Received: 21 January 2021 | Accepted: 15 December 2021
DOI: 10.1111/mms.12913

ARTICLE

Marine Mammal Science

The effect of commercial and artisanal fishing practices on the behavioral budget of bottlenose dolphins off the coast of Montenegro, South Adriatic Sea

Laura E. Rudd | **Tim Awbery** | **Romina Waller** | **Molly Crowe** | **Julianna Bauer** | **Anna Jacquemart** | **Natasa Nikpaljevic** | **Aylin Akkaya**

DMAD – Marine Mammals Research Association, Antalya, Turkey

Correspondence
Laura E. Rudd, DMAD - Marine Mammals Research Association, Fener Mahallesi, 1951. Sk, Muratpaşa, Antalya, Turkey
Email: lerudd1@hotmail.co.uk

Funding information
Rufford Foundation, Grant/Award Number: 27086 - 2

Abstract

The spatial–temporal distribution of cetacean species often overlaps with fishing practices in the Mediterranean, having direct and indirect consequences. This is the first long-term study focusing on the effects of fisheries on the behavior of *T. truncatus* in Montenegro. Focal group scan sampling was used during surveys between September 2016 and August 2020 to create transition probability matrices using first-order Markov chains for behavioral states in both control (absence of fishery practices) and impact chains (presence of fishery practices). Despite the low number of dolphin-fishery interactions in Montenegro, results revealed that the behavioral budgets of *T. truncatus* were significantly altered both for commercial and artisanal fisheries. However, the magnitude of the threat differed between practices, with commercial fisheries altering three out of the four behaviors in the behavioral budget while artisanal fisheries altered just one. Significant behavioral changes due to disturbance can have negative consequences on the energy budget of individuals and while the Montenegrin fishing fleet is currently limited to 224 vessels, the significant effects already witnessed are concerning for Montenegrin bottlenose dolphins. To develop in-situ mitigation strategies, there is a clear need to better understand the impact that fisheries interactions have on these individuals.

KEYWORDS
artisanal fishery, behavioral alterations, behavioral budgets, bottlenose dolphin, commercial fisheries, disturbance, fishing fleet, Markov chain, Mediterranean Sea, trawlers

1 | INTRODUCTION

A decline in fish stocks within the Mediterranean may have a knock-on impact on marine ecosystems, as changes to prey populations impact higher trophic levels such as cetaceans (Bearzi et al., 2009, Hinz et al., 2009). Global marine capture fisheries accounted for 84.4 million tons of landed fish in 2018, Mediterranean and Black Sea 1.31 million tons of landed fish (FAO, 2020). Among all fisheries in the Mediterranean and Black Sea region, only 37.5% of fish stocks were fished at a biologically sustainable level in 2017, with the annual yield of fish landed by fishermen decreasing by 0.53 million tons from the 1980s to 2018 (almost 30%; FAO, 2020).

The reduction in fish stocks could mean that predators must expend more energy traveling larger distances to find fish or must undertake more risky opportunistic feeding strategies such as net depredation (Powell & Wells, 2011). One particular species under threat is the common bottlenose dolphin, *Tursiops truncatus* (Chilvers et al., 2003; Consiglio et al., 1992; Pace et al., 2003). Classified as vulnerable and declining within the Mediterranean (Bearzi et al., 2012), *T. truncatus* is a globally distributed cetacean species that inhabits both temperate and tropical coastal waters (Genov et al., 2008; Holcer et al., 2014; Lusseau, 2004; Wells & Scott, 1999). The latest abundance estimates for the Mediterranean population lie in the low 10,000 s (Fortuna, 2006). Due to the low population size of *T. truncatus*, disturbance could be detrimental to the conservation status of this species. It is estimated that numbers have decreased by at least 30% since the 1940s across the whole Mediterranean Sea (Bearzi et al., 2012), and by as much as 50% across the Adriatic Sea (Bearzi et al., 2004). The Adriatic Sea, regarded as an Ecologically or Biologically Significant Marine Area (EBSA), covers a total surface area of 138,518 km^2 (Macic, 2005). The coastal waters of the Adriatic are thought to be primary hotspots for *T. truncatus*, attributable to their high accessibility and opportunities for feeding (Bearzi, 2002). This exposes the species to an increased risk of disturbance due to their overlapping presence with anthropogenic activities, such as fisheries, placing them in direct competition for resources. Of the 1792 fishing vessels that operate in the Southern Adriatic, the Montenegrin fishing fleet comprises 224 fishing vessels (FAO, 2020; Montenegro Ministry of Agriculture and Rural Development, 2015), including 191 small scale vessels, 13 benthic trawlers, and 20 pelagic trawlers and purse seiners (FAO, 2020). The majority of vessels remain within 8 nautical miles of the coast with only three licenses allowing exploitation of the operational zone between 8 and 12 nautical miles off the coast (Montenegro Ministry of Agriculture and Rural Development, 2015). The coastal distribution of these vessels put them at a greater chance of interacting with cetaceans (Goran & Jelisavka, 2017).

The main target species of trawlers in Montenegrin waters are European hake *(Merluccius merluccius)*, red mullet *(Mullus barbatus)*, deep-water pink *shrimp (Parapenaeus longirostris)*, common squid *(Loligo vulgaris)*, shortfin squid *(Illex coindetii)*, octopus (*Octopus vulgaris* and *Eledone* spp.), and the Norway lobster (*Nephrops norvegicus*) (RAC/SPA - UNEP/MAP, 2013). The catch of small-scale fisheries is understood less well (RAC/SPA - UNEP/MAP, 2016) but it is thought that European pilchard *(Sardina pilchardus)* and European anchovy *(Engraulis encrasicolus)* are heavily fished in northern parts of the country and that bogue *(Boops boops)* make are large part of artisanal catch (RAC/SPA - UNEP/MAP, 2013). Of these species, *M. merluccius* and *L. vulgaris* have been found in the stomach of a *T. truncatus* necropsied in the Adriatic while *M. barbatus*, *I. coindetii*, *O. Vulgaris*, *Eledone cirrhosa*, *S. pilchardus*, *Sepia officinalis*, *Conger conger*, and *E. encrasicolus* have been found in *T. truncatus* necropsied elsewhere in the Mediterranean (Bearzi et al., 2008; Blanco et al., 2001, Miokovic et al., 1999). Stable isotope analyses within the Adriatic have demonstrated that *T. truncatus* are able to alter their prey dependent on availability (Holcer, 2012), and it is therefore likely that bottlenose dolphins in Montenegro are preying on many of the same species that are being fished. The spatial and diet overlap increases the probability of interactions between *T. truncatus* and fishing vessels. Prolonged exposure to fishing practices is believed to cause both short- and long-term impacts on *T. truncatus* (Bejder et al., 2006; Constantine et al., 2004; Pennino et al., 2016). Short-term responses show behavioral changes, such as, lengthened dive intervals, increased swimming speed, fewer resting periods, and changes in acoustic behavior (Bas et al., 2017; Bejder & Samuels, 2003; Lusseau, 2003, 2004; Lusseau & Higham, 2004; Stockin et al., 2008). However, short-term behavioral changes exhibited by cetaceans can be difficult to extrapolate into population impacts (Williams et al., 2006) compared to long term consequences that may include increased injury and mortality rates as a result of vessel strikes, bycatch, and entanglement (Consiglio et al., 1992; Defran & Weller, 2006; Hazelkorn et al., 2016; Stockin et al., 2008).

Cetacean interactions with humans often exhibit a trade-off between perceived risk and reward, so individuals and populations may tolerate disturbance in order to stay in a preferred feeding habitat (Bejder et al., 2006). *T. truncatus* are opportunistic feeders and have been found to associate with trawlers during the retrieval of gill nets, having displayed evidence of net depredation (Au, 1993; Hazelkorn et al., 2016; Pace et al., 2003; Perrin et al., 1994), highlighting the behavioral plasticity of *T. truncatus* to take advantage of anthropogenic activity (Pace et al., 2003).

Markov Chain analysis is a widely employed technique in the field of behavioral biology that measures the effects of extrinsic disturbance factors contributing to change from one event to another (Christiansen et al., 2010; Kassamali-Fox et al., 2015; Lusseau, 2004; Meissner et al., 2015; Stockin et al., 2008). The current study uses this methodology to estimate the impact of different fishing practices on the behavior of *T. truncatus* by comparing both the control (absence of fisheries within a 400 m radius of dolphins) and impact chains (presence of fisheries within a 400 m radius of dolphins). This radius is based on the distance which a behavioral response was induced due to vessel presence in previous literature (Bas et al., 2015; Bedjer & Samuels, 2003; Constantine & Baker, 1997). These can be used to assess the effects of fishing practices (commercial and artisanal fishing boats) within the 400 m radius zone of dolphins, with the aim of highlighting anthropogenic impacts on *T. truncatus* behavioral budgets. Greater understanding of marine mammal and fisheries interactions are needed to assist in marine management.

