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# Factor associated variations in the home range of a resident Adriatic common bottlenose dolphin population

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ABSTRACT

This study investigates the influence of the most dominant factors (association patterns, gender, natal philopatry and anthropogenic pressure) on the home range size of the 44 most resident common bottlenose dolphins (*Tursiops truncatus*) inhabiting the waters of the Cres-Lošinj archipelago (north Adriatic Sea, Croatia), a recently declared NATURA 2000 SCI. Results show that variations in home range patterns (MCP, 95% KDE and 50% KDE home range size) among the individual resident dolphins are primarily related to differences in gender and reflect the way in which different genders respond to external stressors. In addition, results confirm the seasonal influence of nautical tourism on both female and male dolphins through changes in their home range sizes. The overall results improve current knowledge of the main anthropogenic threats that should be taken into consideration when developing conservation measures to be applied to this Cres and Lošinj SCI.

## 1. Introduction

The common bottlenose dolphin (*Tursiops truncatus*) is a cosmopolitan cetacean species with its presence being reported for all temperate and tropical seas (Reeves et al., 2002). In the Adriatic Sea, the presence of local populations inhabiting mainly coastal areas has been confirmed (Genov et al., 2008; Fortuna, 2006; Holcer, 2012; Pleslić et al., 2015; Gaspari et al., 2015). Photo-identification data since 1995 has revealed that the coastal waters of the Cres-Lošinj archipelago (north Adriatic Sea, Croatia) are home to about 200 common bottlenose dolphins (Bearzi et al., 1997; Pleslić et al., 2015). This population is characterised as relatively closed with a low degree of individual displacement to significantly distant areas, and with movements that appear to be strongly habitat dependant (Fortuna, 2006; Genov et al., 2008; Pleslić et al., 2015). High sighting frequency and regular re-sightings of known individual dolphins indicate their long-term fidelity to this specific region. Due to its importance as a habitat for this resident common bottlenose dolphin population, the Cres-Lošinj area was designated as a Site of Community Importance (SCI), part of the European Union NATURA 2000 ecological network (Cres and Lošinj SCI, HR3000161), in December 2014. This is in accordance with the European Habitat Directive (Council Directive 92/43/EEC) that listed *Tursiops truncatus* in Annex II requiring all the EU member states to establish Special Areas of Conservation where populations are resident. Furthermore, according to the article 6 of this Directive, each SCI must be designated a Special Area of Conservation (SAC) within six years, with associated conservation regime corresponding to the ecological requirements of the site.

In order to achieve the preservation of this important habitat of common bottlenose dolphins and therefore to contribute to their conservation it is crucial to identify the resident dolphins' home range. The home range represents a defined area in which an animal lives (Burt, 1943). It is an important ecological feature, which indicates the space required for an individual animal to fulfil its everyday activities. Home ranges may vary between and within species, and can depend on gender, age or season (Burt, 1943; Connor, 2000; Wells et al., 1980). It generally encompasses areas of higher usage as well as those less visited by the animals (Sprogis et al., 2016). Home range size depends on the biological requirements of the individual and is influenced by physical characteristics of the host habitat (topographic features) and the biological components such as the availability of mates for reproduction, the availability of food resources and protection from predators (Ballance, 1992; Defran et al., 1999; Martinez-Serrano et al., 2011; McNab, 1963).

Many marine mammals are capable of travelling very long distances. However, individuals within some populations may remain resident in relatively small areas (Bjørge, 2001). Although these individuals generally have well defined home ranges, their distribution

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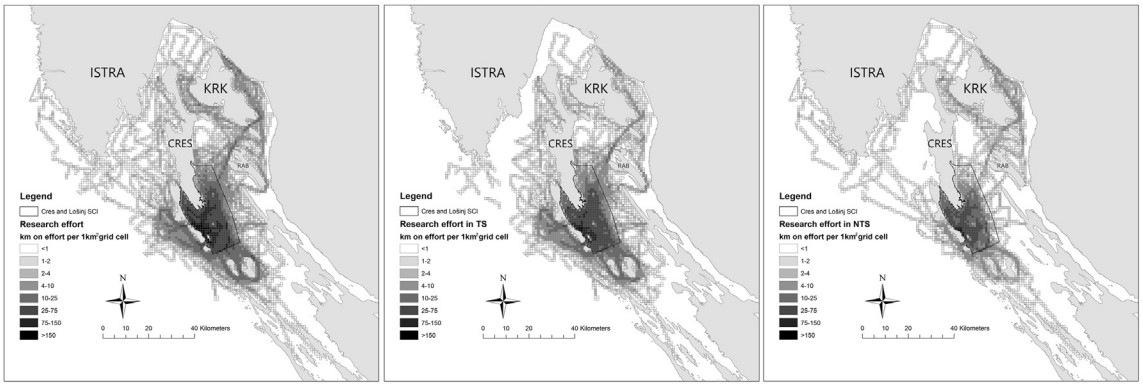


**Fig. 1.** Study area and Cres and Lošinj SCI. Yearly and seasonal research effort is presented in colour scale corresponding to the length in km surveyed within 1 km$^2$ grid cells.

and the use of space within these home ranges refer to the individual movements rather than to an entire population (Morales et al., 2010). This is particularly true in fission-fusion societies, such as those seen in many dolphin species, where individuals within the same population may have greatly different ranging patterns (Defran et al., 1999) and individuals may alternate between local site-fidelity and longer ventures away from the site of their first identification (Bearzi et al., 1997; Genov et al., 2016).

