Non-targeted tourism affects the behavioural budgets of bottlenose dolphins *Tursiops truncatus* in the South Adriatic (Montenegro)

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ABSTRACT: We investigated the short-term effects of non-targeted tourism on the behaviour of bottlenose dolphins *Tursiops truncatus* in the South Adriatic off the coast of Montenegro, by comparing dolphin group behaviour during impact (the presence of non-targeted tourism vessels) and control (absence of all marine vessels) scenarios. Tourism vessel and dolphin behavioural data were collected through systematic weekly land-based surveys. Using instantaneous focal ‘group’ scan sampling, the predominant behaviour of bottlenose dolphin groups was determined. To quantify the effect of vessel interactions on the behavioural budget of the dolphins, we followed a stepwise modelling approach. A first-order Markov chain was used to calculate the transition probabilities between behavioural states before a Monte Carlo simulation estimated the behavioural budgets of dolphins during impact and control situations. In the presence of non-targeted tourism, dolphins were found to be less likely to remain diving (during which dolphins were assumed to be feeding), whilst milling-socialising and surface feeding were completely absent from their behavioural repertoires. Nevertheless, the behavioural budgets demonstrated an increase in resting behaviour in the presence of non-targeted tourism vessels. No significant changes to travelling behaviour were observed. The decrease in foraging behaviour (both surface feeding and diving) could result in a reduction in energy intake for dolphins, which over time (assuming repeated disturbance) could negatively affect body condition, and ultimately survival and reproduction. Regulations on non-targeted tourism should therefore be considered to minimise potential long-term negative effects on dolphins within Montenegrin territorial waters.

KEY WORDS: Non-targeted tourism · Behavioural response · Behavioural budget · Markov chain · Monte Carlo simulation · *Tursiops truncatus* · Montenegro

1. INTRODUCTION

The northernmost region of the Mediterranean basin, the Adriatic Sea, is said to have one of the richest cetacean habitats in the entire Mediterranean basin (Coll et al. 2010). Separated into 3 sections (Northern, Central and Southern Adriatic), the Adriatic Sea contains asymmetrical bathymetry and homogeneous water properties (Artegiani et al. 1997, Cushman-Roisin et al. 2001). The Southern Adriatic basin consists of a deep sub-basin within the Adriatic, characterised by its high salinity in comparison with the Northern basin (Cushman-Roisin et al. 2001). Studies in the South Adriatic have recorded the presence of 5 cetacean species, with bottlenose dolphins *Tursiops truncatus* being the most regularly sighted...
species (Bearzi et al. 2012, Bas et al. 2018, Awbery et al. 2019). Currently, this species’ global conservation status has been classified as Least Concern on the IUCN Red List (Hammond et al. 2008, 2012, Taylor et al. 2012); however, localised data for the Mediterranean region presents a stark contrast, with the subpopulation currently being listed as Vulnerable under IUCN criteria (Bearzi et al. 2012).

Historical culling campaigns, fisheries, entanglement and bycatch (Díaz López 2006, Brotons et al. 2008), prey depletion (Bearzi et al. 2008a,b, 2010), increased marine traffic (Dobler 2002, Fortuna 2006) and contamination from xenobiotics (Storelli et al. 2007, Bearzi et al. 2012) have all contributed towards a declining population trend for this species (Bearzi et al. 2012).

