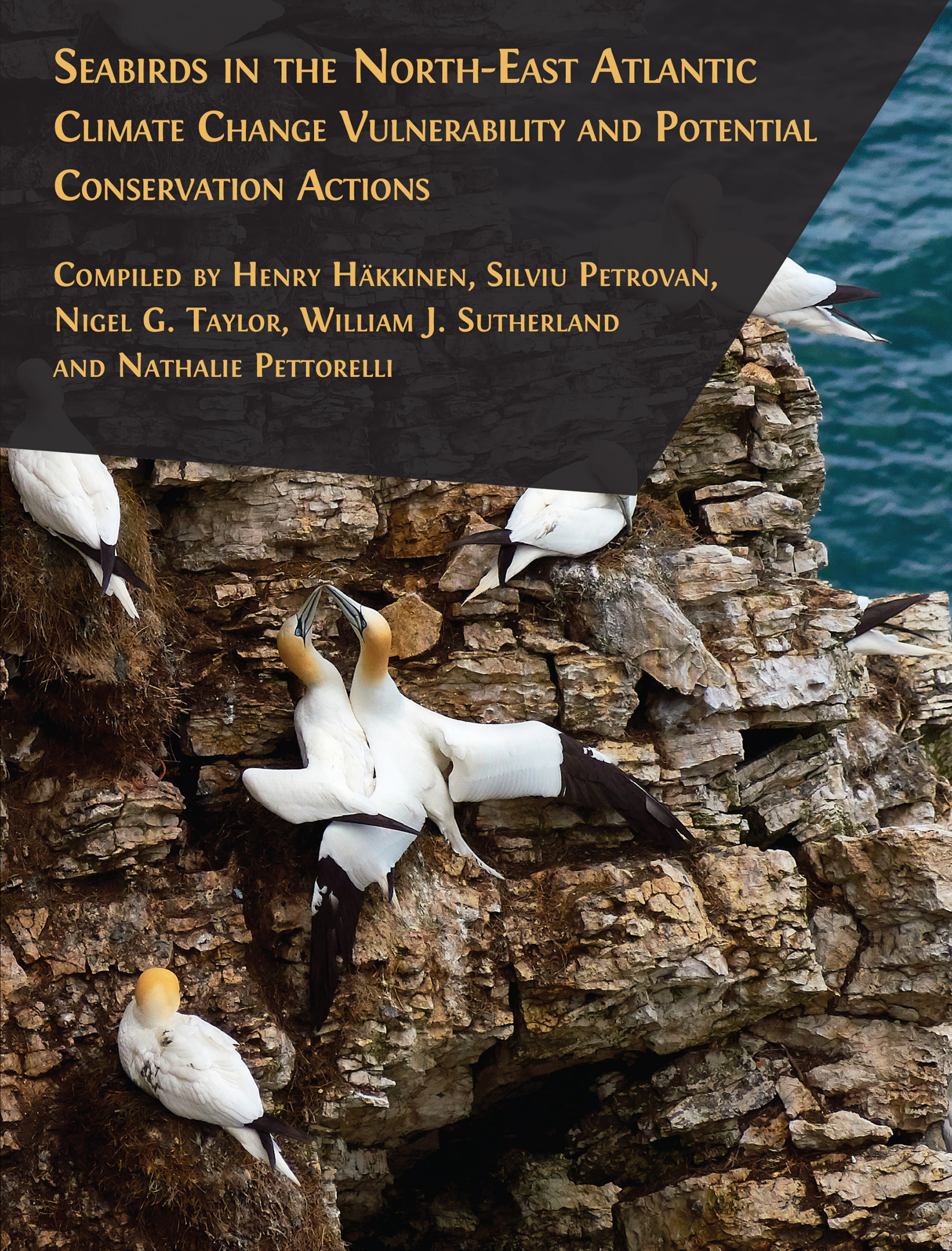
Seabirds in the North-East Atlantic
Climate Change Vulnerability and Potential Conservation Actions

Compiled by Henry Häkkinen, Silviu Petrovan,
Nigel G. Taylor, William J. Sutherland
and Nathalie Pettorelli



https://www.openbookpublishers.com

All external links were active at the time of publication unless otherwise stated and have been archived via the Internet Archive Wayback Machine at https://archive.org/web

Digital material and resources associated with this volume are available at https://doi.org/10.11647/OBP.0343#resources

ISBN Paperback: 978-1-80511-011-8
ISBN Hardback: 978-1-80511-012-5
ISBN Digital (PDF): 978-1-80511-013-2
DOI: 10.11647/OBP.0343

Cover image by Seppo Häkkinen (2023)
Cover design by Jeevanjot Kaur Nagpal

© Image: Seppo Häkkinen

Gulls

(Laridae)

