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Defining management units for cetaceans by combining genetics, morphology, acoustics and satellite tracking

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ABSTRACT

Managing animal units is essential in biological conservation and requires spatial and temporal identification of such units. Since even neighbouring populations often have different conservation status and face different levels of anthropogenic pressure, detailed knowledge of population structure, seasonal range and overlap with animals from neighbouring populations is required to manage each unit separately. Previous studies on genetic structure and morphologic separation suggests three distinct populations of harbour porpoises with limited geographic overlap in the North Sea (NS), the Belt Sea (BS) and the Baltic Proper (BP) region. In this study, we aim to identify a management unit for the BS population of harbour porpoises. We use Argos satellite data and genetics from biopsies of tagged harbour porpoises as well as acoustic data from 40 passive acoustic data loggers to determine management areas with the least overlap between populations and thus the least error when abundance and population status is estimated. Discriminant analysis of the satellite tracking data from the BS and NS populations showed that the best fit of the management unit border during the summer months was an east–west line from Denmark to Sweden at latitude 56.95°N. For the border between BS and BP, satellite tracking data indicate a sharp decline in population density at 13.5°E, with 90% of the locations being west of this line. This was supported by the acoustic data with the average daily detection rate being 27.5 times higher west of 13.5°E as compared to east of 13.5°E. By using this novel multidisciplinary approach, we defined a management unit for the BS harbour porpoise population. We recommend that these boundaries are used for future monitoring efforts of this population under the EU directives. The boundaries may also be used for conservation efforts during the summer months, while seasonal movements of harbour porpoises should be considered during winter.

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1. Introduction

Effective management decisions rely on information on population status of a species, which implies knowledge of distribution, movements, habitat/foraging preferences, identification of population boundaries, health condition, threats and trend in abundance. Such information is rarely available for wild animal populations, and for marine animals living in the continuum of the oceans it is even more difficult to obtain. Many marine species are wide ranging animals that migrate over long distances, possibly mixing with neighbouring populations at certain seasons (e.g. Block et al., 2011). In the last decades, harbour porpoises (*Phocoena phocoena*) have been studied intensely in European waters to identify population delimitations and to monitor the status of the species (e.g., Siebert et al., 2006, Evans and Teilmann, 2009, Wiemann et al., 2010; Alfonsi et al., 2012; Fontaine et al., 2014). The main driver for this effort has been the fact that several thousand harbour porpoises are bycaught each year and drown in European gillnet fisheries (Tregenza et al., 1997; Vinther and Larsen, 2004; Bjørge et al., 2013). Reduced use of gillnets in recent years and the use of pingers has aimed to minimize bycatch, but the status of the harbour porpoises in Europe still remains unclear due to inadequate knowledge on bycatch and abundance for each of the little defined populations (Siebert et al., 2006; Hammond et al., 2013; Benke et al., 2014).

The harbour porpoise is the smallest and most numerous cetacean in European waters (Hammond et al., 2013) and has a wide distribution throughout continental shelf waters. Numerous studies have investigated the population structure of harbour porpoises in the Northeast Atlantic (Andersen et al., 2001, Fontaine et al., 2007) and in particular the waters between the North Sea and the Baltic Sea (e.g. Lockyer, 2003). This area consists of waters from the North Sea through the Skagerrak into the Kattegat, the Danish Belt Seas and the Sound, the western Baltic to the Baltic Proper (Fig. 1). Previous studies on skull morphology (Kinze, 1985; Börjesson and Berggren, 1997; Huggenberger et al., 2002), contaminant levels (Bruhn et al., 1999; Berggren et al., 1999), stable isotopes (Angerbjörn et al., 2006) and genetics (Tiedemann et al., 1996; Wang and Berggren, 1997; Andersen et al., 2001) have aimed to uncover the population structure in this area. The results are somewhat inconsistent, possibly due to small sample sizes, differences in area definitions and methodology. However, recent comprehensive genetic and morphometric studies have pointed to the existence of three harbour porpoise populations in waters between the North Sea and the Baltic Sea (Wiemann et al., 2010; Galatius et al., 2012). These populations inhabit (1) the North Sea and Skagerrak (henceforth referred to as the North Sea = NS), (2) Kattegat, Belt Sea, the Sound and western Baltic (henceforth referred to as the Belt Sea = BS), and (3) the Baltic Proper (BP), respectively (Fig. 1). The three populations are, however, not divided by geographical barriers, and their distributions overlap in so-called "transition zones" (Sveegaard et al., 2011).

The status of the harbour porpoise in the Baltic Proper has long been of concern due to the extensive population decline observed during the past 50–100 years (Skóra et al., 1988; Koschinski, 2002), and the population is listed as 'Critically Endangered' on the IUCN (the International Union for Conservation of Nature) red list (www.iucnredlist.org). Due to the limited number of abundance surveys and the wide confidence intervals the status of the Belt and North Sea populations are uncertain, however, the North Sea host a very large population with a favourable size for long term survival, while the Belt Sea population is much smaller (ASCOBANS, 2012; Hammond et al., 2013; Viquerat et al., 2014). The harbour porpoises inhabiting these three areas thus have different conservation status, occupy habitats with different oceanography, and face different anthropogenic pressures (e.g., due to different fisheries, levels of population and marine traffic) and therefore need to be managed individually.

An essential part of any management programme is monitoring of the population trend. For small cetaceans, this may be achieved by conducting continuous visual surveys from boat or aircraft (e.g., Hammond et al., 2013) following the "Distance sampling methodology" (Buckland et al., 1993). If not accounted for, abundance estimates for the individual population may be artificially inflated by including animals from a neighbouring population. Consequently, identifying geographical borders for each management unit with minimum overlap between populations is of major importance.

Separation of the NS and the BS populations with an east–west border within a transition zone in the Kattegat (waters South of the 58°N and North of 56°N latitudes) is supported by 3D geometric morphometric measurements of 277 skulls (Galatius et al., 2012), satellite tracking of 64 harbour porpoises (Sveegaard et al., 2011) as well as microsatellite and mitochondrial genetic analysis of 497 genetic samples (Andersen et al., 2001; Wiemann et al., 2010). A combination of these studies suggests a transition zone between the BS and BP populations between Fehmarn Belt and 14°20′E.

The genetic evidence for a division between the BS and the BP populations is not as strong as the division between the NS and the BS population, but Wiemann et al. (2010) nevertheless advocated a precautionary division into two separately management units. Furthermore, the less pronounced genetic and morphological difference found between BS and BP compared to the difference found between the NS and the BS population may be due to the young age of the Baltic Proper population: a recent investigation indicates immigration and establishment of harbour porpoises in the Baltic Sea around 9000 years ago when the previously closed connection to the Atlantic Ocean was established through the Danish straits as a result of ice melting in the Arctic, following the last Ice Age (Sommer et al., 2008). Without geographical seclusion, 9000 years is a relatively short time for evolutionary divergence.

In Germany, studies using static acoustic monitoring (SAM) have suggested a seasonally variable boundary between the BS and the BP populations in the Pomeranian Bay area (13°30′E–14°45′E) (Gallus et al., 2012; Benke et al., 2014). These authors hypothesize that the Baltic harbour porpoises move south–west into the Pomeranian Bay from November to March, possibly to avoid ice cover in the inner Baltic, but that the same area is occupied by BS harbour porpoises from July to October and that the two populations thus may be geographically overlapping but separated temporally.