MCCIP Marine Climate Change Impacts Partnership

Topic

Marine mammals

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Executive summary

- The impact of climate change on marine mammals remains poorly understood. As a result, there has been a great deal of speculation but without very much substantive evidence. That evidence for marine mammals is very difficult to obtain, particularly when there are often synergistic effects from **anthropogenic** activities.

- The strongest predictions of effects involve loss of available habitat, especially ice cover to ice-breeding pinnipeds. This is already thought to affect ringed seals and their main predator, the polar bear, in the arctic.

- In UK waters, environmental changes will likely be reflected mainly in responses to changes in prey distribution and abundance as a result of warmer sea temperatures.

- Apparent range shifts have been observed in a number of **odontocete** cetacean species and these could be associated with changes in water temperatures, but at present it is not possible to differentiate between short-term responses to regional resource variability and longer-term ones driven by climate change.

- A wide range of potential impacts of climate change can be listed, mainly operating through marine mammal prey (**zooplankton**, fish and cephalopod abundance and distribution changes). The relative importance of these and their likelihood of occurrence remains unknown.

Full review

Marine Mammals and Climate Change

As warm-blooded vertebrates with both physiological and behavioural mechanisms developed to respond readily to changes in their external environment, marine mammals might be expected to cope well with most environmental variance predicted from climate change. On the other hand, we would anticipate changes in the availability of their habitat (including food resources) could lead to responses in particular cases. The most obvious example in this context is the reduction in ice cover affecting ice-breeding polar seals such as the ringed seal, and its consequent effect upon predators like the polar bear (Stirling *et al*., 1999; Derocher *et al*., 2004; Ferguson *et al*., 2005). Other predicted physical changes to the habitat include increased sea levels modifying shallow seas. These could affect breeding bays and lagoons of coastal species like the vaquita and grey whale (IWC, 1997), and seal caves and other haul-out sites (e.g. the endangered Mediterranean monk seal – Harwood, 2001). Also potentially vulnerable are dugongs and manatees, humpback dolphins, franciscana, tucuxi, and finless porpoise, all of whose diets appear to be dependent upon shallow-water species (sea grasses in the case of sirenians – see Short & Neckles, (1999); and fishes and invertebrates in the case of cetaceans (Würsig *et al*., 2002). However, in the UK, those conditions are not likely to be important at least in the foreseeable future, and even elsewhere, it may be that new habitats become available or that species adapt within the predicted time scale.

Most likely impacts of climate change on marine mammals will be in the form of range changes through effects upon ectothermic prey. Although most marine mammals appear to have catholic diets, in many cases species distributions fall between particular sea temperature boundaries, and this reflects the range preferences of the major prey organisms upon which they are known to feed (Bjørge, 2002).

What is happening now

Recent warming of the seas around the British Isles has coincided with a northward shift in the distribution of zooplankton (Beaugrand *et al*., 2002; Reid *et al*., 2003) and fish species (Beare *et al*., 2004; Perry *et al*., 2005). Those changes are most evident near the northern or southern boundaries of the species range (Rose, 2005). The same appears to be the case for certain cetacean species, with the typical warmer water dolphins – short-beaked common dolphin and striped dolphin recently extending their shelf sea range further north off western Britain and around into the northern North Sea (Evans *et al*., 2003; MacLeod *et al*., 2005). Other warm water species recorded for the first time in the UK in recent years include Blainville's beaked whale (1993) and Fraser's dolphin (1996), whilst nine out of ten strandings of pygmy sperm whale in Britain & Ireland have occurred since 1980 (Evans *et al*., 2003). However, it is unwise to draw too many conclusions from vagrant records such as these; additional warm water species that were recorded in the UK more than fifty years ago include false killer whale (last stranding in

1935) and rough-toothed dolphin (one stranding only, in 1949).

The ability to detect long-term trends in cetaceans around the UK is limited by the paucity of effort-based sightings data before 1980. The recent multiple presence of short-beaked common dolphin schools off northern Scotland and in the northern North Sea is not entirely new, for example. There have been both strandings and sightings in that region during the 1980s (Sheldrick, 1989; Baines *et al*., 2006), and a marked peak in North Sea strandings was reported during the 1930s (Fraser, 1946). These may reflect decadal climatic cycles such as caused by the North Atlantic Oscillation (which was in a positive phase during those periods, characterised by stronger westerly winds, higher sea temperatures, and milder winters with wetter and stormier conditions (Hulme *et al*., 2002).