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

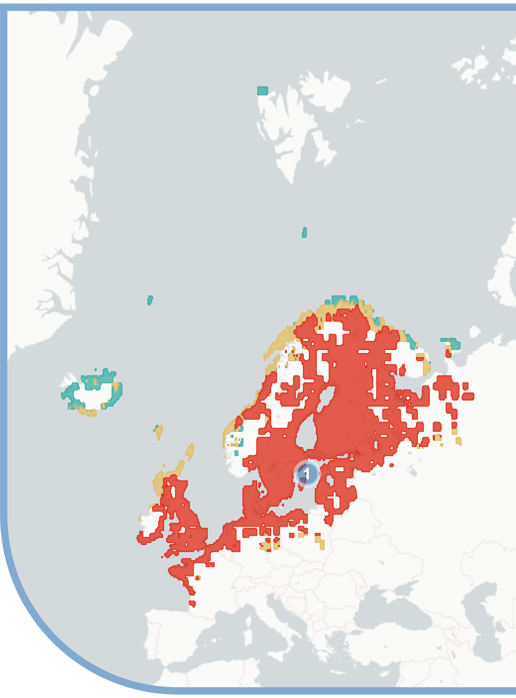
UNIVERSITY OF CAMBRIDGE

ZSL Institute of Zoology

https://doi.org/10.11647/OBP.0343.04

1 European Herring Gull

(*Larus argentatus*)



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 (84% of current range).

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

Current breeding area that is likely to become more suitable (5%).

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Changes in mercury cycling (due to increased sea temperatures) has led to increased exposure to mercury, with negative impacts on herring gull health.

1.1.3 Predicted changes in key prey species:

No key prey assessment was carried out for this species.

1.1.4 Climate change impacts outside of Europe

- Increased flooding due to sea level rise has led to the reduction or destruction of several populations in the US.

1.2 Sensitivity

- Herring gulls often nest in low-lying or exposed areas, which makes them vulnerable to storms and flooding. More frequent extreme storms or flooding during the breeding season could have severe effects on populations.
- During heatwaves, herring gulls' eggs and chicks have been observed suffering high stress and mortality. The overall impact of this on the population is unknown, but it appears herring gulls, especially in exposed areas, are vulnerable to heatwaves and increased frequency and intensity is likely to lower breeding success.
- 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

- Extremely variable diet, and able to exploit many available food sources. This is likely to make herring gulls more resilient to climate change, but note that many individual populations are specialised and are highly reliant on one or a few sources of food (e.g. human discards). Plasticity is therefore likely to vary across populations.
- Herring gulls are also adept at using urban environments which may buffer populations if natural diet or habitat is limited.
- Under the right circumstances, herring gulls can establish new colonies. While they tend to have some site fidelity (especially adults), they have been observed to colonise new areas over time if new areas are particularly high-quality or if previous area is disturbed.

2 Audouin's Gull *(Larus audouinii)*

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 (68% of current range).

Current breeding area that is likely to remain suitable (32%).

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 impacts of climate change on this species.

1.1.3 Predicted changes in key prey species:

1 Key prey species are likely to decline in abundance on the south coast of Portugal.

1.2 Sensitivity

- The majority of the population is concentrated at relatively few breeding sites. This makes the European population as a whole vulnerable to change, including from climate change.
- Audouin's gulls are highly susceptible to other threats, in particular bycatch and predator disturbance. The species is currently sharply declining most likely due to changes in fishing discard practice and high predation rates. Any

additional pressure from climate change is likely to exacerbate these declines.

- The species is highly sensitive to changes in food availability. There can be rapid population growth in years of prey abundance, but rapid declines can occur in poor years. If climate change contributes to declines in key prey species, then gull populations are likely to be heavily impacted.
- Audouin's gulls frequently nest in low-lying or exposed areas (e.g. salt pans), which makes them vulnerable to storms and flooding. More frequent extreme storms or flooding during the breeding season could have severe effects on populations.

1.3 Adaptive capacity

- Following changes in fishing practice and other conservation measures, this previously endangered species recovered and expanded significantly. It appears to be able to grow in number and colonise new areas when conditions are suitable, indicating high dispersal ability.

© Silviu Petrovan

3 Caspian Gull *(Larus cachinnans)*

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 assessment was carried out for this species.

1.2 Sensitivity

- 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

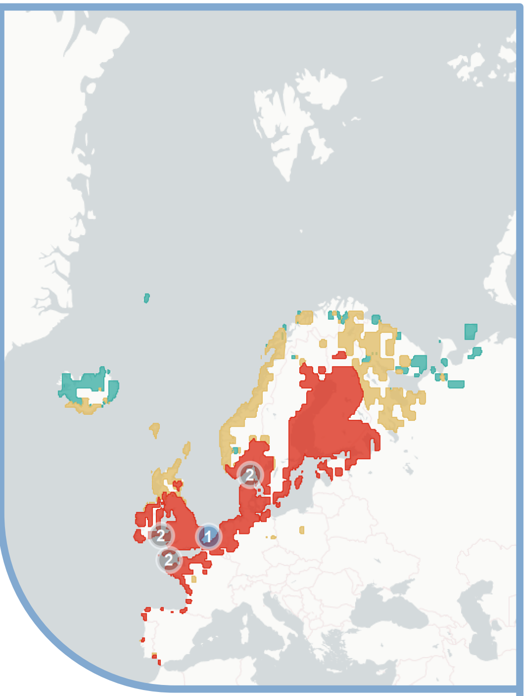
- Caspian gulls have a varied diet and are likely able to prey switch. Change, or loss, of prey species due to climate change is unlikely to have wide-spread impact.
- Caspian gulls have recently expanded their range into several new areas of Europe and the species seems able to disperse and exploit suitable habitat effectively.

