Seabirds in the North-East Atlantic
Climate Change Vulnerability and Potential Conservation Actions

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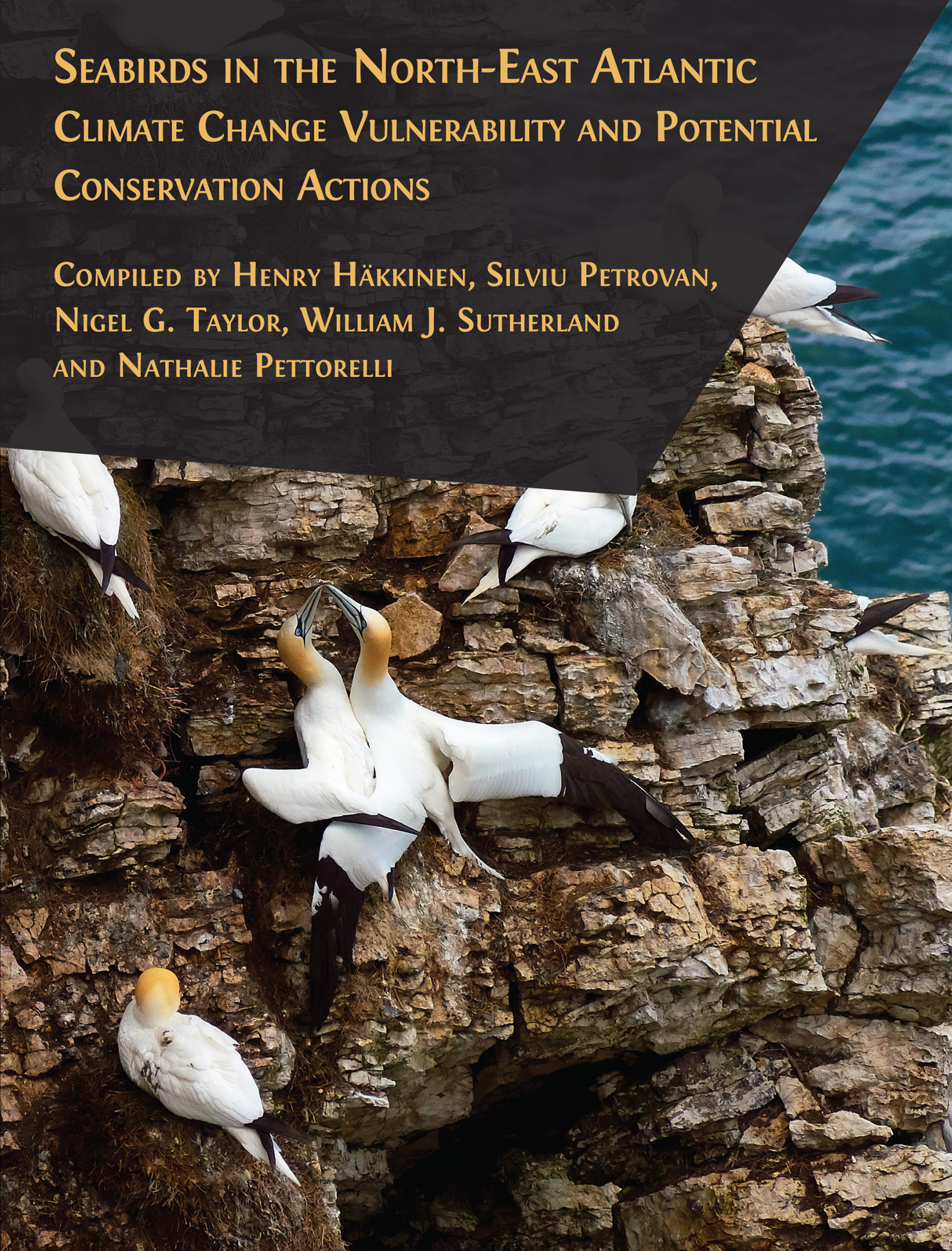