2 | METHODS

2.1 | Survey area

The survey area covers the entire coastline of Montenegro, using a combination of fixed land and boat survey stations (Figure 1). Surveys were carried out between September 2016 and August 2020 with an aim of conducting at least one boat survey and three land surveys a week, although this was not always possible due to weather conditions and other unforeseen circumstances (e.g., an absence of data collection from April to June 2020 due to restrictions imposed by the coronavirus pandemic). Data collection was obtained between 05:00 and 21:00, with each survey lasting a minimum of 3 hr.

2.2 | Data collection

A total of six predetermined theodolite stations were selected to best represent Montenegrin waters: north (Herceg Novi and Luštica Bay), middle (Petrovac and Bar), and south (Utjeha and Ulcinj) (Figure 1). All stations were at least

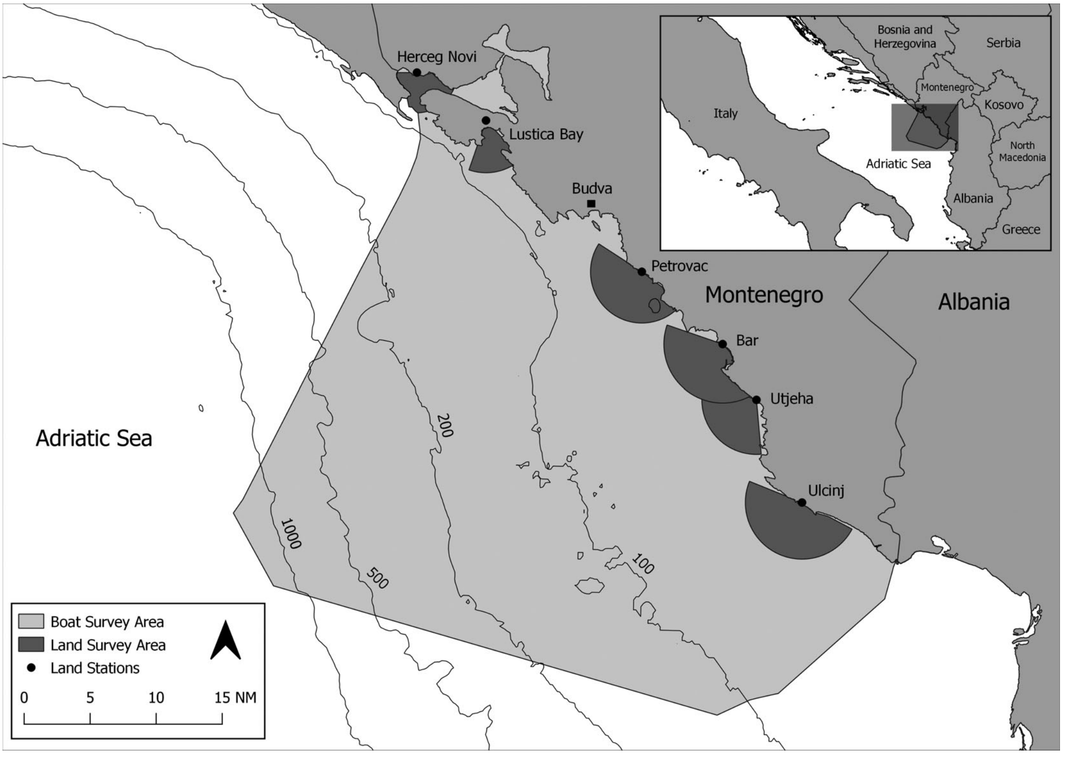

FIGURE 1 Study area including total coverage of land and boat survey efforts.

TABLE 1 Land station coordinates and altitudes.

Land station	Coordinates		Altitude (m)
Herceg-Novi	42.2710°N	18.3224°E	84
Luštica Bay	42.3869°N	18.6592°E	103
Petrovac	42.1230°N	18.5554°E	108
Bar	42.0710°N	19.0418°E	23
Utjeha	41.0301°N	19.0752°E	78
Ulcinj	41.5518°N	19.1243°E	33

20 m above sea level to ensure accurate theodolite readings, while taking into account optimal vantage points for cetacean observation (Table 1). Land surveys were conducted either in the morning (beginning with sunrise) or the afternoon (ending with sunset).

A theodolite (Sokkia DT5A) was used to find the horizontal and vertical angles between the observer and the *T. truncatus* groups and marine vessels. Pythagoras v. 1.2. software was used to convert these angles into geographical positions. As well as recording data on the number of marine vessels, their type (FB (fishing boat), FV (fishing vessel), HSB (high-speed boat), RB (research boat), SB (sailing boat), FE (ferry) HSFE (high-speed ferry), CS (cargo ship), CR (cruise ship), and JET (jet-ski), their activity, and their distance from cetaceans was recorded following the methodology used by Bas *et al*. (2017, 2018). This study focused particularly on fisheries data and fishing activity was divided into two separate categories: commercial fishing vessels (FV), consisting of trawlers and purse seiners (>12 m in length) and artisanal fishing boats ((FB), consisting of smaller purpose-built fishing boats and other recreational boats where fishing gear was clearly visible (<12 m in length)). This study also included boats identified in the aforementioned categories that were not actively fishing as previous studies have shown bottlenose dolphins to interact with boats and scavenge on discards even when vessels were not actively fishing (Durden, 2005; Powell & Wells, 2011).

Boat surveys were conducted using 6 m or 12 m motorboats or sailing boats; traveling at an average speed of 4 knots (Awbery et al., 2019). However, in the case of *T. truncatus* presence, speed was reduced until idle, while ensuring the path of the focal group was not blocked and an observational distance of between ∼50 m and 400 m was maintained. The geographic position of the survey boat was recorded every 3 s using a GNSS (global navigation satellite system) receiver paired with the software Logger v. 2010. In the presence of *T. truncatus*, the distance of the group from the research vessel and their bearing was used to calculate the true coordinates of the focal group (Bas et al., 2018). As with the land-based surveys vessel type, activity and distance from the dolphin group was recorded.

The predominant behavior of the focal group was determined at the start of each 5 min sampling interval using an instantaneous focal group scan sampling method following the methodology of Bas et al. (2017, 2018). For each sampling interval, the behavioral states of individuals within the focal group were scanned and the number of individuals partaking in each behavioral state definition was recorded (Table 2). Behavioral state recordings were dependent upon the surfacing of the focal group at the start of each 5 min scan sample period, and were either defined as diving, socializing units (socializing, resting, or milling), surface-feeding, or travelling. If the focal group was not observed after the last 5 min scan sample, the sampling interval was discarded and restarted upon the focal group being observed again at the surface of the water. In order to differentiate between focal groups at any one time, each group was numbered. If a group became absent for more than 20 min, a resighting would be considered a new group as it was difficult to ascertain if individuals belonged to the previous focal group. The minimum and maximum size of the focal group and their distance to marine traffic were also recorded.

2.3 | Data analysis

To measure the impact of commercial and artisanal fisheries, control and impact chains were created. Impact chains represent the presence of fishery related vessels within a 400 m radius of the focal group (defined as the interaction

TABLE 2 Ethogram of all *T. truncatus* behavioral states used in this study, (adapted from Bas *et al*. 2017).

Behavioral states	Descriptions
Diving (DV)	Characterized by steep dives with long intervals (>10 s). Distances of less than 200 m traveled in >60 s.
Socializing units (SU)	Important cohesive behaviors including Socializing, Resting and Milling Socializing (SOC): Engaged in diverse interactive events. Physical contact with other individuals may be observed. Body contact and aerial events such as full leaps are often observed. Resting (RE): Observed within a tight group (<5 m apart) with slow swimming speeds of <2 kn within a range of 100 m in 60 s. Low group activity detected with no splashes evident. Milling (MI): Nondirectional movement and no changes in group direction. Group cohesion remains similar. Short dive intervals may be observed.
Surface-feeding (SU-FE)	Typically observed in the presence of fish and birds while dolphins are at the surface. Motions include rapid circular dives, uncoordinated re-entry leaps and rapid directional changes.
Traveling (TR)	Individuals move persistently at a speed of >4 kn. Distances of minimum 200 m in <60 s are reached with short and constant dive intervals.
Approaches to boats (AP)	Individuals either bow ride or persistently remain within 10 m of the boat.
Undetermined (UND)	Behavior of the focal group could not be identified.

zone). This limit was chosen because vessels ≤400 m from focal groups have previously demonstrated significant behavioral responses and directional changes (Bas et al., 2015, 2017; Beider & Samuels, 2003; Constantine & Baker 1997; Lusseau, 2003). If no marine vessels were present within the interaction zone, regardless of the type and activity of the vessel, the behavior was included in the control chain and represented the absence of the vessels within the interaction zone.

