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Long-term trends in the use of a protected area by small cetaceans in relation to changes in population status

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ABSTRACT

The requirement to monitor listed species in European designated sites is challenging for long-lived mobile species that only temporarily occupy protected areas. We use a 21 year time series of bottlenose dolphin photo-identification data to assess trends in abundance and conservation status within a Special Area of Conservation (SAC) in Scotland. Mark–recapture methods were used to estimate annual abundance within the SAC from 1990 to 2010. A Bayesian mark–recapture model with a state-space approach was used to estimate overall population trends using data collected across the populations' range. Despite inter-annual variability in the number of dolphins within the SAC, there was a >99% probability that the wider population was stable or increasing. Results indicate that use of the SAC by the wider population has declined. This is the first evidence of long-term trends in the use of an EU protected area by small cetaceans in relation to changes in overall population status. Our results highlight the importance of adapting the survey protocols used in long-term photo-identification studies to maintain high capture probabilities and minimise sampling heterogeneity. Crucially, these data demonstrate the value of collecting

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data from the wider population to assess the success of protected areas designated for mobile predators.

1. Introduction

Estimation of abundance and trends underpins population ecology and is essential information for management and conservation efforts (Krebs, 2001). In some countries, regular assessments of abundance are also a legislative requirement to support conservation of protected species (e.g. Wade and Angliss, 1996) or areas (Cowx et al., 2009). In Europe, the Habitats Directive (92/43/EEC) requires the designation of Special Areas of Conservation (SACs) as a measure to help protect species listed in Annex II. The Directive requires Member States to report on the conservation status of these species on a six year cycle, including information on their abundance within the protected area (European Union, 1992). However, it is challenging to design cost-effective survey programmes that can assess population status, particularly for mobile species that commonly range across the boundaries of protected areas (Hammond et al., 2013).

This problem is particularly acute for cetaceans as they are often widely distributed, highly mobile and spend a high proportion of time underwater, making it difficult to obtain accurate and precise abundance estimates. A long time series of data is typically needed to provide sufficient statistical power to detect trends from estimates of abundance (Taylor et al., 2007; Thompson et al., 2000; Wilson et al., 1999). For example, Taylor et al. (2007) highlight that most marine mammal stocks in the USA have inadequate data to detect a 50% decline in abundance over 15 years. While some studies have used sightings surveys to identify long-term trends in large whale populations (Branch and Butterworth, 2001; Buckland and Breiwick, 2002; Moore and Barlow, 2011), published data on abundance trends in coastal small cetaceans are rare (see Fearnbach et al., 2012, for a recent exception). Nevertheless, information on abundance is available from many small cetacean populations through photo-identification based mark–recapture methods (Berrow et al., 2012; Currey et al., 2011; Durban et al., 2000; Gormley et al., 2012; Nicholson et al., 2012; Pesante et al., 2008). These long-term studies can provide time series of abundance estimates for evaluating trends and informing the management of protected areas established for these populations. However, there are two issues that need to be considered when developing survey programmes for small cetaceans in these areas.

First, whilst standardised survey protocols are preferred in long-term ecological studies (Currey et al., 2007; Magurran et al., 2010), these can overlook the dynamic way in which populations use their range, introducing bias and increasing uncertainty in abundance estimates (Forney, 2000). In mark–recapture studies, both short term (e.g. Nicholson et al., 2012; Parra et al., 2006) and long-term (e.g. Wilson et al., 2004) temporal changes in distribution or ranging patterns may introduce heterogeneity in capture probabilities along otherwise standardised survey routes, resulting in biased abundance estimates. Where these changes occur during a longer-term study, survey protocols may need to be adapted to reduce sampling heterogeneity. Similarly, developments in technology, statistical techniques, changing research priorities, logistics or financial constraints may all lead to modifications to survey protocols over time (Lindenmayer and Likens, 2009; Ringold et al., 1996). The consequences of such flexible approaches must be explored before drawing inference from a long-term time series. Of particular concern to photo-identification mark–recapture studies, where some individuals do not have markings that can be reliably identified between annual survey seasons, are potential changes in the proportion of distinctive or well-marked animals. An accurate estimate of this proportion is required to account for non-distinct animals when estimating total abundance (e.g. Durban et al., 2010; Gormley et al., 2005; Lukoschek and Chilvers, 2008; Read et al., 2003; Wilson et al., 1999). Longer-term temporal changes in this proportion may have an underlying biological basis, for example if age or sex differences in the occurrence of distinctive marks exist, a trend may reflect changes in population age or sex structure. However, it may also be affected by survey protocols. For example, photo quality and mark distinctiveness can be correlated due to photographer bias if more time is spent obtaining quality pictures of well-marked animals (Read et al., 2003).

Secondly, survey effort is typically focused on monitoring abundance trends within only part of the overall range of the population. This means that monitoring programmes generally only provide information on variation in the abundance of individuals using a specific area rather than changes in the population itself (Forney, 2000). In some cases, monitoring may only be conducted within a protected area (Berrow et al., 2012; Gnone et al., 2011; Gormley et al., 2005). Yet European Directives aim to designate networks of core sites that support the conservation status of the wider population (European Union, 1992). Robust design methods could be used to assess the extent of seasonal emigration in and out of such sites (e.g. Nicholson et al., 2012; Smith et al., 2013). However, the collection of at least some information from the wider population may be needed to assess the relative value of the protected area itself (Hooker and Gerber, 2004), and this typically requires a modelling framework that can be used with much sparser data from less frequent surveys (e.g. Corkrey et al., 2008).

Here, we explore these issues using a continuous 21 year time series of data from photo-identification surveys of bottlenose dolphins (*Tursiops truncatus*) off north-east Scotland. Our aim was firstly to use core annual survey data to assess trends in abundance within an SAC over the last two decades, thereby allowing the UK government to contribute to their reporting requirements under the EU Habitats Directive. We then go on to use Corkrey et al. (2008) state-space mark–recapture