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Seabirds

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EXECUTIVE SUMMARY

Between 2000 and 2008, the total number of seabirds breeding in the UK is believed to have decreased by approximately 9%. Breeding success has also declined over the same period. Climate change is partly responsible.

Trends vary between regions. Populations in the Irish Sea region increased on average by 37% during 1986-2007, in contrast to populations in the Eastern English Channel region, the Minches and Western Scotland region and over the Scottish Continental Shelf, which declined on average by 35-48% over the same period.

Mean breeding success has declined since 2000. As with population size, regional differences were apparent. Extremely low values were recorded for the Minches and Western Scotland in 1993, 1998 and 2005-7, but were generally higher than the other Regional Seas. Breeding success for the Scottish Continental Shelf region was lower than average, with mean success in this region very low in 1998, 2001, 2003-5 and 2007.

Evidence suggests climate change, in particular warmer winters, has resulted in major changes in the plankton in the North Sea that have probably reduced the availability and nutritional quality of seabird prey such as sandeels. Data on breeding success of species most sensitive to food shortages such as Arctic skua, kittiwake and shag suggest that climate impacts are greatest in the northern North Sea and Scottish Continental Shelf.

Continued poor breeding success and reduced survival will lead to further declines in some seabird populations in the short and long term.

Models predicting the future range of seabirds under climate change suggest that, by the end of this century, great skua and Arctic skua will no longer breed in the UK and the range of black guillemot, common gull and Arctic tern will shrink so that only Shetland and the most northerly tips of mainland Scotland will hold breeding colonies.

Climate-linked reductions in food supply can have a dramatic impact on the social fabric of colonies, with cases of infanticide recorded in guillemots for the first time.

Increased storminess may reduce available breeding habitat for shoreline-nesting species (e.g. terns), wash away nests and create unfavourable foraging conditions leading to starvation.

FULL REVIEW

1. What is already happening?

Seabird breeding populations in the UK have increased in size over the last century as a direct result of increased protection from hunting and persecution in the UK and overseas. The number of breeding seabirds increased from around 4.5 million in the late 1960s to 7 million by the end of the 1990s when the last census was conducted in 1998-2002 (Mitchell *et al.*, 2004). However, since around the mid-1990s, declines in numbers of breeding seabirds indicate that pressure is once again being exerted. Charting Progress 2 identified climate change as one of the pressures that have had a substantial impact on the UK's breeding seabird populations.

In the UK, between 2000 and 2008, the total number of seabirds breeding in the UK has probably decreased, by around 9% (JNCC, 2009). Changes in breeding numbers have varied greatly between individual species: for example during 2000-2008, abundance decreased by more than 10% in seven species, increased by more than 10% in five species and changed by less than 10% in eight species. Of those seven species declining during 2000-2008, there are substantially fewer European shag, Arctic skua, herring gull and black-legged kittiwake than in 1969. The recently published 'Birds of Conservation Concern 3' included in its red-list three species of seabird: Roseate tern, herring gull and Arctic skua – due to severe declines in their UK breeding populations of more than 50% during the last 25 years.

There has been considerable variation in trends of seabird numbers across the seven Regional Seas (Charting Progress 2: Healthy & Biologically Diverse Seas Feeder Report). The abundance of species breeding around the Irish Sea increased on average by 37% during 1986-2007, in contrast to the species in all other Regional Seas. The abundance of the species in the Eastern English Channel, the Minches and Western Scotland and over the Scottish Continental Shelf had declined on average by 35-48% during 1986-2007. The decline in mean abundance of species in the Minches and Western Scotland started more recently than for the species in the Eastern English Channel and the Scottish Continental Shelf. In some species, the regional variation in trends in abundance has been marked. Numbers of common guillemot breeding in colonies around the Irish Sea increased steadily between 1986 and 2007, by about 250% overall, but in the Northern North Sea, the Minches and Western Scotland and over the Scottish Continental Shelf, similar increases stopped during 2002-05 and since then, declines of around 40% have occurred.

