IMPACTS OF CLIMATE CHANGE ON SEABIRDS

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Executive Summary

Long-term climate change is likely to impact significantly on seabird populations. The breeding behaviour of some seabird populations in the UK been linked to large-scale climatic fluctuations in the North Atlantic, such as the North Atlantic Oscillation (NAO) (Thompson and Ollason 2001; Frederiksen *et al.,* 2004b). Projected consequences of global warming in UK waters, such as sea level rises and increased storminess are likely to have a direct impact on seabird populations. For instance, rising sea levels may reduce the amount of breeding habitat available for shoreline nesting species such as terns; winter storms can cause large-scale mortality or 'wrecks' of seabirds and summer storms can wash whole colonies from cliffs.

Rises in sea temperatures have already caused significant changes lower down the food chain that may be having a serious knock-on effect on seabirds. Around the mid 1980s, rises in sea surface temperatures (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 sandeels (Arnott and Ruxton 2002) - a major source of food for breeding seabirds and their young. The size of sandeels caught by (and available to) Atlantic puffins over the Wee Bankie off south-east 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, south-east 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.,* 2004). At the same site, over-winter survival of adult black-legged kittiwakes during 1986-2002 was lower following warmer winters (i.e. high SST) and breeding success one year later was significantly reduced – this is thought to be linked to variable recruitment of sandeels (Frederiksen *et al.,* 2004a). There have been recent breeding failures at UK colonies amongst those species that rely on sandeels – the poorest breeding seasons since annual monitoring began in 1986 occurred in Orkney, Shetland and the North Sea coast of Britain in 2004 (Mavor *et al.,* 2005; JNCC undated) and in NW Scotland in 2005 (Mavor *et al.,* 2006; JNCC undated). While no direct link has been shown between SST increases, low sandeel biomass and poor seabird breeding performance, the circumstantial evidence is compelling.

Level of Confidence

Medium

Key Sources of Information

See supporting evidence

Supporting Evidence

The breeding behaviour of some seabird populations in the UK has been linked to large-scale climatic fluctuations in the North Atlantic, 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. The likelihood of breeding northern fulmars (*Fulmarus glacialis*) attending a colony at Eynhallow in Orkney and their hatching and fledging success were all negatively correlated with the NAO index (Thompson and Ollason, 2001). Frederiksen *et al.,* (2004b) also found that black-legged kittiwakes (*Rissa tridactyla*) and common guillemots (*Uria aalge*) on the Isle of May, SE Scotland started to breed earlier in years when the NAO was more positive. Such correlations between seabird demographics and past fluctuations in climate provide evidence for the potential for future long-term climate change to have significant consequences on seabird populations, but they tell us little about the processes involved.

Seabirds are long-lived, delay breeding until they are several years old, display high rates of annual survival of adults but low rates of post-fledgling survival. Breeding population size is most immediately affected by factors that influence adult survival and may be affected by changes in breeding success and post-fledgling survival, but only if such changes are sustained over several years.

Projected consequences of global warming in UK waters, such as sea level rises and increased storminess (Mitchell and Ericksen, 1992; Christensen and Christensen, 2003) are likely to have a direct impact on seabird populations. Seabirds that nest along the shoreline, such as little terns (*Sternula albifrons*), are currently undergoing declines in breeding numbers caused by successive years of poor breeding, due to nests being washed away by tidal surges, as well as from predation and human disturbance (Pickerell, 2004). Rising sea levels will exacerbate such effects by reducing the amount of safe breeding habitat available. Furthermore winter storms can cause large-scale mortality or 'wrecks' of seabirds and summer storms can wash whole colonies from cliffs.

Rising sea surface temperatures (SST) in UK waters may have a more indirect effect on seabirds, but arguably a more significant one, by reducing the amount of food available to those species that rely on the lesser sandeel (*Ammodytes marinus*) to feed themselves and their young. 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.,* 2006) and perhaps other species that rely on sandeels. 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 and Ruxton, 2002). The size of sandeels caught by (and available to) Atlantic puffins (*Fratercula arctica*) over the Wee Bankie off south-east Scotland decreased significantly over the period 1973-2002 (Wanless *et al.,* 2004). It appears that these changes lower down the food chain have had a

knock-on effect on seabirds. The survival and body condition of black-legged kittiwakes breeding on Foula, Shetland was associated with sandeel abundance, as is that of their main predator, the Great Skua (*Stercorarius skua),* (Oro and Furness, 2002). Frederiksen *et al.,* (2004a) found that over-winter survival of adult black-legged kittiwakes breeding on the Isle of May during 1986-2002 was lower following warmer winters (i.e. high SST) and that breeding success one year later was significantly reduced. They suggested that the low numbers of 0-group sandeels recruited following a warm winter (cf. Arnott and Ruxton, 2004) would lower the condition of adult Kittiwakes going into the following winter, reducing their chance of survival and subsequent breeding success the following spring when they would be feeding on the same depleted cohort of sandeels.