The Mediterranean Sea has one of the largest coastal tourism industries (Coomber et al. 2016), accounting for 50% of all tourism arrivals worldwide (Simundic & Kulis 2016). For Montenegro in particular, cruise ship and coastal tourism industries are developing rapidly (Cimbaljevic 2013, Cimbaljevic & Muratovic 2018). Between 2011 and 2012, cruise tourism increased by ~9% (Cimbaljevic 2013), whilst the number of cruise ships navigating Montenegrin waters rose by 23.5% between 2012 and 2017 (Cimbaljevic & Muratovic 2018). Most recently, dolphin-watching tours (Štrbenac 2015) and an overall growing tourism industry (Štrbenac 2015, Simundic & Kulis 2016), have led to an increase in the frequency of interactions between tourism vessels and bottlenose dolphins in the Adriatic Sea (Štrbenac 2015). According to the International Maritime Organization (IMO), the overall increase in marine traffic, attributed to seasonal tourism, has presented cetaceans in the Mediterranean with a collision risk 5 times higher than that of the worldwide average (Štrbenac 2015). For Montenegro in particular, despite a low number of occasional dolphin-watching tours, cetacean habitats are targeted by an extensive range of human activities, from maritime transport and tourism to recent seismic activities for oil and gas exploration (Bas et al. 2018, Awbery et al. 2019).

Increases in vessel activity have led to an increase in both direct and indirect threats to cetaceans. Direct threats in the form of ship strikes and behavioural modifications have been reported for other dolphin populations (Meissner et al. 2015), as well as indirect threats such as chemical pollution (Fossi & Marsili 2003, Jepson et al. 2016), prey depletion (Bearzi et al. 2005) and behavioural disruptions (Stensland & Berggren 2007, Christiansen et al. 2010, Holt et al. 2015). Reported changes in cetacean behaviours in response to vessel activities include changes in vocalisation, vertical (increased dive duration and/or depth) and horizontal avoidance (increased swim speed and/or frequency of heading changes) and changes in activity (decreased foraging, resting and socialising). Behavioural changes can carry energetic costs to the targeted animals, by either increasing energy expenditure (metabolic rate) (Williams et al. 2006, Christiansen et al. 2014) and/or decreasing energy (food) intake (Christiansen et al. 2013a, Wisniewska et al. 2016). Repeated behavioural changes can consequently lead to changes in an animal’s body condition (New et al. 2014, Rolland et al. 2016), which in turn can reduce survival and reproduction and hence have population-level consequences (Nabe-Nielsen et al. 2014, Christiansen & Lusseau 2015).

The reactions of cetaceans to a source of disturbance can have compounding effects on key behaviours, but the level of impact depends greatly on the current behaviour of the animal during the interaction (Constantine & Baker 1997). Montenegro itself has high sighting rates of bottlenose dolphins, which suggests there is a degree of residency here and the potential for the same individuals to interact with continued anthropogenic activities in this region. From October 2016 to September 2018, 61% of the individuals identified had been re-sighted within the same year or across different years, and 74% were consistently sighted within 25 km of their initial sighting or re-sighting areas (Awbery et al. 2019). The effects that anthropogenic activities have on bottlenose dolphin behaviour in Montenegro are poorly understood, although the predominantly coastal distribution of both bottlenose dolphins and marine traffic overlap with one another (Awbery et al. 2019). With the majority of previous studies describing behavioural modification through interactions with whale-watching companies or directed tour and leisure boats searching for cetaceans (Lusseau 2003, Lusseau & Higham 2004, Christiansen et al. 2010, Meissner et al. 2015), the present project aims to investigate the potential interaction between bottlenose dolphins and non-targeted tourism vessels (i.e. cruise ships, passenger boats, ferries), as the effect the overall presence tourism vessels have is unknown.

2. MATERIALS AND METHODS

2.1. Data collection

Bottlenose dolphin behaviour and tourism vessel data were collected through systematic weekly land surveys between September 2016 and December
The study area (Fig. 1) covered an estimated 919 km² of Montenegro’s maritime zone on the east coast of the South Adriatic, encompassing coastal (0–200 m depth) waters of Montenegro. Five theodolite stations from Herceg-Nov to Ulcinj were selected along the entire Montenegrin coastline. A Sokkia DT5A theodolite was used to record vertical and horizontal angles of both the approximate centre of dolphin groups and marine vessels (defined as the point where the bow of the vessel meets the water). Theodolite readings were transformed into geographic positions using the positioning software Pythagoras version 1.2. Marine traffic sampling itself was similar to that of Bas et al. (2017a,b, 2018) and recorded the different types of vessels encountered. Only vessels that could be defined as solely used for the purpose of tourism were included in the data for this study.

