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

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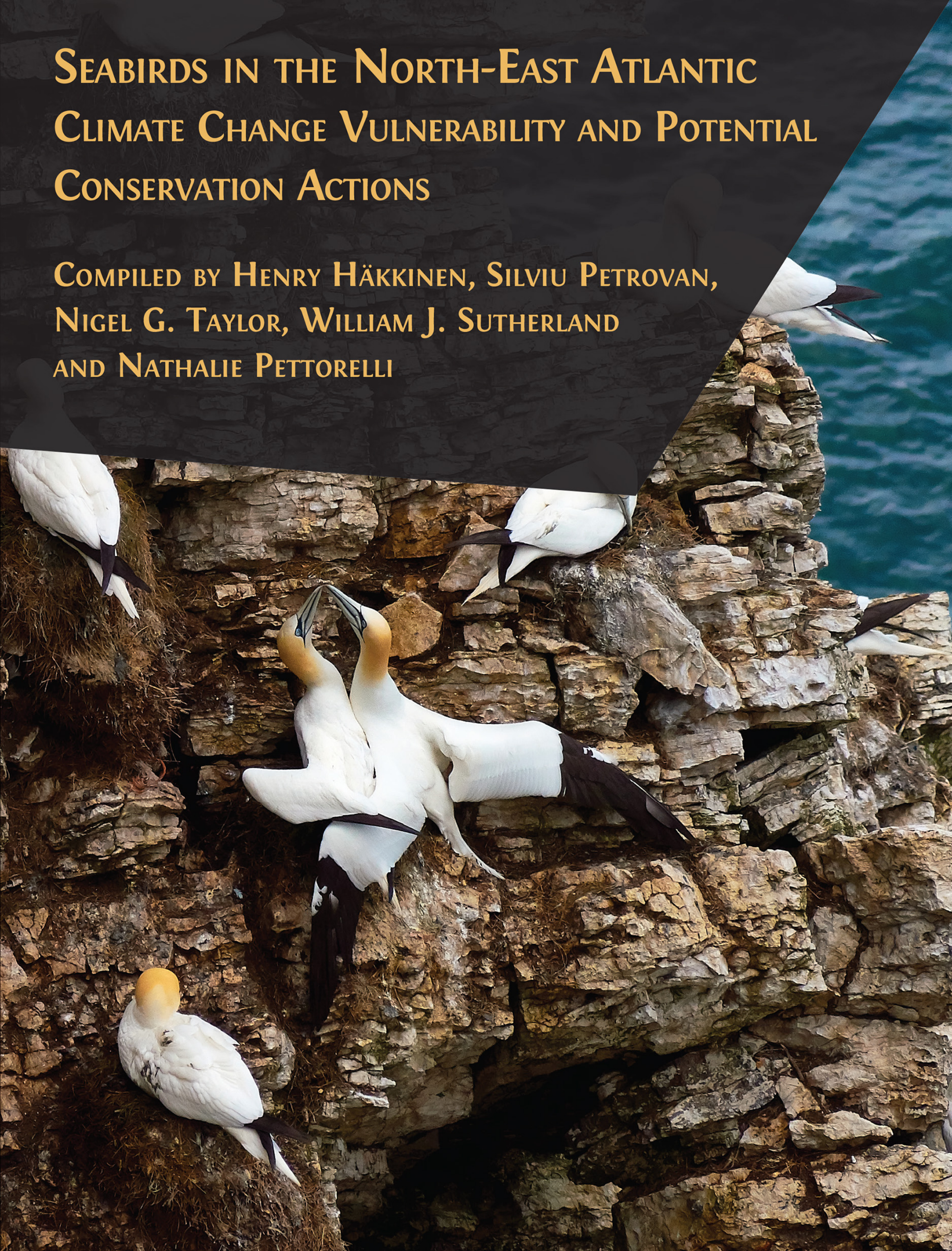

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Terns

(Laridae)

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

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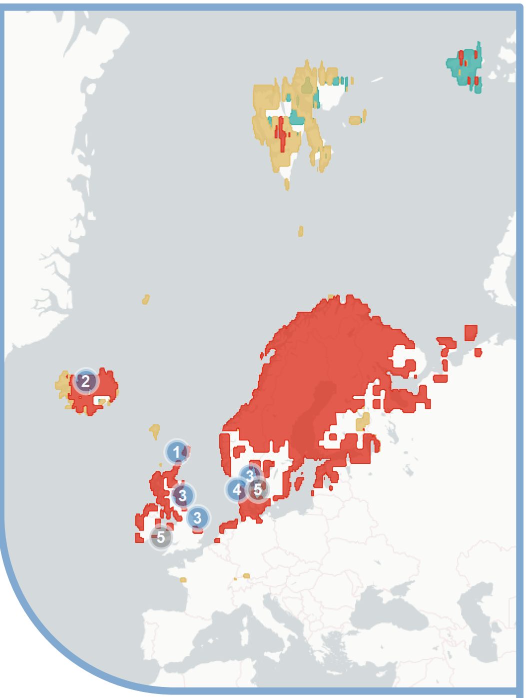
1 Arctic Tern *(Sterna paradisaea)*



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 (87% of current range).