The mean annual breeding success of 21 seabird species (for which sufficient monitoring data are available) has declined in the UK since 2000, reaching a low in 2005, with a temporary increase in 2006 then falling in 2007. In the Minches and Western Scotland, the mean breeding success of seven species was extremely low in 1993, 1998 and 2005-7, but in most other years, was higher than in other Regional Seas. Mean breeding success of six species in the Scottish Continental Shelf region was usually lower than those of the other regions and was particularly low in 1998, 2001, 2003-5 and 2007.

Climate change is thought to be the main cause of reductions in food supply that have led to poor seabird breeding success, lower adult survival and consequently a decline in breeding numbers, particularly at colonies bordering the Northern North Sea and the Scottish Continental Shelf. Given that the majority of the UK's seabirds breed in these two regions, the effects are evident at a UK population scale: for example, in 2008, there were 40% fewer black-legged kittiwake breeding in the UK than in 1969 (JNCC, 2008). Kittiwake and other species such as European shag, Arctic skua, Arctic tern, common guillemot and Atlantic puffin that feed on small pelagic shoaling fish have been most affected by climate change. The evidence for this impact is largely circumstantial: breeding success and survival have been correlated with climate (Thompson and Ollason, 2001; Frederiksen *et al.,* 2004b; Grosbois and Thompson, 2005; Votier *et al.,* 2004, 2008; Harris *et al,.* 2005a; Grosbois *et al.,* 2009; Lewis *et al.,* 2009) and with prey availability (Rindorf *et al.,* 2000, Oro & Furness, 2002, Parsons *et al.,* 2008). Furthermore, recent reductions in prey availability are likely to be caused at least in part by climate change (see below).

Most of the waters around the UK have been warming since the 1980s; for example average winter sea surface temperature (SST) across the northern North Sea has increased by about 1°C since the early 1980s. Around the mid 1980s, this rise in SST led to a complete change in species composition and biomass of the plankton community in the North Sea (Beaugrand *et al.,* 2003) and consequently, a reduction in the recruitment of the lesser sandeel (*Ammodytes marinus*) (Arnott and Ruxton, 2002). During 1986-2002, the over-winter survival of adult black-legged kittiwakes was lower following warmer winters (i.e. high winter SST) and breeding success one year later was significantly reduced – this is thought to have been linked to variable recruitment of sandeels (Frederiksen *et al*.,, 2004b). Both breeding success and survival were also significantly lower in years when an industrial sandeel fishery operated off SE Scotland (Frederiksen *et al.*, 2004b). A similar significant winter SST effect on breeding success was found at six other kittiwake colonies in the Northern North Sea (Frederiksen *et al.,* 2007).

Since the 1990s, the breeding success of kittiwakes along the coasts of the Northern North Sea, the Southern North Sea and the Scottish Continental Shelf has shown a decreasing trend and has been the lowest since widespread recording began, in 1986. Within the Scottish Continental Shelf region, breeding success has been lowest at colonies in Shetland (Mavor *et al.,* 2007). Sandeel distribution in UK waters is patchy, with distinct spawning aggregations resulting from the availability of sandy sediments, and the fact that adult sandeels are relatively sedentary, showing only limited movements between areas (Proctor *et al.*, 1998; Pedersen *et al.*, 1999; Wright *et al.* , 2000). 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). On the west coast of the UK, where sprat (*Sprattus sprattus*) are their main prey (Swann *et al.,* 2004), kittiwakes in some years since 2000 have experienced some of their worst breeding seasons on record. It is unknown at present if increasing SST in regional seas bordering the west of the UK are affecting the availability of sprat.

Other species rely on sandeels and sprat as their main prey, such as European shag, Arctic skua, Arctic tern, common guillemot, razorbill and Atlantic puffin. All these species, particularly those breeding at colonies in the Northern North Sea and around the Northern Isles (in the Scottish Continental Shelf region) have been experiencing poor breeding seasons with increasing frequency, apparently due to a scarcity of prey (Mavor *et al.,* 2007).

It is not just the number of fish that has been limiting breeding success and survival. The quality of prey also appears to have declined. The size of sandeels caught by (and available to) Atlantic puffins over the Wee Bankie in the Northern North Sea off SE Scotland decreased significantly over the period 1973-2002 (Wanless *et al.,* 2004). Furthermore, the energy content of sandeels and sprats that adult common guillemots fed to their young in 2004 on the Isle of May, SE Scotland, was much lower than normal and resulted in lower growth rates of chicks and ultimately the worst breeding season on record for the colony (Wanless *et al.,* 2005).

