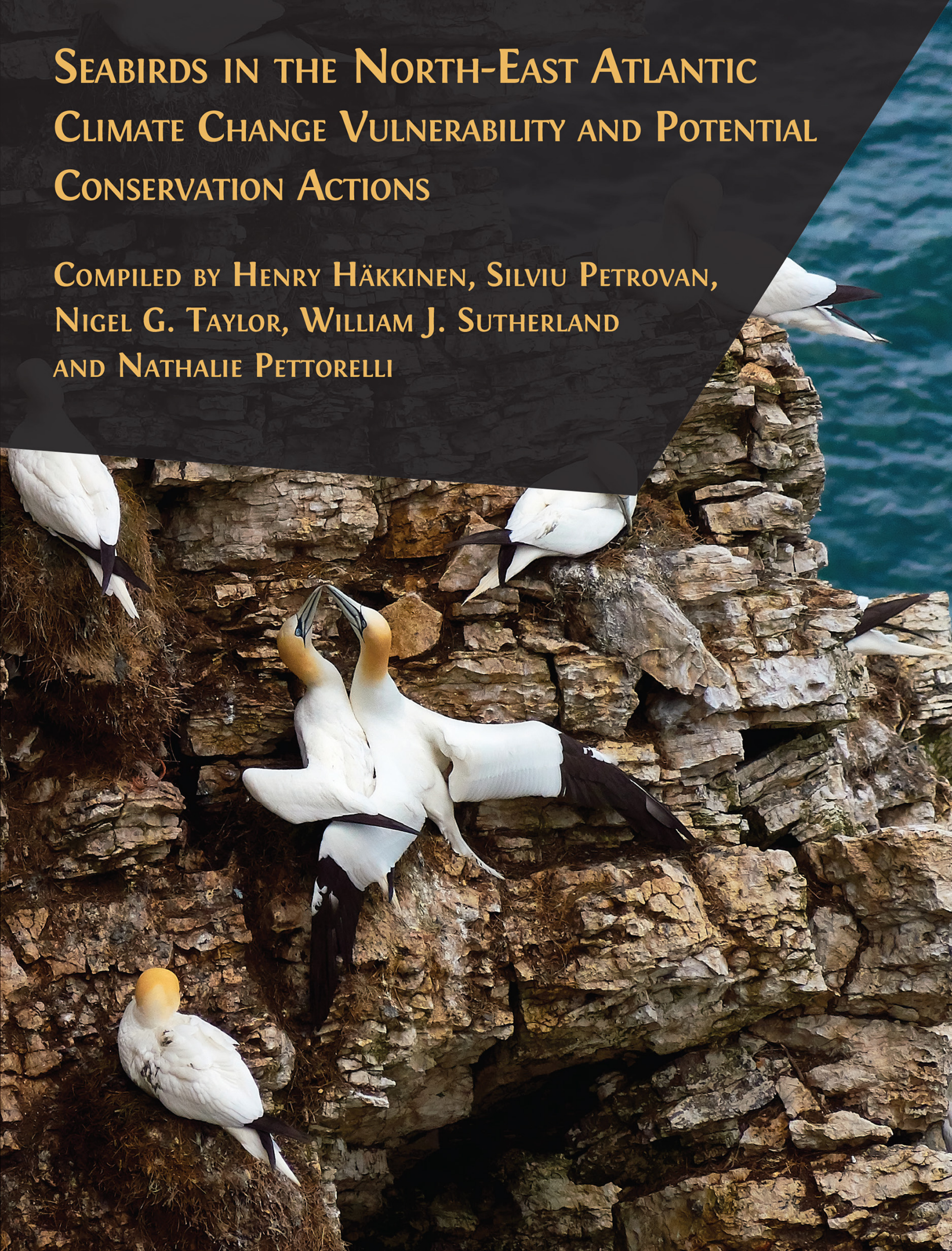
Seabirds in the North-East Atlantic
Climate Change Vulnerability and Potential Conservation Actions

