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THE EFFECTS OF VESSEL TRAFFIC ON THE BEHAVIOURAL PATTERNS OF COMMON DOLPHINS, IN TAGUS ESTUARY, PORTUGAL

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Resumo

O impacto das embarcações nas populações de golfinhos tem sido extensivamente estudado a nível mundial. O golfinho-comum, *Delphinus delphis*, tem visitado o estuário do Tejo nos últimos dois séculos e, nos últimos anos, tem existido um aumento dos avistamentos. Esta área possui elevados níveis de tráfego marítimo ao longo do ano, onde tanto embarcações comerciais quanto de lazer são frequentes. Este estudo fornece os primeiros dados relativos às interações entre golfinhos e embarcações. Para compreender os possíveis efeitos da presença de embarcações no comportamento dos golfinhos, foram realizadas observações a partir de terra de março de 2022 a março de 2023. O tempo despendido em cada comportamento foi diferente quando as embarcações estavam próximas dos golfinhos: os golfinhos-comuns passaram menos tempo em alimentação e deslocação, enquanto o tempo gasto em busca de presas e socialização aumentou. No entanto, não foram encontradas diferenças significativas. A reação neutra foi a mais observada, sendo que o modelo GEE mostrou diferenças estatísticas entre as diferentes reações (positiva, neutra e negativa). Utilizando as cadeias de Markov, as probabilidades de transição comportamental observadas foram diferentes em ambos os cenários (ausência vs presença de embarcações): a probabilidade de transição para um estado de deslocação aumentou quando as embarcações estavam por perto. Este estudo é o primeiro passo para compreender uma potencial fonte de impacto, uma vez que se espera que as empresas de turismo se expandam devido ao aumento de avistamentos de golfinhos.

Palavras-chave: golfinhos-comuns; embarcações; *behavioural budgets*; estuário do Tejo; cadeias de Markov

Abstract

The impact of vessels on dolphins' populations has been extensively studied worldwide. The common dolphin, *Delphinus delphis*, has been visiting the Tagus estuary for the past two centuries, and during the last years, the sightings seem to have increased. This area has high levels of maritime traffic throughout the year, where both commercial and recreational vessels are frequent. This study provides the first insight into the interaction between dolphins and vessels. To understand the possible effects of vessel traffic on the dolphins' behaviour, land-based observations were carried out from March 2022 to March 2023. The behavioural budgets were different when vessels were in the vicinity of dolphins: common dolphins spent less time surface feeding and travelling, while the time spent foraging and socializing increased. However, no statistical differences were found. The neutral reaction was the most observed reaction, and the GEE model showed statistical differences between the different reactions (positive, neutral and negative). Using Markov chains, behavioural transition probabilities were different in both scenarios (absence *vs* presence of vessels): the dolphins were more likely to transition to a travelling state when vessels were nearby. This study is the first step towards understanding a potential impact source since it is expected that tourism companies expand due to the increase in dolphin' sightings.

Keywords: common dolphins; vessel traffic; behavioural budgets; Tagus estuary; Markov chains

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1. Introduction

The oceans have a fundamental role in countries' economies, especially because nations' economies rely on international maritime trade (March *et al.*, 2021; Xu *et al.*, 2020). According to UNCTAD (2022), 80% of the world's goods is transported by sea, and activities such as fishing and tourism have major impacts on the national economies (March *et al.*, 2021). Over the last few decades, the growth of anthropogenic pressure on marine environment has become more obvious (Halpern *et al.*, 2008). In the last year, international maritime trade has increased by 3.2% (UNCTAD, 2022), demonstrating that maritime traffic has grown worldwide (Bas *et al.*, 2017). Many studies have reported the importance of reducing the negative effects caused by anthropogenic activities (Cecchetti *et al.*, 2018; Lemon *et al.*, 2006; Lussean, 2004; Meissner *et al.*, 2015; Stockin *et al.*, 2008). However, the negative effects tend to become more pronounced as vessel traffic expands (Cunha *et al.*, 2017; DeMaster *et al.*, 2001; Nowacek *et al.*, 2001).

The distribution and mortality rate of cetaceans seem to be directly affected by vessel presence, with some species exhibiting long-term impacts (Campana *et al.*, 2015; Meza *et al.*, 2020). Many studies suggested that ship-induced disturbance results in a decrease in the energy budget of individuals (Bas *et al.*, 2017; Cecchetti *et al.*, 2018; Christiansen *et al.*, 2013; Meza *et al.*, 2020) that influences certain basic functions of life (Lachmuth *et al.*, 2011), leading to population-level impacts (Bejder *et al.*, 2006; Cecchetti *et al.*, 2018; Kassamali-Fox *et al.*, 2020) such as alterations in the use of habitat (Cunha *et al.*, 2017). Nevertheless, the response to ships depends on the species and/or the individuals (i.e, the presence of calves, juveniles, and adults), and the type, number and movements of the vessels (Lemon *et al.*, 2006; Lusseau, 2003b). For instance, some species may interact positively with vessels, while others may avoid them, depending on how invasive the interaction becomes (Lemon *et al.*, 2006; Lusseau, 2003b; Nowacek *et al.*, 2001).

One major concern regarding interactions between vessels and cetaceans is the physical injuries due to ship strikes (Campana *et al.*, 2015; Cunha *et al.*, 2017). When an animal collides with vessels, this event can have serious consequences associated with moments of pain and suffering that can cause an individual's death (Ritter & Panigada, 2019). Depending on the species, certain cetaceans can be more vulnerable to these encounters, particularly those that stay at the surface for longer periods (Ritter & Panigada, 2019).

For delphinids, short-term effects due to marine traffic are usually associated with behavioural changes (Cecchetti *et al.*, 2018; Meza *et al.*, 2020), such as modifications in dive behaviour (Cecchetti *et al.*, 2018; Williams *et al.*, 2009), respiration characteristics (Au & Green, 2000; Frid & Dill, 2002; Lundquist *et al.*, 2012), changes in path direction and speed (Au & Green, 2000; Nowacek *et al.*, 2001; Stamation *et al.*, 2009; Timmel *et al.*, 2008) and, in behavioural budgets (Bas *et al.*, 2017; Cecchetti *et al.*, 2018; Marley *et al.*, 2017; Meza *et al.*, 2020). Furthermore, vessel traffic is one of the main causes of underwater noise, which can have serious consequences for cetaceans' communication (Cunha *et al.*, 2017; Erbe, 2002; Scarpaci *et al.*, 2000), since noisier underwater sources can affect vocalization rate (Marley *et al.*, 2017; Pirotta *et al.*, 2012) and mask bioacoustic signalling (Halliday *et al.*, 2019).

