MCCIP Marine Climate Change Impacts Partnership

Topic

Seabirds

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Organisation(s) represented

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Executive Summary

- Poor breeding success, reduced survival and population declines of black-legged kittiwakes in recent years have been strongly linked to climate change, in particular to warmer winters and reductions in availability and nutritional quality of their fish prey (e.g. sandeels). Evidence suggests other species may have been similarly affected.
- In 2006 and 2007 poor breeding success at some colonies of kittiwakes and other species such as puffins coincided with a dramatic increase in the number of snake pipefish being brought back to feed chicks. Snake pipefish are virtually indigestible and can choke young chicks. No link has been established between climate change and the sudden occurrence of snake pipefish in UK waters in 2003.
- Colonial breeding may make it more difficult for some species to adapt to climate-induced changes in prey availability.
- Continued poor breeding success and reduced survival will lead to further declines in some seabird populations in the short and long term.
- Long-term climate change will result in the northwards contraction of the range of some species and consequently a decline in population size.
- Anticipated sea-level rise and increased storminess may reduce available breeding habitat for shoreline-nesting species (e.g. terns) and wash away nests.

Full review

Current and future climate change is likely to affect seabirds in two major ways, either directly through an increased frequency of severe weather causing e.g. nest flooding, or indirectly through changes in their food supply. The consensus is that indirect effects are likely to be more important for most species. How climate change affects seabirds is therefore to a large extent determined by how sensitive their preferred prey is to changes in temperature, salinity etc., and whether alternative prey is, or will become, available.

The breeding of seabirds in the UK has already been linked to large-scale climatic fluctuations, such as the **North Atlantic Oscillation (NAO)**. The NAO influences winter weather conditions in the UK and northern Europe, with more positive NAO indices resulting in warm, wet and stormy weather and more negative indices producing colder and drier conditions. For example, the more positive the NAO, the more likely northern fulmar (*Fulmarus glacialis*) chicks were to fledge successfully (Thompson & Ollason, 2001) and the earlier black-legged kittiwakes (*Rissa tridactyla*) and common guillemots (*Uria aalge*) started to breed (Frederiksen *et al.,* 2004a).

Seabirds are very long-lived, and changes in population size tend to be slow. However, some remarkable changes in UK seabirds have occurred recently. Black-legged kittiwake populations in the North Sea have decreased by more than 50% since 1990, and declines have also occurred in e.g. Arctic skuas (S*tercorarius parasiticus*) and European shags (*Phalacrocorax aristotelis*) (Mavor *et al.,* 2006). The most recent information on breeding success, from 2006 (www.jncc.gov.uk/page1550), showed that seabirds on the west coast of Britain had their second successive poor season; for some colonies it was the worst on record. This was surprising since these colonies appeared unaffected in 2004 when colonies on the east coast experienced widespread breeding failures that made front-page headlines (environment.independent.co.uk/article49640.ece).

The area of the UK that appears to have been most affected by seabird population declines is Shetland, which is one of the most important areas for breeding seabirds in Europe. The total numbers of Arctic skuas, Arctic terns (*Sterna paradisaea*) and black-legged kittiwakes breeding in Shetland fell by 42%, 19% and 62% respectively between two censuses in 1985-88 and 1998-2002 (Mitchell *et al.,* 2004). The declines were associated with poor breeding success and, subsequently, the decline in these species has continued, with 2004 the least productive year on record for all three species (Mavor *et al.,* 2005).

This poor breeding in Shetland and in other parts of the UK appeared to be the result of adult birds being unable to find enough food to feed their chicks or even consider breeding in the first place. In Shetland Arctic skuas, Arctic terns, kittiwakes and other species feed mainly on lesser sandeels (*Ammodytes marinus*). The survival and body condition of black-legged kittiwakes breeding on Foula, Shetland was strongly associated with sandeel abundance, as was that of their main predator, the Great Skua (*Stercorarius skua*) (Oro & Furness, 2002). These sandeels originate from the spawning stock around Orkney and are carried by currents to the waters around Shetland. Therefore the number of sandeels around Shetland is dependent on the success of the Orkney stock. As a result, the annual breeding success of black-legged kittiwakes on Shetland is correlated with those on Orkney, but the latter are usually more successful (Frederiksen *et al.,* 2005; Mavor *et al.,* 2006). However, in the mid-1980s currents failed to deliver larval sandeel to Shetland and the stock there collapsed, leading to successive years of breeding failures of several important seabird populations (Wright, 1996).

