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Habitat selection of two island-associated dolphin species from the south-west Indian Ocean

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ABSTRACT

Identifying suitable habitats of protected species is an essential question in ecology and conservation planning. Modelling approaches have been widely used to identify environmental features that contribute to a species' ecological requirements and distribution. On Reunion Island, a fast-growing French territory located in the south-western Indian Ocean, anthropogenic impacts are mainly concentrated along the coast, representing a potential threat for Indo-Pacific bottlenose (*Tursiops aduncus*) and spinner (*Stenella longirostris*) dolphins, two resident coastal species. Beside coastal development, commercial and recreational dolphin-watching are growing, particularly along the west coast. To promote effective local management, habitat modelling was applied using presence-only data collected from 2008 to 2012 on the west coast of the island. Ecological Niche Factor Analyses were used to investigate the effect of physiographic variables on the distribution of these two dolphin species and delineate suitable habitats. It was found that the core habitat of Indo-Pacific bottlenose dolphins was mainly restricted by depth and confined to coastal waters ranging from 4.7 to 75.8 m deep. The species preferentially used soft substrates (sand and mud) and tended to be ubiquitous in terms of substrate type/color used. Foraging activities were significantly related to soft substrates. The diurnal core habitat of spinner dolphins was confined to one discrete area, on the flat portion of the insular shelf, between 45.1 m and 70.7 m of depth. Suitable habitat was mainly related to soft and light-colored substrates, with a clear avoidance of dark-colored substrates. The core habitats of both species were very restrained spatially and therefore vulnerable to human activities. The fine scale habitat mapping achieved in this study represents baseline data to conduct ad hoc impact assessment and support conservation actions.

1. Introduction

Hutchinson (1957) defined the "ecological niche" as a hypervolume with *n*-dimensions where all environmental conditions are gathered to ensure population survival. *N*-niche dimensions are often classified into three main approaches, these being "habitat" (spatial distribution), "seasonality" (temporal distribution), and "resources" (trophic relationships). In practice, assessing all the *n*-dimensions that make up a niche is extremely challenging, especially for large and mobile species such as marine mammals and only part of an ecological niche is commonly assessed when investigating the factors driving a species' distribution. Generally, only available environmental data that are assumed to play an important role in a species' ecology, are taken into account. The most common variables used to assess cetacean habitat preferences are abiotic factors that have either a direct or indirect influence on distribution (e.g. depth, slope and distance from shore, temperature, salinity, etc.), mainly because they are fixed parameters that can be accurately and systematically measured (Cribb et al., 2008; Embling et al., 2010; Gannier and Petiau, 2006; Mannocci et al., 2015; Praca and Gannier, 2008; Praca et al., 2009; Roberts et al., 2016). Based on remote sensing data, biotic factors such as chlorophyll-a concentration are sometimes used as a proxy of productivity and prey abundance at a large spatial scale (Mannocci et al., 2015; Panigada et al., 2008; Praca et al., 2009; Roberts et al., 2016). Thus, despite being considered as one of the main forces driving a species' distribution, prey availability and predation risk are rarely considered in predictive models (Eierman and Connor, 2014; Heithaus and Dill, 2002; MacLeod et al., 2004; Torres et al., 2008), especially due to the complex nature of the data and their spatio-temporal variability. Instead, few studies have investigated seabed influence on cetacean distribution as this factor may have an effect on prey distribution and may affect predator detection (MacLeod et al., 2004; Thorne et al., 2012;

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Torres et al., 2008; Tyne et al., 2015).

Identifying and quantifying key habitats for cetaceans is crucial for management and conservation planning and can provide scientific bases to mitigate the impact of human activities. Coastal development can have a significant impact on cetacean habitat through chemical pollutants (Mwevura et al., 2010; Pierce et al., 2008), acoustic pollution (Borggaard et al., 1999; Dähne et al., 2013), and non-degradable litter such as plastic debris (Simmonds, 2012). Vessel traffic and whale- or dolphin-watching activities have also been shown to affect animal behavior and are believed to have an impact on breeding and fitness if resting periods are disturbed (see Parsons (2012) for a review). In Reunion Island, a French overseas territory located in the south-west Indian Ocean, human activities and their impacts on coastal marine habitats are intensifying as a result of population growth. Coastal planning and project developments in the marine environment (e.g. harbor extension, embankment, road construction, renewable energy, etc…) are increasing. Whale/dolphin-watching is growing on the west coast of the island and no specific legislation regulates this activity, although a code of conduct is in place (http://www.globice.org/02_Charte.htm). To date, knowledge on habitat requirements of coastal cetacean species are lacking to conduct ad hoc impact assessment and support conservation actions.