Herring gull chick © Silviu Petrovan

4 Lesser Black-backed Gull

(*Larus fuscus*)

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 (61% of current range).

Current breeding area that is likely to remain suitable (27%).

Current breeding area that is likely to become more suitable (12%).

1.1.2 Current impacts attributed to climate change:

1 **Positive Impact:** Positive Impact: Increased prey availability during the breeding season has led to population growth.

1.1.3 Predicted changes in key prey species:

2 Key prey species are likely to decline in abundance on the south coast of Norway, the southern Irish Sea and along the Brittany Coast.

1.2 Sensitivity

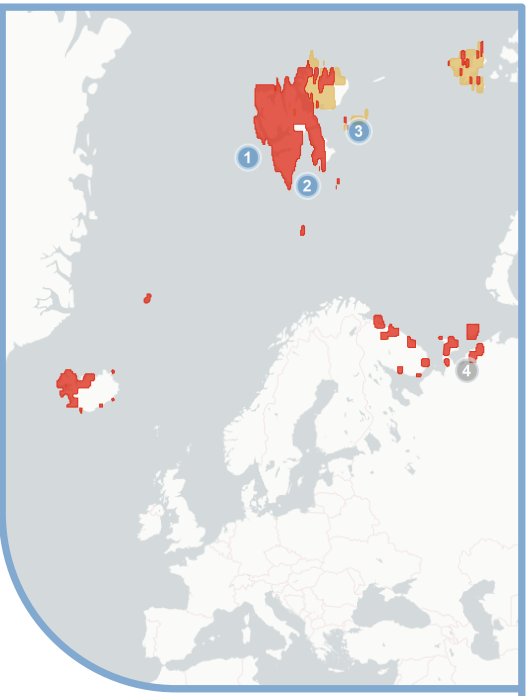
- Lesser black-backed gulls typically nest in low-lying or exposed areas, which makes them vulnerable to storms and flooding. More frequent extreme storms or flooding during the breeding season could have severe effects on populations.

- During heatwaves, lesser black-backed gull eggs and chicks have been observed suffering high stress and mortality. The overall impact of this on the population is unknown, but it appears gulls, especially in exposed areas, are vulnerable to heatwaves and increased frequency and intensity is likely to lower breeding success.
- 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

- Extremely variable diet, and able to exploit many available food sources. This is likely to make lesser black-backed gulls more resilient to climate change, but note that many individual populations are specialised and are highly reliant on one or a few sources of food (e.g. human discards). In particular, the subspecies *Larus fuscus fuscus* in the Baltic are heavily reliant on spawning herring during the breeding season. Plasticity is therefore likely to vary across populations.
- Lesser black-backed gulls are also adept at using urban environments which may buffer populations if natural diet or habitat is limited.
- Under the right circumstances, lesser black-backed gulls can establish new colonies. While they tend to have some site fidelity (especially adults), they have been observed to colonise new areas over time if they are particularly high-quality or if previous area is disturbed.

5 Glaucous Gull (*Larus hyperboreus*)



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 (77% of current range).

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

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

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** There has been increased predation by polar bears, most likely due to reduction in sea ice and therefore a lack of alternative prey. In some years this has severely affected breeding success.

2 **Negative Impact:** Climate change is likely contributing to higher concentrations of contaminants ingested by glaucous gulls. The overall effect on the population is unknown, but presumably negative.

3 **Negative Impact:** Climate change has contributed to a range shift in several helminth parasites, which has led to glaucous gulls being exposed to novel parasites, as well as increased parasite load. Effect on population is unknown, but presumably negative.

1.1.3 Predicted changes in key prey species:

4 Key prey species are likely to decline in abundance along the Kanin Peninsula and southern Barents Sea.

1.1.4 Climate change impacts outside of Europe

- Glaucous gull colonies display higher rates of cannibalism and lower breeding success in response to higher sea temperatures. This is presumably due to lack of marine prey, and is likely to be exacerbated with further climate change.

