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Crossing boundaries for cetacean conservation: Setting research priorities to guide management of harbour porpoises

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ABSTRACT

Effective management of natural resources involves a multidisciplinary perspective to address complex issues in data poor-environments. With mobile species that do not conform to human-defined borders a cross-boundary approach is essential. There is a continuing concern of ecological sustainability of marine environments, which demands monitoring of ecosystem indicators. Such indicators are increasingly derived from monitoring sentinel species. Harbour porpoises (*Phocoena phocoena*) are included as indicator species in several national and international agreements. Increasing exposure to anthropogenic stressors may impact harbour porpoise populations. To investigate these risks, a better understanding of threats and their effect is required. This study aimed to identify current knowledge gaps, to predict future pressures or threats, and to define useful conservation indicators to facilitate future research on harbour porpoises in the North Sea, through expert elicitation gained in a two-round Delphi approach. The three most important knowledge gaps addressed were bycatch, population dynamics, and the cumulative effects of multiple stressors. Bycatch was predicted as the highest concern for porpoises in the next 20 years, followed by chemical and noise pollution, respectively. A list of essential indicators aiming to increase understanding of harbour porpoises' health status was established and studying causes of death, distribution, abundance, habitat use and diet composition were scored as most relevant. These results should guide research focus and management objectives of harbour porpoise populations and the study design could be translated to serve managers in other geographical areas aiming to identify knowledge gaps and defining research priorities for other wildlife species.

1. Introduction

Human impact has transformed the world's oceans, by direct and indirect means, to such an extent that there is a rising concern on the ecological sustainability of most marine ecosystems [1,10,23]. Increased sea surface temperatures, coastal development, removal of prey species, habitat degradation, and chemical or noise pollution all can result in ecosystem changes, influencing population numbers and species composition [1,18,29]. The management of the marine environment often involves complex decisions at an international scale where managers need to deal with data-poor environments and lack of ecological understanding [16].

Marine mammals are used as sentinels for monitoring of aquatic ecosystems, as they are relatively long-lived, highly mobile species which feed at or near the top of the food chain [1,3,18]. For example, studies on arctic ecosystems revealed that increases in water temperature accompanied by a decline in prey availability resulted in spatial and temporal shifts of sea-ice dependent species [6,26,29] and decreases in abundance and migration changes of mysticetes [18]. The use of marine mammals as ecosystem sentinels, however, goes beyond investigating changes in distribution and abundance. Their overall health status can reflect the health of the ecosystem in which they live, making monitoring of cetacean population health a useful endeavour that can provide crucial information far beyond the individual populations themselves [4]. One key example is the investigation of bioaccumulation of persistent organic pollutants (POPs) and heavy metals in cetacean tissue. From the presence and concentrations of such pollutants one can infer contamination levels in the marine ecosystem, and this may provide an early warning system for potential human health hazards (e.g. [2,7,14,15,27,28]).

Harbour porpoises (*Phocoena phocoena*) are protected and included under several international, European and national conventions.

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International protection is provided by e.g. the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) [8,13,24]. On a European scale, the European Union Habitats and Species Directive 1992 recognise the harbour porpoise as a '*species of community interest which is in need of strict protection*' and porpoises are listed under Annex II and IV that aim to establish a network of Special Areas of Conservation (SACs) and requires establishment of distinct conservation and management needs, respectively. In 2008, the Marine Strategy Framework Directive (MSFD) was formally adopted by the EU and the first EU legislative instrument related to the protection of marine biodiversity. It aims '*to achieve or maintain good environmental status within the marine environment by the year 2020 at the latest*' and determined 'good environmental status descriptors', among which several relate to the harbour porpoise [8,13,24]. On regional scales, the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) aims to achieve and maintain a favourable conservation status for small cetaceans within their agreement area. Here, the harbour porpoise is an abundant and widespread species with a population size of around 350,000 individuals [11].

Frequent exposure of harbour porpoises to human activities has raised concerns among conservationists, both in terms of direct impacts as well as nonlethal effects impacting population viability. The available knowledge on pressures affecting this species varies widely, and specific topics, such as climate change, urgently require further attention. Protection measures for harbour porpoises need to be implemented at a scale relevant to their ecosystem. To be effective and as encouraged by existing conventions this requires international co-ordination, yet most current research and management efforts are implemented at a national level [5,13]. To meet the requirements of both the EU Habitats Directive and MSFD, a broad approach identifying current knowledge gaps and predicting future threats is necessary to adequately assess the health status of harbour porpoise populations. This involves a clear understanding of the risks associated with increasing exposure to anthropogenic pressures [12,21,25].