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Gannets and Cormorants

(Sulidae and Phalacrocoracidae)

An assessment of climate change vulnerability and potential conservation actions for gulls and cormorants in the North-East Atlantic

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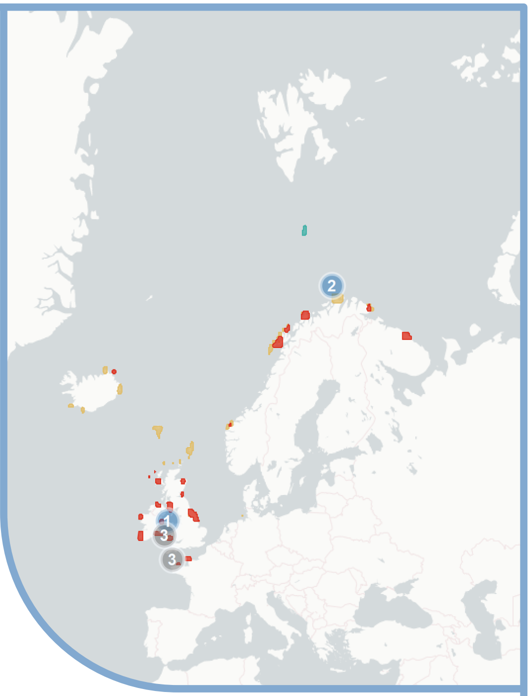
1 Northern Gannet (*Morus bassanus*)

1.1 Evidence for exposure



1.1.1 Potential changes in breeding habitat suitability (by 2100):

Current breeding area that is likely to become less suitable (62% of current range).

Current breeding area that is likely to remain suitable (37%).

Current breeding area that is likely to become more suitable (1%).

1.1.2 Current impacts attributed to climate change:

1 **Neutral Impact:** Gannets are undertaking longer foraging trips, most likely in response to prey shortages due to climate change. Although this likely increases the energetic costs of foraging, there have so far been no observed impacts on breeding success or mortality.

2 **Positive Impact:** Gannets have established new colonies as key prey species have shifted further north.

1.1.3 Predicted changes in key prey species:

3 Key prey species are likely to decline in abundance in the southern Irish Sea and on the north coast of France.

1.1.4 Climate change impacts outside of Europe:

- Marine heatwaves in North America have resulted in wide-spread breeding failure and in some cases temporary desertion of colonies. Most likely because of prey shortages, but heat stress could play a role as well. It is difficult to attribute individual climate events to climate change, but heatwaves are becoming more common and more extreme, and will likely continue to do so.

- Lack of key prey species (mackerel) due to warmer average marine temperatures and over-exploitation has caused low breeding success in a southern population of gannets in Canada.

1.2 Sensitivity

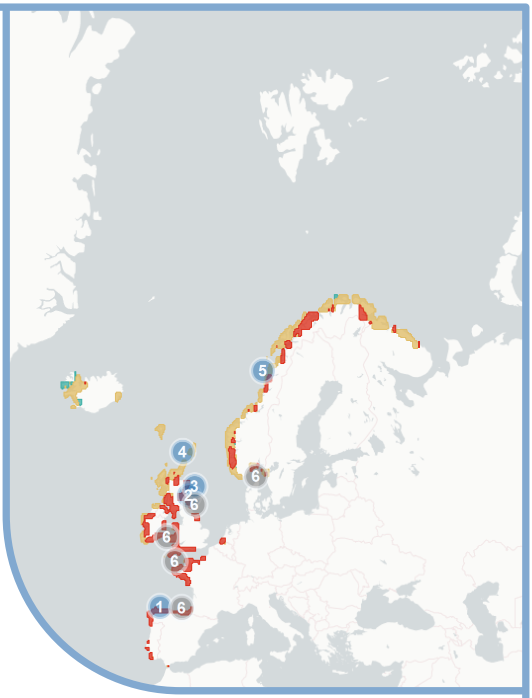
- Heatwaves are known to cause heat stress in gannet chicks and adults. So far this has not been observed to significantly affect populations in Europe, but heatwaves in other parts of their range have caused breeding failures and temporary colony desertion.
- This species has a long generation length (>10 years), which may slow recovery from severe impacts and increases population extinction risk.