Instantaneous focal ‘group’ scan sampling (Bas et al. 2017a,b, 2018) was used to determine the predominant behaviour of bottlenose dolphins. Behaviours of individuals in a group were recorded by scanning the focal group from one side to the other, from which the predominant behavioural state of the group, the behaviour that >50% of individuals in the group were engaged in, was determined. A group was defined as 2 or more dolphins within close distance (each individual <50 m apart) of each other (Bas et al. 2017b). The approximate group size and proximity to non-targeted tourism vessels was also recorded. The behavioural state of the focal group was recorded at the start of every 5 min scan sample period, with behavioural states being defined as travelling, diving, surface feeding, resting, socialising and milling (Table 1). Our definitions of behavioural states are widely accepted across research already undertaken and form the basis of most studies (Lusseau 2003, Christiansen et al. 2010, Bas et al. 2015). Sampling of behaviours was dependent on the focal group being observable at the surface of the water. If the focal group was not observed for 5 min after the last scan sample, the next observation of a dolphin group was recorded as a new group so as to avoid falsely identifying a new group as an existing group (Bas et al. 2017b, 2018). Impact scenarios were defined as a dolphin group being within a 400 m radius of tourism-related vessels, and thus the behavioural transition was added to the impact chain. The 400 m radius limit (the ‘reaction zone’) was chosen, as marine vessels <400 m from dolphin focal groups have been found to induce behavioural responses as a result of a dolphin–vessel interactions (Constantine & Baker 1997, Bejder & Samuels 2003, Bas et al.)

Fig. 1. The effective survey area of the study (inset: Montenegro and bordering countries). To estimate the survey coverage of each theodolite station (black triangles), the distance to the horizon was calculated and then halved. Nm indicates nautical miles.
In addition, several environmental variables (cloud cover, Beaufort sea state, glare, visibility) were assessed and recorded every 60 min, or whenever conditions notably changed. Surveys were conducted in conditions of Beaufort 3 or less and where the visibility from the survey site out towards the horizon was at least 5 km. Fixed data such as air and sea surface temperature and wind speed and direction were also collected and a tide table was utilised to assess the tide and swell height during survey efforts.

2.2. Data processing

Two-way contingency tables were created between preceding and succeeding behavioural states during control and impact situations using the calculated number of transitions between differing behavioural states (Bas et al. 2017b). Behavioural samples where a minimum of 2 behavioural transitions occurred within a single dolphin group were included in the analysis. The control chain represents the absence not only of tourism-related vessels but of all marine vessels. In situations when it was not implicitly clear whether a behavioural state was part of the control or the impact chain (i.e. vessels arrived or departed within the time frame), the data were removed from the analyses (Meissner et al. 2015). The sample sizes for milling and socialising were too small to include them individually in the analysis and these behavioural states were therefore combined as milling-socialising and were analysed together.

2.3. Effect of vessel presence on dolphin behavioural budget

To quantify the effect of vessel interactions on the behavioural budget of the dolphins, we followed a stepwise modelling approach similar to Christiansen et al. (2013b). Initially, a first-order Markov chain was used to calculate the transition probabilities between behavioural states (the proportion of time a behavioural state was followed by another behavioural state), using the 2-way contingency tables, one for control and one for impact situations (Lusseau 2003, Christiansen et al. 2010). Following the methods of Christiansen et al. (2013b), we then used Monte Carlo simulations to estimate the behavioural budgets of dolphins during impact and control situations (for details, see Christiansen et al. 2013b). A time series of behavioural states was first created in R, with diving being arbitrarily chosen as the initial starting state. The second behavioural state in the time series was then randomly assigned based on the transition probability of moving from diving (the initial state) to another behavioural state, and the situation (control or impact). The third behavioural state would then be randomly assigned based on the second behavioural state and so on, until a time series of 1000 states had been created. The first 100 states were then removed as a burn-in period to ensure that each time series started with a random behavioural state. The simulation duration was set to 24 h (24 h × 60 min h⁻¹ / 5 min timestep⁻¹ = 288 timesteps, each representing a 5 min scan sample) to represent the dolphin’s diel behaviour. The resulting time series was then used to calculate the behavioural budgets

