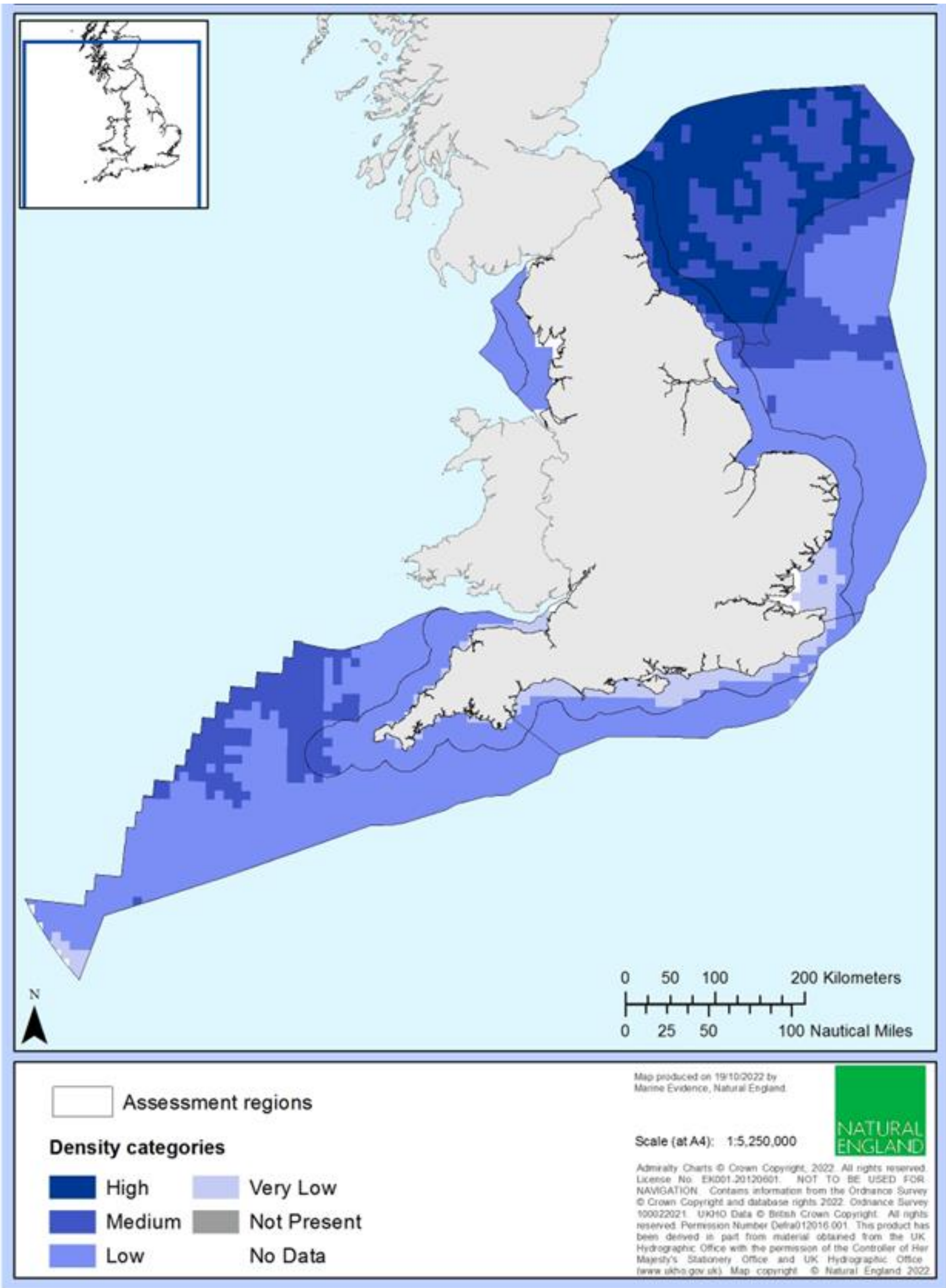
Map 17: Manx shearwater - breeding



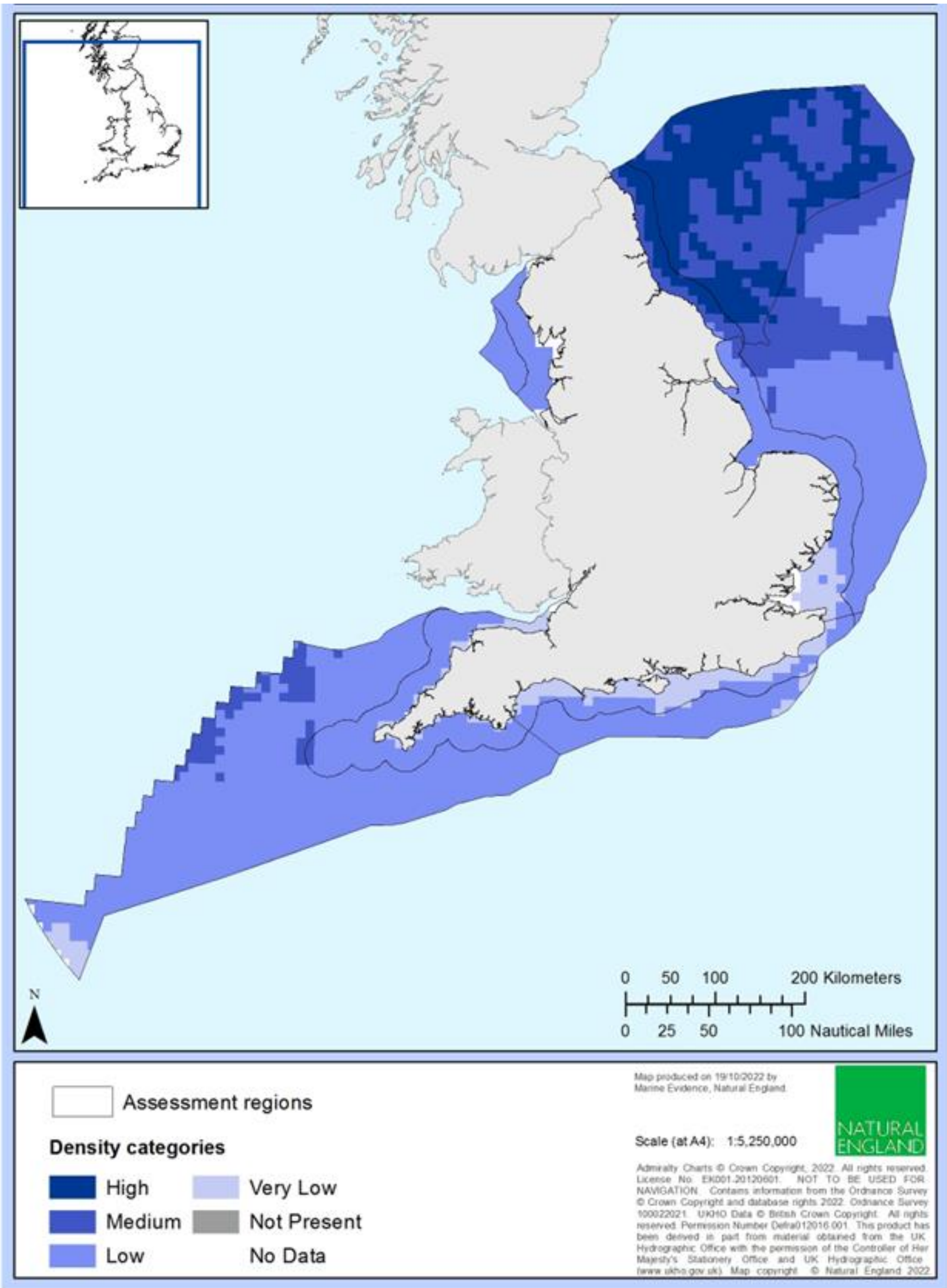
Map 18: Manx shearwater - non-breeding, passage



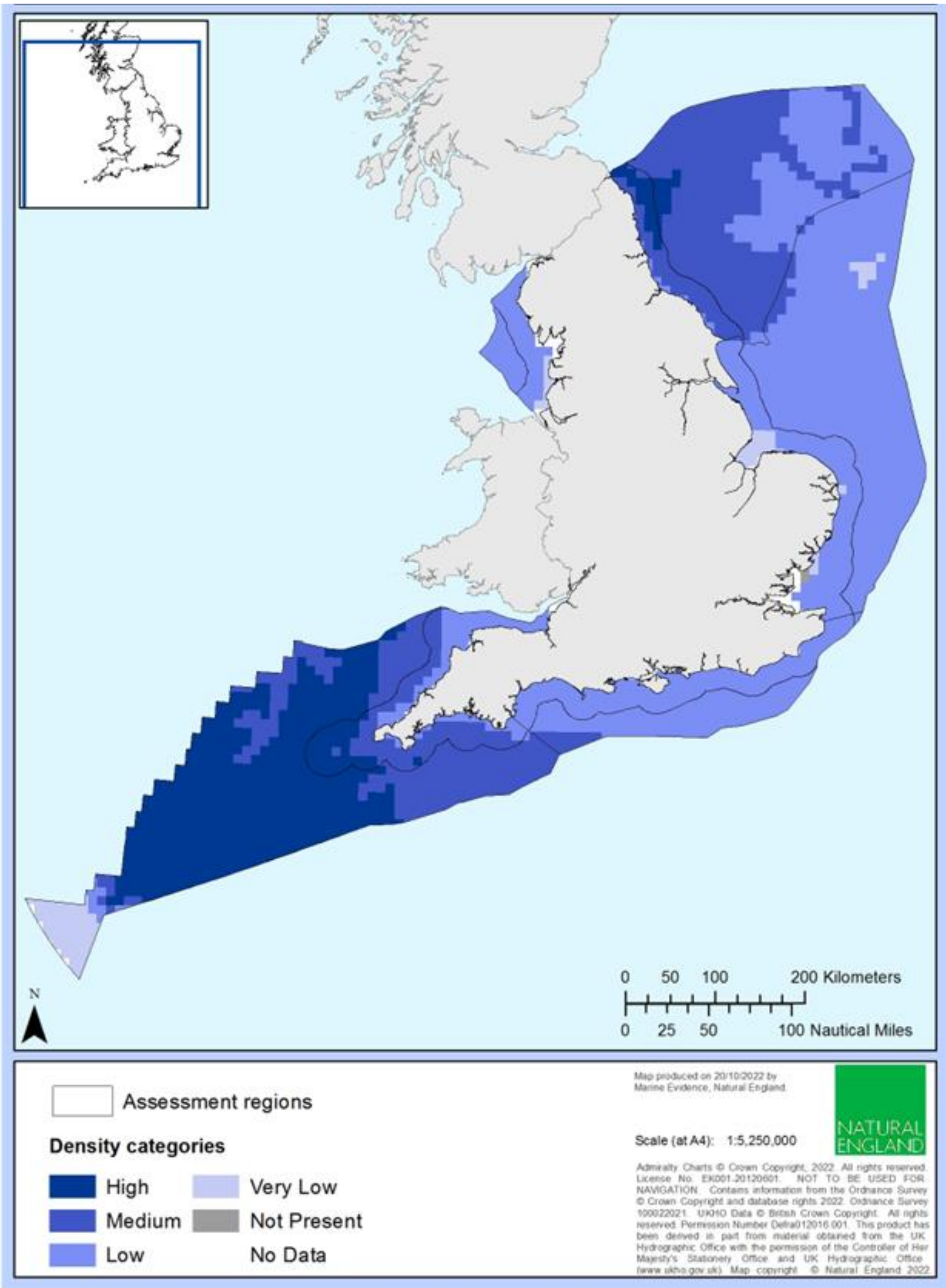
Map 19: Northern fulmar - breeding



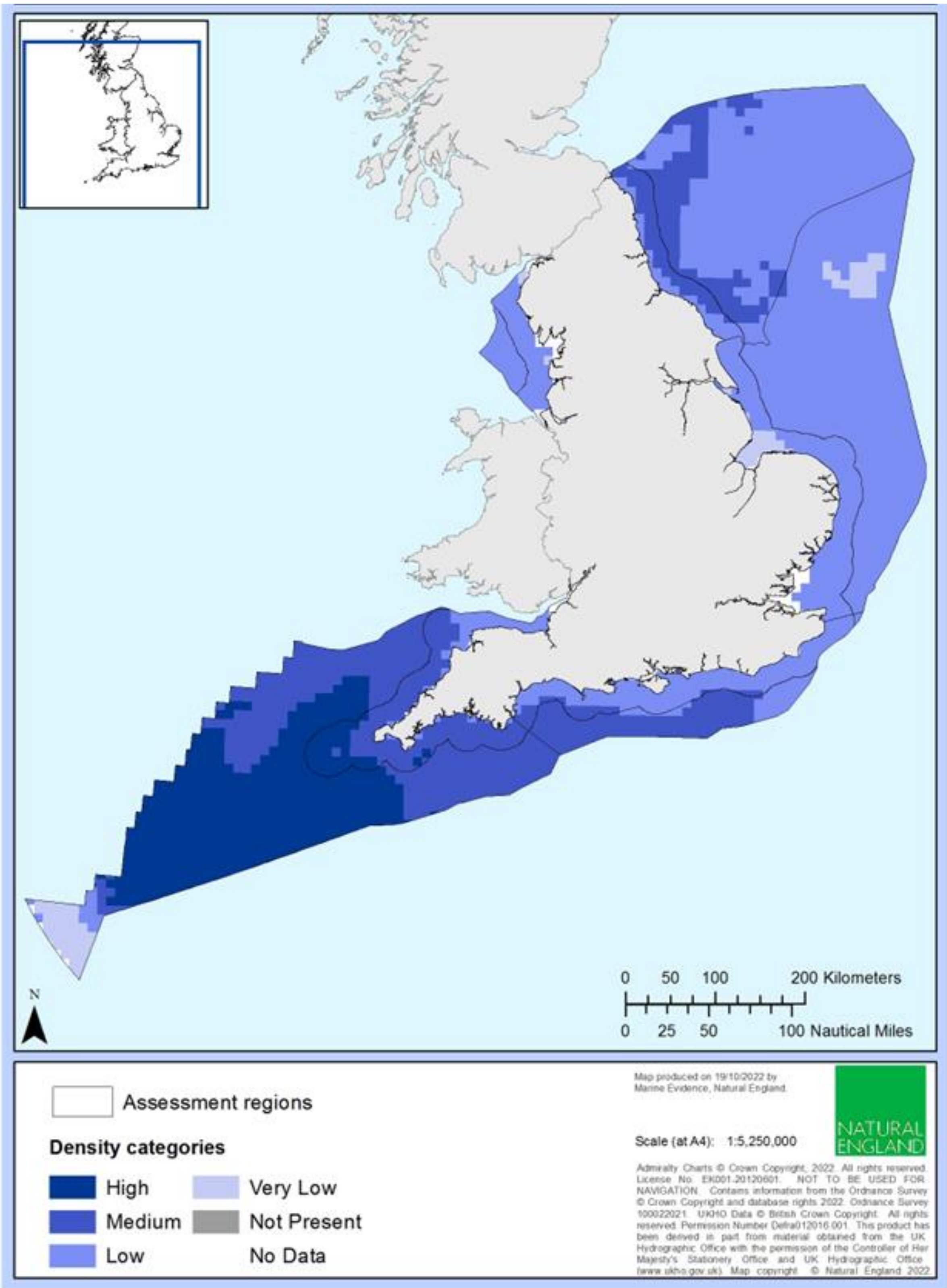
Map 20: Northern fulmar - non-breeding



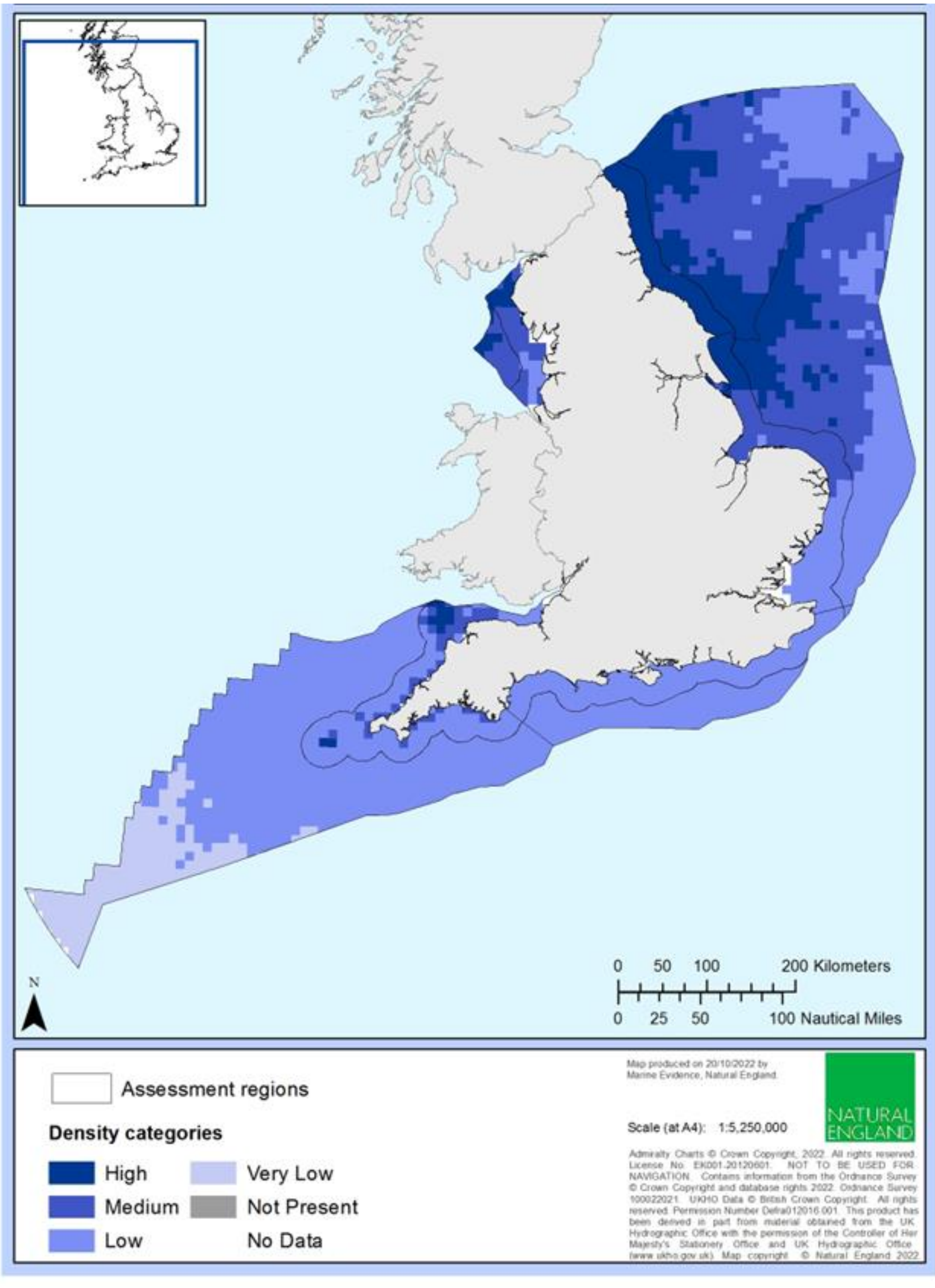
Map 21: Northern gannet - breeding



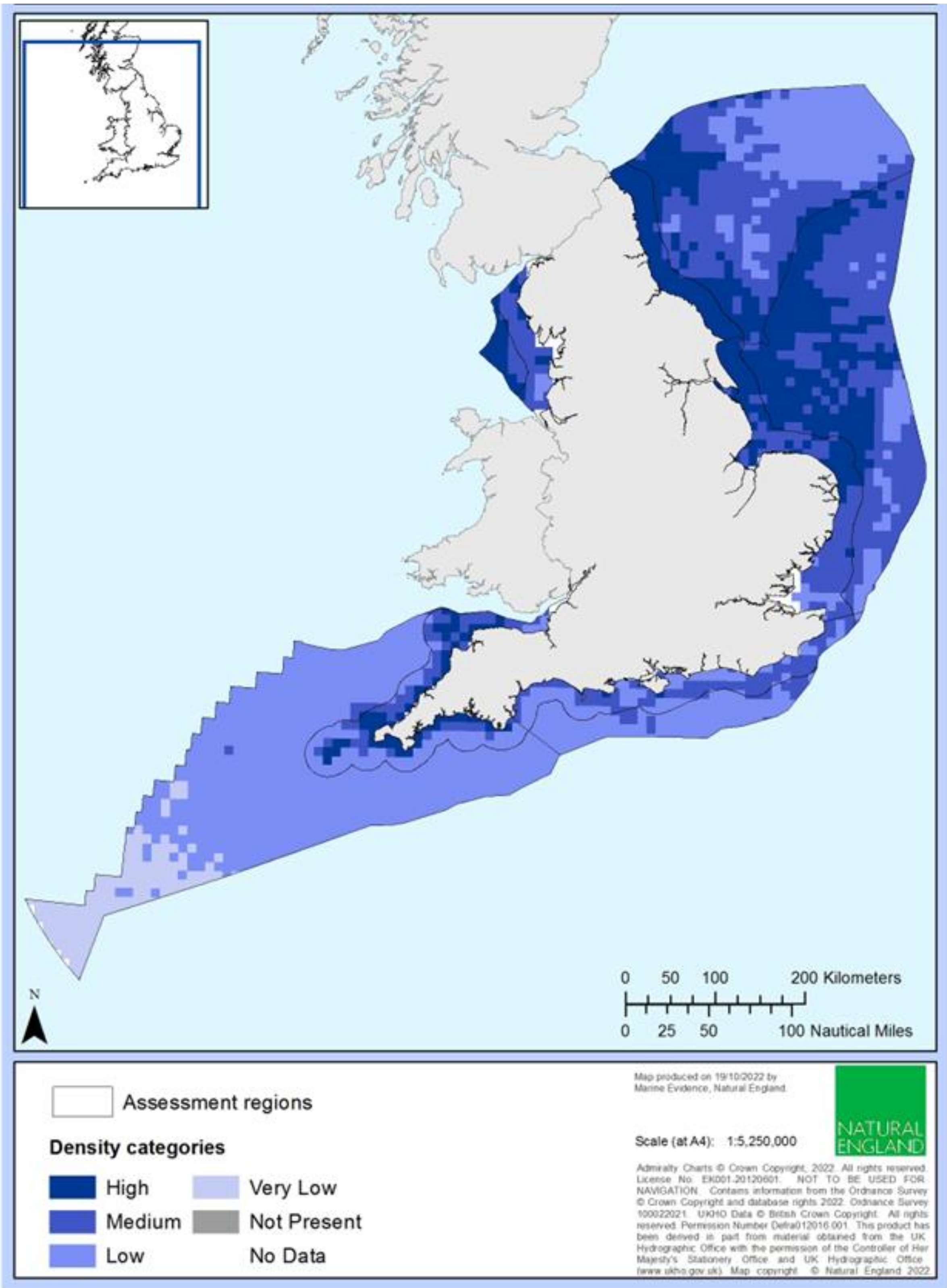
Map 22: Northern gannet - non-breeding



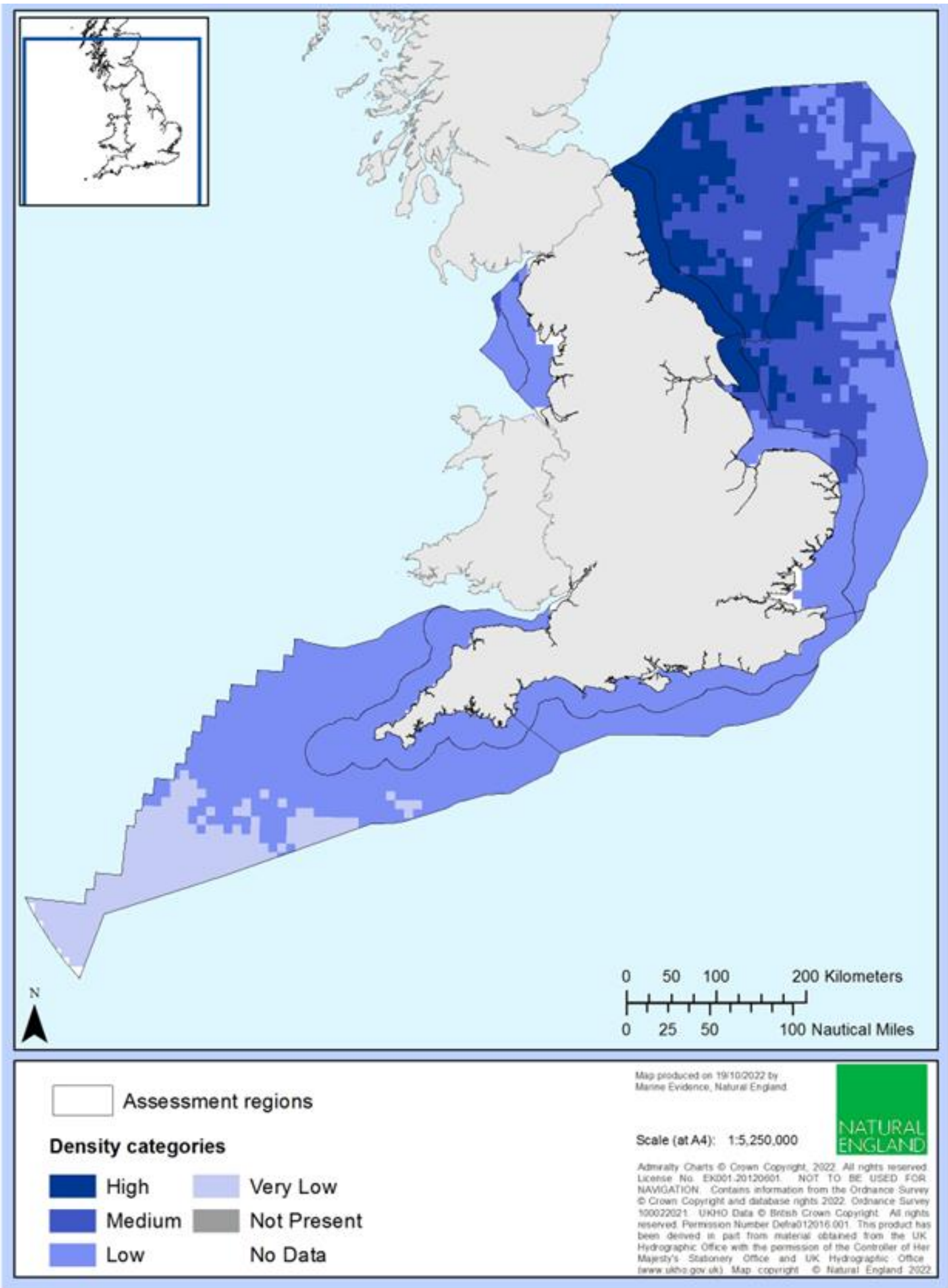
Map 23: Razorbill - breeding



Map 24: Razorbill - non-breeding

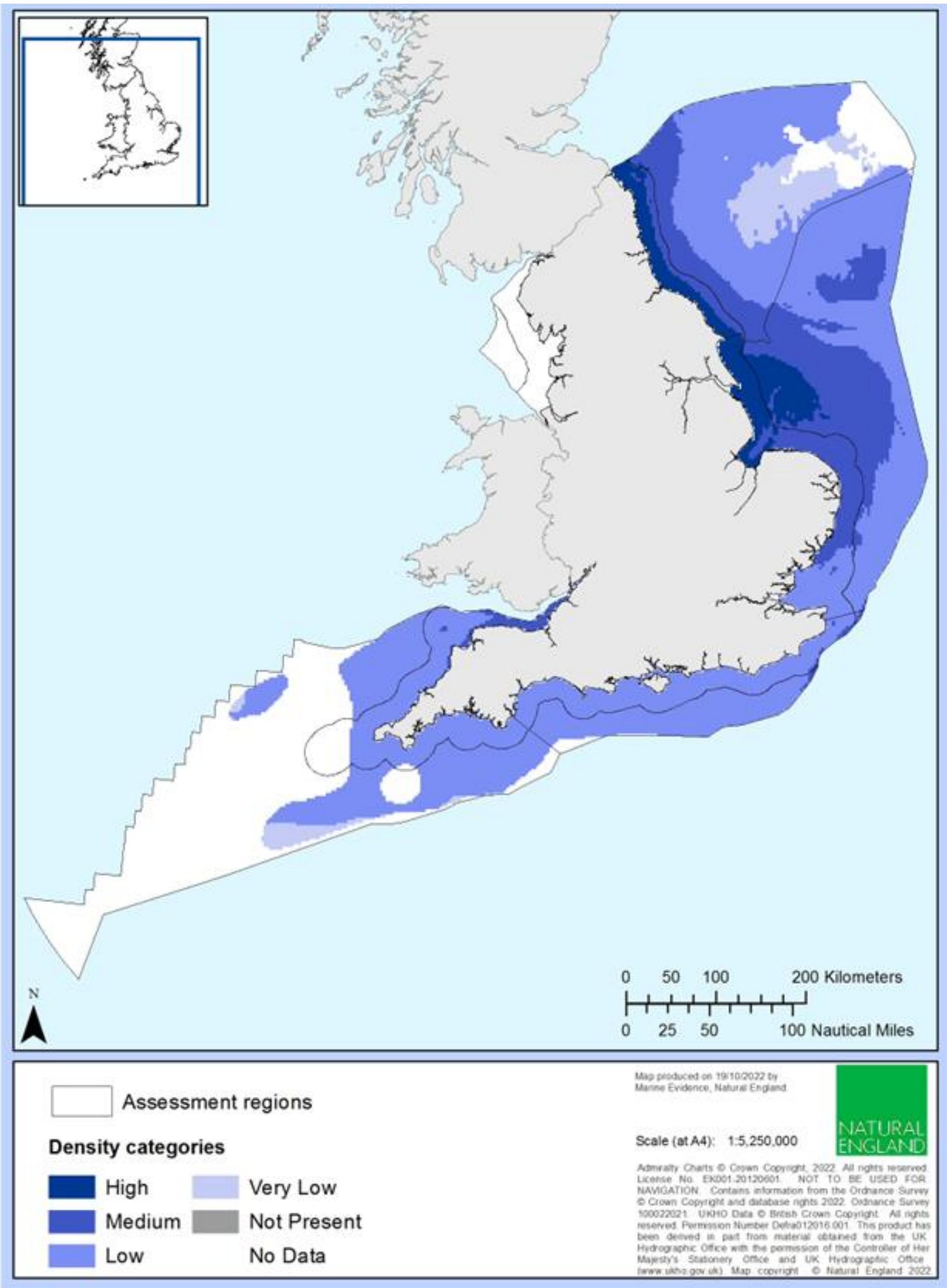


Map 25: Razorbill - non-breeding, passage

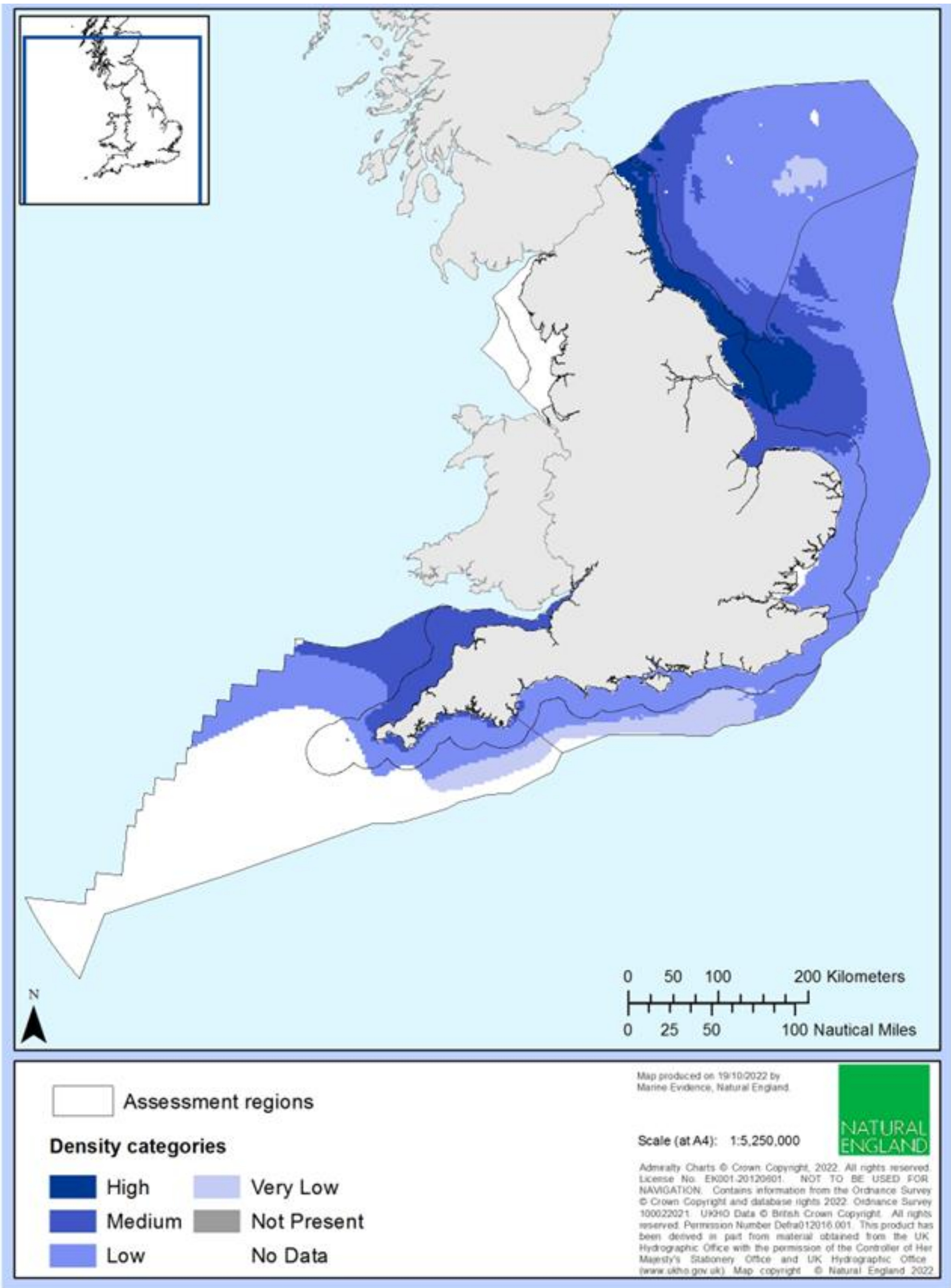


Seabird Mapping & Sensitivity Tool (SeaMaST) categorised density distribution maps

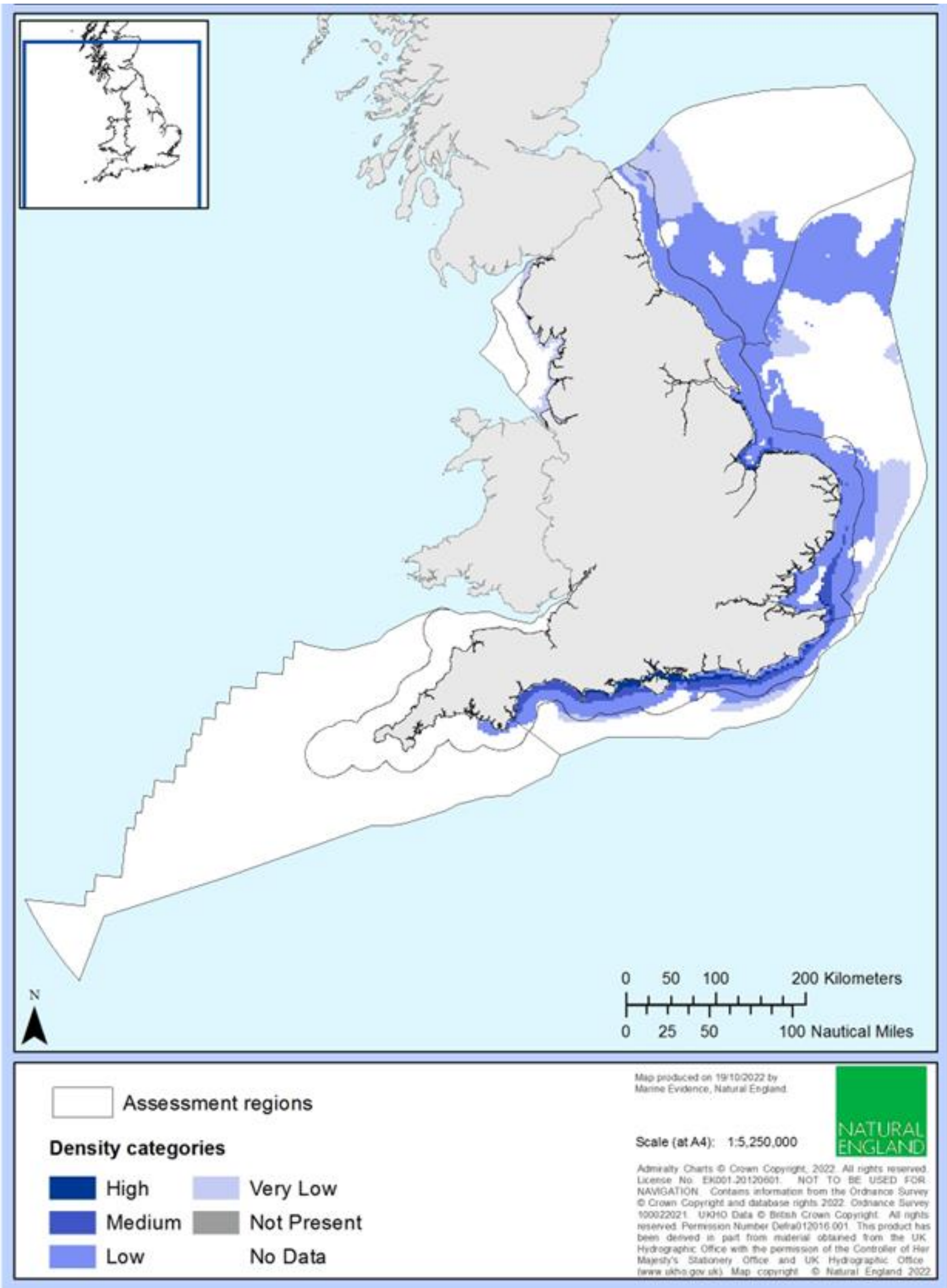
Map 26: Arctic skua - breeding



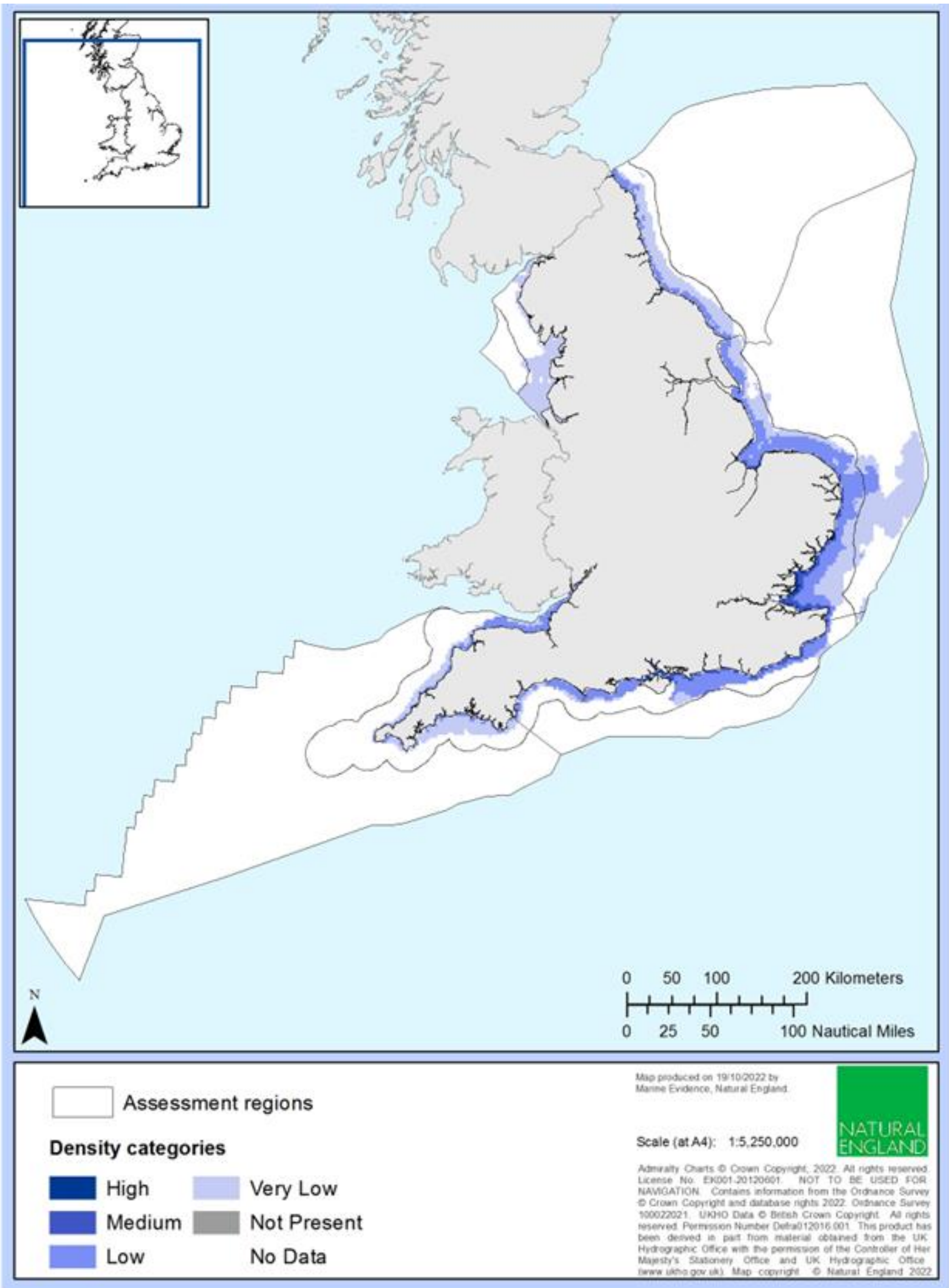
Map 27: Arctic skua - non-breeding, passage