Preceding and succeeding behavioral states were recorded for control and impact chains in order to create the transition probability matrix for the Markov chains. Preceding behavior represents the first recorded behavioral state (at time t) of the focal group while succeeding behavior was defined as the follow-up behavior (at time $t + 5$ min) of the preceding behavior. Two-way contingency tables formed from preceding and succeeding behaviors were created for both control and impact chains. The contingency tables were used to investigate the temporal dependency of behavioral states calculating the number of times that a preceding behavior transitioned to a succeeding behavior (Christiansen et al., 2010, 2013; Lusseau, 2003; Meissner et al., 2015). During the creation of contingency tables, a minimum of three consecutive sampling units (≥15 min) were deemed required to form a control chain. The impact chain considered any presence of fishery related vessels (≥5 min) and included the sampling period directly before or after a vessel presence in the impact chain as it was likely the boat was in the vicinity and so should not be disregarded. Similarly, if there was a small interruption (≤10 min) where a different vessel category was present between two sets of sampling periods where fishing vessels were present then this data was also added to the relevant impact chain. Transition probabilities between behavioral states were calculated using the following formula as in Christiansen et al. (2010):

$$pij = \frac{aij}{\sum_{j=1}^{4} aij}, \sum_{j=1}^{4} pij = 1$$

where pij represents the transition probability from the preceding behavioral state, i, to the following behavioral state, j (i and j range from 1 to 4, as a total of four behavioral states were studied, aij is the number of transitions observed from behavior i to j and $\sum aij$ is the total number of observations, where i is the preceding state (Christiansen et al., 2010).

Sample sizes for resting, milling, and socializing were too small to include them individually in the analysis. As these are all important cohesive behaviors and crucial when attempting to establish critical habitats and future conservation strategies (Lusseau & Higham, 2004), these behaviors were combined as socializing units and analyzed together as in Bas *et al*. (2017).

Before proceeding, an exploratory analysis of the effect of survey type (land vs. boat), season, and presence of fishing vessel (vs. control), on transition probabilities was performed using a generalized linear model with the Gaussian family and identity link function. Numerous models were tested comparing these variables with the Akaike's information criterion (AIC) values used to select the most suitable model. This model retained the presence of fishing vessels and season, which were both found to have a significant effect on the probability of a particular behavioral transition occurring. We found no significant effect of any interaction between presence of fishery vessel and season found in any of the models and so they were further investigated independently. We also found no significant difference between behavioral transition observed in land-based and boat-based surveys in any of the models combined these two data sets.

Using the statistics package R (version 3.6.1), a time series of states was created for the control and impact chains. Diving was the first state listed in the transition probability matrix, so, was arbitrarily assigned as the initial state. The second behavioral state was randomly assigned based on the transition probability of moving from diving to each of the succeeding states. This process of the behavior being randomly selected based on the previous state and its associated transition probabilities was repeated until 1,000 behavioral states were created. A burn-in period of the first 100 states was removed to ensure that the time series began with a random behavioral state (removing the bias of assigning diving). The simulation was limited to 24 hr (288 time steps) in order to estimate the dolphin's cumulative diel behavior (as in Clarkson et al., 2020; Perez-Jorge et al., 2017), and the number of recorded states for diving, socializing units, surface-feeding, and traveling were divided by the total states to give the proportion of time spent in each behavioral state.

In order to investigate any potential effect that season has on behavior a similar methodology was used with the data divided into spring (March–May), summer (June–August), autumn (September–November), and winter (December–January). With the data subdivided, the number of impact behavioral transitions collected per season were deemed too small for meaningful analysis (commercial fisheries: $n = 10–19$, artisanal fisheries: $n = 13–51$) and so just the control data was analyzed ($n = 60–138$) by season.

3 | RESULTS

3.1 | Survey effort

A total of 598 surveys (2,084 hr 53 min) were conducted between September 15, 2016, and August 24, 2020 (Table 3). Of these, *T. truncatus* were encountered on 195 surveys with a total of 309 focal groups which resulted in the collection of 1,780 five-minute sampling units (148.3 hr) of behavioral data. Of these data, travelling and diving accounted for the majority of observed behaviors representing 43.3% and 33.4%, respectively. Socializing units and surface-feeding accounted for 10.2% and 7.3%, respectively, while the remainder of observations consisted of approaches to boats (3.8%) and undetermined behaviors (2.0%).

3.2 | Transition probabilities and behavior budgets

T. truncatus were sighted within a 400 m vicinity of marine vessels in 971 sampling units (54.6% of the recorded time) of which 293 sampling units (16.5% of the recorded time) belonged to fishing practices. Fisheries interactions were observed during a total of 157 sampling units (8.8% of the recorded time) for artisanal fisheries and 136 sampling units (7.6% of the recorded time) for commercial fisheries. Once the data rules detailed in the methodology had been applied this left 65 sampling units in the presence of commercial vessels and 127 in the presence of artisanal vessels (Table 3).

The temporal dependence of behavioral states was significantly altered in the presence of both fishing practices. Of the 16 possible behavioral transitions, five changed significantly in the vicinity of artisanal fishery, while nine behavioral transitions changed in the presence of commercial fishing vessels. While the continuation of socializing units significantly decreased (.55 to .40), the probability of socializing following diving behavior significantly

TABLE 3 Survey effort for each season and survey method (land or boat) alongside the number of *Tursiops truncatus* behavioral transitions recorded in each situation.

	No. behavioral transitions			Survey effort (hr)			Behavioral transitions per 100 hr of survey		
Season	FV	FB	Control	Land	Boat	Total	FV	FB	Control
Spring	18	13	138	370.37	135.48	505.85	3.56	2.57	27.28
Summer	18	48	60	408.58	226.42	635	2.83	7.56	9.45
Autumn	10	51	93	408.97	156.71	565.68	1.77	9.02	16.44
Winter	19	15	80	318.75	59.6	378.35	5.02	3.96	21.14
Total	65	127	371	1,506.67	578.21	2,084.88	3.12	6.09	17.79

increased (.05 to .18) in the presence of artisanal fisheries. Furthermore, while the probability of surface-feeding followed by diving behavior significantly decreased (.31 to .11), the probability of travelling as a succeeding behavior of surface-feeding significantly increased (.14 to .33). However, when diving or traveling was the preceding behavior, no significant alteration in the succeeding behavior was noted in the vicinity of artisanal fisheries.

On the contrary, the probability of maintaining the same behavioral states in the presence of commercial fishing vessels was significantly decreased for diving (.60 to .48), surface-feeding (.50 to .29), and traveling (.69 to .46), whereas the probability of continuing to engage in socializing behavior only declined by 5% (.55 to .50). The probability of traveling as a succeeding behavior of socializing significantly decreased (.31 to .00) in the vicinity of commercial fishing vessels. Furthermore, the probability of surface-feeding as a succeeding behavior of diving (.07 to .24) and travelling (.05 to .15) significantly increased and the probability of diving behavior as a succeeding behavior of socializing (.12 to .50), surface-feeding (.31 to .50), and traveling (.21 to .31) significantly increased within the interaction zone of commercial fishing vessels (Figure 2).

There was a significant difference between the control and impact budget in the presence of both fishery practices. The dominant behavior was traveling, making up 45% (95% highest posterior density interval [HPD] 0.35–0.55), followed by diving behavior, making up 35% (95% HPD 0.26–0.43) of the control budget. The probability of these activities remained similar in the presence of artisanal fisheries with traveling behavior reaching 48% (95% HPD 0.38–0.57) and diving behavior slightly dropping to 33% (95% HPD 0.26–0.41) in the impact situation. However, in the presence of commercial fishing vessels, diving behavior became the dominant behavior and formed 45% (95% HPD 0.39–0.51) of the impact budget. Regarding the individual behavioral states, only surface feeding behavior significantly decreased from 10.0% (95% HPD 5.2–15.6) in the control budget to 2.4% (95% HPD 0.3–5.2) in the impact budget, in the vicinity of artisanal fisheries (Figure 3a), whereas three out of four behavioral states showed significant alteration in the vicinity of commercial fishing vessels. Diving behavior significantly increased to 45% (95% HPD; 0.39–0.51) in the impact budget. Surface feeding behavior significantly increased to 20% (95% HPD 0.15–0.25) in the impact budget from 10% (95% 0.05–0.16) in the control budget. Lastly, traveling behavior significantly decreased and formed 22% (95% HPD 0.15–0.28) of the impact budget in the presence of commercial fishing vessels (Figure 3b).