1.3 Adaptive capacity

- Gannets occasionally establish new colonies, there are multiple records of them colonising or recolonising areas following environmental change or removal of threats.
- Individuals are often very loyal to breeding sites. Once adults establish a nest site they will return for many years, which reduces their capacity to adapt to change at breeding sites.
- Diet is variable across their range and over time. Long term studies have noticed shifts in primary prey species over several decades, which indicates some capacity for populations to shift diet.
- Gannets have been noted to change phenology, but not in correlation to changes in conditions. Overall there is little change in migration timing, and the underlying causes for any observed changes is uncertain.
- Gannets forage over large areas and show considerable flexibility in foraging behaviour, local changes in prey availability are unlikely to have a large impact.

2 European Shag *(Gulosus aristotelis)*

1.1 Evidence for exposure



1.1.1 Potential changes in breeding habitat suitability (by 2100):

Current breeding area that is likely to become less suitable (44% of current range).

Current breeding area that is likely to remain suitable (60%).

Current breeding area that is likely to become more suitable (6%).

1.1.2 Current impacts attributed to climate change:

1 **Neutral Impact:** Shags have advanced their laying date, most likely due to changes in marine temperatures and subsequently in prey availability.

2 **Neutral Impact:** The diet composition of shags has changed a great deal, likely in response to climate change driven changes in the marine ecosystem.

3 **Negative Impact:** Extreme storms during the shag breeding season have led to wide-spread nest destruction, nesting failure and a net reduction in annual population production.

4 **Negative Impact:** Recent declines in shag populations because of high adult mortality are most likely because of increasingly severe winter storms.

5 **Neutral Impact:** Shags breed later as winters have become colder.

1.1.3 Predicted changes in key prey species:

6 Key prey species are likely to decline in abundance in the Irish Sea, the north-east of the UK, the northern coast of Spain and along the coast of Brittany