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

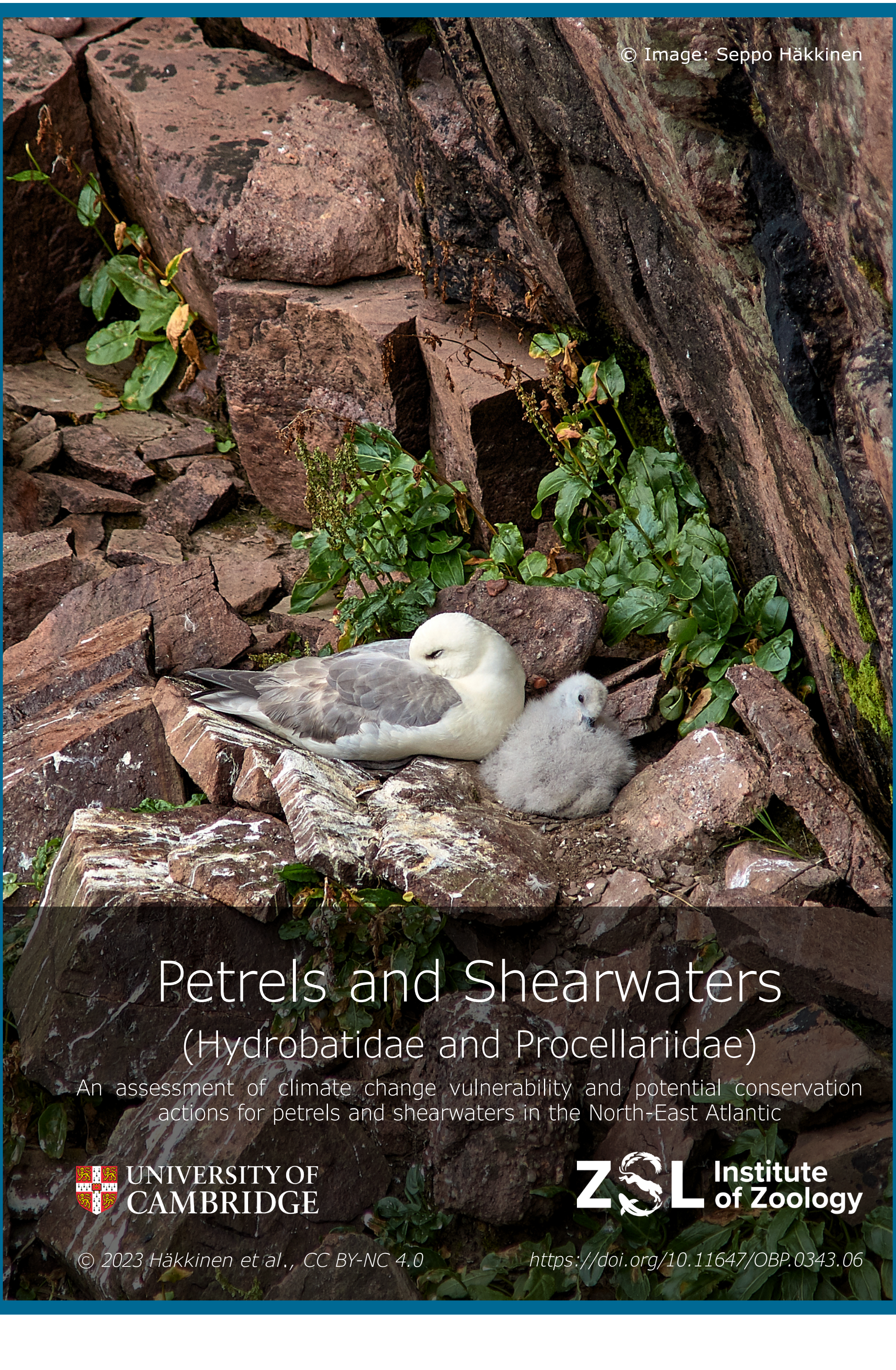


https://www.openbookpublishers.com

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

Petrels and Shearwaters

(Hydrobatidae and Procellariidae)

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

UNIVERSITY OF CAMBRIDGE

ZSL Institute of Zoology

https://doi.org/10.11647/OBP.0343.06

1 Cory's Shearwater

(*Calonectris borealis*)

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 **Neutral Impact:** New colonies have been established outside of the species' normal range. The cause is uncertain, but likely related to prey range shifts and warming conditions.

