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Viewpoint

Developing water quality standards for coastal dolphins

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Abstract

The EU Habitats Directive requires Member States to consider the potential impact of sewage discharges on protected wildlife populations, but efforts to reduce these threats are constrained by the lack of appropriate water quality guidelines for wildlife. In Scotland, recommendations for higher discharge standards in areas frequented by bottlenose dolphins have been criticised on the basis of scientific uncertainty. This Viewpoint article outlines the background to this issue, and discusses whether the scientific frameworks used for assessing water quality standards for human bathers can realistically be used to develop water quality standards for coastal dolphins. Importantly, it highlights that widely accepted EU standards for human bathers are based on extremely limited scientific data, and argues that unrealistic demands for empirical data from wildlife populations should not prevent more precautionary measures being introduced to reduce disease risks to these species.

Keywords: Sewage; Dolphins; Habitats directive; Bathing water; Disease

1. Introduction

Cetaceans are potentially vulnerable to a wide range of human and livestock pathogens (Britt et al., 1979; Buck, 1980; Minette, 1986), and the presence of chemical markers (Kannan et al., 2005) and antibiotic resistance (Stoddard et al., 2005) in marine mammals also point to direct contact with sewage effluent. However, whilst there is widespread agreement over the need to reduce potential impacts of sewage and other contaminants on these species (Simmonds and Hutchinson, 1996; Scott and Parsons, 2005), a lack of data on the extent of these risks constrains efforts to improve the quality of those coastal waters frequented by cetaceans.

Recently, requirements under the EU Habitats and species directive have focused attention on this issue. In Scotland, there is currently extensive investment in new sewage treatment works to meet the requirements of the EU Urban Waste Treatment Directive. Several of these works are within, or adjacent to, a Special Area of Conservation (SAC) that was designated in 2005 to protect the small and vulnerable population of bottlenose dolphins (*Tursiops truncatus*) that occurs along the east coast of Scotland (http://www.jncc.gov.uk/ProtectedSites/SACselection/). Numbering only around 130 individuals, this is not only the most northerly resident *Tursiops* population, but also the only resident population remaining in the North Sea (Wilson et al., 1999). As one of the few SAC's designated to protect this Annex II listed species, the Moray Firth SAC therefore plays a vital role in the Natura 2000 network, as well as offering significant economic advantages for an expanding ecotourism industry in the Scottish Highlands (Woods-Ballard et al., 2003).

2. Appropriate assessments for sewage discharges under the EU Habitats Directive

Like all new activities that pose a significant risk to species or habitats protected within SACs, new sewage treatment schemes require an *appropriate assessment*; an evaluation of the schemes' potential impact on the site's conservation objectives. Importantly, appropriate assessments within SACs go beyond traditional environmental

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assessments, because the burden of proof is on competent authorities to ensure that the development will not affect the integrity of the site. Appropriate assessments for the upgrading of existing sewage outfalls, many of which currently have little or no existing treatment, have raised particular challenges. There is no doubt that these schemes should provide improvements in local water quality, thereby benefiting recreational users, bottlenose dolphins and other wildlife. But this in itself may be insufficient to guarantee a projects' approval under the EU Habitats Regulations. Alterations to an existing outfall demand the same level of assessment as an entirely new development. Because conditions at some existing outfalls are so poor, even moderate improvements in water quality may be insufficient to reach the standard at which the future health of protected dolphin populations can be assured. The problem here, is determining precisely what this standard should be. Whilst there are accepted water quality standards for human bathing and recreation, no equivalent guidelines exist for cetaceans or other wildlife species.