Black-legged kittiwakes and terns feed on sandeels just below the surface, while Arctic skuas (*Stercorarious parasiticus*) 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 (*Phalacrocorax aristotelis*) 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. In 2003 and 2004, sandeel shortages around Orkney and Shetland resulted in depressed breeding success of common guillemots and razorbills (*Alca torda*), more so in 2004 - the poorest breeding season on record for these species, with unprecedented total breeding failure at some colonies (Mavor *et al.,* 2005). Common guillemots on the Isle of May in 2004 also suffered a significantly lower productivity that was associated with adults apparently forced to switch from feeding their chicks on sandeels to feeding them predominantly on clupeids (eg. sprats *Sprattus sprattus*; Harris *et al.,* 2005). Chicks were in poor condition despite being fed normal quantities of fish, but the energy content of the fish was greatly reduced compared to previous years, but it is unknown why this was so (Wanless *et al.,* 2005).

The area of the UK that appears to have been most affected by poor sandeel availability is Shetland, which is one of the most important areas for breeding seabirds in Europe. In Shetland waters, sandeels are recruited from the advection of larvae from the spawning stock around Orkney and 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.,* 2006; Mavor *et al.,* 2006). Indeed, the collapse of the sandeel stock around Shetland in the mid 1980s that resulted in the breeding failure of several important seabird species, was believed to be a result of very low levels of sandeel recruitment from the Orkney stock (Wright, 1996). Between 1985 and 1990, seabirds in Shetland, namely Arctic terns, (*Sterna paradisaea*), Arctic Skuas, Great Skuas, black-legged kittiwakes and Atlantic puffins experienced successive years of breeding failure due to the collapse of the local sandeel stock. Since then, sandeel availability and breeding success has fluctuated. As a result of successive years of poor breeding success and subsequently low recruitment, the breeding populations of Arctic skuas, Arctic terns

and black–legged kittiwakes in Shetland have declined by 42%, 19% and 62% respectively between 1985-88 and the Seabird 2000 census in 1998-2002 (Mitchell *et al.,.,,* 2004). Since the completion of Seabird 2000, numbers of Arctic Skuas, Arctic Terns and Black–legged Kittiwakes at monitored colonies in Shetland continue to decline, and look set to do so over the next few years following poor breeding success in successive years between 2001 and 2004 (Mavor *et al.,* 2002, 2003, 2004, 2005). The breeding season in 2004 was the least productive on record for all three species, not only in Shetland, but unusually also in Orkney, with few young fledged across the entire Northern Isles. Poor productivity was also experienced at other colonies along the UK's North Sea coast (Mavor *et al.,* 2005).

A potentially confounding effect on the interaction between seabirds and sandeels is the commercial fishery for sandeels that operates in the North Sea. Most of the sandeel fishing in the North Sea occurs beyond the foraging range of seabirds in UK colonies, apart from over the Wee Bankie and around Shetland. A precautionary ban was imposed on the Shetland fishery in 1990-95 and subsequent catches were limited to low levels, with a voluntary ban around south Shetland in 2004, but seabird breeding success there still appears to be restricted by shortage of food. The presence of the sandeel fishery during 1990-99 over the Wee Bankie, within range of the Isle of May, was significantly associated with low breeding success of black-legged kittiwakes there. Since 2000, when a precautionary ban was imposed on sandeel fishing over the Wee Bankie (as part of an area from north-east Scotland to Northumberland), kittiwake breeding success on the Isle of May showed some signs of improvement, up until 2004 when breeding success was poor (Harris *et al.,* 2005). At the same time, common guillemots on the Isle of May switched from feeding their chicks on sandeels to feeding predominantly on clupeids (presumably due to a shortage of sandeels) and consequently suffered their worst breeding season on record (see above). Frederiksen *et al.,* (2004a) predicted that if SST in the North Sea increased in the future and the sandeel fishery resumed, the kittiwake population on the Isle of May (and perhaps other nearby colonies) would enter into a *"catastrophic decline*".

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References

Arnott, S. A. and Ruxton, G. D. 2002. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Mar. Ecol. Prog. Ser. 238: 199-210.

Beaugrand, G., Brander, K. M., Lindley, A., Souissi, S. and Reid, P. C. 2003. Plankton effect on cod recruitment in the North Sea. Nature 426: 661-664.

Christensen, J.H and O.B. Christensen. 2003. Severe summer flooding in Europe. Nature 421: 805.

Frederiksen, M., Harris, M. P., Daunt, F., Rothery, P. and Wanless, S. 2004a. Scale-dependent climate signals drive breeding phenology of three seabird species. Global Change Biology 10: 1214-1221.

