MARINE CLIMATE CHANGE IMPACTS PARTNERSHIP: SCIENCE REVIEW
MCCIP Science Review 2013: 149-154
Submitted June 2013
Published online 28 November 2013
doi:10.14465/2013.arc16.149-154

Impacts of climate change on waterbirds

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EXECUTIVE SUMMARY

There is increasing evidence that the overwintering distributions of many coastal waders have shifted in recent decades in response to warming. In the last decade, this has resulted in declines in usage of east coast sites in favour of The Netherlands, although during recent cold winters, this trend has been partially reversed.

These changes have probably resulted from a redistribution of individuals rather than changes in survival, either in response to an altered tendency towards cold-weather movements or changing juvenile settlement patterns.

There is increasing evidence that similar distribution changes have occurred in seaduck, which may be taking advantage of ice-free conditions in the Baltic, and in coastal wintering waterfowl.

Little egret has become much more common on estuaries in winter in response to the increasing breeding population. Projected future increases in great white egret, cattle egret and glossy ibis populations also likely to become regular users of British estuaries in winter.

Models project future increases in the abundance of many wintering wader and waterbird populations in the UK in response to projected warming, although some are projected to decline. Most current SPAs are likely to continue to support internationally important numbers of wintering waterbirds, even under a high-emissions 2080 scenario.

Potential changes in sea level may alter estuarine sediment patterns, with likely impacts on wintering waterbird communities, particularly at sites where coastal defences are maintained.

Significant warming is projected to reduce the Arctic and subarctic breeding ranges of wintering waterbirds by about 50 % by the end of the century. This suggests that despite improving winter conditions in the UK, wintering populations of many species here may decline.

1. WHAT IS ALREADY HAPPENING?

Wintering wader and waterfowl communities have been regularly counted by Wetland Bird Survey (WeBS www.bto.org/webs) surveyors on a monthly basis at a wide range of sites, particularly large estuaries and wetlands, to provide population trends for most species that date back to the mid-1960s (e.g. Holt *et al.*, 2012). International Waterbird Census (www.wetlands.org/iwc) counts provide additional data from across Europe. These data have already provided increasing evidence that recent climate change has impacted on the distribution and communities of waders wintering in the UK and across Europe. As reported in the last report card (Austin, 2010), the distribution of 8/9 common estuarine waders (Charadrii) within the UK is linked to temperature, with fewer birds occupying western estuaries during mild winters (Austin and Rehfisch, 2005). This effect was particularly apparent in species of small body size. Distributions of three wader species that winter on open coasts have shown similar shifts through time (Rehfisch *et al.*, 2004). Across north-west Europe there was been a significant north-easterly shift in the wintering distribution of 5/7 wader species from January 1981 to January 2000 of 75 – 119 km in extent (Maclean *et al.*, 2008). Here, the strongest responses of population size to temperature were most apparent at the coldest sites.

More detailed analyses of French data have shown that these changes have been associated with significant changes in community composition at each site. From 1977 to 2009 populations of species which tend to be associated with warmer winter climates have tended to increase in abundance relative to those that occupy cooler climates. This change is equivalent to a 20 km northwards shift in community composition per year (Godet *et al.* 2011). Probably linked to these shifts, there has been a significant increase in species-richness of the wader communities on British estuaries over the same period (Mendez *et al.* 2012).

Several hypotheses have been proposed to account for these changes. Firstly, they are likely to partly reflect changes in overwinter survival rates. Periods of severe (cold, wet) winter weather are known to have cause increased mortality of waders (Clark, 1982, 2004, 2009; Peach *et al.*, 1994; Insley 1997; Catchpole *et al.*, 1999; Piersma *et al.*, 2005), and therefore, increasing winter temperatures, at least to 2009, are likely to have increased survival rates, potentially accounting for the recently increasing populations in the coldest locations occupied by particular species observed by Maclean *et al.* (2008). Secondly, however, the rapidity of the observed shifts suggests that they may also be driven by the movement of individuals (Austin and Rehfisch, 2005; Rehfisch *et al.*, 2004; Rehfisch and Austin, 2006; Maclean *et al.*, 2008). In particular, the increasing proportion of individuals from a range of species wintering on eastern estuaries, which tend to be colder, but more productive, probably means that birds have been able to take advantage of feeding on those sites for longer, with reduced risk of mortality as a result of severe weather (Austin and Rehfisch, 2005). Although wintering waders tend to exhibit a relatively high-degree of site-fidelity (Rehfisch *et al.*,1996; Pearce-Higgins, 2001), they may make cold-weather movements in response to severe weather, and the eastward shifts may reflect a decreasing preponderance to do so in recent years.