The effects of marine traffic can be cumulative with other known threats such as pollution, habitat loss and fisheries (Piwetz, 2012; Wang *et al.*, 2016), particularly for coastal cetaceans (Kassamali-Fox *et al.*, 2020; Meissner *et al.*, 2015), where anthropogenic pressure is higher (Cunha *et al.*, 2017).

While it is difficult to understand the long-term implications, behavioural studies help to comprehend the impacts of vessel interactions and they can be used to infer effects on individuals' fitness, survival and ultimately, their consequences at population level (Lusseau, 2003a). Therefore, activity budgets can provide valuable insights into biological responses to a specific threat and be used as a proxy in impact assessment studies and mitigation strategies (Brakes & Dall, 2016).

In Portugal, the Tagus estuary has a very important role in maritime transportation and the main shipping terminal (Port of Lisbon) is located there (Batista *et al.*, 2022). Here, vessel traffic is very intense, and commercial and recreational vessels are frequent year-round. Apart from this, fishing communities are installed along the banks of the Tagus estuary, for centuries (Batista *et al.*, 2022), and the possible effects for delphinids can include prey depletion, habitat destruction and bycatch (Bearzi *et al.*, 2003). Additionally, there are several tourism companies dedicated to maritime activities, including five companies of dolphin-watching (Batista *et al.*, 2022).

One of the several species found in the Tagus estuary is the common dolphin, *Delphinus delphis* Linnaeus, 1758. This species has been visiting the estuary for over two centuries, although there was a 40-year period where no sightings were reported, probably due to overfishing and pollution (Brito, 2019). Nowadays, it is frequent to find common dolphins travelling and feeding in the Tagus estuary, usually in groups with calves, but the lack of scientific studies in this region makes it difficult to understand the main drivers of dolphins' visits to the estuary. *D. delphis*, like other delphinids, are generalists, capable of feeding on small fishes and cephalopods species (Perrin, 2008). Because common dolphins are highly sociable animals, it is frequent to find them in proximity to vessels (Neumann & Orams, 2006), which could mean they are susceptible to potential cumulative effects (Cecchetti *et al.*, 2018; Meissner *et al.*, 2015).

Given the charismatic nature of cetaceans, the dolphin-watching industry is expected to develop wherever the existence of these specie is known (Constantine *et al.*, 2004) and such activities may have significant impacts on dolphins' behaviour. If the Tagus estuary is, in fact, an important feeding and nursing area, assessing the impact of vessels in these individuals is critical.

This study provides the first insight into the interactions between common dolphins and vessels in the Tagus estuary, with baseline information on the behavioural effects of vessel traffic in the region. Here, I investigated the effects of vessels presence on the dolphins' behavioural budget and studied behavioural transitions of the Tagus estuary.

2. Material and Methods

2.1 Study Area

The study area is located at the lower section of Tagus estuary (the approximate position is 38º 40' 56.3" N, 9º 15' 55.7" W) and covers an area with approximately 28 Km^2 (Figure 2.1).

Figure 2.1 - Map of the study area. The red triangle represents the VTS tower where land-based observations were carried out.

The Tagus estuary is a mesotidal estuary located in the central west coast of Portugal (Vaz *et al.*, 2019). It has a diverse geomorphology: the upper section includes shallow waters (0 – 12 m) and is mainly characterized by the presence of salt marshes, the lower section is deeper (25 – 30 m), has higher salinity, is characterized by marine sands and it is more urbanized (Batista *et al.*, 2022; Guerreiro *et al.*, 2015; Vaz *et al.*, 2019). The average temperatures vary seasonally, where in the summer can reach a minimum of 18ºC, and in the winter are below 16ºC (IPMA, 2023).

Due to the presence of the main Portuguese shipping terminal, the Port of Lisbon, Tagus estuary has a very intense maritime traffic. Commercial vessels are common throughout the year due to the presence of the navigation channel that exists in the lower section of the estuary (Porto de Lisboa, 2023). Additionally, it is frequent the presence of passenger transportation vessels, such as ferry boats, transporting a significant number of people from the south side to the north side (and vice-verse) daily (Batista *et al.*, 2022). Furthermore, fishing activities, recreational vessels, water sports and tourism vessels are common in this area (Batista *et al.*, 2022; Guerreiro *et al.*, 2015).

2.2 Data Collection

Land-based observations were carried out from a high vantage point in VTS tower (in Algés, Lisbon). From March 2022 to March 2023, a team with a minimum of two trained observers undertook shifts between 8 am and 4 pm, on every other day. These surveys were carried out with high visibility, Beauford < 4 and absence of precipitation.

To detect the presence of dolphins' groups, the study area was scanned by the observers every 5 minutes, with binoculars (Cannon 12×36 IS III and Cannon 10×30 IS II) and a telescope (Nikon PROSTAFF 5 82 mm with 20-60× magnification), sequentially. Scans were conducted from left to right, covering the entire study area. As soon as cetaceans were sighted, continuous group sampling started and information regarding species, behaviour patterns, and presence/absence of vessels was registered in 5 min information blocks until the group was lost or left the study area (Annexe IV). For this study, a "group" was defined as an association of relatively close dolphins that exhibited a common pattern of behaviour. Behavioural patterns were categorized as *surface feeding*, *foraging*, *travelling*, *socializing* or *resting* (Table 2.1). The most frequent behavioural pattern observed during the 5-min sample was defined as the dominant activity state. In case vessels were present near the focal group (within a radius of

200 m), the type of vessels and the interactions with the dolphins (positive, neutral, or negative) were noted (Table 2.2). Additional information collected during the observations is presented in the Annexe II.

Table 2.1 - **Description of the behavioural patterns considered in this study, adapted from Neumann (2001).**

Behavioural Pattern (Abbreviation)	Definition
Surface feeding (FEE)	Individuals performing with short submersions (< 30 sec), within the same area. Dolphins might be seen circulating a limited perimeter and leaping, accompanied by birds.
Foraging (FOR)	Group changes direction frequently with variable diving periods (medium submersions with +/- 1 min and longer submersions with >1 min).
Travelling (TRA)	Group moves in a consistent direction with variable diving periods.
Socializing (SOC)	Individuals move in different directions with short submersions. It is frequent to find dolphins in physical contact with one another and synchronise movements.
Resting (RES)	Individuals clustered at the surface in a constant direction.