Sandeels are the main prey for many seabirds breeding along the North Sea coast, while elsewhere, other species such as sprat (*Sprattus sprattus)* and herring (*Clupea harengus*) are predominantly taken. Sandeel distribution in UK waters is patchy, with distinct spawning aggregations (Proctor *et al.,* 1998; Pedersen *et al.,* 1999) and the varying fortunes of these distinct sandeel stocks may have led to the observed geographical variation in breeding success of black-legged kittiwakes (Frederiksen *et al.,* 2005) and perhaps other species that rely on sandeels. Black-legged kittiwakes and terns feed on sandeels just below the surface, while Arctic skuas steal sandeels from these species (and also from auks) and so are dependent on the ability of other species to find food and therefore tend to exhibit poor breeding success in the same years as their hosts (Mavor *et al.,* 2006). Other piscivorous species such as auks, European shags and great cormorants (*Phalacrocorax carbo*) can reach food much deeper below the surface by pursuit diving or by plunge-diving (northern gannet, *Morus bassanus*) and so tend to have access to a wider range of prey even when some fish stocks are low. However, diving species are by no means immune to the effects of food shortages. For instance, on the Isle of May, the breeding success of European shags has been positively correlated with the size of the local sandeel stock (Rindorf *et al.,* 2000) and in years of poor sandeel availability, up to 60% of the breeding population of shags on the island have deferred breeding.

It is not only a shortage of sandeels that may be affecting seabirds, but also a reduction in quality. In 2004, the energy content of sandeels, sprats and herring brought back to the Isle of May by seabirds was much lower than in previous years and as a consequence, chicks were in poor condition and many failed to fledge, despite being fed normal quantities of fish (Wanless *et al.,* 2005). Furthermore, the size of sandeels caught by (and available to) Atlantic puffins (*Fratercula arctica*) from the Isle of May decreased by 40% over the period 1973-2002 (Wanless *et al.,* 2004).

It was widely claimed that the recent shortages and/or poor quality of sandeels are a result of climate change. This claim relies on two separate but as yet unconnected pieces of evidence. The first relates to sandeels in the North Sea. Around the mid 1980s, rises in sea surface temperatures (SST) led to a shift in the plankton communities in the North Sea, whereby species composition and biomass completely changed (Beaugrand *et al.,* 2003), and consequently there was a reduction in sandeel recruitment (Arnott & Ruxton, 2002). The second relates to a growing number of studies that have shown the effects of SST on UK seabird populations. For instance, both breeding success and individual survival of black-legged kittiwakes in the North Sea was lower following warm winters (when SST was higher). Most other studies also indicate that high temperatures, particularly in winter, are detrimental to seabirds: survival was lower during or after mild winters for Atlantic puffins (Harris *et al.,* 2005), common guillemots (Votier *et al.,* 2005) and Northern fulmars (Grosbois & Thompson*,* 2005).

It is generally assumed that this happens because recruitment to fish stocks is low during warm winters, due either to lack of suitable food at the right time or increased predation. However, it is unclear how much climate-induced changes in sandeel populations may be contributing to poor breeding. For instance, on the west coast of Britain, where seabirds are much less reliant on sandeels, it is unclear what is inhibiting seabirds' ability to find enough food. In Shetland it has been suggested that the recovery of the herring stock to levels not seen for 40 years, has increased the predation pressure on larval sandeels and reduced the sandeel availability to seabirds (Frederiksen *et al.,* 2007). Elsewhere in the North there is evidence that fisheries have had a significant impact on seabird populations. Fisheries can have both positive and negative effects. Industrial fisheries for fishmeal compete directly with seabirds for small, oily 'forage' fish such as sandeels. There is substantial evidence that sandeel fisheries on the Wee Bankie off SE Scotland during the 1990s had negative effects on black-legged kittiwakes in that area (Frederiksen *et al.,* 2004b). On the other hand, discards from fisheries for human consumption have provided an important food source for some seabirds, and recent declines in discards have probably affected these species (Votier *et al.,* 2004). Overfishing of predatory fish such as cod may have had a long-term positive effect on seabirds by allowing forage fish stocks to increase.