<table>
<thead>
<tr>
<th>Behavioural state</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Travelling (TRA)</td>
<td>Travelling: Movement of the group with constant speed and direction, surfacing at intervals of 3 to 5 s. Animals often seen travelling in a given direction for at least 200 m in 1 min.</td>
</tr>
<tr>
<td>Diving (DIVE)</td>
<td>Characterised by steep dives, dolphins stay within a ~100 m radius within 1 min, moving in varied directions and spending more time underwater than at the surface. This behaviour often relates to foraging.</td>
</tr>
<tr>
<td>Surface feeding (SF)</td>
<td>Movement is extremely varied, characterised by energetic surfacing, changes in swim speed and rapid directional changes. There are likely to be birds and fish present.</td>
</tr>
<tr>
<td>Resting (REST)</td>
<td>Dolphins travel very slowly in a coordinated manner, staying close to one another and close to the surface. Dive intervals are short (2–3 s) and group activity is very low.</td>
</tr>
<tr>
<td>Milling (MILL) or Socialising (SOC)</td>
<td>Milling: Non-directional movements where the individuals all appear to face different angles Socialising: The observed physical contact between dolphins. Includes chasing, body contact and aerial interactions.</td>
</tr>
</tbody>
</table>

Table 1. Definitions of dolphin group behavioural states used during data collection
of the dolphins by summing together the number of times a certain behavioural state occurred and dividing it by the total length (i.e. duration) of the time series (i.e. 288 timesteps). To obtain an estimate of the variation in the simulation output, the simulation process was repeated for 1000 iterations, both for control and impact situations. This resulted in a density distribution around the relative proportion of each behavioural state during control and impact, from which the 95% highest posterior density (95% HPD) intervals were estimated for each behavioural state.

2.4. Tourism vessel density

Non-targeted tourism vessel density was calculated for the entire study period for each season. Seasons were classified as autumn (September, October, November), winter (December, January, February), spring (March, April, May) and summer (June, July, August). Data were prepared, visualised and analysed in ESRI ArcGIS software version 9.3. The kernel density function was used to apply a raster map of non-targeted tourism vessels. This was performed within a circular neighbourhood for each raster cell of 200 m, with a radius of 2000 m.

3. RESULTS

3.1. Sightings

A total of 320 d (970.50 h) were spent searching for bottlenose dolphins along the Montenegrin coastline between September 2016 and December 2018. Of these, 96 d were spent in the presence of bottlenose dolphins, corresponding to 132 focal group follows. Of the 320 d spent searching for bottlenose dolphins, 311 d of observation were performed in sea states of Beaufort 3 or less, with 94 of the 96 sightings occurring in those conditions. A total of 9 surveys were performed on days when the Beaufort was greater than 3 or could not be determined. A total of 87.50 h of behavioural data were collected from the 132 focal group follows.

Overall, the number of behavioural transitions recorded was 410, of which travelling behaviour was the most commonly observed behaviour, being observed 188 times. Diving behaviour was observed 144 times, milling-socialising 24 times, resting behaviour 25 times and surface feeding 29 times. While 374 (91.2%) transitions were recorded in the control chain, a total of 36 (8.8%) transitions occurred in the vicinity of non-targeted tourism vessels (impact situations).

3.2. Observations in relation to tourism density

Bottlenose dolphins were found to be present 40.5% of the time at the most northern coastal survey location (Herceg-Nov) during land survey observations and were present 23.1 and 31.7% of the time at the middle (Petrovac and Bar) and southern (Utjeha and Ulcinj) survey locations respectively.