1.1.3 Predicted changes in key prey species:

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

1.2 Sensitivity

- Cory's shearwaters can suffer mass-mortalities, especially following extreme storms or hurricanes in tropical parts of their range. Changes in how and where hurricanes occur could have significant impacts on shearwaters.
- Extreme positive and negative NAO indices drastically impact adult foraging

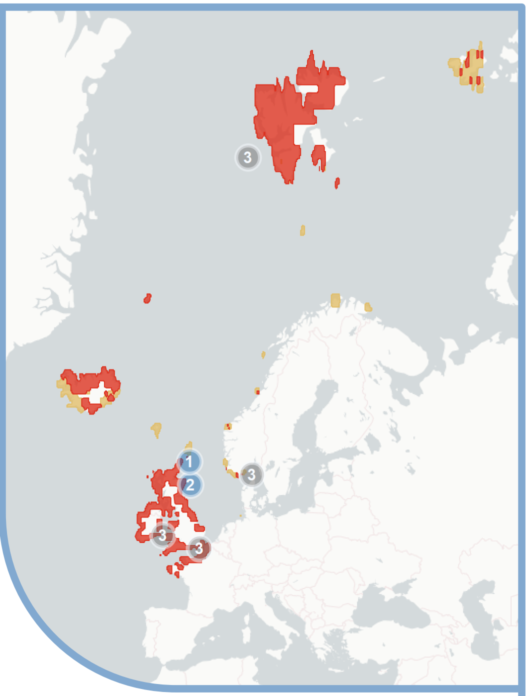
patterns, adult condition, and chick condition, very likely because of changes in prey availability. Extreme fluctuations are likely to become more common in the future, and therefore may heavily impact shearwater breeding populations.

- Cory's shearwaters rely on wind conditions to soar and use as little energy as possible. Changes in wind strength, direction and patterns could heavily impact energy use and migration paths.
- Cory's shearwaters have high breeding synchrony; the majority of birds in a population will lay their eggs in a short period of time. If temporal shifts in key prey availability occur it could have a significant impact on breeding 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

- Analysis of laying dates has shown that, regardless of sea temperatures and weather conditions, there is little variance in Cory's shearwater phenology. It is unlikely they will adapt their laying date to changing conditions.
- Cory's shearwater shows little plasticity in choosing nesting sites, and can even choose maladaptively in the presence of predators. Although it recently has established in northern Spain, this is believed to be a rare event. High site fidelity means it is unlikely to change sites as a response to climate change.
- Cory's shearwater change their foraging strategy and prey species based on prey availability. This, combined with a relatively flexible diet, is likely to make them more resilient to climate change.

2 Northern Fulmar (*Fulmarus glacialis*)



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 (80% of current range).

Current breeding area that is likely to remain suitable (20%).

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

1.1.2 Current impacts attributed to climate change:

1 **Neutral Impact:** Warmer winters have resulted in lower adult survival and lower reproductive success in the following year. Mechanism uncertain, but could be related to marine productivity or to frequency and severity of storms.

2 **Negative Impact:** Higher sea temperatures typically correlate with lower breeding success. Mechanism unknown, but likely mediated through prey availability. Continued warming may cause long-term declines in populations.

1.1.3 Predicted changes in key prey species:

3 Key prey species are likely to decline in abundance in the Irish Sea, the English Channel, the southern coast of Norway and along the Brittany coast.

1.2 Sensitivity

- Fulmars are prone to wrecks across their range. Previous wrecks have been attributed to a combination of sustained high winds, unusually warm waters, and reduced food availability, all of which are more likely to occur more frequently due to climate change.
- Fulmars rely on wind conditions to soar and use as little energy as possible. Changes in wind strength, direction and patterns could heavily impact energy use and migration paths.
- Storms are also known to have some negative effects on fulmar breeding success as they lead to more difficult foraging conditions and lower body condition. Changes in storm patterns may affect fulmar breeding success, as well as contribute to wrecks.
- This species has a long generation length (>10 years), which may slow recovery from severe impacts and increases population extinction risk.
- Fulmars have high breeding synchrony; the majority of birds in a population will lay their eggs in a short period of time. If temporal shifts in key prey availability occur it could have significant impacts on breeding population.