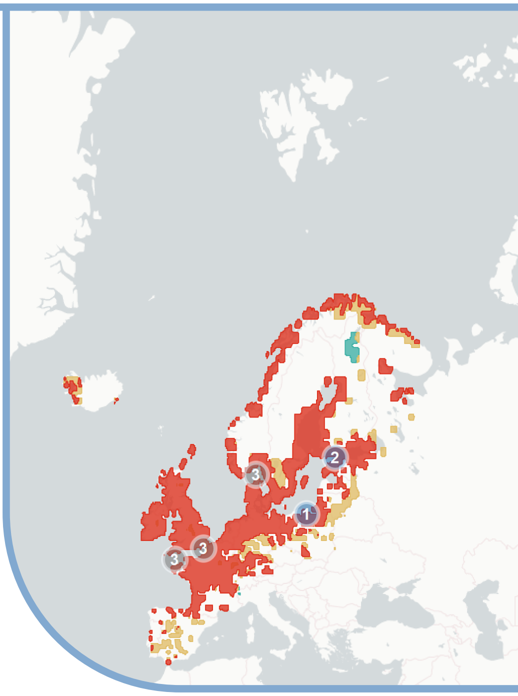
1.2 Sensitivity

- Shags only have partially water-proof feathers, and as such are prone to water-logging and hypothermia in wet, cold weather. Extreme events often result in wide-scale mortality ('wrecks') and breeding failure, as such predicted increases in storm frequency and intensity could have severe impacts on shags.
- When food is plentiful shag populations also often recover quite quickly, and so often follow a "boom and bust" cycle. This may be helpful in response to climate change as populations can recover quickly, but also makes them sensitive to rapid change as populations can become locally extinct quickly.
- While in many populations shags have a varied diet, in others they are heavily dependent on sandeels, saithe or herring. Previous decreases in prey species have led to lower breeding success. For some populations, any change to key prey availability due to climate change could have severe consequences.
- Shags typically nest on low-lying habitats, often only a few metres from the water-line, which are vulnerable to flooding and being washed away. Sea-level rise or an increase in wave action during the breeding season could have significant impacts on breeding colonies.
- Many shag populations heavily rely on kelp forest habitats, especially during the breeding season. Many kelp forests known to be important to shags are either declining due to climate change or are likely to be very vulnerable to climate change. So far, the impact of the decline in kelp forests on shags is unknown, but is potentially severe.
- Shags are likely to be sensitive to heatwaves, as they are commonly observed gular fluttering on hot days, and absorb heat very effectively. Other species of shags are known to be impacted by heatwaves, which cause poor breeding seasons and increased mortality. Heatwaves are likely to become more frequent and extreme due to climate change.
- The species is declining in many parts of its range. The causes behind these declines are not well understood, but climate change and extreme weather events are one likely cause.

1.3 Adaptive capacity

- Shags are known to change their phenology, probably in correlation to resource availability. This is likely to buffer some effects of climate change as shags may change breeding timing to match prey availability.
- Foraging strategy and behaviour varies substantially across populations and individuals. In general shags are flexible and generalist in terms of prey and foraging habitat, but individuals are often specialised.

3 Great Cormorant (*Phalacrocorax carbo*)



1.1 Evidence for exposure

1.1.1 Potential changes in breeding habitat suitability (by 2100):

Current breeding area that is likely to become less suitable (76% of current range).

Current breeding area that is likely to remain suitable (23%).

Current breeding area that is likely to become more suitable (1%).

1.1.2 Current impacts attributed to climate change:

1 **Neutral Impact:** Cormorants that migrate to coastal areas during the winter are now migrating later, most likely due to less and later ice on freshwater feeding areas.

2 **Positive Impact:** Cormorants are expanding their range due to increased availability of prey, in large part due to declines in competing marine predators, which in turn are partially driven by climate change.

1.1.3 Predicted changes in key prey species:

3 Key prey species are likely to decline in abundance in the Irish Sea, on the coast of Brittany, the north of Denmark, and across the English Channel.

1.1.4 Climate change impacts outside of Europe:

- Cormorants in Greenland have spread their summer range further north, most likely due to warmer sea temperatures and changes in food availability. However, this has also likely increased the costs of migration, as cormorants have further to travel to reach ice-free areas in winter.

1.2 Sensitivity

- Cormorant population trends are correlated with local sea surface temperature, it seems likely that in many areas warmer waters will benefit cormorants. Sensitivity is therefore likely to be low in many areas. However, there is likely a limit to northern expansion as cormorants cannot forage effectively in areas with short periods of daylight.
- Cormorants are sensitive to extreme weather events, including extreme cold periods and high rainfall. Cormorants only have partially water-proof feathers, and as such are prone to water-logging and hypothermia in wet, cold weather. The northern edge of their range is likely set by winter temperatures, and the duration of sea and lake ice.

1.3 Adaptive capacity

- Following historical declines and several local extinctions, this species has greatly recovered following increased protection and decreased persecution, and has recolonised many areas of its previous range. It therefore seems likely that cormorants can redistribute and establish new populations in response to climate change.
- Cormorants generally have low site fidelity, and mass relocations are relatively common. It seems likely that cormorants can rapidly redistribute to more suitable areas if negative impacts occur.
- This species has a diverse diet, but this varies depending on population. Some populations variously prey on up to 20 species, depending on availability, whereas others are heavily on one or a few species. The effect of a loss of a key prey species is likely to vary depending on area and population.