It was deemed unlikely that research boat type influenced *T. truncatus* behavior ($\chi^2 = 5.15$, $df = 6$, $p = .52$). Similarly, when *T. truncatus* were in an impact situation with a fishing vessel as a closest vessel, there was no significant difference in behavior regardless of whether the research boat was within 100 m, within 100–200 m, or further than 200 m of the dolphin group ($\chi^2 = 2.33$, $df = 6$, $p = .88$), and thus, it was the additional presence of the research boat

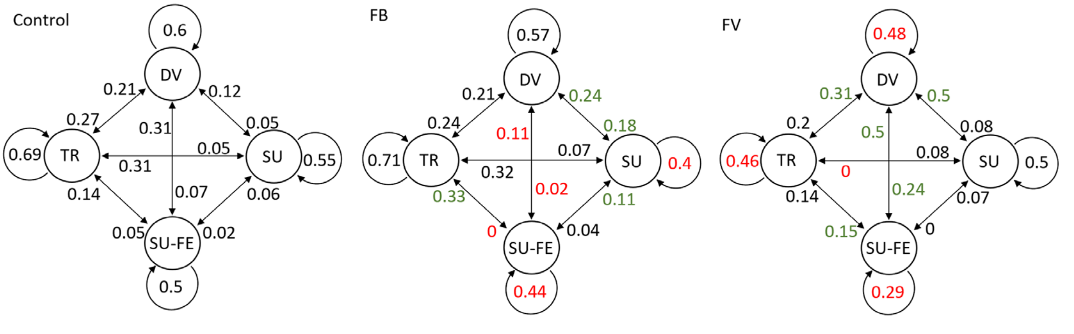

FIGURE 2 Markov chains representing probabilities for observed *T. truncatus* behavioral state transitions in the absence of and in response to fisheries, displayed for control (C) and impact (I) chains: FB (artisanal fisheries) and FV (commercial trawlers). The four behavioral states are diving (DV), socializing units (SU), surface-feeding (S-F), and traveling (TR). Values represent transition probabilities (percentages), Those with a change in 5% or more have been displayed in red (decrease) and green (increase) to highlight the biggest changes.

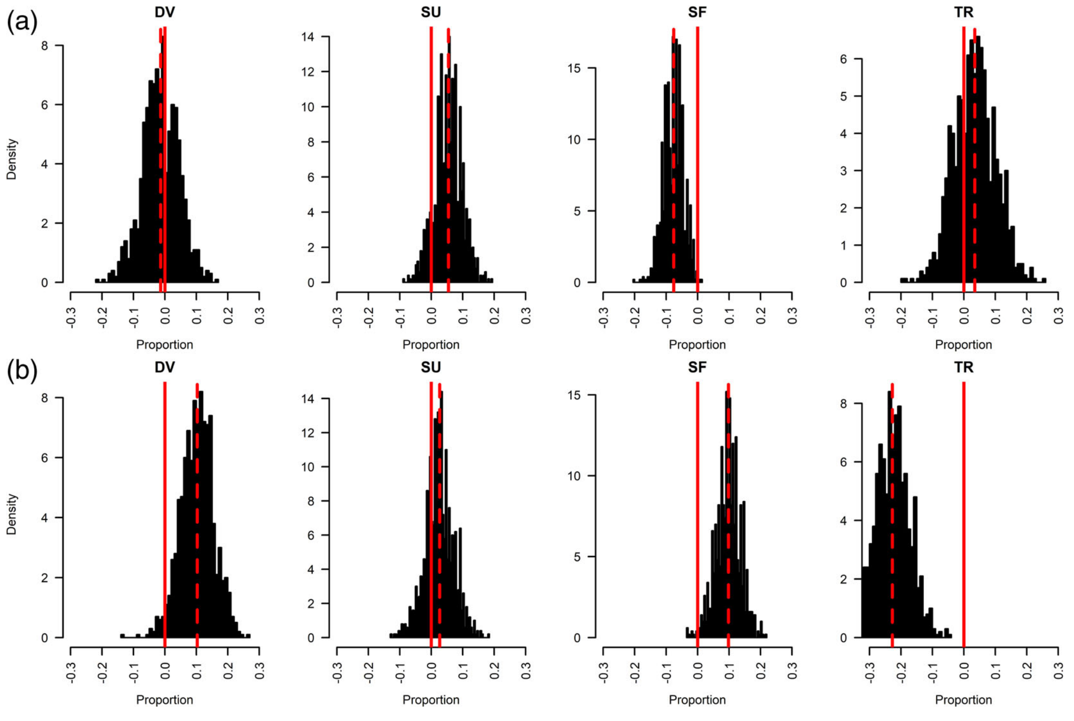

FIGURE 3 The effect of artisanal vessel interactions and commercial vessel interactions, respectively, on dolphin behavioral budget (difference in proportion of time spent in each behavioral state between impact and control situations). Each subfigure represents the distribution of estimated effects obtained from the Monte Carlo simulation (i.e., 1,000 iterations) for a specific behavioral state (DV = diving, SU = socializing units, SF = surface-feeding, TR = traveling). The red dashed vertical lines represent the mean value of each distribution, while the red solid vertical lines represent zero (no effect).

is thought to have limited effect. However, there were only a limited number of "impact" sampling units from boat-based surveys, and this should be investigated further as more data is collected.

3.3 | Seasonal differences

Generally speaking, the seasonal control results were reflective of the overall control budget with summer, autumn, and winter dominated by traveling behaviors as with the overall control budget being notably higher in summer (52.7%, 95% HPD 44.8–60.4 compared to 45%, 95% HPD 0.35–0.45; Table 4, Figure 4). While diving was the most commonly observed in spring, traveling in spring was very similar to the overall control budget (44.7%, 95% HPD 0.35–0.54). A much lower proportion of diving was seen in summer (19.5%, 95% HDP 13.9–25.3; Table 4, Figure 4). Socializing made up the highest proportion in summer and autumn (22.8%, 95% HPD 17–30.2 and 25.6%, 95% HPD 16.7–34.7, respectively) and this was considerably higher than the control (10.0%, 95% HPD 5.2–15.6). In contrast socializing was considerably lower than the overall control in spring and winter (1.5%, 95% HPD 0.3–2.8 and 4.7%, 95% HPD 1–8.7, respectively). Surface-feeding was considerably higher in winter (23.3%, 95% HPD 13.5–33) than the control 10% (5.2–15.6), while other seasons were marginally lower (Table 4, Figure 4).

There was also seasonal variation in the number of times *T. truncatus* were in an impact situation. *T. truncatus* were least likely to be recorded in the absence of boats in summer with just 9.45 transitions in the control zone per 100 hr of effort (Table 3). The highest number of interactions with artisanal fishing boats was in summer and autumn

TABLE 4 Seasonal changes in probability of *Tursiops truncatus* transitioning into each behavioral state. DV = diving, SU = socializing units, SF = surface-feeding, TR = Traveling, HPD = highest posterior density interval.

	DV (95% HPD)	SOC (95% HPD)	SF (95% HPD)	TR (95% HPD)
Spring	47.2% (38.5–55.6)	1.5% (0.3–2.8)	6.7% (2.8–11.5)	44.7% (35.4–53.8)
Summer	19.5% (13.9–25.3)	22.8% (17–30.2)	5% (2.8–7.3)	52.7% (44.8–60.4)
Autumn	33.1% (24.7–41)	25.6% (16.7–34.7)	6.8% (2.4–11.8)	34.5% (24.7–45.8)
Winter	29.5% (24–36.5)	4.7% (1–8.7)	23.3% (13.5–33)	42.5% (33.7–51)
Overall	34.8% (26–43.1)	10.5% (4.9–6.3)	10% (5.2–15.6)	44.6% (35.8–53.5)