1.3 Adaptive capacity

- Atlantic population has expanded dramatically in range and number during last 200 years, likely driven by increase in fishery discards. Species readily colonises new areas if they are suitable, which is likely to help fulmars adapt to climate change.
- Juveniles very frequently disperse to other colonies, but once breeding the species has very high site fidelity. Although new colonies are formed readily, existing populations are very unlikely to relocate.
- Very variable diet, even within comparatively small area. Different populations prey on very different species, presumably in response to availability. This is likely to buffer impacts of climate change and changes in marine ecosystems.
- Fulmars frequently skip breeding in poor conditions; this may be adaptive in response to climate change as it allows adults to maximise condition for good breeding years.
- Fulmars have shifted their migration timing and laying date in some populations; this may be related to conditions in breeding and non-breeding areas but the underlying reasons are currently unknown.

3 Band-rumped Storm-petrel

(*Hydrobates castro*)

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 species are predicted to decline for this species.

1.2 Sensitivity

- Species is declining in many areas; range was likely much larger historically but has been greatly reduced by introduced predators. Any additional pressure from climate change is likely to accelerate these declines
- Band-rumped storm-petrels rely on wind conditions to soar and use as little energy as possible. Changes in wind strength, direction and patterns could

heavily impact energy use and migration paths.

- Band-rumped storm-petrels have high breeding synchrony; the majority of birds in a population will lay their eggs in a short period of time. If temporal shifts in key prey availability occur it could have significant impacts on breeding 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

- Species has very high fidelity to breeding areas, and even to individual burrows. Unlikely to disperse and colonise new areas readily in response to climate change.
- There is very limited mixing between populations in storm-petrels. This can be adaptive (as it increases likelihood of local adaptation) or non-adaptive (as immigration to support populations is unlikely).

Northern fulmar chick © Seppo Häkkinen

4 Leach's Storm-petrel

(*Hydrobates leucorhous*)

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 (24%).

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

- Leach's storm-petrels in North America have changed their prey species and foraging strategy in response to shifts in the marine ecosystem partially driven by climate change.
- Heatwaves in North America have impacted storm-petrel colonies and resulted in changes in diet, loss of condition and wrecks.
- Leach's storm-petrel reproductive success has been linked to global temperature. Warmer temperatures result in higher reproductive success, up until a certain threshold after which it decreases. The mechanism is unknown.

1.2 Sensitivity

- Species has a large population and large range but is rapidly declining across its range. The exact cause is not certain, but there are likely a number of factors, including bycatch, avian and mammal predation, pollution and disturbance. Any additional pressure from climate change is likely to accelerate these declines.
- Known to wreck in great numbers in various parts of its range, especially when strong prolonged off-shore winds occur, which can blow petrels far from their usual migration route. Changes in wind and storm patterns could potentially have significant impacts.
- High temperatures in other parts of the species' range, especially heat-waves, are associated with lower prey availability, loss of condition, lower reproductive output and sometimes with die-offs. An increase in temperature or heatwaves is likely to have a significant impact on breeding colonies.
- Leach's storm-petrels rely on wind conditions to soar and use as little energy as possible. Changes in wind strength, direction and patterns could heavily impact energy use and migration paths.
- 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

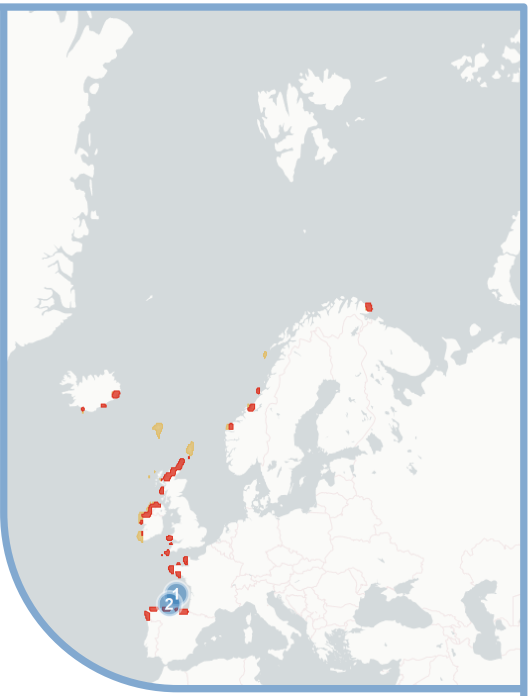
- Leach's storm-petrel has a flexible migration strategy, and changes its migration route, stop-overs and wintering areas based on conditions. Local changes to migration routes are unlikely to have a major impact.
- Leach's storm-petrel is known to change prey species and foraging areas in response to changes in conditions. They have a very large foraging range and local changes in climate are therefore less likely to have a large impact.
- Analysis of laying dates has shown that, regardless of SST and weather conditions, there is little variance in shearwater phenology. It is unlikely they will adapt their laying date to changing conditions.
- Species has very high fidelity to breeding areas. Unlikely to disperse and colonise new areas readily.
- There is very limited mixing between populations in storm-petrels. This can be adaptive (as it increases likelihood of local adaptation) or non-adaptive (as immigration to support populations is unlikely).