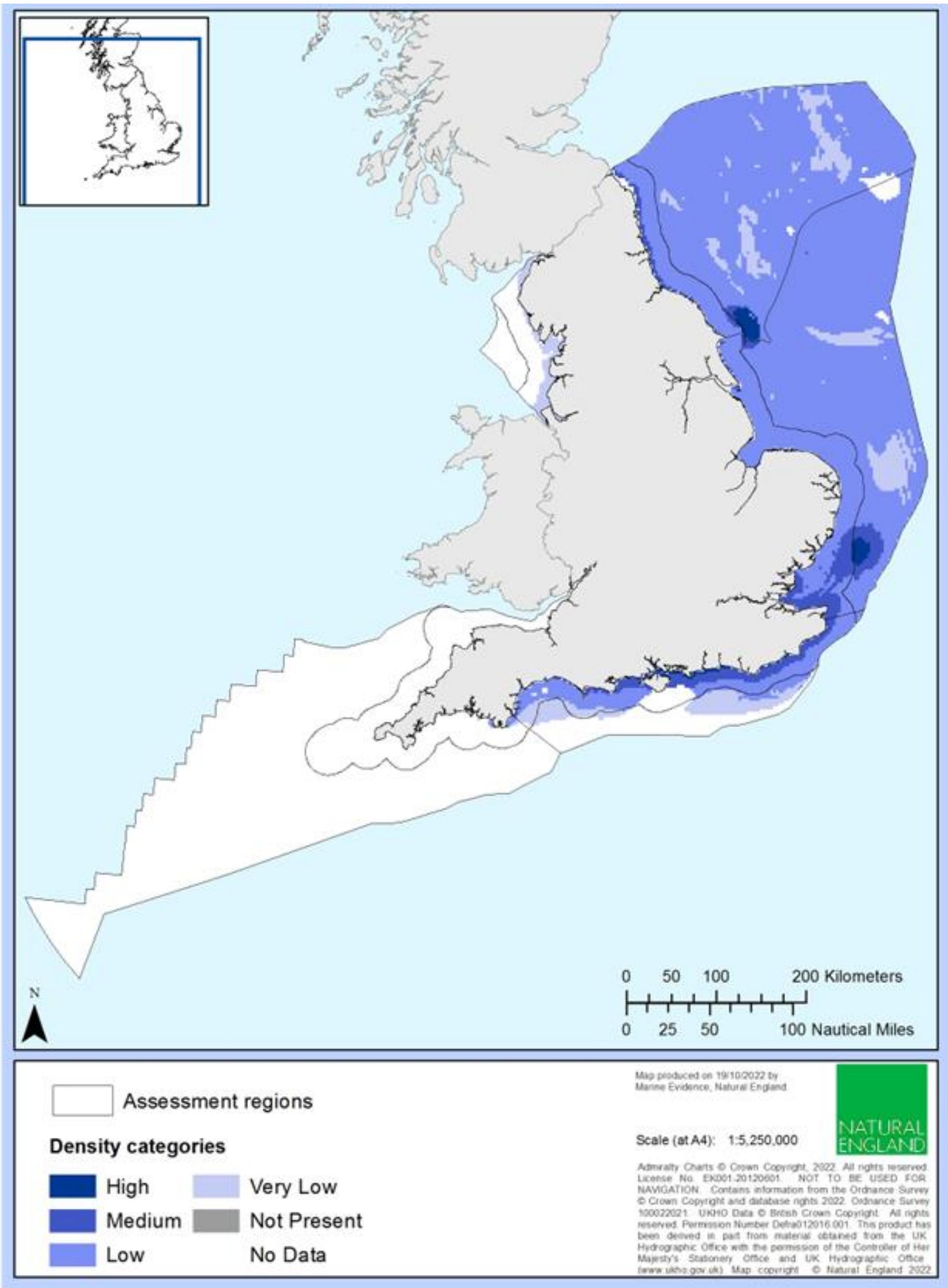
Map 28: Black-headed gull - breeding



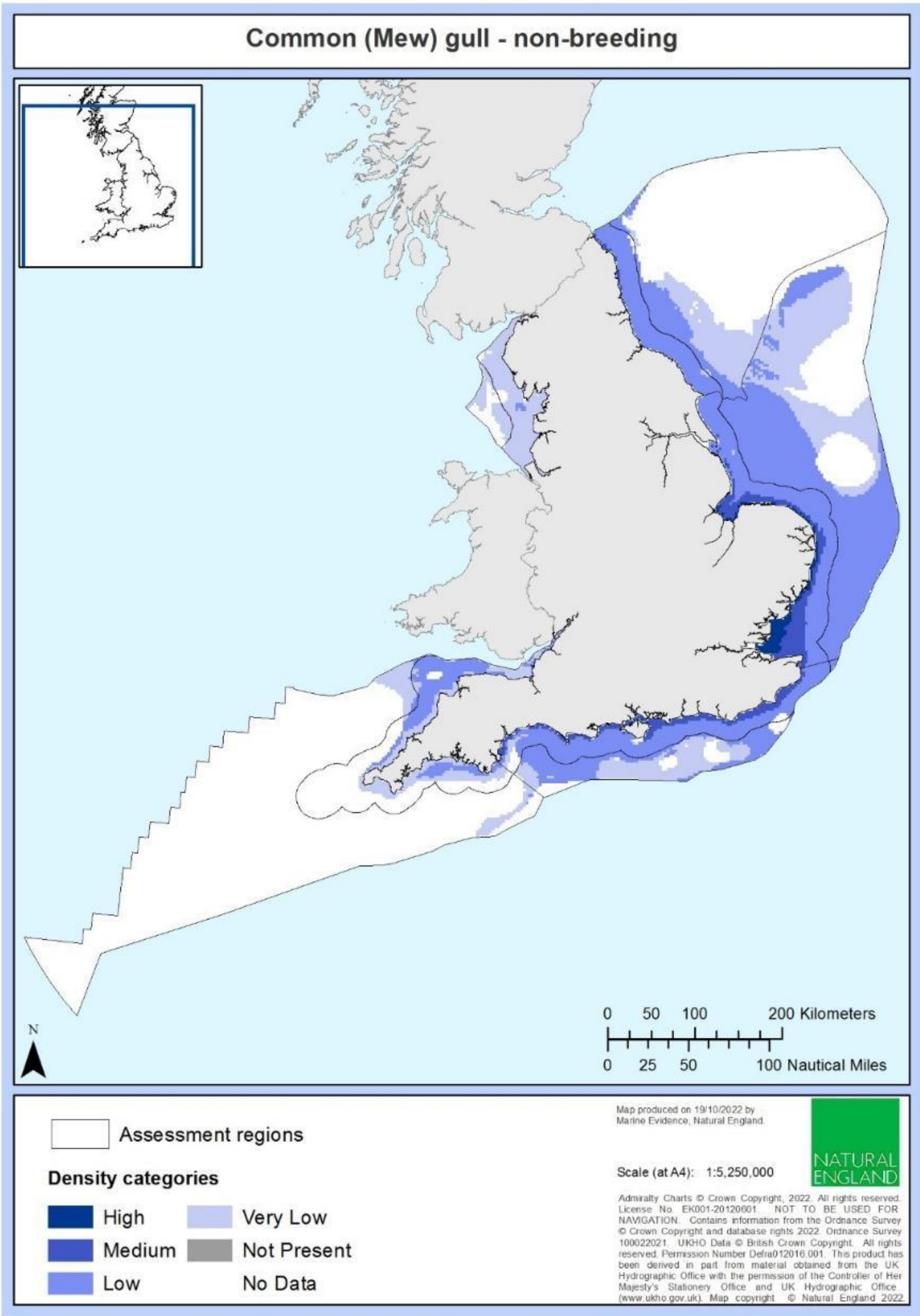
Map 29: Black-headed gull - non-breeding



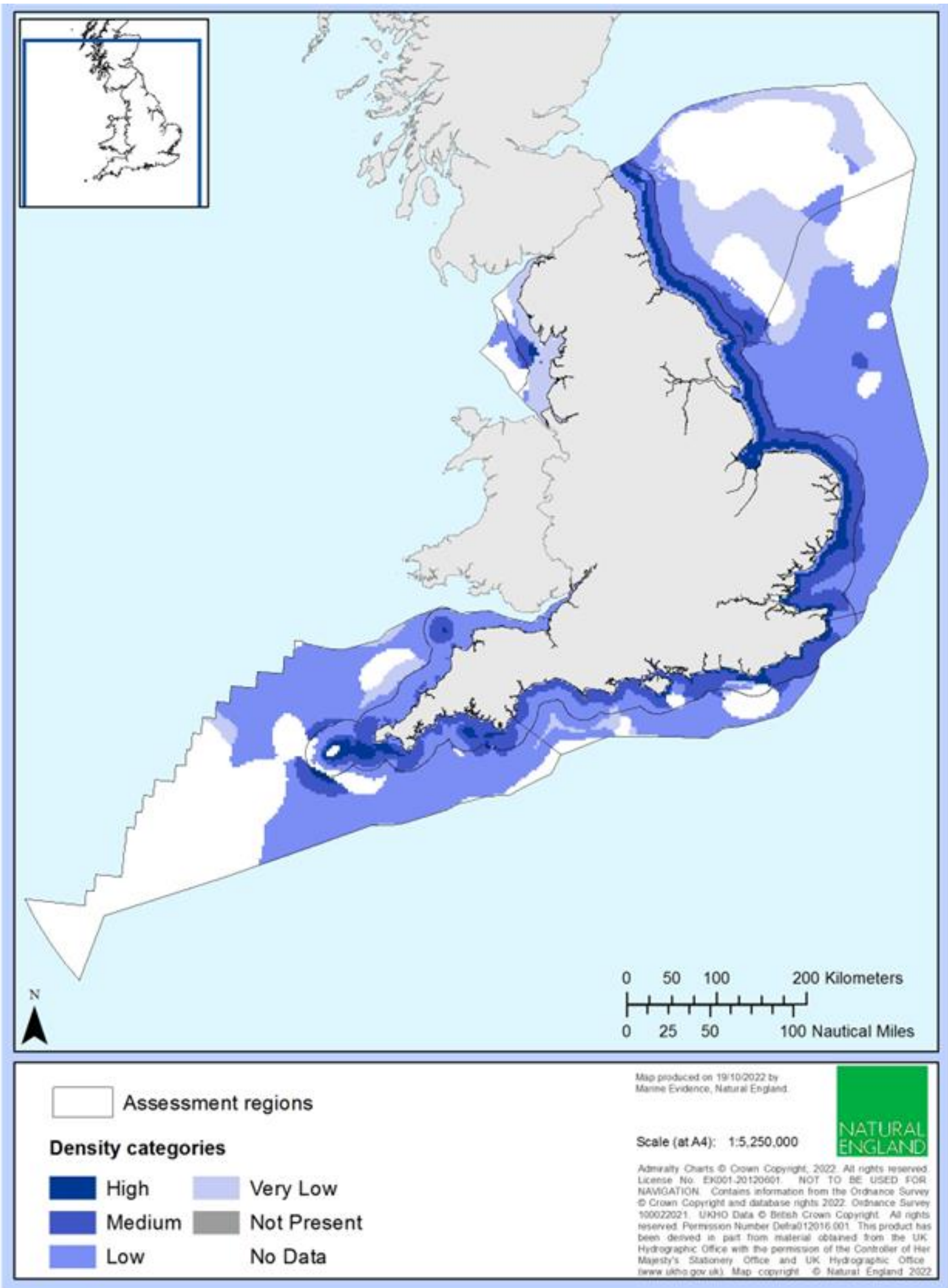
Map 30: Common (Mew) gull - breeding



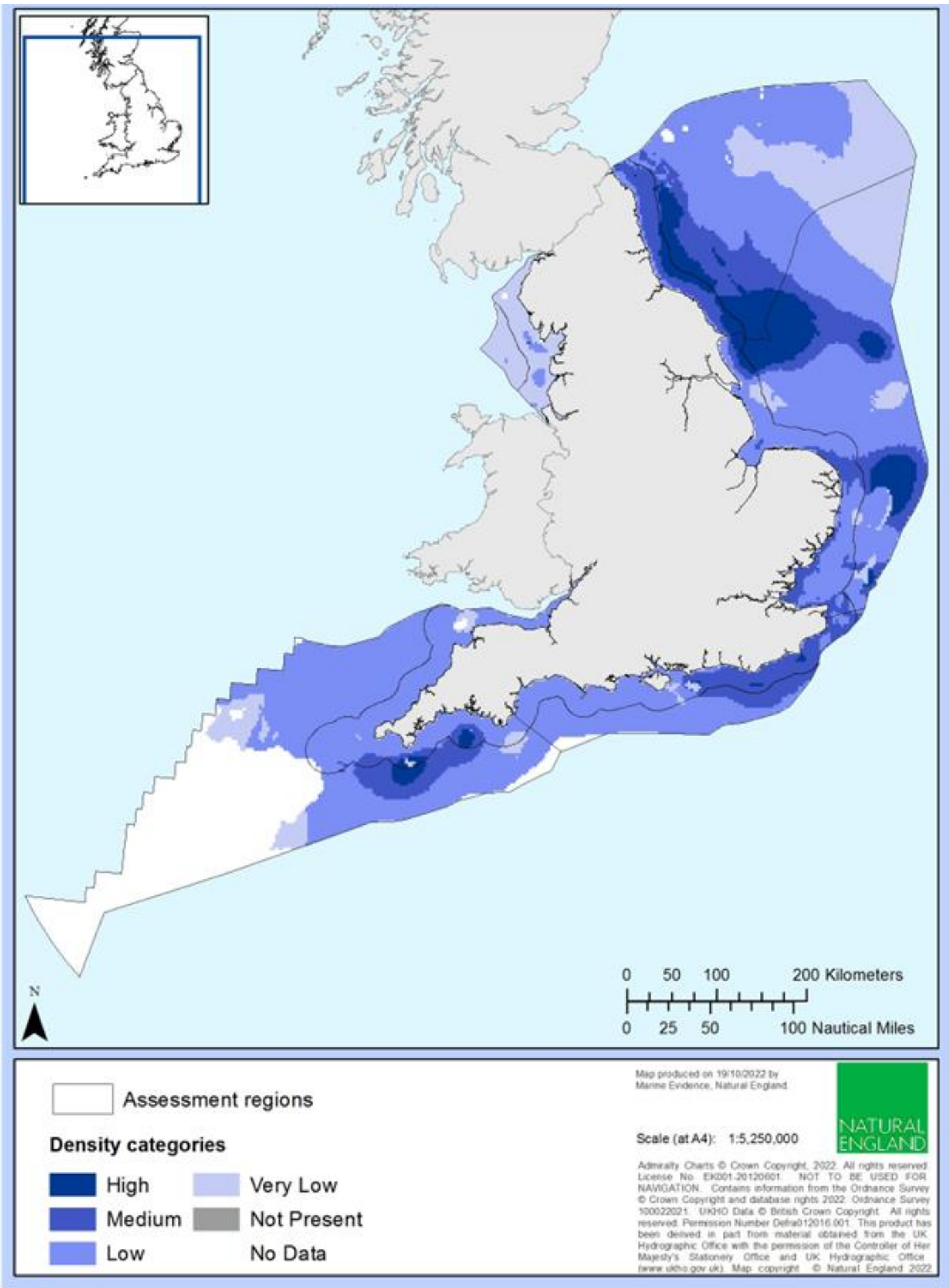
Map 31: Common (Mew) gull - non-breeding



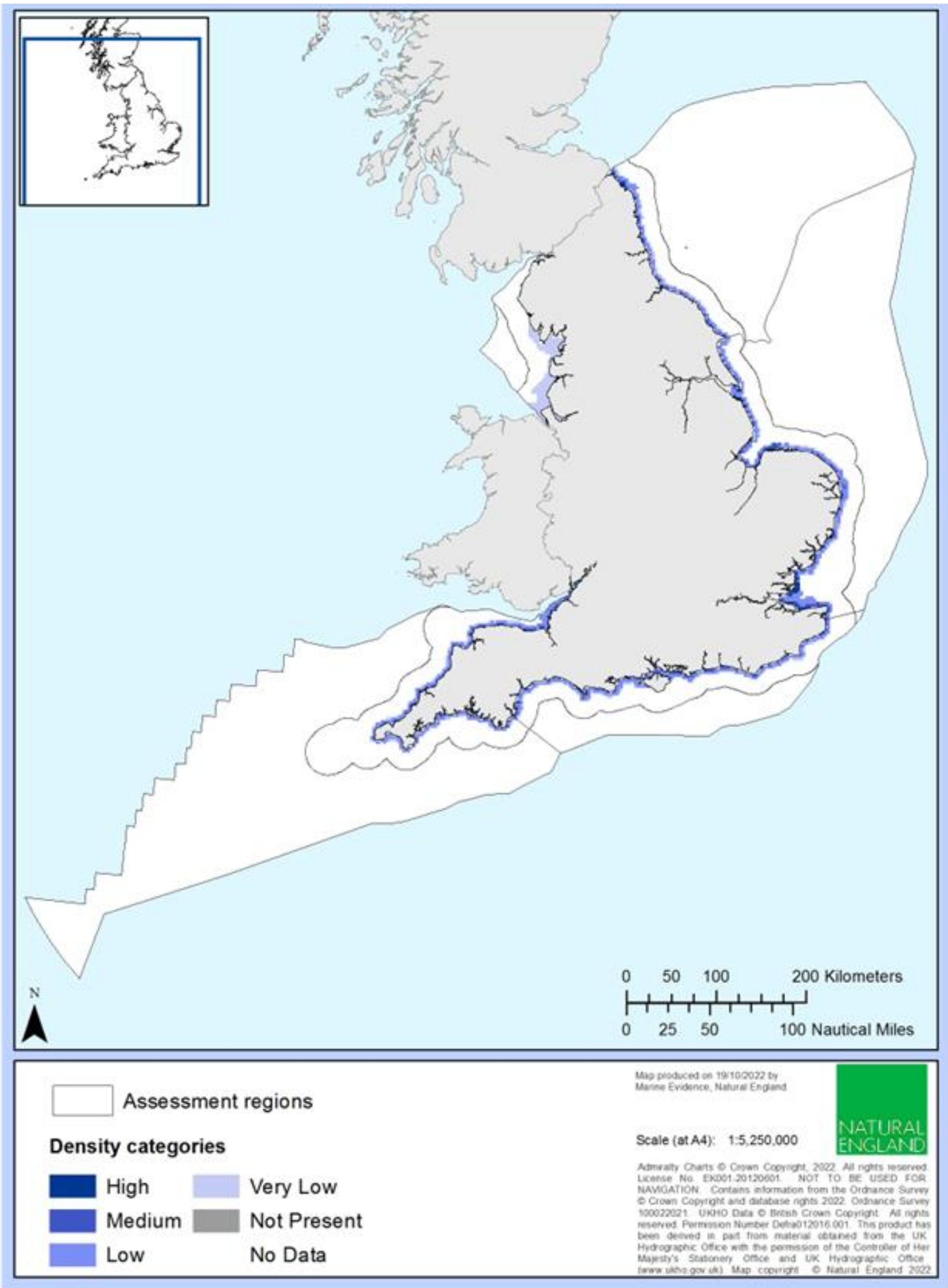
Map 32: Great black-backed gull - breeding


0 50 100 200 Kilometers
0 25 50 100 Nautical Miles
N
Assessment regions
Density categories
High
Medium
Low
Very Low
Not Present
No Data
Map produced on 19/10/2022 by Marine Evidence, Natural England.
Scale (at A4): 1:5,250,000
NATURAL ENGLAND

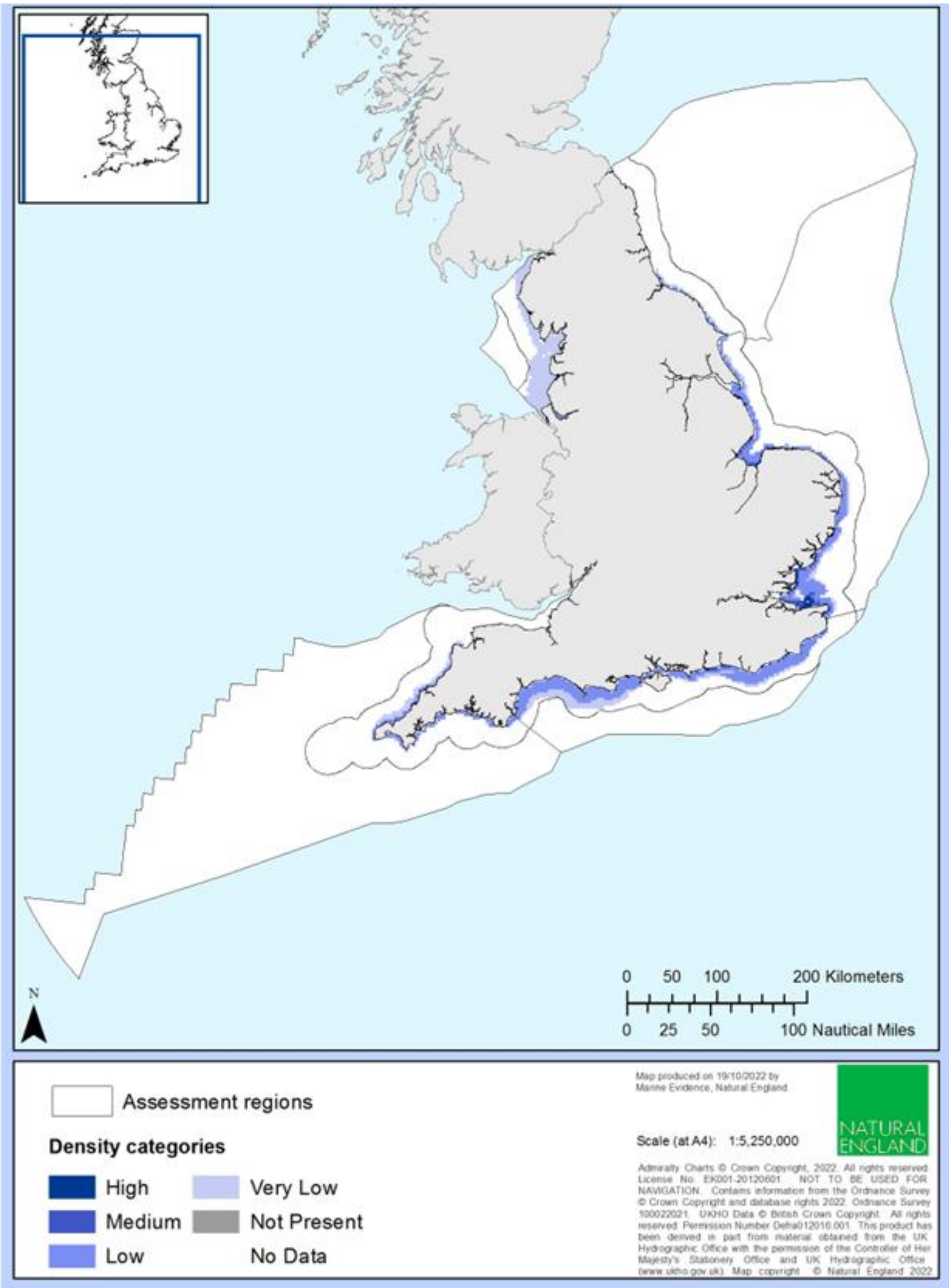
Map 33: Great black-backed gull – non-breeding



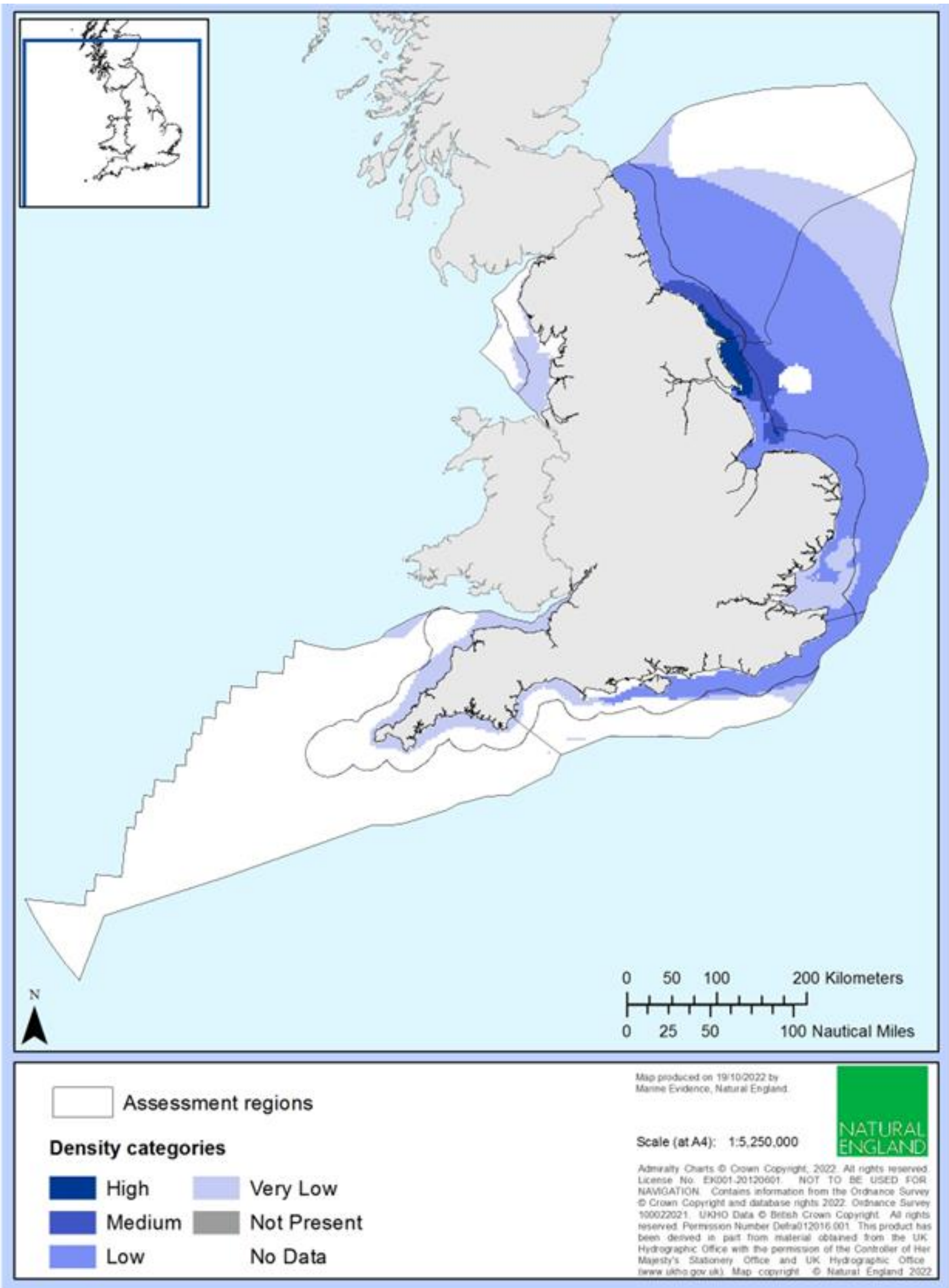
Map 34: Great cormorant - breeding



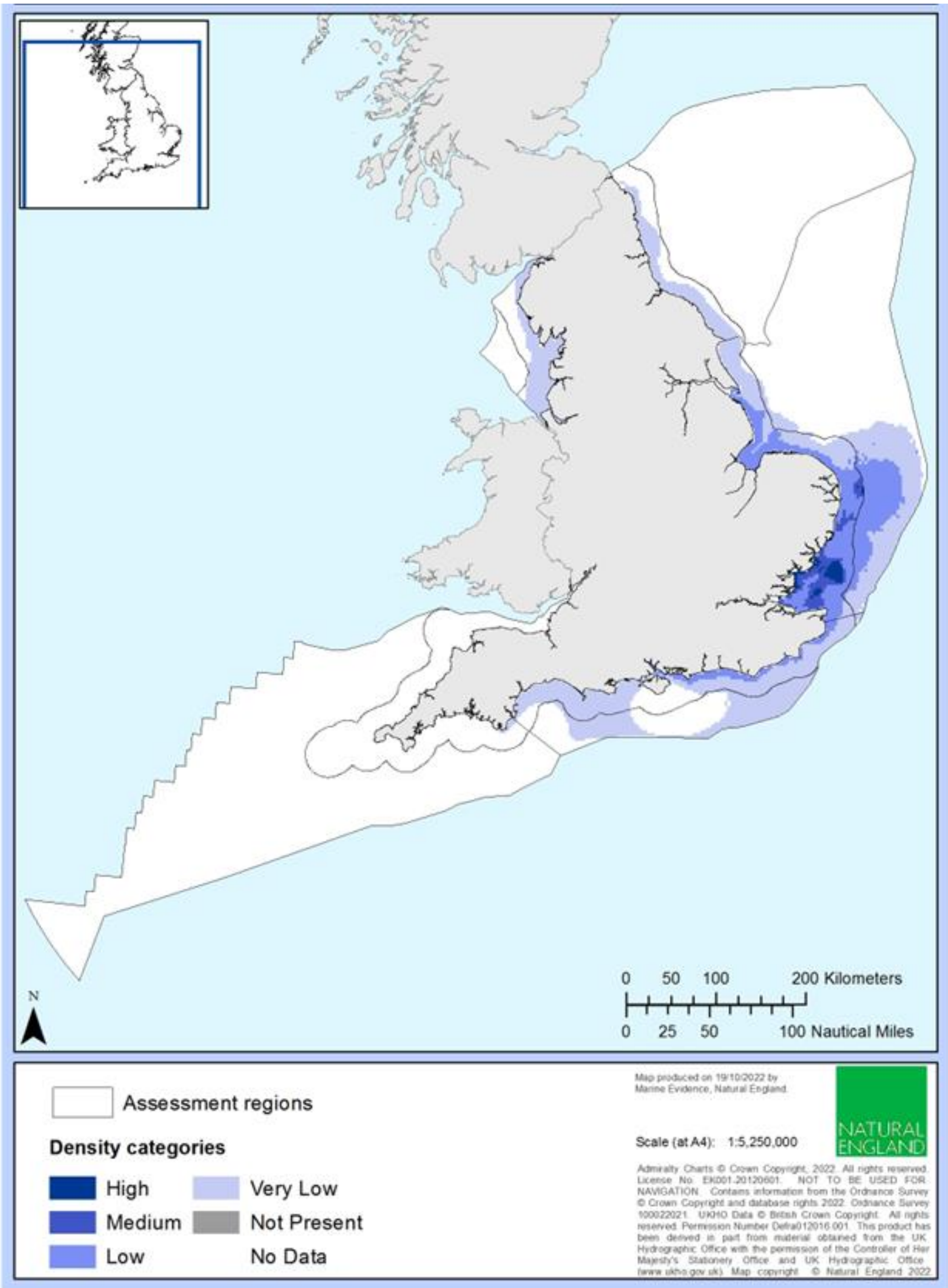
Map 35: Great cormorant non-breeding



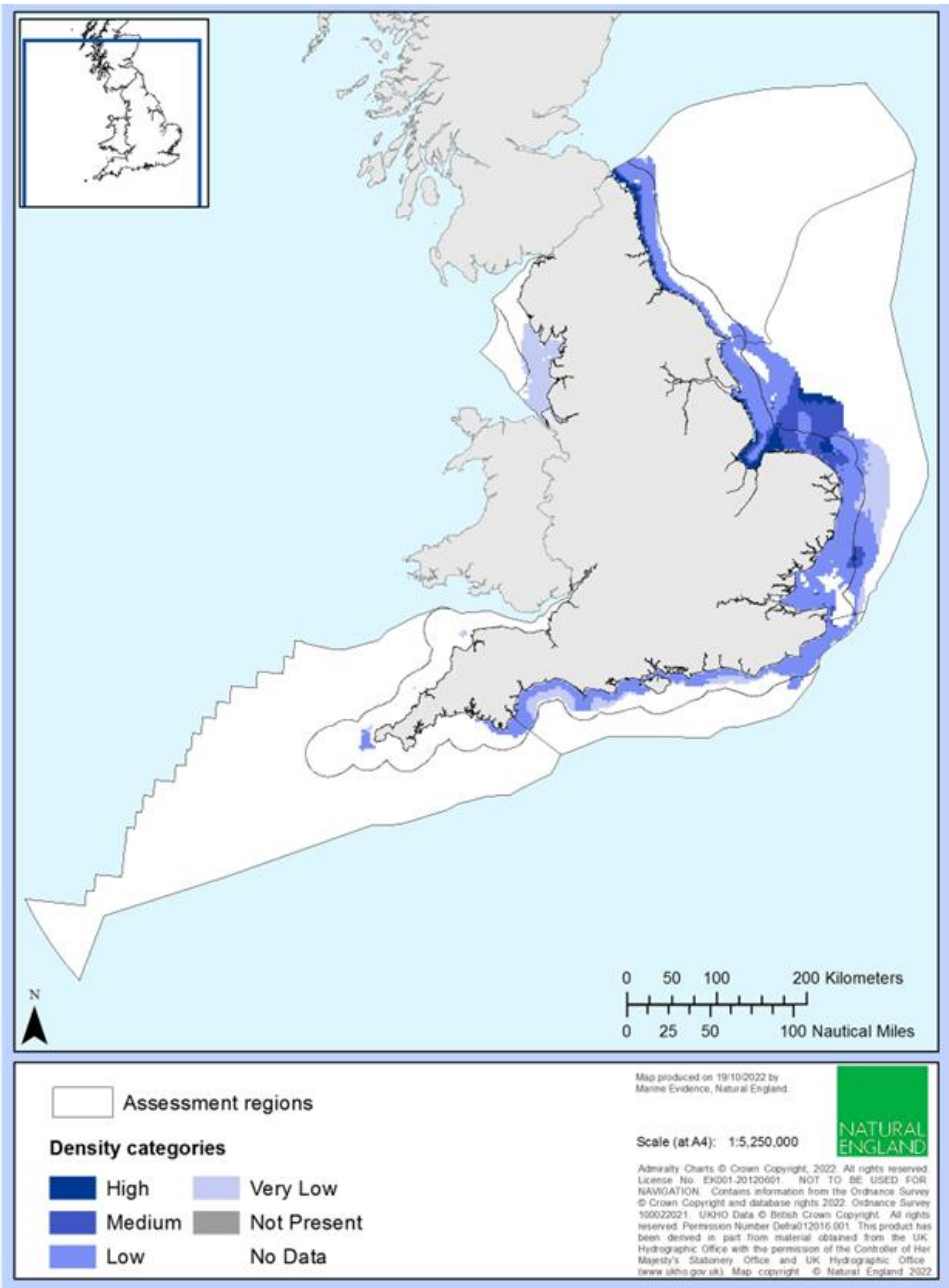
Map 36: Little gull - non-breeding



Map 37: Red-throated diver - non-breeding

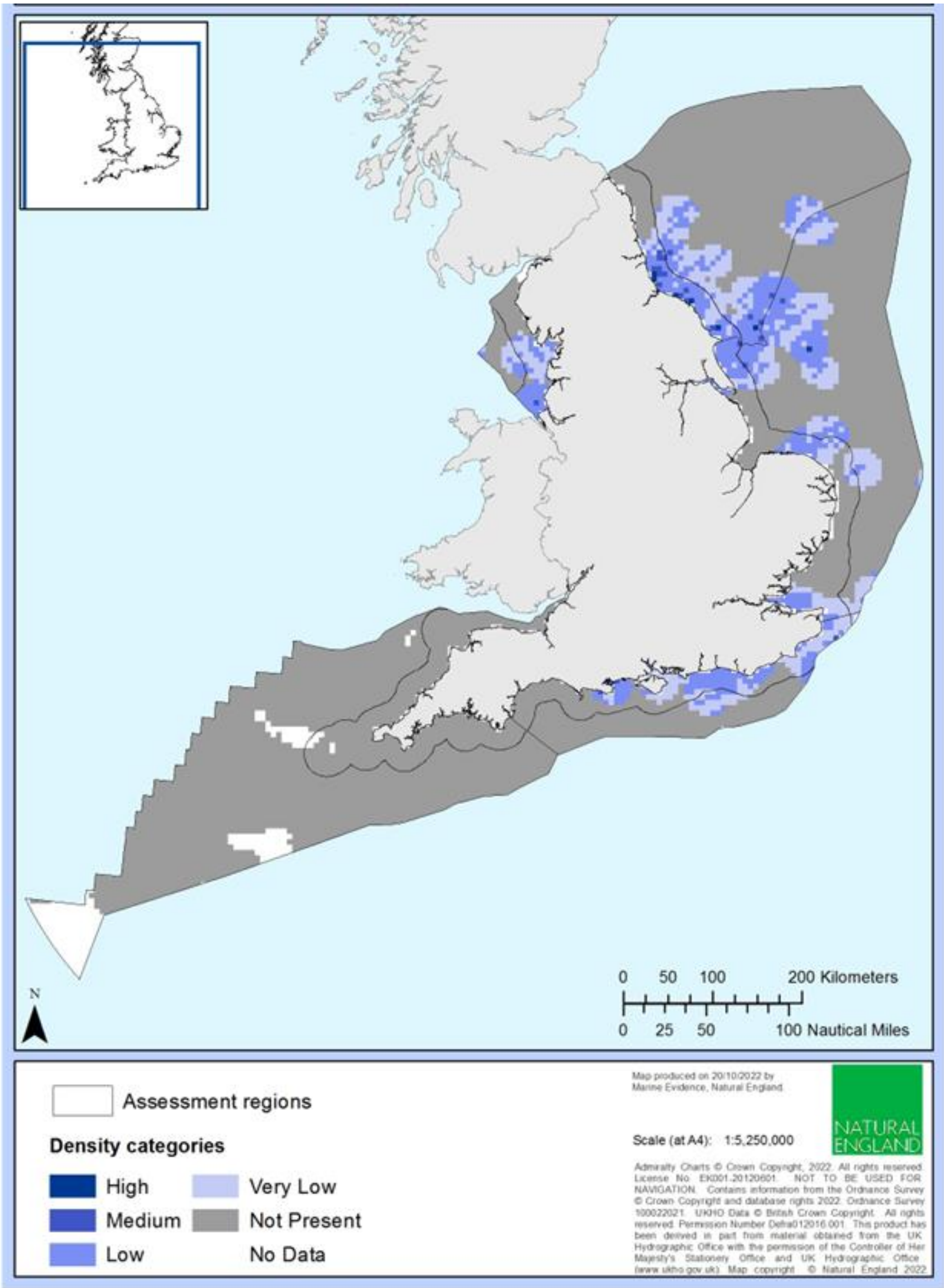


Map 38: Sandwich tern - breeding

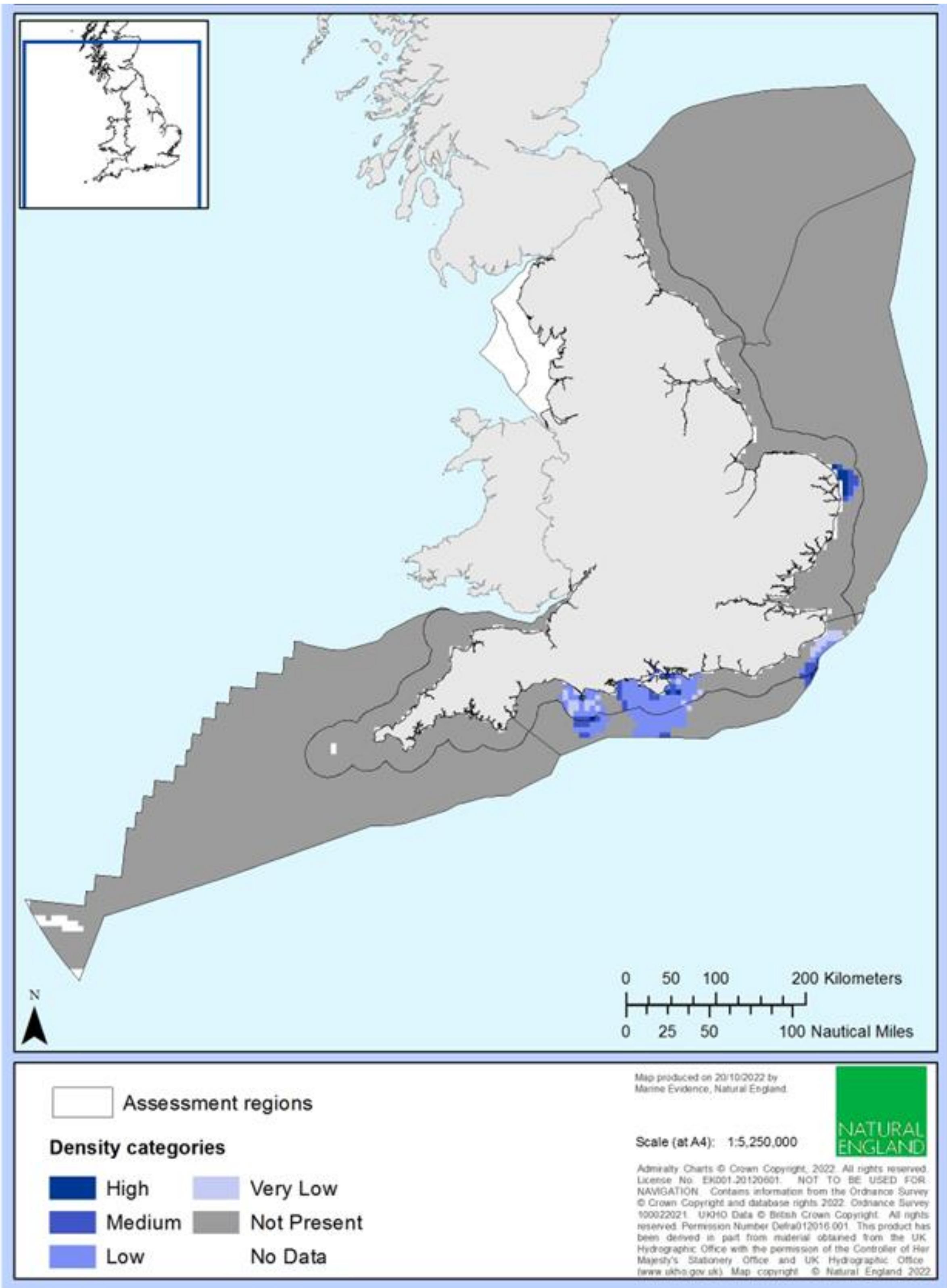


ESAS European Seabirds at Sea (ESAS)

