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## Starvation and sandeel consumption in harbour porpoises in the Scottish North Sea

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### References

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## Invited reply

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Based on the evidence of a link between the likelihood of starvation and a lack of sandeels in the diet of porpoises in the Scottish North Sea in spring, we suggested that if climate change has a negative effect on sandeel availability, this could result in more starving porpoises in this area (MacLeod *et al.* 2007). In their reply, Thompson *et al.* (2007) raise a number of concerns and suggest that our study may confuse current conservation efforts for porpoises.

In European waters, conservation efforts primarily focus on fishery by-catch, disturbance, biocontaminants, distribution and changes in abundance (Hammond *et al.* 2002). While impacts of food availability on seabirds have received much attention, little consideration has been given to its effects on porpoises and other small cetaceans. We have been careful to stress that our conclusions were based on a small dataset from a localized area but we argue that highlighting a possible concern worthy of further research is a positive contribution to conservation.

Thompson *et al.* query the biological significance of our findings. Although the sample size was small, the relationship was sufficiently marked to be of note and was statistically significant. While percentages are used in the text, statistical analysis was based on frequencies and readers could readily reconstruct actual numbers from information provided.

Thompson *et al.* suggest that the sampling unit for analysing diet should be individual porpoises rather than number of sandeels recovered from all stomachs. The relative merits of different quantification methods are well documented (e.g. Pierce & Boyle 1991). Giving similar weights to individuals containing one sandeel and many other prey and to individuals only containing many sandeels alone could give a misleading impression of the overall dietary contribution of sandeels. Thompson *et al.* correctly assert that many small sandeels could have been replaced by fewer, larger prey to give a similar energy intake. This was investigated (although not originally reported) and there was no evidence that this occurred (e.g. mean prey length was 10.5 cm (s.d., 5.0 cm) March 1992–2001 and 8.8 cm (s.d., 4.0 cm) March 2002–2003).

Thompson *et al.* contend that the increase in the proportion of starving porpoises could arise from decreases in other causes of death. Repeating the analysis using three cause of death categories (trauma (bottlenose dolphin kills/by-catch), pathological and starvation), the significant difference ( $\chi^2_2 = 17.6$ ;

$p < 0.0001$ ) is solely driven by a higher number of starved animals in spring 2002–2003 than expected ( $\chi^2_1 = 11.48$ ;  $p < 0.0001$ ).

We agree with Thompson *et al.* that the relationship between diet and likelihood of starvation requires further research and a larger sample size, although we suspect that the phenomenon is limited to spring in the Scottish North Sea (due to variations in the importance of sandeels in porpoise diet in space and time—Santos *et al.* 2004). Thus, bringing in data from other geographical areas and times of year may conceal any more spatio-temporally limited relationship, and the only option to increase the sample size is to wait for more animals to strand in spring on Scottish North Sea coasts.

As Thompson *et al.* point out, climate change is not the only factor affecting local sandeel abundance. There has been an increase in sandeel biomass in the Firth of Forth since the closure of the industrial fishery in the North Sea in 2000 (Greenstreet *et al.* 2006), although other sandeel aggregations remain depleted particularly in the northern North Sea and sandeel spawning stock biomass in the North Sea as a whole has been below the safe biological limit since 2001 (Anonymous 2006). It has also been suggested that there is a link between climatic conditions and the size and energy content of sandeels in the Scottish North Sea (Wanless *et al.* 2004), and this could contribute to an increased likelihood of starvation even if the overall biomass increases. Similarly, the effect of climate on the timing of key events may negatively affect sandeel availability at critical times and lead to an increased likelihood of starvation despite local increases in biomass.

We stand by the core finding of our study that there appears to be a link between sandeel consumption and the likelihood of starvation for porpoises in the Scottish North Sea in spring, but agree that more research is needed to confirm this relationship, and the extent to which it applies to the porpoise population as a whole. We feel that highlighting this issue is a positive contribution to conservation efforts for porpoises in the Scottish North Sea.

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