Previous studies on the behavioural ecology of common bottlenose dolphins (*Tursiops truncatus*, Montagu 1821) have revealed a great variability in their home range characteristics (Connor et al., 2000; Defran et al., 1999; Wells et al., 1999) that may be due to habitat heterogeneity or to differences in the use of space between the genders (Connor, 2000; Wells et al., 1980). As dolphins are social animals, association patterns among individuals, as well as their kinship, may also influence their space use and ranging patterns (Frère et al., 2010). In fact, home range overlap between the individuals may often provide indirect information on the social bonds between them (Carter et al., 2009; Frère et al., 2010).

In many cases, variations in home range patterns between dolphins may be associated to external perturbations and reflect a change in the quality or availability of their preferred habitats. In coastal areas, subject to intense human exploitation, changes in home range size and habitat use may be particularly frequent (Bejder et al., 2006; Fortuna, 2006; Jensen et al., 2009; Rako et al., 2013a).

In the Adriatic Sea dolphins lack natural predators due to the reduced presence of large shark species (De Maddalena and Heim, 2012; Jukić-Peladić, 2001). The main threat they face is intense human use of their ecosystem, particularly related to fishing and seasonal tourism, the two dominant human activities within the Cres–Lošinj area (Mackelworth et al., 2003; Fortuna, 2006).

The local fishery within the study area consists mainly of the small bottom trawlers (< 12 m) and gillnetters active in the area throughout the whole year, with number on trawlers being higher during the winter months (Rako et al., 2013b). Previous studies within this area have found a positive correlation between the trawling locations and the presence of dolphins (Bearzi et al., 1999; Zekan, 2011). This is due to both, opportunistic feeding by dolphins on the concentrated food source represented by a bottom trawling net and overlap of feeding and fishing grounds. Feeding behind trawlers is a strategy energetically less demanding in comparison to other feeding strategies that require searching and capturing of the prey (Fortuna et al., 1996).

Adversely, activities related to tourism are seasonal; in particular, there is a substantial increase in the number of recreational boats using this area during the summer months (Fortuna, 2006; Rako et al., 2013b). This has affected the bottlenose dolphin distribution and habitat use in the region (Fortuna, 2006; Rako et al., 2013a). There is an estimated increase of 350% in the number of short-term moorings in the summer months (Lošinj Y/C Marina LP-turizam d.o.o. and Marina Lošinj *Morus alba* d.o.o., pers. comm., 24 November 2016). Intense leisure boating has already proven to have an impact on the distribution and acoustic communication of residents of this dolphin population (Rako et al., 2013a; Rako-Gospić and Picciulin, 2016).

Based on 10 years of photo-identification data, this paper assesses the home range characteristics of the 44 most resident bottlenose dolphins in the Cres-Lošinj population. It evaluates the influence of the most dominant factors, association patterns, gender, natal philopatry and anthropogenic pressure, on the size of their home range. The results provide a better understanding of ranging patterns of these resident bottlenose dolphins and identify the main anthropogenic threats that should be taken into consideration when developing conservation measures to be applied to this Cres and Lošinj SCI.

## 2. Materials and methods

The home range estimates of individual bottlenose dolphins were based on photo-identification surveys carried out in the Cres-Lošinj archipelago (northern Adriatic Sea, Fig. 1) between 2005 and 2014. Daily surveys were conducted using a 5.8 m RIB powered by a four-stroke 90 HP outboard engine, in favourable sea conditions (sea state ≤ 2 Beaufort scale and visibility not obscured by haze, fog or rain) at a speed of about 15 knots. The research area (Fig. 1) extends over approximately 2000 km$^2$ and includes Cres-Lošinj SCI (HR3000161). It is characterised by numerous islands and islets, steep rocky shores and a seabed patched with muddy areas and sea grass flats. The average sea depth is about 70 m (Arko-Pijevac et al., 2003).

Photo-identification surveys were conducted throughout the year, although research effort was most intense between May and September due to the adverse weather conditions in the winter months (Fig. 1). The photo-identification protocol is described in detail by Pleslić et al. (2015). To account for the unevenly distributed research effort and to test whether it may have affected the frequency of sightings of individual dolphins, collected data were normalized by calculating individual dolphin encounter rates (ER; Bearzi et al., 2005; Fortuna, 2006; Rako et al., 2013a). These ERs were calculated as $n_i/L$, where $n_i$ is the overall or seasonal number of individual dolphin encounters and L is the length in kilometers of the overall or seasonal survey effort. The yearly and seasonal effort and ER of individual dolphins are presented in Table 2.

In order to achieve the independence of the home range calculations from the sampling size, the increased sampling rates are highly recommended as it improves home range estimates (Fieberg, 2007; de Faria Oshima and de Oliveira Santos, 2016). In the present study, dolphins were categorised as 'resident' following the criteria provided by Gubbins (2002) and Chen et al. (2011), i.e. dolphins have the highest re-sighting rate (> 20 observations) and they are seen at least once each year. The minimum number of locations for each individual was 21 and the maximum was 109. For dolphins seen more than once per