A north-east directional shift is likely to have been responsible for concurrent increases in numbers of coastal waterbirds wintering in The Netherlands, particularly at the principal site of the Wadden Sea (e.g. Hornman *et al.* 2012), and may have been responsible for declines in wader numbers on the east coast of Britain during the 2000s. It is pertinent therefore, that four of the five wader species whose range centroids were shown by Maclean *et al.* (2008) to have shifted in the period 1980-2000, have subsequently increased in the UK during recent cold winters such as November 2010 to January 2011 (Holt *et al.*, 2012), when presumably more of the birds wintering in The Netherlands occupied sites in eastern England again. This is indicated by regional WeBS trends, where increases have been most marked in the eastern England region (which includes important estuaries such as The Wash, Humber Estuary and Breydon Water) (Figure 1).

Furthermore, the observed shifts may reflect increasing patterns of juvenile settlement at more northern or north-eastern sites as they become increasingly suitable in response to climate change. Observed changes in the winter distribution of an expanding black-tailed godwit population in the UK illustrate the importance of such juvenile settlement in driving increasing colonisation of otherwise unoccupied sites (Gunnarsson *et al.*, 2005). Although, similar analyses have not been undertaken for coastal or marine wildfowl, there is evidence that increasing numbers of many species are taking advantage of ice-free waters in the Baltic countries, waters formerly unavailable throughout much of the winter while they remained frozen. In the Baltic, the wintering distribution of many species has shifted northwards in recent years (Nilsson 2005, 2008). Declines in velvet scoter and long-tailed duck recorded from the eastern coast of Scotland may reflect this process, although widespread population declines of both species have also occurred (BirdLife International 2012). This has been demonstrated in mallard, some of which winter around the UK coast, although many occupy inland

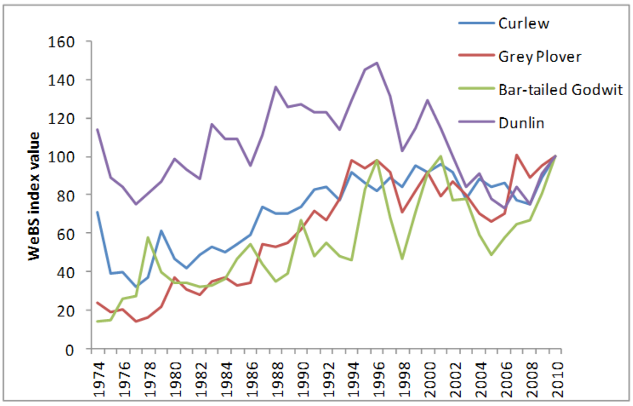


Figure 1: Annual WeBS indices for four waders wintering in eastern England. As shown, the three most recent cold winters have seen a reversal of the downward trends of the preceding decade.

wetlands. As expected, long-distance winter movements of this species are related to cold weather, and have decreased in frequency in recent years (Sauter *et al.*, 2010), leading to fewer individuals from eastern Scandinavia wintering on eastern English coasts (Gunnarsson *et al.*, 2012). Further evidence for climate change impacts on the migratory behaviour of waterbirds comes from Lehikoinen and Jaatinen (2012), who show that the timing of autumn migration of 6 / 15 wildfowl has been delayed in response to warming, and may underpin northwards shifts in the wintering distribution of these species. Species whose UK winter populations comprise birds from more than one biogeographic breeding population may show differential regional trends according to their origin. For example, numbers of wintering Slavonian grebes are increasing in Shetland and west Scotland (a sub-population presumed to be of Icelandic origin), whereas the species has decreased on the south and east coasts of England (a sub-population considered more likely to be of Scandinavian breeding origin) (Harvey and Heubeck, 2012).

Other groups of waterbirds also make regular use of coastal sites, including herons. The little egret has expanded northwards from Europe, both in terms of population size and distribution, in the last 20 years. Populations at estuaries in northern England are now expanding at similar rate to those which typified south coast sites 15 years ago. The species may expand into Scotland if climate allows. Other waterbirds, such as great white egret, cattle egret and glossy ibis, all of which use estuaries in winter, are also showing signs of increasing in the UK.