1.2 Sensitivity

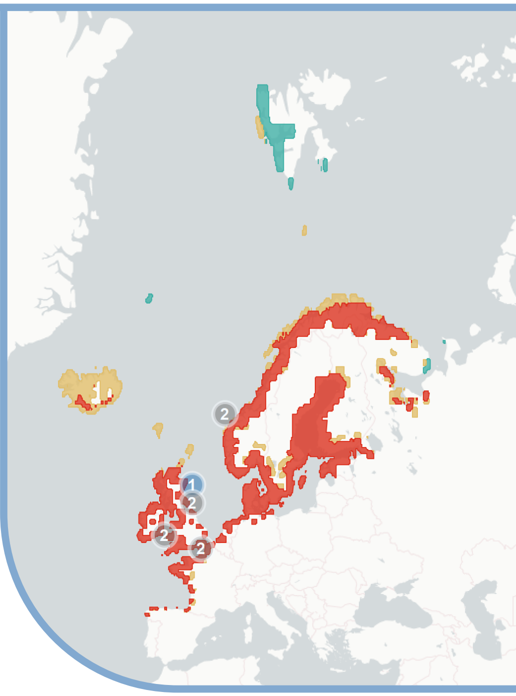
- Chicks are susceptible to weather-related mortality, especially if severe wet weather occurs during hatching and first week post-hatch. Changes, especially an increase, in precipitation during key breeding periods may have large impacts on chick survival.
- Glaucous gulls have high accumulation of POP compounds, and current modelling suggests potential exacerbation of POPs and mercury in marine food webs due to climate change (i.e., increasing temperatures). Currently no negative impacts have been observed, but higher levels of bioaccummulation in the future is a potential risk to gull health.
- Avian flu has been recently recorded in some populations of glaucous gulls; warmer weather in the future may contribute to outbreaks.
- Competing species, such as herring gulls, are shifting their ranges north, in part in relation to climate change. This may lead to competition in the future if ranges overlap.

1.3 Adaptive capacity

- Very diverse diet, consisting of fish, marine invertebrates, bird eggs and young, small birds and mammals, carrion, refuse, seaweed, berries. Loss of one food source is unlikely to have a major impact on most populations.

6 Great Black-backed Gull

(*Larus marinus*)



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 (26%).

Current breeding area that is likely to become more suitable (4%).

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Higher sea temperatures correlate with lower breeding success. Mechanism unknown, but likely mediated through prey availability.

1.1.3 Predicted changes in key prey species:

2 Key prey species are likely to decline in abundance in the Irish Sea, as well as along the Norwegian coast, southern coast of the UK and the Brittany Coast.

1.2 Sensitivity

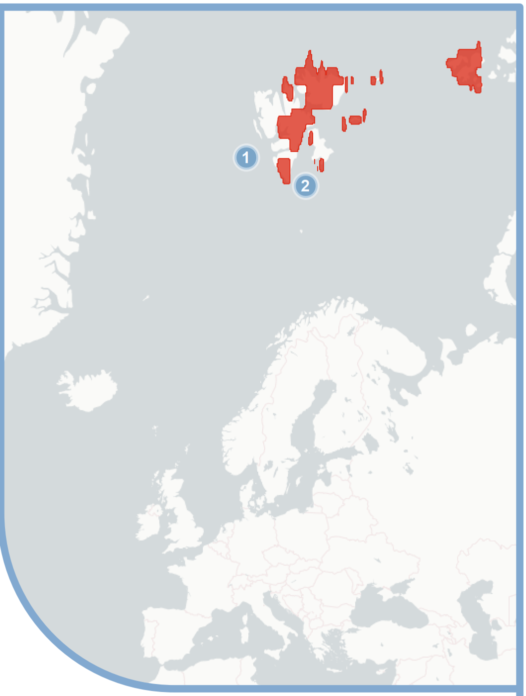
- Great black-backed gulls are declining in areas of the eastern Atlantic, likely due to reductions in fishing discards. Any additional impacts, such as from climate change, are likely to exacerbate this decline.
- This species has a long generation length (>10 years), which may slow recovery from severe impacts and increases population extinction risk.

1.3 Adaptive capacity

- Extremely variable diet, and able to exploit many available food sources. This is likely to make great black-backed gulls more resilient to climate change, but note that many individual populations are specialised and are highly reliant on one or a few sources of food (e.g. human discards). Plasticity is therefore likely to vary across populations.
- Great black-backed gulls have historically shown range expansions when pressures have been alleviated, there is evidence they can colonise or re-colonise areas if they are particularly high-quality or if previous areas are disturbed.
- Great black-backed gulls occasionally use urban habitats and resources, which may buffer populations if natural diet or habitat is limited.

Herring gulls © Silviu Petrovan

7 Ivory Gull (*Pagophila eburnea*)



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:

1 **Negative Impact:** Ivory gulls are heavily reliant on sea ice for breeding and hunting, recent decreases in sea ice are leading to rapid changes in population size and range.

2 **Negative Impact:** As a secondary impact of sea ice loss, ivory gulls face more competition from other ivory gulls and from other species for resources.

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:

- Climate change is known to have several other impacts in other parts of the species range, in particular through changing winter food supplies, increasing competition with other marine birds, and increased predation due to increased access to previously isolated colonies.

1.2 Sensitivity

- Ivory gulls are highly dependent on sea ice; declines in population size and range have been linked in several areas to decreases in sea ice, particularly across the Canadian Arctic and Greenland.
- Ivory gulls breed in extremely remote colonies which limits disturbance risk, but also makes monitoring and any potential conservation actions difficult.
- Ivory gulls are sensitive to extreme climatic events; extreme heavy rainfall and windstorms have recently led to total breeding failures in Greenland. If climate change results in more extreme or more frequent extreme weather, this is likely to have severe impacts on ivory gull populations.
- 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

- Ivory gulls have a varied diet and are opportunistic feeders. The loss of one prey species is unlikely to have a major impact on the populations.
- There is high connectivity and gene flow among populations, suggesting that populations are genetically diverse and there is significant exchange between populations. This could increase resilience to climate change as adaptive variation and immigration/emigration are more likely.