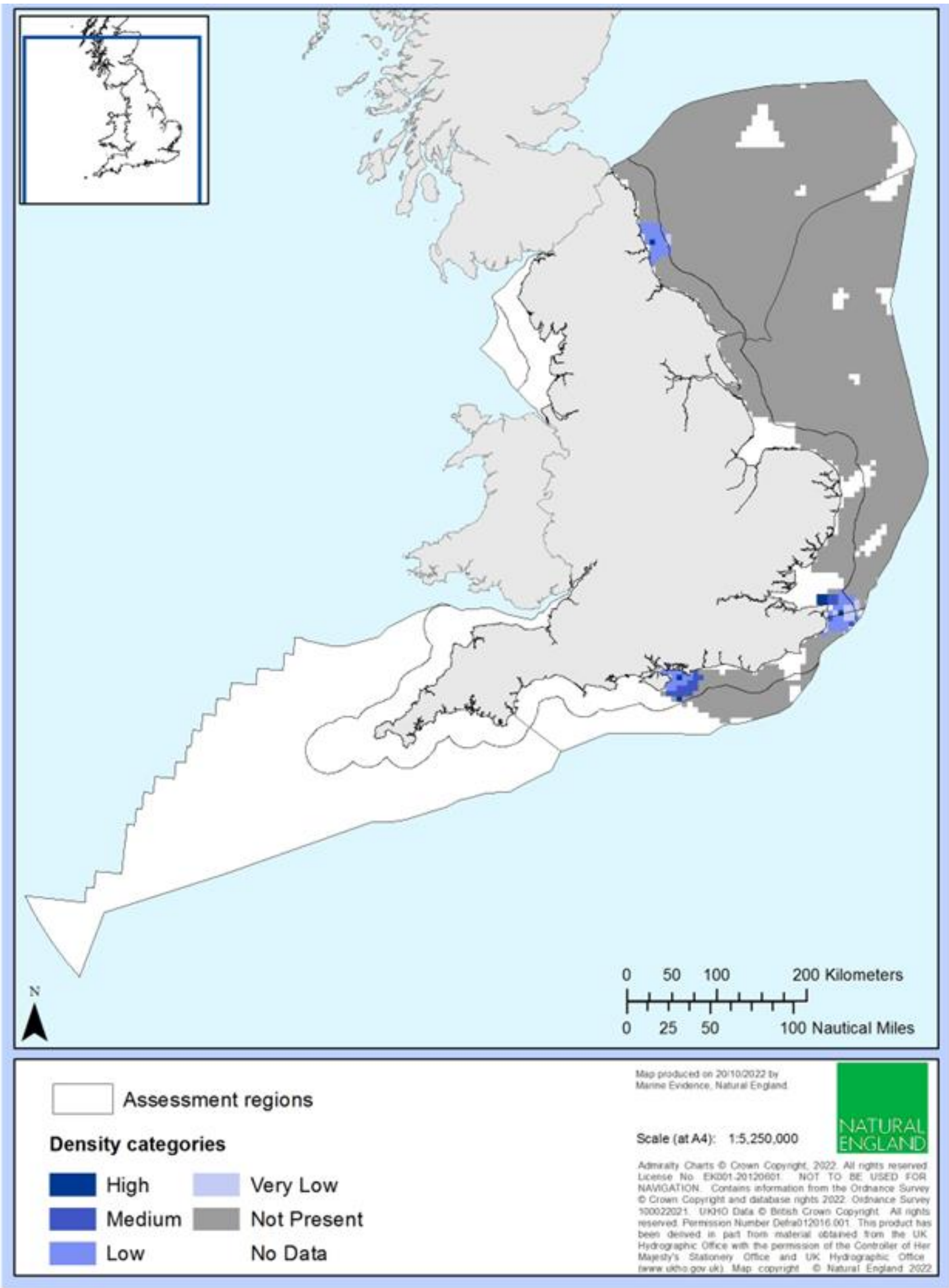
Map 39: Little gull - non-breeding, passage



Map 40: Mediterranean gull - non-breeding

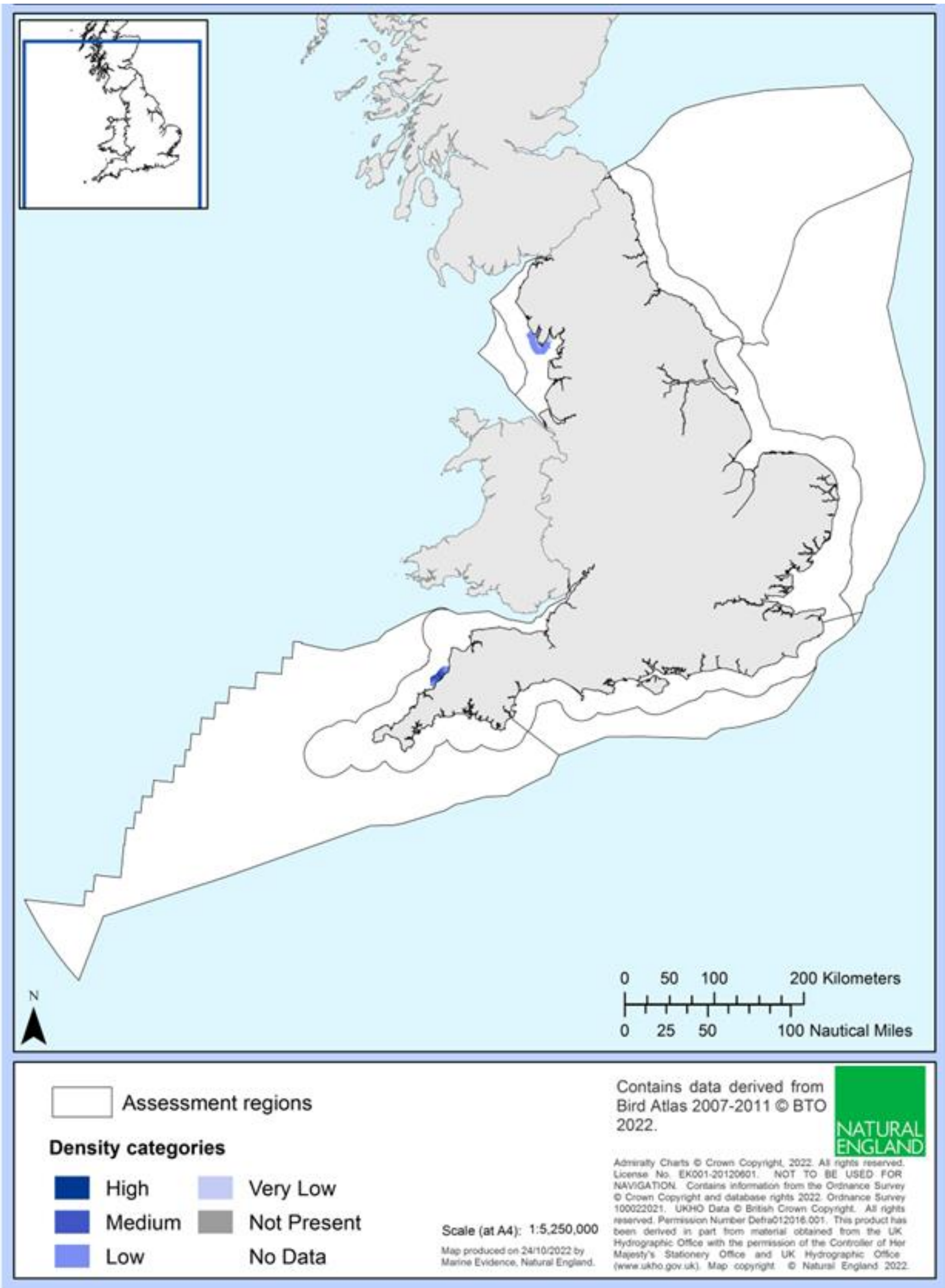


Map 41: Sandwich tern - non-breeding, passage

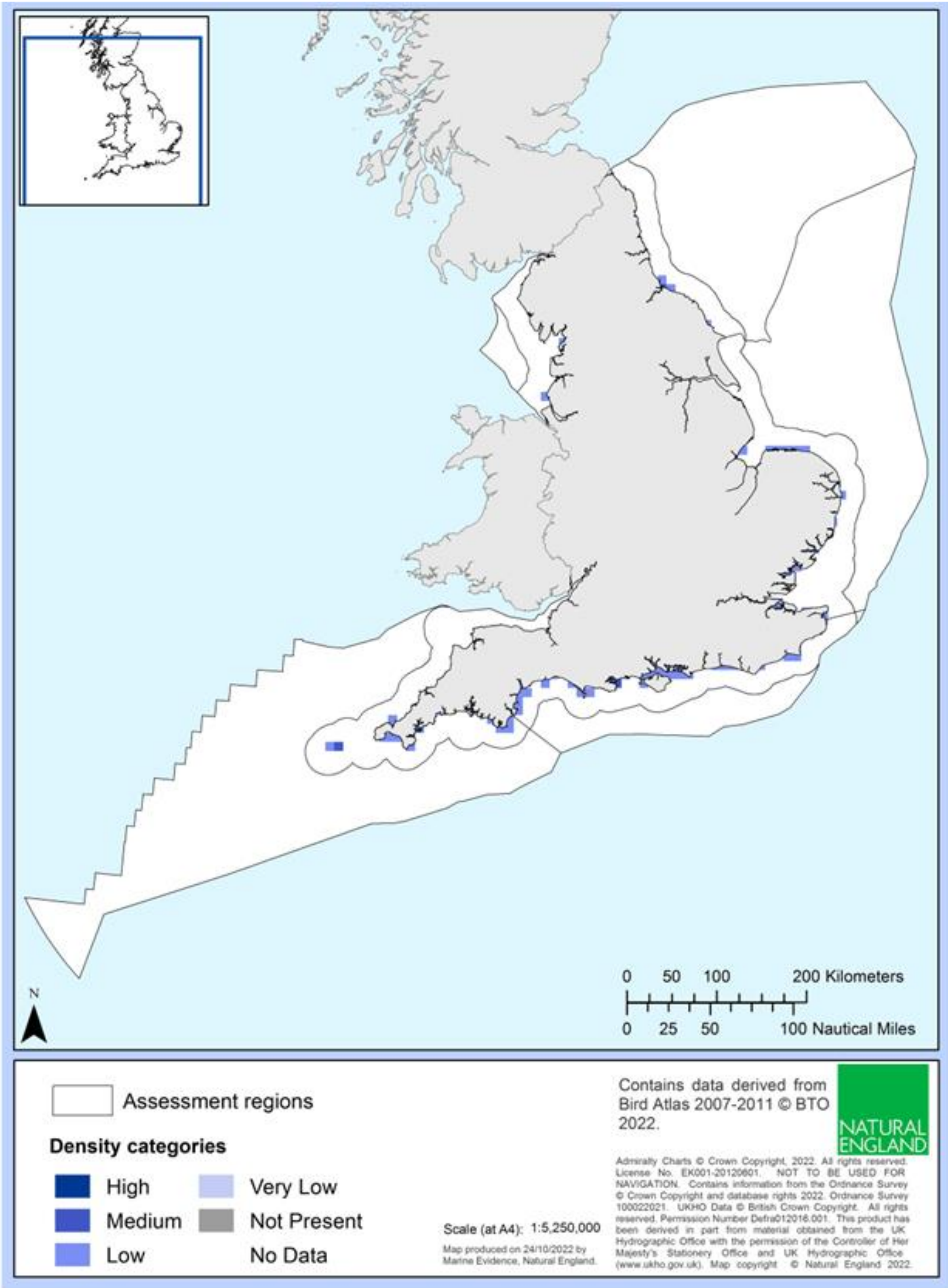


British Trust for Ornithology, Bird Atlas 2007-2011 categorised density distribution maps

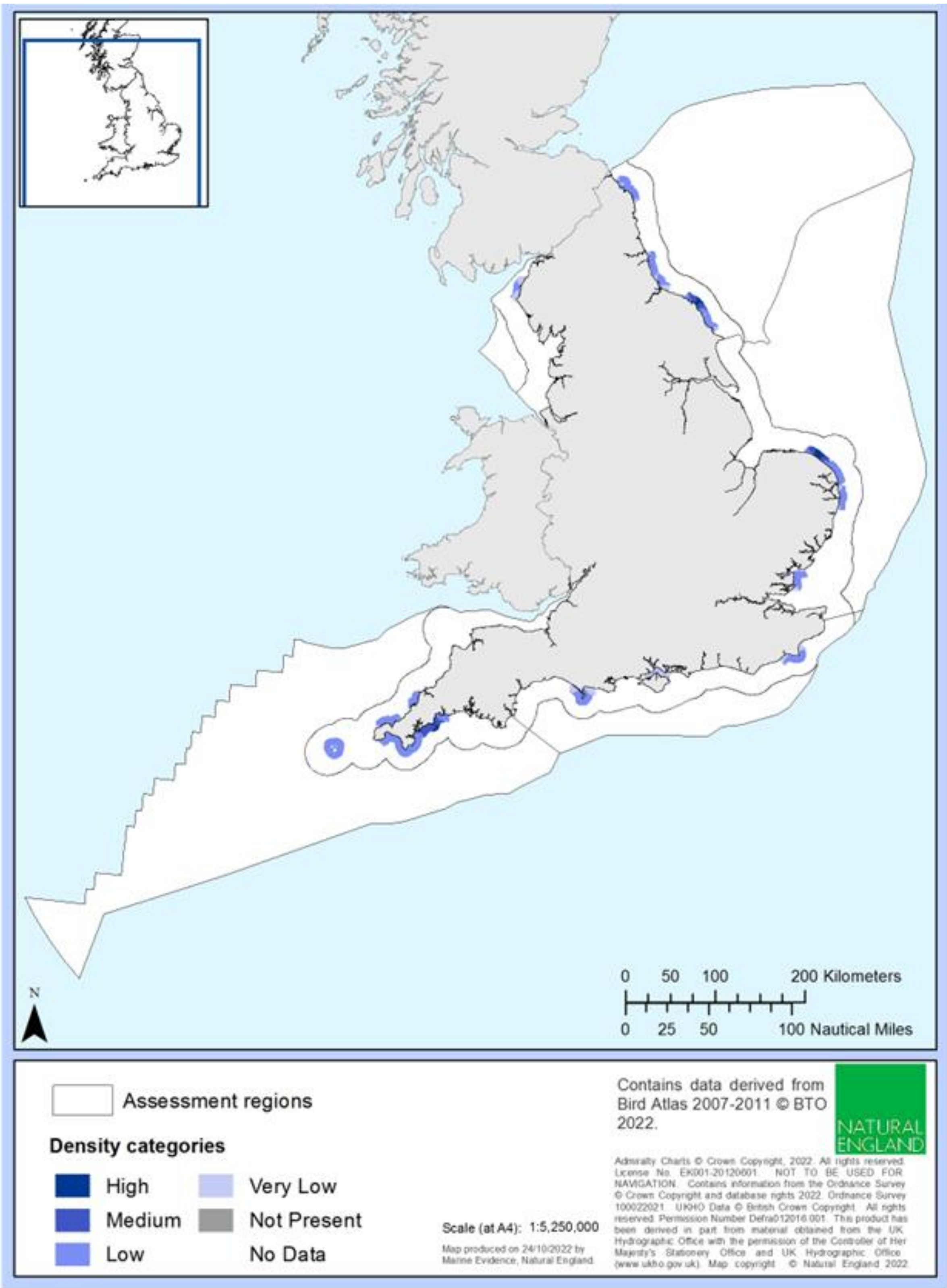
Map 42: Black guillemot -non-breeding



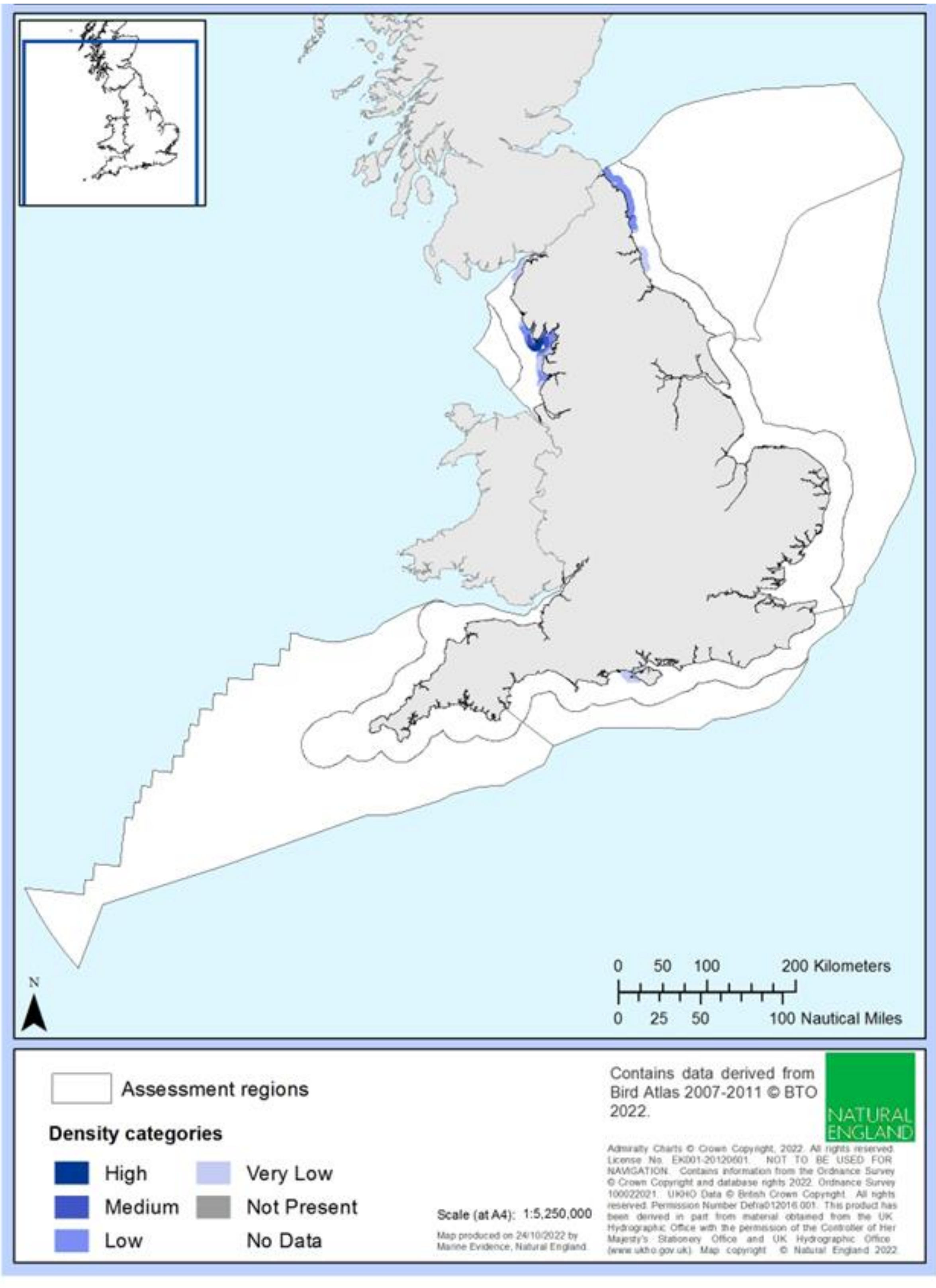
Map 43: Black-necked grebe - non-breeding



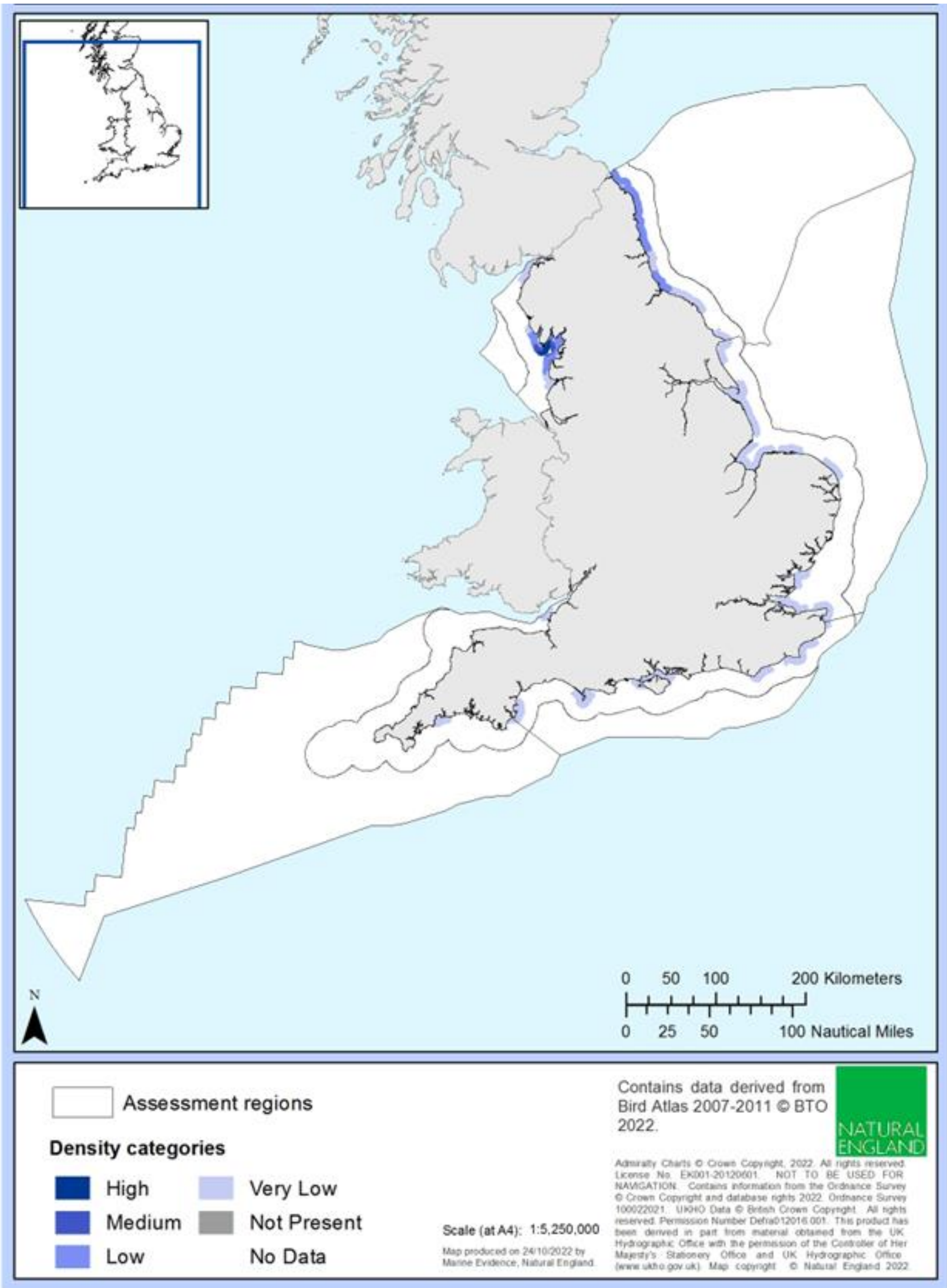
Map 44: Black-throated diver - non-breeding



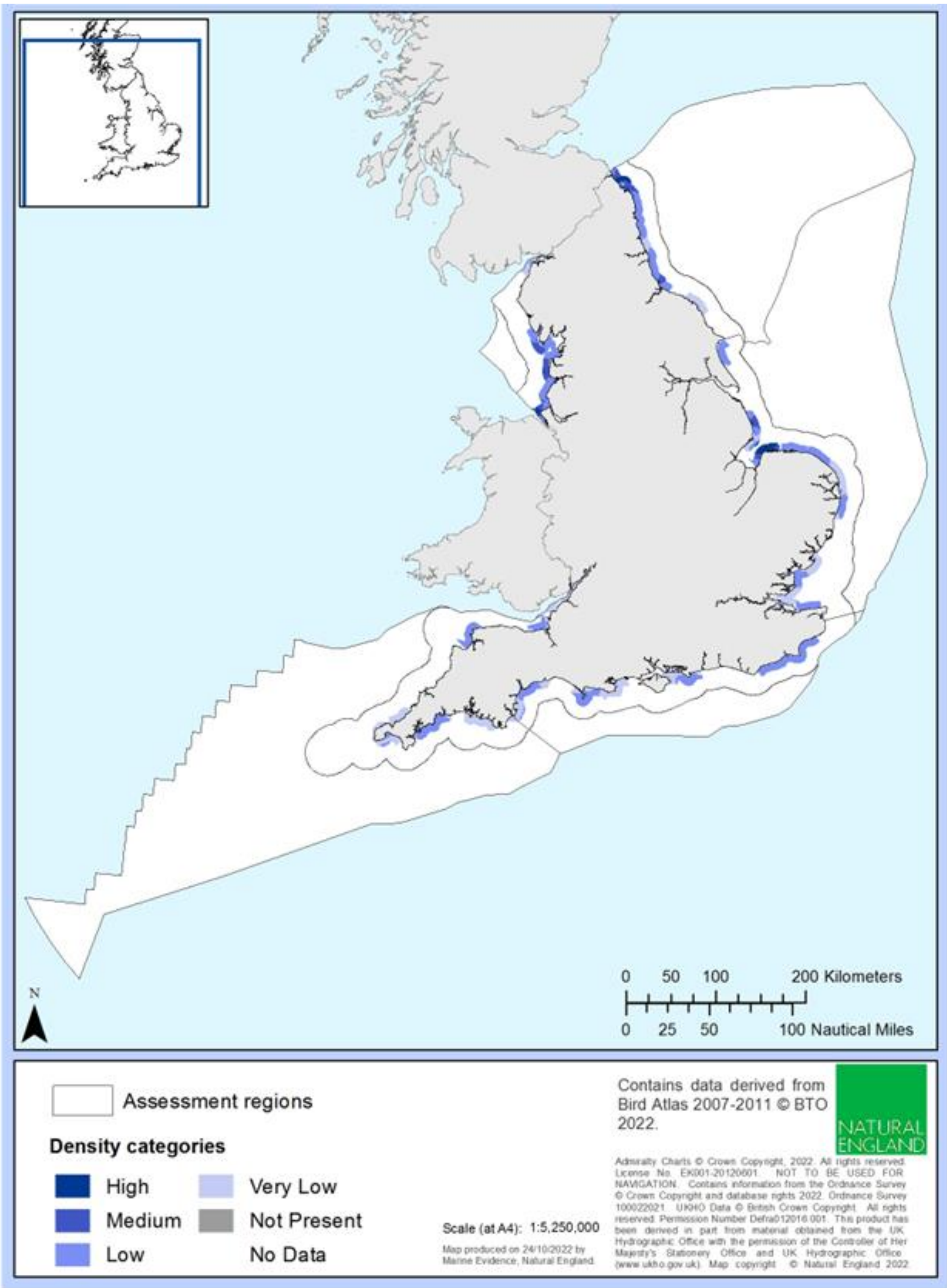
Map 45: Common eider - breeding



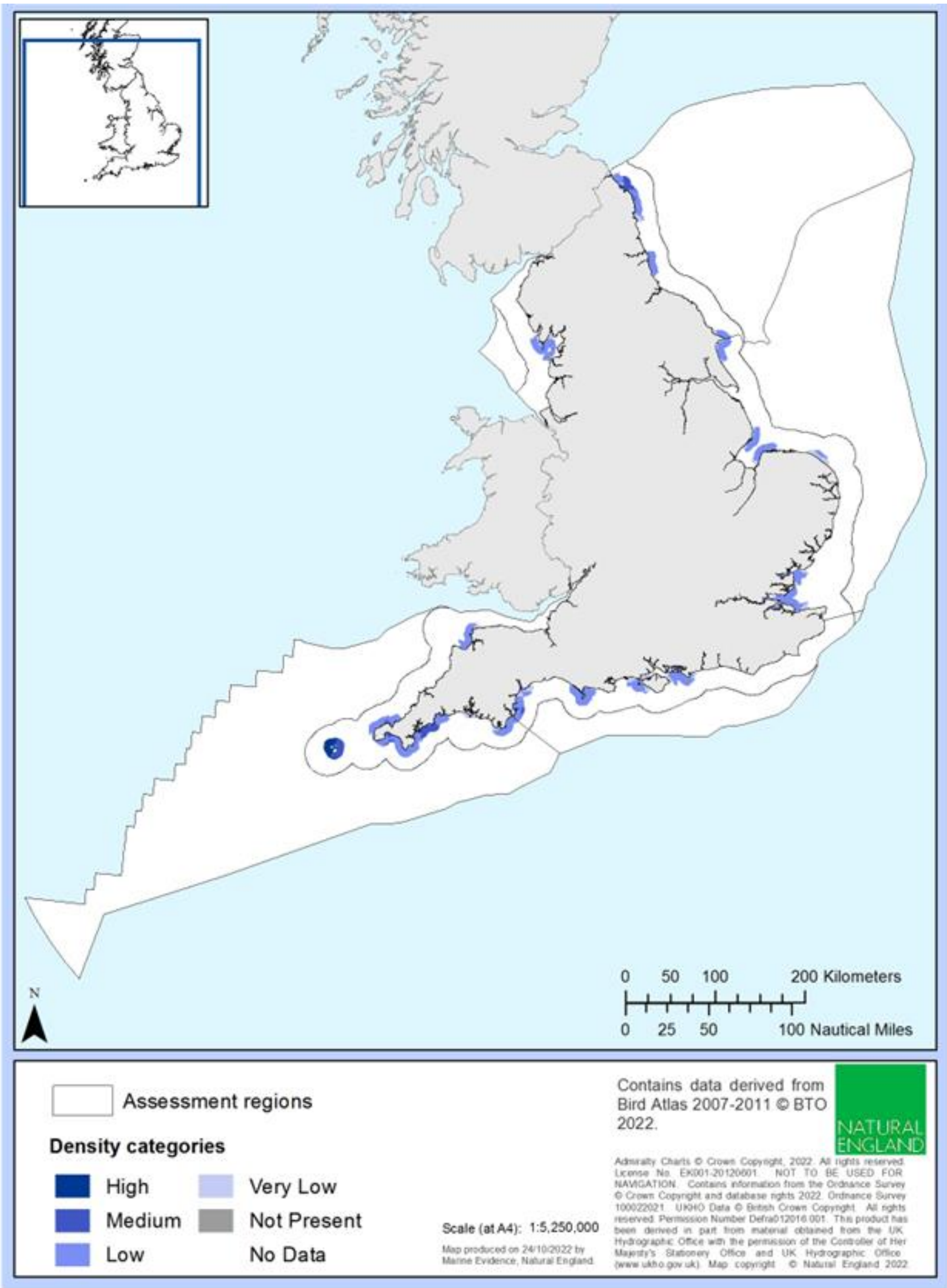
Map 46: Common eider - non-breeding



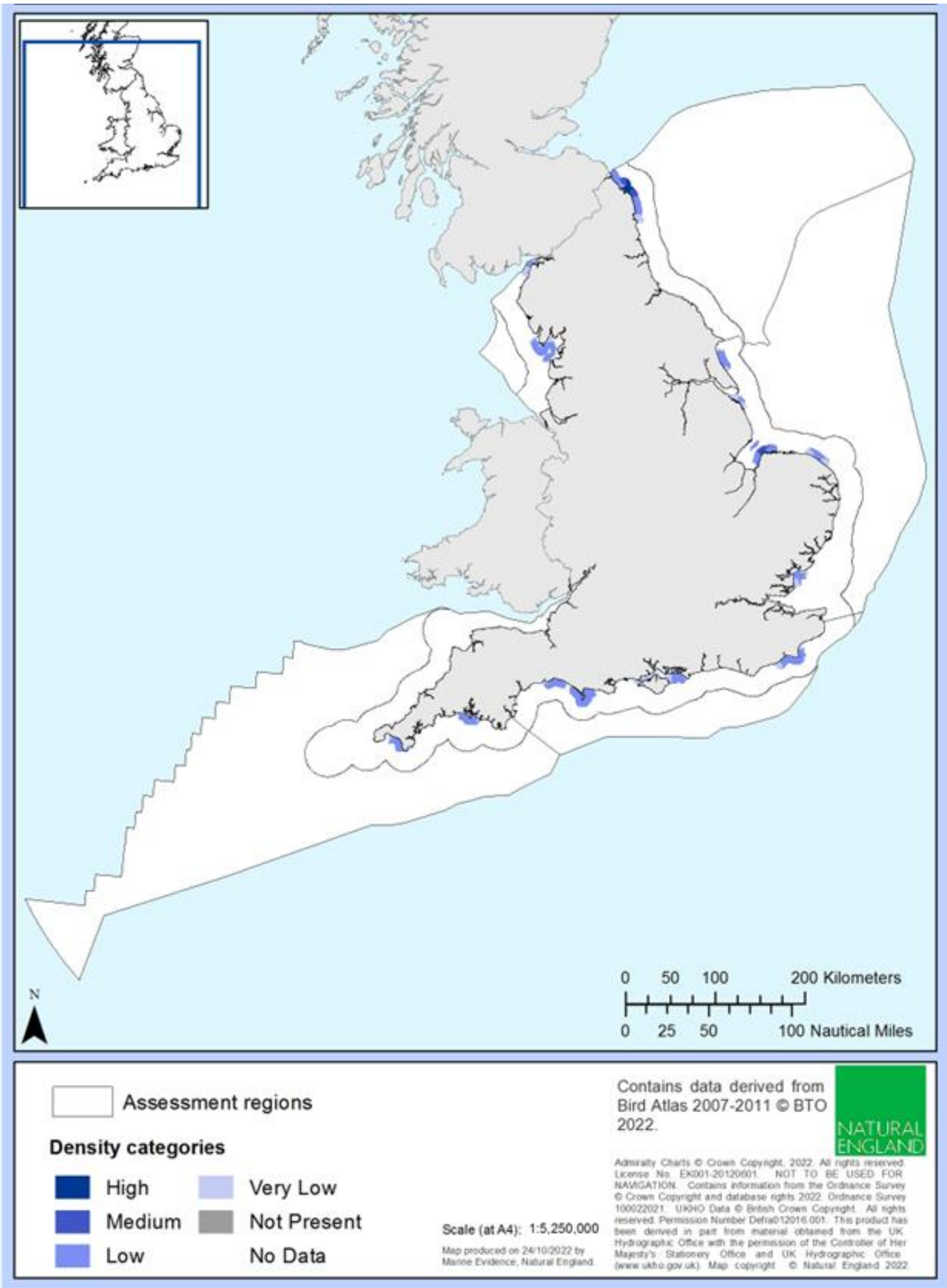
Map 47: Common scoter - non-breeding



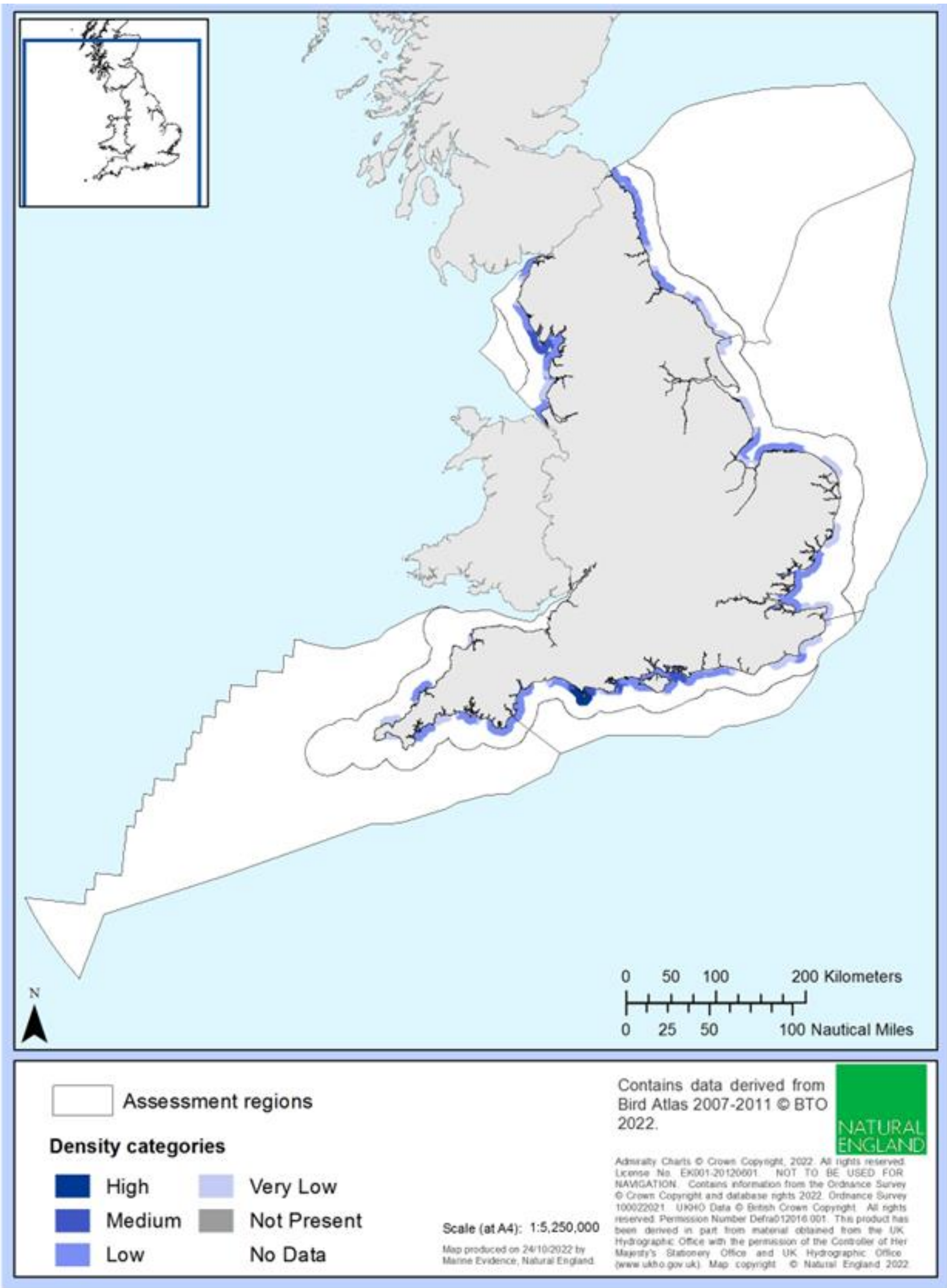
Map 48: Great northern diver - non-breeding


0 50 100 200 Kilometers
0 25 50 100 Nautical Miles
N
Assessment regions
Density categories
High
Medium
Low
Very Low
Not Present
No Data
Scale (at A4): 1:5,250,000
Map produced on 24/10/2022 by Marine Evidence, Natural England
Contains data derived from Bird Atlas 2007-2011 © BTO 2022.
NATURAL ENGLAND
Admiralty Charts © Crown Copyright, 2022. All rights reserved. License No. EK001-20120601. NOT TO BE USED FOR NAVIGATION. Contains information from the Ordnance Survey © Crown Copyright and database rights 2022. Ordnance Survey 100022021. UKHO Data © British Crown Copyright. All rights reserved. Permission Number Defra012016.001. This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). Map copyright © Natural England 2022.