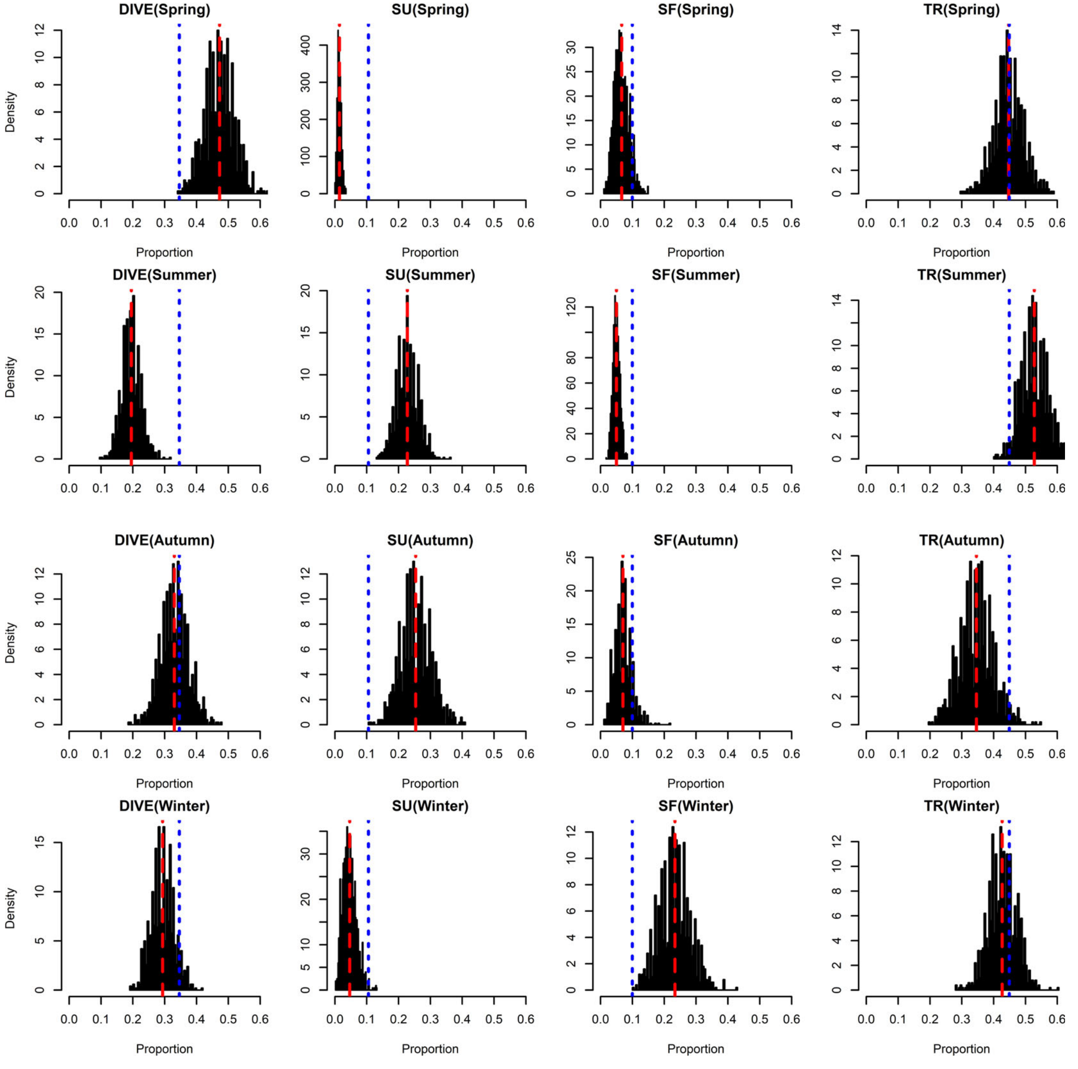

FIGURE 4 Seasonal behavioral budget for *Tursiops truncatus*. Each subfigure represents the distribution of estimated effects obtained from the Monte Carlo simulation (i.e., 1,000 iterations) for a specific behavioral state (DV = diving, SU = socializing units, SF = surface-feeding, TR = traveling). The red dashed vertical lines represent the mean value of each distribution, while the blue dotted line represents the annual mean.

with 7.56 and 9.02 behavioral transitions recorded per 100 hr of effort. Spring and winter had the highest number of interactions with commercial fisheries with 3.56 and 5.02 behavioral transitions recorded per 100 hr of effort (Table 3).

4 | DISCUSSION

Increasing human pressure on the world's oceans is negatively impacting marine ecosystems. No area is thought to be exempt from anthropogenic influence, with >40% of habitats affected by multiple drivers (Halpern et al., 2008). The effect of marine vessels, specifically dolphin tours, on the behavioral alterations of bottlenose dolphins has largely been reported on in previous literature (Christiansen et al., 2010; Christiansen & Lusseau, 2015; Constantine et al., 2004; Heiler et al., 2016; La Manna, 2013; Luis et al., 2014; Lusseau, 2003, 2004; Stockin et al., 2008). Few studies, however, have focused on the effect of fisheries on bottlenose dolphins' behavioral budgets (Durden, 2005; Genov et al., 2008; Pace et al., 2003; Powell & Wells, 2011). The current study is the first to consider the impact of fisheries on the under-studied population of *T. truncatus* in Montenegrin waters, South Adriatic. As in many studies on the effect of tourism boats (Christiansen & Lusseau, 2015; Clarkson et al., 2020; Constantine, 2004; Heiler et al., 2016; Lusseau, 2003, 2004; Stockin et al., 2008), significant changes were found in *T. truncatus* behavior, both in the presence of commercial fishing vessels, and artisanal fishing boats (Figure 3a, b). Based on these results, commercial fishing vessels significantly affected three out of four predetermined behavioral states, suggesting that the behavioral budget of the species considerably changes in the presence of commercial fishing vessels. Whereas, in the presence of artisanal fishing boats, *T. truncatus* generally engaged in behavioral states that were similar to the control situation with only surface feeding considerably declining in the entire budget in the presence of artisanal fisheries. Despite artisanal fisheries appearing to have somewhat less of an impact on the dolphins, the decline of an important feeding behavior should not be overlooked.

The control behavioral budget of *T. truncatus* had two clear dominant behaviors, traveling comprising 45% of the time, and diving comprising 35%. In the presence of artisanal fishing boats, the time taken by these two behaviors was not found to change. However, diving was the predominant behavior in the budget in the presence of commercial fishing vessels and its dominance may indicate that dolphins demonstrated a behavioral shift, favoring foraging in close proximity to commercial fishing vessels within Montenegrin waters.

In addition to the increase in diving, surface-feeding behavior also showed considerable increase in the vicinity of commercial fishing vessels. The significant increase both in surface feeding and diving behavior indicates the development of opportunistic feeding behaviors by the species. This behavioral alteration is consistent with previous studies that have demonstrated that *T. truncatus* can adapt to changing conditions by developing new foraging techniques and a tolerance for fishing vessel disturbance if the cost-to-benefit balance seems to work in their favor (Chilvers et al., 2003; Jaiteh et al., 2012; La Manna et al., 2013; Lusseau et al., 2009; Stockin et al., 2008). Individuals can begin to rely on trawling activity as a method of receiving provisional food resources (Lusseau et al., 2009; Stokin et al., 2008). However, the dependence on fishing vessels for food sources come with severe costs associated with natural behavioral alterations, entanglement, and collision risk (Brotons et al., 2007; Jaiteh et al., 2012; Pace et al., 2003; Zappes et al., 2013). The continued reliance on human activity for food is likely to interfere with the ability of the individuals to attain prey and increase the chance of displacement from their optimal foraging grounds (Lusseau et al., 2009). Further, this may increase existing negative opinions regarding dolphins held by fishing communities, which may result in severe direct and indirect consequences for the species itself. These may include increased line output to counteract damage or loss of nets which could increase the risk of bycatch, or even direct culling by fishers to reduce number of “pests” (Geraci et al., 2019; Pardalou & Tsikliras, 2018; Snape et al., 2018). In stark contrast to this, the decrease in traveling behavior seems to coincide with the increase in diving and surface-feeding behavior in the vicinity of commercial fishing vessels which suggests that habitat usage and home range of Montenegrin dolphins may be altered in the presence of commercial fishing vessels, which eventually has the potential to lead to temporary or permanent habitat displacement. Thus far in the Adriatic, trawling has been shown to effect fine-scale distribution (Bonizzoni et al., 2020) and even cause dolphins to leave protected areas (Pleslić et al., 2015).

There were also noticeable seasonal variations in behavior, with socializing being at its highest during summer and autumn (Figure 4), which is likely due to mating behaviors and interactions with new calves following a 12-month gestation period (Blasi et al., 2020; Weller 1998). This period coincided with the highest number of transitions in which dolphins were in the presence of artisanal fishing boats as well as the lowest amount of control transitions per unit of effort suggesting that *T. truncatus* are more likely to be in the vicinity of vessels during these seasons. These data are supported by an increase in tourist and recreational activities in these seasons and it is also possible that defensive cohesive demonstration in response to increased density of boats has been erroneously recorded as socializing behavior (Clarkson et al., 2020). These results are in contrast with the findings of Vermeulen et al., (2015) who reported socializing peaking in winter and spring in Patagonia and more locally with Bearzi et al., (1999) in Croatia who reported no consistent patterns in behaviors with significant difference in seasonal behaviors between years. As more data are gathered in Montenegro, an investigation into interannual variability of behavior would be beneficial.

In contrast to socializing, surface feeding was predominant in the winter, possibly due to increased energy demands with lower water temperatures or due to less prey availability and therefore an increased search time (Brager 1993;Miller et al., 2010; Weller 1998). Winter was also the season with the most recorded transitions per unit effort in the presence of commercial fishing vessels. No seasonal fisheries data are available for Montenegro but in neighboring Croatia the highest catches were common sole, *Solea solea* and *Sepia officinalis* (Matić-Skoko et al., 2017). While *S. solea* has not been recorded as a prey species of *T. truncatus*, *S. officinalis* has, as has *Merluccius merluccius, Conger conger*, and *Octopus vulgaris* (Bearzi et al., 2008; Blanco et al., 2001; Miokovic et al., 1999), which were also found to form a relatively high proportion of Croatian catches in winter (Matić-Skoko et al., 2017). It is therefore likely that during winter the high level of interactions with fishing vessels is due to an overlap in fishing interests between dolphins and fishermen.