3. Scientific frameworks for assessing water quality standards

Ideally, one should base water quality standards for wildlife populations on a similar scientific framework to that developed for humans. But is this realistic and practical for cetaceans? The latest World Health Organisation (WHO) framework for setting bathing guidelines (Kay et al., 2004) requires two key pieces of scientific data. First, epidemiological data to estimate the dose–response relationship relating risk of infection to swimmers to different bacterial concentrations in their bathing water. Secondly, sampling data that describe the probability density function of bacterial concentrations in bathing waters, and which are then used to estimate the probability that bathers will be exposed to bacterial concentrations above a certain limit. Building upon these scientific data, policy decisions must then be made on acceptable levels of risk to the bathing population. Only once these policy decisions are agreed can the dose–response curve and distribution of bacterial concentrations be integrated to calculate appropriate water quality standards. Applying this framework to dolphin or other wildlife populations is far from straightforward. Whilst anecdotal data from veterinary records or post-mortem studies can identify some of the human pathogens posing a risk to cetaceans (e.g., Britt et al., 1979; Buck, 1980; Minette, 1986; Parsons and Jefferson, 2000), no data exist to estimate dose–response relationships. Indeed, it is currently impossible to identify a study design that would allow one to directly collect such data from free-living dolphins. There are only a few areas worldwide where dolphins can be routinely captured and released to assess health status (e.g., Harper et al., 2003; Wells et al., 2005). But, more importantly, these data cannot be reliably linked with information on those individuals' previous contact with different water bodies. Realistically then, this framework can only be applied if we accept that data from more tractable systems are used as a proxy for assessing potential rates of infection in dolphins. Using inference from model systems is widely accepted by scientists, but has often been challenged by politicians and managers who prefer to see any water quality guidelines for wildlife based upon scientific data relating directly to the system of interest. Yet current water quality guidelines for human bathers also rely heavily on data from a few model systems. An extensive review of all suitable epidemiological data by the WHO (Pruss, 1998) identified only two studies that could be used to provide suitable dose–response relationships for human swimmers, both based upon the same single randomised trial involving adults from the UK (Kay et al., 1994). The most recent WHO guidelines are therefore underpinned by a dose–response relationship for one model system, using rates of gastroenteritis as a proxy for other more serious diseases that could be contracted from contaminated waters (see also Fleisher et al., 1998). Furthermore, as the authors of the WHO guidelines highlight, this study involved only healthy adult volunteers, and further data are required from younger bathers to assess risks to children. For ethical reasons, bathers could only be asked to swim in waters that routinely met bathing water standards, so the form of the dose–response relationship at higher levels of bacterial contamination also remains unknown (Kay et al., 1994). Thus, whilst robust scientific frameworks now exist to identify suitable water quality standards for human bathers, there are few data available, even for humans, to parameterise these models. As a result, they too depend upon extrapolation from model systems (one randomised trial) and the use of proxy indicators (incidence of gastroenteritis).

4. Meeting the requirements of the EU Habitats Directive; a pragmatic interim approach?

The responsibility for providing the Scottish Executive with advice on conservation issues such as this lies with Scottish Natural Heritage (SNH). In the absence of suitable water quality standards for cetaceans, SNH has argued that nationally agreed standards for human recreational waters should be applied to those areas used most intensively by dolphins. These are essentially the same microbiological standards as those required by the EU for bathing waters in summer, but Scottish recreational standards require that these standards are met throughout the year. Using existing data from boat based surveys (Wilson et al., 1997), SNH have identified three key areas that are regularly frequented by dolphins in the Moray Firth SAC. There remains some uncertainty over the precise boundaries of these areas, but their importance to these animals is also supported by research on fine-scale movements (Mendes et al., 2002), vocal behaviour (Janik, 2000) and surface behaviours (Hastie et al., 2004). The extent to which this behaviour has brought these dolphins into contact with sewage contaminated waters is highlighted in the most inshore of these areas, the Kessock Channel (Mendes et al., 2002). Until

2000, untreated sewage from Inverness' population of 50,000 was discharged into this channel. At the same time, studies showed that many dolphins visited the area daily during the summer months, and photographic studies of naturally-marked dolphins confirmed that up to 30% of the whole population could visit the area in a single season (Thompson et al., 2000a).

In the absence of internationally agreed water quality standards for cetaceans, SNH's proposal that areas with exceptionally high levels of dolphin activity should meet recreational water standards therefore seemed sensible. The suggestion was certainly welcomed by the Scottish Environmental Protection Agency (SEPA). Whilst recognising that the approach was not ideal, it at least provided SEPA with clear guidance on the treatment levels that they would require to meet their obligations under the EU Habitats Directive. Nevertheless, this approach has been challenged on two main counts. The first relates to the precise boundaries of the areas frequented by dolphins. To a large extent, this problem simply results from a reliance on dolphin distribution data that have been collected for other purposes. Techniques for providing more robust estimates of the dolphins' spatial distribution across the SAC are well established and could certainly be collected if time and resources permitted. The second challenge questions the scientific basis for using human recreational water quality standards as a proxy for cetaceans; the implication being that these standards were excessively high, even for the small areas (<1% of the total area of the Moray Firth SAC) currently considered as areas regularly frequented by dolphins. The limited scientific data underpinning the proposed use of human water quality standards for dolphins has been recognised throughout this process. But many stakeholders who have criticised this precautionary approach to protect wildlife appear unaware of the limited scientific data underpinning the well accepted human bathing water standards. As Kay et al. (2004) highlight, there is no epidemiological rationale for the microbiological standards for human bathing waters specified in the EU Directive 76/60/EEC. Furthermore, recent revisions to these standards were investigated by a UK House of Lords Select Committee, which also highlighted that they were not based on any clear scientific data. Overall, Kay et al.'s (2004) evaluation of the basis of human recreational water quality standards in both Europe and North America suggests that scientific data underpinning all existing standards are either lacking or have been discredited. The new WHO guidelines provide a much stronger framework that places policy decisions on acceptable levels of risk within a firm scientific framework. However, as the authors highlight, the guidelines are not perfect, and they clearly lack the scientific certainty being demanded of those stakeholders who are promoting improvements in water quality standards to protect cetaceans. Even if estimates of exposure levels and dose response curves for cetaceans were available, the establishment of water quality guidelines would still require these scientific data to be subject to policy decisions on acceptable levels of risk. In the case of the new WHO guidelines, the scientific data were used to determine appropriate water quality standards for four bands of acceptable risk; ranging from the equivalent of 1 in 100, to 1 in 10, bathers acquiring gastroenteritis after a single ten minute exposure (Kay et al., 2004). In our context, it is interesting to consider whether either the regulators or the public would accept a 1 in 10 (or even a 1 in 100) risk of a dolphin being infected with a human pathogen each time it spent 10 min in an area meeting recreational water quality standards.

