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Review of New Information on Pollution, Underwater Sound and Disturbance

Document 56

Disappearing bottlenose dolphins (*Tursiops truncatus*) – is there a link to chemical pollution?

Action Requested

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Disappearing bottlenose dolphins (*Tursiops truncatus*) – is there a link to chemical pollution?

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ABSTRACT

A strong association has been found between poor health status (mortality due to infectious disease) and chemical contamination for a large sample of UK-stranded harbour porpoises (*Phocoena phocoena*) collected since 1990. This association exists for blubber concentrations above 17 ppm total PCBs lipid weight. Bottlenose dolphins (*Tursiops truncatus*) in the same region and time period show even higher levels of contamination – up to one order of magnitude higher PCB levels in blubber. The gradual temporal decline in PCB levels in UK-stranded harbour porpoises since 1990 indicates that, historically, levels of exposure in both porpoises and bottlenose dolphins would have been even higher than at present. We consider the available evidence that shows a decline in bottlenose dolphins at the peak time for PCB exposure and theorise the likely link between these two matters.

Key words: PCBs, porpoise, *Phocoena phocoena*, bottlenose dolphin, *Tursiops truncatus*, pollution, health, thresholds

INTRODUCTION

It has long been known that cetaceans and other marine mammals can accumulate high levels of a wide range of chemical pollutants, such as the polychlorinated biphenyls (PCBs) and certain pesticides, including dichlorodiphenyltrichlororthane (DDT), that are persistent, bioaccumulative and toxic (see for example Wageman and Muir, 1984; Reijnders *et al*., 1996 and papers therein). Whilst the presence of a complex variety of toxic compounds, sometimes described as a 'cocktail' of contaminants, is now possible to verify in body tissues, the consequences of their presence are far less apparent. The importance of determining what levels can cause significant adverse physiological affects is, however, clear and such information can allow an evaluation of the vulnerability of populations to be made and help to inform conservation and management plans. However, this is a difficult task given that a range of compounds that are involved and that they may exert their influences via various mechanisms which may enhance or inhibit the toxicity of each. Reijnders (1996) provided a helpful review including listing a number of case studies where disorders have been linked to high pollutant levels in cetaceans. These included liver disease in bottlenose dolphins, *Tursiops truncatus*, associated with mercury accumulation; reproductive problems in beluga whales, *Delphinapterus leucas*, linked to high levels of lead, mercury, PCBs, DDT and their metabolites; a suite of pathological disorders indicating lowered immunocompetence in the same species caused by high levels of organochlorines, including PCBs; and suppressed testosterone in male Dall's porpoises, *Phocoenoides dalli*.

Various attempts have been made to establish risk assessment criteria for exposure to pollutants for cetaceans mainly based on concentrations found in body tissues (Simmonds, 2003). For example, several decades ago, Wageman and Muir (1984) suggested, based on their evaluation of the literature available at this time, that total PCB concentrations of more than 50 parts per million (ppm) wet weight might pose a health risk to cetaceans. More recently, Weisbrod *et al.* (2000) looked at this issue for the endangered Northeast Atlantic right whale, *Eubalaena glacialis*, population. They reported total PCB values of 5.7 ± 8.9 ppm lipid weight and total pesticides of 11.4 ± 15.4 ppm lipid weight. Based on studies on other marine mammals, where there was evidence of immune problems and endocrine (and other alterations) correlated with total wet weight PCB concentrations of >20ppm and >60 ppm, respectively, Weisbrod *et al*. (2000) concluded that the levels that they were seeing were significantly lower than those causing impacts in studies on other animals and, hence, they did not have evidence that the endangered whales were exposed to hazardous pollution levels. Weisbrod *et al*. (2000) used the same criteria as O'Shea and Brownell (1994) who had earlier made a similar conclusion in their evaluation of risk to a range of baleen whales, noting that most blubber residue concentrations were less than 5ppm (although they also noted many higher values in the literature).

Another approach that has been used to assess cetacean pollution burdens is 'Toxic Equivalency'. This calculates a combined toxicity factor for certain highly toxic compounds that accumulate in tissues, including the dioxin-like PCBs, and then sums them together to give an overall value (for more details of this approach see Simmonds, 2003). One interesting result from this approach is that it shows that in many environmental samples it is the PCBs (rather than the dioxins or furans) that are the main contributors to the final value calculated.