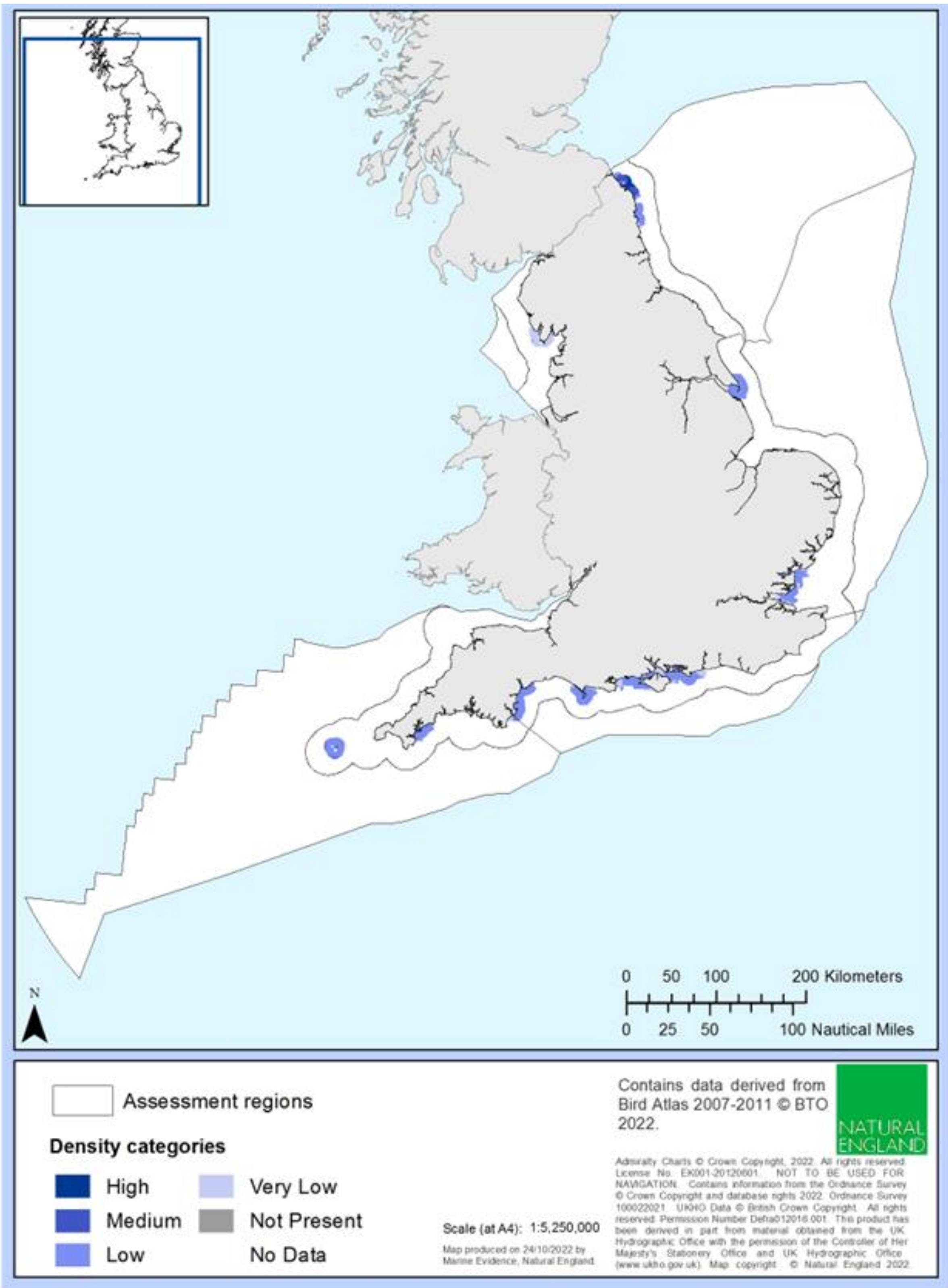
Map 49: Long-tailed duck - non-breeding



Map 50: Red-breasted merganser - non-breeding



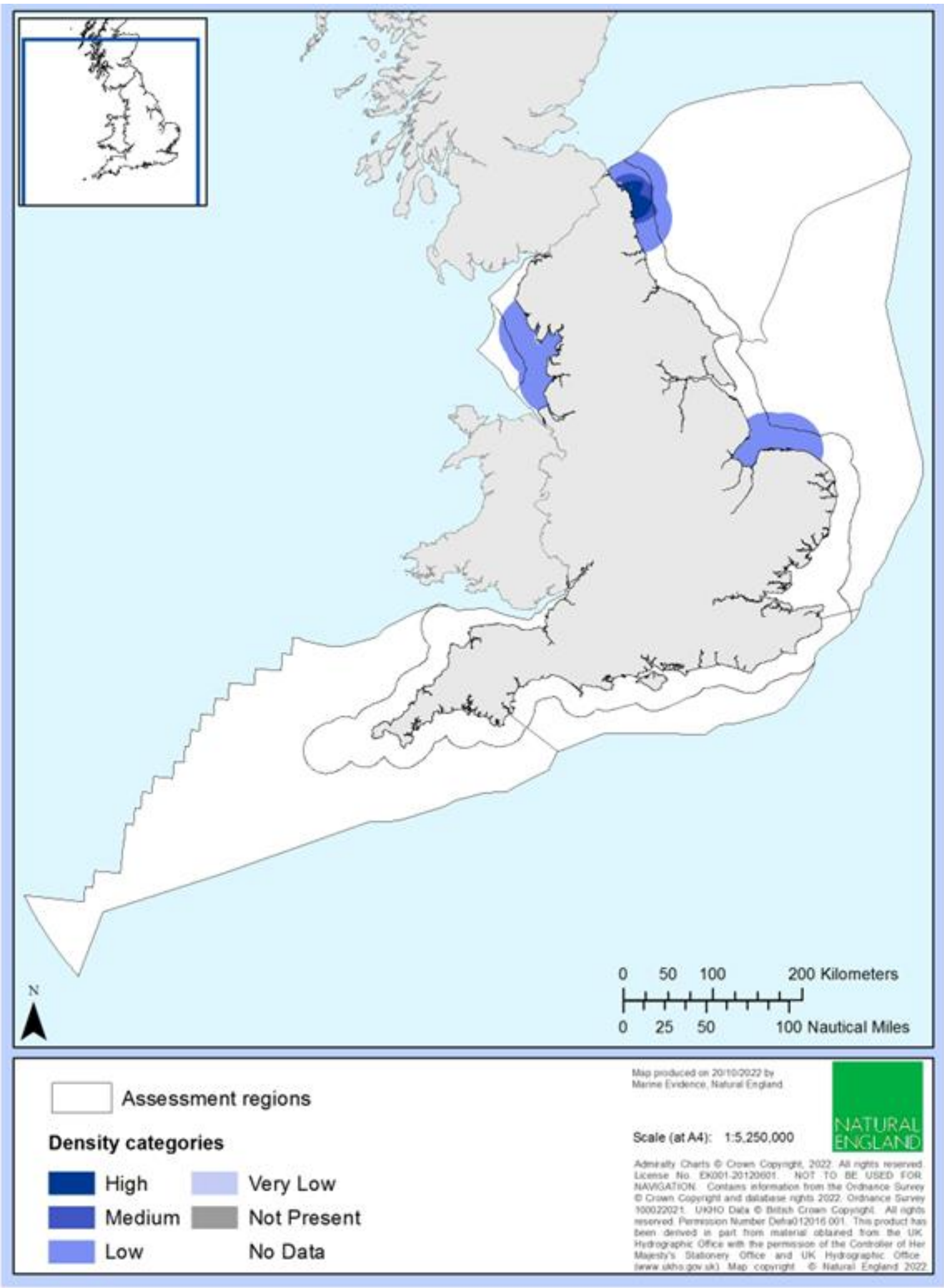
Map 51: Slavonian grebe - non-breeding



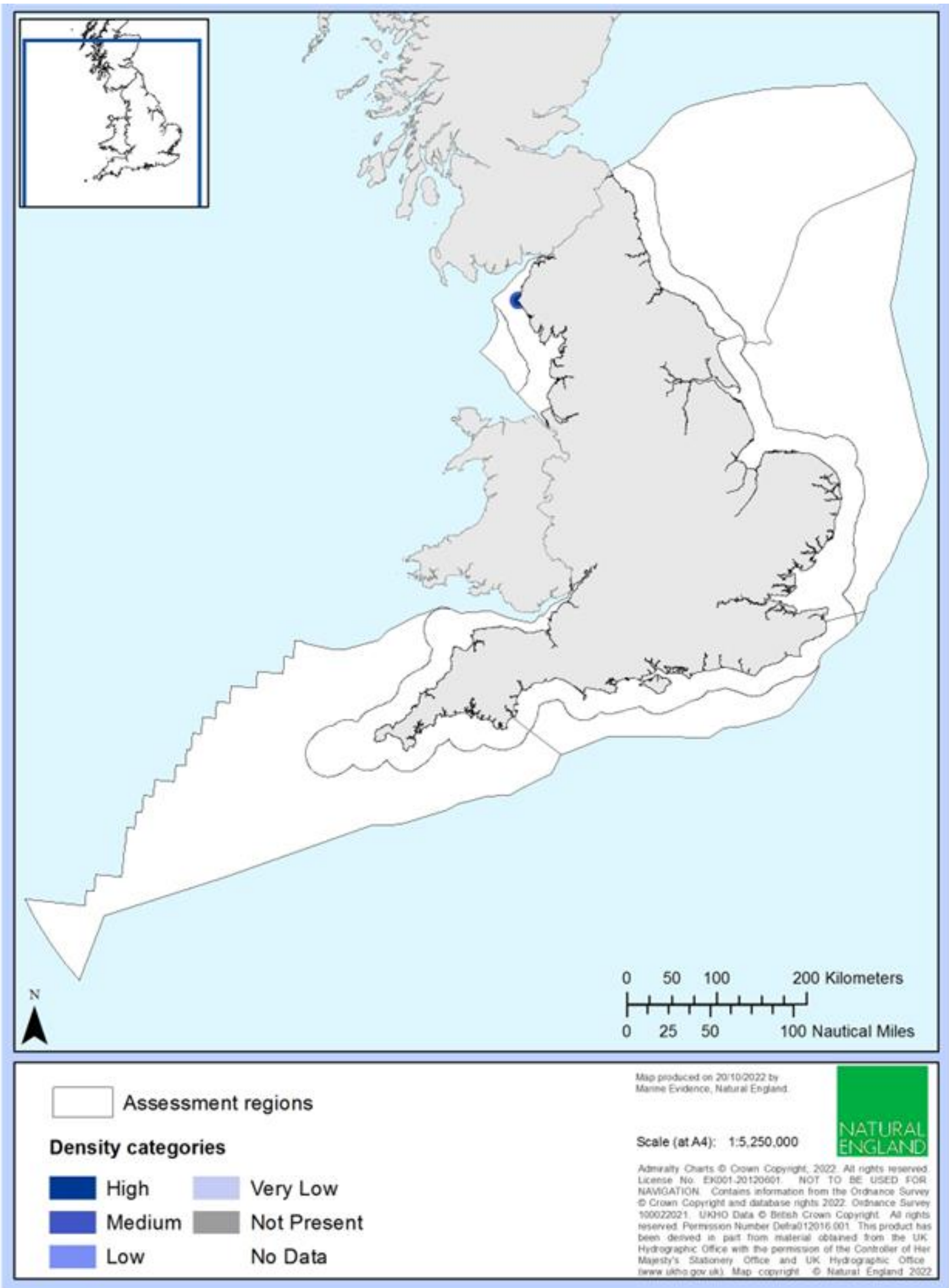
Sea Bird Monitoring Programme foraging radii categorised density distribution maps

Note: Roseate tern has been excluded because it is a Schedule 1 species.

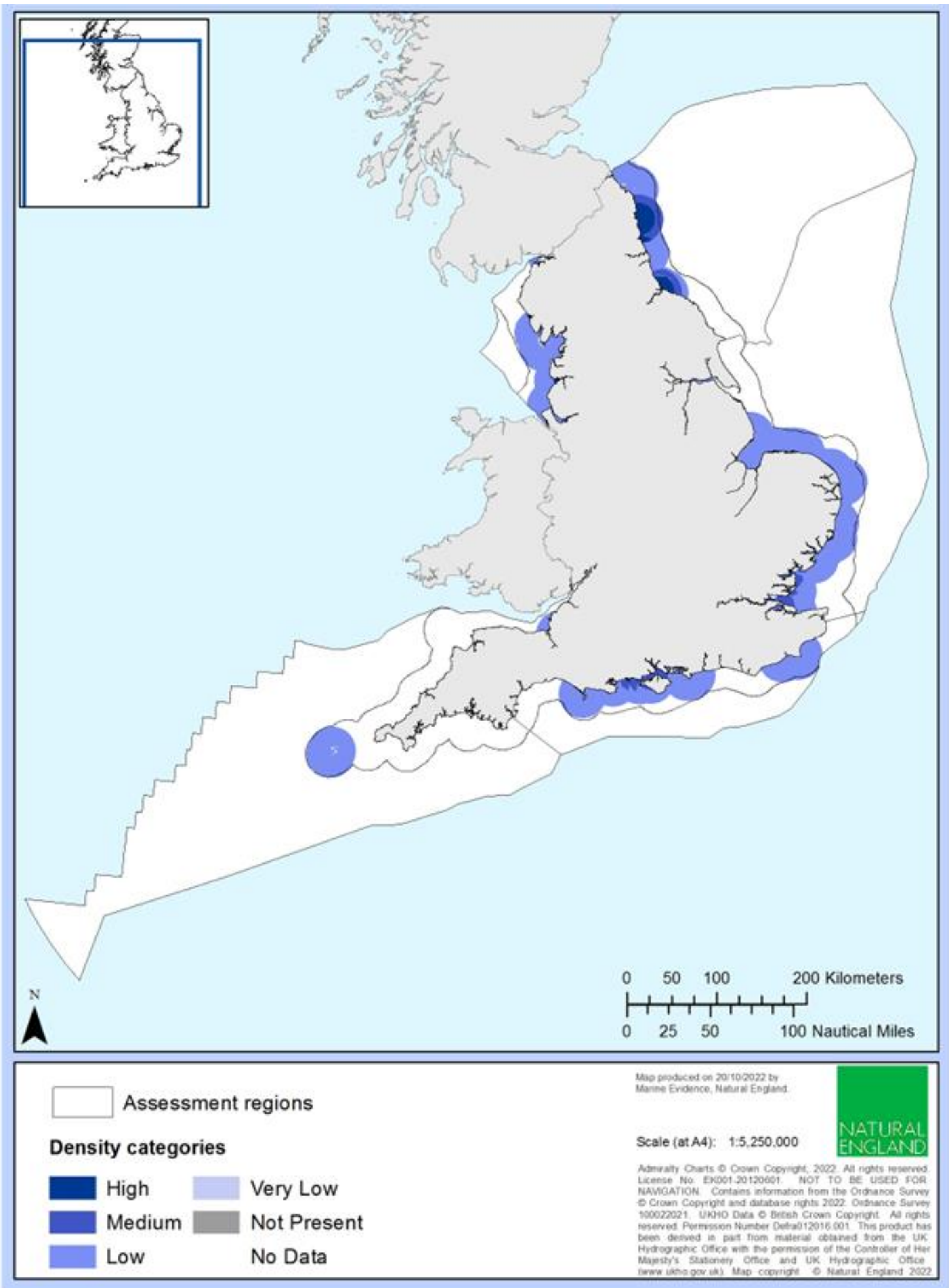
Map 52: Arctic tern - breeding



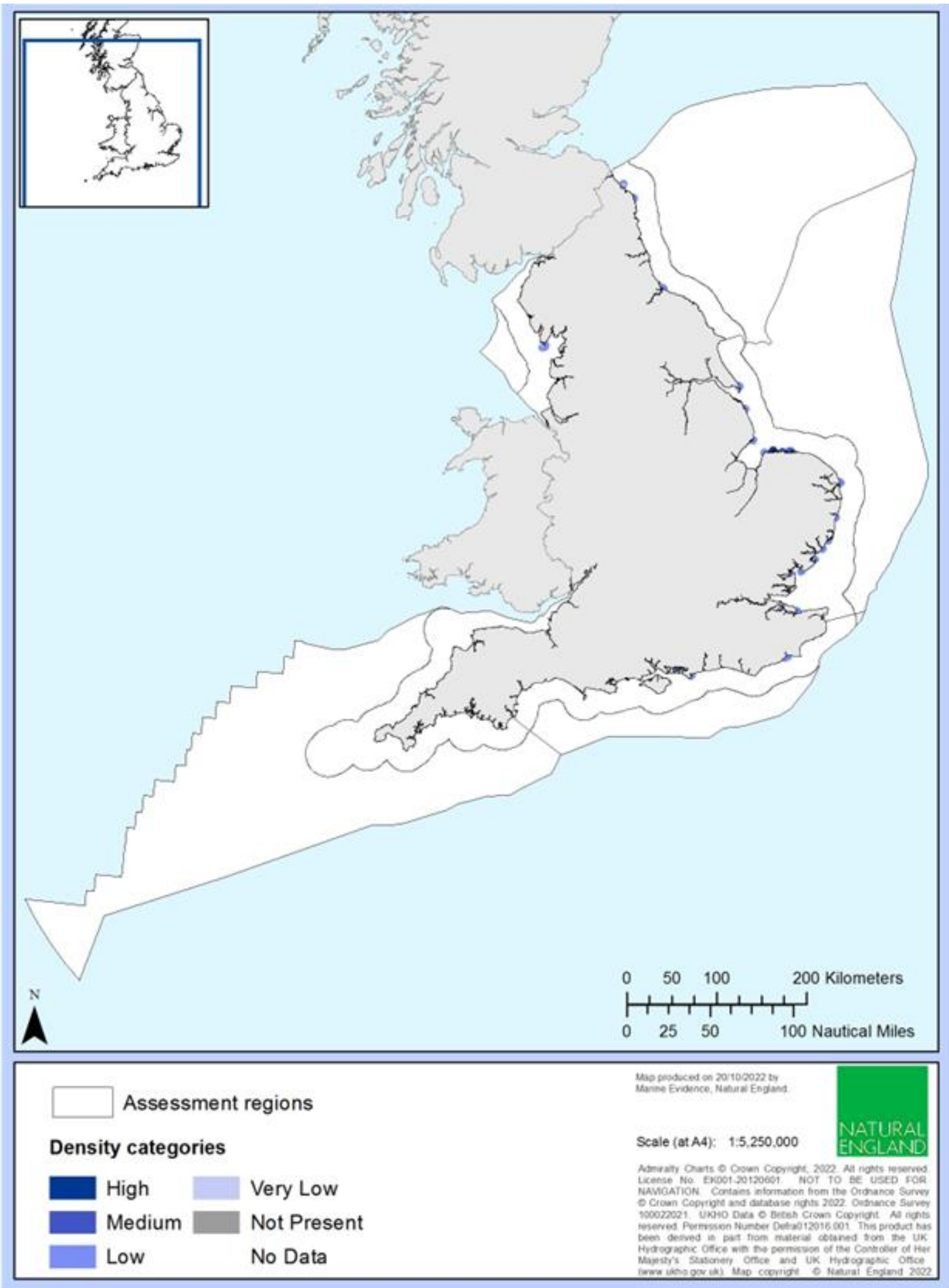
Map 53: Black guillemot - breeding



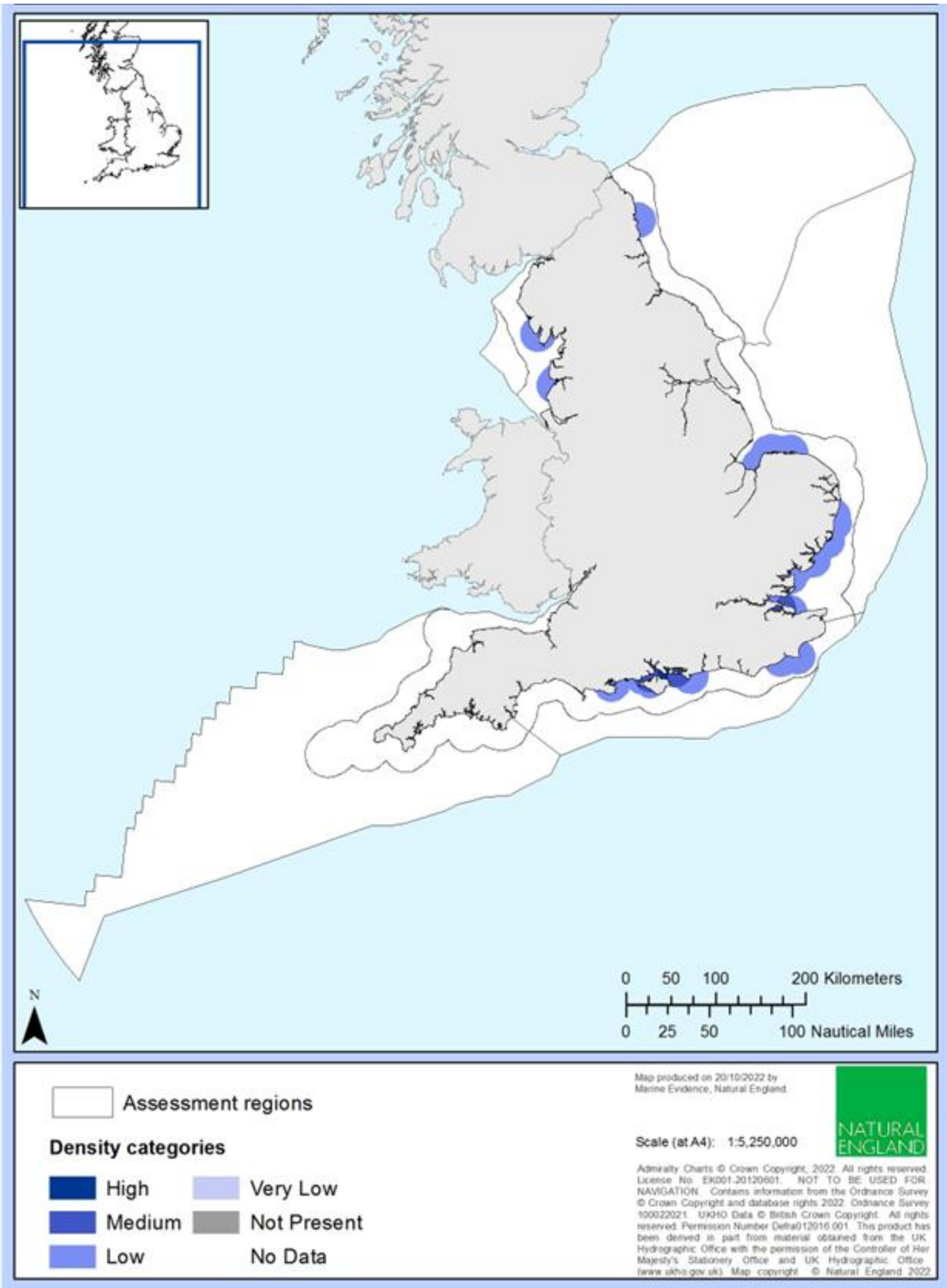
Map 54: Common tern - breeding



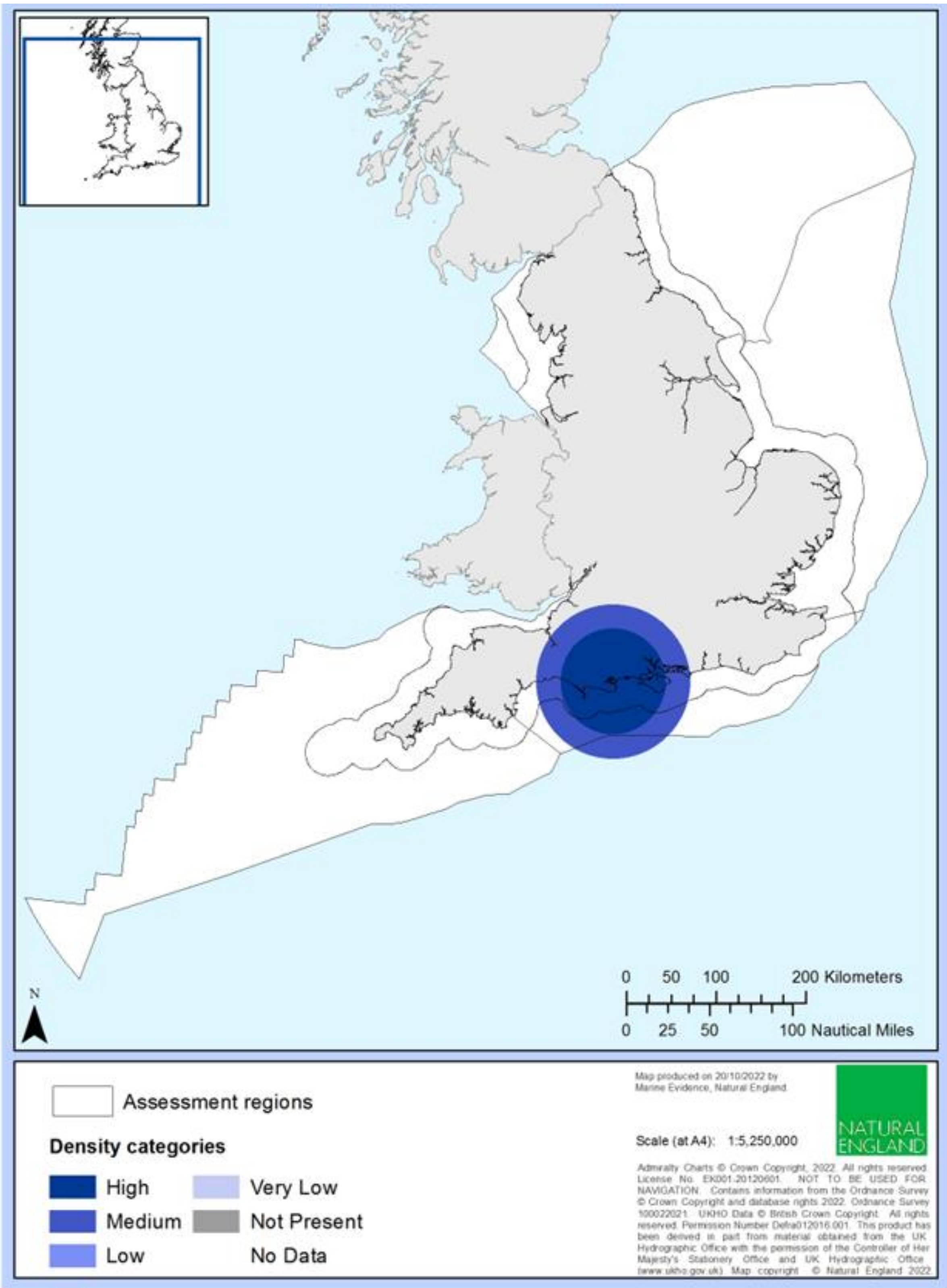
Map 55: Little tern - breeding



Map 56: Mediterranean gull - breeding

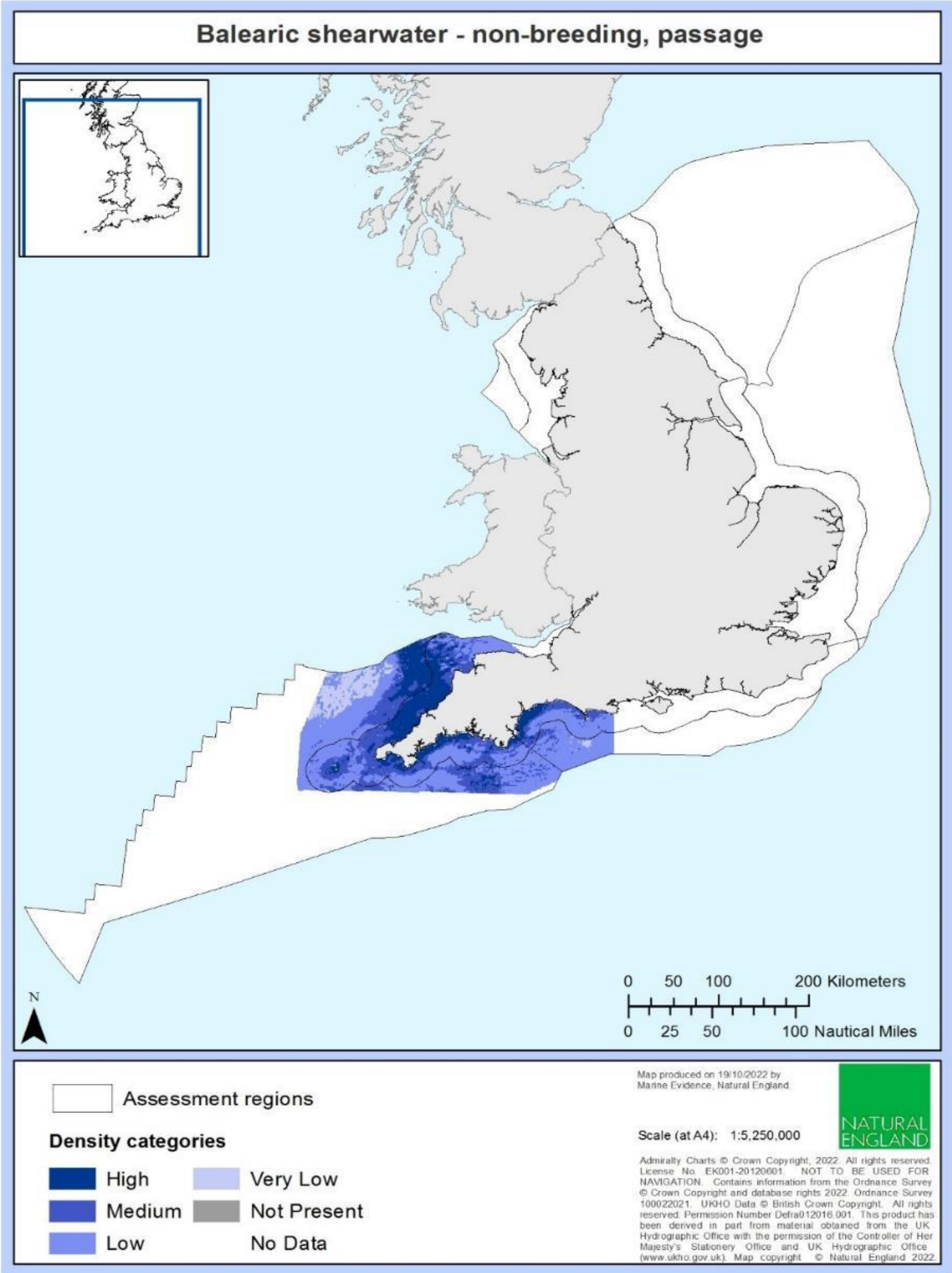


Map 57: Yellow-legged gull - breeding



Balearic shearwater categorised density distribution map

Map 58: Balearic shearwater - non-breeding, passage



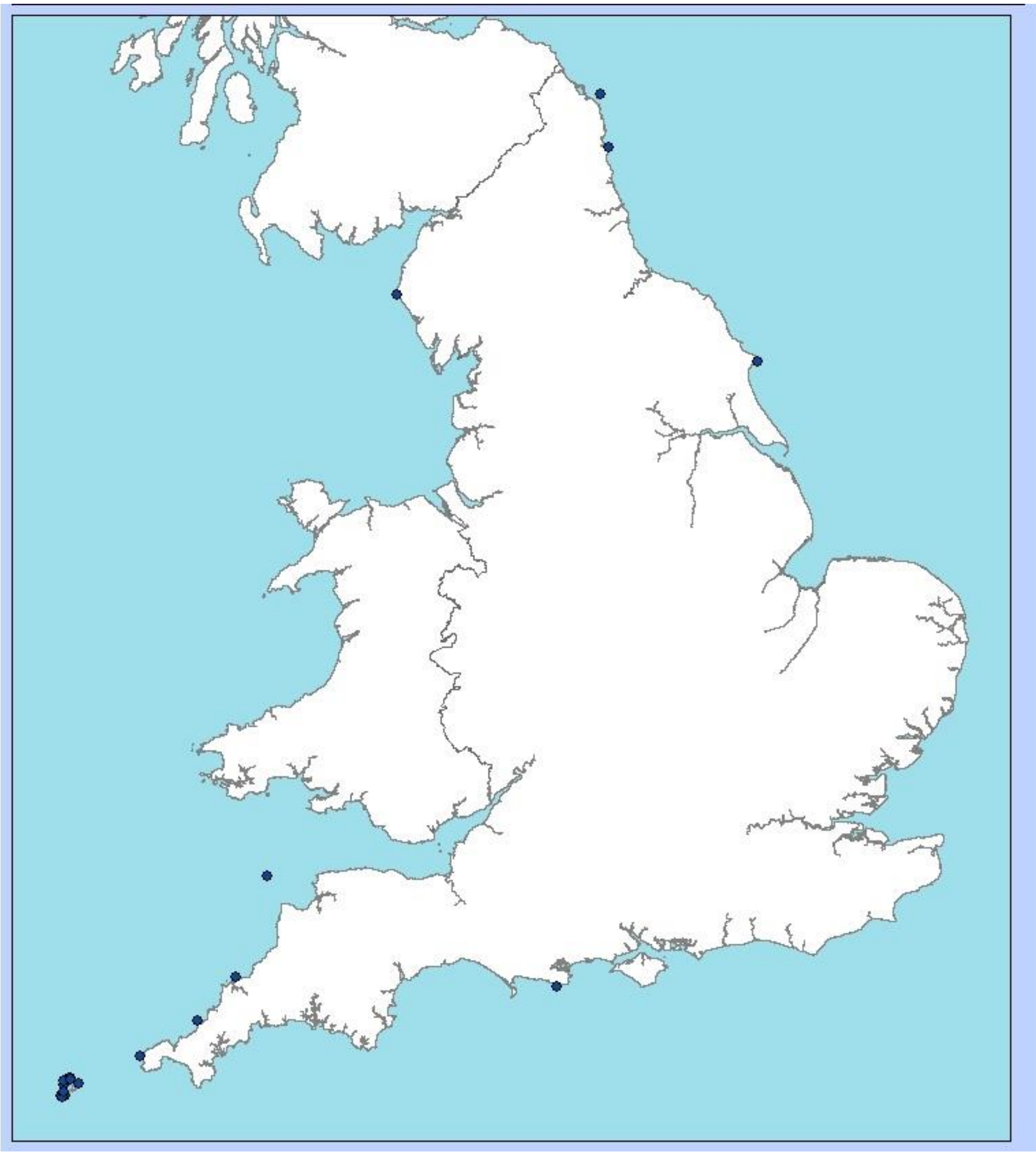
• Appendix 16. Locations of SMP seabird breeding colonies in England.

Maps 59 to 79 show the seabird breeding colony locations for species breeding in England that were included in the colony assessment. Roseate tern has been excluded because it is a Schedule 1 species.

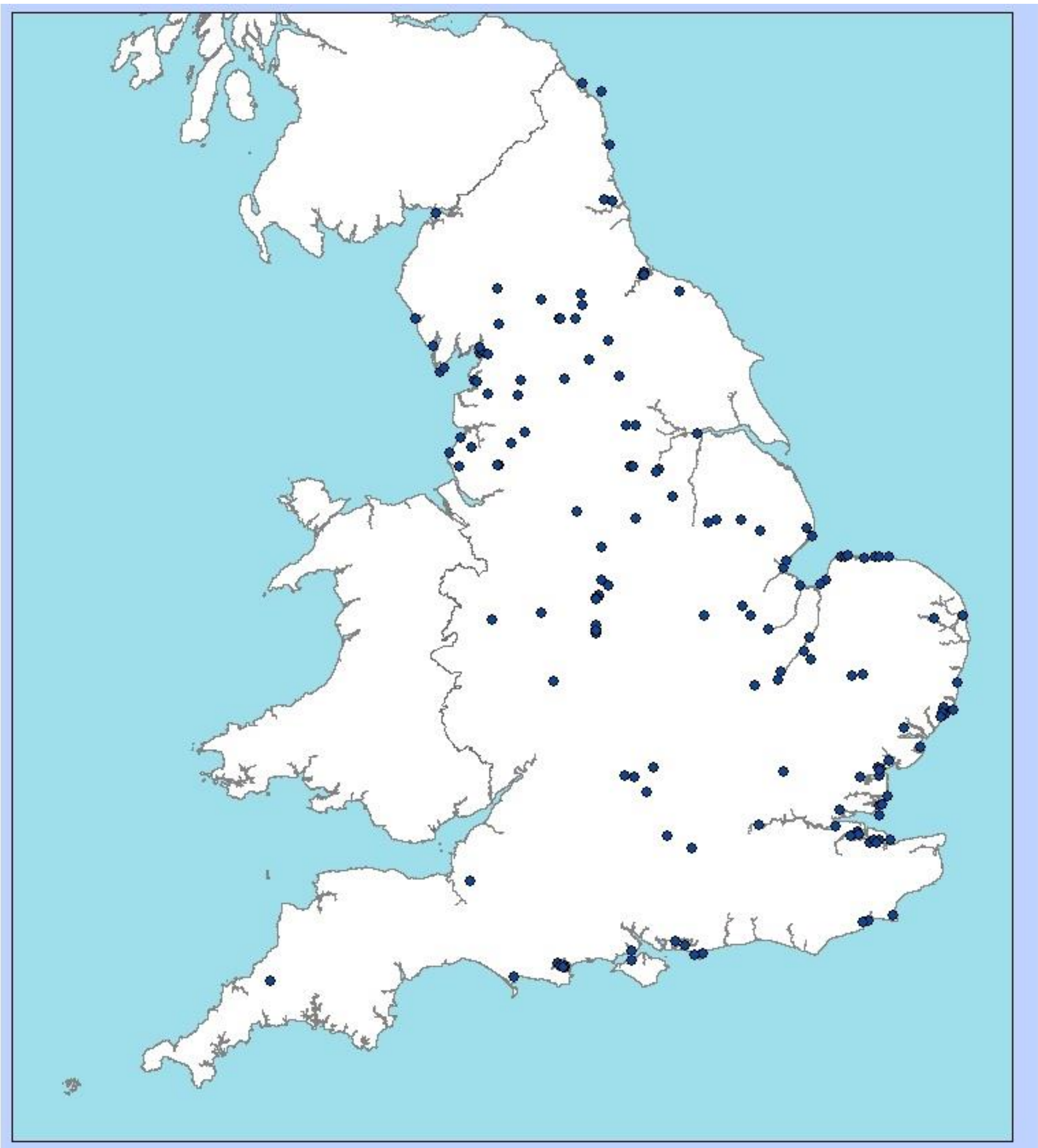
The following maps contain Seabird Monitoring Programme colony data supplied by JNCC (JNCC, 2022). They contain, or are based on, information supplied by Natural England. They contain, or are derived from, information supplied by Ordnance Survey. © Crown copyright and database rights 2022. Ordnance Survey 100022021.