Current breeding area that is likely to remain suitable (10%).

Current breeding area that is likely to become more suitable (3%).

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Changes in prey availability during the breeding season have led to population declines (debated).

2 **Negative Impact:** Changes in prey availability during the breeding season have led to population declines.

3 **Neutral Impact:** Arctic terns are arriving from migration and breeding earlier.

4 **Neutral Impact:** Juvenile Arctic terns have begun to disperse further, distance has increased in correlation with warmer winters. Mechanism unknown, but likely mediated through prey availability.

1.1.3 Predicted changes in key prey species:

5 Key prey species are likely to decline in abundance in the Irish Sea and around North Denmark.

1.2 Sensitivity

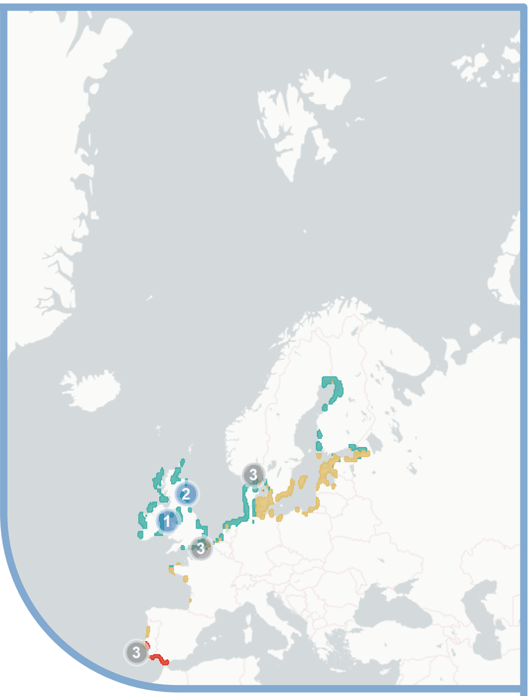
- Around the North Sea Arctic terns are very dependent on sandeels and highly sensitive to prey depletion. Lack of sandeels can cause mass breeding failures, and several have been observed in recent years. If climate change contributes to the decline of sandeels this is likely to have severe consequences on tern populations.
- Tern productivity decreases as sea surface temperature gets higher, most likely due to prey availability. While the mechanism is unclear, projected increases in sea temperature are likely to negatively impact tern populations.
- Arctic terns are primarily surface feeders. If climate change results in prolonged stormy weather, or extended heatwaves drive prey species into deeper water, then it would likely result in Arctic terns struggling to forage effectively.
- 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

- Dispersal between colonies in Denmark has steadily increased over the last 70 years, in correlation with changes in climate (winter NAO). The exact mechanism is unknown, but high dispersal typically means more genetic flow and therefore resilience in the population.
- Arctic terns can skip breeding when conditions are particularly poor. This is likely to be adaptive in the face of climate change as it conserves resources in poor years and maximises breeding success in good years
- Arctic tern populations have a wide variation in migration strategy in terms of route and timing. This is likely to make populations more resilient as impacts to one part of the migration route are unlikely to have major impacts on the population as a whole.
- Arctic terns likely have high site fidelity, particularly at stable colonies. There are few examples of Arctic terns establishing new colonies spontaneously. They are unlikely to shift their range quickly in response to climate change.

2 Little Tern *(Sternula albifrons)*

1.1 Evidence for exposure



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

- (red) Current breeding area that is likely to become less suitable (3% of current range).
- (yellow) Current breeding area that is likely to remain suitable (57%).
- (teal) Current breeding area that is likely to become more suitable (59%).

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Little tern nests are frequently washed away by tidal surges, such events are becoming more frequent or extensive due to rising sea levels.

2 **Negative Impact:** As sea temperature has increased over time, tern productivity has decreased. Mechanism unknown, but likely mediated through prey availability.

1.1.3 Predicted changes in key prey species:

3 Key prey species are likely to decline in abundance in southern Portugal, along the southern coast of England, the coasts of Belgium and the Netherlands and around North Denmark.