Many of our wintering waders and waterbirds breed in Arctic and subarctic regions that have experienced some of the greatest warming trends around the world in recent years. They are therefore potentially vulnerable to additional impacts of climate change outside of the UK. Recent evidence suggests that changes in the timing or abundance of invertebrate food resources in the Arctic may affect wader productivity (e.g. McKinnon *et al.*, 2012), whilst recent destabilisation of lemming cycles in the Arctic will significantly affect predator populations (Schmidt *et al.*, 2012), with potentially significant impacts on wader and waterfowl productivity, which have previously been tied to such cycles (Summers *et al*., 1998). However, there is little evidence for these processes impacting on wintering wader and waterfowl populations in the UK to date, although this could be due to a lack of specific research in this area, which should be addressed as a high priority.

In addition to climate change, migratory waterbird populations are vulnerable to a range of other pressures and processes. In particular, excessive harvesting by shellfisheries have led to significant increases in oystercatcher mortality and declines in knot, shelduck and oystercatcher populations on The Wash (Atkinson *et al*., 2010). Potentially disentangling these processes from those relating to climate change may be difficult, particularly given likely interactions between the two processes. The effect of severe winter weather on oystercatcher mortality was greatest in years of low shellfish abundance (Atkinson *et al*., 2003). Similarly, coastal development leading to habitat loss may also reduce the condition and survival of displaced birds, even if they move elsewhere (Burton *et al*., 2006). Ensuring appropriate attribution of climate change impacts on these populations is therefore important, but challenging. For example, declining wader populations in Portugal might be thought a response to large-scale climate change leading to northwards shifts in distribution, but instead appears to be better attributed to habitat loss and disturbance at roost sites (Catry *et al*., 2011).

2. WHAT COULD HAPPEN?

Future climate change impacts are likely to affect these species on their breeding grounds, passage areas and wintering grounds, making them likely to be particularly sensitive to future climate change impacts.

On the breeding grounds, climate change projections are for contractions in range extent by the end of the century in response to warming (Huntley *et al*., 2007). Based on a selection of twelve widespread waders which winter on the UK coasts, and 21 wintering waterfowl which use coastal habitats to at least some extent, potential future breeding ranges across Europe are likely to be about 50 % less in extent than the current range under an end of century HadCM3 B2 scenario; a lower mid-range scenario based upon a reduced rate of population growth and technological diversification, leading to a doubling of CO_2 emissions from 1990 to 2100 (Nakicenovic and Swart, 2000). This range reduction is calculated from the R scores of Huntley *et al*. (2007), which give the proportional change between future projected 2070-2099 and current ranges as follows (mean for 12 waders, R = 0.49; mean for 21 geese and ducks, R = 0.48; mean for eight divers and grebes, R = 0.69). Many of these species breed in northern Arctic and subarctic environments where warming is projected to be greatest (Wernham *et al*., 2002; Delany *et al*., 2009), and may therefore be particularly vulnerable to change, for example through changes in food resources, predation rates and habitat change. These pressures may indicate that future climate change impacts during the course of this century are likely to reduce the size of the flyway population of many of these species. Precisely how these changes will impact on specific wintering populations will depend on how those individuals redistribute themselves across a changing wintering range (see below).

Future projections of climate change impacts are now available for wintering waterbird populations in the UK as a result of the CHAINSPAN project (Pearce-Higgins *et al*., 2011). Data from France, Ireland, the Netherlands and the UK were used to model the density of 47 wintering waterbird species in response to temperature and precipitation, and used to make projections about how their abundance may change in response to future climate change. Fourteen of the 15 wader species modelled showed positive relationships between winter temperature and density, but negative correlations between summer temperature and density. The same trends were also apparent for wintering waterbirds (including divers and grebes), although less strongly; 14 of 29 species exhibited positive correlations between density and winter temperature, compared to five with negative correlations, and 14 of 29 showed negative effects of summer temperature upon density. Positive relationships with winter temperature are probably indicative of the negative effects of cold winter weather on the abundance and survival of wintering waders and waterbirds at the site-level outlined in the previous section. They may therefore directly reflect demographic processes, or indicate potential movements in the distribution of individuals in response to climate change. Interestingly, Dalby *et al*. (2012) suggest that temperature has a weak effect on the winter distribution of dabbling ducks in Europe, which may account for the weaker effect of temperature found for waterfowl than waders. Consistent negative effects of summer warming may initially appear difficult to account for, as this is not the period when the birds are present at the sites. However, there is increasing evidence that such lagged effects may be biologically meaningful and operate through effects on site condition, such as through negative effects of warming on prey abundance (see Pearce-Higgins *et al*., 2010).