Another species reported to have recently exhibited latitudinal range shifts is the white-beaked dolphin, a species of largely cold temperate to arctic waters (Evans *et al*., 2003, MacLeod *et al.*, 2005, 2007b; Baines *et al*., 2006). On the other hand, these may not necessarily be directly related to sea temperature changes but simply reflect changes in the status of particular fish stocks that are favoured prey of the species. Stranding records have shown a significant increase in the southern North Sea since the 1960s, and the species now regularly occurs in the Southern Bight (Bakker & Smeenk 1987, Kinze *et al.* 1997; Camphuysen & Peet, 2006). Likewise, Risso's dolphins (which feed principally upon small cephalopods such as cuttlefish and octopus) are now recorded regularly in the North Sea off East Scotland and Northeast England, after being very scarce here between the 1980s and 2000 (Evans *et al*., 2003; Sea Watch Foundation database). This emphasises the difficulties in interpreting regional changes in status, not only because there are many potential confounding effects (not least being human over-exploitation of fish or squid stocks) but also because those marine mammal species may simply be responding to regional variability in resource availability independent of climate change.

Amongst marine mammals, information on population trends, breeding success and feeding ecology is best for seals. However, at present, there is no evidence that climate change has affected either of the two UK breeding species (grey and harbour seal), although elsewhere in the world, several authors have attempted to link changes in seal population dynamics and life history parameters to climate change (Sun *et al*., 2004, McMahon & Burton, 2005; Forcada *et al*., 2005).

What could happen in the future

Responses both at the individual and population level of marine mammal species to climate change are currently poorly understood. Making predictions about future impacts becomes even more speculative. In the last ten years, a number of marine mammal scientists have attempted to do this (Tynan & DeMaster, 1997; IWC, 1997; Würsig *et al*., 2002; Learmonth *et al*., 2006; Simmonds & Isaac, 2007). The main potential impacts are summarised under the following headings:

Range shifts: As a result of increased sea temperatures, it is thought that species will shift their ranges latitudinally. This may not necessarily result in a negative response, although species with restricted distributions such as the vaquita, river dolphins, bowhead whale, narwhal, and polar seals, may be unable to change their geographic range (Tynan & DeMaster, 1997; IWC, 1997). In the UK, one might expect species like the short-beaked common and striped dolphin to occur more regularly in northern Britain, displacing the white-beaked and Atlantic white–sided dolphin. Cuvier's beaked whale may become more regular in offshore canyons, and there could be more records of warm-water vagrants to North-west Europe (e.g. Bryde's whale, pygmy sperm whale, rough-toothed dolphin, and Atlantic spotted dolphin). Baleen whales (e.g. humpback whale) that move southwards to warmer waters to winter and breed may increasingly do so within UK waters.

Changes to physical habitat: The melting of sea ice clearly poses a threat to those marine mammals (such as seals) that use it for hauling out or breeding, as well as to their predators (Harwood, 2001; Derocher *et al*., 2004; Ferguson *et al*., 2005). Changes to open-water refugia in the ice may affect species like beluga and narwhal (Heide-Jørgensen & Laidre, 2004; Laidre & Heide-Jørgensen, 2005). Rising sea levels may affect shallow water species such as tucuxi, humpback dolphin, and finless porpoise, as well as those species such as the grey whale, calving in shallow coastal bays (IWC, 1997; Würsig *et al*., 2002). In the UK, however, it is unlikely that changes to the physical habitat will affect cetaceans, although some seal haul-out / breeding locations in caves or on low-lying coasts (e.g. Monach Isles for grey seals, parts of The Wash for harbour seals) may be lost or modified. Increases in storm frequency and associated wave surges could exacerbate effects. On the other hand, seals may adapt to these changes and new habitats may be created.

Changes to the food web: Effects of changes to community structure are probably the most difficult to predict. Changes in ocean currents and the positions of associated fronts as well as in ocean mixing, deep water production and coastal upwellings could have profound effects on biological productivity (Walther *et al*., 2002; Stenseth *et al*., 2002, 2004), which in turn is likely to affect top predators such as marine mammals (IWC, 1997; Bjørge, 2002; Würsig *et al*., 2002). Species with restricted diets (such as right whales which feed largely upon copepod aggregations) are thought to be particularly vulnerable (Greene & Pershing, 2004; Leaper *et al*., 2005). However, in most cases it is hard to determine how those changes would impact particular marine mammal species (Trites *et al*., 2006).

More complicated scenarios include mismatches in synchrony between predator and prey, either in time or location (Edwards & Richardson, 2004). This uncoupling of phenological relationships at different trophic levels is thought to have been responsible for recent failures in sandeel recruitment in the North Sea (Arnott & Ruxton, 2002) and consequent breeding failures amongst several UK seabird species largely dependent on sandeels (Rindorf *et al*., 2000; Frederiksen *et al*., 2004, 2005; Wanless *et al*., 2005; Mavor *et al*., 2006). There has been much speculation that the recent shift in abundance of harbour porpoises from the northern to southern North Sea may be due to a shortage of sandeels, a known prey item, and this has led to suggestions of food starvation amongst stranded porpoises (MacLeod *et al*., 2007a) although some arguments have been made that there is little evidential support for this conclusion (Thompson *et al.*, 2007). At present, we have little idea to what extent species like the harbour porpoise have particular dietary preferences although high-energy shoaling fish such as herring, sprat and sandeel often form important components of porpoise diet (Santos *et al*., 2004; Evans *et al*., 2007).