5 European Storm-petrel

(*Hydrobates pelagicus*)

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 (28%).

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

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** High winds and storms in the non-breeding season cause increased mortality, lower body condition, and reduced breeding success. While individual extreme climate events are difficult to attribute to climate change, it is likely that climate change is driving an increase in their frequency and/or intensity.

2 **Neutral Impact:** A shift towards warmer, drier and calmer conditions has resulted in lower storm-petrel abundance. The mechanism is unknown, but likely related to changes in marine ecosystem and key prey availability.

1.1.3 Predicted changes in key prey species:

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

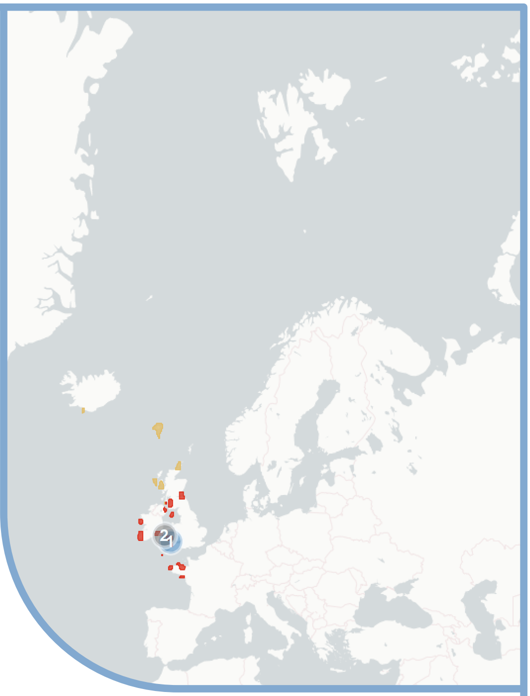
1.2 Sensitivity

- Studies in other parts of this species' range have found it is sensitive to high rainfall and low temperatures, which causes high chick mortality. If climate change causes periods of low temperatures and higher rainfall during the breeding season, this may heavily impact juvenile survival.
- Mortality of breeding storm-petrels is significantly increased during summers with a high incidence of heavy storms, as they create difficult foraging conditions and lower body condition. Projected increase in the frequency of storms may therefore heavily impact storm-petrel populations.
- European storm-petrels rely on wind patterns to fly and navigate; at high wind speeds storm-petrels are vulnerable to being storm-driven. Higher incidence of extreme wind events is likely to have significant impacts on foraging ability and marine distribution.
- This species has a long generation length (>10 years), which may slow recovery from severe impacts and increase population extinction risk.

1.3 Adaptive capacity

- Analysis of laying dates has shown that, regardless of sea temperatures and weather conditions, there is little variance in storm-petrel phenology. It is unlikely they will adapt their laying date to changing conditions, which could make them vulnerable to climate change. However, additional evidence has found that changes in marine temperature do not affect breeding success for storm-petrels in the Mediterranean.
- In response to poor breeding conditions, European storm-petrels can skip breeding events. This could buffer the negative effects of climate change, as storm-petrels could maintain body condition even in poor years by skipping breeding.
- Species has very high fidelity to breeding areas. Unlikely to disperse and colonise new areas readily. However, there is anecdotal evidence that European storm-petrels will recolonise old breeding sites if key threats are removed (e.g. predators).
- European storm-petrels have flexible foraging behaviour and prey on a wide variety of species. They are likely to take advantage of alternative prey sources if climate change impacts one or a few prey species.
- There is very limited mixing between populations in storm-petrels. This can be adaptive (as it increases likelihood of local adaptation) or non-adaptive (as immigration to support populations is unlikely).