A limitation of this study is that specific details on vessels in the impact situation were not collected. Artisanal fishing boats in this study included small purpose-built fishing boats with outboard engines and as well as other motorboats that had visible fishing gear. Commercial vessels included trawlers (including beam and pelagic) as well as purse seiners. While different vessel types produce different frequencies (Richardson & Würsig, 1997, Weilgart, 2007), they also produce different source levels (Erbe et al., 2019; Richardson & Würsig, 1997) dependent on size, type and age. In addition to this, trawlers and purse seiners have different fishing gear and methodologies, and future studies should refine these broad vessel categories into finer categories to investigate differences to dolphin response that these different vessel types may have.

The Mediterranean and Black Sea has 86,500 fishing vessels, comprising both artisanal and commercial vessels; 12.3% of which are in the Adriatic Sea (FAO, 2018). Capture production in Montenegrin fisheries has increased from 734.8 to 1015 tons between 2006 and 2018 (FAO, 2020). Commercial vessels within Montenegro had average landings of 787 tons in 2014 with a 13.1% increase between 2015 and 2016 (FAO, 2018). In addition, the Montenegrin fleet has increased rapidly in size over recent years, reaching 224 from 128 in 2015 (FAO, 2020; Montenegro Ministry of Agriculture and Rural Development, 2015). An increase in fleet size directly results in an increase in the frequency of human-wildlife interactions (Hoyt, 2001), specifically when threatened species distribution overlap with the human pressure as with *T. truncatus*.

While short-term effects on the behavioral budget of *T. truncatus* were exhibited during this study, the long-term effects of behavioral budget change on fitness, reproductive success or population size are likely to not be seen for up to 30 years, due to the longevity of the species (Constantine et al., 2004). The results of this study suggest that artisanal fisheries form a more sustainable method of fishing with relatively less impact on the threatened *T. truncatus* populations in Montenegro, yet the significant decline in surface-feeding behavior still must be considered and thus the interaction should be minimized. At this stage it is unclear how much of an impact on the population this behavioral change could have, however, changes to important behaviors such a feeding and socializing units are likely to affect the population if prolonged. Future research should aim to determine whether this decline is attributed to the artisanal fishery or merely just to marine vessels independent of their activity since the presence of boats alone can affect behavioral budgets (Bas et al., 2017; Christiansen, 2013; Papale, 2012). A similar study in Montenegro reported that when tourist vessels were within 400 m of bottlenose dolphins, surface-feeding was nonexistent despite it comprising 7.6% of the behavioral budget in the absence of nontargeted tourist vessels (Clarkson et al., 2020) and thus further investigation into the possible effect of vessel type is required.

Despite the low number of commercial fishing activities in Montenegro, compared to neighboring countries, the significant alterations in the behavior of *T. truncatus* are concerning, particularly when coupled with the reported effects of the tourist industry. The results of this study form an important contribution to understanding the effect of fisheries on *T. truncatus* in Montenegro and directing future fishing management and mitigation decisions within the Mediterranean Sea. Improving our understanding of how different types of vessels are affecting behavior of *T. truncatus* in Montenegro and highlights the importance of considering different vessels classes separately.

This study has important implications for conservation management. The two vessel categories were shown to have different effects on *T. truncatus* behavior, as well as having different effects to tourist vessels (Clarkson et al., 2020) within Montenegrin waters. This suggests that generic management plans are unlikely to be sufficient and highlights the importance of understanding how animals like *T. truncatus* may be affected by multiple different stressors when considering their conservation. Decision makers in Montenegro have taken the first steps towards the conservation of the marine environment. The authors urge that this information be used to inform and adopt management and conservation policies, including the use of fishing protected areas in order to minimize the effect of marine vessels on the vulnerable populations of T. truncatus.

ACKNOWLEDGMENTS

The authors would like to thank the dedicated interns of Montenegro Dolphin Research, especially to Fredrik Christiansen and Jack Clarkson for their invaluable contributions. This project was made possible by DMAD-Marine Mammals Research Association and the Rufford Foundation as the main providers for funding support. A special thanks also goes out to Xenia Schultz for her statistical support.

AUTHOR CONTRIBUTIONS

Tim Awbery: Data curation; formal analysis; writing – original draft; writing – review and editing. **Romina Waller:** Data curation; formal analysis; writing – original draft; writing – review and editing. **Molly Crowe:** Formal analysis; visualization; writing – review and editing. **Julianna Bauer:** Formal analysis; writing – review and editing. **Anna Jacquemart:** Writing – review and editing. **Natasa Nikpaljevic:** Funding acquisition; writing – review and editing. **Aylin Akkaya:** Conceptualization; data curation; formal analysis; methodology; project administration; supervision; validation; writing – review and editing.

ORCID

Laura E. Rudd https://orcid.org/0000-0002-9003-4284
Tim Awbery https://orcid.org/0000-0003-4338-8351
Molly Crowe https://orcid.org/0000-0002-1143-1928
Aylin Akkaya https://orcid.org/0000-0002-0414-770X

REFERENCES

Au, W. W. L. (1993). *The sonar of dolphins*. Springer.

Akkaya, A., Awbery, T., Brouwer, S., Rudd, L., Goosens, C., Nikpaljevic, N., & Varda, D. (2021). *Turning research into conservation outputs for cetacean protection in Montenegro* (Technical Report 2019–2021). Montenegro Dolphin Research. https://doi.org/10.13140/RG.2.2.32448.05127

Awbery, T., Nikpaljevic, N., Clarkson, J., Abbiss, L., Van Der Pou Kraan, D., Liebig, P., Todorovic, S., & Bas, A. A. (2019). *Bottlenose and striped dolphins of Montenegro: An insight into sighting variations, behavioural patterns, photo-identification, core habitats, marine traffic and conservation initiatives* (Technical Report 2017–2018), Montenegro Dolphin Research. https://doi.org/10.13140/RG.2.2.26977.35683/1

Baş, A. A., Amaha Öztürk, A., & Öztürk, B. (2015). Selection of critical habitats for bottlenose dolphins (*Tursiops truncatus*) based on behavioral data, in relation to marine traffic in the Istanbul Strait, *Turkey*. *Marine Mammal Science*, *31*(3), 979–997. https://doi.org/10.1111/mms.12202

Bas, A. A., Affinito, F., Martin, S., Vollmer, A., Gansen, C., Morris, N., Frontier, N., Nikpaljevic, N., & Vujovic, A. (2018). *Bottlenose dolphins and striped dolphins: species distribution, behavioural patterns, encounter rates, residency patterns and hotspots in Montenegro, south Adriatic*. Montenegro Dolphin Project.

Bas, A. A., Christiansen, F., Ozturk, B., Ozturk, A. A., Erdogan, M. A., & Watson, L. J. (2017). Marine vessels alter the behaviour of bottlenose dolphins (*Tursiops truncatus*) in the Istanbul Strait, Turkey. *Endangered Species Research*, *34*, 1–14. https://doi.org/10.3354/esr00836

Bearzi, G. (2002). Interactions between cetacean and fisheries in the Mediterranean Sea. *Cetaceans of the Mediterranean and Black Seas: State of knowledge and conservation strategies.* A report to the ACCOBAMS secretariat, Monaco.

Bearzi, G., Agazzi, S., Bonizzoni, S., Costa, M., & Azzellino, A. (2008). Dolphins in a bottle: abundance, residency patterns and conservation of bottlenose dolphins *Tursiops truncatus* in the semi-closed eutrophic Amvrakikos Gulf, Greece. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *18*(2), 130–146. https://doi.org/10.1002/aqc.843

Bearzi, G., Fortuna, C., & Reeves, R. (2009). Ecology and conservation of common bottlenose dolphins *Tursiops truncatus* in the Mediterranean Sea. *Mammal Review*, *39*(2), 92. https://doi.org/10.1111/j.1365-2907.2008.00133.x.

Bearzi, G., Fortuna, C., & Reeves, R. R. (2012). *Tursiops truncatus* (Mediterranean subpopulation). *IUCN Red List of Threatened Species 2012*, e.T16369383A16369386. https://doi.org/10.2305/IUCN.UK.2012-1.RLTS.T16369383A16369386.en

Bearzi, G., Holcer, D., & Notarbartolo Di Sciara, G. (2004). The role of historical dolphin takes and habitat degradation in shaping the present status of northern Adriatic cetaceans. *Aquatic Conservation of Marine and Freshwater Ecosystems*, *14*, 363–379. https://doi.org/10.1002/aqc.626

Bearzi, G., Politi, E., & Notarbartolo di Sciara, G. (1999). Diurnal behavior of free ranging bottlenose dolphins in the Kvarnerić (Northern Adriatic Sea). *Marine Mammal Science*, *15*(4), 1065–1097. https://doi.org/10.1111/j.1748-7692.1999.tb00878.x

Bejder, L., & Samuels, A. (2003). Evaluating the effects of nature-based tourism on cetaceans. In N. Gales, M. Hindell, & R. Kirkwood (Eds.), *Marine mammals and humans: Towards a sustainable balance* (pp. 229–256). CSIRO, Collingwood, Australia.

