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Temporal patterns in habitat use by small cetaceans at an oceanographically dynamic marine renewable energy test site in the Celtic Sea

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ABSTRACT

Shelf-seas are highly dynamic and oceanographically complex environments, which likely influences the spatio-temporal distributions of marine megafauna such as marine mammals. As such, understanding natural patterns in habitat use by these animals is essential when attempting to ascertain and assess the impacts of anthropogenically induced disturbances, such as those associated with marine renewable energy installations (MREIs). This study uses a five year (2009–2013) passive acoustics (C-POD) dataset to examine the use of an oceanographically dynamic marine renewable energy test site by small cetaceans, dolphins (unspecified delphinids) and harbour porpoises *Phocoena phocoena*, in the southern Celtic Sea. To examine how temporal patterns in habitat use across the site related to oceanographic changes occurring over broad seasonal scales as well as those driven by fine scale (bi-weekly) localised processes (that may be masked by seasonal trends), separate analyses were conducted using (1) all daily animal detection rates spanning the entire five year dataset and (2) daily animal detection rates taken only during the summer months (defined as mid-June to mid-October) of 2010 (when continuous monitoring was carried out at multiple discrete locations across the site). In both instances, generalised additive mixed effects models (GAMMs) were used to link detection rates to a suite of environmental variables representative of the oceanography of the region. We show that increased harbour porpoise detection rates in the late winter/early spring (January–March) are associated with low sea surface temperatures (SST), whilst peaks in dolphin detection rates in the summer (July–September) coincide with increased SSTs and the presence of a tidal-mixing front. Moreover, across the summer months of 2010, dolphin detection rates were found to respond to small scale changes in SST and position in the spring-neap cycle, possibly reflective of a preference for the stratified waters immediately offshore of the front. Together, these findings suggest that habitat use by small cetaceans within shelf-seas is temporally variable, species specific and likely driven by complex bottom-up processes. As such, the effective conservation management of shelf-seas requires that we understand the dynamic complexities of these systems and the species that inhabit them. In particular, we emphasise the need for a good understanding of the natural drivers of habitat use by marine megafauna before the potential impacts of anthropogenically induced disturbances, such as those associated with the construction, maintenance and operation of MREIs, can be assessed.

1. Introduction

Mid to high latitude shelf-seas are frequently subjected to a multitude of anthropogenic pressures, many of which are impacting the abundances, behaviours and distributions of marine megafauna such as marine mammals (Pirotta et al., 2013; Pirotta et al., 2014a; Lewison et al., 2014; McCauley et al., 2015). In recent

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years, marine renewable energy installations (MREIs) have received a lot of attention owing to the potential for these structures to disrupt and/or disturb the habitats of these animals (Gill, 2005; Inger et al., 2009; Grecian et al., 2010; Witt et al., 2012). However, assessing the impact of this may be confounded by the highly mobile nature of many marine megafauna alongside the dynamic structures of the systems they exploit (Scales et al., 2014b; Benjamins et al., 2015). As such, to be able to adequately inform regional marine planning procedures, a good understanding of the processes that drive spatio-temporal variability in habitat use by these animals is required (Shields et al., 2009; Scott et al., 2014; Waggitt and Scott, 2014).

Mounting evidence suggests many marine megafauna concentrate in localised foraging regions (Hastie et al., 2004; Sydeman et al., 2006; Weimerskirch, 2007), the situations of which are driven through bottom-up oceanographic processes that increase prey accessibility (Russell et al., 1999; Vlietstra et al., 2005; Stevick et al. 2008; Embling et al., 2012). Many of these processes vary temporally in their occurrence, with concomitant consequences on the availability of the associated prey resources that attract marine megafauna (Van der Kooij et al., 2008; Embling et al., 2012, 2013; Cox et al., 2013). For example, regions of stratification (Hunt and Harrison, 1990; Scott et al., 2010; Cox et al., 2013) develop seasonally during the spring and summer, when increased solar irradiation heats surface waters sufficiently so as to overcome tidal and wind driven turbulent mixing (Pingree et al., 1976; Pingree and Griffiths, 1978). This drives the formation of tidal-mixing fronts (Begg and Reid, 1997; Durazo et al., 1998; Jahncke et al., 2005), which mark the transitional zones between resultant stratified offshore waters and permanently mixing inshore coastal waters (Simpson and Hunter, 1974). The positions and strengths of these features may additionally alter over more localised scales with changes in turbulent mixing with the spring-neap tidal cycle and passing storm events (Nahas et al., 2005; Pisoni et al., 2015). As such, the distributions of marine megafauna across oceanographically dynamic areas may vary over both large (seasonal) and short (bi-weekly/weekly) temporal scales, and failing to account for these natural patterns in habitat use may obfuscate behavioural changes in response to anthropogenically induced disturbances (e.g. the construction, maintenance and operation of many MREIs; Dolman and Simmonds, 2010; Bailey et al., 2014).