Mapping of non-targeted tourism vessels identified that the most northern coastline of Montenegro (Herceg-Nov) held the greatest density of non-targeted tourism throughout each season (Fig. 2). Non-targeted tourism vessel density was greatest at each survey site during summer months, with little disparity between the densities for spring and autumn. During the winter, survey site locations only experienced non-targeted tourism vessel presence in Herceg-Nov and Utjeha, and not in the other areas.

3.3. Behavioural transitions

Markov chain analysis demonstrated that interactions with non-targeted tourism vessels had a significant effect on the transition probability between dolphin behavioural states (Fig. 3). Dolphins were less likely to remain in a milling-socialising (milling-socialising→milling-socialising: 3.8 to 0%), surface feeding (surface feeding→surface feeding: 43.3 to 0%) or diving (diving→diving: 58.6 to 45.4%) in the presence of non-targeted tourism vessels. Conversely, dolphins were observed to drastically increase their resting state following diving (diving→resting: 2.2 to 18.2%) and travelling (travelling→resting: 1.8 to 10.5%) in the presence of non-targeted tourism vessels. Dolphins were also more likely to remain in a resting behaviour (resting→resting: 41.2 to 66.7%) when non-targeted tourism vessels were present. No differences were observed when dolphins were travelling and remained in that behavioural state (67.8 to 68.4%) or when transitioning from travelling to diving (23.6 to 21.1%). Finally, in the presence of non-targeted tourism vessels, dolphins demonstrated an increase in travelling behaviour following diving (diving→travelling: 27.8 to 36.4%).

3.4. Effects of vessel presence on dolphin behavioural budget

The simulated behavioural budgets showed that dolphins significantly changed their behaviour in the presence of vessels, with 4 of the 5 behavioural states being significantly different between impact and con-
Fig. 2. Recorded seasonal density distribution of non-targeted tourism vessels during land surveys between September 2016 and December 2018. Upper left panel: summer; upper right: spring; lower left: autumn; lower right: winter. Nm indicates nautical miles.
trol situations (Figs. 4 & 5). Diving decreased from 36.5% (95% HPD: 29.5 to 45.5) during control to 20.2% (95% HPD: 13.9 to 27.1) during impact situations, which is equivalent to a decrease of 16.3 percent units (95% HPD: 6.2 to 27.1) (Figs. 4 & 5). Milling-socialising and surface feeding represented 5.7% (95% HPD: 2.4 to 9.4) and 7.6% (95% HPD: 3.5 to 13.2) of the behavioural budget of dolphins during control situations, but were absent from their behavioural repertoire in the presence of vessels (Figs. 4 & 5). In contrast, resting increased by 23.1 percent units (95% HPD: 13.5 to 33.0) in relative proportion during interactions with vessels, from 4.3% (95% HPD: 1.0 to 7.6) to 27.4% (95% HPD: 17.7 to 36.1) (Figs. 3 & 4). Although travelling increased by 6.5 percent units (95% HPD: –6.2 to 18.8) during vessel interactions, there was no significant difference between control (mean: 45.9%, 95% HPD: 36.8 to 54.9) and impact situations (mean: 52.4%, 95% HPD: 43.8 to 60.4) (Figs. 4 & 5).

3.5. Seasonal variation in dolphin activity

The activity pattern of the dolphins varied seasonally for milling-socializing ($\chi^2_3 = 12.8$, $p = 0.005$) and resting ($\chi^2_3 = 12057$, $p < 0.0001$) behaviours (Fig. 6). Dolphins were less likely to show milling-socialising behaviour during spring and summer in comparison to autumn and winter (Fig. 6). Resting behaviour was observed significantly less during spring compared to summer and autumn, and was never observed during winter (Fig. 6).