Table 2.2 - **Definitions of dolphins' reaction to vessels.**

Reaction to Vessels	Description
Positive	Dolphins actively approach the vessels; Presence of bow riding.
Neutral	Dolphins do not alter their behavioural pattern.
Negative	Dolphins change/stop their behavioural pattern; Longer diving periods; Separation of the group; Presence of tail slap.

2.3 Video Recording and Analysis

For complementary information regarding the dolphins' behaviour, sightings were recorded with a Canon Legria HF R606 camera. Video sampling was analysed through the VLC Media Player software (version 3.0.17.3) and all information regarding the location, group composition and behaviour was registered (Annexe V). Subsequently, this information was cross-checked with on-site records.

2.4 Statistical Analysis

For statistical analysis, continuous recordings were grouped in "events". Each event included all 5-min blocks from the first sighting until the group was lost or left the area. A 15-minutes interval in-between events was stablished to assure sample independence.

To assess the activity behavioural budgets and dolphins' reactions to vessels, *surface feeding* and *socializing* were excluded from statistical analysis, due to the limited number of observations (N = 7 and N = 11, respectively).

All statistical analysis were conducted in RStudio version 4.2.3.

2.4.1 Activity Behavioural Budgets

To study the effect of vessels in the behaviour of common dolphins, activity budgets were calculated according to the scenarios:

1. Absence of vessels;
2. Presence of vessels.

For each event, time spent on each behavioural category (*foraging* and *travelling*) was summed for the two previous scenarios. A Shapiro-Wilk test and a Levene's test were applied to test the normality and homogeneity of variances, respectively. Since data did not present normality and homoscedasticity, even when outliers were removed, Mann-Whitney U test was applied to compare the activity behavioural budgets of common dolphins in the presence and absence of vessels.

2.4.2 Reactions to Vessels

To further understand the possible effects of vessels on dolphins' behaviour, reactions of dolphins to vessels were analysed using Generalized Estimating Equations (GEE). When the data is in clusters, this statistical test can evaluate the correlation within a cluster, assuming the independence in the different clusters (Halekoh *et al.*, 2006).

In GEEs, it is possible to select a baseline category for each variable considered for the study. The baseline category for behavioural pattern was *travelling*, while *neutral* was defined for the dolphins' reactions to vessels. Using the RStudio package '*geeglm'* with an exchangeable correlation structure and a gamma distribution, three models were developed: (1) the time spent as function of the reaction to vessels; (2) the time spent as function of the reaction to vessels and the different behaviour patterns; (3) the time spent as function of the reaction to vessels, the different activity patterns, and the relation between these two. According to Halekoh *et al.* (2006), the exchangeable correlation structure is highly recommended when the data has categorical variables, and the gamma distribution can be used when the outcome variable is continuous and has a left-skewed distribution. To assess the model that better fit the data, it was applied the ANOVA method, which compares the models using Wald test (Halekoh *et al.*, 2006).

2.4.3 Behavioural transitions

Markov chains were used to assess dolphins' behavioural transitions in two possible scenarios: (1) Control scenario, with no vessels; (2) Impact scenario, with vessels in the area. Because observations within an event are dependent on the immediately preceding observations, first-order Markov chains were selected. The following statistical procedure is an adaptation of Lusseau (2003a).

A "transition" occurs when dolphins go from the preceding behaviour state *i* to a succeeding behaviour state *j*. Dividing the data into the two possible scenarios, the transitions were recorded in a three-way contingency table – vessels presence versus preceding observation versus succeeding observation. Then, the transition probabilities for the two scenarios were calculated using:

$$p_{ij} = \frac{a_{ij}}{\sum_{j=1}^{s} a_{ij}}, \sum_{j=1}^{s} p_{ij} = 1,$$

where a_{ij} is the number of transitions observed from *i* to *j*, and p_{ij} is the transition probability from *i* to *j*.

All behaviour patterns were used for this analysis, and the RStudio package utilized was '*markovchain*'.

3. Results

In a total of 942.9 hours (in 147 days) of land-based observations, common dolphins were sighted for 48.9 hours (in 38 days). Dolphins' sighting periods corresponded to 67 events and a total of 575 5-minute behavioural samples (327 without vessels and 248 in the presence of vessels).

In general, dolphins spent an average of 28.3 ± 3.46 minutes in the study area, when there were no vessels in their vicinity. In this scenario, the minimum time of observation was 4 minutes, and the maximum was 132 minutes. The average time dolphins spend with vessels was sightly inferior, 23.5 ± 2.55 minutes, ranging between 2 and 74 minutes (Figure 3.1). These differences were not statistically significant (U = 3124, p = 0.7).

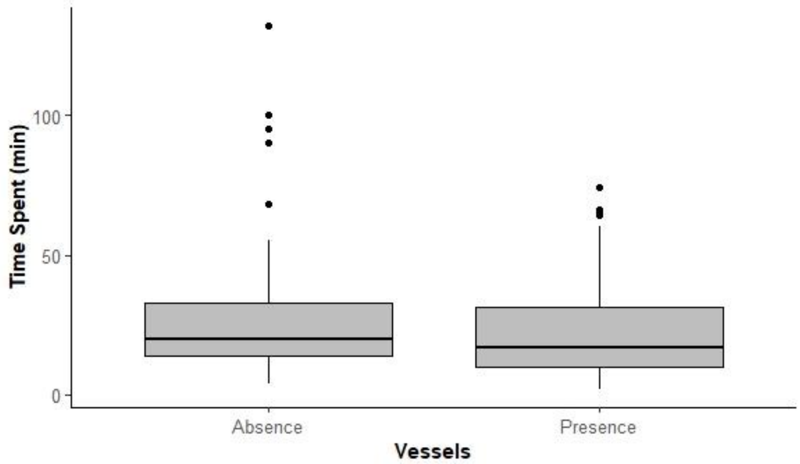

Figure 3.1 – Time spent, in minutes, in the study area, when dolphins were observed in the absence or presence of vessels.

3.1 Activity Behavioural Budgets

Overall, common dolphins spent most of their time *travelling* (60.5%) and *foraging* (34.6%). *Surface feeding* and *socializing* comprise 1.2% and 1.9% of common dolphins' activity budget in the lower section of Tagus estuary.