European shag © Seppo Häkkinen

Potential actions in response to climate change: Gannets and Cormorants (Sulidae and Phalacrocoracidae)

In this section we list and assess possible local conservation actions that could be carried out in response to identified climate change impacts. This section is not grouped by species, but by identified impacts. If an impact or action is specific to one or a few species, this information is included in the action summary or in the footnotes. Effectiveness, relevance, strength and transparency scores are based on the available evidence we collated (see Appendix 2), and therefore all statements regarding limited or a lack of evidence relate to the collated evidence base, and does not infer that no such studies exist.

1 Impact: Increased frequency/severity of storms (including wind, rain and wave action) increases foraging difficulty and/or mortality

Summary:
Several local actions may be possible to limit mortality or increase recovery on a small scale, but for larger populations effective local action is difficult. Supporting the population in more general ways (increasing adult survival, limiting chick mortality) may be the most effective method.

Intervention	Evidence of Effectiveness	R	S	T
Provide supplementary food during the breeding season	Trialled on many seabird species. Limited evidence for effectiveness in gannets and cormorants, though it has been found to have some minor benefits for non-European gannets. Typically very labour intensive and difficult, and probably only plausible for small populations.	3	4	3

Provide supplementary food during the non-breeding season	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds.	NA	NA	NA
Rehabilitate sick or injured birds	For groups of long-lived, large birds, rehabilitation is known to be an effective way to support populations. However, examples in seabirds are scarce and the overall effectiveness for most species is unknown. There are several reports of successful rehabilitation and release of gannets, cormorants and shags, but many note that treatment is difficult as these species are easily distressed, especially cormorants, and prone to disease in captivity.	1	2	3

Green = Likely to be beneficial. Red = Unlikely to be beneficial, may have negative impact.
Orange = contradicting or uncertain evidence. Grey = Limited evidence.
R = relevance rating. **S** = strength rating. **T** = transparency rating. All ratings on a scale of 1 to 5, where 5 is the highest.

Details:

Provide supplementary food during the breeding season
Relevance (R): 3 studies in the evidence base focus on gannets and cormorants, 13 on other seabirds and 0 on other birds. **Strength (S):** The evidence base was comprised of 16 studies. Of these 10 were considered to have a good sample size, and 14 had a clear metric for effectiveness. **Transparency (T):** 16 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 13 had a published methodology, and 4 justified their rationale.

Rehabilitate sick or injured birds
Relevance (R): 1 studies in the evidence base focus on gannets and cormorants, 2 on other seabirds and 4 on other birds. **Strength (S):** The evidence base was comprised of 7 studies. Of these 4 were considered to have a good sample size, and 1 had a clear metric for effectiveness. **Transparency (T):** 7 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 5 had a published methodology, and 5 justified their rationale.

2 Impact: Increased frequency/severity of storms (including wind, rain and wave action) causes nest destruction

Summary:
While there are several local actions that may prevent or mitigate local nest destruction, they have not been trialled widely and wide-spread evidence to support their use is currently lacking. If changes in extreme weather threatens the viability of a population, then several actions are available to encourage translocation of populations to safer areas.

Intervention	Evidence of Effectiveness	R	S	T
Alter habitat to encourage birds to leave an area	Few trials on seabirds and none on gannets or cormorants, has been effective in some other seabird groups. This action could be investigated for cormorants and shags, as this action is more viable for species lower site fidelity and areas with other available breeding habitat nearby.	2	2	3
Artificially incubate or hand-rear chicks to support population	Known to be effective for some seabirds, though labour intensive and usually only appropriate for small populations. No documented examples of hand-rearing in cormorants or gannets.	2	2	1
Install barriers to prevent flooding	While likely to prevent flooding there is currently no evidence available on this action's effectiveness in relation to seabird conservation.	NA	NA	NA
Make new colonies more attractive to encourage birds to colonise	Several actions have been trialled across seabird species to encourage colonisation, with variable success, including the use of decoys, acoustic cues, smells and improved habitat. There is limited evidence for cormorants and gannets, but several examples exist where cormorants have been successfully encouraged to new areas with artificial vocalisations and decoys.	2	4	3