A number of findings indicating potential effects on other marine taxa could also impact upon marine mammals through the food chain. Examples include reductions in salinity, increases in CO_2 and consequent decreases in pH particularly affecting cephalopods (Boyle, 1983; Pörtner *et al*., 2004; Royal Society, 2005). Several marine mammal species feed either exclusively or to a large extent upon cephalopods.

Susceptibility to disease and contaminants: Global warming has been implicated in the worldwide increase in reports of diseases affecting marine organisms, including marine mammals (Harvell *et al*., 2002; Geraci & Lounsbury, 2002; Lafferty *et al*., 2004). Climate change has the potential to increase pathogen development and survival rates, disease transmission, and host susceptibility (Harvell *et al*., 2002), whilst higher temperatures may stress organisms, increasing their susceptibility to some diseases (Lafferty *et al*., 2004).

The frequency and severity of toxic algal blooms are also predicted to increase as a result of nutrient enrichment (increased rainfall and freshwater runoff) and increased temperature (Peperzak, 2003). Mass die-offs due to fatal poisonings have been reported in several marine mammal species, for example Mediterranean monk seals, California sea lions, bottlenose dolphins, and Florida manatees (Hernández *et al*., 1998; Geraci *et al*., 1999; Scholin *et al*., 2000; Geraci & Lounsbury, 2002; Domingo *et al*., 2002).

Finally, there are some suggestions that habitat degradation may occur through effects of climate upon pollutant burdens (MacDonald *et al*., 2005).

As yet, most of the above predictions remain speculative and unsubstantiated by unequivocal evidence. This reflects the difficulties in studying marine mammals, using experimental approaches to test hypotheses, and disentangling various potential confounding variables.

Confidence assessments

'What is already happening' – Low

'What could happen in the future' – Low

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

Our knowledge of gross status changes is good for seals but moderate-poor for cetaceans, whilst our understanding of links between demography and climate for both groups is poor. We therefore can only have a low level of confidence in what is happening now in relation to climate. As for what may happen in the future, without any clear understanding of impacts on marine mammals, in most cases it is impossible to make confident predictions.

Some marine mammal scientists are more confident than others that we are witnessing ecological effects of climate change as opposed to responses of individuals and local populations to local environmental variability. The statistical power to discriminate between the two remains low. Although more could be done to improve the current level of confidence, there will always be an upper limit to our ability to link population changes to the physical or biological drivers associated with climate change, particularly for some of the less accessible cetacean species.

Knowledge gaps

- A pre-requisite to assessing impacts of climate change on marine mammals at a population level is a long-term, wide-ranging, monitoring programme that can discriminate between regional population responses and those occurring on a wider geographical scale. This is presently lacking for all UK cetacean species, whilst for seals there remain regions (e.g. Irish Sea) with only patchy coverage.

- Our knowledge of trends in basic life history parameters (growth rates, age at sexual maturity, reproductive rates, and mortality) for all cetacean species with the possible exception of harbour porpoise is woefully inadequate, based upon small sample sizes from a restricted number of areas, and without long-term continuity of data. For the majority of species, we are unlikely to obtain adequate information in the foreseeable future given how difficult they are to study and the resources available to do so. However, certain species could be targeted for more intensive study with some likelihood of success. In UK waters, these include (in addition to harbour porpoise) bottlenose dolphin, short-beaked common dolphin, white-beaked dolphin, Risso's dolphin, and minke whale.

- Functional responses to environmental change through physiological and behavioural mechanisms are also poorly understood for most marine mammal species. For this, seals are rather better suited to experimental studies where variables can be controlled. Once individual responses are better understood, it may be possible to make predictions at the population level.

- Too little is known about how changes in fish, cephalopod and plankton dispersion, distribution and abundance may affect the foraging ecology of particular marine mammal species. Often, one of the major gaps in information lies in the lack of data for non-commercial fish and cephalopod species, although even for some commercial species, such information is lacking.

Commercial impacts

No marine mammal species in the UK is exploited directly, although changes in the status and distribution of marine mammals could potentially have commercial effects if species that are targeted by the ecotourism industry become scarce, or alternatively if there are changes in competitive relations (e.g. an increase in seal predation upon commercially important fish).

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