Based on the models of Pearce-Higgins *et al*. (2011), future projections are for general increases in the abundance of many migratory waterbird populations across the UK in response to climate change. This is due largely to the positive relationship between winter temperature and abundance. Thus 22 wintering or passage waterbird species populations were projected to increase by more than 25 % by 2050 under a medium emissions scenario compared to 10 projected to decline by more than 25 % over the same timeframe. The species for which projected increases were associated with the greatest confidence were Slavonian grebe, little egret, dark-bellied brent goose, red-breasted merganser, ringed plover, greenshank, sanderling and snipe, whilst knot was the species with the greatest confidence in climate-change mediated population declines being likely. Although these models are relatively simplistic, and underpinned by a wide-range of assumptions, there is evidence across all the species modelled that recent population trends were correlated with the projected sensitivity of those species to future climate change. Further confidence in the results can be derived from the fact that increases were projected to be most apparent in the north and east, reflecting recent trends with respect to distributional shifts described in the previous section. There is, however, some suggestion that declines in Arctic sea ice may be linked to increasing severity of winter weather in Europe (Liu *et al*., 2012), which is not taken account of in these future projections. Were this to happen, for example over the short- to medium-term, then it might be expected to drive a westward shift in the distribution of wintering waders and waterfowl from the continent to Europe to the UK, reversing the direction of the observed shift.

In addition to these impacts, climate change is projected to impact on sea levels through direct thermal expansion, melting ice sheets and increased frequency of storm surges. These changes may reduce the extent of intertidal habitats and saltmarsh (Pethick and Crooks, 2000), leading to an estimated 3,000 ha of habitat loss within 100 years (Ausden *et al*., 2011). Whilst the extent of saltmarsh habitats are showing a strong declining trend around England, this appears largely to result from the interaction between increased storm activity, the reinforcement of hard coastal defence and land reclamation (Pye, 2000; van der Wal and Pye, 2004; Wolters *et al*., 2005). Any loss of saltmarsh in response to climate change would potentially also impact on coastal breeding species such as redshank, whilst loss of shingle breeding areas may affect ringed plovers. Any changes in sea level are projected to alter the shape of estuaries, with potential implications for their character. At sites where there is no sea defence, sea-level rise is likely to widen the estuary, increasing wave action and increasing the grain size of the substrate. This will favour species of sandy rather than muddy sediments (Austin and Rehfisch, 2003). However, where the coast continues to be defended, then the consequences will be more deleterious. For example, at the Humber, a 30 cm rise in sea level is predicted to reduce the area of exposed mudflat by 7 % but the biomass of invertebrate food by up to 23 %, again depending on changes in sedimentation (Fujii and Raffaelli, 2008).

In summary, future warming is likely to improve climatic conditions for many overwintering waders and waterbirds in the UK. This may lead to localised population increases in response to improved overwinter survival. Alternatively, population declines may occur in the UK, as birds increasingly shift north and east to more favourable and productive wintering locations that have previously been too cold. Thirdly, wintering species may be potentially impacted by climate change impacts on the breeding grounds, whilst passage migrants may also be affected by negative impacts of climate change further south. Given the likely magnitude of projected future climate change across the high latitude breeding ranges of many of these species, it is likely that it will be through climate change impacts in the Arctic and boreal regions that the greatest effects of climate change on our internationally important wintering waterbird populations will be manifest.

3. 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:

a. Most research focused on the effects of climate change on waterbirds has been derived from programmes that monitor over-wintering populations, something that we in the UK do especially well. However, the waterbirds that the UK hosts during the winter breed largely in Arctic and sub-Arctic regions where there is a paucity of monitoring. Changes in annual productivity and predation pressure on the breeding grounds may outweigh any changes occurring on the wintering grounds. There is a general consensus amongst scientists that monitoring on the breeding grounds is a priority for the conservation of many of these species. This is a priority that remains unchanged from the previous report card, and potentially could be partially addressed by further analyses of ringing data from individuals caught on the wintering grounds to estimate breeding productivity.

b. To understand changes in waterbird populations in response to climate change it is necessary to develop integrated population models that include annual productivity, adult and juvenile survival and to explore how these are affected by climate change. These are likely to be particularly valuable in order to incorporate potentially contrasting effects of climate change on both productivity and over-winter survival and likely changes in juvenile settlement patterns. This was also a priority listed in the previous report card.