Intervention	Evidence of Effectiveness	R	S	T
Manually relocate nests	This has been reported by practitioners as an effective action to assist seabirds on low-lying beaches in the Baltic, though on species other than cormorants and gannets. However, to our knowledge there are no broad-scale studies or reviews of this action's effectiveness.	NA	NA	NA
Provide additional shelter or protection from extreme weather (flooding)	There are few trials on seabird species, and most report little to no benefit for breeding populations. However, evidence is limited and more research is needed on this action's overall effectiveness. We found no published trials on gannet or cormorant species.	1	3	5
Provide artificial nesting sites	Tried extensively on many seabird species with significant benefit to many species. Artificial nesting sites have been successfully used to support several cormorant species; they readily visit, nest and breed at artificial nesting sites. No documented examples in gannets.	2	5	3
Repair/ support nests to support breeding	Very limited evidence for effectiveness in seabirds, though known to be effective in other birds. No known examples in gannet or cormorant species.	2	5	3
Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but no documented examples in gannets or cormorants. Effectiveness and likelihood of success is poorly understood.	2	4	4

Green = Likely to be beneficial. Red = Unlikely to be beneficial, may have negative impact. Orange = contradicting or uncertain evidence. Grey = Limited evidence.
R = relevance rating. S = strength rating. T = transparency rating. All ratings on a scale of 1 to 5, where 5 is the highest.

Details:

Alter habitat to encourage birds to leave an area
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 2 on other seabirds and 0 on other birds. **Strength (S):** The evidence base was comprised of 2 studies. Of these 2 were considered to have a good sample size, and 0 had a clear metric for effectiveness. **Transparency (T):** 2 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 2 had a published methodology, and 1 justified their rationale.

Artificially incubate or hand-rear chicks to support population
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 40 on other seabirds and 0 on other birds. **Strength (S):** The evidence base was comprised of 40 studies. Of these 9 were considered to have a good sample size, and 19 had a clear metric for effectiveness. **Transparency (T):** 26 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 17 had a published methodology, and 4 justified their rationale.

Make new colonies more attractive to encourage birds to colonise
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 38 on other seabirds and 6 on other birds. **Strength (S):** The evidence base was comprised of 44 studies. Of these 31 were considered to have a good sample size, and 18 had a clear metric for effectiveness. **Transparency (T):** 44 studies included were published and peer-reviewed, of which 1 were literature reviews or meta-analyses, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 30 had a published methodology, and 22 justified their rationale.

Provide additional shelter or protection from extreme weather (flooding)
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 0 on other seabirds and 3 on other birds. **Strength (S):** The evidence base was comprised of 3 studies. Of these 1 was considered to have a good sample size, and 2 had a clear metric for effectiveness. **Transparency (T):** 3 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 3 had a published methodology, and 3 justified their rationale.

Provide artificial nesting sites
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 53 on other seabirds and 1 on other birds. **Strength (S):** The evidence base was comprised of 54 studies. Of these 50 were considered to have a good sample size,

and 33 had a clear metric for effectiveness. **Transparency (T):** 53 studies included were published and peer-reviewed, of which 2 were literature reviews or meta-analyses, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 33 had a published methodology, and 27 justified their rationale.

Repair/support nests to support breeding
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 2 on other seabirds and 1 on other birds. **Strength (S):** The evidence base was comprised of 3 studies. Of these 1 was considered to have a good sample size, and 1 had a clear metric for effectiveness. **Transparency (T):** 3 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 1 had a published methodology, and 3 justified their rationale.

Translocate the population to a more suitable breeding area
Relevance (R): 0 studies in the evidence base focus on gannets and cormorants, 15 on other seabirds and 0 on other birds. **Strength (S):** The evidence base was comprised of 15 studies. Of these 13 were considered to have a good sample size, and 9 had a clear metric for effectiveness. **Transparency (T):** 14 studies included were published and peer-reviewed, of which 1 were literature reviews or meta-analyses, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 11 had a published methodology, and 9 justified their rationale.