Map 59: **Arctic tern breeding colonies in England**

Map 60: Atlantic puffin breeding colonies in England

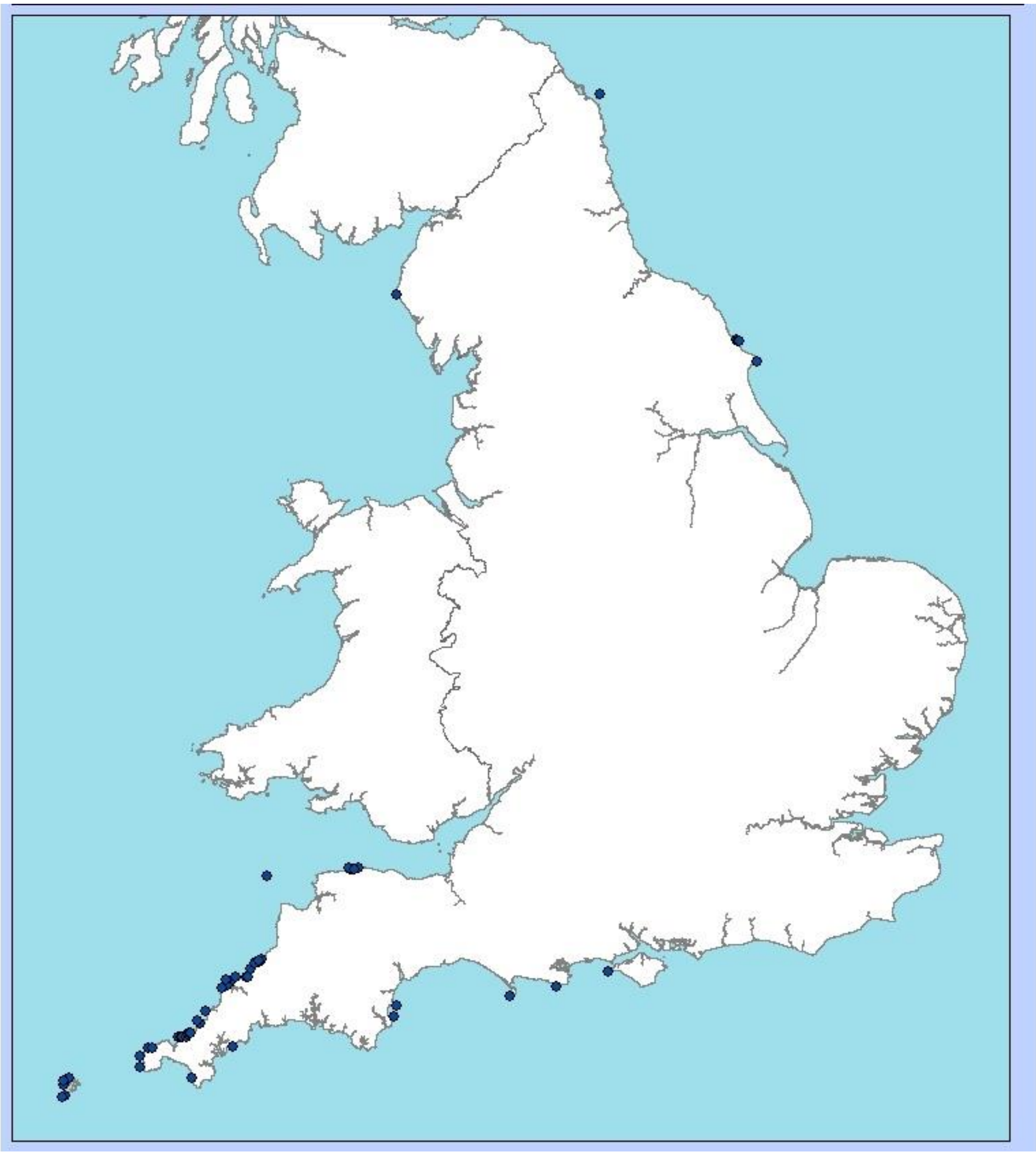


Map 61: Black-headed gull breeding colonies in England

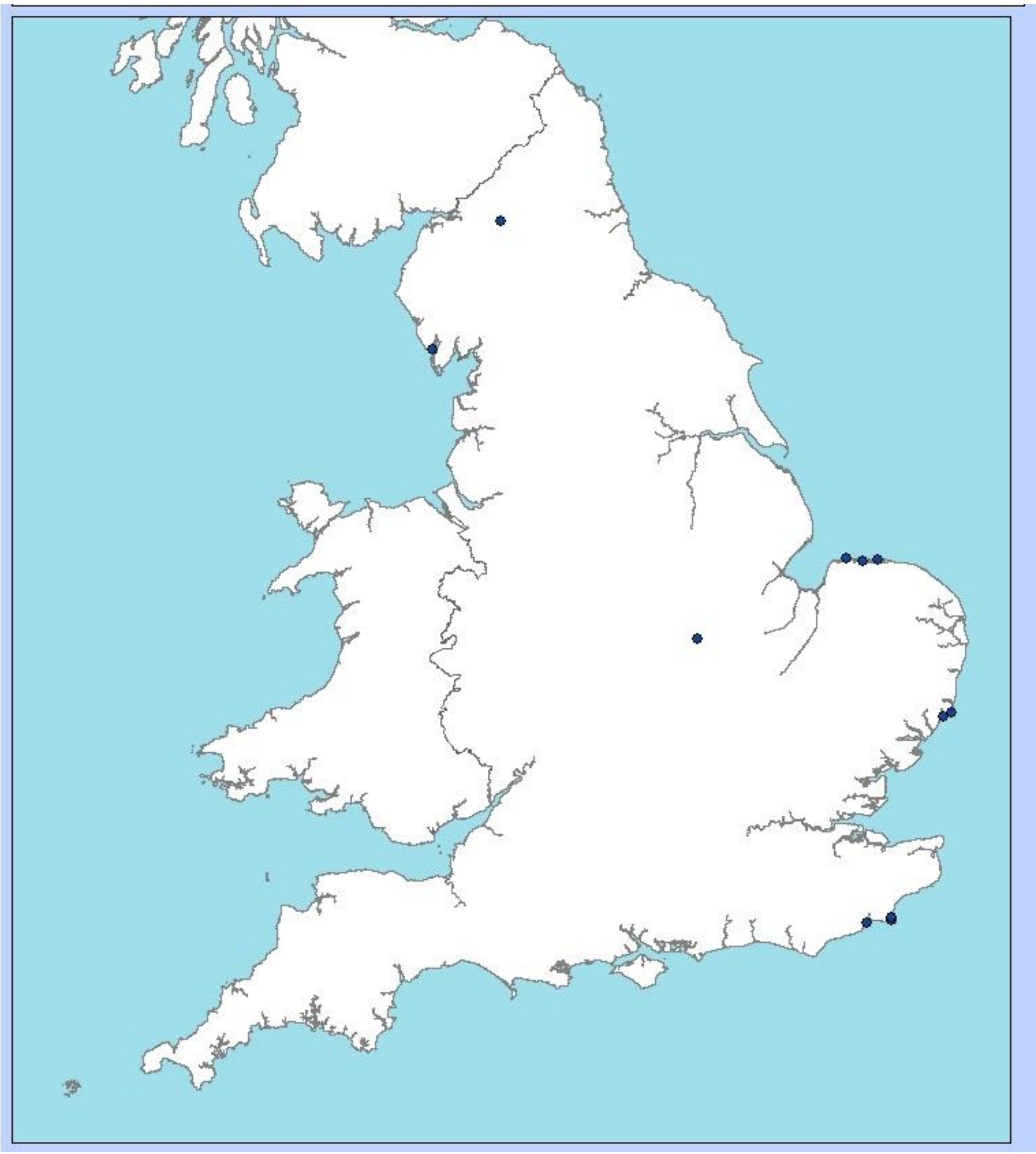


Map 62: Common eider breeding colonies in England

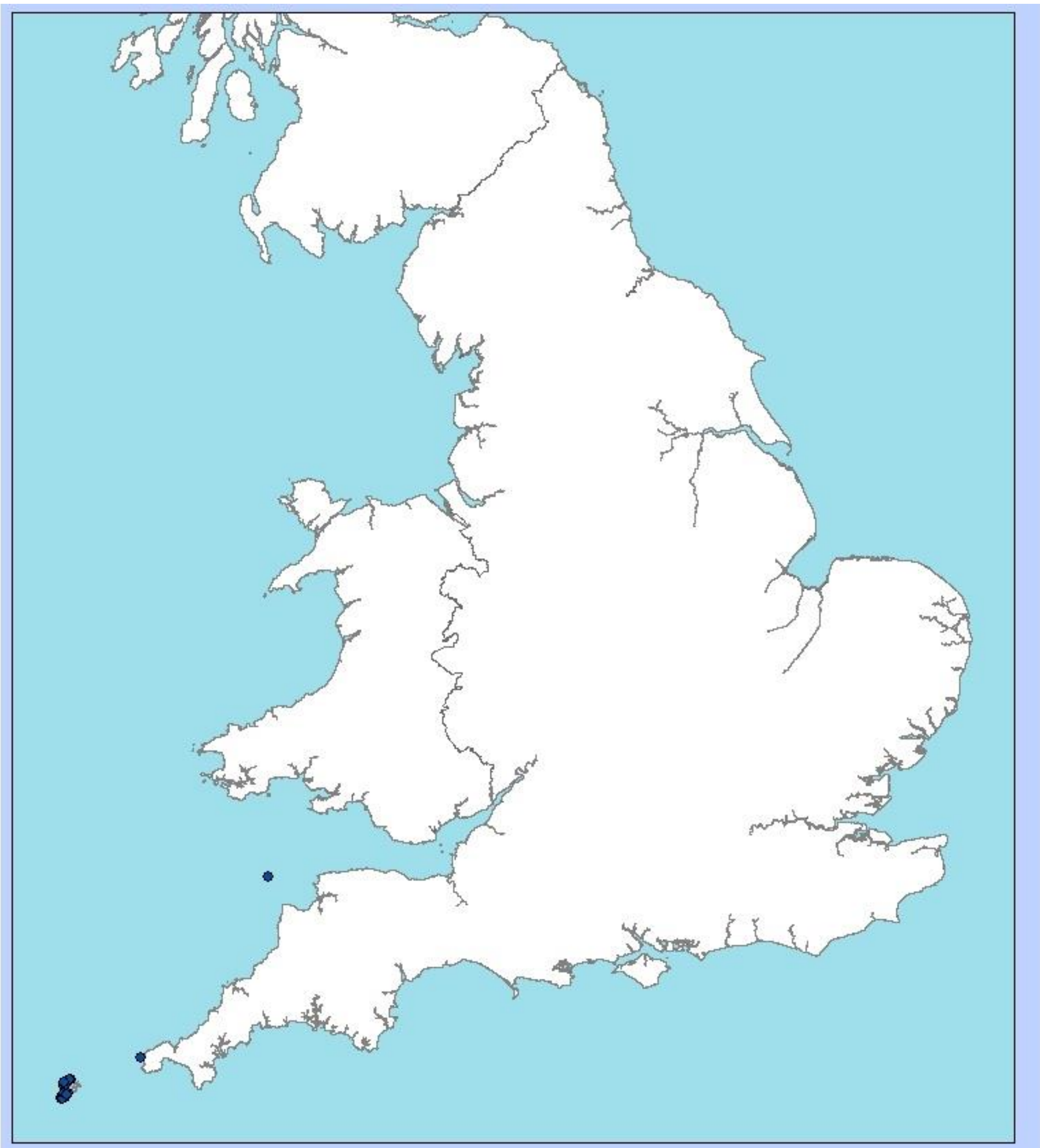
Map 63: Common guillemot breeding colonies in England



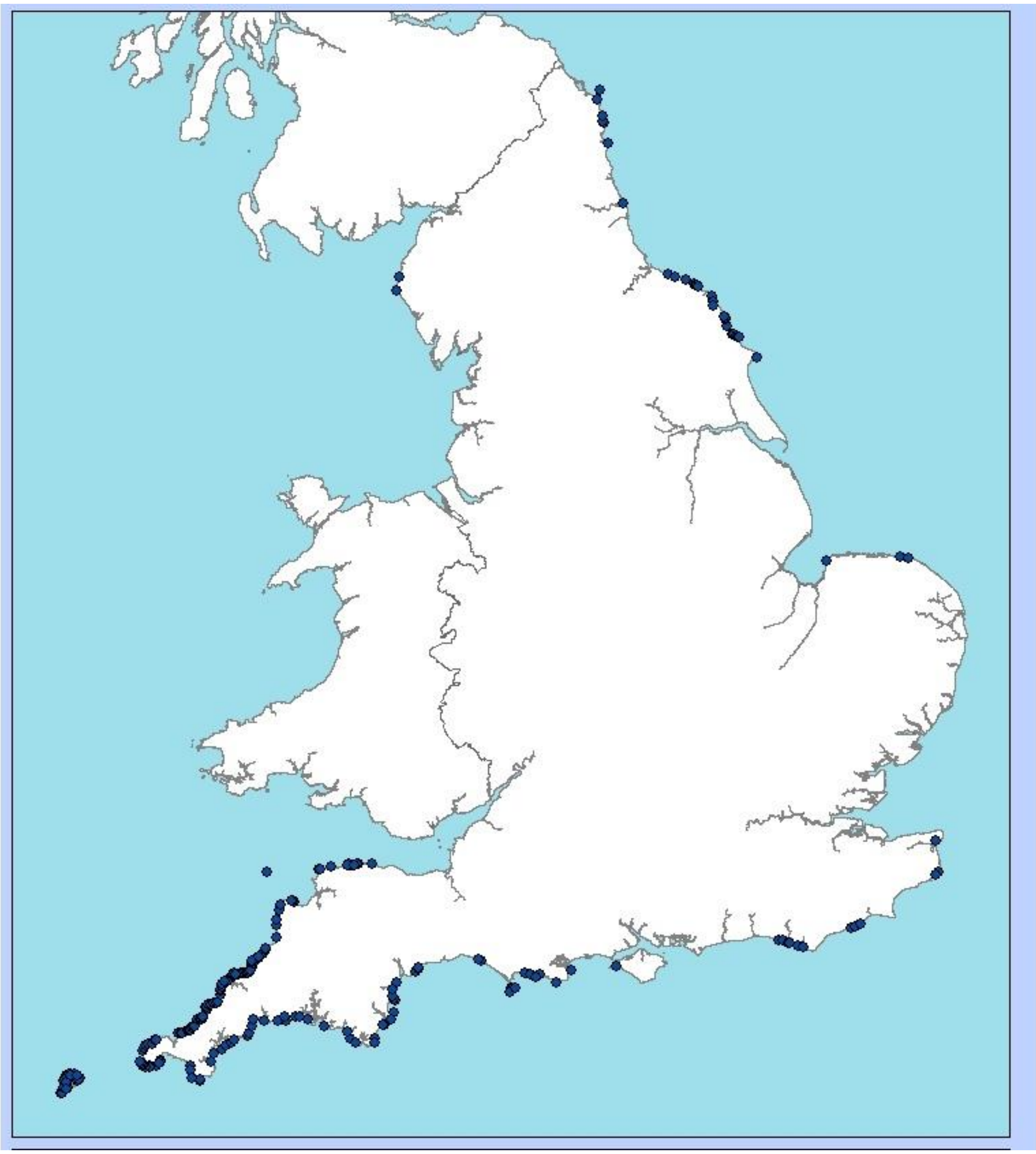
Map 64: **Common gull breeding colonies in England**



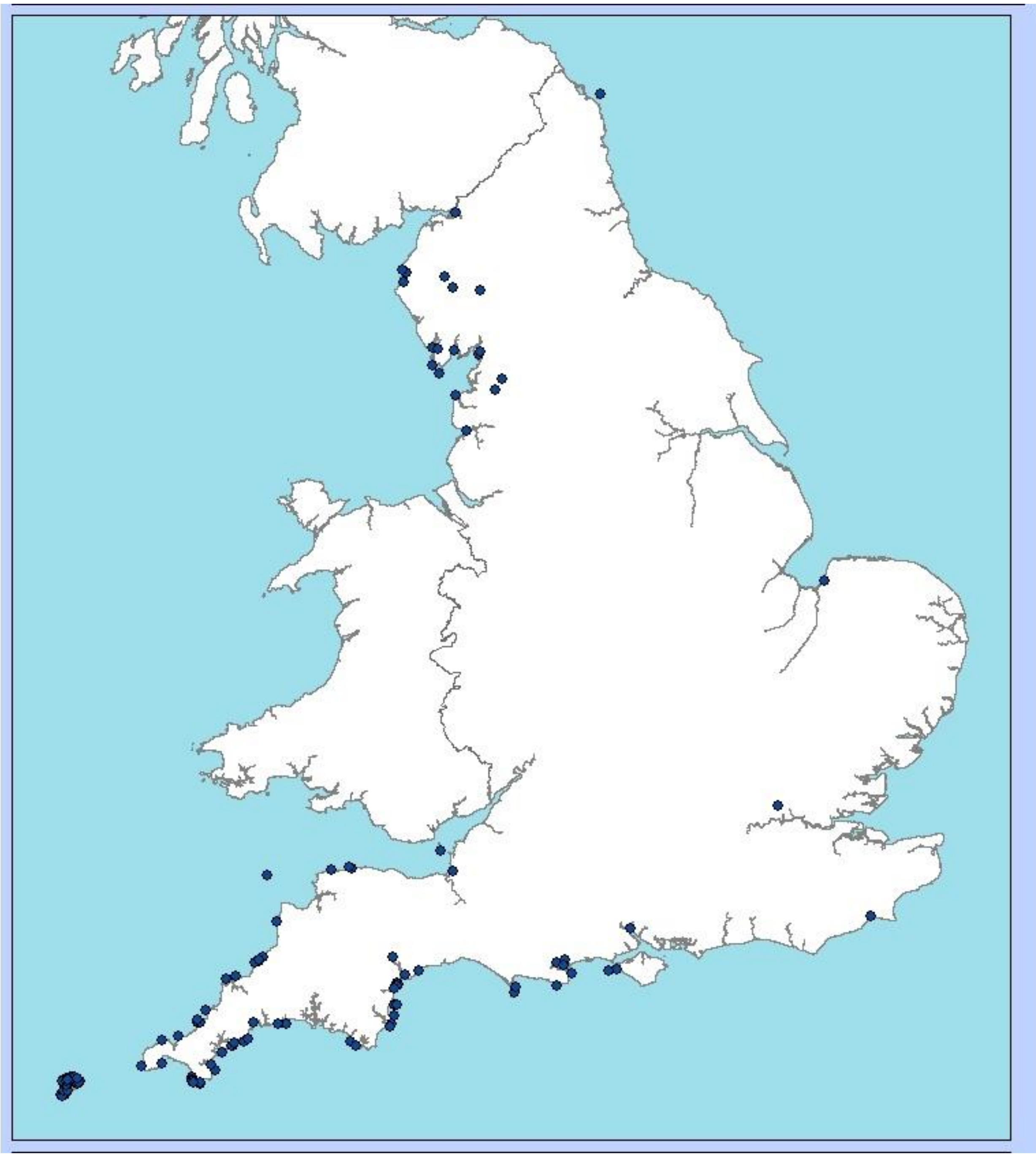
Map 65: **European storm petrel breeding colonies in England**



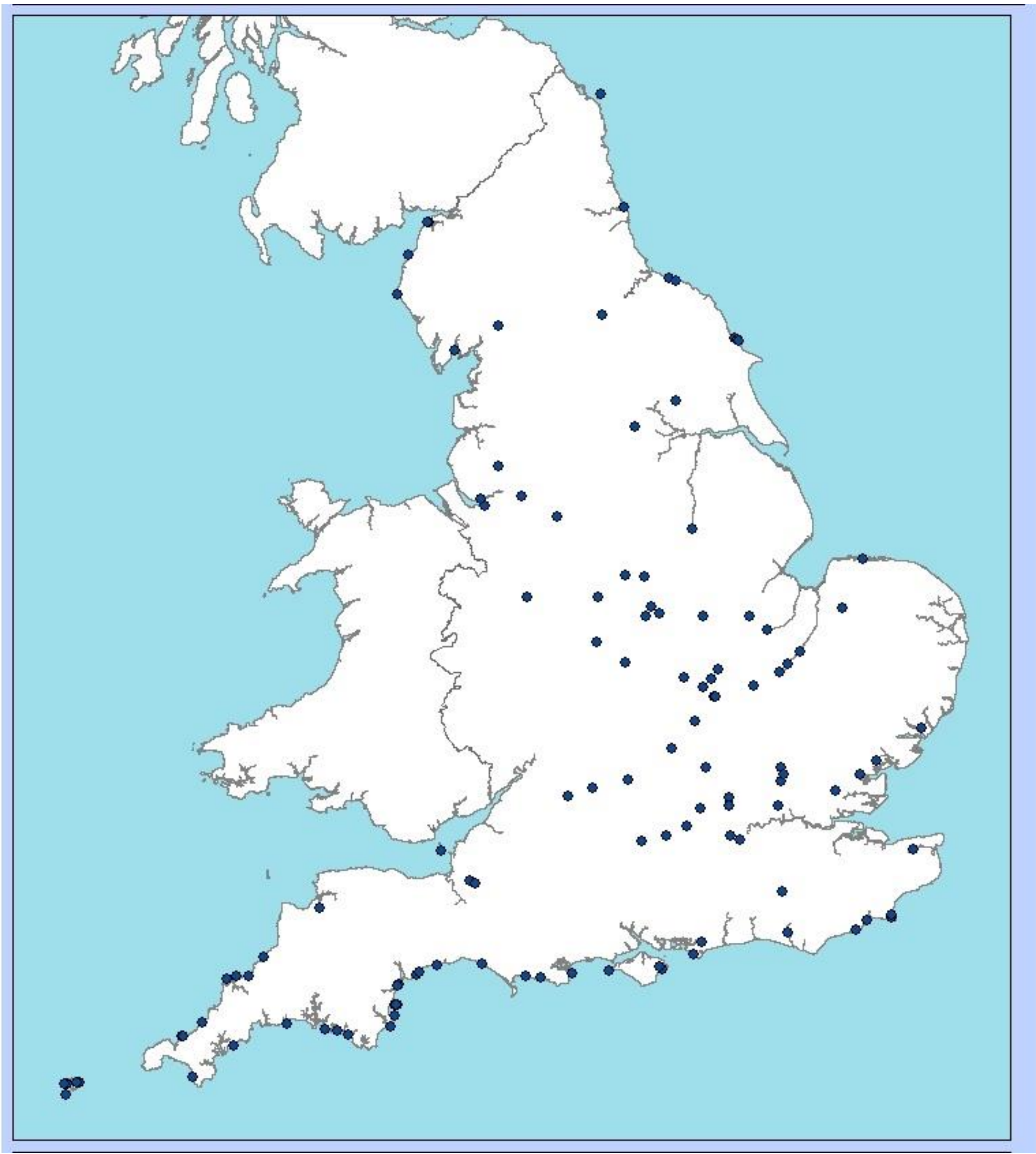
Map 66: **Northern fulmar breeding colonies in England**



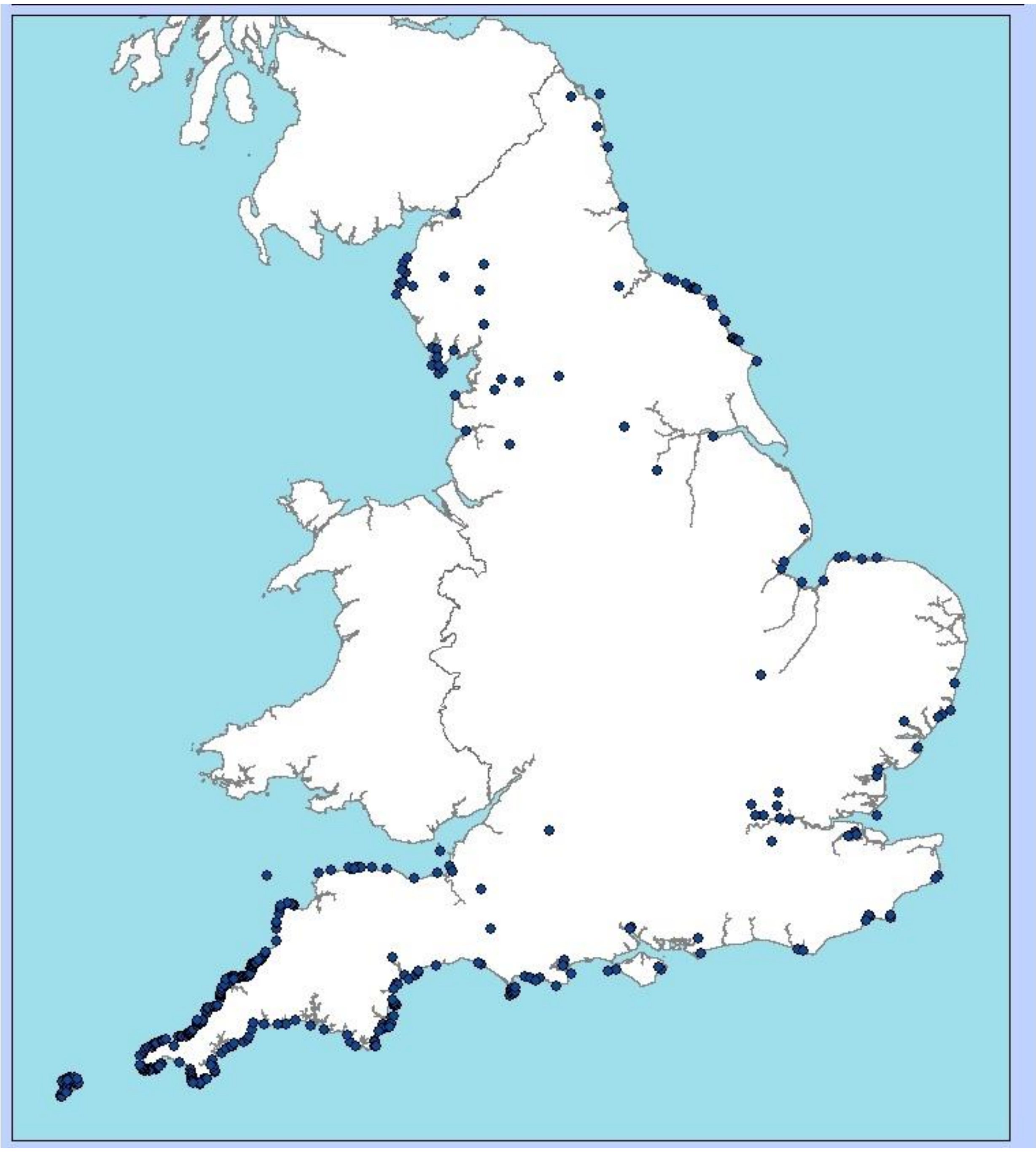
Map 67: Great black-backed gull breeding colonies in England



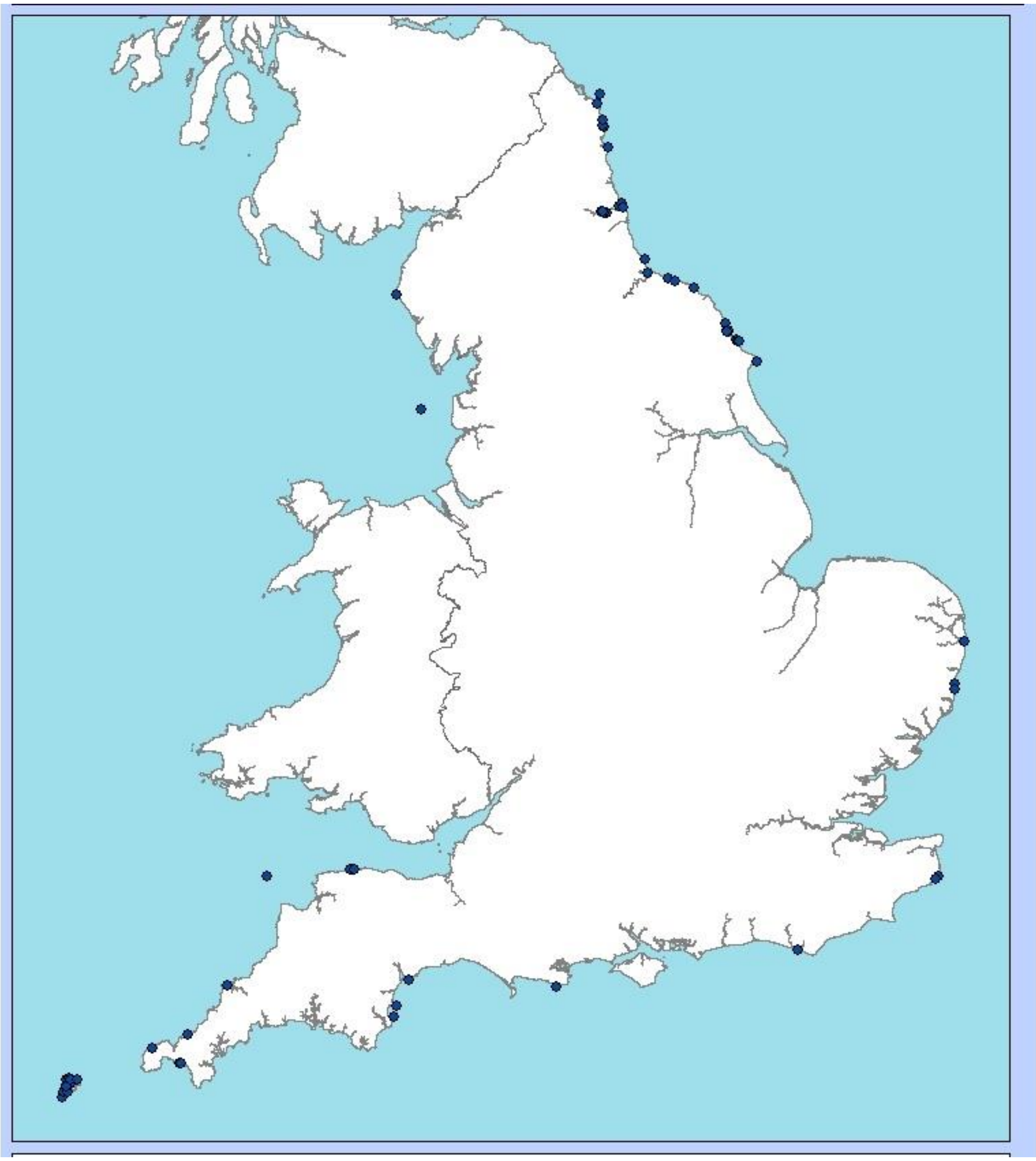
Map 68: **Great cormorant breeding colonies in England**



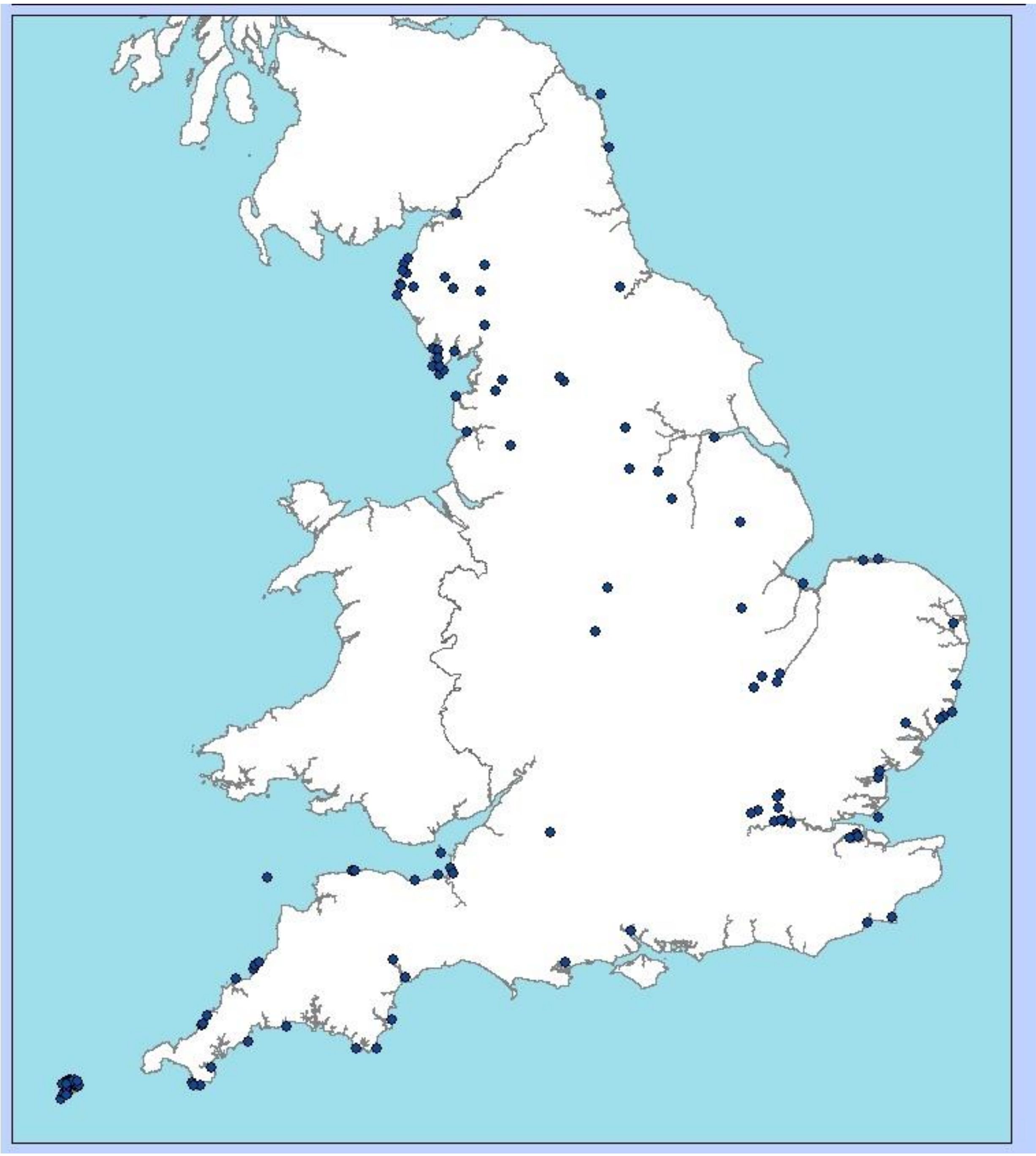
Map 69: **Herring gull breeding colonies in England**



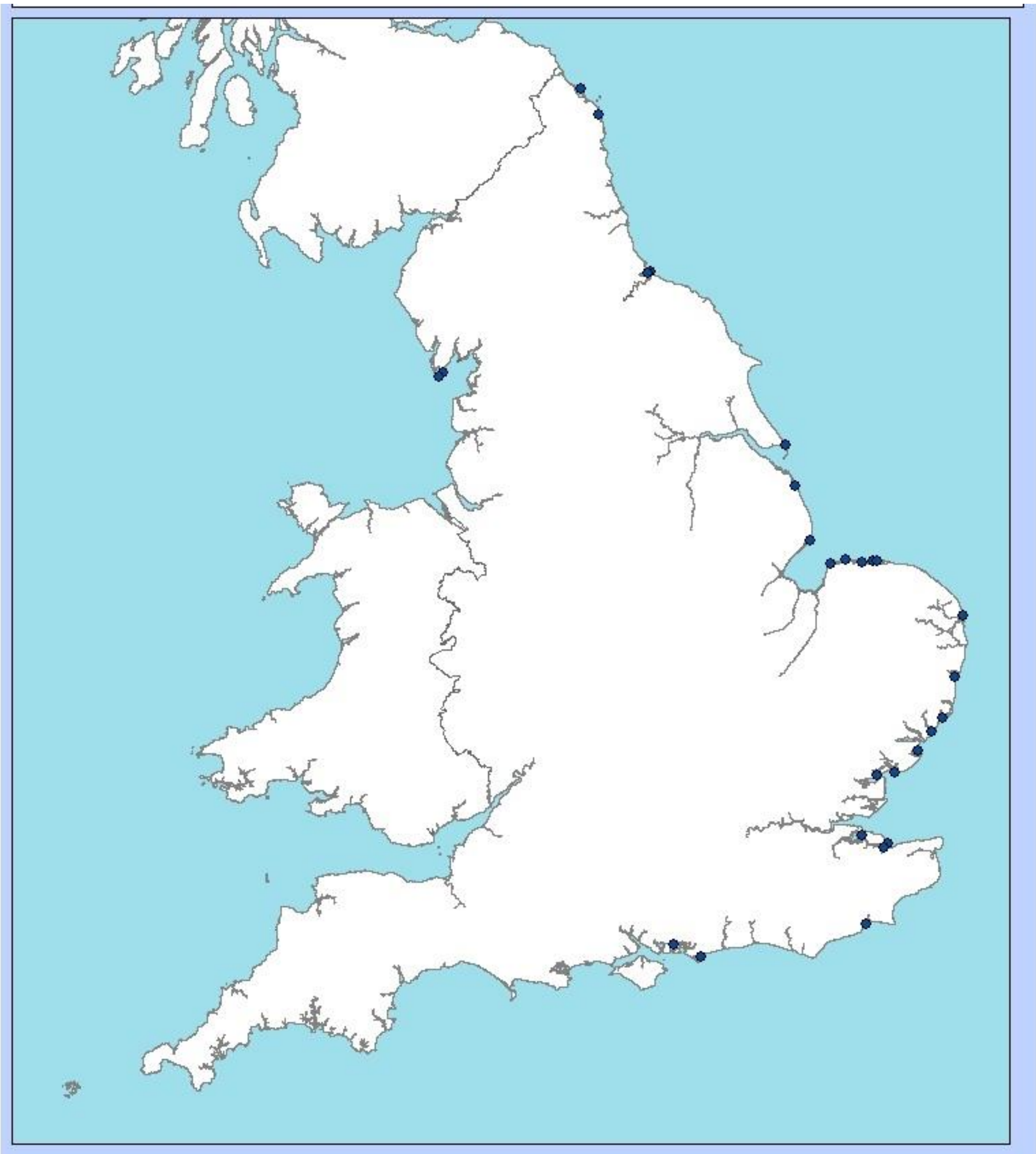
Map 70: **Black-legged kittiwake breeding colonies in England**



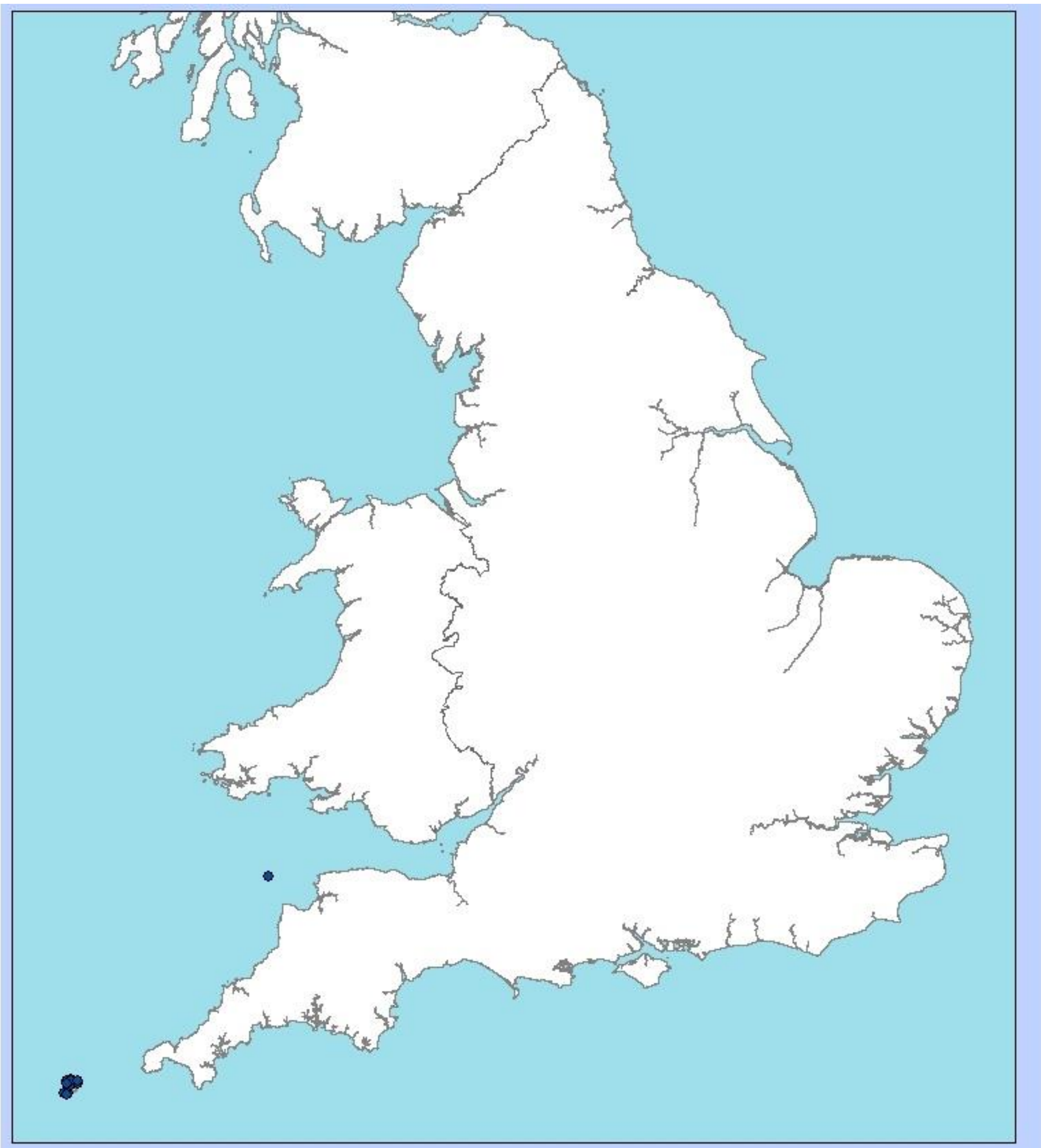
Map 71: **Lesser black-backed gull breeding colonies in England**



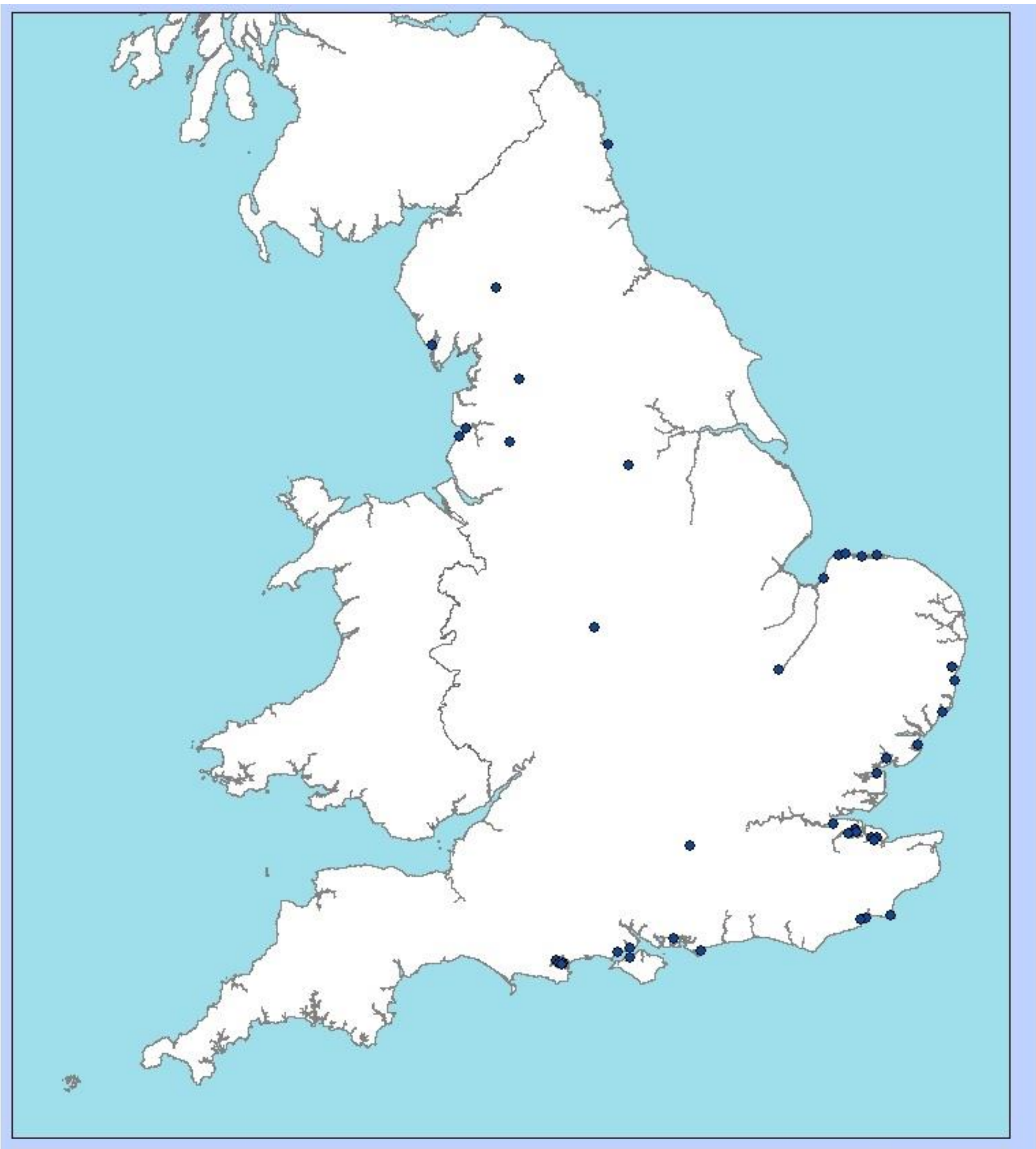
Map 72: **Little tern breeding colonies in England**