Among the 21 cetacean species recorded in Reunion (Dulau-Drouot et al., 2008; Globice, unpublished data), the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the spinner dolphin (*Stenella longirostris*) are the most commonly encountered year-round in coastal waters. Indo-Pacific bottlenose dolphins are observed all along the coast in waters 22 m deep on average (Dulau-Drouot et al., 2008). Spinner dolphins use a larger depth range (3–720 m), and, their spatial distribution can overlap with *T. aduncus* in the morning (Dulau-Drouot et al., 2008). In general, spinner dolphins are known to undertake daily movements between sheltered bays and reefs, used for resting and social activities in the morning, and offshore waters reached in the late afternoon for nocturnal feeding purposes (Norris et al., 1994; Tyne et al., 2014). Off Reunion, spinner dolphins appear to not favor sheltered and enclosed bays for resting, but rather occur in deeper waters over insular shelf waters (Dulau-Drouot et al., 2008).

This study aimed at using a presence-only modelling approach to describe habitat preferences of Indo-Pacific bottlenose and spinner dolphins off Reunion, using fine scale bathymetric and sedimentary data. An Ecological Niche Factor Analysis (ENFA), which provides a measure of the realized niche within the available habitat (Hirzel and Arlettaz, 2003; Hirzel et al., 2002, 2006) was used in order to produce habitat suitability maps and to identify core habitats for both species. Presence-only models have the advantage of discarding potential biases associated with absence data (Gu and Swihart, 2004). For highly mobile marine mammals, it is indeed very difficult to discriminate true absence data from false absence data (i.e. areas used by a species but no sightings made during the survey), especially when survey efforts are insufficient or uneven. ENFA has been tested and proved to be robust to describe cetacean habitats (Hirzel et al., 2001; MacLeod et al., 2008; Praca and Gannier, 2008; Praca et al., 2009; Skov et al., 2008a), and has also been used for other marine species (McKinney et al., 2012; Skov et al., 2008b; Stewart et al., 2014) and more generally for mobile mammals (Mertzanis et al., 2008).

2. Materials and methods

2.1. Data collection

Presence data were collected from 2008 to 2012 off Reunion Island (55°33′E, 21°07′S). Boat-based surveys were conducted up to 12 nautical miles offshore, in good weather conditions (Beaufort <3), and at an average speed of 6 knots. Daily surveys lasted between 3 and 6 h and were conducted both in the morning and the afternoon. Effort spatial distribution was constrained by general weather conditions, port location, and boat availabilities. The west coast was surveyed on a regular basis, while the north and south coasts were covered to a lesser extent. The east coast was poorly surveyed, mostly due to its exposure to rougher sea conditions (Fig. 1).

Search efforts were recorded along the survey tracks by reporting time, GPS positions and sea state conditions every 15 min. When cetaceans were detected, sighting positions were recorded together with the group's estimated size and main activity according to four categories: socializing, resting, travelling, and foraging.

2.2. Environmental variables

Ecological Niche Factor Analyses (ENFA) were performed using Biomapper 4.0 software (Hirzel et al., 2002, 2004) to model habitat

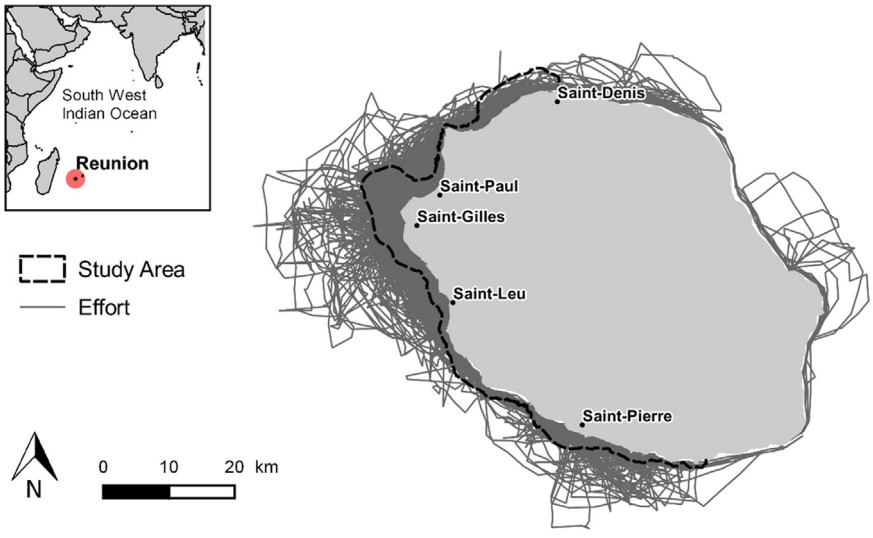

Fig. 1. Searching effort conducted during boat-based surveys around Reunion in 2008–2012 and the study Area used to run the ENFA model, delineated by the 100 m depth contour, on the west coast of the island.