1.2 Sensitivity

- Little terns have a varied diet, but many colonies rely on one or a few prey species. Sensitivity to changes in prey is likely to vary across its range. In some populations (such as in Algarve, Portugal), warmer temperatures have been linked to lower key prey availability and lower breeding success, though there has been no long-term trend observed over time.
- Coastal populations breed commonly on flat beaches, which are prone to flooding due to storms, tidal surges or sea level rise. A rise in extreme weather events would likely impact breeding success of little terns.
- Little terns are primarily surface feeders and have a limited foraging range during the breeding season. This increases their sensitivity to changes in prey availability, and they would likely be heavily impacted if climate change results in prolonged stormy weather, or extended heatwaves drive prey species into deeper water.
- Little terns face high levels of predation threat, notably in the Baltic, and several of their key predators (e.g. minks and foxes) are becoming more abundant and spreading, in part due to climate change. So far this has not heavily impacted little tern populations, but continued climate change may result in declines due to predation.

1.3 Adaptive capacity

- Little terns can change their phenology based on climate and weather. Populations in Finland change their migration timing in response to winter and spring climate, and their laying date in response to local weather conditions. This may allow little terns to respond to changing climate and mitigate impacts leading up to the breeding season.
- Little terns often display low site fidelity and will change breeding site from year to year, especially in response to disturbance. This is likely to be adaptive in terms of climate change, as it seems highly likely little terns will redistribute to more suitable areas if available.

3 Roseate Tern (*Sterna dougallii*)

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 (100% of current range).

Current breeding area that is likely to remain suitable (0%).

Current breeding area that is likely to become more suitable (0%).

1.1.2 Current impacts attributed to climate change:

We did not identify any current impacts of climate change for this species.

1.1.3 Predicted changes in key prey species:

1 Key prey species are likely to decline in abundance in the English Channel.

1.2 Sensitivity

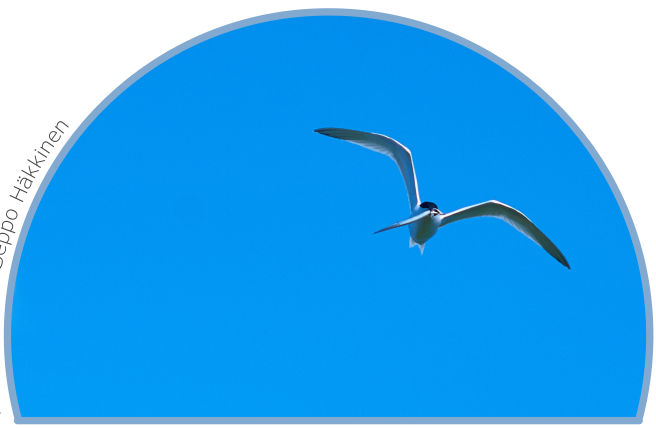
- Roseate terns have a small range in Europe, and many populations have historically gone extinct due to persecution, disturbance, or extreme climate events. Increased pressure from climate change is likely to increase risk of declines or local extinction.
- Roseate terns are primarily surface feeders. If climate change results in prolonged stormy weather, or extended heatwaves drive prey species into

deeper water, then it would likely result in terns struggling to forage effectively.

- Roseate terns are specialist foragers, and prey on relatively few species compared to other terns. They may be particularly sensitive to changes in key prey species.
- Many European Roseate terns winter off the coast of west Africa, where prey availability is linked to key upwelling systems. There is evidence that these upwellings may change or be disrupted by climate change. If this happens it is likely to have severe consequences on tern mortality, condition during the breeding season and timing of migration.
- Roseate terns only nest around other terns, in particular common terns, and rely on them for protection from more aggressive species. Any impacts to these other species is likely to have negative consequences for roseate terns.

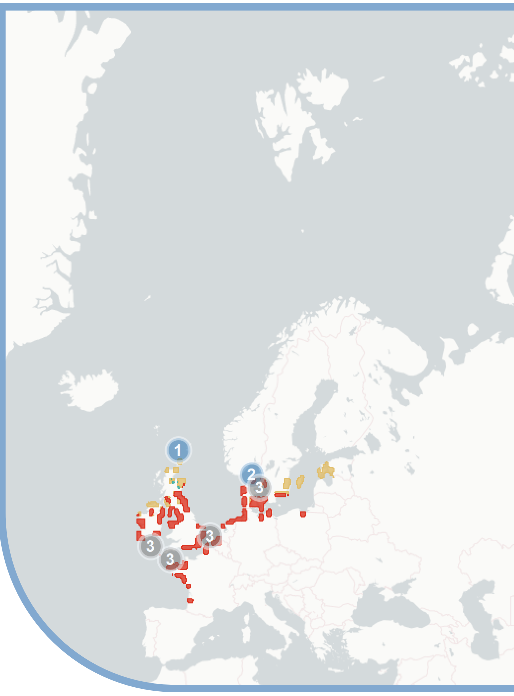
1.3 Adaptive capacity

- The eastern Atlantic roseate tern population is thought to be a closed population, so is unlikely to be supplemented by individuals from other colonies. Genetic diversity is unlikely to increase and may result in bottlenecks, possibly hampering recovery if climate change results in population decline.