Colony functioning and integrity is maintained by a wide range of behavioural and physiological mechanisms that may be disrupted if external conditions deteriorate. A major breakdown in the social behaviour of common guillemots breeding on the Isle of May, south-east Scotland, occurred during a period when birds were severely short of food (Ashbrook *et al.,* 2008). Continuous video records revealed that up to 50% of chicks were being left unattended by their parents. Normally one adult stays with the chick to protect it while the mate is away feeding. However, if food is in very short supply then both parents are forced to forage simultaneously, leaving the chick alone on the cliff ledge surrounded by other adult guillemots. It was anticipated that the main threat to unattended chicks would come from aerial predators such as herring gulls that breed in large numbers on the Isle of May. However, the videos revealed a very different picture with unattended chicks attacked not by gulls but by neighbouring guillemots. In some cases these assaults were so severe that chicks were thrown off the cliff. Attacks by neighbours were the main cause of chick mortality and breeding success was the lowest recorded in 30 years. This is the first time such behaviour has been recorded in guillemots and graphically highlights how environmentally-induced aggression can undermine the benefits of colonial breeding.

Climate change models are projecting a possible increase in the frequency of extreme weather events. The consequences on species may be significant since population growth rates can be reduced with increased climate variability even without a change in mean weather conditions. Modelling studies predicting seabird responses to climate change are at an early stage, The European shag *Phalacrocorax aristotelis* shows large variability in population size in parts of its range. This pattern is particularly apparent in the Northern North Sea region. An analysis of a 43 year data set of survival rate on the Isle of May, SE Scotland, has revealed that survival was highly variable for all age groups (Frederiksen *et al.,* 2008a). For adults, this variability was largely explained by very poor survival during extreme weather events, in particular sustained periods of strong onshore winds and high rainfall. Onshore winds may create particular difficulties for foraging birds along the east coast of the UK because of the lack of shelter. A population model predicted that an increase in frequency of extreme weather events would lead to reduced population growth and an increasing probability of extinction. Vulnerability to extreme weather needs to be considered when predicting the impacts of climate change on seabirds.

Additional pressure from commercial fishing may be adding to the climate-driven impact on food shortages. For, instance in the Northern North Sea off south-east Scotland a sandeel fishery that operated in the 1990s significantly depressed adult survival and breeding success of black-legged kittiwakes at adjacent colonies compared with years prior to the fishery opening and after it was closed (Daunt *et al.,* 2008; Frederiksen *et al.,* 2008b). It is not known if sandeel fisheries also contributed by continuing to operate immediately outside the closed area and elsewhere in the North Sea, but mostly beyond the foraging range of UK seabird colonies. Since 2000 there has been a ban on sandeel fishing off eastern Scotland and NE England. If fishing is resumed to levels that significantly reduce local sandeel stock size, it would probably exacerbate reductions in breeding success and survival caused by increases in sea surface temperature as a result of climate change (Frederiksen *et al.,* 2004b, 2005, 2008b).

For years, some seabirds have benefited from fisheries through food provided at sea by discharging offal and discarding undersize fish. As a result, the abundance of scavenging species (e.g. great skua, northern fulmar) may have been elevated above levels that naturally occurring food sources could sustain (Tasker & Furness, 1996). The necessary introduction of measures to conserve fish stocks has consequently reduced the amount of discards, as has the decline of some commercial fisheries, which has also resulted in less offal being discharged. It is conceivable that the reduction in food provided by the fishing industry may have contributed to a population downturn of fulmars and other offshore surface-feeders since the mid-1990s (JNCC, 2008, Reeves & Furness, 2002). Another consequence of fewer discards is that great skuas have had to rely increasingly on other food sources, including the predation of other seabirds, which is having a negative impact on their prey populations (e.g. Arctic skuas – Votier *et al.,* 2004).