8 Black-legged Kittiwake

(Rissa tridactyla)

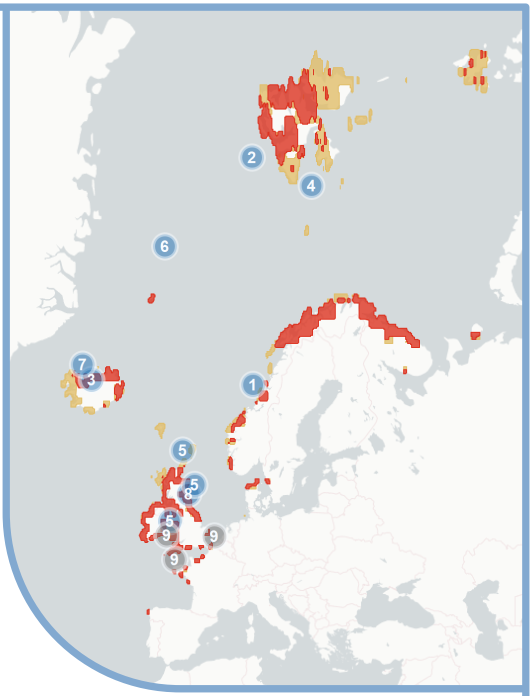
1.1 Evidence for exposure

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

Current breeding area that is likely to become less suitable (60% of current range).

Current breeding area that is likely to remain suitable (40%).

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



1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Decreased prey availability due to warmer seas has led to lower breeding success.

2 **Neutral Impact:** Kittiwake diet has changed significantly due to climate-change driven shift in prey assemblage. However, so far this has not resulted in any demonstrated change in breeding success.

3 **Neutral Impact:** Kittiwake populations have shifted their range in response to changes in distribution of key prey species.

4 **Neutral Impact:** Climate change has contributed to a range shift in several helminth parasites, which has led to kittiwakes being exposed to novel parasites, as well as increased parasite load. Effect on population is unknown, but most likely negative.

5 **Negative Impact:** Higher sea temperatures correlate with lower breeding success. Mechanism unknown, but potentially mediated through prey availability. Alternative theories suggest fishery pressure has been a large

contributing factor.

6 **Negative Impact:** Kittiwake colonies have declined during periods of rapid ocean warming. Mechanism unknown, but likely due to rapid changes in marine ecosystems and prey availability.

7 **Negative Impact:** Extreme storms during the non-breeding season have led to mass mortality of kittiwakes ('wrecks').

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

1.1.3 Predicted changes in key prey species:

9 Key prey species are likely to decline in abundance in the Irish Sea, throughout the English Channel and along the Brittany Coast.

1.1.4 Climate change impacts outside of Europe

- Recent heatwaves in the North Pacific have resulted in mass mortality and wide-spread breeding failure at kittiwake colonies.

1.2 Sensitivity

- There appears to be strong variation in regional responses to climate change. The impacts of climate change on kittiwakes in Scotland have not been seen elsewhere in the UK. In addition, there is some debate on whether the drastic declines of kittiwake colonies in Scotland were primarily due to climate change or fisheries. The sensitivity of different populations to climate change is likely to vary.
- Large kittiwake colonies in the north Atlantic are supported indirectly by copepods (as they form the basis of the marine food chain). Projections of copepod abundance suggest they will range shift north, with large impacts on seabird colonies.
- Many kittiwake colonies are dependent on the timing of availability of key prey species, such as sandeels. Key prey species such as sandeels are known to be sensitive to warming temperatures, which may result in a phenological mismatch.
- Kittiwakes forage at or near the sea surface. If climate change results in more frequent or prolonged storms or prey moving into deeper water, it is likely to have significant impacts on kittiwake foraging.

1.3 Adaptive capacity

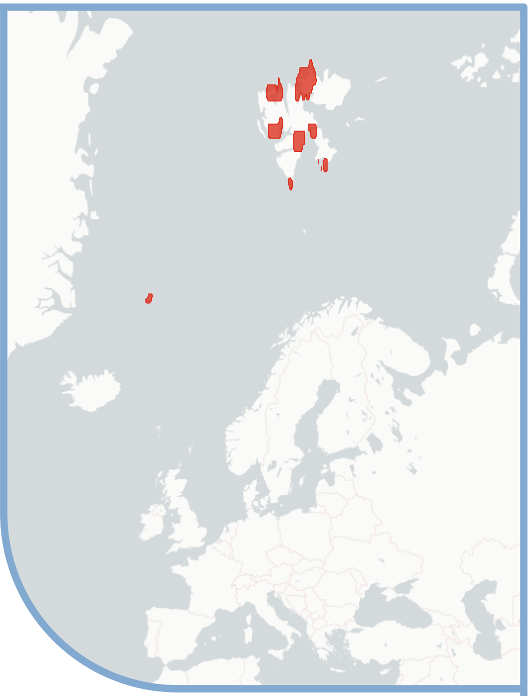
- There is some tentative evidence that kittiwakes can adaptively change their phenology based on studies in Svalbard. Populations in Scotland have also changed their laying date, possibly related to conditions in breeding and non-breeding areas.
- Under the right circumstances, kittiwakes can establish new colonies. While they tend to have some site fidelity (especially adults), they have been observed to colonise new areas over time if they are particularly high-quality or if previous area is disturbed.
- Kittiwakes occasionally use urban habitats and resources, especially where artificial nesting habitat is available, which may buffer populations if natural diet or habitat is limited.