5. Further research needs

It is not currently possible to draw upon scientific studies to determine whether or not human recreational water quality standards are excessively stringent for areas used by dolphins. SNH's response to this criticism has been that, given these uncertainties, it is most appropriate to take a precautionary approach. The dose–response curve underpinning the new WHO guidelines is based on infection rates resulting from a standard exposure of just 10 min, during which bathers each immersed their head three times. Given that this level of exposure is likely to be low compared with that experienced by many coastal cetacean populations, SNH's precautionary approach seems entirely appropriate. Future research should now aim to provide better quantitative estimates of the extent to which individual dolphins are exposed to waters of differing bacterial quality, requiring analysis of data on individual dolphin movement patterns, and estimates of the amount of time that animals spend in key areas. In addition, microbiological sampling beyond the usual bathing beaches and outfall pipes, is required to provide data on bacterial levels throughout those areas that are regularly used by dolphins. At the very least, these data can then provide a more informed comparison of the extent to which individual dolphins and individual bathers may be in contact with waterborne pathogens that occur in these coastal areas.

Reviews of the human epidemiological studies have highlighted how difficult it has proved to obtain good scientific data to underpin water quality guidelines for human bathers (Pruss, 1998). Realistically, it will be impossible to collect data from most wild populations to estimate cetacean dose–response relationships in European waters. On the other hand, it might be possible to use other local species as a proxy for cetaceans. Seals can be relatively easily handled, allowing epidemiological studies to be based upon blood and microbiological samples obtained from wild populations (Thompson et al., 2002; Stoddard et al., 2005). The prevalence of some indicator pathogens could also be determined through analyses of faecal samples (Kullas et al., 2002; Clough et al., 2003), which can be routinely collected from seals at their resting sites without having to handle the animals. In areas like the Moray Firth SAC, where seals share the same coastal habitats as cetaceans, such studies could provide better insights into the extent to which marine mammals are exposed to pathogens from humans and livestock.

More scientific data could therefore help us develop water quality guidelines for cetaceans within this and other marine protected areas. Nevertheless, as argued by SNH, an absence of such data should not prevent steps being taken to improve water quality in these areas. Similarly, the lack of direct evidence that sewage contamination adversely impacts these populations should not be seen as a reason for delaying positive management measures. Programmes established to monitor changes in cetacean abundance or survival have low statistical power to detect change, and their populations can reach dangerously low levels before any direct evidence emerges (Thompson et al., 2000b). Furthermore, even if negative population trends or unusual disease syndromes are identified, these may be influenced by many different factors, and there can remain considerable uncertainty over the key causative factors.

Recognising these problems, the multi-agency management plan for the Moray Firth SAC identified the need to take positive management measures to reduce potential threats. In practice, however, efforts to reduce the potential impact of sewage contamination have focused on case-by-case evaluations for each individual sewage treatment scheme. As some schemes cater for just a few hundred people, whilst others serve populations of up to 50,000, their potential impact on local water quality varies enormously. Yet despite the close proximity of several of these schemes, and the requirement to consider cumulative effects, each appropriate assessment has been made in isolation. Not only has this led to inefficiencies in the assessment process, but this lack of co-ordination makes it less likely that effort, and money, will be invested in ways which will provide the greatest overall benefit to water quality in those parts of the Moray Firth SAC most regularly used by the dolphins. In particular, heavy investment in treatment works for small towns may play only a very limited role in improving local water quality. What is now urgently needed is a more strategic view of the current state of the water quality within this and similar protected areas, and identification of the main sources of contamination from both point sources and diffuse inputs (e.g. see Wither et al., 2005). Ideally, this should be integral to the appropriate assessment procedure, such that actions to reduce inputs from other sources could be put forward as mitigation that balances decisions to retain lower levels of treatment within smaller communities. Without this strategic view, it will remain impossible to develop cost-effective actions to target those sources of microbiological contamination most likely to adversely impact protected cetaceans and other wildlife.

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