Charting Progress 2 identifies six pressures other than climate change and over-exploitation through fishing that may have had an impact on UK Seabird populations. The impacts from the introduction of non-indigenous species were considered to be high. Introductions of non-native mammals to islands have had major negative impacts on the resident colonies of ground-nesting seabirds (Craik, 1997, 1998; Mitchell & Ratcliffe, 2007; Ratcliffe *et al.* 2008). Mammals such as brown rat (*Rattus norwegicus*) and American mink (*Mustela vison*) predate on seabird eggs, chicks and in some cases, adult birds. Predation by mammals has caused the extinction of some colonies of ground-nesting seabirds such as terns, gulls, storm-petrels, Manx shearwater and Atlantic puffin. Other colonies have been substantially depleted, with seabirds confined to breeding in places that are inaccessible to predators.

Other pressures were considered to be low at present. Activities associated with the development of offshore renewable energy sources and with leisure and recreation can create visual disturbance to seabirds that effectively leads to the loss of habitat available for foraging, nest building and other essential activities. These impacts are currently localised and considered to be low across the UK as a whole. Fishing can also increase mortality in some species such as northern fulmars and auks that are caught by long-line and other fisheries in UK waters (Dunn & Steel, 2001), but quantitative data on seabird bycatch are currently lacking (ICES, 2008). Despite large numbers of seabirds from UK colonies having been killed by contamination with hazardous substances resulting from oil spills from ships during the last 20 years, there does not appear to have had any substantial lasting effect on the size of the UK breeding populations of those species affected (mainly common guillemot and razorbill). Marine litter is ingested by northern fulmars and other surface feeding seabirds (van Franeker *et al.,* 2005). As a consequence, non- degradable plastics accumulate in large quantities in their stomachs. However, it is unclear what effect this ingested litter has on the birds' health and long term survival.

Continued monitoring of species at risk will provide an early warning of negative impacts of the principal pressures on populations.

2. What could happen in the future?

Most seabird species in the UK are at the southern limit of their range in the North-east Atlantic – this may be because they are adapted to living in a particular climate. If this is the case, as the climate in the UK changes we may expect a shift in range that may or not cause a decrease in breeding numbers, depending on the availability of nesting sites and food elsewhere. By the end of 21st century, as a result of changes in climate, great skua and Arctic skua may no longer breed in the UK and the range of black guillemot, common gull and Arctic tern may shrink so much that only Shetland and the most northerly tips of mainland Scotland would hold breeding colonies. These predictions are based on modelling by Huntley *et al.* (2007) who described the 'climate envelope' that each species currently occupies in Europe and predicted how the shape of this envelope and hence the breeding range of the birds would change by the last 30 years of the 21st century. The climate envelope was a composite of measures of a) winter cold, b) overall warmth or growing season, and c) available moisture. Their predictions seem sensible given that these species, particularly the skuas, are confined to colder parts of the northern hemisphere (Furness, 1988) and that their food is not necessarily confined to such areas. The predicted extinctions of both skuas are of conservation concern, given that Artic skua numbers in the UK have declined rapidly in recent years (JNCC, 2009) and that the UK holds 60% of the world breeding population of great skuas (Furness and Ratcliffe, 2004). Huntley *et al.,* (2007) also predicted that Leach's storm-petrel would no longer be breeding in the UK by the end of the 21st century. This is unlikely to result solely as a result of the climate predictions used, since they breed in warmer climes than currently experienced in the UK and the current distribution in the Scottish Continental Shelf is positively correlated with the proximity to deep oceanic water where they feed on plankton concentrated by upwellings and ocean currents (Mitchell 2004). Thus, future changes in the number and distribution of Leach's storm-petrel breeding in the UK are likely to result indirectly from climate change via changes in their planktonic food resources rather than as a direct response to changes in air temperature and humidity or rainfall. Huntley *et al.* (2007) also predicted that by the end of 21st century most other species would no longer be breeding in south eastern England, but it is uncertain whether the total numbers of these species breeding in the UK would decrease substantially as a result, given that only a small proportion of the UK's population breed there.