© Silviu Petrovan

(This page and overleaf): Black-legged kittiwakes

9 Sabine's Gull *(Xema sabini)*

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:

No key prey assessment was carried out for this species.

1.2 Sensitivity

- As a high-Arctic species, it is likely that Sabine's gull is sensitive to climate change as the Arctic is currently undergoing rapid climate and ecological change. However no impacts have been observed so far.
- There are generally few assessments of individual populations or their relative status, so impacts may not be recorded.
- There is evidence that annual survival is affected by extreme climatic events

in its tropical, non-breeding range; these may become more frequent with climate change.

- Sabine's gulls typically nest in low-lying, flooded areas, often very close to the high-tide line, which makes them vulnerable to storms and flooding. More frequent extreme storms or flooding during the breeding season could have severe effects on populations.

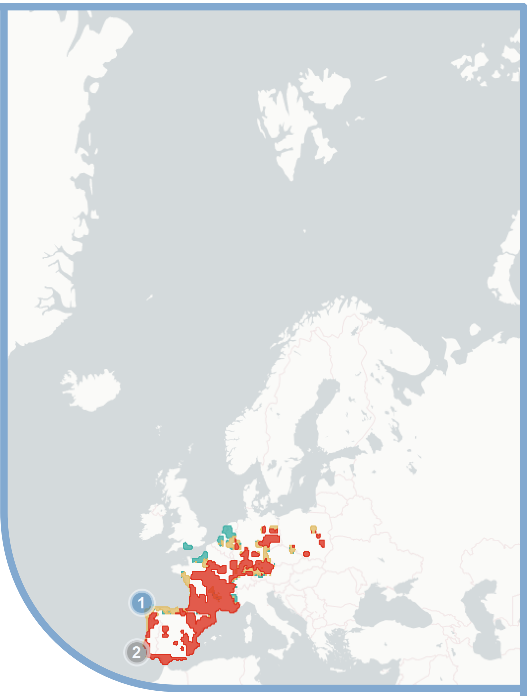
1.3 Adaptive capacity

- Populations of Sabine's gull overlap and meet during the non-breeding season (low migratory connectivity). Because of this, immigration is more likely to buffer climate change impacts, and higher genetic diversity of populations means adaptive response to climate change is more likely.

Black-legged kittiwake © Silviu Petrovan

10 Yellow-legged Gull

(*Larus michahellis*)



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 (65% of current range).

Current breeding area that is likely to remain suitable (21%).

Current breeding area that is likely to become more suitable (14%).

1.1.2 Current impacts attributed to climate change:

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

1.1.3 Predicted changes in key prey species:

2 Key prey species are likely to decline in abundance on the south coast of Portugal.

1.2 Sensitivity

- 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

- Very varied and opportunistic diet, including fish, invertebrates, mammals, refuse and offal, bird eggs and chicks. Yellow-legged gulls have been observed to change their primary prey species if one source becomes unavailable.
- Under the right circumstances, yellow-legged gulls can establish new colonies. While they tend to have some site fidelity (especially adults), they have been observed to colonise new areas over time if they are particularly high-quality or if previous area is disturbed.

Herring gulls © Silviu Petrovan

Potential actions in response to climate change: Gulls (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: Increase in competition

Summary:
Local actions to prevent or mitigate the effects of competition are not well understood, and their effectiveness is unclear. In many contexts they are likely to be difficult or impossible to carry out on large populations. Supporting populations more generally (increasing adult survival, limiting chick mortality) may be a more appropriate strategy.

Intervention	Evidence of Effectiveness	R	S	T
Protect nest sites from competitors	Rarely trialled in seabirds, some benefits found in other non-seabird groups. Likely to be difficult due to large, cosmopolitan nature of many colonies; may be possible for species with spread-out, discrete nest-sites.	1	3	2
Reduce competition by removing competitor species	Trialled mostly on terns, but unclear if it is effective or not. Very scarce evidence for gulls, it has been trialled but the overall effectiveness is unclear. More research needed if this action is to be considered as a viable action.	3	3	3

Use supplementary feeding to reduce competition	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds.	NA	NA	NA

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:

Protect nest sites from competitors
Relevance (R): 0 studies in the evidence base focus on gulls, 2 on other seabirds and 5 on other birds. **Strength (S):** The evidence base was comprised of 7 studies. Of these 5 were considered to have a good sample size, and 2 had a clear metric for effectiveness. **Transparency (T):** 6 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 4 justified their rationale.