Frederiksen, M., Wanless, S., Harris, M. P., Rothery, P. and Wilson, L. J. 2004b. The role of industrial fishery and oceanographic changes in the decline of the North Sea black-legged kittiwakes. J. Appl. Ecol. 41 (6): 1129-1139.

Frederiksen, M., Wright, P. J., Harris, M. P., Mavor, R. A., Heubeck, M., Wanless, S. 2006. Regional patterns of kittiwake *Rissa tridactyla* breeding success are related to variability in sandeel recruitment. Mar. Ecol. Prog. Ser. 300: 201- 211.

Harris, M. P., Wanless, S., Murray, S., and Mackley, E. 2005. Isle of May seabird studies in 2004. JNCC Report No.375, Joint Nature Conservation Committee, Peterborough, UK.

Pickerell, G. 2004. Little Tern *Sterna albifrons*. Pp. 339-349 in Mitchell, P. I., Newton, S. F., Ratcliffe, N. and Dunn, T. E. 2004. Seabird Populations of Britain and Ireland. T and A D Poyser; London.

Mavor, R. A., Parsons, M., Heubeck, M., Pickerell, G. and Schmitt, S. 2003. Seabird numbers and breeding success in Britain and Ireland, 2002. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No.27.)

Mavor, R. A., Parsons, M., Heubeck, H. and Schmitt, S. 2004. Seabird numbers and breeding success in Britain and Ireland, 2003. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No.28.)

Mavor, R. A., Parsons, M., Heubeck, M. and Schmitt, S. 2005. Seabird numbers and breeding success in Britain and Ireland, 2004. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No.29)

Mavor, R. A., Parsons, M., Heubeck, M. and Schmitt, S. 2006. Seabird numbers and breeding success in Britain and Ireland, 2004. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No.30)

Mavor, R. A., Pickerell, G ., Heubeck, M. and Mitchell, P. I. 2002. Seabird numbers and breeding success in Britain and Ireland, 2001. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No.26.)

Mitchell, J. K and N. J. Ericksen 1992. Effects of climate change on weather-related disasters. In Confronting Climate Change; risks, implications and responses (ed I. M. Mintzer) pp. 141-151. Cambridge University Press, Cambridge.

Mitchell, P. I., Newton, S. F., Ratcliffe, N. and Dunn, T. E. 2004. Seabird Populations of Britain and Ireland. T and A D Poyser; London.

Monaghan,P., Uttley, J. D., and Okill, J. D. (1989) Terns and sandeels: seabirds as indicators of changes in marine fish populations. *J. Fish Biol.* 35**,** pp. 339-340

Newton, S. 2004. Roseate Tern *Sterna dougallii*. Pp. 302-314 in: Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. 2004. Seabird Populations of Britain and Ireland. T. and A.D. Poyser, London.

Oro, D. and Furness, R. W. 2002. Influences of food availability and predation on survival of Kittiwakes. Ecology 83: 2516-2528.

Pedersen, S. A., Lewy, P. and Wright, P. 1999. Assessments of the lesser sandeel (Ammodytes marinus) in the North Sea based on revised stock divisions. Fish Res 41: 221-241.

Proctor, R., Wright, P. J. and Everitt, A. (1998). Modelling the transport of larval sandeels on the north west European shelf. Fish Oceanogr. 7: 347-354.

Rindorf, A., Wanless, S., and Harris, M. P. 2000. Effects of changes in sandeel availability on the reproductive output of seabirds. Mar. Ecol. Prog. Ser. 202: 241-252.

Seabird monitoring Programme – http://www.jncc.gov.uk/seabirds

Thompson, P. and Ollason, J.C. 2001. Lagged effects of ocean climate change on fulmar population dynamics. Nature 413: 417-420.

Uttley,J., Monaghan, P., and White, S. (1989) Differential effects of reduced sandeel availability on two sympatrically breeding species of tern. *Ornis Scandinavica* 20**:** 273-277

Wanless, S., Wright, P. J., Harris, M. P. and Elston, D. A. 2004. Evidence for decrease in size of lesser sandeels Ammodytes marinus in a North Sea aggregation over a 30-yr period. Mar. Ecol. Prog. Ser. 279: 237-246.

Wanless, S., Harris, M. P., Redman, P. and Speakman, J. R. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Mar. Ecol. Prog. Ser. 294: 1-8.

Wright, P. J. 1996. Is there a conflict between sandeel fisheries and seabirds? A case study at Shetland. In: Greenstreet, S. P. R., Tasker, M. L. (eds) Aquatic predators and their prey. Fishing News Books, Oxford, pp. 154-165.

Wright, P. J., Jensen, H. and Tuck, I. 2000. The influence of sediment type on the distribution of the lesser sandeel*, Ammodytes marinus*. J. Sea Res. 44:243-256