Climate change is considered to impact on seabirds primarily by reducing the number, quality or availability of prey fish, in particular sandeels, and this process is expected to intensify in the future. The continued warming of waters around much of the UK has led to changes in species competition and abundance at lower trophic levels (Kirby & Beaugrand, 2009), with detrimental effects on sandeels (van Deurs *et al.,* 2009). If sea temperatures continue to rise as predicted, it is likely that kittiwakes and other seabirds that feed on small shoaling fish will continue to experience poor breeding seasons with increasing frequency. The combination of reduced recruitment and lower adult survival associated with high sea temperatures (Frederiksen *et al.,* 2004b) will lead to further large declines in population size. Already, by 2007, the numbers of kittiwakes breeding in Shetland had declined by around 80% since the early 1990s. Furthermore, an outcome of increased atmospheric CO_2 that is of increasing concern is ocean acidification, whose consequences may be felt right up the food chain to sandeels and associated top predators. Additional consequences of climate change, such as coastal dead zones (Diaz and Rosenberg, 2008), are becoming increasingly apparent and may have important consequences for seabirds.

Emerging prey species may be critical to the future wellbeing of seabirds. However, to be an effective alternative to current prey such as sandeels they will have to fulfil important criteria of abundance, availability and quality. From 2003, there was a dramatic increase in the occurrence of the snake pipefish (*Entelurus aequoreus*) in British waters (Kirby *et al.*, 2006; Harris *et al.*, 2007). Many seabird species were observed bringing snake pipefish to their chicks in several colonies around the UK. Pipefish are hard to swallow and have a low energy content (Harris *et al.,,* 2008), so they are a poor food source for seabird young. Another species to have appeared in the diet of species in the last two years is the rockling (*Enchelyopus* sp.). Rockling appear more palatable and nutritious to seabirds. Other species, including those coming from the Pacific via the North West passage, may become increasingly important. However, pipefish are now virtually absent at seabird colonies, so it is not clear whether emerging species will persist as an alternative prey for seabirds.

Furthermore, it is unclear whether emerging species that persist will be of sufficient abundance or quality to be adequate substitutes for current prey.

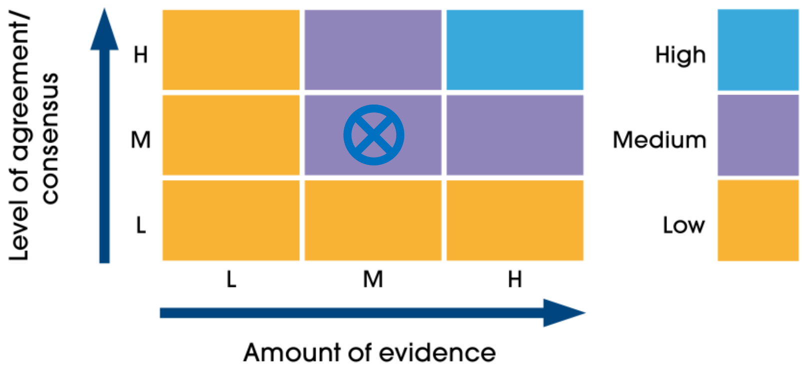
Recent increases in jellyfish, which have been linked to overfishing and climate change, have been observed around the world including in UK waters (Purcell *et al.,* 2007) and may have a significant impact on seabirds. Jellyfish constitute a proportion of the diet of fulmars. However, they may impact on a larger suite of seabird species since they are in direct competition with forage fish, including lesser sandeels, for planktonic food such as copepods, while also being predators on fish larvae. Although quantitative estimates of jellyfish abundance and distribution in UK waters are limited, research effort is expected to increase. This should include their impact as predators and competitors in ecosystems and consequences for top predators such as seabirds.

Future climate change is also likely to have direct impacts on breeding seabirds. Rising sea levels, particularly in the southern North Sea may wash away coastal nesting habitat of ground-nesting seabirds such as terns. Increases in storminess may lead to nests being washed away during the summer or to large scale mortality during the winter, as the recent analysis on European shags has demonstrated (Frederiksen *et al.,* 2008a; see above).