Map 73: **Manx shearwater breeding colonies in England**

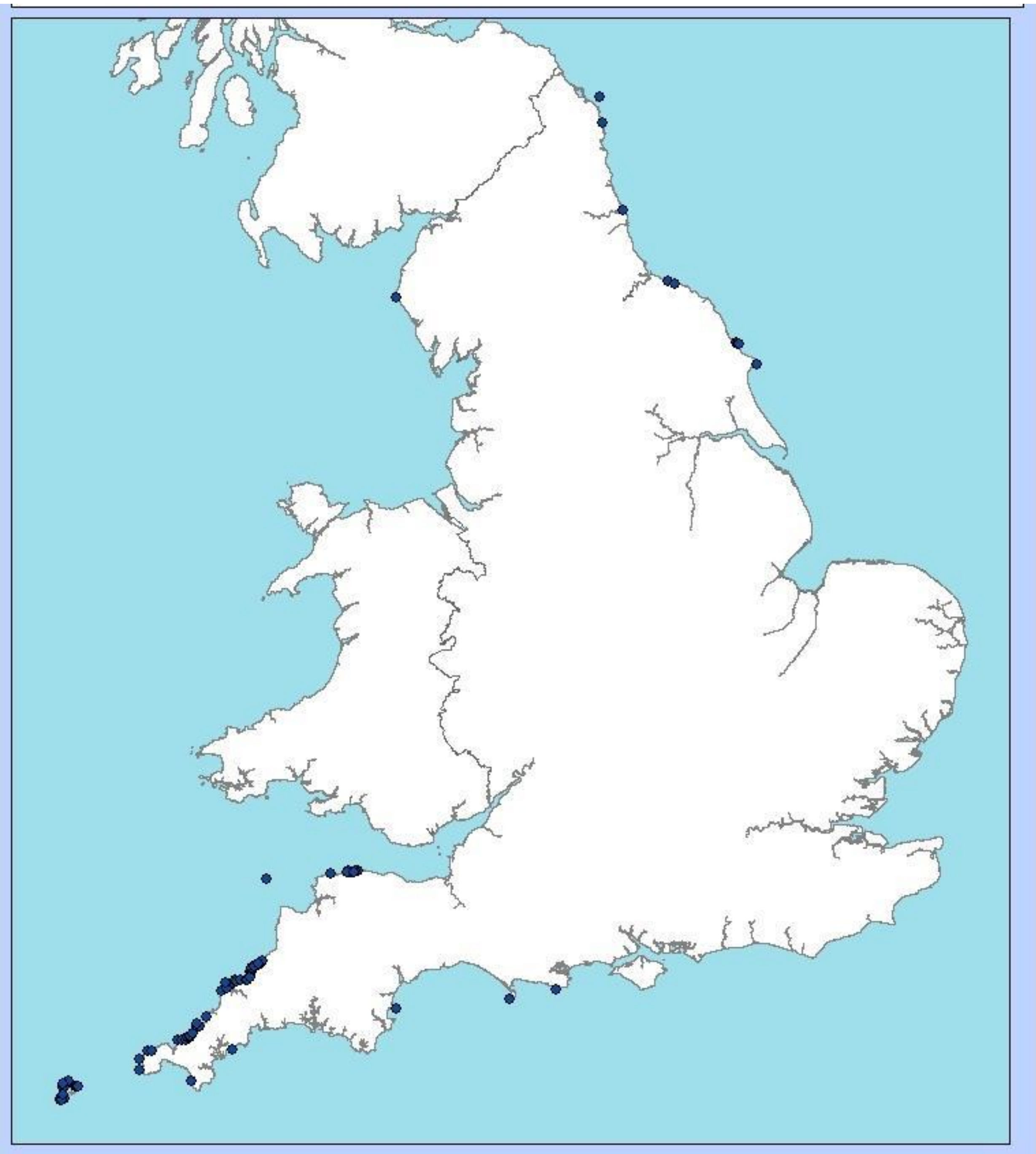


Map 74: **Mediterranean gull breeding colonies in England**



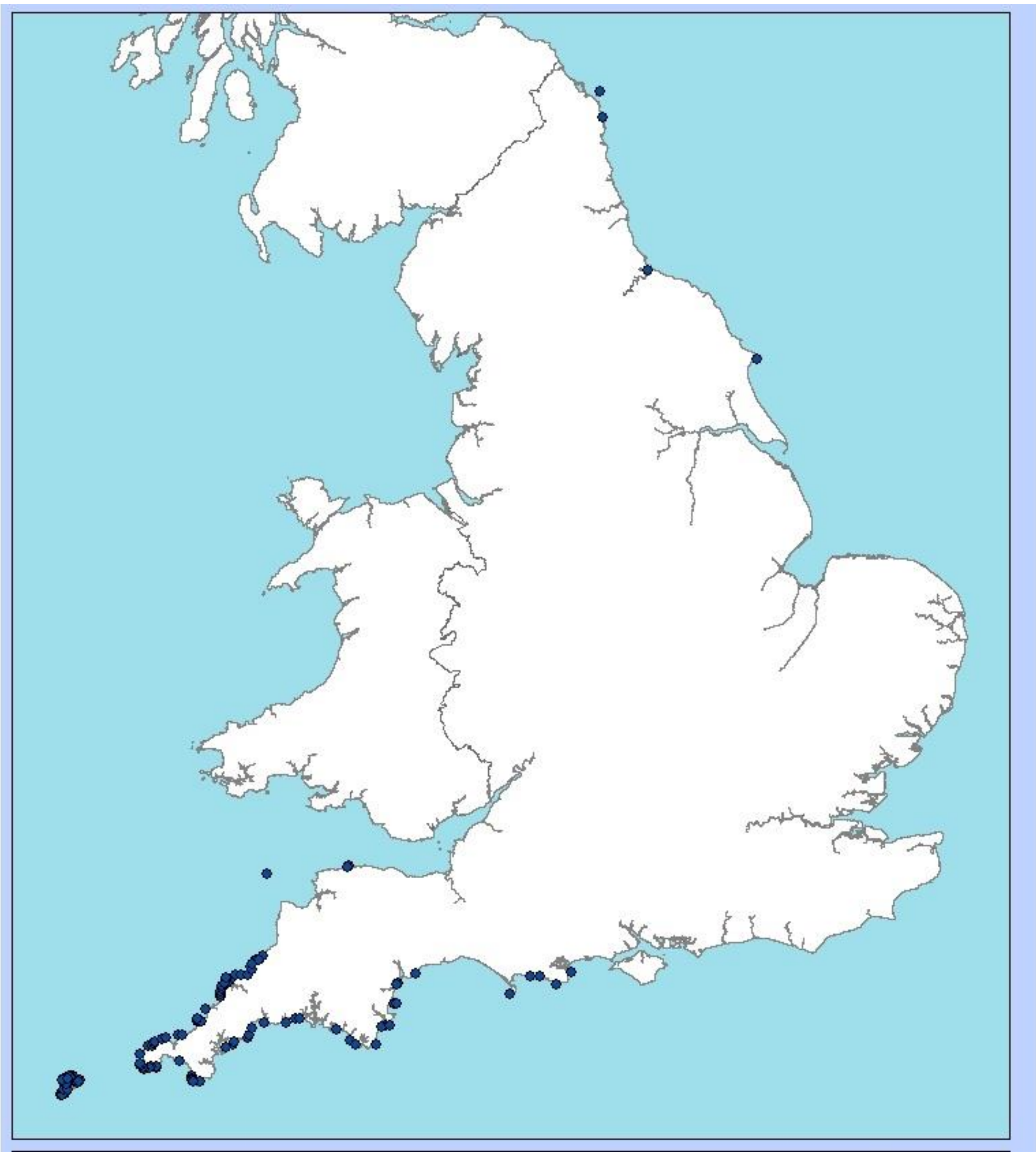
Map 75: **Northern gannet breeding colonies in England**

Map 76: **Razorbill breeding colonies in England**



Map 77: **Sandwich tern breeding colonies in England**

Map 78: **European shag breeding colonies in England**



Map 79: **Yellow-legged gull breeding colonies in England**

- # Appendix 17. Evidence-based reasons for recommendations.

Feeding

Recommendation F1:

Develop a Forage Fish Policy (or similar mechanism) to implement an ecosystem approach to fisheries management decisions that consider the importance of prey for seabirds

Evidence-based reason for recommendation

Forage fish as seabird prey

Forage fish are small to intermediate-sized species (or larger species at early life stages), occurring in schools or dense aggregations, and function as a main pathway for energy to flow from phyto- and zooplankton to higher trophic level predators such as seabirds. Three important groups of forage fish species for seabirds are sandeels, clupeids (herrings and sprat) and gadoids (eg cod, whiting, pollock). Nearly half of UK seabird species are known to feed on sandeels, whilst clupeids can be particularly important when sandeel abundance is low, especially during chick provisioning (ICES 1996, Edmonds *et al.* 2021). Gadoids are prey for around a quarter of UK seabirds (Edmonds *et al.* 2021) (see Table 44).

Table 44. Seabird species/groups that feed primarily on forage fish species in UK waters.

(ICES, 1996, Edmonds et al. 2021)

Bird species /group	**Prey**		
	Sandeels	**Clupeids**	**Gadoids**
Divers (red-throated diver, black-throated diver, great northern diver)	X	X	X
Northern fulmar	X	X	X
Shearwaters (Manx shearwater)	X	X	
Great cormorant, European shag	X	X	X
Northern gannet	X	X	X
Gulls (herring gull, lesser black-backed gull, black-legged kittiwake)	X	X	X
Skuas (great skua, Arctic skua)	X	X	X
Terns (common tern, Arctic tern, roseate tern, Sandwich tern, little tern)	X	X	X
Auks (Atlantic puffin, common guillemot, razorbill, black guillemot)	X	X	X

Links between forage fish and seabird population health

There is strong evidence that seabird productivity, survival and population abundance are closely associated with prey resource availability, in particular the availability of ‘forage fish’ species (Rindorf *et al.* 2000, Mitchell *et al.* 2004, Frederiksen *et al.* 2004, Wanless *et al.* 2005, Furness 2007).

Due to high site fidelity, sandeels provide a reliable source of prey for seabirds foraging from land in the breeding season, when they are particularly sensitive to fluctuations in the local food supply (Furness 2002, Wanless *et al.* 2005). Species such as black-legged kittiwake and European shag, and groups including auks and terns, are especially likely to be impacted by decreased sandeel abundance and availability (Edmonds *et al.* 2021). Breeding success of black-legged kittiwake and terns has been identified as being highly vulnerable to reduced food abundance (Harris & Wanless 1990, Frank & Becker 1992, Monaghan 1992, Furness & Tasker 2000, Carroll *et al.* 2017). Winter mortality of common guillemot increased as a result of large-scale changes of food availability in the North Sea in 1980s (Heubeck 2000), whilst Fauchald *et al.* (2011) indicate that herring was important in regulating the abundance of seabirds wintering in the North Sea through a bottom-up interaction.

Several studies have shown that the breeding success and adult survival of North Sea black-legged kittiwakes are strongly affected by sandeel stock biomass (Rindorf *et al.* 2000, Furness & Tasker 2000, Daunt *et al.* 2008, OSPAR Commission (Convention for the Protection of the Marine Environment of the North-East Atlantic) 2009) and/or the presence of a sandeel fishery nearby (Frederiksen *et al.* 2004, Carroll *et al.* 2017).

An ecosystem approach to fisheries management

The pressure ‘reduction in quantity or quality of available food’ is associated particularly with fisheries that target forage fish, especially those fished at or beyond sustainable limits. North Sea sandeel spawning stock biomass (SSB) is currently below MSY and there is a potential risk to the stock sustainability (ICES 2020). Whilst much focus has previously been given to discrete geographic closures, or the improvement of stock assessment methodologies, the failure of the current management system to maintain populations of forage fish at sustainable levels suggests the need for a change in approach. An ecosystem approach to fisheries management that is built on a more mature understanding of the ecosystem role of forage fish, the impacts of environmental variability on forage fish production, and the impacts of forage fish production on the wider food web is required to benefit seabirds and the wider marine ecosystem (Hill *et al.* 2019, Bastardie *et al.* 2021). Such a Forage Fish Policy should define and include all forage fish species (at the relevant size or life-history stage) that are likely to be ecologically important and the fisheries (eg industrial to small-scale) that can impact them.

An ecosystem-based Forage Fish Policy should address key forage fish species and a range of management approaches. These could include:

- A detailed review of the status and management of other forage fish species in UK waters;
- Further consideration of stock and basin-level management for those species identified as policy priorities, alongside consideration of potential displacement and associated ecological, economic and social impacts.
- Prioritisation of the development of management for forage fish species who may be targeted following displacement of other fisheries;

- A strategic approach to monitoring forage fish and their predators;
- The development of predator and/ or ecosystem reference points that account for the requirements of marine predators and environmental variability;
- Targeted reduction of bycatch and incidental mortality of forage fish species in other fisheries; and
- The protection of essential fish habitat (EFH), especially for forage fish with complex population structure and those which are benthic spawners (eg herring and sandeel).

Such an approach would deliver world class fisheries management in-line with recent forage fish policy development in the US (Forage Fish Conservation Act 2021) and Canada (Policy on New Fisheries for Forage Species 2010). Implementation of world class fisheries management will provide a solid foundation for Defra to galvanize support from other countries with whom forage fish stocks are shared and international co-operation is required for a truly ecosystem-based approach.

Furthermore, policy-driven changes in spatial-temporal patterns of fishing effort (for instance, discarding undersize or unwanted catch, or offal from processing) have the potential to impact some seabird species which are known to rely on this (Sherley *et al.* 2020). Under an ecosystem approach we should better understand how changes in fisheries policy (eg the Landings Obligation), catch restrictions, and displacement (which could reduce or increase energetic-related foraging pressures) impact discard-dependent seabirds.

Likely success of sandeel management measures to benefit seabirds within a Forage Fish Policy

In the short term, reducing or preventing catches of those forage fish with the most established links to the health of seabird populations and the wider environment (eg sandeel in the North Sea) should be prioritised. Results of indicative Ecopath with Ecosystem (EwE) modelling undertaken by Natural England (in advice recently provided to Defra) suggests that reductions in sandeel fishing results in benefits sandeel stocks and seabirds.

However, the relationships between fisheries pressure, sandeel stock recruitment and stock size are complex, so instant stock recovery may not occur. Research has suggested that climate-related regime shifts in the North Sea have impacted relative size-at-age, energy content of sandeels and affected their recruitment and resilience (Arnot & Ruxton 2002, Wanless *et al.* 2004): forage fish populations typically respond strongly to climate-driven changes in marine systems (Engelhard *et al.* 2014). Interactions between forage fish, the changing environment, their predators, and complex food web feedbacks that lead to increased competition (eg between juvenile gadoids and adult forage fish) may also influence expected recovery rates of forage fish, as well as influence trends in other species within the ecosystem.

As with any ecosystem intervention, there are associated uncertainties for ecosystem benefits with sandeel management measures. However, sandeel populations themselves should become more resilient to pressures such as climate change, and such a measure could contribute to the Ecosystem Objective of the Fisheries Act 2020. Uncertainties in success for seabirds should not prevent measures being taken, according to the precautionary approach to fisheries management in the same act.

Other considerations for a Forage Fish Policy

Before implementation of any new management approaches to the North Sea sandeel fishery are implemented, detailed consideration should be given to the risk of displacement of fishing effort. Depending on the scale of the management implemented, displacement may concentrate effort on sandeel stocks outside the management area, or displace effort onto other forage fish stocks and other ecoregions within English waters. In some cases, these stocks may have ecological traits which make them particularly susceptible to exploitation (eg boarfish which live to approximately 30 years old; White *et al.* 2011, Hüssy *et al.* 2012), or may have no stock assessment or management in place. Additionally, whilst the food webs of the North Sea are amongst the best studied in the world, much less is known about the role of forage fish in the wider Celtic Seas ecoregion.

Although a Forage Fish Policy could implement an ecosystem-based approach to managing forage fish *fisheries*, to truly apply ecosystem-based management for *forage fish* will also require consideration of the impacts of other marine activities and developments known to impact these species. Noise (Perrow *et al.* 2011, Kok *et al.* 2021), pollution and eutrophication (Piroddi *et al.* 2021), and plastics (Chavarry *et al.* 2022) have all been shown to have impacts on forage fish. It is important that both marine planning and assessment of plan- and project-level human activity take a holistic view of marine ecosystems and the potential impacts activities might have.

Climate change considerations

One of the key pathways through which seabirds are impacted by climate change is through changes to their food. Climate change may cause changes in the population sizes, distributions, and seasonality of prey species, all of which may affect the availability of prey for seabird species (IPCC (Intergovernmental Panel on Climate Change) 2022b). As prey depletion is already a known issue for seabird species and has been linked to overfishing, the additional risk of prey depletion caused by climate change means that it is even more important that fisheries are managed in such a way as to ensure that enough fish are available to seabirds and other predators, with resilience to likely impacts of climate change built into fisheries management (Capuzzo *et al.* 2017, IPCC 2022b). This is particularly important for fisheries of key forage species, such as sandeels and clupeids given the potential for increasing importance of clupeids as seabird prey due to climate change-related changes in sandeel abundance. Declines in the abundance, size and nutritional value of sandeels in the North Sea have been linked to increasing sea surface temperatures (SST) caused by climate change (Wanless *et al.* 2005, Daunt & Mitchell 2013, Wanless *et al.* 2018). This is likely linked to climate change-related changes in the abundance and energetic value of the sandeel's zooplankton prey (Frederiksen *et al.* 2007, Lindegren *et al.* 2018, Olin *et al.* 2022). Model simulations suggest that, while fishing largely contributed to the abrupt decline of North Sea sandeels during the late 1990s and the following period of low biomass, a complete recovery of the stock to the highly productive levels of the early 1980s would only be possible through changes in the surrounding ecosystem, involving lower temperatures and improved feeding conditions (Lindegren *et al.* 2018). Unlike many other fish species, sandeels are generally not free to move into deeper waters in response to warming sea temperatures because they are highly habitat specific, tightly associated with coarse sandy sediments (Holland *et al.* 2005). For that reason, they have been identified as being at particular risk from climate change (Heath *et al.* 2012). The overall importance and quality of sandeels in the diets of seabirds has declined at one intensively studied North Sea colony; whilst closing a local sandeel fishery did coincide with increased kittiwake breeding success, across all species studied there was little indication of a change in importance of sandeels relative to other prey species (Wanless *et al.* 2018). Instead, marked community-level changes in seabird diet composition over the last three decades may reflect changes in the prey community with increased abundance of small clupeids (eg, sprat) (Anderson *et al.* 2014). Future climate change impacts on marine ecosystems are still poorly understood but are predicted to increase, and there is a need to reduce the impacts of non-climate pressures (such as fishing) on marine ecosystems to increase their resilience to climate change impacts (IPCC 2022b). The increasing role of climate change in shaping marine ecosystems and the uncertainties around cause-and effect should not be seen as barriers to implementing an Ecosystem Approach to fisheries management. Rather, they should increase the urgency with which we seek to remove pressures and implement new ecosystem-based approaches to achieving resilient marine food webs and ocean recovery.

Recommendation F2:

Effective protection, conservation and restoration of seabird marine habitats

Evidence-based reason for recommendation

The importance of seabird MPAs

Marine protected areas (MPAs, including marine SPAs, Marine Conservation Zones (MCZs) and HPMAs) are only effective when they are well managed (Edgar and others 2014, Gill and others 2017, Nikitine and others 2018, Benyon and others 2020). However, the management of effectiveness of MPAs has repeatedly been queried (Edgar and others 2014, Nikitine and others 2018, IPCC 2022c). Some MPAs for highly sensitive marine birds (especially red-throated divers) have had offshore wind development occur within them, leading to problems with consenting and compensation (Allen and others 2019). For management to be effective, MPAs need to have clear conservation objectives, management plans, and adequate funding to allow enforcement and ongoing monitoring (Edgar and others 2014, Gill and others 2017, Benyon and others 2020). Continued and regular monitoring is required to assess the effectiveness of protection measures and allow for refinements to MPA boundaries (Ronconi and others 2012, Nikitine and others 2018).

The establishment of MPAs for seabirds has been identified as a key tool in seabird conservation (Camphuysen and others 2012, Lewison and others 2012, Ronconi and others 2012, Wakefield and others 2017, Oppel and others 2018, Cleasby and others 2020). (Here MPAs refers to those protected sites in England which include areas of sea below mean high water, either as stand-alone marine areas or as ‘marine extensions’ to breeding colonies). For instance, depletion of seabird prey has been identified as a major cause of seabird declines, and MPAs that exclude fishing activity have been shown to improve the condition of marine ecosystems and increase fish populations both within MPAs and in surrounding areas, through spill-over effects (Edgar and others 2014, Gill and others 2017, Marshall and others 2019, Benyon and others 2020, Brander and others 2020, IPCC 2022c).

MPA sufficiency, including foraging areas

In England, MPAs are designated for non-breeding marine birds and some breeding seabirds. The latter are protected where marine areas reflect limited foraging ranges (eg tern species) or 'maintenance extensions', the marine waters around breeding colonies used for certain essential (mainly non-feeding) behaviours. The foraging grounds of wide-ranging species and groups including northern gannets, shearwaters, gulls, auks and European storm petrels do not have MPA protection, and neither do areas of aggregation in the post- and non-breeding season, instead relying on 'functional linkage' with protected colonies. Ecologically, the most important areas are key foraging areas, and these are likely to be different at different times of the year and between species, although different species may share foraging areas (Camphuysen and others 2012, Oppel and others 2018, Buckingham and others 2022). Although an ecological approach to the sufficiency of SPAs has been carried out on land (Stroud and others 2016), no marine equivalent has been published.

Should such a review demonstrate a lack of ecological sufficiency, the designation of key seabird foraging areas as MPAs could therefore provide conservation benefits for seabird populations (Camphuysen and others 2012, Oppel and others 2018) as they would be subject to management and development control; for instance, fisheries by-laws would be possible, and some areas could be considered as HPMAs (Benyon and others 2020) where conservation requirements suggested this approach was necessary. Seabird foraging and/or? aggregating MPAs should be chosen based on areas of high repeated use by seabird species and the ecological importance of these areas to seabird species (Camphuysen and others 2012). Key foraging areas may be identified through the use of survey and tracking data (Waggitt and others 2019, Cleasby and others 2020). Key foraging areas may also vary between colonies, so colony-specific foraging areas should be considered in order to fully protect populations (Wakefield and others 2017). Areas where aggregations of birds gather to undergo flightless moult, as in the case of auks and sea ducks, should also be considered as of high ecological importance and candidates for MPA designation (Camphuysen and others 2012, Oppel and others 2018, Buckingham and others 2022).

The benefits of MPAs to marine ecosystems and fish populations have been shown to be greatest when these areas exclude fishing and other extractive activities, which could be done through by-laws or HPMA designation (Edgar and others 2014, Nikitine and others 2018 Benyon and others 2020, Brander and others 2020, Mitchell and others 2020, IPCC 2022c), although there are monitoring, compliance and displacement considerations. Some fishing practices, such as bottom trawling and dredging, may also damage benthic habitats and thereby have negative impacts on the marine ecosystems on which seabirds rely (Benyon and others 2020, Edmonds and others 2021). Restricting such measures in certain areas may create recovery opportunities for seabirds by increasing natural abundance of fish and invertebrate prey within restored marine habitats (Edmonds and others 2021). Larger MPAs also have greater ecological benefits which could point to benefits of seabird foraging MPA designation (Edgar and others 2014). Seabirds are considered to be good indicators of the health of marine ecosystems, so MPAs that protect seabird populations are also likely to have ecological benefits for wider marine ecosystems (Ronconi and others 2012, Oppel and others 2018, Cleasby and others 2020).

Marine areas outside MPAs

The high mobility of seabirds means that protected areas alone are unlikely to be sufficient for their conservation, particularly for some of the more widely dispersing species that tend not to aggregate (Lewison and others 2012, Oppel and others 2018). MPAs therefore need to be integrated into a wider, ecosystem-based approach to the management of marine habitats (Lewison and others 2012, Ronconi and others 2012, Nikitine and others 2018), with reference to drivers such as GES under the UKMS.

Climate change considerations

Marine protected areas can contribute to climate change resilience in marine ecosystems, but only when they are effectively managed (IPCC 2022b, IPCC 2022c). Adequate monitoring is required not just to assess the effectiveness of management measures, but also to be able to detect changes that might be caused by climate change (IPCC 2022b). Heavy trawling and dredging activities damage marine seabed habitats, releasing carbon into the water column, where it can re-mineralize and eventually re-enter the atmosphere, contributing to rising carbon dioxide (CO_2) levels (Stephenson & Johnson 2021). Healthy, undamaged seabed habitats are capable of sequestering large amounts of carbon (‘blue carbon’), thereby helping to reduce atmospheric CO_2 levels (Stephenson & Johnson 2021, IPCC 2022a).

Seabird populations are facing multiple threats caused by climate change, most notably via impacts on their food supply, which have been shown to negatively impact on productivity and survival, and the impacts of extreme weather events (Mitchell and others 2020, Johnston and others 2021). Although some of these impacts can be mitigated against, many are already happening and predicted to increase, regardless of mitigation measures (IPCC 2022b). Reducing the impacts of non-climate pressures, by protecting the habitats and food they rely on, will be vital to enable seabird populations to cope with the impacts of climate change (Furness 2016, Alderman & Hobday 2016, IPCC 2022b).

Breeding

Recommendation B1:

Conservation, restoration and creation of seabird breeding habitats at colonies

Evidence-based reason for recommendation

Reduction in extent and quality of seabird breeding habitat in England

Reduction in the extent and quality of habitat is one of the most widely reported pressures affecting England’s breeding seabirds (Lock and others 2022), especially at soft coast sites (eg sand and shingle beaches, saltmarsh) which make up the majority of colony locations. 98% of these sites were reported to be affected, with impacts highest on ground-nesting tern and gull species (Lock and others 2022). Similarly, Site Improvement Plans (SIPs) generated by IPENS (Improvement Programme for England's Natura 2000 Sites) showed that 97% of English SPAs with breeding seabirds features listed a reduction in the extent or quality of habitat as an issue (Natural England 2015a); more widely, large areas of England's coastal habitats have been lost since the end of World War II (Miles & Richardson 2018): 50% of shingle habitat; 18% of sand dunes; 15% of saltmarsh). Furthermore, 57% of Special Area of Conservation (SAC)-designated saltmarsh, 76% of coastal vegetated shingle, and 66% of sand dunes were assessed as being in unfavourable condition (Miles & Richardson 2018). The IPENS Coastal Management Theme Plan (Natural England 2015c) concluded that the overall status of England's intertidal habitats was 'bad-deteriorating'.

Without intervention, 5,000 Ha of protected coastal habitats is predicted to be lost by 2060 (Miles & Richardson 2018), with even greater areas being functionally lost as breeding habitat due to regular flooding. Previously, these losses were mainly from development and land claim, but the key future threats to coastal habitats are from climate change-related sea level rise, coastal erosion, and coastal squeeze (Natural England 2015a, Miles & Richardson 2018, Manning and others 2021, Lock and others 2022).

Climate-change driven changes to coastal breeding habitats

Mean sea levels in the UK have already risen by approximately 17cm since the start of the 20th century and climate predictions show that they will continue to rise under all emissions scenarios until at least the year 2100 (Lawton and others 2010, Fung and others 2018, Met Office 2021). Increases in sea level rise are difficult to predict, but are likely to be greatest in southern and eastern England (Marine Climate Change Impacts Partnership (MCCIP) 2020). Rising sea levels mean that more coastal seabird breeding habitat will be lost, and the risk of intermittent flooding of nest sites is also increased (Natural England 2015b, Pearce-Higgins 2021, IPCC 2022b). In addition to mean sea level rise, the risks of extreme sea levels and flooding are compounded by increases in storm swells and heavy rainfall events (MCCIP 2020, IPCC 2022a). Degraded coastal habitats are also more vulnerable to flooding due to sea level rise and increases in heavy rainfall and storm surges (Natural England 2015b, Miles & Richardson 2018, IPCC 2022a). Species that nest on the ground in sand and shingle habitats, such as terns and gulls, are particularly at risk, as large areas of these types of habitats can be lost rapidly with only minor increases in sea level (Johnston and others 2021). Many current breeding sites for terns and gulls on beaches and low-lying near-shore islands are likely to become unsuitable or be lost entirely within the next 10 years (Ross-Smith and others 2014, Ausden and others 2015, Miles & Richardson 2018, Dias and others 2019, Babcock & Booth 2020, Lock and others 2022). Little terns are particularly at risk because they tend to nest just above the high-water mark (Miles & Richardson 2018, Natural England & RSPB 2020). In recent years, high proportions of the UK's little tern nests have been flooded out (Lock and others 2022). Alternative nesting habitat may not be available, or birds may be forced to relocate to less suitable nesting areas, where they are more vulnerable to the impacts of disturbance and predation (Miles & Richardson 2018, Lock and others 2022). Several former tern colonies have been abandoned as breeding sites due to the habitat becoming unsuitable for various reasons, including flooding (Babcock & Booth 2020, Lock and others 2022). Future increases in sea levels and heavy rainfall due to climate change could lead to higher rates of cliff erosion, affecting the availability of suitable breeding habitat for cliff-nesting seabird species

(Morecroft & Speakman 2015, Natural England & RSPB 2020). Increases in the frequency and severity of summer storms could also effectively reduce the available breeding habitat for cliff-nesting species if more exposed locations become unsuitable. Further loss of breeding habitat could have negative consequences for seabird populations, particularly those already in decline (Newell and others 2015, Furness 2016, Johnston and others 2021, Lock and others 2022).

Opportunities for habitat creation

Lock and others (2022) estimated that a programme of soft coast habitat creation around England's south and east coasts could provide safe nesting habitat for an additional 30,000 pairs of gulls and terns. Increasing the availability of safe soft coast locations for breeding seabirds would enable the development of new seabird colonies, which could increase seabird abundance and the resilience of these populations to localised impacts. Additional safe nesting habitat could allow the roseate tern (currently restricted to one offshore island in England) to recolonise parts of its former range. Decoys and lures can be used to attract birds to safe new breeding habitats (Ratcliffe and others 2008b, Jones & Kress 2012, Babcock & Booth 2020).

There is a need to protect and restore England's coastal habitats within protected sites to ensure that their conservation objectives are met, as well as to ensure sufficient suitable breeding habitat for England's breeding seabirds (Natural England 2015a, Lock and others 2022). The restoration of coastal habitats also helps to protect coastlines from the impacts of rising sea levels, at least in the short term (Crick and others 2020, IPCC 2022a). The Lawton Report (2010) highlighted the need to improve the quality of existing wildlife sites as well as increase the size and number of such sites.

Recent work done by the RSPB and Natural England (Lock and others 2022) has led to the creation of a register of all of England's seabird colonies, identifying the specific issues at each site and the necessary interventions required to address these issues. Additionally, 22 'Priority Sites' were identified, based on the proportions of England's breeding seabirds that they hold, so that such interventions can be prioritised to target those sites with the greatest possible conservation gains. Prioritised interventions have also been roughly costed for a five-year programme (see Lock and others 2022 and summary tables in Appendix 1).

Climate change considerations

Healthy coastal and intertidal habitats and well-managed realignment schemes help to protect ecosystems and people from the impacts of sea level rise and increases in storms (Natural England 2015b, Miles & Richardson 2018, Natural England & RSPB 2020, IPCC 2022b). There are concerns that climate change may increase levels of recreational disturbance at coastal sites, increasing the need to provide disturbance-free habitats for nesting birds (Natural England & RSPB 2020).

Seabird populations are facing multiple threats caused by climate change, most notably via impacts on their food supply, which have been shown to negatively impact on productivity and survival, and the impacts of extreme weather events (Mitchell and others 2020, Johnston and others 2021). Although some of these impacts can be mitigated against, many are already happening and predicted to increase, regardless of mitigation measures (IPCC 2022a). Reducing the impacts of non-climate pressures, such as loss of breeding habitat, will be vital to enable seabird populations to cope with the impacts of climate change (Furness 2016, Alderman & Hobday 2016, IPCC 2022a).

Recommendation B2:

Increased site management to safeguard breeding seabirds against disturbance and predation

Evidence-based reason for recommendation

Disturbance

Disturbance is the most widely reported pressure affecting England's breeding seabirds (Lock and others 2022), with 100% of English SPAs with breeding seabird features listing disturbance as an issue (SIPs from IPENS: Natural England 2015a). Site managers see disturbance as a growing issue, and human recreational disturbance at coastal sites is predicted to increase (Lock and others 2022, Natural England & RSPB 2020). Disturbance of nesting seabirds is mostly caused by such recreational activities – beachgoers, dogwalkers, climbers and recreational fishers on land, and recreational watercraft such as jet skis from the sea (Lock and others 2022). Disturbance is particularly an issue for ground-nesting birds such as terns and gulls at soft coast sites, but it affects all seabird colonies to some extent (Ross-Smith and others 2014, Babcock & Booth 2020, Lock and others 2022); cliff-nesting species may be more vulnerable to disturbance from the sea (Lock and others 2022). Disturbance at nest sites can have significant negative impacts on seabird breeding success through increased exposure of eggs and young to predation and the elements and can lead to the abandonment of nest sites and even entire colonies (Hunt 1972, Robert & Ralph 1975, Burger 1981, Hockin and others 1992, Ross-Smith and others 2014).

Predation

Predation is a widely reported issue, particularly for colonies of ground-nesting birds such as terns and gulls at soft coast sites, which includes a large proportion of England's breeding seabirds (Lock and others 2022). Mammalian predators are known to have the greatest negative impacts on ground-nesting seabirds (Smith and others 2010, Lavers and others 2010, Roos and others 2018, Babcock & Booth 2020). Population densities of many generalist mammalian predators have increased in the UK and are now amongst the highest in Europe (Roos and others 2018). Predation of eggs and young negatively impacts seabird breeding success and high levels of predation can lead to total reproductive failure in gull and tern colonies (Southern & Southern 1979, Southern and others 1985, Ross-Smith and others 2014, Babcock & Booth 2020). High levels of predation can also lead to the abandonment of nest sites or even entire colonies, effectively amounting to loss of breeding habitat (Ross-Smith and others 2014, Babcock & Booth 2020).

The negative impacts of disturbance and predation reinforce each other: disturbance increases the risk of predation, while the presence of predators causes disturbance (Hockin and others 1992, Hunt 1972, Lock and others 2022).

Recent work done by the RSPB and Natural England (Lock and others 2022) has led to the creation of a register of all of England's seabird colonies, identifying the specific issues at each site and the necessary interventions required to address these issues. Additionally, 22 'Priority Sites' were identified, based on the proportions of England's breeding seabirds that they hold, so that such interventions can be prioritised to target those sites with the greatest possible conservation gains. Prioritised interventions have also been roughly costed for a five-year programme (see Lock and others 2022 and summary tables in Appendix 1).

Climate change considerations

There are concerns that climate change may increase levels of recreational disturbance at coastal sites (Natural England & RSPB 2020). Loss of coastal habitats due to climate change-induced sea level rise is likely to reduce the number and size of seabird colonies, and smaller seabird colonies are likely to be more vulnerable to impacts of disturbance and predation (Ross-Smith and others 2014). Higher densities of birds of different species concentrated into smaller colonies also increases the risks of interspecific competition and predation as well as predation by other seabird species (eg, large gulls predating terns).

Seabird populations are facing multiple threats caused by climate change, most notably via impacts on their food supply, which have been shown to negatively impact on productivity and survival (Mitchell and others 2020). Although some of these impacts can be mitigated against, many are already happening and predicted to increase, regardless of mitigation measures (IPCC 2022a). Reducing the impacts of non-climate pressures, such as disturbance and predation, will be vital to enable seabird populations to cope with the impacts of climate change (Furness 2016, Alderman & Hobday 2016, IPCC 2022a).

Recommendation B3*: Improve and increase efforts to reduce the emergence, spread and impacts of pathogens and parasites in seabirds*

Evidence-based reason for recommendation

Given that disease, and particularly HPAI, is now a serious threat to the UK's seabird populations, and that such disease outbreaks are predicted to increase in future, there is an urgent need to develop and implement measures to reduce the emergence, spread, and impacts of disease (Mu and others 2014, Khan and others 2019, Lee and others 2020, AEWA (Agreement on the Conservation of African-Eurasian Migratory Waterbirds) 2022, RSPB 2022, Walton 2022). However, there has been very little research conducted into possible methods of preventing and treating disease (and parasites) in seabirds (Hakkinen and others 2022).

The England Wildlife Health Strategy (Defra 2009) states that government has a responsibility to intervene in wildlife disease issues when the impact of a disease is significant enough to cause a decline in the population viability of a species officially recognised as of conservation concern, or where the impact could lead to a species becoming threatened. These criteria are likely met by the summer 2022 outbreak of HPAI in England's seabirds, particularly in the case of roseate terns, which are a red-listed BoCC5 species, and which have experienced at least 28% adult mortality during the course of this outbreak (Ibrahim Alfarwi, *pers comm*).

Obviously, the movements of wild birds cannot be controlled in the way that those of captive birds can. However, effective biosecurity methods may help to reduce the spread of pathogens and parasites and should be put in place for all activities occurring at seabird colonies, including ecotourism, monitoring and ringing activities (AEWA 2022, RSPB 2022). These biosecurity measures could be tied in with biosecurity measures already developed for reducing the spread of invasive non-native species to seabird islands (see recommendation B4), but would be equally necessary at mainland colonies and for activities taking place outside the breeding season. The removal of sick and dead birds from colonies may be an option to reduce the spread of disease, particularly where birds such as gulls or skuas may be scavenging on carcasses (Khan and others 2019, Banyard and others 2022). However, carcass removal may lead to increased disturbance of colonies and recruitment of non-breeding individuals into vacant territories which could increase transmission rates. More information is required about the epidemiology of disease in different species to be able to inform such decisions, and such decisions may need to be made on a site-by-site basis. Feasibility and health and safety of personnel carrying out such activities also needs to be considered.

Vaccination may be an effective method to protect seabird colonies from disease (Bourret and others 2018, Khan and others 2019). Bourret and others (2018) demonstrated that vaccination successfully increased resistance to avian cholera and fledging probability in Indian yellow-nosed albatross *Thalassarche carteri* chicks. However, there has been very little research done on vaccination of wild bird species and there are few vaccines considered safe and effective against wildlife pathogens (Bourret and others 2018). Currently available avian influenza vaccines are not known to be effective outside of poultry (HM Government 2021). Vaccination of wild birds is also logistically difficult and resource-intensive and likely only an option for species of conservation concern (Bourret and others 2018, Khan and others 2019). Alderman & Hobday (2016) treated shy albatross *Thalassarche cauta* chicks with insecticide to reduce the transmission of vector-borne disease by ectoparasites and showed that survival of treated chicks was significantly higher. Treatment for parasites may therefore be an effective way of reducing the impacts of vector-borne diseases, depending on the epidemiology of the disease in question.

In situations where the risk of extinction or local extinction is particularly high, it may be possible to protect breeding populations by bringing a small number of individuals into captivity, to become part of a captive breeding programme, or to ‘head-start’ eggs or chicks for later release. However, the logistics of such an operation would be difficult and involve biosecurity concerns, the availability of suitable avicultural facilities with sufficient capacity, and sufficient avicultural expertise to adequately care for birds (Geoff Hilton, *pers. comm*).

The transmission of disease between captive birds (particularly poultry) and wild birds should also be minimised to reduce the spread of disease and the emergence of new pathogens (AEWA 2022). Interactions between wild birds and captive birds should be avoided wherever possible, and biosecurity measures put in place to reduce the risk of transmission between captive and wild populations. Verhagen and others (2021) concluded that the most effective way to address the risk posed by avian influenza is to effectively control poultry disease and therefore reduce the risk of novel viruses emerging and the associated threats to wildlife as well as zoonotic risks to humans.