In a warming environment, the timing of many annual events is likely to change, and predators such as seabirds need to be able to adjust when they breed to when food is available. Common guillemots tend to breed earlier following mild winters (as indicated by the NAO index), presumably because prey availability peaks earlier in such years (Frederiksen *et al*., 2004a). Detailed studies show that although breeding earlier is better for individual females, because they are more likely to raise a chick successfully, their ability to do so is constrained by the need to breed at the same time as other females in this highly social species (Reed *et al*., 2006). Guillemots breed at extremely high densities (up to 20 pairs per square metre), and breeding at the same time ensures eggs and chicks get protection from neighbours against predators and inclement weather. Given the current rapid pace of climate change, these results give some cause for concern and suggest that social constraints are likely to slow down the rate at which guillemots can adapt their timing of breeding to when prey is available through natural selection.

Since 2003, a dramatic increase in the occurrence of the snake pipefish (*Entelurus aequoreus*) has been observed in British waters (Kirby *et al*., 2006; Harris *et al*., 2007). The cause of this increase is at present unknown. This long, thin and bony fish often occurs near the sea surface and is a slow swimmer, and as a consequence it is very easy for seabirds to catch. Many seabird species have been observed bringing snake pipefish to their chicks in several colonies around the UK, with the number of observations increasing up to 2006, and there are also many records of birds feeding on them at other times of the year (Harris *et al*., 2007). However, these fish are very difficult to swallow and their energy content is low (Harris *et al*., in review), so they are a poor food source for growing seabird chicks. Indeed, there are many records of chicks rejecting pipefish, and occasionally young birds have been observed to choke to death while trying to swallow them. Catching snake pipefish thus seems at best to be a waste of effort for seabird parents and could potentially be harmful, and they are not a viable alternative food source when preferred prey (small oily fish, mainly sandeels) are in short supply, as has been the case in recent years.

Modelling studies predicting how seabirds will respond to climate change in the long term are still at an early stage, but some general predictions can be made. Many of the common breeding seabirds in the UK are at or near the southern edge of their range, and it therefore seems likely that they would be affected by current and future climate change, and that populations may decline and ranges contract northwards. At the same time, very few seabird species currently breeding south of the UK seem likely to take up residence here. A decline in numbers and diversity of breeding seabirds is therefore expected in the longer term.

Because seabirds are very long-lived, it is only possible to document and understand the causes of changes in population size and distribution by continuous monitoring over many years. Trends in population size and breeding success of all UK seabirds are monitored under the Seabird Monitoring Programme (see www.jncc.gov.uk/seabirds), coordinated by the Joint Nature Conservation Committee, the Royal Society for the Protection of Birds and the Shetland Oil Terminal Environmental Advisory Group. More detailed data on a selection of species come from a small number of sites where intensive long-term studies take place. The most important of these sites is the Isle of May in the Firth of Forth, where breeding success, survival of adult and young birds, foraging behaviour and diet of five key species are followed in great detail by the Centre for Ecology & Hydrology, which also carries out research on how seabirds are affected by climate (www.ceh.ac.uk/sections/bpp/Coastal.htm). Other sites providing important information are Foula in Shetland (University of Glasgow), Eynhallow in Orkney (University of Aberdeen) and Skomer in SW Wales (Universities of Sheffield and Oxford, Wildlife Trust for South and West Wales).

Confidence assessments

'What is already happening' – Medium
'What could happen in the future' – Low

	what is happening now	what could happen in the future
Amount of evidence	moderate	low
Level of agreement or consensus	high	moderate
Level of confidence	medium	low

Knowledge gaps

- Too little is known about seabirds, their diet, fish abundance and plankton ecology in areas outside the North Sea, particularly off the west coast of Scotland. Survey coverage should be improved in this area. Better survey coverage of e.g. seabird demography and phenology would also be extremely valuable, and would allow the generality of findings from a few highly detailed studies to be assessed.
- The response of seabird prey, i.e. mostly small fish such as sandeels, to climate change is not at all well understood. We need to know why recruitment of sandeels and possibly other species seems to be negatively affected by warmer winters. Likewise, we need to know whether the recent population explosion of snake pipefish is linked to climate change.
- A better understanding is needed of how individuals respond to climate change. Seabird populations consist of very long-lived individuals, and their ability to cope with climate change at the population level will to a large extent be determined by how individuals respond. The options for micro-evolutionary change may also be constrained by social interactions among individuals. Resolving these questions will require detailed long-term studies of marked individuals.

Commercial impacts

A potential major decline in breeding seabirds would be likely to affect the ecotourism industry, particularly in Scotland.

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