6 Manx Shearwater (*Puffinus puffinus*)



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 (66% of current range)
- Current breeding area that is likely to remain suitable (34%)
- Current breeding area that is likely to become more suitable (0%)

1.1.2 Current impacts attributed to climate change:

1 **Negative Impact:** Reduced prey availability during the breeding season has led to longer foraging trips and lower condition in adults and chicks.

1.1.3 Predicted changes in key prey species:

2 Key prey species are likely to decline in abundance in the Irish Sea.

1.1.4 Climate change impacts outside of Europe

- Manx shearwaters are known to be sensitive to climate change in the tropics, particularly to wrecks caused by storms, which are becoming more common due to changes in the El Niño cycle.

1.2 Sensitivity

- Manx shearwater burrows are prone to flooding; heavy rainfall during the incubation period can result in many nests being lost. Some populations may even be constrained by the number of nest sites that are prone to flooding. An increase in extreme precipitation events due to climate change is likely to have significant impacts on shearwater populations.
- Manx shearwaters, and shearwaters in general, rely on wind conditions to soar and use as little energy as possible. Changes in wind strength, direction and patterns could heavily impact energy use and migration paths.
- This species has a long generation length (>10 years), which may slow recovery from severe impacts and increase population extinction risk.

1.3 Adaptive capacity

- Juveniles occasionally disperse to other colonies, but once breeding the species has very high fidelity. There is limited mixing between groups, leading to population divergence, and they are unlikely to disperse to or found new colonies.
- Despite the species' generally high site fidelity, Manx shearwaters have colonised parts of North America in the last century, indicating the species can successfully establish new colonies. Climate change is potentially a contributing factor to this shift in distribution. However, this is considered a relatively rare event, and it seems unlikely the species can rapidly shift their distribution in response to climate change.

Northern fulmar © Silviu Petrovan

Potential actions in response to climate change: Petrels and Shearwaters (Hydrobatidae and Procellariidae)

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:
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
Provide supplementary food during the breeding season	Trialled on many seabird species. Very limited trials on petrels and shearwaters, and with limited success. It may be possible to feed a small number of chicks for a limited amount of time, but feeding adults supplementary food is likely unfeasible or, at the least, extremely challenging.	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. Several species of petrels and shearwaters have been rescued and rehabilitated, but success rates are generally very low. Many species are prone to respiratory problems unless release is quick.	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): 2 studies in the evidence base focus on petrels and shearwaters, 14 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 petrels and shearwaters, 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.

2 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. Several petrel and shearwater species have been hand-reared successfully, but typically in small numbers. Longer-term ex-situ populations are likely to be unfeasible.	3	2	3
Make new colonies more attractive to encourage birds to colonise	Trialled extensively across other seabirds, with variable success. However, in petrels and shearwaters the use of vocalisations, smells and suitable burrows have been generally successful in encouraging establishment, especially when combined with other conservation actions. The effectiveness of each individual action is mixed, and varies depending on the species and population in question.	2	4	3

Provide supplementary food during the breeding season	Trialled on many seabird species. Very limited trials on petrels and shearwaters, and with limited success. It may be possible to feed a small number of chicks for a limited amount of time, but feeding adults supplementary food is likely unfeasible or, at the least, extremely challenging.	3	4	3
Translocate the population to a more suitable breeding area	Known to be beneficial in several seabird groups, and multiple translocations of petrels and shearwaters have been carried out successfully. There is a substantial body of work on maximising translocation success, and encouraging establishment. Note however translocations have been in the context of island restoration and predator removal, and (like many other actions) have not been trialled as a response to climate change.	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:

Artificially incubate or hand-rear chicks to support population
Relevance (R): 4 studies in the evidence base focus on petrels and shearwaters, 36 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): 9 studies in the evidence base focus on petrels and shearwaters, 29 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): 2 studies in the evidence base focus on petrels and shearwaters, 14 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): 7 studies in the evidence base focus on petrels and shearwaters, 8 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.

Northern fulmars