When vessels were in proximity, dolphins spent less time *surface feeding* (N = 2, 10 min vs N = 5, 15 min) and *travelling* (N = 160, 17.4 min vs N = 188, 18.7 min), while the time spent *foraging* (N = 76, 16.6 min vs N = 123, 15.6 min) and *socializing* (N = 6, 6.6 min vs N = 5, 4.5 min) increased (Figure 3.2).

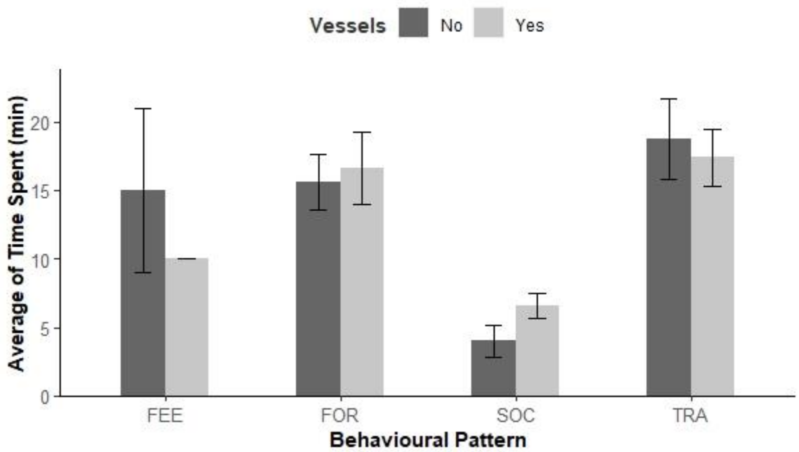

Figure 3.2 – Average of time that dolphins spent in each behaviour in the absence (dark grey) or in the presence (light grey) of vessels. The average time was obtained through the sum of the time spent in each behaviour within each event. Error bars represent the standard error. FEE – surface feeding; FOR – foraging; SOC – socializing; TRA – travelling.

When comparing the behavioural states of *foraging* and *travelling*, no significant differences were found between the two scenarios (*foraging*: U = 492, $p = 0.7$; *travelling:* U = 1113, $p = 0.8$).

3.2 Reactions to Vessels

All reactions (positive, neutral and negative) were observed during the dolphin sightings. In the majority of the vessels' interactions, dolphins exhibit a neutral reaction (80.2% of the observation time). Although other reactions were less frequent, negative reactions (15.9%) were nearly five times as numerous as the positive ones (3.9%).

During *travelling*, the neutral reaction was the most common response to vessels (N = 123, 15.22 ± 1.76 minutes), followed by the negative (N = 21, 7.53 ± 1.09 minutes) and the positive reaction (N = 5, 6.25 ± 1.23 minutes). The *foraging* activity exhibited a similar result: the average duration of neutral responses was 13.67 ± 2.51 minutes (N = 56), and the negative reactions were the followers (N = 15, 9.50 ± 1.35 minutes). However, the positive reaction was recorded for a shorter period (N = 4, 4.50 ± 0.87 minutes), when compared to *travelling* activity.

When dolphins were *socializing*, only negative and neutral reactions were recorded (N = 1, 10 and N = 5, 5.75 minutes respectively). *Surface feeding* was observed only during one event, and dolphins exhibited a neutral reaction to vessels presence for 10 minutes (Figure 3.3).

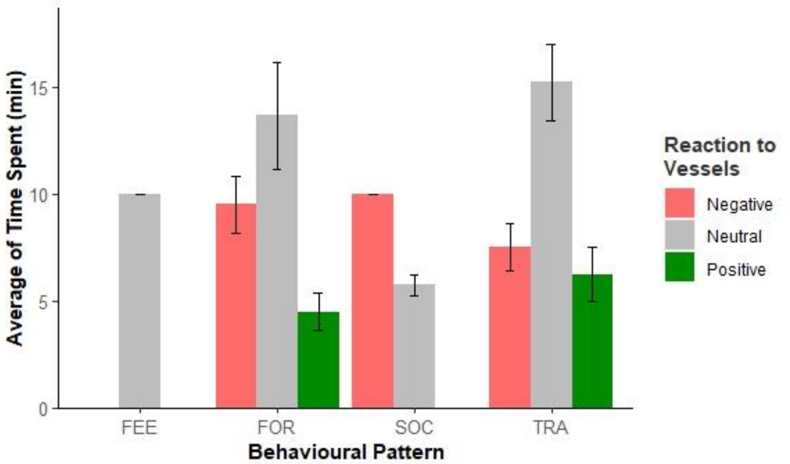

Figure 3.3 – Reactions of dolphins to the vessels during each behaviour observed. The average of time that dolphins spent in the different reactions was obtained through the sum of the time spent in each behaviour and reaction within each event. Error bars represent the standard error. FEE – surface feeding; FOR – foraging; SOC – socializing; TRA – travelling.

According with the statistical approach, there were three potential predict models that could explain further the possible effect of vessels into dolphins' behaviour. Using the Wald's test, the best model was the one who had time spent as a function of the reaction to vessels, with the activity patterns and with the relation between these two (Table 3.1).

Table 3.1 – Comparison of the models by Wald test. The model formula is structure as "response variable ~predictor variables", with the operator ~ meaning "as function of" and * meaning "interaction between covariates ". DF – degrees of freedom.

Candidate models		
M1: time ~ reaction to vessels		
M2: time ~ reaction to vessels + activity patterns		
*M3: time ~ reaction to vessels + activity patterns + reaction to vessels*activity pattern*		
Model comparison	**DF**	***p-value***
M1 vs M2	1	0.79
M1 vs M3	3	0.26
M2 vs M3	2	0.14

Specifically, the results from the third model showed statistically significant differences in the time that dolphins spent in each reaction. According to this model, the time that dolphins spent in negative and positive reactions was significantly less than the time they spent exhibiting neutral reactions (Table 3.2; Figure 3.4).

Table 3.2 – Results from the model 3.