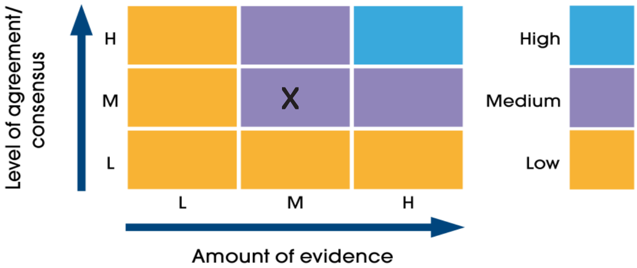
c. Coastal sites are under increasing pressure from other anthropogenic influences, such as fisheries, land reclamation and disturbance. There is increasing evidence that these pressures may interact to exacerbate the negative consequences of severe weather events. With likely increasing expansion of marine renewables, which may also add to the pressures on at least some of these species through either mortality or disturbance, there is an urgent need to continue to quantify these potential impacts and their likely interactions with future climate change.

4. SOCIO-ECONOMIC IMPACTS

Waterbirds are popular with the general public and attract a high level of eco-tourism. Many also represent important quarry species for wildfowlers. Changes in numbers and distributions of these species could affect the importance of particular sites to either birdwatchers or wildfowlers. Many waterbirds are important predators of intertidal invertebrates. In some cases they are seen as competitors with the shellfish industry. Changes in distribution could result in new conflicts. The corollary of this is that waterbirds foraging on intertidal areas occupy a central position in nutrient flow and maintaining the ecological balance. Consequently, changes in numbers in either direction may affect the ecological balance in perhaps unforeseen ways. Many internationally important protected areas, such as Special Protected Areas (SPAs) are designated because of their wintering waterbird interest. Whilst the impacts of climate change on the long-term importance of these sites has been the cause for debate (e.g. Dodd *et al*., 2010), recent evidence suggests that current protected areas will continue to be resilient to climate change impacts in the future. Although the precise species assemblage they support may change, they are likely to continue to support internationally important numbers (Pearce-Higgins *et al*., 2011; Thomas *et al*., 2012), and therefore should continue to be protected.

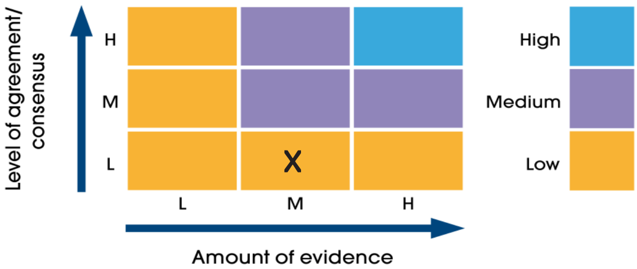
5. CONFIDENCE ASSESSMENT

What is already happening?



Since the last report card, there has been an increasing number of papers continuing to describe changes in the over-winter distribution of waders and possibly wildfowl at a time of warming. Although these do not tend to directly attribute the observed changes in warming, they support the previous studies that do. Therefore, in relation to describing the impacts of climate change on the wintering distribution of these species, the confidence of the assessment has increased to medium, based on a greater amount of evidence. However, there remains relatively little evidence and low consensus with respect to the impacts of climate change on the Arctic and subarctic breeding grounds of these species, despite rapid warming. This reflects a lack of monitoring data from these areas, and research using information from the wintering grounds to infer trends in productivity.

What could happen?



Waterbirds are generally highly mobile and adaptable species. Many species over-wintering in the UK also over-winter in southern Europe and Africa where they inhabit a variety of habitats and feed on a wide range of prey. It is therefore difficult to predict how these species will adapt to climate change on the wintering grounds. Whilst projected future changes in the UK are likely to be for increasing amelioration of the winter climate for these species, it is unclear whether this will lead to increases in abundance here, or shifts in distribution north and east. It is also likely that impacts of climate change on the breeding grounds may become increasingly important in determining the overall abundance of Arctic and subarctic breeding species, but these impacts are highly uncertain. Our confidence in this assessment therefore remains largely unchanged, although associated with a greater amount of evidence.

CITATION

Please cite this document as:

Pearce-Higgins, J.W. and Holt, C.A. (2013) Impacts of climate change on waterbirds, *MCCIP Science Review 2013*, 149-154, doi:10.14465/2013.arc16.149-154

ACKNOWLEDGEMENTS

This review was facilitated by Wetland Bird Survey (WeBS) funds. WeBS is a partnership between the British Trust for Ornithology (BTO), Royal Society for Protection of Birds (RSPB) and Joint Nature Conservation Commitee (JNCC), in association with the Wildfowl & Wetlands Trust (WWT).

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