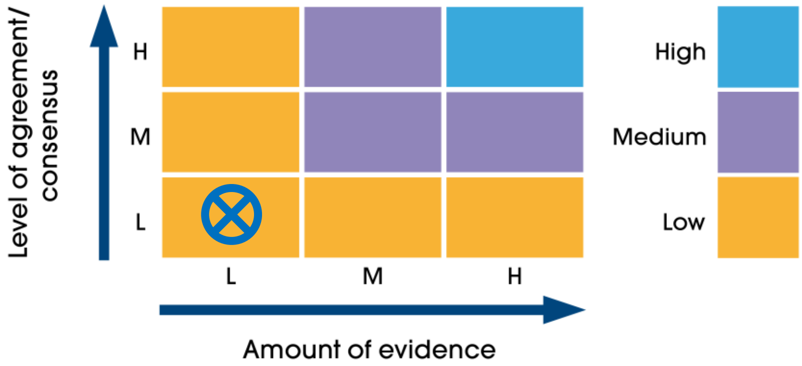
Other drivers of seabird populations are also expected to interact with climate change in complex ways. The previously demonstrated additive effect of fisheries and sea temperatures (Frederiksen *et al.,* 2004b) is unlikely to be maintained at higher sea surface temperatures, with climate effects predicted to override fishery effects. Another potential driver of immediate and future relevance is the impact of marine renewables on seabirds, which may interact with climate change if the latter results in seabird range shifts, changing the spatial overlap with fixed developments. This issue is likely to become increasingly important as UK and devolved governments strive to meet their targets for renewable energy production. Finally, research demonstrating the deterimental impact of parasites on seabirds is increasing (Duneau *et al.,* 2008; Reed *et al.,* 2008) and there is widespread concern that climate change may interact with disease, since increasing temperatures can alter host susceptibility, pathogen survival and disease transmission rates (Lafferty, 2009).

3. Confidence in the science

What is already happening: **Medium**



What could happen: **Low**



The level of confidence hasn't changed since the 2007-2008 Annual Report Card. The amount of evidence on what is already happening is moderate since aspects of the ecology of seabirds are comparatively well understood. Consensus on the key drivers of seabirds is also moderate. In contrast, there is little strong evidence about what will happen in the future, because of the combination of the uncertainty surrounding climate change projections, and the knock-on effects, including how climate will interact with current and emerging drivers of change such as fisheries, marine renewables and disease. For these reasons, there is less consensus and in particular model confidence with future changes than with current changes.

4. Knowledge gaps

The top priority knowledge gaps that need to be addressed in the short term to provide better advice to be given to policy makers are:

1. In the short-term we need to better understand the nature of the interactions between climate, plankton and sandeels in order to predict the likely magnitude of future impacts on seabirds and to devise measures that may mitigate the impacts of climate change. A particular priority is information on sandeel population dynamics that provide the link between seabirds and secondary production. For instance, it is unclear why sandeel recruitment is negatively correlated with SST (see Arnott & Ruxton, 2002). We need a better understanding of the nature of the relationship between sandeel populations and secondary production, predation, fisheries and density dependent factors such as cannibalism (van Deurs *et al.,* 2009). .
2. Whilst the focus to date has been on the interaction between seabirds and sandeels, other fish species are important prey for some species in certain regions. Of most significance is the little attention that has been given to the likely impact of rising SST on sprat and herring, which predominate in the diet of piscivorous seabirds in regional seas west of the UK e.g. in the Irish Sea and in the Minches and Western Scotland. Seabirds breeding there have generally had more successful seasons than around the North Sea up until 2005, after which birds appear to have been struggling to find enough fish and have consequently had poor breeding success. Work is required to determine whether these food shortages in the west are a result of increasing SST or some other factor. An understanding of the relationship between emerging species and climate change is also likely to become increasingly important.
3. It is becoming increasingly apparent that a number of factors can affect seabirds simultaneously. These interactions are likely to be complex but are

poorly understood. An important priority for the future is to quantify the interactions between climate change and other drivers such as fisheries, disease and marine renewables.

There is strong consensus that these represent important knowledge gaps.

5. Socio-economic impacts

Seabirds provide an important source of income for some local economies – seabirds have a wide appeal to people: spectacular 'seabird cities' and enigmatic species like the Atlantic puffin draw visitors from near and far**.**

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