Bejder, L., Samuels, A., Whitehead, H., Gales, H., Gales, N., Mann, J., Connor, R., Heithau, M., Watson-Capps, J., Flaherty, C., & Krutzen, M. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, *20*, 1791–1798. https://doi.org/10.1111/j.1523-1739.2006.00540.x

Blanco, C., Salomón, O. and Raga, J.A. (2001). Diet of the bottlenose dolphin (*Tursiops truncatus*) in the western Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom*, *81*(6), 1053–1058. https://doi.org/10.1017/S0025315401005057

Blasi, M. F., Bruno, C., & Boitani, L. (2020). Female reproductive output in a Mediterranean bottlenose dolphin *Tursiops truncatus* population. *Aquatic Biology*, *29*, 123–136.

Bonizzoni, S., Furey, N. B., & Bearzi, G. (2020). Bottlenose dolphins (*Tursiops truncatus*) in the north-western Adriatic Sea: Spatial distribution and effects of trawling. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(3), 635–650. https://doi.org/10.1002/aqc.3433

Bräger, S. (1993). Diurnal and seasonal behavior patterns of bottlenose dolphins (*Tursiops truncatus*). *Marine Mammal Science*, *9*(4), 434–438. https://doi.org/10.1111/j.1748-7692.1993.tb00477.x

Brotons, J. M., Grau, A. M., & Rendell, L. (2007). Estimating the impact of interactions between bottlenose dolphins and artisanal fisheries around the Balearic Islands. *Marine Mammal Science*, *24*(1), 112–117. https://doi.org/10.1111/j.1748-7692.2007.00164.x

Chilvers, B. L., Corkeron, P. J., & Puotinen, M. L. (2003). Influence of trawling on the behaviour and spatial distribution of Indo-pacific bottlenose dolphins (*Tursiops aduncus*) in Moreton Bay, Australia. *Canadian Journal of Zoology*, *81*(12), 1947–1955. https://doi.org/10.1139/z03-195

Christiansen, F., & Lusseau, D. (2015). Linking behaviour to vital rates to measure the effects of non-lethal disturbance on wildlife. *Conservation Letters*, *8*, 424–431. https://doi.org/10.1111/conl.12166

Christiansen, F., Lusseau, D., Stensland, E., & Berggren, P. (2010). Effects of tourist boats on the behaviour of Indo-Pacific bottlenose dolphins off the south coast of Zanzibar. *Endangered Species Research*, *11*, 91–99. https://doi.org/10.3354/esr00265

Christiansen, F., Rasmussen, M. H., & Lusseau, D. (2013). Inferring activity budgets in wild animals to estimate the consequences of disturbances. *Behavioural Ecology*, *24*(6), 1415–1425. https://doi.org/10.1093/beheco/art086

Clarkson, J., Christiansen, F., Awbery, T., Abbiss, L., Nikpaljevic, N. and Akkaya, A. (2020). Non-targeted tourism affects the behavioural budgets of bottlenose dolphins Tursiops truncatus in the South Adriatic (Montenegro). *Marine Ecology Progress Series*, *638*, 165–176. https://doi.org/10.3354/meps13257

Consiglio, C., Arcangeli, A., Cristo, B., Marini, L., & Torchio, A. (1992). Interactions between *Tursiops truncatus* and fisheries along north-eastern coasts of Sardinia, Italy. *European Research on Cetaceans*, *6*, 32–34.

Constantine, R., & Baker, C. S. (1997). *Monitoring the commercial swim-with-dolphin operations in the Bay of Islands. Science for Conservation*, *56*. Department of Conservation, Wellington, New Zealand.

Constantine, R., Bunton, D. H., & Dennis, T. (2004). Dolphin-watching tour boats change bottlenose dolphin *(Tursiops truncatus)* behaviour. *Biological Conservation*, *17*(3), 299–307. https://doi.org/10.1016/j.biocon.2003.12.009

Defran, R. H., & Weller, D. W. (2006). Occurrence, distribution, site fidelity and school size of bottlenose dolphins *(Tursiops truncatus)* off San Diego, *California. Marine Mammal Science*, *15*(2), 366–380. https://doi.org/10.1111/j.1748-7692.1999.tb00807.x

Durden, W. N. (2005). The harmful effects of inadvertently conditioning a wild bottlenose dolphin (*Tursiops truncatus*) to interact with fishing vessels in the Indian River Lagoon, Florida, USA. *Aquatic Mammals*, *31*(4), 413–419. https://doi.org/10.1578/AM.31.4.2005.413

Erbe, C., Marley, S. A., Schoeman, R. P., Smith, J. N., Trigg, L. E., & Embling, C. B. (2019). The effects of ship noise on marine mammals—a review. *Frontiers in Marine Science*, *6*, 606. https://doi.org/10.3389/fmars.2019.00606

FAO (Food and Agriculture Organization of the United Nations). (2018). *The state of Mediterranean and Black Sea fisheries*. General Fisheries Commission for the Mediterranean. Rome.

FAO (Food and Agriculture Organization of the United Nations). (2020). *The state of world fisheries and aquaculture*. Sustainability in Action. Rome.

Fortuna, C. M. (2006). *Ecology and conservation of bottlenose dolphins* (Tursiops truncatus) *in the north-eastern Adriatic Sea* [Doctoral dissertation]. University of St. Andrews. https://research-repository.st-andrews.ac.uk/handle/10023/157

Genov, T., Kotnjek, P., Lesjak, J., & Hace, A. (2008). Bottlenose dolphins (*Tursiops truncatus*) in Slovenia and adjacent waters (Northern Adriatic Sea). *Annales*, *18*(2), 228–230.

Geraci, M. L., Falsone, F., Scannella, D., Sardo, G., & Vitale, S. (2019). Dolphin-fisheries interactions: An Increasing problem for Mediterranean small-scale fisheries. *Examines Marine Biology and Oceanography*, *3*(1). https:/https://doi.org/10.31031/EIMBO.2019.03.000552

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Argrosa, C., Bruno, J. F., Casey, K. S., Ebert, C., Fox, H. E., Fujita, R., Heinemann, D., Lenihan, H. S., Madin, E. M. P., Perry, M. T., Selig, E. R., Spalding, M., Steneck, R., & Watson, R. (2008). A global map of human impact on marine ecosystems. *Science*, *319*(5865), 948–952. https://doi.org/10.1126/science.1149345

Hazelkorn, R. A., Schulte, B. A., & Cox, T. M. (2016). Persistent effects of begging on common bottlenose dolphin (*Tursiops truncatus*) behaviour in an estuarine population. *Aquatic Mammals*, *42*(4), 531. https://doi.org/10.1578/AM.42.4.2016.531, 541

Heiler, J., Elwen, S. H., Kriesell, H. J., & Gridley, T. (2016). Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. *Animal Behaviour*, *117*, 167–177. https://doi.org/10.1016/j.anbehav.2016.04.014

Hinz, H., Prieto, V., & Kaiser, M. J. (2009). Trawl disturbance on benthic communities: chronic effects and experimental predictions. *Ecological Applications*, *19*(3), 761–773. https://doi.org/10.1890/08-0351.1

Holcer, D. (2012). *Ecology of the common bottlenose dolphin*, Tursiops truncatus *(Montagu, 1821) in the Central Adriatic Sea* [Doctoral dissertation]. University of Zagreb.

Holcer, D., Fortuna, C. M., & Mackelworth, P. C. (2014). Status and conservation of cetaceans in the Adriatic Sea. Draft internal report for the purposes of the Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Malaga, Spain, 7–11 April 2014.

Hoyt, E. (2001). *Whale watching 2001: Worldwide tourism numbers, expenditures, and expanding socioeconomic benefits* (1st ed.). International Fund for Animal Welfare.

Jaiteh, V. F., Allen, S. J., Meeuwig, J. J., & Loneragan, N. R. (2012). Subsurface behavior of bottlenose dolphins (*Tursiops truncatus*) interacting with fish trawl nets in northwestern Australia: Implications for bycatch mitigation. *Marine Mammal Science*, *29*(3), 266–281. https://doi.org/10.1111/j.1748-7692.2012.00620.x

Kassamali-Fox, A., Christiansen, F., Quinones-Lebron, S., Rusk, A., Johanna, L., Collado, M., & Kaplin, B. (2015). *Using Markov chains to model the impacts of the dolphin watching industry on the dolphin community of Dolphin Bay*, *Bocas del Toro*, *Panama*. Report SC/66a/WW11 presented to the Scientific Committee of the International Whaling Commission.