Kannan *et al*. (2000) suggested a level of 17 ppm total PCBs (lipid weight) as a "threshold" tissue level of concern for cetaceans; based on a review of physiological effects seen in otters, seals and other species. However, only very recently has strong evidence been available directly from cetaceans to support using such a tissue threshold concentration for risk assessment. This comes from investigations of a large number of UK-stranded harbour porpoises that were analysed using internationally standardised methodology for necropsy and pollutant analyses (Jepson *et al*., 2005; Hall *et al*., 2006a). These investigations showed that significant associations between elevated PCBs levels (sum of 25 individual chlorobiphenyl congeners) and animals that died of infectious diseases, but that these associations only occurred in porpoises with total PCBs level exceeding the 17ppm total PCBs threshold as proposed by Kannan *et al.* (2000).

The IWC has also supported a programme of work (known as Pollution 2000+) to look at pollutants in cetaceans, seeking to elucidate causal-effect relationships, particularly with respect to the potential affects of PCBs on reproduction, retinoid levels and some immune system variables (IWC, 2007). To date the work has focused on bottlenose dolphins and a potential relationship between some immune system bio-indicators and PCB blubber concentrations has been found in Sarasota Bay animals. The IWC has also published a special volume 'Chemical Pollutants and Cetaceans' (Reijnders *et al*., 1999).

BOTTLENOSE DOLPHIN DISTRIBUTION CHANGES

It appears that bottlenose dolphins have declined in the Northeast Atlantic. At the current time, there are well established, but small, populations in the Moray Firth, in Scotland, Cardigan Bay in Wales, on the coast of Brittany in France and in the Shannon Estuary in Ireland and the Brittany Coast in France (Reid *et al*., 2003). There are also regular sightings of bottlenose dolphins off Cornwall, Devon and Dorset. The historical occurrence of bottlenose dolphins off southwest England has been carefully investigated and there is good evidence that they were missing probably from the late 1970s and only returned in September 1991 (Tregenza, 1992). This particular group appears to have decreased from some 30- 40 animals in the 1990s when they were studied by Wood (1998) to only about 12 now (Tregenza pers obs.).

There is also evidence that bottlenose dolphins were once present in the southern North Sea where they now appear to be absent except for occasional transitory visits. Haelters (2005), for example, has reviewed the data for the Belgian coast and concluded that bottlenose dolphins occurred off the Belgian coast at least in the 1930s and the 1960s-1970s, but apart from occasional vagrants, are no longer present.

The long term records of cetacean strandings in the UK support a declining bottlenose dolphin population in UK waters. Data collected by The Natural History Museum, London since 1913 show that in the late 1960s, and through the 1970s and 1980s, there was a reduction in the overall number of bottlenose dolphin strandings in the UK compared to data collected from previous decades (Sheldrick 1989; Sheldrick *et al.* 1994) (Table 1.). In the same period there was an apparent contraction in the geographic range of strandings in the UK. For example, since records began in 1913 bottlenose dolphins have stranded in the Morecambe Bay region of NW England in every decade until the late 1960s. Since then, strandings of bottlenose dolphins have been extremely rare events in this region (Sheldrick 1989; Sheldrick *et al.* 1994, Jepson 2005). Despite significantly increased observer effort since 1990 after the UK Government began funding systematic investigations of cetacean carcasses stranded in the UK, bottlenose dolphin strandings are still effectively absent from most UK regions (Jepson 2005).

Evidence has been found for a similar but earlier decline in harbour porpoises in the same area (Tregenza, 1992), consistent with a failure of recruitment in a shorter lived species. Porpoises were recorded from estuaries and rias around the English coast and disappeared from those in Cornwall in the 1950s to 1960s. Rias in which they had been persecuted as pest species by salmon fishermen still have no, or very infrequent, sightings of porpoises and the prey species of porpoises in these locations are likely to have included eels, which are known to have carried very high burdens of OC pesticides (Tregenza pers comm.).

IS POLLUTION TO BLAME?