M3: time ~ reaction to vessels + activity pattern + reaction to vessels activity pattern*				
	Estimate	**Std. error**	**Wald**	***ρ-value***
Foraging	-1.3938	3.1795	0.19	0.66112
Negative reaction	-7.6938	1.9985	14.82	0.00012 ***
Positive reaction	-8.8409	2.0913	17.87	2.4×10^{-5}***
Foraging: negative reaction	3.3181	3.4617	0.92	0.33781
Foraging: positive reaction	-0.0335	3.3456	0.00	0.99210
				*** *p-value* < 0.001

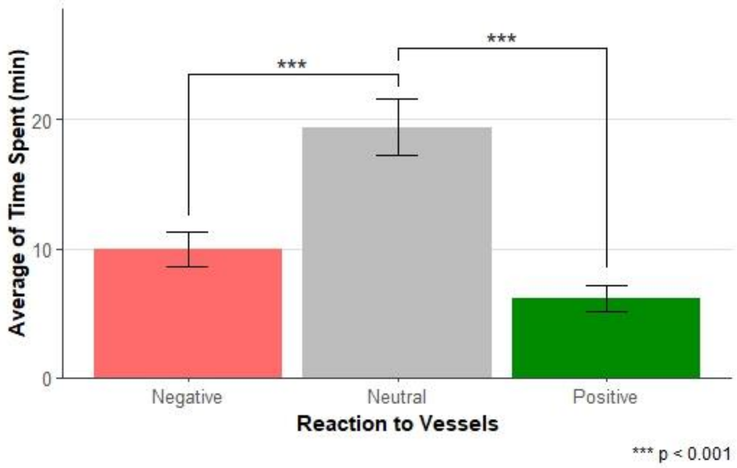

Figure 3.4 – Average of time spent in each reaction to vessels. The average of time that dolphins spent in the different reactions was obtained through the sum of the time spent in each behaviour and reaction within each event. The statistical results are provided from the GEE.

Furthermore, in GEE models, an estimated correlation parameter alpha indicates the strength of correlation between observations from the same event. In this case, α = - 0.0611, suggesting a weak negative correlation. This means that observations within an event may be somewhat independent of each other, but there may still be some level of correlation between them.

3.3 Behavioural transitions

The interaction between the dolphins and vessels influences the transitions in behavioural patterns, but the effects were not homogenous over all transitions.

In both scenarios, there were never registered the following transitions: (1) *travelling* to *feeding*; (2) *feeding* to *socializing*; (3) *socializing* to *feeding.*

When dolphins were sighted without vessels in their vicinity, the transitions that occurred more often were *travelling* to *travelling* ($P_{TRA\text{-}TRA}$ = 0.73), *socializing* to *travelling* ($P_{SOC\text{-}TRA}$ = 0.6), *foraging* to *foraging* ($P_{FOR\text{-}FOR}$ = 0.57) and *feeding* to *foraging* ($P_{FEE\text{-}FOR}$ = 0.5).

When dolphins were in proximity to vessels, transitions from *foraging* to *socializing* and from *feeding* to *foraging* were not observed. Similarly, to the scenario with no vessels, the most common transitions were *travelling* to *travelling* ($P_{TRA\text{-}TRA}$ = 0.79), *socializing* to *travelling* ($P_{SOC\text{-}TRA}$ = 0.6) and *foraging* to *foraging* ($P_{FOR\text{-}FOR}$ = 0.58). However, the transitions *foraging* to *travelling* ($P_{FOR\text{-}TRA}$ = 0.41) slightly increased and *feeding* to *travelling* ($P_{FEE\text{-}TRA}$ = 0.5) doubled when vessels were in the vicinity of dolphins. On the contrary, the transition *travelling* to *foraging* ($P_{TRA\text{-}FOR}$ = 0.18) showed a decreased in the scenario with vessels presence (Figure 3.5).

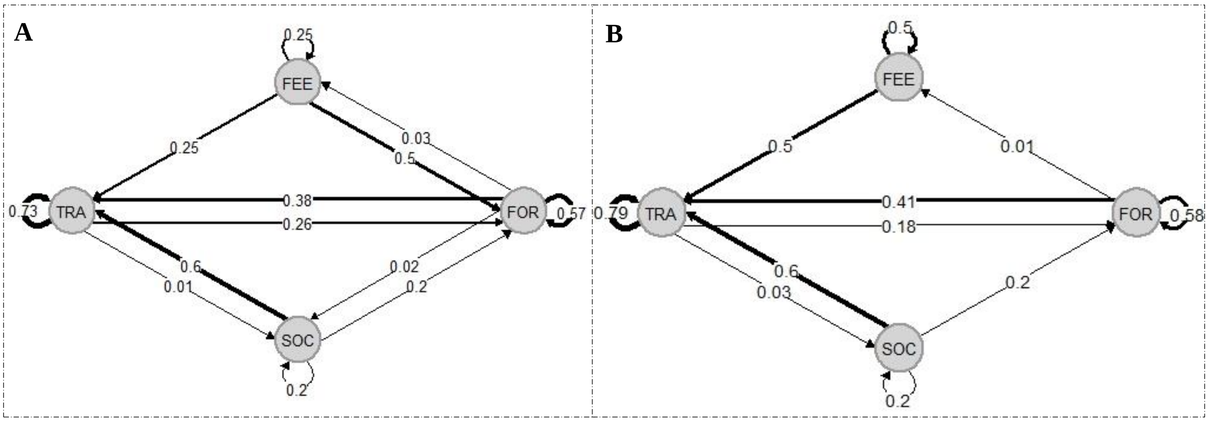

Figure 3.5 – Markov chains representing behavioural transitions probabilities: (A) control chain; (B) impact chain. FEE – surface feeding; FOR – foraging; SOC – socializing; TRA – travelling.

4. Discussion

Assessing the effects of vessels on marine species always poses a challenge. Understanding and interpreting the changes in cetaceans' behaviour is crucial for overcoming this difficulty.

This is the first study conducted regarding the effects of vessels on common dolphins' behaviour in the Tagus estuary and the results here presented highlight the influence of vessels in different aspects of dolphins' daily activities in the area.

During this study, four of the five behavioural states were recorded, where *travelling* and *foraging* were the most recorded. This can provide insight into the habitat use of common dolphins, particularly in cases where *resting* behaviour has not been observed. Because the sightings of common dolphins in these environments are rare, it is essential to understand the reasons for their visits. In Tagus estuary, it is hypothesized that the presence of common dolphins may be influenced by factors such as salinity and temperature, as it has been proved to be the case with other delphinids (Batista *et al.*, 2022; Booth & Thomas, 2021; Mintzer & Fazioli, 2021; Rodriguez *et al.*, 2021). Another factor to considered is the availability of preferred preys, such as cuttlefish and mullet (Batista *et al.*, 2022), indicating, possibly, that Tagus estuary may be an important feeding area. Additionally, it is also important to examine the presence of vessels closely, to comprehend how this species may be affected.