In this study expert opinions were exploited through a two-round Delphi approach that aimed to identify current knowledge gaps, predict future pressures or threats and suggest useful conservation indicators to guide research and monitoring, at an international and interdisciplinary level. The outcomes of this study subsequently identified and ranked research priorities as defined by the panel of marine mammal experts, with the aim that this could inform future conservation management and mitigate threats to harbour porpoises.

2. Materials and methods

2.1. The Delphi method

The Delphi method is a survey-based research approach that enables experts to collectively address complex problems through structured group communication. It comprises two- or more rounds of questionnaires, each followed by a feedback round that enables participants to clarify and revise responses from previous rounds to ensure accurate judgements [19,21]. The Delphi method has been used previously in a range of disciplines, such as nursing, tourism and medicine, and is particularly powerful assessing complex issues in data poor environments. One of its major strengths is the possibility for people to respond anonymously, reducing the influence of social pressure and 'group-thinking', yet allowing collation of both formal and informal knowledge in a transparent and robust way [16,19]. Use of the Delphi method in conservation and ecological management is still uncommon [19].

2.2. Study area and expert panel

The North Sea was used as the study area, due to the increasing anthropogenic activities in this area (e.g. expansion of offshore windfarm industry) and as it borders multiple countries, all with their own national conservation focus. Experts working in different sectors and geographic areas were selected to generate a complete and robust judgement on the issues addressed. Experts were individuals knowledgeable in harbour porpoise conservation, and particularly practitioners and policy-makers working in this field, which was ensured by their affiliation to two conservation bodies:

1. Members of the Advisory Committee (AC) of ASCOBANS, with a sub-selection on those affiliated to North Sea bordering countries. The AC provides advice and information to the Secretariat and the involved Parties on the conservation and management of small cetaceans and on other matters related to the running of the Agreement on an annual base. Each Party is entitled to appoint at least one member and additional advisors to the AC, and therefore consists of experts with different background; both researchers, as well as conservationist and policy-makers. It annually discusses current knowledge (both published and unpublished) and conservation issues. This selection resulted in 81 contacts.
2. Members of the North Sea Group (NSG), which is the steering group for the ASCOBANS conservation plan for harbour porpoises in the North Sea. This overlapped with the AC selection with 72%, however, an additional eleven contacts were identified through the NSG.

Invited experts suggested other colleagues for participation, resulting in 14 additional participants. 106 people were invited to the first round of the survey. All survey participants voluntarily contributed to this study and contribution was kept anonymous among the expert panel and within the research team, except for the facilitator.

2.3. The Delphi design and process

A two-round Delphi exercise was electronically conducted between January and March 2017. The first round of the questionnaire was unstructured, allowing participants to give open answers and comment on the issues raised. The second round summarised responses obtained in the first round, which was provided as feedback to the panel and allowed them to revaluate the topics addressed. The questionnaire of the second round involved evaluation and rating of the answers gained in round one. Both questionnaires can be found in the online Supporting information. Round one was accessible for 17 workdays, during which reminders were sent to encourage the experts to participate. Round two was made available 15 workdays later and was accessible for an additional 24 workdays. During all stages of both surveys, the expert panel was given the opportunity to provide suggestions or additional information, if desired.

Demographic information on the participants, current country of work, main field of expertise (open-question) and main field of work (closed-question with options: research, welfare, advocacy, government, monitoring or other) was requested to assess the spread in sectors of expertise and geographical areas of the panel. Collation and reviewing of responses was done by three members of the research team. The first task in the process was to encourage the panel to think about what 'harbour porpoise health' means and involves. The survey focus was on three major topics: identifying knowledge gaps, predicting future pressures or threats, and defining conservation indicators.

2.3.1. Defining 'health'

At the beginning of the survey, experts were given the summary statement of a previous Delphi study on polar bears (*Ursus maritimus*) [21] on the definition of health: "*Polar bear health is a multidisciplinary concept and is concerned with multiple factors that affect polar bears. Polar bear health can be applied at the individual, species, and ecosystem levels, but its most important defining characteristics are whether a population can respond to factors in its environment and sustain itself long term.*". With the aim of encouraging the panel to think about what assessing 'health