4. DISCUSSION

In response to an increase in global marine traffic, many recent studies have focussed on the potential impacts of marine vessels on the behavioural budget of cetaceans (Lusseau 2003, 2004, Constantine et al. 2004, Lusseau & Higham 2004, Lusseau et al. 2006, Christiansen et al. 2010, 2013a, Bas et al. 2017a,b, Marley et al. 2017). Despite reported changes in the behaviour of cetaceans towards dolphin- and whale-watching vessels, relatively little is known about the potential effect resulting from interactions between cetaceans and other types of tourism vessels that do not directly target cetaceans (e.g. cruise ships, passenger boats and recreational watercraft). The current study demonstrates that the behaviour of bottlenose dolphins off the coast of Montenegro is significantly affected by interactions with non-targeted tourism vessels, despite the low association rate, with only 8% of the total behavioural transitions recorded in the vicinity of tourism vessels, and the short-term differences in the transition probabilities were significantly strong enough to alter the dolphins’ behavioural budget at the current level of vessel interaction.

Following interactions with non-targeted tourism vessels, dolphins were more likely to decrease their diving behaviour and increase their resting behaviour, with a complete absence of surface feeding and milling-socialising behaviours. Some of these trends, however, may be attributed to the seasonal variation in dolphin behaviour, where the probability of spending time in a specific behavioural state varied seasonally. Existing literature for the Adriatic Sea has already pointed out that behaviour is best explained when considering the effect of seasonality (Bearzi et al. 1999, Affinito et al. 2018) which points towards which behaviours are most likely to be affected.

A previous study using the current database reported similar patterns of seasonality for socialising behaviours between September 2016 and October 2017, where they were most frequently observed
during autumn and winter seasons (Affinito et al. 2018). The current study showed that bottlenose dolphins demonstrated low levels of milling-socialising activity in spring and summer, encompassing seasons when non-targeted tourism vessels were present in their greatest densities throughout the Montenegrin coastline. Milling-socialising behaviours are often associated with conspecific relationships between social species such as bottlenose dolphins and contribute to building relationships which develop and maintain conspecific relationships (Lindstrom 1999, Stanton & Mann 2012, Marley et al. 2017), thus allowing information to be exchanged among group members (Herzing 2000, Lusseau 2006). Interruptions to such behaviours, particularly in bottlenose dolphin juveniles and calves, can impede aspects of
early development for learning foraging strategies, physical manoeuvres and other social behaviours (Kuczaj et al. 2006, Stanton & Mann 2012, Marley et al. 2017). Although our results, and those in the literature (Affinito et al. 2018), demonstrate increased milling-socialising behaviours during autumn and winter, the absence of behavioural observations of bottlenose dolphins before the data used in this study were collected makes it hard to conclude whether these behaviours were absent as a result of seasonality, or due to increased non-targeted tourism density. Thus, without further research, it is not possible to suggest the possibility of decreased socialising opportunities in young bottlenose dolphins when considering the link between milling-socialising behaviours and non-targeted tourism vessels.

The unusual increase in resting behaviour in the vicinity of non-targeted tourism vessels contradicts the results of previous research, which found that resting behaviour decreased in the presence of marine traffic and is likely to be the first behaviour to be negatively affected (Lusseau & Higham 2004, Christiansen et al. 2013b, Bas et al. 2017a). Resting behaviour in general, however, was only recorded in 37 behavioural sequences throughout this study, which makes it difficult to ascertain the certainty of the degree of this result. Moreover, Affinito et al. (2018) demonstrated that resting behaviours increased during autumn and winter months, correlating with seasons which demonstrate lower levels of tourism pressure. Although our results contradict previous literature, it should be noted that it is likely for some cases of human disturbance, such as marine vessel presence, to be perceived as an increase in predation risk to some species (Heithaus & Dill 2002, Beale & Monaghan 2004). In the case of bottlenose dolphins, their behavioural response to non-targeted tourism vessels during summer may be mistaken for resting behaviours, as dolphins themselves are known to form significantly tighter groups to increase cohesiveness in the presence of vessels (Bejder et al. 1999, Mattson et al. 2005, Steckenerreuter et al. 2011). Despite there being a possibility that resting behaviours were influenced by seasonality or misidentification of behaviour as a result of the predator defence mechanism, it is important to carry out targeted research for an accurate conclusion.