While mitigation measures to limit the spread and impacts of disease may be limited, there is evidence to show that the susceptibility of individual seabirds to disease is exacerbated by the presence of other environmental stressors. The impacts of disease are likely to be greater on birds that are already suffering from nutritional stress or from the presence of toxins (Stidworthy & Denk 2018, Khan and others 2019, Sebastiano and others 2022). Reducing the impacts of other pressures on seabirds could therefore help to reduce the impacts of disease. Furthermore, habitat loss and degradation may lead to higher concentrations of individuals in fewer suitable locations, which further facilitates the spread of disease and potentially exacerbates population-level impacts (Hofmeister & Van Hemert 2018, IPCC 2022b). Improving the extent and quality of supporting habitat for breeding seabirds, and the number of breeding colonies, could therefore reduce the impacts of disease on seabird populations. Population-level impacts of multiple different pressures on seabirds are likely to be additive, so reducing the impacts on seabird populations of other anthropogenic pressures and improving the resilience of populations is critical to mitigating the impacts of disease.

Climate change considerations

Seabird populations are facing multiple threats caused by climate change, most notably via impacts on their food supply, which have been shown to negatively impact on productivity and survival (Mitchell and others 2020). Climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future (Dennis & Fisher 2018, Dias and others 2019, Johnston and others 2021, IPCC 2022b). Habitat loss and degradation caused by climate change (eg, rising sea levels) may lead to higher concentrations of individuals in fewer suitable locations, which further facilitates the spread of disease and potentially exacerbates population-level impacts (Hofmeister & Van Hemert 2018, IPCC 2022b). Reducing the impacts on seabirds of other anthropogenic pressures, including those caused or exacerbated by climate change could help to reduce the impacts of disease. Likewise, reducing the impacts of pathogens and parasites on seabird populations could help seabird populations to cope with the impacts of climate change (Alderman & Hobday 2016, IPCC 2022b).

Recommendation B4:

Eradication of invasive mammalian predators from existing (and potentially suitable) breeding seabird islands and implementation of associated island biosecurity measures

Evidence-based reason for recommendation:

Rationale for eradication

Invasive mammalian predators are acknowledged to be one of the top threats to seabird populations worldwide (Jones and others 2008, Dias 2019). Seabirds nesting on islands are vulnerable to the impacts of non-native invasive mammalian predators such as brown rat, domestic cat and American mink, which have often been introduced to UK seabird islands (Thomas and others 2017). Rats are a common invasive on islands, having severe negative impacts on breeding seabird populations (Jones and others 2008, Stanbury and others 2017). However, successful eradications of rats and other invasive mammalian predators from islands are possible, and where they have been carried out, the recovery of seabird populations has often been drastic (Thorsen and others 2000, Jones 2010, Stanbury and others 2017, Thomas and others 2017, Brooke and others 2018, Booker and others 2019) and there have also been positive effects on wider terrestrial and marine ecosystems (Benkwitt and others 2021). Successful eradications need to be followed up with robust biosecurity measures to prevent reinvasion, along with a system of rapid response to deal with any incursions quickly before they can spread (Stanbury and others 2017, Thomas and others 2017). It is also possible for invasive mammalian predators to find their way to islands that are currently invasive-free, either via natural means (eg, swimming) or introduced accidentally by humans. The potential negative impacts on breeding seabird populations of such invasions on invasive-free islands are severe, so biosecurity measures and rapid response are required for all seabird islands (Stanbury and others 2017, Thomas and others 2017, Booker and others 2019, Lock and others 2022).

Eradications in England

The relatively few offshore islands England has include some of its most important sites for seabirds: the Isles of Scilly, the Farne Islands, Coquet Island and Lundy Island (Lock and others 2022). Together, these support all of England's breeding Manx shearwater, European storm petrel, and roseate tern, and the majority of breeding European shag, Arctic tern, and Atlantic puffin (Lock and others 2022). In 2002, black rats were successfully eradicated from Lundy, and in 2013, brown rats were successfully eradicated from two of the Scillies – St Agnes and Gugh (Bell and others 2019, Booker and others 2019). Both eradications resulted in recolonisation by European storm petrels as well as increases in the populations of Manx shearwater and other seabird species (Brown and others 2011, Heaney & St Pierre 2017, Booker and others 2019). Brown rats are still widespread, however, on the remainder of the Isles of Scilly, where they are thought to be negatively impacting seabird populations (Heaney & St Pierre 2017, Lock and others 2022). The Farne Islands and Coquet Island have remained free from invasive mammalian predators although a rat was detected on Coquet in 2018, which highlights the need for ongoing biosecurity measures combined with a system of rapid response if and when incursions are detected (Lock and others 2022).

Knowledge gaps

The status of other, smaller, islands is largely unknown and would require investigation to establish the potential for seabird recovery through removal of predators. This includes several small south-west islands such as Steepholm, The Mouls, Mullion Island, Great Mew Stone, etc.

Climate change considerations

Seabird populations are facing multiple threats caused by climate change, most notably via impacts on their food supply, which have been shown to negatively impact on productivity and survival (Mitchell and others 2020). Although some of these impacts can be mitigated against, many are already happening and predicted to increase, regardless of mitigation measures (IPCC 2022a). Reducing the impacts of non-climate pressures, such as predation, will be vital to enable seabird populations to cope with the impacts of climate change (Furness 2016, Alderman & Hobday 2016, IPCC 2022a). Climate change may facilitate the spread and establishment of invasive non-native species (Ziska & Dukes 2014).

Surviving

Recommendation S1:

Develop mitigation and monitoring best practice for key seabird bycatch risk areas (identified through improved understanding)

Evidence-based reason for recommendation

Recent studies have provided evidence that identifies the UK offshore demersal longline and <10 m static net fleets as the highest priority fleets with which to target further seabird bycatch mitigation measures due to observed seabird bycatch (Anderson and others 2021).

Fisheries management measures that oblige fishers to mitigate seabird bycatch and/or spatially limit longlining activity away from seabird colonies/hotspots could provide ecological opportunities for seabirds (Edmonds and others 2021).

Longlines

Whilst longline fishery activities are predominantly located outside of English EEZ waters there is a small offshore demersal longline fishery operating in its far south-west reaches and inshore in the English Channel and North Sea; Northridge and others 2020), England’s seabirds can encounter these fishing activities, and hence be at risk of bycatch, during the non-breeding season when birds may disperse over a wider area. Northern fulmar represents the largest component of bycatch in the UK-registered demersal longline fleet, for which mitigation measures could have the potential to result in substantial population gains (Miles and others 2020). Several simple and effective seabird bycatch mitigation measures for longline fisheries already exist, such as use of an appropriate line weighting regime to maximise hook sink rates close to the stern of the vessel to reduce the availability of baits to seabirds; actively deterring birds from baited hooks by means of bird scaring lines; and setting at night (ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2019, Anderson and others 2021). Most mitigation measures have been developed and tested in the southern hemisphere longline fisheries (eg, Gilman and others 2021, Sullivan and others 2018, Domingo and others 2017, Cherel and others 1996), however, there has been limited work to test, adapt or implement these measures for demersal longlines, which are predominantly used in the North-East Atlantic, including the UK fleet (Rouxel and others 2022). In 2012 the European Union (EU) published an Action Plan for reducing bycatch of seabirds in fishing gears, which required that member states implement at least two proven mitigation measures in longline fisheries, such as night setting, bird-scaring lines or line weighting in accordance with minimum technical standards as set out in ACAP guidelines (European Commission 2012). However, Mitchell and others (2021) found that those mitigation measures are still not required to be implemented in most EU longline fisheries. While some mitigation measures are in place on some UK-registered vessels (eg, voluntarily using night setting and bird-scaring lines (Northridge and others 2020)), the extent and efficacy are poorly understood. However, a preliminary study of line sink rate has recently been completed, highlighting the likely limited benefits of traditional mitigation measures in this fishery (eg, bird scaring lines) to prevent seabird bycatch (Anderson and others 2021).

Gill nets (static nets)

The typical means of fishing for clupeids involves gill nets which have been found to be harmful to seabirds (Žydelis and others 2013). This fishing method is associated with seabird bycatch, especially of common guillemots (Northridge and others 2020), that has the potential to adversely impact discrete seabird populations chronically at low levels across the North Sea and in south-west waters / the Celtic Sea, and acutely when occurring adjacent to breeding colonies. There are an extensive number of different types of gillnet fisheries around the UK. Most fisheries use monofilament nets, but gear can vary between gillnet, tangle net and trammel net. The extent, number of vessels involved, and complexity of the UK static net fleet makes mitigating the impacts of seabird bycatch extremely difficult, and no one mitigation measure is likely to work in all scenarios (Anderson and others 2021). Although technical mitigation measures to reduce seabird bycatch in gillnets have been investigated (eg, visual alerts such as highly visible netting and netting or acoustic alerts, Melvin and others 2001, Field and others 2019, Bielli and others 2020), much of this research is ongoing and, unlike longline and trawl fisheries, there are still no best practice mitigation measures (Cleasby and others 2022). Therefore, at present the most feasible measures for minimising gillnet bycatch are through spatial and temporal regulation of fishing effort or gear substitution (Žydelis and others 2013, Cleasby and others 2022). Other measures are in place or under development to reduce bycatch (primarily of common guillemots and razorbills), for example:

- In one part of the inshore fixed net fishery at Filey Bay, fishers, conservation organisations and fishery managers successfully worked together to reduce bycatch of auks. The measures included knowledge exchange, increased net attendance, high visibility net material and stopping overnight soaking of nets (Quayle 2015). The fishery is currently subject to a public consultation.
- The Cornwall Sea Fisheries District St Ives Bay Gill Net Fishery Byelaw 2011[10] curtails the fisheries activity if bycatch exceeds an agreed level. The Cornwall IFCA's Code of Practice for net fishing in St Ives Bay[11] supplements the aim of the 2011 Byelaw and notes that bycatch tends to occur in specific weather conditions.
- The Cornwall IFCA also has a Code of Practice for net fishing in the Falmouth Bay to St Austell Bay SPA[12], which also relates to seabird bycatch.
- A partnership between conservation organisations (RSPB, BirdLife, CIFCA and NE) and gill-net fishers in Cornwall is trialling LEBs and predator-shaped kites as a

potential measure to reduce seabird bycatch at the Falmouth Bay to St Austell Bay SPA.

- Ørsted have recently undertaken at-sea implementation trials of LEBs, as part of the bycatch reduction proposals for in-principal compensation work for the Hornsea 4 OWF application (GoBe 2022).

Mid-water trawling

Mid-water trawling in UK waters is associated with bycatch of common guillemot, razorbill and great cormorant, although the relative numbers of birds caught is thought to be small and not currently considered of conservation concern (Northridge and others 2020). Bycatch in this fishery is most likely due to net entanglement, primarily during trawling, where the trawl headline is in close proximity to the surface. Birds are likely flushed and those that escape-dive have the potential to be caught in the net as it is towed (Northridge and others 2020). There could be benefit from targeted monitoring (ie, with cameras) to assess the mechanism of bycatch events for this gear type (Anderson and others 2021). It is possible that some bycatch occurs during net hauling and, in instances such as these, an important mitigation measure is safe retrieval of live individuals. Given the form that seabird bycatch takes in this fishery (ie, mid-trawl through flushing of birds ahead of the deployed net), it seems unlikely that a suitable mitigation measure will be found, and in any case the numbers of birds involved is probably small (meaning that other fisheries should be prioritised over mitigation in this fleet). Safe handling of birds caught during hauling would seem the primary mitigation measure for this fishery (Anderson and others 2021).

Purse seine fishery

There is little direct information of bycatch from the small UK purse-seine fleet (Anderson and others 2021). Evidence from Spain indicates shearwaters are vulnerable to bycatch in purse-seines and in the south-west of the English EEZ, shearwaters and gannets may be at risk, notably the critically endangered Balearic shearwater (Anderson and others 2021). Although mitigation methods have been researched in Chilean fisheries (Suazo and others 2019) only a voluntary code of conduct is in place to record bycaught birds in the UK fishery. Improved monitoring of bycatch in the fishery would be beneficial to determine its extent. However, the sporadic occurrence of the birds at sea coupled with low observer coverage may yield indeterminant data (Anderson and others 2021).

Abandoned, lost and discarded fishing gear

Fishing gear is often made from long-lasting synthetic polymers, such as nylon, and lost and abandoned gear (sometimes known as ghost gear) is a long-term problem in the marine environment. Abandoned, lost or discarded gear can trap and often kill large fish, crustaceans, turtles, cetaceans and other organisms. Other animals, such as seabirds, are attracted to potential prey trapped in the gear and become trapped themselves (Good and others2009, Vitorino and others 2022).

Climate change considerations

The environmental effects of climate change are not reversible in the short to medium term (years to decades). So, while it may be difficult to address the impacts of climate change on seabirds directly, measures can be taken that will increase the resilience of seabirds to the effects of climate change, by reducing the cumulative impacts of other pressures, including bycatch. Climate change is causing species distributions in the northern hemisphere to shift northwards (Elliot and others 2015, Pearce-Higgins 2021, IPCC 2022b). Seabird species may also shift their range to follow their prey, particularly outside the breeding season when their movements aren't so constrained (Furness 2016, Mitchell and others 2020). If we understand where seabirds might move to in response to climate change and prey redistributions, we can review whether there are likely to be new bycatch hotspot areas and hence fisheries management bycatch mitigation measures can be implemented in areas where there is a future chance of fishing bycatch happening.

Recommendation S2:

Strengthen the use of mitigation hierarchy to reduce impacts to seabirds and promote recovery through strategic sustainable development (especially from offshore wind farms)

Evidence-based reason for recommendation

Many seabird species are known be sensitive to collision, visual disturbance, and possibly above or below water noise, including avoidance of areas within and around anthropogenic activities that cause these pressures (eg, Drewitt & Langston 2006, 2008, Allen and others 2019). The UK has ambitious targets for reaching net zero by 2050 and offshore renewable energy generation, predominantly OWFs, is key to reaching this objective. Therefore, the risk of lethal and sub-lethal impacts to sensitive species will increase if not dealt with appropriately in the planning and consenting process for OWFs.

The mitigation hierarchy for sustainable development requires projects to, wherever possible: avoid impact, eg through careful planning at plan and project scale; reduce or mitigate impact, eg through changes in design that remove impact pathways or reduce levels of impact; and compensate for residual impact that cannot be avoided or mitigated in cases where a development is consented on the basis that there are no alternative solutions and the project is in the public interest despite adverse environmental impact. This hierarchy provides the framework for development control, including the Habitats Regulations Assessment process to assess impacts to protected seabird features of SPAs and similar provisions for Marine Conservation Zones.

However, early development of offshore wind in the UK often took place in step with increasing understanding of the impacts of development on seabirds. Thus, for example, there are OWF developments within and / or close to SPAs for sensitive species including red-throated divers (Allen and others 2019) and gulls such as black-legged kittiwakes and lesser black-backed gulls (Bradbury and others 2014). Mitigation options were limited, and compensation due to unavoidable adverse effects has only recently been required.

This recommendation would ensure that the mitigation hierarchy features more prominently in all stages of development. Additionally, a fourth step relating to enhancement of seabird populations, habitats and food sources should be added, that recognises the benefits that could result from development, such as through Net Gain. This is explored further in Natural England's Approach to Offshore Wind (Natural England 2021), which should provide a template for planning and implementing this recommendation.

Climate change considerations

The reduction of carbon emissions by increasing the amount of renewable energy created in the UK is key to reducing the magnitude and extent of climate change. It is important for seabird conservation that carbon emissions are reduced to lessen the impacts of climate change on seabird species, eg, changes to prey distributions, sea level rise, etc. This will lead to an increase in numbers of OWFs across the England EEZ, along with the possible increase in numbers outside of English waters that birds interact with at other times of the year. As climate-driven processes progressively affect marine ecosystems, it will be important to factor predictions about consequent likely change to seabird distributions into application of the mitigation hierarchy, particularly in the planning of new development areas, but also in terms of changing species requirements for mitigation and compensation.

Recommendation S3:

Effective protection, conservation and restoration of seabird marine habitats

See recommendation F2.

Recommendation S4:

Reduce marine litter and its impacts on seabirds

Evidence-based reason for recommendation

Marine litter

Anthropogenic litter is distributed across the marine environment with no restrictions from political or administrative boundaries, although there is evidence it is retained in the local 'deposit area' and can potentially remain for years (Lebreton and others 2019). We have defined litter as any manufactured or processed solid material from anthropogenic activities that are discarded, disposed of or abandoned in the natural environment, including plastics, metals, timber, rope, fishing gear and their degraded components, e.g,. microplastic particles. It is a major issue for the health of the marine environment due to its resilience and permanency as well as its increasing abundance (Gall & Thompson 2015). Plastic debris is a major component of marine litter, comprising around 70% of litter on beaches (Nelms and others 2020) and plastic production continues to rise, it is predicted that annual emissions could be up to 53 million tonnes by 2030 (Borrelle and others 2020). Marine litter has been shown to impact over 690 marine species (Gall & Thompson 2015).

Marine litter and seabirds

Seabirds are affected by marine litter, especially plastic litter, through entanglement, nest incorporation and ingestion and these can have sub-lethal or lethal impacts (Gall & Thompson 2015; O'Hanlon and others 2017).

Seabirds will interact with litter from a range of sources; in a study of litter collected at MPAs across the UK, litter from fishing activities was most common in MPAs in the south-west while at MPAs close to rivers and estuaries sewage related debris was most widespread (Nelms and others 2020). The most prevalent material was plastic.

Ingestion

There are limited data on the spatiotemporal variation in impacts of marine litter on seabirds, but a review of north-eastern Atlantic Ocean studies showed evidence for plastic ingestion in 25 seabird species (O'Hanlon and others 2017). Ingestion has been linked to seabird mortality in a dose-dependent way, by causing gut obstruction and reducing food intake (Roman and others 2019a). Size of particles ingested vary, although research from petrel species found plastics that were 2-10 mm in size were most frequently ingested and retained, and this may represent a key size classification that poses most risk (Roman and others 2019b). Microplastics may also be ingested via food, since they have been documented in a range of species from lugworms to fish and crustacea (GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), 2016). OSPAR's common indicator for Marine Litter (D10) is partly assessed through the proportion of beached North Sea northern fulmars with more than 0.1 g of plastic in their stomachs; the goal is for no more than 10% but currently the figure is 68-69% for the east and southern regions of England (OSPAR Commission 2017a). Only 7% of the beached birds studied had no plastic in their stomach and these results show the abundance of floating plastic in the environment. The monitoring of plastic ingested by northern fulmars by OSPAR has also provided information on changes to sources of floating litter in the North Sea. The emissions of industrial plastic pellets have reduced over two decades; however, the plastic from consumer waste has increased (OSPAR Commission 2017a).

Ingestion of plastics is also an issue for chicks as evidence from the southern hemisphere shows birds such as shearwaters feed plastic to chicks. The stomach contents of chicks reared near shore were being fed higher levels of plastic when compared to offshore island colonies (Verlis and others 2018).

In addition, microplastics can act as vectors for hazardous substances; this can be from within the chemical composition of the plastic, eg, stabilisers and flame retardants such as PBDEs (polybrominated diphenyl ethers; Neumann and others 2021), or on the surface of the plastic, eg toxic chemicals or heavy metals (GESAMP, 2016). PBDEs detected in seabirds were found in ingested plastic and liver tissue of birds with ingested plastic, and can be associated with neurotoxic changes, hormone / enzyme changes and may be involved in encouraging tumours to grow (Neumann and others 2021). The relative importance of this as a source of chemicals to wildlife relative to others still needs to be ascertained.

Nest incorporation

In a review of the occurrences nest incorporation across the north-eastern Atlantic Ocean, three studies showed nest incorporation (from two species: northern gannet and black-legged kittiwake; O'Hanlon and others 2017). To improve the data available, a recent study outlined a method for investigating nest incorporation in seabird nests by including the collection of observations alongside other research, including bird ringing (O'Hanlon and others 2019, O'Hanlon and others 2021). This opportunistic method generated over 10,000 observations of nests from five European countries with 12% of nests containing litter (O'Hanlon and others 2021). Unfortunately, data on the full impacts of such interactions with litter are lacking; for example, mortality rates from entanglement in litter at the colony, in nests, and at sea, are unknown.

In studies of incorporation of litter into nests, thread plastic (eg rope, net) was most commonly observed (Provencher and others 2017, O'Hanlon and others 2021). In a study of northern gannet nests, birds appeared to prefer thread plastics, commonly associated with fishing and aquaculture activities, as the proportion of threadlike items in nests was significantly greater than the proportion on beaches (O'Hanlon and others 2019). Threadlike and sheet debris were most common from observations of nests of 10 species across 41 European colonies (O'Hanlon and others 2021).

Climate change considerations

Marine litter and climate change are intricately linked. Firstly 99% of plastics are made from fossil fuels and their production is estimated to produce over 400 million tonnes of greenhouse gases annually (UNEP 2021). Secondly, marine litter is recognised as a threat multiplier which means that it acts with other pressures, such as climate change, to have greater detrimental impacts than if they occurred in isolation (Lincoln and others, 2022). This can be because ecosystem resilience is undermined by the presence of marine litter and ecosystems are less able to respond to the pressures from climate change.

Recommendation S5:

Continue to work towards GES for contaminants and reduce the impacts of contaminants on seabirds

Evidence-based reason for recommendation

Chemical contaminants enter the marine environment from several sources, from the terrestrial environment via sewage effluents and coastal landfill sites and from emissions at sea by vessels and industries with structures in the marine environment. Seabirds can be impacted by contamination from synthetic compounds, hydrocarbons and transition elements including heavy metals. Due to bioaccumulation and biomagnification, seabirds, as foragers, scavengers, and predators, can be exposed to environmental contaminants of concern (Blévin and others, 2017).

Synthetic chemical compounds

Synthetic compounds (chemicals manufactured for a variety of industrial processes and commercial applications) include pesticides, pharmaceuticals and veterinary medicines and are persistent, bioaccumulative and/or toxic (BPT) to seabirds. There is limited understanding of exposure and resulting impacts in marine birds. Most effects of contamination by synthetic compounds on seabirds are probably linked to chronic exposure to relatively low levels of chemical contaminants. Some persistent organic pollutants (POPs), regulated under the UNEP Stockholm Conventions, can have endocrine disrupting effects (ED); for example, by impacting endogenous hormone functions (Jenssen 2006). There is extensive evidence of ED effects in black-legged kittiwakes in the Arctic, affecting their oxidative stress levels (eg, Costantini and others 2019) and thyroid hormone levels (eg, Svendsen and others 2018).

Crude oil

Crude oil (hereafter ‘oil’) spills and contamination from hydrocarbons can cause sublethal and lethal effects. The volume of oil spilled varies annually but is mostly small and of relatively minor significance unless there is a major disaster (Defra 2015). The number and volume of oil spills from oil tankers have reduced since the 1970s (Burgherr 2007). Oil spills can be catastrophic when they do occur, with, for instance, estimates of ~4,500 dead common scoters followed the 1996 *Sea Empress* oil spill in south Wales (Banks and others 2008). Seabirds are at risk of exposure to oil which can lead to direct physical effects of oiling on feathers resulting in hypothermia, starvation and drowning along with sub-lethal impacts of toxicity from ingestion of oil (Leighton, 1993; Stephenson 1997). Aside from the direct, immediate impacts of catastrophic oil spills, longer-term effects are associated with chronic exposures to relatively low concentration levels of pollutants, as well as ecosystem changes (Banks and others 2008, Moreno and others 2013). Surveys of beached birds are an important method to understand geographical and temporal patterns of oil pollution affecting seabirds (Furness & Camphuysen 1997).

Metals

Metals enter the marine environment from several sources, including natural processes and agricultural or industrial practices, and can cause sublethal effects (OSPAR Commission 2017b; Whitney & Cristol 2017). For example, mercury is highly toxic and can cause neurological deficiencies, immune disruption or lowered egg hatchability (Chastel and others 2022), and in black-legged kittiwakes, mercury contamination caused skipping reproduction, delayed hatching and reduced reproductive performance (Tartu and others 2013, Tartu and others 2016). After decades of work to reduce mercury emissions in air and water, a study of birds in the Arctic showed that 23 out of 24 bird species studied were shown to have mean mercury concentrations at or below the low toxicity impact level for fitness risks (Burnham and others 2019, Ackerman and others 2016). However, a recent study of great skuas showed mercury concentrations that were some of the highest in Arctic and North Atlantic seabirds and associated with toxicity risks, the found a suggested carry-over effect, with mercury concentrations from the non-breeding period impacting skuas during the breeding season, for example with lower hatching success (Albert and others, 2022).

Status of UK waters

The UK has largely achieved its aim of GES for contaminants (Defra, 2021). Concentration of hazardous substances and their biological effects are generally meeting the target thresholds as agreed through the UKMS (HM Government, 2012). Highly persistent legacy chemicals are the cause of the few failures in meeting the targets for Descriptor 8 in the UKMS, mainly in coastal waters close to polluted sources (moat.cefas.co.uk). An outstanding issue for GES is PCB 118, one of the most toxic polychlorinated biphenyls, which is above the environmental assessment criterion measured by Charting Progress 2 (UK Marine Monitoring and Assessment Strategy (UKMMAS), 2010). There are still concerns around point-source issues and upstream issues. There needs to be a stronger connection between the Water Framework Directive and UKMS to allow integration between terrestrial, marine and coastal water issues.

There are transboundary issues with contaminants and chemical pollution as hydrodynamics in the marine environment mean that contaminants could come from outside English waters or spread from English waters into other areas.

Climate change considerations

Climate change is resulting in extreme weather and increased frequency and severity of storms. This is a physical threat to the oil and gas industry and could lead to an increase in the risk of oil spills (Cruz & Krausmann, 2013). In addition, the severe weather events increase the risk of remobilisation and potential exposure of contaminants from benthic sediments and the terrestrial environment from coastal erosion. Also, increased sea temperatures could influence the toxicities of chemical pollutants and their uptake by organisms (Schiedek and others 2007).

Knowledge

Knowledge Recommendation K1:

Fund long-term monitoring of key seabird colonies in England to ensure representative picture

Evidence-based reason for recommendation

Monitoring of breeding seabird demography

Having up-to-date information on seabird population sizes and trends and understanding the drivers of population change is vital to their conservation (Tasker 2000, Lewison and others 2012, Furness 2016, Bolton and others 2019, Mitchell and others 2020). Declines in breeding populations of seabirds are particularly difficult to detect, due to the influence of non-breeding and immature birds, so estimates of abundance alone are not enough (Lewison and others 2012, Horswill and others 2018). Understanding seabird population trends and the drivers of population change also requires accurate estimations of demographic rates (Lewison and others 2012, Genovart and others 2018), such as:

Adult and juvenile survival (e.g,. colour-ringing)

- Breeding productivity (eg, direct or remote observation)
- Recruitment of new breeders (eg, colour-ringing; direct or remote observation)
- Dispersal (eg, colour-ringing; direct or remote observation)

Monitoring of seabird diet

Information about seabird diet and trophic ecology is also extremely important (Lewison and others 2012, Ceia and others 2022). Seabirds are typically top predators in marine food chains and are vulnerable to changes to their prey (Barrett and others 2007, Lewison and others 2012), meaning they are good indicators of the health of marine ecosystems (Barrett and others 2007, Mallory and others 2010, Lewison and others 2012). Seabirds are particularly vulnerable to changes in the abundance, availability and quality of prey during the breeding season, when they are geographically constrained as central-place foragers and when growing chicks may have specific nutritional requirements (Furness 2016, Mitchell and others 2020). Monitoring the prey provided to chicks during the breeding season helps us to understand local availability of prey and examine how this influences breeding success, for instance by recording:

- Type of prey
- Size of prey
- Provisioning rate (fish per unit time)
- Foraging time (time away from nest)

Current seabird monitoring

Seabird colony monitoring in the UK is overseen by the SMP. Recent reports have suggested that the current sampling effort under the SMP is insufficient to accurately describe trends in abundance or productivity or to detect and quantify impacts of pressures on populations for many species (Cook and others 2019, Dunn 2021, Edmonds and others 2021). The SMP has four ‘key sites’, which benefit from funding to ensure long-term demography and diet monitoring is possible. These sites are Canna (Scotland); Isle of May (Scotland); Fair Isle (Scotland); and Skomer (Wales). There is no formal, comprehensive, long-term funding of colony monitoring of this type in England. However, England supports both the largest mainland colony in the UK (Flamborough & Filey Coast SPA) and the colony representing the far south of the UK range (Isles of Scilly SPA). Monitoring of these colonies is largely limited to relatively small-scale NGO (and, sometimes, privately)-funded studies of productivity, and there is a requirement for much more to inform understanding of changes at both site and regional scale.

Away from these sites, much of the scheme is reliant upon volunteer surveyors. Maintaining an energised, engaged, dedicated network of volunteers is therefore crucial to the continued value of the SMP.

Relatively modest investment could lead to massive improvements in understanding of conservation needs.

This includes:

- More accurate assessment of impact from marine development, eg, through improved population viability analysis (PVA) models, which are a key method for assessing potential future impacts on seabird populations of offshore renewable developments and other pressures (Cook and others 2019, Searle and others 2020, O'Hanlon and others 2021) [demographic rates];
- Improved information for GES indicators and site condition assessment [demographic rates; diet studies];
- Understanding of regional variation in the influence of climate change demographic rates (Searle and others 2022);
- Understanding prey type, foraging time and provisioning rate to inform fisheries management [diet studies].

Fieldworkers undertaking monitoring activities at colonies can also collect additional information on seabird health and anthropogenic impacts (eg plastic pollution, disease screening: Mallory and others 2010, O'Hanlon and others 2017); see recommendations S4, K4.

Climate change considerations

Seabird abundance, productivity, survival, and phenology have all been shown to be affected by climate change-related impacts (Johnston and others 2021). The impacts of climate change on seabird populations are many and varied and may act on species simultaneously and in concert with other anthropogenic threats (Mitchell and others 2020, Johnston and others 2021). Long-term population monitoring datasets are crucial if we are to be able to understand the impacts of climate change on seabird populations and distinguish these from natural fluctuations and if we are to be able to factor these impacts into PVA projections (Johnston and others 2021, Pearce-Higgins 2021, Orgeret and others 2022, Searle and others 2022), especially where current monitoring may not represent English parts of the UK range.

Recommendation K2:

Increase funding of bird monitoring schemes to inform seabird conservation requirements

Evidence-based reason for recommendation

The importance of monitoring

Long-term monitoring data is vital in order to be able to distinguish natural fluctuations from anthropogenic impacts, particularly for long-lived species like seabirds (Furness 2016, Johnston and others 2021, Orgeret and others 2022). Long-term colony monitoring is also important to be able to measure the impacts of environmental or anthropogenic pressures and to assess effectiveness of conservation or mitigation measures (Lewison and others 2012, Johnston and others 2021, Pearce-Higgins 2021).

In addition to ‘key site’ monitoring, equally important data is gathered in various ways at other breeding and non-breeding locations, including at sea. Accurate information about the distribution and habitat use of seabirds at sea, and how these might change with life-stage and season, is similarly vital to understanding their ecology and make informed decisions about their conservation (Wakefield and others 2017, Oppel and others 2018, Carroll and others 2019, Johnston and others 2020, Pearce-Higgins 2021).

Current monitoring and additional requirements

As well as the ad hoc and project-specific monitoring that may take place, there are several national projects aiming to gather information on seabird abundance, productivity, survival and diet.

This includes:

- The SMP, the national scheme collating breeding seabird abundance and productivity data from sites where monitoring takes place (professionally or voluntarily), administered by BTO on behalf of a partnership;
- Periodic seabird censuses of abundance, organised by JNCC;
- Retrapping Adults for Survival (RAS), the colour-ringing scheme used to estimate seabird survival, administered by BTO;
- Seabirdwatch, a Citizen Science initiative designed to monitor seabirds using remote sensing technology to detect eg, prey delivery, productivity, causes of nest failure, etc;
- The Winter Gull Roost Survey (WinGS), a periodic survey estimating gulls at roosts in the non-breeding season, administered by BTO;
- European Seabirds at Sea (ESAS) and VSAS, schemes collecting and / or collating data on seabird abundance and distribution at sea; and
- Various projects collecting information on seabird movements, such as FAME (Future of the Atlantic Marine Environment) and STAR (Seabird Tracking And Recording).

The SMP collates monitoring data from seabird breeding colonies in the UK and Ireland, largely collected by volunteers (Tasker 2000, Pearce-Higgins 2021, SMP 2022) and therefore somewhat reliant on funded leadership and strategic support; this effort is more widespread but less intensive and less formal than the ‘key site’ monitoring (Cook and others 2019, SMP 2022).

The current sampling effort under the SMP is not considered to be sufficient to accurately describe trends in abundance or productivity for several species (Cook and others 2019, Dunn 2021, Edmonds and others 2021). Recent analyses of existing data by the BTO concluded that current monitoring of seabird populations is insufficient to detect and quantify impacts of OWFs (Cook and others 2019, Pearce-Higgins 2021). Productivity monitoring methods also vary between sites, which makes it difficult to collate data and understand trends (Cook and others 2019).

There is a particular need to increase and improve monitoring for species that are currently under-monitored, such as burrow-nesting species (eg, Atlantic puffins, Manx shearwaters, and European storm petrels) and tern species that can move between sites from year to year (Horswill and others 2018, Cook and others 2019, Johnston and others 2021, Pearce-Higgins 2021). There is also a need to increase the number of sites at which monitoring data is routinely and regularly collected. Currently, monitoring is limited both spatially and temporally by logistic and financial concerns (Horswill and others 2018, Cook and others 2019). Regular monitoring is important because demographic parameters can vary considerably between years (Cook and others 2019). While annual monitoring may be logistically difficult at some sites, statistical analyses suggest that biennial counts should be sufficient to detect meaningful population changes in most cases (Cook and others 2019).

Recent technological developments have made new methods available for monitoring seabirds that may help to make some monitoring more feasible and cost-effective (Edney & Wood 2021). Drones (unmanned aerial vehicles; UAVs) can be used to accurately count large colonies from the air (Edney & Wood 2021, Hayes and others 2021). Time-lapse photography and motion-triggered photography allow the remote monitoring of phenology, productivity, and predation (Edney & Wood 2021). Infra-red and thermal imaging technology make it possible to monitor burrow-nesting and nocturnal visiting seabirds such as Manx shearwaters and European storm petrels (Edney & Wood 2021).

Demographic rates can vary geographically, within species, and this variation is poorly understood (Horswill and others 2018, Cook and others 2019, Searle and others 2022). There is concern that most of the existing information on demographic rates comes from a small sample of sites, and so may not be representative of other colonies or of populations as a whole (Horswill and others 2018, Cook and others 2019, Johnston and others 2021). A large proportion of studies published on UK seabird populations have been carried out on the Isle of May in Scotland, which is an SMP key site with long-term monitoring programmes (Johnston and others 2021). There are no SMP key sites in England (see recommendation K1). Assessing risks to specific breeding populations (eg, with regards to a proposed development) requires population-specific information on demographic rates that is often lacking (Horswill and others 2018). Distributions of breeding seabirds of the same species are often segregated according to breeding colony, and so exposure to risk and thus survival rates may also be colony-specific (Genovart and others 2018, Bolton and others 2019). There may also be regional variation in the influence of climate change demographic rates (Searle and others 2022).

Complete breeding seabird censuses are carried out once every 15 - 20 years, and the results from the most recent census ('Seabirds Count' 2015 – 2021) are being collated at present (Pearce-Higgins 2021, SMP 2022). This census did not receive up-front dedicated funding and was in jeopardy of non-delivery, leading to high-profile public criticism (McKie 2017).

Adult survival is one of the most poorly monitored demographic parameters, in terms of numbers of species and numbers of locations (Cook and others 2019). This is a key evidence gap because seabirds, as long-lived and slow-maturing species, are particularly sensitive to changes in adult survival rates (Lewison and others 2012, Horswill and others 2018). Adult survival rates can also vary within species between different colonies (Genovart and others 2018, Horswill and others 2018, Bolton and others 2019). While parameters such as abundance and productivity can be measured by conducting observations at colonies, measuring survival rates requires undertaking capture-mark-recapture studies involving ringing and colour-ringing individual birds, which requires more effort and skill (Horswill and others 2018, Cook and others 2019). These are usually undertaken at seabird colonies by seabird ringing groups as part of RAS schemes. Where it is possible to colour-ring birds, the amount of data gathered is increased because 'recaptures' are possible by observers in the form of 're-sightings' which can be done more often and by a wider section of the public. For RAS schemes to provide robust estimates of adult survival rates, they need to ring a certain number of birds, recapture/resight a certain number of birds, and run for a minimum of ten years (Horswill and others 2018, Cook and others 2019, O'Hanlon and others 2021).

Juvenile survival rates, measured in similar ways, are also important and help us to understand the proportions of seabird populations that are made up of immature and non-breeding birds, which is a key evidence gap for many species (O'Hanlon and others 2021). Ringing and colour-ringing schemes also help us to gain information about the movements of birds between colonies (Horswill and others 2018, O'Hanlon and others 2021). Levels of recruitment and dispersal can greatly affect the resilience of local populations and the ability of species to adapt to pressures such as habitat loss or climate change (Lewison and others 2012, Russell and others 2015). Monitoring multiple parameters at the same site adds value to the data, so opportunities to monitor survival rates at sites where abundance and productivity are also monitored should be a priority (Cook and others 2019).

Standardisation of monitoring methods and data formats is also important to facilitate collation and analysis of data from multiple sites (Tasker 2000, Cook and others 2019). The current source of methodologies for seabird monitoring is the Seabird Monitoring Handbook (Walsh and others 1995) but there is a need to update this to reflect changes and emerging methods and ensure standardisation of approaches (Cook and others 2019).

Fieldworkers undertaking monitoring activities at colonies could also collect additional information on seabird ecology and anthropogenic impacts, such as levels of incorporation of plastic into nests (Mallory and others 2010, O'Hanlon and others 2017). As ringing and colour-ringing projects involve the capture and handling of live seabirds by skilled fieldworkers, there is an opportunity (as well as an ethical imperative) to collect as much information as possible as part of this process (Mallory and others 2010). Collecting as much biometric information as possible helps to inform our understanding of seabird health and sublethal effects (Mallory and others 2010, Daunt and others 2020). It may also be possible for fieldworkers to simultaneously collect samples to inform studies of diet (through observations or by taking sample of dropped fish, regurgitates, pellets, faeces, or feathers for stable isotope analysis), movements, genetics, disease, or contaminant levels (Barrett and others 2007, Mallory and others 2010). Such samples could also be useful for other studies such as plastic ingestion, health, and contaminant levels (Mallory and others 2010, O'Hanlon and others 2017).

There are many different methods that can be used to study seabird diet, each of which have advantages and disadvantages (Barrett and others 2007, Ceia and others 2022). To minimise bias, at least two different methods should be used to study diet, where possible (Ceia and others 2022). Samples of dropped or regurgitated food, faeces or pellets can be collected at breeding and/or roosting sites (Barrett and others 2007, Lewison and others 2012, Ceia and others 2022). Observations can be made of breeding adults returning to colonies with food for chicks, for some species that carry prey obviously in their bills (Lewison and others 2012). Improvements in camera technology mean that more observations of this type can be made and recorded in a permanent way (Gaglio and others 2017, Edney & Wood 2021). Photo-sampling has been shown to be an effective and reliable method for estimating seabird prey composition (Gaglio and others 2017). High quality handheld cameras are widespread and allow seabird diet to monitored via citizen science at a much wider scale, as with the RSPB "Puffarazzi" project (Edney & Wood 2021). Time-lapse and motion-triggered cameras can record seabird prey at colonies remotely, which provides considerable advantages for remote or logistically difficult locations (Gaglio and others 2017, Edney & Wood 2021).

Newer techniques for studying seabird diet include biochemical methods such as stable isotope analysis, lipid analysis and DNA metabarcoding (Barrett and others 2007, Lewison and others 2012, Ceia and others 2022. Such biochemical methods can provide useful data on diet outside of the breeding season (Barrett and others 2007, Ceia and others 2022). Combining biochemical methods with more traditional methods potentially gives a more detailed and less biased picture of seabird diet (Barrett and others 2007, Ceia and others 2022).

While most of the above relates to breeding seabird populations, it is important to note that there is also a need for more up-to-date information on population sizes of seabirds wintering in England, particularly wintering gulls (Banks and others 2007, Frost and others 2019). The Winter Gull Roost Survey has not been conducted in the UK since 2006, which means up-to-date estimates for wintering gull species are badly lacking (Banks and others 2007, Frost and others 2019). This was identified as an issue in the last SPA Review, preventing many gull species achieving sufficiency of protection (Stroud and others 2016).

There are two main ways of obtaining information on the spatial distribution and habitat use of seabirds at sea: surveys and tracking. Both methods have advantages and disadvantages (Carroll and others 2019, Cleasby and others 2020, Searle and others 2020). Boat-based visual surveys of seabirds began in 1979 but have more recently been mostly replaced by digital aerial surveys from planes (Buckland and others 2012, Carroll and others 2019). Surveys have the advantage of counting all birds, regardless of age-class or breeding status, and of identifying absence as well as presence of birds, however, surveys are limited to daylight and suitable weather conditions (Carroll and others 2019).

Tracking of individual birds provides information on seabird movements both day and night, in all weathers, and allowing those movements to be attributed to specific breeding colonies (Carroll and others 2019, Cleasby and others 2020). Tracking devices can also be used to infer behaviour and provide information on foraging areas (Camphuysen and others 2012, Lewison and others 2012). Tracking birds with Global Positioning System (GPS) tags provides high resolution spatial data and has been used to identify core areas and foraging ranges (Johnston and others 2020). However, the size of GPS tags and the limited options for humane attachment restrict the use of this type of tag to certain species, and often to breeding adults for short time periods during the breeding season (Camphuysen and others 2012, Oppel and others 2018, Carroll and others 2019, Johnston and others 2020). Geolocator tags are far less spatially accurate but are much smaller and longer-lasting and can therefore be used to provide coarse-scale data on the year-round movements of birds (Johnston and others 2020, Searle and others 2020, Buckingham and others 2022). However, the need for tag retrieval also limits the use of these tags to breeding adult birds (Buckingham and others 2022).