In this study, the time that dolphins spent in the lower section of Tagus estuary with and without vessels was very similar, which possibly indicates that the presence of vessels does not limit the time spent in the area. Dolphins' presence in estuaries is quite frequent around the world, especially bottlenose dolphins (Batista *et al.*, 2022; Moreno & Mathews, 2018). However, there are no studies regarding common dolphins' populations in estuaries associated with vessel traffic. In bottlenose dolphins' populations, it is suggested that the use of estuarine habitats is related to prey availability and the vessel traffic seems to be a second factor to considered, even if some populations are known to have short-term effects due to the frequent presence of vessels (Félix *et al.*, 2022; Fury & Harrison, 2011; Marley *et al.*, 2016).

Although differences were found in the behavioural budgets, these results were not statistically significant. One possible reason for this outcome is the limited number of samples, especially for *surface feeding* and *socializing*, that may hinder the statistical analysis. More time is needed to better assess the differences in behavioural budgets in the absence or presence of vessels. Dolphins were observed *surface feeding*, *foraging*, *socializing* and *travelling* in both conditions (with and without vessels); yet, it is interesting to notice that when vessels were in proximity to the dolphins, they spent less time *surface feeding* and *travelling,* while the time spent *foraging* and *socializing* increased. In a study by Christiansen *et al.* (2010), bottlenose dolphins were recorded with higher duration of *foraging* behaviour during interaction with tour boats, and the authors suggested that this increase might be required to compensate for energy lost during these encounters. Furthermore, Marley *et al.* (2017) explained that prey behaviours may change in the presence of vessels, leading to easier predation by the dolphins. Based on these hypotheses, it was expected that there would be an increase in *surface feeding*. However, in this study, *surface feeding* decreased when vessels were present. This suggests that other factors might be influencing *surface feeding* behaviour. Underwater noise can effectively disrupt communication between individuals and affect the decision-making process (Quintana Martín-Montalvo *et al.*, 2021) as well as feeding behaviours, because they need to be coordinated and the noise from vessel traffic can mask this communication (Meissner *et al.*, 2015; Papale *et al.*, 2012).

Moreover, it is important to consider the possibility of incorrect labelling *foraging* behaviour. In previous studies, it has been reported that when dolphins are disturbed by vessels, they do vertical avoidance, and the surface behaviour can be easily misidentified (Lusseau, 2003a; Marley *et al.*, 2017). In a study by Ng & Leung (2003), dolphins were observed to have longer dives when vessel traffic was very intense. Thus, it is possible that the increase of *foraging* when vessels were presence might be, in fact, a result of misclassification of evasive manoeuvres, due to the observation of scattered groups and long submersions.

To clarify the effects on dolphins' behaviour, an analysis was conducted on the reactions of the dolphins during the encounters. In most of the events, dolphins exhibit a neutral reaction. The neutral reaction might indicate the absence of immediate disturbance, as it has been previously reported for other delphinids, when assessing behavioural responses to cargo ships (Ng & Leung, 2003).

It is important to note that certain variables or circumstances may have the potential to change the outcome of the scenario in question. The response to vessels can be influenced according to vessel type, exposure duration, and number of vessels (Campana *et al.*, 2015; Lusseau, 2003a; Marley *et al.*, 2017). The study by Marley *et al.* (2017) discovered that dolphins' behavioural budgets varied according to the number of vessels. In this study, none of these factors were explored. It is important to establish a clear correlation between the type of vessels and the number of vessels involved in interactions with dolphins. Furthermore, in a study by Papale *et al.* (2012), negative reactions occur in 70% of the encounters between dolphins and speed boats, resulting in changes on dolphins' behaviour. The unpredictability of vessels in high velocity seems to have impact on dolphins' responses (Ng & Leung, 2003). Additionally, various studies have shown the impacts of underwater noise on cetaceans (Erbe, 2002; Erbe *et al.*, 2019; Luís *et al.*, 2014; Marley *et al.*, 2017). In this study, the response to vessels varied according to the dolphins' behaviour and negative reactions were observed during *foraging*, *socializing* and *travelling*, possibly indicating that these behaviours were interrupted by the vessels' presence at some point.

Evaluating the short-term impacts of vessels helps to establish a clear link to possible long-term effects. Certain groups of cetaceans have been observed to relocate temporarily from regions that experience high levels of maritime traffic (Cunha *et al.*, 2017), while others completely avoid these areas (Lussean, 2004; Quintana Martín-Montalvo *et al.*, 2021; Senigaglia *et al.*, 2016). Previous research consistently shows that individuals frequently alter their behaviour in response to approaching vessels as a direct method of avoidance (Quintana Martín-Montalvo *et al.*, 2021). Our findings regarding the behavioural transitions are in line with these results. The transitions from *foraging* to *travelling* increased when vessels were in proximity to the dolphins and the probability of *surface feeding* transit to *travelling* doubled. This might be a clear indicator of behavioural disruption as a direct reaction to a vessel interaction (Quintana Martín-Montalvo *et al.*, 2021). If feeding behaviour is constantly disrupted, it could have serious consequences for the individuals and the population. Previous research has indicated that a reduction in food intake can result in lasting consequences on an individual's reproductive achievement, overall physical health, and trigger nutritional distress (Lusseau & Bejder, 2007; Meissner *et al.*, 2015; Quintana Martín-Montalvo *et al.*, 2021).

5. Final Considerations

Sightings of common dolphins in estuaries are very unusual, but in the Tagus estuary are becoming more frequent, and the presence of groups with calves and juveniles is now regular (Batista *et al.*, 2022). The presence of young individuals may influence the behaviour observed and possibly the reaction to vessels; thus, it is important to understand how the encounters with vessels may influence the relations between mother-child dyads. Also, *foraging* activity is the second most behaviour recorded in this study, so the Tagus estuary may be an important feeding area for this species. In this study, it was possible to observe small differences in behavioural budgets when vessels are near dolphins, negative reactions to vessels and changes in behavioural transitions during *foraging* and *feeding* events. It is essential to look at these results closely and understand what they could possibly mean in the future. The Tagus estuary is an area with intense maritime traffic (including tourism companies with licences for observations of cetaceans) that, probably, will have effects on the behaviour of dolphins. Furthermore, maritime traffic in this area is increasing and it is expected that whale and dolphin watching companies will expand their activities due to the sightings' frequency. For these reasons, a continuous study of these dolphins' visits and monitorization is very important, as well as it is critical to assess other factors that can influence the dolphins' response to vessels in future studies.