Reduce competition by removing competitor species
Relevance (R): 1 study in the evidence base focusses on gulls, 11 on other seabirds and 0 on other birds. **Strength (S):** The evidence base was comprised of 12 studies. Of these 10 were considered to have a good sample size, and 5 had a clear metric for effectiveness. **Transparency (T):** 12 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 8 had a published methodology, and 7 justified their rationale.

2 Impact: Increase in mammal predation

Summary:
Invasive mammals are a major threat to many seabird populations, and as such there is a well-established literature on mammal exclusion, management and eradication detailing effective methods and case studies. However, there are more limited options when the mammalian predator in question is itself a conservation target, or is not easily managed. Nevertheless, for many situations there are several, well-researched, actions available that can benefit seabird populations effectively.

Intervention	Evidence of Effectiveness	R	S	T
Manage/ eradicate mammalian predators	Strong evidence that predator management can assist seabird populations if under heavy predation pressure, and if carried out effectively. Several successful examples in gulls.	3	5	3
Physically protect nests with barriers or enclosures	Trialled extensively on many seabird groups, mostly with success, though depends on the species and the design of the barrier. Some trials on gulls, in particular on Audouin's gull, have shown benefits and lowered predation.	3	4	4
Reduce predation by translocating predators	Few trials on seabirds, and none for gulls. Existing evidence suggests this action can be beneficial and reduce egg/chick predation, and could be a possible action if other forms of predator management are not viable.	2	4	3
Repel predators with acoustic, chemical or visual deterrents	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds.	NA	NA	NA
Use supplementary feeding to reduce predation	Very few trials on seabirds, and none on gulls. No studies have shown this action is effective.	NA	NA	NA

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:

Manage/eradicate mammalian predators

Relevance (R): 2 studies in the evidence base focus on gulls, 43 on other seabirds and 4 on other birds. **Strength (S):** The evidence base was comprised of 52 studies. Of these 44 were considered to have a good sample size, and 34 had a clear metric for effectiveness. **Transparency (T):** 52 studies included were published and peer-reviewed, of which 5 were literature reviews or meta-analyses, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 24 had a published methodology, and 28 justified their rationale.

Physically protect nests with barriers or enclosures

Relevance (R): 3 studies in the evidence base focus on gulls, 9 on other seabirds and 6 on other birds. **Strength (S):** The evidence base was comprised of 18 studies. Of these 16 were considered to have a good sample size, and 12 had a clear metric for effectiveness. **Transparency (T):** 17 studies included were published and peer-reviewed, 0 were from the grey literature, and 0 were anecdotal. Of the studies included, 11 had a published methodology, and 12 justified their rationale.

Reduce predation by translocating predators

Relevance (R): 0 studies in the evidence base focus on gulls, 2 on other seabirds and 2 on other birds. **Strength (S):** The evidence base was comprised of 4 studies. Of these 4 were considered to have a good sample size, and 3 had a clear metric for effectiveness. **Transparency (T):** 4 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 3 justified their rationale.

Use supplementary feeding to reduce predation

Relevance (R): 0 studies in the evidence base focus on gulls, 1 on other seabirds and 3 on other birds. **Strength (S):** The evidence base was comprised of 4 studies. Of these 4 were considered to have a good sample size, and 4 had a clear metric for effectiveness. **Transparency (T):** 4 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 4 justified their rationale.

3 Impact: Increased exposure to pollution and heavy metals

Summary:
The effects of pollution and heavy metals are known to have serious consequences for gulls, but despite this there are no current actions that are well-researched. It is likely prevention is more effective than treatment, so the most effective action in many cases is to deter gulls (if possible) from using a heavily polluted area.

Intervention	Evidence of Effectiveness	R	S	T
Alter habitat to encourage birds to leave an area	Very limited evidence for seabirds, and none for gulls. Several successful examples of this action in terns, but more research needed before this is considered as a viable option for gulls.	2	2	3
Reduce exposure to pollutants	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds.	NA	NA	NA
Treat sick or injured birds affected by pollution/ heavy metals	This is a hypothetical action. We found no published studies assessing this action's effectiveness for seabirds (and did not include evidence regarding treatment following oil spills). Likely to be resource intensive.	NA	NA	NA

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 gulls, 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.

4 Impact: Reduced area of breeding or foraging habitat

Summary:
On a local scale, providing artificial nesting sites can be an effective method of counteracting this impact, though there are relatively few trials on gulls. Outside of this, if lack of habitat 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 gulls. Several trials of this action have been successful and encouraged terns to shift breeding sites. However, this action is likely more viable for species with lower site fidelity and areas with other available breeding habitat nearby.	2	2	3
Make new colonies more attractive to encourage birds to colonise	Several different methods have been trialled extensively across other seabirds, with variable success depending on method and species. No evidence currently available for gulls, the effectiveness of decoys, acoustic cues, smells and improved habitat is currently unknown.	2	4	3
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 kittiwake populations, for other gull species results have been mixed but several species have benefited from artificial nesting sites.	3	5	3
Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but evidence for gulls is limited. Several failed attempts have been recorded, and to our knowledge no successful translocations of gulls have been carried out.	3	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 gulls, 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.