Arctic tern © Seppo Häkkinen

4 Sandwich Tern (*Thalasseus sandvicensis*)



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 (72% of current range).

Current breeding area that is likely to remain suitable (26%).

Current breeding area that is likely to become more suitable (2%).

1.1.2 Current impacts attributed to climate change:

1 **Neutral Impact:** Sandwich terns are changing their migration timing and arriving earlier to breeding sites.

2 **Neutral Impact:** Sandwich terns are changing their migration timing, both migration and breeding events are occurring later, making the breeding season shorter.

1.1.3 Predicted changes in key prey species:

3 Key prey species are likely to decline in abundance on the southern coast of England, around the Brittany coast, around North Denmark and around the south coast of Ireland.

1.2 Sensitivity

- As Sandwich terns nest on low-lying ground close to the water's edge, their nests are vulnerable to tidal inundation. So far there are no studies on whether climate change is affecting breeding populations through increased flooding, but predictions of increased storminess and sea-level rise under climate change scenarios may lead to more nesting populations being lost.

1.3 Adaptive capacity

- Sandwich terns have flexible migration and laying phenology, and several populations have already changed the timing of migration and breeding in response to climate change. However, whether this is adaptive or not is currently unknown.
- Sandwich terns often display low site fidelity and will change breeding site from year to year in response to changing conditions or disturbance. This is likely to be adaptive in terms of climate change, as it seems highly likely Sandwich terns will redistribute to more suitable areas if available.

Sandwich tern © Silviu Petrovan

5 Caspian Tern *(Hydroprogne caspia)*

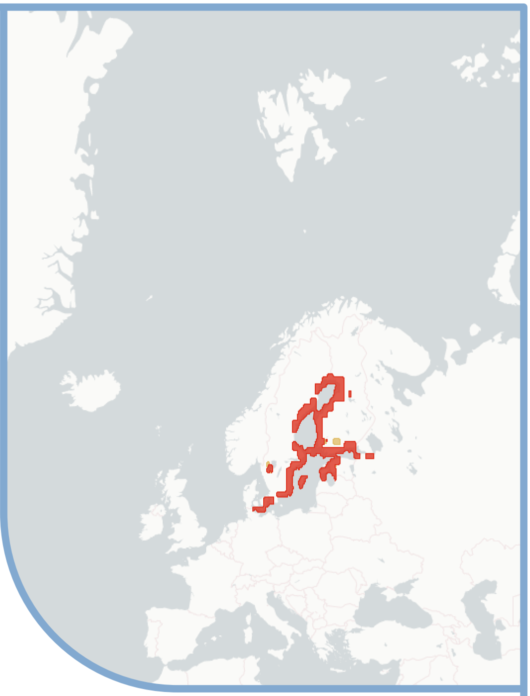
1.1 Evidence for exposure

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

Current breeding area that is likely to become less suitable (97% of current range).

Current breeding area that is likely to remain suitable (3%).

Current breeding area that is likely to become more suitable (0%).



1.1.2 Current impacts attributed to climate change:

We did not identify any current impacts of climate change for this species.

1.1.3 Predicted changes in key prey species:

No key prey species are predicted to decline for this species.

1.1.4 Climate change impacts outside of Europe

- Caspian terns in North America have been negatively affected by heatwaves, warming seas, severe storms, and increased frequency of flooding, all of which are linked to climate change.

1.2 Sensitivity

- Caspian tern chicks are sensitive to heatwaves, and particularly hot summers in the US have resulted in mass mortality. Heatwaves are likely to become more frequent and extreme due to climate change, which will likely negatively impact Caspian terns.
- Caspian terns are vulnerable to predation by American minks, which are increasing in some locations in part due to climate change. No effect on populations has been observed so far, but climate change may contribute to additional predation pressure.
- Caspian terns in Europe typically nest on low-lying beaches, making them sensitive to flooding and tidal surges. Extreme weather events are projected to become more frequent in many areas, and therefore may lower tern breeding success.
- Caspian terns are primarily surface feeders. If climate change results in prolonged stormy weather, or extended heatwaves drive prey species into deeper water, then it would likely result in Caspian terns struggling to forage effectively.
- Caspian terns typically only nest on rocky substrates with very little vegetation. Additional growth can cause them to abandon nesting sites. This is particularly an issue in the Baltic due to high levels of nutrients on islands, and is likely to be exacerbated by climate change.