There are many factors that may be negatively impacting on coastal bottlenose dolphins, including bycatch in fishing nets and disturbance from increased commercial and leisure shipping. Lipid soluble persistent pollutants are known to be rapidly transferred to and accumulate in young while they are fed milk by contaminated mothers. This may cause a failure of recruitment of offspring to the population. Cockcroft *et al*. (1989) reported on organic contaminants in a large sample of bottlenose dolphins killed in shark nets off the east coast of South Africa. They noted the very rapid transfer of these pollutants to calves via mothers' milk, illustrating that the first born calves would usually receive the greatest load. Cockcroft *et al.* suggested that the levels of pollutants that this population was encountering presented a risk to fertility and health (especially of the young), and postulating a possible mortality of these calves. They concluded that the management of these animals, which they noted were already stressed by other factors, including the high toll of the shark nets, should take pollution into account.

Risk assessment analyses have also been conducted for reproductive impairment in coastal bottlenose dolphin populations in US waters (Schwacke *et al*., 2002; Hall *et al*., 2006b). These studies predicted high levels of neonatal mortality in primiparous females in three coastal bottlenose dolphin populations. These studies are also highly consistent with empirical observations of first calf mortality in bottlenose dolphins in Sarasota Bay, Florida that was associated with higher PCB levels in primiparous females and their calves (Wells *et al*., 2005).

So, there are two main reasons for suspecting that chemical pollution may be a primary determinant in the demise of this species in the waters of northern Europe, and potentially elsewhere:

- Firstly, the very high PCB burdens seen in bottlenose dolphins in the UK (figure 1.), noting that levels would have been even higher than this previously. At this level of contamination we would expect there to be physiological consequences for these animals, potentially including suppression of immune and reproductive function; and
- Secondly, whilst trends in PCBs and other organochlorines in the environment are complex, the likely time of the demise of this species in the region appears to coincide with the peak period of PCB contamination from the late 1960s onwards.

Aguilar *et al*. (2002) comment that when data from the 1970s to the 1990s are considered, levels of all organochlorine compounds in the blubber of cetaceans and pinnipeds often show decreasing trends in the Baltic Sea, the North Sea, the Mediterranean Sea, the Atlantic and Pacific coasts of the USA and Canada, and the Sea of Japan. The use of PCBs was discontinued in the 1970s but there was no immediate replacement, enforcement of controls was poor and they lingered in use. Furthermore, Aguilar *et al*. (2002) stressed their high stability making their disposal costly and difficult, causing large quantities to be stored and also a movement of capacitors containing PCBs from developed countries to developing ones. They supported the notion that PCB levels in marine biota are unlikely to decline significantly in the near future, and certainly not before 2010–2030. In addition, the mass deployment of monofilament gillnets from the 1970s onwards, appears to follow the start of the decline in bottlenose dolphins, which would seem to suggest that fisheries were not to blame for the onset of this decline.

CONCLUSION

Whilst it is inevitable that many factors will act together to affect cetaceans, we suggest that chemical pollution has been and remains a major factor in suppressing their populations. The notion that organic chemical pollution is a significant threat to marine mammals in general and bottlenose dolphins in particular is not a new one. For example Cummins (1988) raised concerns about PCB disposal and an extinction risk to marine mammals. He emphasised the very high levels of PCB contamination being reported at that time from some odontocetes

The risk that we postulate here for bottlenose dolphins in the North East Atlantic is likely to also be true for similarly contaminated bottlenose dolphin populations elsewhere in the world – meaning those living adjacent to highly industrialised coastlines, and whilst there is likely to be some degree of variation in response to toxic substances between species, such concerns may well affect other species too.

PCBs are now slowly declining in the North-east Atlantic. However, they remain an important threat and conservation plans need to take into account their effects.

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Table 1. Strandings of bottlenose dolphins in the UK 1913-2007.

YEARS	TOTAL UK	MORECAMBE BAY
1913-20	19	2
1921-30	28	2
1931-40	44	2
1941-50	27	2
1951-60	37	15
1961-70	41	17
1971-80	26	0
1981-90	15	0
1991-2000*	59	0
2001-2007*	59	3

* From 1990 onwards, the reporting effort for cetacean strandings increased significantly due to the initiation of UK government funding for the systematic recording and post-mortem examination of UK-stranded cetaceans.

Figure 1. Contaminant levels in harbour porpoises, *Phocoena phocoena*, and bottlenose dolphins, *Tursiops truncatus*, sampled around the UK.