The significant decrease in diving behaviour and the complete absence of surface feeding, however, cannot solely be explained by the seasonal variation behaviours. Despite our study and the literature demonstrating increased surface-feeding behaviours during winter (Affinito et al. 2018), the complete absence of this behaviour in the vicinity of non-targeted tourism vessels clarifies the effect these vessels have on bottlenose dolphins, when considering that surface feeding was observed in control situations across all seasons. The significant absence of surface feeding and diving is likely to reduce the foraging ability and energy intake of dolphins (Williams et al. 2006, Christiansen et al. 2010). Similarly, previous studies have associated diving behaviour with foraging activity in dolphins (Shane 1990, Constantine et al. 2004, Lundquist et al. 2012, Meissner et al. 2015), although it has been suggested as a method of vertical avoidance by dolphins towards vessels (Lusseau 2003, Bas et al. 2017a, Marley et al. 2017). With vessel interactions leading to a reduction in diving behaviours of dolphins in Montenegro, it is unlikely that diving represents an avoidance strategy in this population. As energy acquisition becomes limited, the repeated interruptions by non-targeted tourism vessels are likely to have long-term negative effects on dolphin survival rates, especially where the population becomes limited by resource availability (Williams et al. 2006, Christiansen et al. 2013b, Meissner et al. 2015).

Despite the current relatively low level of interaction between Montenegrin bottlenose dolphins and non-targeted tourism vessels, annual cruise tourism continues to increase in this region (Cimaljevic 2013, Cimaljevic & Muratovic 2018). Herceg-Novi in particular holds the greatest density of tourism vessels

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Fig. 6. Seasonal variation in the probability of bottlenose dolphins performing different behavioural states (see Table 1) in the absence of vessel traffic. Error bars: 95% CI
throughout each season and has been identified as the location with the greatest probability of bottlenose dolphin presence. This location in particular has also been identified as a core zone for bottlenose dolphins annually (Awbery et al. 2019), and thus, further research into the uses of this site are paramount if effective and viable conservation measures are to be suggested.

The proven behavioural responses measured in this study emphasise the need for immediate actions in order to mitigate anthropogenic impacts. Lusseau (2003) and Kovacs et al. (2017) have previously suggested safeguarding critical locations on the basis of behavioural budgets. Using such behavioural budget thresholds provides a biologically meaningful and quantifiable dataset to describe areas of coastline as either ‘critical’ or ‘important’ for particular cetacean activities and could be used for the designation of areas in Montenegrin waters.

5. CONCLUSIONS

The Montenegrin coastline currently lacks effective protective measures for both bottlenose dolphins and marine ecosystems despite their national and international protection status. This study provided evidence to support the hypothesis that non-targeted tourism activities can have negative effects on the behaviour of bottlenose dolphins off the coast of Montenegro. The current level of interaction, despite being negligible in comparison to other studies (Stensland & Berggren 2007, Christiansen et al. 2010, Meissner et al. 2015, Bas et al. 2017a,b, Marley et al. 2017), has already demonstrated significant effects on the behavioural budgets for surface feeding and diving in bottlenose dolphins. As levels of anthropogenic activity increase seasonally, the cumulative impacts from long-term and increased tourism exposure should be of particular concern. Future research should take into account the intra-annual variations of non-targeted tourism density displayed and begin to explore the possibility of how this impacts upon dolphin behavioural budgets for each season. The future growth of the tourism industry in Montenegro should be given careful consideration, particularly in Herceg-Nov. By identifying seasonal critical habitats and how they overlap with core tourism zones, control measures can begin to be developed, such as marine vessel density limitations, vessel-free zones and specifying specific routes for the transit of cruise ships and passenger boats, to reduce anthropogenic impacts.

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