La Manna, G., Manghi, M., Pavan, G., Lo Mascolo, F., & Sarà, G. (2013). Behavioural strategies of common bottlenose dolphins (*Tursiops truncatus*) in response to different kinds of boats in the waters of Lampedusa Island (Italy). *Aquatic Conservation: Marine and Freshwater Ecosystems*, *23*, 745–757. https://doi.org/10.1002/aqc.2355

Luis, A. R., Couchinho, M. N., & Dos Santos, M. E. (2014). Changes in the acoustic behavior of resident bottlenose dolphins near operating vessels. *Marine Mammal Science*, *30*(4), 1417–1426. https://doi.org/10.1111/mms.12125

Lusseau, D. (2003). Effects of tour boats on the behaviour of bottlenose dolphins: using Markov chains to model anthropogenic impacts. *Conservation Biology*, *17*(6), 1785–1793. https://doi.org/10.1111/j.1523-1739.2003.00054.x

Lusseau, D. (2004). The hidden cost of tourism: detecting long-term effects of tourism using behavioural information. *Ecology and Society*, *9*(1), 2.

Lusseau, D., Bain, D. E., Williams, R., & Smith, J. C. (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research*, *6*, 211–221. https://doi.org/10.3354/esr00154

Lusseau, D., & Higham, J. E. S. (2004). Managing the Impacts of dolphin-based tourism through definition of critical habitats: the case of bottlenose dolphins (*Tursiops* spp.) in Doubtful Sound, New Zealand. *Tourism Management*, *25*, 657–667. https://doi.org/10.1016/j.tourman.2003.08.012

Macic, V. (2005). *A short overview of the status of aquaculture in Montenegro*. General Fisheries Council for the Mediterranean. https://www.fao.org/3/a0141e/A0141E04.htm

Matić-skoko, S., Ikica, Z., Vrdoljak, D., Peharda, M., Tutman, P., Dragičević, B., Joksimović, A., Dulčić, J., Đurović, M., Mandić, M., & Marković, O. (2017). A comparative approach to the Croatian and Montenegrin small-scale fisheries (Ssf) in the coastal Eastern Adriatic Sea: Fishing gears and target species. *Acta Adriatica*, *58*(3), 459–479.

Meissner, A. M., Christiansen, F., Martinez, E., Pawley, M. D. M., Orams, M. B., & Stockin, K. A. (2015). Behavioural effects of tourism on oceanic common dolphins, *Delphinus* sp., in New Zealand: The effects of Markov analysis variations and current tour operator compliance with regulations. *PLoS ONE*, *10*(1), 33–34. https://doi.org/10.1371/journal.pone.0116962

Miller, L. J., Solangi, M., & Kuczaj, S. A., II. (2010). Seasonal and diurnal patterns of behavior exhibited by Atlantic bottlenose dolphins (*Tursiops truncatus*) in the Mississippi Sound. *Ethology*, *116*(12), 1127–1137.

Miokovic, D., Kovacic, D., Pribanic, S. (1999). Stomach content analysis of one bottlenose dolphin (*Tursiops truncatus*, Montague 1821) from the Adriatic Sea. *Natura Croatica*, *8*(1), 61–65.

Montenegro Ministry of Agriculture and Rural Development. (2015). *Fisheries strategy of Montenegro 2015–2020 with an action plan (for transposition, implementation and enforcement of EU Acquis).* http://faolex.fao.org/docs/pdf/mne180908.pdf

Pace, D. S., Pulcini, M., & Triossi, F. (2003). Interactions with fisheries: modalities of opportunistic feeding for bottlenose dolphins at Lampedusa Island (Italy). *European Research on Cetaceans*, *17*, 110–114.

Papale, E., Azzolin, M. and Giacoma, C. (2012). Vessel traffic affects bottlenose dolphin (*Tursiops truncatus*) behaviour in waters surrounding Lampedusa Island, south Italy. *Journal of the Marine Biological Association of the United Kingdom*, *92*(8), 1877–1885. https://doi.org/10.1017/S002531541100083X

Pardalou, A., & Tsikliras, A. C. (2018). Anecdotal information on dolphin-fisheries interactions based on empirical knowledge of fishers in the northeastern Mediterranean Sea. *Ethics in Science and Environmental Politics*, *18*, 1–8.

Pennino, M. G., Pérez Roda, M. A., & Pierce, G. J. (2016). Effects of vessel traffic on relative abundance and behaviour of cetaceans: the case of the bottlenose dolphins in the Archipelago de La Maddalena, north-western Mediterranean Sea. *Hydrobiologica*, *776*(2), 237. https://doi.org/10.1007/s10750-016-2756-0, 248

Pérez-Jorge, S., Louzao, M., Oro, D., Pereira, T., Corne, C., Wijtten, Z., Gomes, I., Wambua, J., & Christiansen, F. (2017). Estimating the cumulative effects of the nature-based tourism in a coastal dolphin population from southern Kenya. *Deep Sea Research Part II: Topical Studies in Oceanography*, *140*, 278–289.

Perrin, W. F., Donovan, G. P., & Barlow, J. (1994). Gillnets and cetaceans. *Reports of the International Whaling Commission*. *Special Issue 15*.

Pleslić, G., Rako Gospić, N., Mackelworth, P., Wiemann, A., Holcer, D., & Fortuna, C. (2015). The abundance of common bottlenose dolphins (*Tursiops truncatus*) in the former special marine reserve of the Cres Lošinj Archipelago, Croatia. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *25*(1), 125–137. https://doi.org/10.1002/aqc.2416

Powell, J. R., & Wells, R. S. (2011). Recreational fishing depredation and associated behaviors involving common bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, *Florida. Marine Mammal Science*, *27*(1), 111–129. https://doi.org/10.1111/j.1748-7692.2010.00401.x

RAC/SPA-UNEP/MAP. (2013). Fishery activities assessment in Montenegro: case study of five selected parts of Montenegrin coast. In M. Djurović & O. Marković (Eds.), *RAC/SPA - MedMPAnet Project*, Tunis.

RAC/SPA-UNEP/MAP. (2016). Montenegro: Platamuni and Ratac areas. Summary report of the available knowledge and gap analysis. In G. Torchia, F. Pititto, C. Rais, E. Trainito, F. Badalamenti, C. Romano, C. Amosso, C. Bouafif, M. Dragan, S. Camisassi, D. Tronconi, V. Macic, Y. R. Sghaier, & A. Ouerghi (Eds.), *RAC/SPA - MedKeyHabitats Project*, Tunis.

Richardson, W. J., & Würsig, B. (1997). Influences of man-made noise and other human actions on cetacean behaviour. *Marine & Freshwater Behaviour & Physiology*, *29*(1–4), 183–209. https://doi.org/10.1080/10236249709379006

Snape, R. T. E., Broderick, A. C., Çiçek, B. A., Fuller, W. J., Tregenza, N., Witt, M. J., & Godley, B. J. (2018). Conflict between dolphins and a data-scarce fishery of the European Union. *Human Ecology*, *46*, 423–433 https://doi.org/10.1007/s10745-018-9989-7

Stockin, K. A., Lusseau, D., Binedell, V., Wiseman, N., & Orams, M. B. (2008). Tourism affects the behavioural budgets in common dolphin *Delphinus* sp. in the Hauraki Gulf, New Zealand. *Marine Ecology Progress Series*, *355*, 287–295. https://doi.org/10.3354/meps07386

Wells, R. S., & Scott, M. D. (1999). Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In S. H. Ridgway & R. Harrison (Eds.), *Handbook of marine mammals: The second book of dolphins and porpoises*, (Vol. 6, pp. 137–182). Academic Press.

Vermeulen, E., Holsbeek, L., & Das, K. (2015). Diurnal and seasonal variation in the behaviour of bottlenose dolphins (*Tursiops truncatus*) in Bahía San Antonio, Patagonia, Argentina. *Aquatic Mammals*, *41*(3), 272–283. https://doi.org/10.1578/AM.41.3.2015.272

Weilgart, L. S. (2007). A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology*, *20*(2), 159–168.

Weller, D. W. (1998). *Global and regional variation in the biology and behavior of bottlenose dolphins* [Doctoral dissertation]. Texas A&M University.

Williams, R., Lusseau, D., & Hammond, P. S. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biological Conservation*, *113*(3), 301–311. https://doi.org/10.1016/j.biocon.2006.06.010

Zappes, C. A., Pinto de Sa Alves, L. C., Ventura da Silva, C., Azedevo, A. dF., Di Beneditto, A. P. M., & Andriolo, A. (2013). Accidents between artisanal fisheries and cetaceans on the Brazilian coast and Central Amazon: Proposals for integrated management. *Ocean and Coastal Management*, *85*(A), 46–57. https://doi.org/10.1016/j.ocecoaman.2013.09.004

How to cite this article: Rudd, L. E., Awbery, T., Waller, R., Crowe, M., Bauer, J., Jacquemart, A., Nikpaljevic, N., & Akkaya, A. (2022). The effect of commercial and artisanal fishing practices on the behavioral budget of bottlenose dolphins off the coast of Montenegro, South Adriatic Sea. *Marine Mammal Science*, 1–17. https://doi.org/10.1111/mms.12913