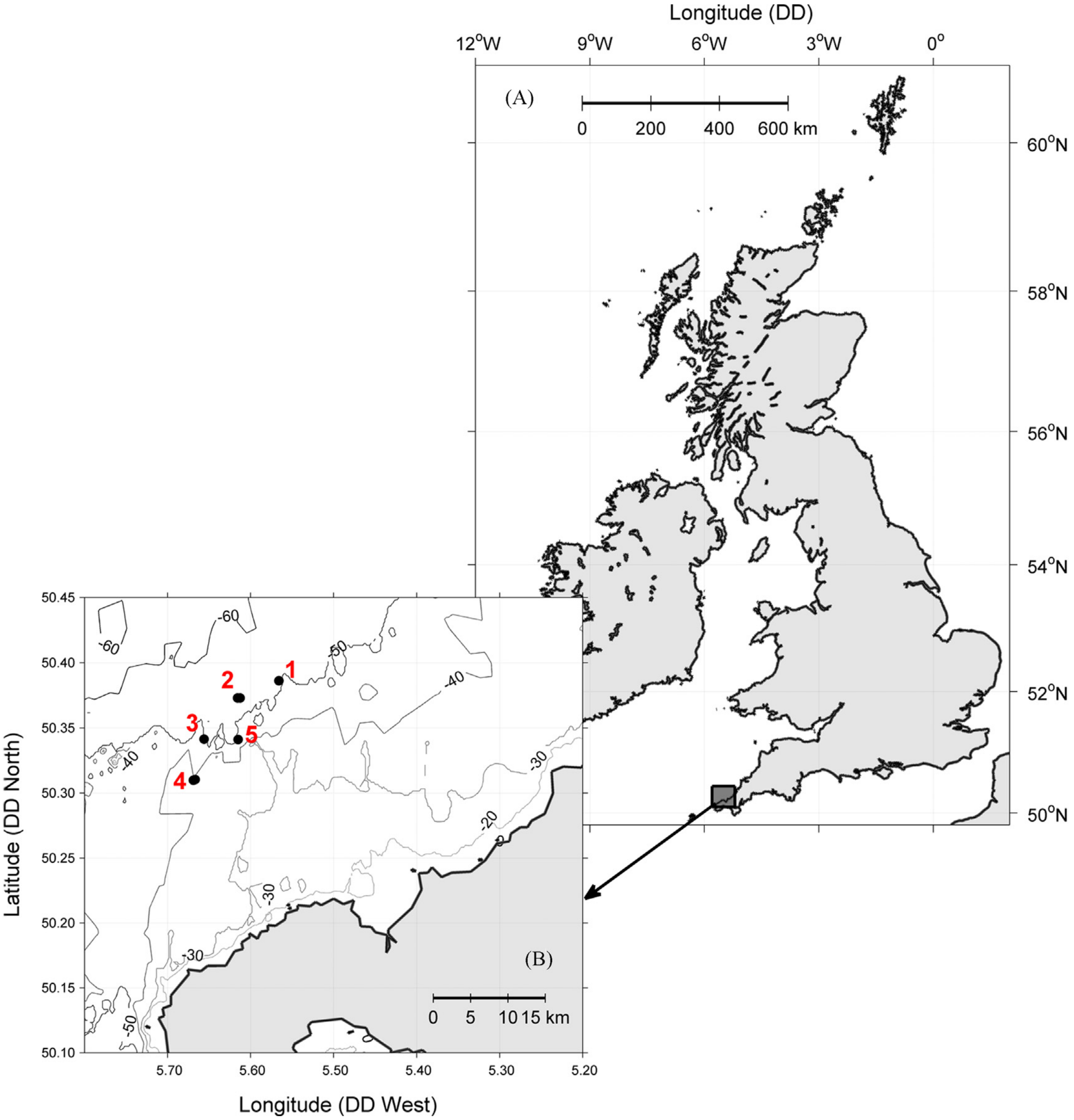

Fig. 1. The study site (A) in the context of the UK, and (B) with bathymetric contours and the position of each deployment station (black filled circles with station IDs indicated in red). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)