Motus tags are small Very High Frequency (VHF) tags, light enough to deploy on much smaller species, and do not require retrieval as they rely on a network of receivers that log the presence of tagged individuals (Crewe and others 2020). Receivers are relatively cheap and could be placed at colonies and on offshore infrastructure to build a picture of an individual bird’s movements. However, this system is still in the early stages of development in Europe, including a project within the Crown Estate’s Offshore Wind Evidence & Change Programme led by RSPB.

Other methods of investigating seabird movement patterns and habitat use include stable isotope analysis, which can provide broad-scale information on seabird movements and foraging ecology (Lewison and others 2012, Furness 2015). Information on seabird prey is sorely lacking and most of what exists relates to the chick-rearing period. Stable isotope analysis can help provide an indication of prey taken outside of the breeding season (Lewison and others 2012).

Climate change considerations

Seabird abundance, productivity, survival, and phenology have all been shown to be affected by climate change-related impacts (Johnston and others 2021). The impacts of climate change on seabird populations are many and varied and may act on species simultaneously and in concert with other anthropogenic threats (Mitchell and others 2020, Johnston and others 2021). Long-term population monitoring datasets are crucial if we are to be able to understand the impacts of climate change on seabird populations and distinguish these from natural fluctuations, and if we are to be able to factor these impacts into PVA projections (Johnston and others 2021, Pearce-Higgins 2021, Orgeret and others 2022, Searle et a 2022).

Recommendation K3:

Implement a system of recording and investigating seabird mass mortality events (“wrecks”)

Evidence-based reason for recommendation

Mass mortality events of seabirds (or “wrecks”) have always occurred, usually associated with winter storms. However, there is concern that such events are becoming more common and more severe, and their causes are often unclear (Anker-Nilssen and others 2017, Diamond and others 2020, Glencross and others 2021). It is also possible that some such events go unnoticed (SEAPOP 2022). Given that seabirds are long-lived, slow-reproducing species, adult mortality sustained during such events can have serious implications for populations (Clairbaux 2020, Johnston and others 2021). The frequency and severity of storm events that could cause mass mortality are predicted to increase with climate change, and this could have severe implications for seabird populations, particularly those already in decline (Louzao and others 2019; Johnston and others 2021, IPCC 2022b).

Unfortunately, the causes of seabird wrecks are not always fully documented, investigated or understood (Clairbaux and others 2021, Glencross and others 2021). Only a small proportion of the birds that die are typically washed ashore, so it can be difficult to estimate the full extent of the mortality, as well as the geographic origin of carcasses (Anker-Nilssen and others 2017, Louzao and others 2019, Piatt and others 2020). Of those carcasses that are washed ashore in accessible locations, only a small proportion are usually subjected to post-mortem tests to investigate cause of death (Jones and others 2019, Daunt & Andrews *in prep*). The paucity of long-term seabird monitoring studies at colonies also makes it difficult to understand the effects wrecks have on seabird demographics (Anker-Nilssen and others 2017).

Marine heatwaves can also cause mass mortality of seabirds through sudden changes to seabird prey. The frequency, intensity, duration and extent of marine heatwaves are predicted to increase with climate change (Piatt and others 2020, IPCC 2022b). A large marine heatwave that occurred in the Northeast Pacific between 2014 and 2016 and extended from California to Alaska (nicknamed ‘the blob’) led to several mass mortality events of seabirds through starvation, including thousands of Cassin’s auklets *Ptychoramphus aleuticus* and an estimated one million common guillemot, as well as tufted puffins *Fratercula cirrhata* and crested auklets *Aethia cristatella* (Jones and others 2018, Jones and others 2019, Piatt and others 2020). A marine heatwave in the northwest Atlantic in the winter of 2012-2013 reduced plankton levels and led to mass mortality of razorbills and Atlantic puffins (Diamond and others 2020).

Marine heatwaves can also lead to HABs, which are algal blooms that produce toxins that are detrimental to other species (Jones and others 2017, Piatt and others 2020). HABs have been implicated in mass mortality events of cormorants, terns, auks, waterfowl, shearwaters, pelicans, and black-legged kittiwakes, although the majority of these incidents have not been well documented (Jones and others 2017, Johnston and others 2021). HABs are becoming more frequent globally and are predicted to increase with climate change, with some models predicting increases in the North Sea (Jones and others 2017, IPCC 2022b).

Mass mortality events can also occur during the breeding season, due to environmental conditions or disease. In 2016, a heatwave caused mass mortality of chicks of imperial cormorant *Leucocarbo atriceps* at a colony in Argentina (Quintana and others 2022). Outbreaks of HPAI at UK seabird colonies in the summer of 2021 and the summer of 2022 have caused unprecedented mortality levels at colonies (Banyard and others 2022, Walton 2022).

In autumn 2021 and winter 2021/2022, a seabird wreck occurred in the North Sea that was unprecedented in magnitude and geographic scale given the time of year and lack of association with severe weather (Fullick and others 2022, Daunt & Andrews *in prep*). The birds, mostly common guillemot and razorbill, appear to have starved, but the reasons for such sudden and serious changes to the food chain remain unclear currently (Daunt & Andrews *in prep*). Understanding the causes of mass mortality events in seabirds could provide important information about changes in the marine ecosystems on which they depend (eg, HABs, contaminants, litter (Diamond and others 2020)). Mass mortality events can also have severe and long-lasting impacts on seabird populations, particularly those that are already in decline (Anker-Nilssen and others 2017, Jones and others 2019, Mitchell and others 2020, Piatt and others 2020). The impacts of mass mortality events on seabird populations are also poorly studied, largely due to a lack of long-term seabird monitoring data (Anker-Nilssen and others 2017, Glencross and others 2021).

In most cases, neither the extent of mortality nor the causes of mass mortality events are properly documented or investigated (Anker-Nilssen and others 2017, Clairbaux and others 2021, Glencross and others 2021). Some countries have more sophisticated systems of surveying for and reporting seabird mortality and investigating cause of death than is currently the case in the UK. In the USA, The Coastal Observation and Seabird Survey Team (COASST) is a citizen science program in which trained volunteers conduct monthly beach surveys, and record and photograph seabird carcasses according to a standard protocol (Jones and others 2019, COASST 2022). When a mass mortality event is detected, an alert system sets in motion a protocol for additional reporting and collecting of sample carcasses that are post-mortemed and tested for disease and toxins (Jones and others 2019). In Norway, volunteer surveys of beached seabirds are conducted every fortnight throughout the autumn and winter months. Surveys are financed by the Norwegian Environment Agency who also collect sample carcasses for post-mortem (Anker-Nilssen and others 2017).

Climate change considerations

Increases in seabird mass mortality events have been linked to climate change (Anker-Nilssen and others 2017, Diamond and others 2020, Glencross and others 2021). The frequency and severity of storm events that could cause mass mortality events are predicted to increase with climate change (Louzao and others 2019, Johnston and others 2021, IPCC 2022b). The frequency, intensity, duration and extent of marine heatwaves, which can cause mass mortality of seabirds, are predicted to increase with climate change (Piatt and others 2020, IPCC 2022b). HABs, which can cause mass mortality of seabirds, are becoming more frequent globally and are predicted to increase with climate change, with some models predicting increases in the North Sea (Jones and others 2017, IPCC 2022b). Climate change may also cause changes in the population sizes, distributions, and seasonality of prey species, which could lead to mass starvation in seabirds (IPCC 2022b). There is therefore a need for more information on the causes and extent of mass mortality events in seabirds in order to be able to inform seabird conservation, and to understand the impacts of climate change on seabird populations and on marine ecosystems (Louzao and others 2019, Clairbaux and others 2021, Glencross and others 2021, IPCC 2022b).

Recommendation K4:

Improve the evidence base relating to the causes, prevalence, and impacts of disease in seabirds

Evidence-based reason for recommendation

Impacts of pathogens and parasites

There is increasing concern amongst seabird ecologists that disease and parasitism may pose serious threats to seabird populations (Mitchell and others 2020, Hakkinen and others 2022). Seabirds can be affected by a wide range of parasites and pathogens, ranging from ectoparasites such as ticks to microbial pathogens such as viruses and bacteria (Khan and others 2019). As long-lived, wide-ranging species, seabirds may be more exposed to pathogens and parasites than other taxa and may act as vectors (Mallory and others 2010, Khan and others 2019). High concentrations of individuals at breeding colonies, combined with high site fidelity, may increase the risk of exposure and transmission amongst seabird species (Bourret and others 2018, Stidworthy & Denk 2018, Mitchell and others 2020).

Highly Pathogenic Avian Influenza (HPAI)

Diseases such as HPAI (and avian cholera) can cause mass mortality and colony collapse in seabirds (Bourret and others 2018, Khan and others 2019). Recently, outbreaks of HPAI in great skuas in summer 2021 and in multiple breeding seabird species at multiple colonies in summer 2022 have caused unprecedented mass mortality of breeding seabirds in the UK (Banyard and others 2022, RSPB 2022, Walton 2022). The summer 2022 HPAI outbreak is unprecedented in both seasonality, number of species affected, and extent of mortality, and there is concern that it could have severe population-level impacts on species of conservation concern (AEWA 2022, CMS 2022, Miller 2022, RSPB 2022). Species confirmed to be affected by HPAI so far in 2022 include great skua, common eider, northern gannet, Atlantic puffin, common guillemot, great black-backed gull, herring gull, black-headed gull, Arctic tern, common tern, Sandwich tern, and roseate tern (HM Government 2022). The impact of the disease at the UK's only breeding colony of the red-listed roseate tern on Coquet Island is particularly worrying. The true extent of this outbreak on populations of seabirds in the UK remains to be seen, but disease (particularly HPAI) now poses a serious threat to the UK's seabird populations, and conservation gains could be lost due to disease within a short period of time (AEWA 2022, RSPB 2022, Walton 2022).

Botulism

Botulism has also been known to cause mass mortality in some bird species, including gulls (Ortiz & Smith 1994, Malik and others 2021). Recent outbreaks of disease associated with Bisgaard taxon bacteria in Common and Sandwich terns in the U.S.A caused mass mortality, and Bisgaard taxon bacteria were also found to have likely caused mass mortality in breeding Arctic terns in the UK in 2016 and 2019 (Duff and others 2021, Niedringhaus and others 2021) Other pathogens have been linked to breeding season mortality in UK seabirds in recent years including botulism *Clostridium botulinum* in terns and viral duck enteritis *Anatid alphaherpesvirus 1* in common eider in the Irish Sea in 1992 (Duff and others 2021, C. Raven *pers comm*).

Ectoparasites and disease associated with them can lead to reduced breeding success through nest abandonment and chick mortality (Khan and others 2019).

There is growing evidence that climate change exacerbates the risks of wildlife disease, and Climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future (Elliot and others 2015, Dennis & Fisher 2018, Dias and others 2019, Hofmeister & Van Hemert 2018, Johnston and others 2021, Hakkinen and others 2022, IPCC 2022b). See “Climate change considerations”.

Evidence needs

The England Wildlife Health Strategy (Defra 2009) states that government has a responsibility to intervene in wildlife disease issues when the impact of a disease is significant enough to cause a decline in the population viability of a species officially recognised as of conservation concern, or where the impact could lead to a species becoming threatened.

Even though the risk posed by disease to seabird populations is of increasing concern, our understanding of seabird disease ecology and parasitology is limited (Khan and others 2019, Hakkinen and others 2022). There are major evidence gaps concerning the prevalence of pathogens and parasites, transmission pathways, and population-level impacts, which are compounded by the limitations of our knowledge of seabird movements and population dynamics (Khan and others 2019, Pearce-Higgins 2021, Searle and others 2022). Improving our understanding of seabird diseases and their epidemiology will require further research (Lewison and others 2012, Khan and others 2019). Understanding the epidemiology and transmission of HPAI viruses in different seabird species will be critical to inform mitigation measures in future (Banyard and others 2022). There is also uncertainty with respect to the persistence of HPAI viruses in the environment and in infected carcasses, which has implications for site management (Yamamoto and others 2017). A greater understanding of the ecology and evolution of pathogens in wild birds would also inform measures aimed at protected captive birds and safeguarding food security (Verhagen and others 2021).

Understanding the prevalence, spread, and extent of mortality of HPAI and other diseases in seabird populations will require more monitoring and surveillance than is currently undertaken (Banyard 2022, Miller 2022, RSPB 2022, Walton 2022). Current knowledge of disease ecology tends to be limited to testing done when mass mortality events occur (Khan and others 2019). However, not all mass mortality events are detected or documented and not all carcasses are found or reported during mass mortality events (Wobeser 2007, Anker-Nilssen and others 2017, Clairbaux and others 2021, Glencross and others 2021). Even where mass mortality events are reported and testing is carried out, testing is usually only carried out on a small sample of carcasses (Khan and others 2019, Glencross and others 2021). Currently, samples of carcasses of suspected HPAI in wild birds in England are tested by the APHA. However, this system does not currently record the extent of mortality and is therefore insufficient to estimate the impact of the mortality on wild bird populations. Currently, recording the extent of mortality is done on an ad-hoc, passive basis by volunteers or colony managers (Banyard and others 2022).

Furthermore, there is little understanding of the prevalence of infection in apparently healthy birds who may be carriers capable of transmitting infections without succumbing to them (Khan

and others 2019). Disease screening could be incorporated into regular seabird monitoring efforts, with additional samples taken for testing during seabird ringing and handling activities (Mallory and others 2010). The development of novel testing methods such as metabarcoding could help with this (Khan and others 2019). Understanding the impact that disease outbreaks have on populations of different seabird species, both in terms of adult mortality and reduced breeding success, will be vital to inform conservation effort (Banyard and others 2022). Mass mortality events, such as those caused by severe disease outbreaks, can have severe and long-lasting impacts on seabird populations, particularly those that are already in decline (Anker-Nilssen and others 2017, Jones and others 2019, Mitchell and others 2020, Piatt and others 2020). The impacts of mass mortality events on seabird populations are poorly studied, largely due to a lack of long-term seabird monitoring data (Anker-Nilssen and others 2017, Glencross and others 2021). Current seabird population monitoring in the UK is insufficient to detect changes and attribute change to specific drivers (Cook and others 2019). Seabird populations are sensitive to adult mortality, but adult survival is one of the most poorly monitored demographic parameter in seabird populations in the UK (Horswill and others 2018, Cook and others 2019). Interactions between pathogens, parasites and other environmental stressors are also poorly understood and require further research (Khan and others 2019, Sebastiano and others 2022).
Climate change considerations There is growing evidence that climate change exacerbates the risks of wildlife disease by altering the ranges of hosts and infectious organisms and by enhancing the reproduction, spread and persistence of pathogens, parasites and vectors (Elliot and others 2015, Dennis & Fisher 2018, Dias and others 2019, Hofmeister & Van Hemert 2018, Mitchell and others 2020, Hakkinen and others 2022). Climate change could facilitate the range expansion of the pathogens and parasites themselves as well as their potential persistence throughout the annual cycle (Mallory and others 2010, Khan and others 2019, Hakkinen and others 2022). Wider changes in geographical ranges bring species that were previously geographically separated together, thereby increasing the risk of disease transmission and the emergence of new pathogens that can infect more species in ‘spill-over’ events (Rideout and others 2017, Dennis & Fisher 2018, Hofmeister & Van Hemert 2018, Khan and others 2019, Carlson and others 2022). Increasing temperatures, increases in precipitation, and higher water levels due to sea level rise could all contribute to an increased risk of transmission and higher levels of parasitism (Hofmeister & Van Hemert 2018, Khan and others 2019, Mitchell and others 2020, Johnston and others 2021). Higher temperatures and other environmental stressors may also make individuals more susceptible to disease and parasitism (Mitchell and others 2020, IPCC 2022b). Climate change is predicted to lead to increased emergence, transmission and virulence of infectious disease in birds in the future (Dennis & Fisher 2018, Dias and others 2019, Johnston and others 2021, IPCC 2022b). The recent increases in the incidence and severity of avian influenza (AI) outbreaks in wild birds have been linked to climate change, and future increases in AI outbreaks caused by climate change are predicted (Mu and others 2014, Lee and others 2020). Habitat loss and degradation may lead to higher concentrations of individuals in fewer suitable locations, which further facilitates the spread of disease and potentially exacerbates population-level impacts (Hofmeister & Van Hemert 2018, IPCC 2022b). Our understanding of the way climate change impacts may interact with other

pressures faced by seabirds is currently limited (Khan and others 2019, Hakkinen and others 2022).

Recommendation K5:

Increase and improve long-term monitoring of seabird prey and marine ecosystem health

Evidence-based reason for recommendation

Monitoring seabird prey

As marine predators at or near the top of marine food chains, seabirds are particularly vulnerable to the impacts of changes in marine food webs at lower trophic levels (Furness 2016; Pearce-Higgins 2021). Seabirds are considered to be good indicators of the health of marine ecosystems (Ronconi and others 2012, Oppel and others 2018, Cleasby and others 2020). The most widely consumed type of prey for seabirds is fish, especially sandeels (Edmonds and others 2021). Changes in the abundance, availability, phenology and nutritional quality of sandeels have been shown to have negative impacts on the survival and breeding success of several species of seabird (Wanless and others 2005, Frederiksen and others 2007, Carroll and others 2015, Wanless and others 2018, Mitchell and others 2020, Johnston and others 2021). There is therefore a need to monitor sandeel populations because of their importance to seabird populations and to assess the effects of management measures such as fishery closures (Dunn 2021, Edmonds and others 2021). Sandeels play a key role in North Sea food webs and there are key evidence gaps regarding the drivers of sandeel populations, their phenology, diet, and the potential impacts of climate change (Greenstreet and others 2010, Olin and others 2022). Sandeel populations may also be affected by the expanding offshore renewables industry and there is a need to monitor these potential impacts (van Deurs and others 2012).

Traditionally, marine monitoring has been focused on collecting data relating to commercial fish stocks, to inform fisheries quotas, but information on other marine organisms is lacking (Eriksen and others 2018, Turrell 2018). In addition to fish species, many seabirds feed on invertebrates, but invertebrate populations are generally poorly monitored (Edmonds and others 2021). There are still large gaps in our understanding of marine trophic ecology for the intermediate trophic levels, including small fish and invertebrates (Hobday and others 2015). Fish populations also rely on organisms at other trophic levels. Sandeel populations, and those of other forage species, are strongly affected by the dynamics of their plankton prey (Olin and others 2022). Ongoing changes to plankton communities, which have been linked to climate change, are likely to have knock-on effects on sandeel populations and marine ecosystems in general (Gremillet & Boulinier 2009, Capuzzo and others 2017, Olin and others 2022, Johnston and others 2021, IPCC 2022b). There is therefore a need to continue developing our understanding of marine ecosystems and thus for marine ecosystem monitoring (Eriksen and others 2018, Turrell 2018) to inform likely effects on seabirds. Without understanding how ecosystems function and what the impacts of anthropogenic pressures are on these ecosystems, it is difficult to determine and quantify causes of ecosystem change and therefore difficult to prioritise interventions for conservation.

Evidence needs

Major knowledge gaps exist in our understanding of the combined impacts of multiple pressures on marine ecosystems (IPCC 2022c). Detecting changes and attributing them to specific drivers is particularly difficult in marine ecosystems because of their complexity (IPCC 2022b). Current marine monitoring systems are not thought to be sufficient to be able to study these combined impacts, particularly when the multiple impacts of climate change are considered (Elliot and others 2015, IPCC 2022b, IPCC 2022c). “Integrated monitoring” or “ecosystem monitoring” is required in order to further our understanding of marine ecosystems and detect and interpret changes (Elliot and others 2015, Eriksen and others 2018, Turrell 2018, IPCC 2022b). The mismatch between observed and modelled distributions highlights the need for improved monitoring (Elliot and others 2015). The spatial and temporal scale of monitoring programmes, their sampling frequency, and the longevity of programmes all affect their ability to detect change (Elliot and others 2015, Turrell 2018). Combining different monitoring methods allows the collection of different types of data (Hobday and others 2015, Eriksen and others 2018). Strategic coordination between different monitoring schemes allows more data to be collected in a more cost-effective way (Turrell 2018). Standardised methods and data formats allow multiple datasets to be combined to maximise their value (Elliot and others 2015, Turrell 2018). Combining multiple datasets vastly improves the value of marine monitoring data, and collaborations between different monitoring schemes and between different countries – especially those sharing the same oceanic basins – could improve our understanding of marine ecosystems and save costs (Hobday and others 2015, Turrell 2018). Joint large-scale monitoring and management of marine ecosystems by Norway and Russia in the Barents Sea led to a greater understanding of food webs and considerable increases in stock biomasses of commercially important fish stocks (Eriksen and others 2018).

Climate change considerations

Warming temperatures, increased stratification and ocean acidification caused by climate change are leading to phytoplankton declines and changes in phytoplankton species composition that have repercussions for the entire ecosystem (Elliot and others 2015, Capuzzo and others 2017, Johnston and others 2021, IPCC 2022b). Global marine primary productivity has declined significantly since 1999 due to decreased phytoplankton biomass caused by climate change (Gremillet & Boulinier 2009, IPCC 2022b). These declines are projected to continue, and to lead to even greater declines in total marine animal biomass as the effects are amplified up food chains (IPCC 2022b). Distributions of phytoplankton are also likely to be affected by warming temperatures (Johnston and others 2021, IPCC 2022b). Changes to the timing of phytoplankton blooms have knock-on effects on food webs through trophic mismatches (Elliot and others 2015, Johnston and others 2021, IPCC 2022b). Climate change also affects the distributions, abundance, size and species composition of zooplankton communities, with global declines in zooplankton biomass predicted (Furness 2016, IPCC 2022b). Copepods (a group of zooplankton species that are important in marine food webs) have declined in biomass and altered in species composition in the North-East Atlantic and in the North Sea (Elliot and others 2015, Capuzzo and others 2017, MCCIP 2020, IPCC 2022b).

Fish are affected by these changes at lower trophic levels, with trophic mismatches between fish and plankton abundance leading to fish recruitment failures that are predicted to increase, particularly at higher latitudes (Capuzzo and others 2017, IPCC 2022b). Fish are also affected directly by climate change. Temperature changes affect fish growth, survival, and reproduction (Gremillet & Boulinier 2009, MCCIP 2020). Higher temperatures in the North Sea have led to earlier spawning in mackerel *Scomber scombrus* and earlier maturation in herring *Clupea harengus* and sole *Solea solea*. Fish also change their distributions in response to climate change (Barrett and others 2012, Elliot and others 2015, Lima and others 2022). Fish communities in UK waters have already changed substantially, with declines in cold-water species such as cod *Gadus morhua* and eelpout *Zoarces viviparus* and increases in warm-water species such as European anchovy *Engraulis encrasicolus* (Elliot and others 2015, MCCIP 2020, IPCC 2022b).

Less mobile marine species that are not capable of adapting their distributions to cope with climate change are predicted to experience high mortality (IPCC 2022b). These include key habitat-forming species such as corals, kelps, and seagrasses, and the consequent habitat loss could therefore have considerable impacts on marine and coastal ecosystems (IPCC 2022b).

Climate change can also affect marine food webs through top-down impacts, where increases in predatory species add to pressures on lower trophic organisms (Furness 2016, Johnston and others 2021). Jellyfish have increased worldwide due to climate change and add to predation pressure on zooplankton and fish larvae (IPCC 2022b). Bottom-up and top-down impacts occurring simultaneously compound negative impacts and further destabilise marine food webs (Johnston and others 2021, IPCC 2022b). Rapid changes in marine ecosystems caused by climate change could lead to food web collapses, mass mortality events and ecological ‘tipping points’ that result in permanent changes (IPCC 2022b). The combined effects of climate change at the lower trophic levels amplify up marine food webs and are resulting in changes to the distribution, abundance, availability and quality of the forage fish species relied upon by seabirds as prey (Barrett and others 2012, Furness 2016, Pearce-Higgins 2021, IPCC 2022b). Survival and reproductive success of seabirds is affected by these changes to their prey (Sandvik and others 2012, Furness 2016, Pearce-Higgins 2021). Higher winter SSTs have been shown to be negatively correlated with sandeel recruitment in the North Sea (Frederiksen and others 2007). The abundance of sandeels in the North Sea has declined over the past forty years, and changes in the timing of key life history events have also occurred (Wanless and others 2018, Mitchell and others 2020). Sandeel health and growth also appears to have been affected, as sandeels have declined in size and been shown to be of lower nutritional value (Wanless and others 2005, Wanless and others 2018).

Seabird breeding success in the North Sea has been shown to be negatively impacted by declines in sandeels as a key prey item, and therefore indirectly impacted by increased SSTs (Furness 2016, Johnston and others 2021, Pearce-Higgins 2021). Overall, it is therefore likely that the predicted increases in SSTs in UK waters will lead to further reductions in survival and breeding success for seabirds that feed on small shoaling fish (Mitchell and others 2020).

There are key knowledge gaps with respect to the differing responses of marine organisms to the impacts of climate change, and the combined, cascading, and interacting impacts of climate change on marine ecosystems (IPCC 2022b, IPCC 2022c).

Recommendation K6:

Improve understanding of scale and spatio-temporal distribution of seabird bycatch to drive targeted action where and when required

Evidence-based reason for recommendation

Existing knowledge

The incidental capture of non-target species in marine fisheries, or bycatch, can present a significant pressure on marine bird populations worldwide and is one of several pressures faced by certain species in the UK and England. Dias and others (2019) identify bycatch as one of the top three threats to seabirds globally, although driven by high-profile issues with longline (Anderson and others 2011) and gill-net fisheries (Zydelis and others 2013). Although some seabird bycatch data have been collected for many years under the UKBMP, until Northridge and others (2020) provided the first seabird estimates, relatively little has been known about the levels of bycatch mortality from the UK fishing fleet. Northridge (ibid) used bycatch rates sampled by the UKBMP, using dedicated on-board observers, and scaled up to England-wide seabird populations using estimates of fishing effort (align with devolved nations). The authors acknowledge that biases exist in the current sampling regime of bird bycatch by the UKBMP, and that a more accurate and representative estimate of bycatch will only be possible once improvements to current sampling are introduced. The study reported a minimum of ten seabird species were recorded from monitored fishing operations (hauls) carried out under the UKBMP since 1997, on UK vessels, totalling 587 individuals during that period. The most frequently recorded species were common guillemots (in gillnet and midwater trawl fisheries) and northern fulmars (in longline fisheries), although northern fulmar and great cormorant are thought to be the most affected species in terms of population impacts (Miles and others 2020).

Evidence needs

There are many English seabird species for which bycatch estimates are yet to be made, because they have not to date been recorded by the UKBMP. It is not clear whether bycatch of these species is under-recorded / not sampled or not occurring / occurring at extremely low rates as there is a lack of systematic data collection and therefore limited data availability, particularly for inshore fisheries and netting types. Some of these species have had high bycatch rates reported in other countries, such as sea ducks, divers (other than great-northern), black guillemot and various shearwater species (Miles and others 2020). For example, there is little direct information on seabird bycatch in the UK-registered purse-seine fleet, which is relatively limited in extent and effort. Evidence from Spain indicates occasional mortality of shearwaters targeting small pelagic fish during hauling of purse-seiners (Anderson and others 2021). In Portugal, a similar fishery found that bycatch incidents occurred on an irregular basis but could affect large numbers of birds during one event (although how representative this may be of the UK fleet is unknown) (Oliveira and others 2015). This may potentially be a problem for Balearic shearwaters, which occur in waters off south-west England (Anderson and others 2021). As part of the new BMP contract Defra will be looking to investigate whether other fisheries like purse seining and pelagic trawls are high risk fisheries for seabird bycatch.

Climate change considerations

The environmental effects of climate change are not reversible in the short to medium term (years to decades, IPCC, 2022b). Therefore, while it may be difficult to address the impacts of climate change on seabirds directly, measures can be taken that will increase the resilience of seabirds to the effects of climate change, by reducing the cumulative impacts of other pressures, including bycatch.

Recommendation K7:

Develop an up-to-date, live database to describe cumulative anthropogenic impacts on seabird populations and prioritise action

Evidence-based reason for recommendation

Anthropogenic sources of seabird mortality

Seabird populations can be directly impacted by a variety of anthropogenic activities, including those described in other recommendations, such as:

- Marine renewable developments, including OWFs through potential collision risk and visual disturbance/displacement (Drewitt & Langston 2006, 2008, Allen and others 2019)
- Licensed activities such as culling of adult birds, egg/nest destruction, egg collection (Ross-Smith and others 2014)
- Mortality due to bycatch in fishing gear and nets (eg, Northridge and others 2020)
- Mortality due to ingestion of plastics (Roman and others 2019a) and contaminants, such as oil spills (eg, Banks and others 2008)
- Displacement from marine activities, for instance involving displacement by ships (eg, Schwemmer and others 2011)

The potential impacts of many of these activities are assessed through Environmental Impact Assessment (EIA) under the Environmental Impact Assessment (EIA) Directive (85/337/EEC) (retained EU law) and Habitats Regulations Assessments (HRAs) under the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales and the Conservation of Offshore Marine Habitats and Species regulations 2017.

Whilst each plan / project will separately undertake a cumulative / in-combination assessment, typically information is not readily available to allow assessments to factor in activities that may cumulatively affect a seabird population. For example, offshore wind cumulative / in-combination assessments typically include predicted mortalities for all relevant OWF, but do not include the additional impacts from licensed activities and bycatch mortality that may be acting on the same seabird populations.

Collation of cumulative impact data

There is a need for a cumulative impact assessment database which incorporates data from multiple data sources, which should be part of the thematic assessments for marine indicators under OSPAR and the UKMS. This could potentially be achieved by an agreed, national database that combines the potential quantitative impacts of all these activities. This will enable a more complete understanding of the cumulative impacts of developments / activities on seabird populations and drive action through the mitigation hierarchy, including compensation where necessary. There are parallels with the Marine Noise Registry, which aims to understand cumulative noise impact across marine space, so that an activity can be managed in the least harmful fashion.

Work is currently underway on such a tool for offshore renewables: the Marine Scotland commissioned CEF for Key Ecological Receptors (seabirds and marine mammals) project began in 2020 and should be completed later in 2022. This work aims to facilitate the robust assessment of cumulative effects of offshore renewable developments using a consistent and transparent approach to the collation and analysis of the best available data. For seabirds this covers both collision risk and displacement from offshore wind and covers a UK wide scale. The CEF will provide a baseline of current effects and the flexibility to add new projects to produce an updated cumulative effects assessment, for both project level and cumulative effects. Therefore, this may potentially provide a basis for development of a wider cumulative effects database.

Key to success will be the ability and impetus to feed in data on impact from other activities.

Climate change considerations

As climate change effects begin to affect seabird foraging and nesting areas, impacts from other marine activities may become more or less important to their existence. Additionally, assessment of impact within a Net Zero or natural capital framework could point to solutions that, for instance, unlock mitigation or compensation actions that enable balancing of impact against climate change alleviating activities.

Recommendation K8:

Promote and enable strategic baseline and impact monitoring of seabirds in relation to marine infrastructure (especially offshore wind farms)

Evidence-based reason for recommendation

The UK has ambitious targets for reaching net zero by 2050 and offshore renewable energy generation, predominantly OWFs, is key to reaching this objective. Species within the scope of the ESCaRP are known to be at risk of negative impacts from OWF including mortality through collision with offshore wind turbines and displacement from the OWF sites. The issues are associated with the construction, operation, maintenance and decommissioning of OWFs. *Evidence needs* Improved data on seabird distribution at all times of the year is required at the planning stage of future offshore wind leasing rounds. In a recent study on scenarios of future offshore wind locations (Arup, 2022) it was highlighted that more detailed datasets for sensitive seabird foraging areas is required to be able to make future policy and planning decisions for marine spatial planning of OWFs at a UK scale. Projects and initiatives such as the Marine Natural Capital Ecosystem Assessment, Celtic Sea Power and POSEIDON are beginning to undertake strategic baseline at-sea data collection for seabirds in English and Welsh waters in order to produce national scale modelled maps of distribution and abundance, but gaps will remain. Strategic programmes of at-sea data collection are required to fill these and ensure that marine planning is based on high confidence seabird information, in particular offshore areas with low data and evidence. Such an approach would also allow bespoke project-specific data collection targeted at issues of importance, which should lead to faster and less uncertain decision-making. There is also a need for such a strategic programme to improve understanding of seabird potential interaction with marine development, particularly where this can feed into evidence cycles informing mitigation. An example is bird flight height, which greatly affects potential to be at risk of collision and can be used to design mitigations relating to wind turbine design (specifically 'draught height' of turbines above the sea surface). Emerging application of technologies such as Lidar should be incorporated into strategic evidence gathering programmes to drive understanding of likely collision and associated mitigation. Monitoring of trials to mark blades and make them more visible to seabirds is also required. Following consent, it is typical for projects to undertake post-consent monitoring (PCM) at project scale, to monitor effects of development. This can focus on collision, displacement, or both. Project-scale PCM has limited value for some issues, which may be best studied at wider strategic scale. A system of strategic compensation requires licensing, funding and operational issues to be resolved, but could allow widespread and novel techniques of monitoring seabird impact to be applied. For instance, developments in remote sensing technology are starting to allow cameras (and radars) to measure collision impact; modifying the PCM landscape could allow targets to be developed relating to eg, the number of cameras deployed on turbines in key areas of sensitivity. Similarly, large-scale studies of displacement rates of species like common guillemots and razorbills are necessary to ensure impact assessments are accurate. Under-researched topics including attraction to light and underwater / above water noise effects could be opened up. Such PCM changes would transform our understanding of impact and unlock methods of impact reduction and mitigation. The recommendation is applicable to fixed and floating wind.
Climate change considerations

Strategic programmes to collect information used in OWF planning, assessment and mitigation must factor in likely changes in seabird distribution and abundance driven by climate change. For instance, models of seabird distribution could be developed to estimate future changes driven by climate-mediated changes to marine ecosystems, allowing medium and long-term marine planning to factor in such predictions to considerations.

12. List of abbreviations

ACAP - Agreement on the Conservation of Albatrosses and Petrels

AEWA - Agreement on the Conservation of African-Eurasian Migratory Waterbirds

AI - Avian Influenza

AIPZ - Avian Influenza Prevention Zone

ALDFG - Abandoned, Lost and Discarded Fishing Gear

AMOC - Atlantic Meridional Overturning Circulation

AOB - Apparently Occupied Burrows

AON - Apparently Occupied Nests

AOT - Apparently Occupied Territories

APHA - Animal and Plant Health Agency

ASCII - American Standard Code for Information Interchange

BBC - British Broadcasting Corporation

BBS - Breeding Bird Survey

BDMPS - Biologically Defined Minimum Population Scales

BEIS - Department for Business, Energy & Industrial Strategy

BESS - British Energy Security Strategy

BoCC 5 - Birds of Conservation Concern 5 (Stanbury and others 2021)

BOU - British Ornithologists' Union

BTO - British Trust for Ornithology

CEF - Cumulative Effects Framework

Cefas - Centre for Environment, Fisheries and Aquaculture Science

CEH - Centre for Ecology and Hydrology

CFP - Common Fisheries Policy

CMS - Convention on the Conservation of Migratory Species of Wild Animals

CO_2 - Carbon dioxide

COASST - The Coastal Observation and Seabird Survey Team

CP2 - Charting Progress 2

CR - Critically endangered

DEFRA - Department for Environment, Food & Rural Affairs

DNA - Deoxyribonucleic acid

EA - Environment Agency

EC - European Commission

ED - Endocrine Disrupting

EEC - European Economic Community

EEZ - Exclusive Economic Zone

EFH - Essential Fish Habitat

EIA - Environmental Impact Assessment

EMS - European Marine Site

EN - Endangered

ESAS - European Seabirds at Sea

ESCaRP - English Seabird Conservation and Recovery Pathway

ESRI - Environmental Systems Research Institute

EU - European Union

FAME - Future of the Atlantic Marine Environment

FAO - Food and Agricultural Organisation

FAO - Food and Agriculture Organisation of the United Nations

FCS - Favourable Conservation Status

FeAST - Feature Activity Sensitivity Tool

GB - Great Britain

GEE - General Estimating Equations

GES - Good Environmental Status

GESAMP - Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

GIS - Geographic Information System

GLM - Generalized Linear Models

GMSL - Global Mean Sea Levels

GPA - Global Programme of Action

GPS - Global Positioning System

GW - Gigawatt

HAB - Harmful Algal Blooms

HASEC - Hazardous Substances and Eutrophication Committee

HDD - Horizontal Directional Drilling

HM - Her Majesty's

HPAI - Highly Pathogenic Avian Influenza

HPMA - Highly Protected Marine Areas

HRA - Habitats Regulation Assessment

ICCAT - International Commission for the Conservation of Atlantic Tunas

ICES - International Council for the Exploration of the Seas

ICS - International Chamber of Shipping

IFCA - Inshore Fisheries and Conservation Authority

IIN - Import Information Note

IMO - International Maritime Organisation

IND - Individual

INIS - Invasive Non-Indigenous Species

INNS - Invasive Non-Native Species

IOTC - Indian Ocean Tuna Commission

IPCC - Intergovernmental Panel on Climate Change

IPENS - Improvement Programme for England's Natura 2000 Sites

IROPI - Imperative Reasons of Overriding Public Interest

IUCN - International Union for Conservation of Nature

JNCC - Joint Nature Conservation Committee

KIS-ORCA - The Kingfisher Information Service – Offshore Renewable Cable Awareness

LC - Least Concern

LCPA - List of Chemicals for Priority Action

LEB - Looming Eye' Buoys

LNRS - Local Nature Recovery Strategies

LSPC - List of Substances of Possible Concern

MARPOL - Marine Pollution

MCCIP - Marine Climate Change Impacts Partnership

MCZ - Marine Conservation Zone

MERP - Marine Ecosystems Research Programme

MHW - Marine heatwaves

MMO - Marine Management Organisation

mNCEA - marine Natural Capital and Ecosystem Assessment Programme

MPA - Marine Protected Area

MSFD - Marine Strategy Framework Directive

MSY - Maximum Sustainable Yield

MWCAT - Massachusetts Wildlife Climate Action Tool

NAD - Notifiable Avian Disease

NAFO - Northwest Atlantic Fisheries Organisation

NASCO - North Atlantic Salmon Conservation Organisation

NDE - No Direct Effects

NE - Natural England

NEAFC - North-East Atlantic Fisheries Commission

NERC - Natural Environment and Rural Communities

NGO - Non-Governmental Organisation

NHCP - National Habitat Compensation Programme

NHCP - National Habitat Compensation Programme

NNR - National Nature Reserve

NOA - North Atlantic Oscillation

NR - Not Relevant

NRN - Nature Recovery Networks

NSIP - Nationally Significant Infrastructure Project

NT - Near Threatened

OCIMF - Oil Companies' International Marine Forum

OPEPs - Oil Pollution Emergency Plans

ORJIP - Offshore Renewables Joint Industry Programme

OSPAR - Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)

OWEAP - Offshore Wind Enabling Actions Programme

OWEC - Offshore Wind Evidence and Change

OWF - Offshore Wind Farm

PAH - Polycyclic Aromatic Hydrocarbons

PAT - Proxy Assessment Tool

PBDE - Polybrominated Diphenyl Ether

PCM - Post-Consent Monitoring

POPs - Persistent Organic Pollutants

POSEIDON - Planning Offshore Wind Strategic Environmental Decisions

PSS - Protected Site Strategies

PVA - Population Viability Analysis

QA - Quality Assurance

RAP ML - Regional Action Plan on Marine Litter

RAS - Retrapping Adults for Survival

REM - Remote Electronic Monitoring

RSPB - Royal Society for the Protection of Birds

RYA - Royal Yachting Association

SAC - Special Area of Conservation

SANG - Suitable Alternative Natural Greenspace

SeaMaST - Seabird Mapping and Sensitivity Tool

SEAPOP - SEAbird POPulations

ShMPs - Shoreline Management Plans

SIPs - IPENS SPA Site Improvement Plans

SMP - Seabird Monitoring Programme

SNCB - Statutory Nature Conservation Body

SPA - Special Protection Area

SSB - Spawning stock biomass

SSCS - Scottish Seabird Conservation Strategy

SSSI - Sites of Special Scientific Interest

SST - Sea Surface Temperature

STAR - Seabird Tracking And Recording

TAC - Total Allowable Catch

TBT - Tributyltin

TCA - Trade and Cooperation Agreement

UAV - Unmanned Aerial Vehicles

UK - United Kingdom

UK REACH - UK registration, Evaluation, Authorisation and Restriction of Chemicals

UKBMP - UK Bycatch Monitoring Programme

UKHO - UK Hydrographic Office

UKMMAS - UK Marine Monitoring and Assessment Strategy

UKMS - UK Marine Strategy

UN - United Nations

UNCLOS - United Nations Convention on the Law of the Sea

UNEP - United Nations Environment Programme

UTM - Universal Transverse Mercator

VHF - Very High Frequency

VMS - Vessel Monitoring Systems

VSAS - Volunteer Surveys at Sea

VU - Vulnerable

WCCS - Western Channel and Celtic Seas

WeBS - Wetland Bird Survey

WFD - Water Framework Directive

WGS - World Geodetic System

WinGS	- Winter Gull Roost Survey
WNAO	- Winter North Atlantic Oscillation
WOZEP	- The Offshore Wind Ecological Programme