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7. Annexe

7.1 Annexe I – State of the Art

7.1.1 The importance of behavioural studies in marine mammals

Niko Tinberg was one of the first ethologists to define behaviour as “the total movements made by the intact animal”(Dugatkin, 2013). However, this definition is not consensual and has been widely debated (Dugatkin, 2013). A study by Levitis *et al.* (2009) suggested that the appropriate definition is “the internally coordinated responses (actions or inactions) of whole living organisms (individuals or groups) to internal and/or external stimuli, excluding responses more easily understood as development changes”. This means that the response to a situation can reveal important information about how an animal can adapt to specific conditions within its habitat (Martin & Bateson, 2007).

In the case of marine mammals, the same principal is applied, although the study of behaviour can be very demanding (Nowacek *et al.*, 2016), especially because they are incredibly mobile animals who spend most of their time in the ocean (Mann, 1999).

Altmann (1974) introduced the concept of “behavioural states”, explaining that it is easier to understand how an animal behaves by dividing the behaviour into different categories. In 2001, a study by Neumann applied this concept and described the importance of using behavioural budgets in comprehending the behaviour of common dolphins in New Zealand (Neumann, 2001). Lusseau (2003a) went further and, evaluated the behavioural budgets to assess the biological significance of human activities on bottlenose dolphins. Through rigorous analysis of the behavioural patterns, it is now possible to study changes in behavioural states and their relationship with the potential sources of impact (Bas *et al.*, 2017).

Early studies of aquatic animals likely began with observations on land (Morete *et al.*, 2018). Nowadays, this methodology is widely used, since land-based visual observations can provide information on species occurrence, distribution, ecology and behaviour (Acevedo-Gutiérrez, 2008), without interacting with animals, and possibly disturbing their natural behaviour (Morete *et al.*, 2018).

Land-based studies may be conducted for as long as necessary (Morete *et al.*, 2018). When this method is used in combination with other methods, such as acoustics, genetics and boat surveys, scientific results are more stringent (Morete *et al.*, 2018). In a study by Marley *et* *al.* (2017), through non-invasive methods both acoustic and land-based, it was demonstrated that bottlenose dolphins were disturbed in areas with high-density vessels.

Meza *et al.* (2020) conducted a study in the Istanbul Strait where was discovered that purse seine vessels change the behaviour of three species of cetaceans which could lead to long-term impacts for these species. This study was the first step in figuring out where and when conservation measures should be implemented since indirect interactions between cetaceans and fisheries could be comprehended. This reveals the importance of land-based observations, especially the information this method can provide in marine mammals helping to establish conservation action and development management plans and guidelines for different species (Morete *et al.*, 2018; Piwetz *et al.*, 2018).

7.1.1.1 The importance of behavioural studies for conservation strategies

Current studies use behavioural patterns to understand the impacts of interactions between animals and anthropogenic activities. Changes in behavioural patterns are perceived to be the first sign of potential threat, leading to the knowledge of where and when to adopt appropriate conservation strategies (Arcangeli & Crosti, 2009). Similarly, these changes may hep understand whether they achieved the intended outcome (Brakes & Dall, 2016).

Due to the increase in anthropogenic pressure and the urge to understand what this pressure can do to different populations, conservation studies have become significantly more important (Cecchetti *et al.*, 2018; Whitehead, 2010). Efforts have been made to make use of the knowledge on behavioural ecology to conservation actions and see if those actions are getting positive results (Brakes & Dall, 2016). Sutherland (1998) was one of the first scientist to highlight ways in which behavioural studies can be used to contribute to conservation. A recent study by Stack *et al.* (2020) discovered that the resting behaviour of the Maui Nui spinner dolphins' population was compromised due to the intense marine traffic. For this reason, additional management strategies were suggested, particularly for areas where dolphins were seen at rest and regarding the distance between vessels and dolphins (Stack *et al.*, 2020). Koroza & Evans (2022) noticed that the marine traffic Code of Conduct was not fully protecting the population of bottlenose dolphins in Cardigan Bay and, consequently, proposed various conservation measures using behavioural analysis.

7.1.2 Effects of vessels in delphinids

Marine traffic is a major concern as it is one of the causes of impacts on marine life, particularly for coastal dolphins (Marley *et al.*, 2017; Nowacek *et al.*, 2001). As the world develops, marine traffic is expected to expand, increasing the potential for disruption of marine species (Cunha *et al.*, 2017; Nowacek *et al.*, 2001). For this reason, studies on the effects of vessels on cetaceans have emphasized the weight that the management of these issues have regarding the conservation of marine mammals (Bas *et al.*, 2017; Kight & Swaddle, 2011; Lemon *et al.*, 2006).

7.1.2.1 <u>Short-term effects</u>

Studies that assess the impact of interactions between cetaceans and vessels are typically based on behavioural assessment (Bejder *et al.*, 2006). Cetaceans respond to the presence of vessels by exhibiting different behaviours, depending on their level of stress (Campana *et al.*, 2015; Lusseau, 2003a). The responses can be influenced by the composition of the group (Quintana Martín-Montalvo *et al.*, 2021). For instance, some studies discovered that more cohesive groups have a higher level of alertness compared to dispersive groups and the smaller the groups, the more likely it is that they will avoid interaction with boats (Neumann & Orams, 2006; Tyne *et al.*, 2018). In the Fremantle Inner Harbour (Western Australia), Marley *et al.* (2017) discovered significant behavioural changes when vessel density was higher.

Typically, the responses to the vessels' presence are attraction, escape, or indifference (Lemon *et al.*, 2006; Lusseau, 2003b). Several studies have documented short-term behavioural changes in different dolphin species. In the study by Janik & Thompson (1996), the counting of individuals of bottlenose dolphins declined during interactions with vessels. This may imply that the diving periods were longer in proximity to vessels. A study by Ng & Leung (2003) proves this point when they discovered that Indo-Pacific humpback dolphins dove for longer duration in areas with high marine traffic. Behavioural state patterns also have shown differences in the immediacy of vessels: the surface movements can become more unpredictable and behavioural activity budgets can be modified (Lusseau, 2003a). For example, Kassamali-Fox *et al.* (2020) showed that the bottlenose dolphins travelled more in the encounter with vessels, leading to a reduced time in foraging. Furthermore, in a study by Stockin *et al.* (2008), a population of common dolphins spent less time searching for food and resting when tourism vessels approached the group.