1.3 Adaptive capacity

- Caspian terns are known to abandon and re-locate colonies following changes in environmental conditions or disturbance. This is likely to be adaptive in terms of climate change, as it seems highly likely terns will redistribute to more suitable areas if available.

Potential actions in response to climate change: Terns (Laridae)

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: Reduced prey availability during breeding season

Summary:

Several local actions may assist breeding populations on a small scale, but direct intervention on a large scale is likely to be extremely difficult. General conservation actions to protect fish stocks and local marine areas may be the most effective method. If a population is likely to suffer major losses, even with conservation help, then translocations could be considered.

Intervention	Evidence of Effectiveness	R	S	T
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. There are anecdotal examples of terns being hand-reared, but details are unknown. Arctic terns have been kept ex-situ in small numbers.	2	2	1
Make new colonies more attractive to encourage birds to colonise	Many species of tern have been successfully relocated using a variety of techniques to make new areas more attractive, in particular vocalisations and modification of habitat. While not every attempted relocation has been successful, there are numerous notable successes, including successful relocation of large populations containing thousands of individuals.	4	4	3

Provide supplementary food during the breeding season	Trialled on many seabird species, with mixed success. Few, if any, successful examples for terns, though some supplemental feeding has been attempted on a very local scale. Typically very labour intensive and difficult, especially as many tern species strongly prefer living prey and are unlikely to take dead prey. Unlikely to be effective for many terns, or only plausible for small populations.	2	4	3
Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but few if any examples in terns. Attempts to move populations have typically used attractants to encourage movement, rather than manual translocation. If the target species has high site fidelity, manual translocation may be appropriate but little is known about methods and effectiveness of tern translocation.	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:

Artificially incubate or hand-rear chicks to support population
Relevance (R): 0 studies in the evidence base focus on terns, 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): 22 studies in the evidence base focus on terns, 16 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 supplementary food during the breeding season
Relevance (R): 0 studies in the evidence base focus on terns, 16 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.

Translocate the population to a more suitable breeding area
Relevance (R): 0 studies in the evidence base focus on terns, 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.

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	There are limited trials of this action, however there are several successful examples of modifying habitat to encourage terns to leave, typically by encouraging vegetation to overgrow nesting areas. There are currently no available examples in other seabirds.	5	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. There are anecdotal examples of terns being hand-reared, but details are unknown. Arctic terns have been kept ex-situ in small numbers.	2	2	1
Install barriers to prevent flooding	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds.	NA	NA	NA
Make new colonies more attractive to encourage birds to colonise	Many species of tern have been successfully relocated using a variety of techniques to make new areas more attractive, in particular vocalisations and modification of habitat. While not every attempted relocation has been successful, there are numerous notable successes, including successful relocation of large populations containing thousands of individuals.	4	4	3
Manually relocate nests	There is no published evidence regarding this action's effectiveness. However, first-hand accounts from practitioners have reported that manually moving nests has been trialled, and with some success. Likely to only be viable for a few nests at the edge of colonies, as larger interventions are laborious, cause mass disturbance, and may result in terns abandoning nests.	NA	NA	NA
Provide additional shelter or protection from extreme weather (flooding)	There have been some attempts to provide shelter for tern populations to protect nests from flooding, however none so far have shown any significant benefit. Novel methods may provide more protection, but this requires further research.	2	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 a variety of tern species, including the use of artificial islands, floating rafts and nest-boxes.	3	5	3
Repair/ support nests to support breeding	There is limited evidence to support this action, as few trials have been carried out on any seabird species, and those that exist are on a very local scale. No attempts have been made on terns. More research needed to determine effectiveness of this action.	2	2	3
Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but few, if any, examples in terns. Attempts to move populations have typically used attractants to encourage movement, rather than manual translocation. If the target species has high site fidelity, manual translocation may be appropriate but little is known about methods and effectiveness of tern translocation.	4	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): 2 studies in the evidence base focus on terns, 0 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 terns, 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): 22 studies in the evidence base focus on terns, 16 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): 1 study in the evidence base focusses on terns, 0 on other seabirds and 2 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): 17 studies in the evidence base focus on terns, 35 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): 1 study in the evidence base focusses on terns, 1 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 terns, 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.