Make new colonies more attractive to encourage birds to colonise
Relevance (R): 0 studies in the evidence base focus on gulls, 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 artificial nesting sites
Relevance (R): 1 study in the evidence base focusses on gulls, 51 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.

Translocate the population to a more suitable breeding area
Relevance (R): 1 study in the evidence base focusses on gulls, 14 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.

5 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. Many gull species have been successfully hand-reared and bred, but typically in small numbers. Likely to be difficult for many species, especially those that breed in coastal, inaccessible habitats.	3	2	1
Make new colonies more attractive to encourage birds to colonise	Several different methods have been trialled extensively across other seabirds, with variable success depending on method and species. No evidence currently available for gulls, the effectiveness of decoys, acoustic cues, smells and improved habitat is currently unknown.	2	4	3
Provide supplementary food during the breeding season	Trialled on many seabird species. Known to be beneficial for several gull species, but success varies. Many gulls will scavenge any available food source, so it is feasible to provide supplementary food. However, as many gull populations are already reliant on discards, there are ethical concerns regarding wide-spread use of supplemental feeding to support populations.	2	4	3

Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but evidence for gulls is limited. Several failed attempts have been recorded, and to our knowledge no successful translocations of gulls have been carried out.	3	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): 2 studies in the evidence base focus on gulls, 38 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 gulls, 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 supplementary food during the breeding season
Relevance (R): 4 studies in the evidence base focus on gulls, 12 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): 1 study in the evidence base focusses on gulls, 14 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.

6 Impact: Increased parasite load

Summary:
Treatment and prevention options are available for some parasites, but they are generally rarely trialled on seabirds, and the bulk of available knowledge is based on non-seabird species. Careful consideration and planning is needed before embarking on mass-treatment of seabird populations, to avoid unintended negative consequences.

Intervention	Evidence of Effectiveness	R	S	T
Inoculation or treatment against disease and parasites	Extensive literature exists for treatment of birds in general, but limited examples for seabirds and none for gulls. Many treatment and prevention options are available, but those that have been trialled have limited success, or even cause more harm than benefits, in wild seabird populations. The advisability of this action likely depends on the species and context in question. Endoparasite treatment in seabirds is particularly under-researched.	1	5	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.

Inoculation or treatment against disease and parasites
Relevance (R): 0 studies in the evidence base focus on gulls, 5 on other seabirds and 29 on other birds. **Strength (S):** The evidence base was comprised of 34 studies. Of these 25 were considered to have a good sample size, and 22 had a

clear metric for effectiveness. **Transparency (T):** 34 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, 21 had a published methodology, and 26 justified their rationale.

7 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 gulls. Several trials of this action have been successful and encouraged terns to shift breeding sites. However, this action is likely more viable for species with 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. Gulls have been successfully hand-reared, but only in very small numbers. Likely to be difficult for many species, especially those that breed in steep, inaccessible habitats.	3	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 different methods have been trialled extensively across other seabirds, with variable success depending on method and species. No evidence currently available for gulls, the effectiveness of decoys, acoustic cues, smells and improved habitat is currently unknown.	2	4	3
Manually relocate nests	This has been reported by practitioners as an effective action to assist seabirds on low-lying beaches in the Baltic. However, to our knowledge there are no broad-scale studies or reviews of this action's effectiveness. The risk of disturbance is high, so is likely only an option as a last resort.	NA	NA	NA
Provide additional shelter or protection from extreme weather (flooding)	There are few trials on seabird species, most known examples are on terns, 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 gull 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 kittiwake populations; for other gull species results have been mixed but several species have benefited from artificial nesting sites.	3	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 gull species.	2	2	3

Translocate the population to a more suitable breeding area	Known to be beneficial in other seabird groups, but evidence for gulls is limited. Several failed attempts have been recorded, and to our knowledge no successful translocations of gulls have been carried out.	3	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 gulls, 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): 2 studies in the evidence base focus on gulls, 38 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 gulls, 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 gulls, 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): 1 study in the evidence base focusses on gulls, 51 on other seabirds and 1 on other birds. S**trength (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 gulls, 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): 1 study in the evidence base focusses on gulls, 14 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.

8 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. Known to be beneficial for several gull species, but success varies. Many gulls will scavenge any available food source, so it is feasible to provide supplementary food. However, as many gull populations are already reliant on discards, there are ethical concerns regarding wide-spread use of supplemental feeding to support 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. While possible, especially for species that remain near land, the same concerns apply as during the breeding season. Many gull populations are already reliant on discards, and there are ethical concerns regarding wide-spread use of supplemental feeding to support populations.	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. However, there are numerous successful reports of rehabilitation and release in various gull species from rescue centres. Likely a feasible action, at least at small numbers of individuals.	1	2	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.

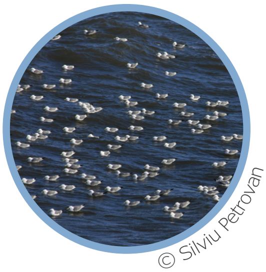
Details:

Provide supplementary food during the breeding season

Relevance (R): 4 studies in the evidence base focus on gulls, 12 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): 0 studies in the evidence base focus on gulls, 3 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.


© Silviu Petrovan