Besides this, noise levels in the oceans are becoming more pronounced as marine traffic increases which can lead to variations in vocalization rates (Cecchetti *et al.*, 2018). In the Canaries archipelago, Papale *et al.* (2015) demonstrated that three species of dolphins modify their whistles frequency in the presence of anthropogenic noise. In a study by Luís *et al.* (2014), a resident population of bottlenose dolphins, in Sado estuary, changed their acoustic behaviour when vessels were present: social calls had different frequencies and the duration, and some vocalizations had a decrease in emission rates.

7.1.2.2 Long-term effects

Short-term cumulative negative effects on marine life may affect human pressure resilience and have long-term impacts (Quintana Martín-Montalvo *et al.*, 2021). A major concern is how the changes in activity behavioural budgets can influence the ecology and physiology of an individual (Kassamali-Fox *et al.*, 2020). These short-term effects can influence an individual's energy use (Cecchetti *et al.*, 2018), which could impact a species' reproductive success and even trigger a decline in a population (Bejder *et al.*, 2006; Christiansen *et al.*, 2015; Kassamali-Fox *et al.*, 2020).

The constant noise pollution can lead to changes in the acoustic behaviour of dolphins that may have permanent consequences (Cunha *et al.*, 2017). Several studies have uncovered a range of impacts on dolphins, such as "masking" communication, frequency changes and auditory damage (Erbe, 2002; Marley *et al.*, 2017; Merchant *et al.*, 2014; Weilgart, 2007). In addition, stranding and mortality can happen due to frequent noise pollutions (Weilgart, 2007).

One of the direct effects of the vessels' presence is the occurrence of collisions with vessels that may result in serious injury or possibly death (Cunha *et al.*, 2017; Silber *et al.*, 2012). Furthermore, some populations exhibit temporary displacements (Cunha *et al.*, 2017) and other may completely avoid a zone with extensive maritime traffic (Lussean, 2004; Quintana Martín-Montalvo *et al.*, 2021; Senigaglia *et al.*, 2016).

7.1.3 Historical information on cetaceans occurring in Tagus estuary

The historical literature on cetacean occurrences and distribution on the coasts of Portugal reveals the frequent presence of different species (Brito *et al.*, 2008; Brito & Vieira, 2009, 2010). However, it was not until recently that efforts were made to better understand these historical reports (Brito & Vieira, 2009).

Fishing communities have reported the presence of cetaceans in the Tagus estuary for more than two centuries (Batista *et al.*, 2022). An important Portuguese naturalist, Baldaque da Silva, describes the frequent occurrence of a specie known as Toninha, in the late 19th century:

"Toninha (Delphinus communis, Lin.) – the cetacean that is seen so often, cutting the water of our coast, following the march of the great steamers of greater progress, and that sometimes enters ports and rivers in pursuit of schools of small fish, reaches up 2 meters (...) In the Tagus and Sado river, groups of toninhas often enter, up to great distance from the river's mouth"(Da Silva, 1891, p. 56)

According to Vieira *et al.* (2009), the name "Toninha" corresponds to the name given by the local population and refers to the common dolphin (*Delphinus delphis)*. Nevertheless, historical sources indicate that different species of cetaceans have entered the Tagus estuary at some point (Brito, 2019). During the 17th century, it was often reported that wild tunas entered the Tagus estuary, but based on the description that was made, it is now believed to be bottlenose dolphins, *Tursiops truncatus* (Dias & Marques, 1999).

The sightings of cetaceans become more evident in the 20th century when several observations revealed that dolphin occurrences in the estuary were recurrent and may be linked to the predation of squid and cuttlefish (Batista *et al.*, 2022). However, by the 1960s, dolphin observations had become rare, and it was believed that the disappearance was due to overfishing and pollution (Brito, 2019).

After 40 years, dolphins were sighted again in the Tagus estuary and at least two species were identified: common dolphin (*D. delphis*) and bottlenose dolphin (*Tursiops truncatus*) (Batista *et al.*, 2022). Nowadays, the occurrences of *D. delphis* seems to be increasing, but the lack of baseline studies in the region hinders possible comparisons.

7.1.4 The common dolphin

7.1.4.1 Taxonomy

The common dolphin was first described by Linnaeus in 1758, but it took more than two centuries to clarify its taxonomy status due to this species' cosmopolitan distribution (Murphy *et al.*, 2013). In the 1990s, morphological and genetic analyses of specimens from the Northeast Pacific Ocean resulted in the identification of two distinct species of common dolphins: the short-beaked common dolphin, *Delphinus delphis* Linnaeus, 1758, and the long-beaked common dolphin, *Delphinus capensis* Gray, 1828) (Heyning & Perrin, 1994; Rosel *et al.*, 1994). Nevertheless, several studies that defended this division was not valid (Bell *et al.*, 2002; Samaai *et al.*, 2005). According to a study by Cunha *et al.* (2015), based on genetic analysis of specimens from different locations in the world conducted in the Atlantic Ocean, only one specie exists (*D. delphis*). In 2016, the Society for Marine Mammalogy Committee on Taxonomy established that all common dolphins belong to a single species, *Delphinus delphis* (Committee on Taxonomy, 2023), that can be divided into four subspecies based on populations' location: the Common Dolphin (*D. d. delphis* Linnaeus, 1758), the Eastern Noth Pacific Long-Beaked Common Dolphin (*D. d. bairdii* Dall, 1873), the Black Sea Common Dolphin (*D. d. ponticus* Barabash, 1935) and the Indo-Pacific Common Dolphin (*D. d. tropicalis* van Bree, 1971).

7.1.4.2 General Characteristics

D. delphis is a small cetacean (Bearzi *et al.*, 2003) characterized by a distinct colour pattern, thoracic patch has a yellow colour, and the rest of the body is dark grey (Perrin, 2008). Adults can reach up to 1.6 – 2.0 m long and weight about 200 kg (Perrin, 2008).

Nowadays, *D. delphis* is one of the most abundant cetacean species (Perrin, 2008) with a wide distribution worldwide (Caputo *et al.*, 2020; Giralt Paradell *et al.*, 2019; Mason *et al.*, 2021). It is generally considered that the distribution of cetaceans in space and time is shaped by environmental factors that influence the availability of prey on different spatial and temporal scales (Correia *et al.*, 2019). Common dolphins can be found in offshore and inshore temperate and tropical waters in the Atlantic and Pacific Oceans (Giralt Paradell *et al.*, 2019; Heyning & Perrin, 1994; Perrin, 2008). In the Northeast Atlantic, this species is very abundant and its distribution ranges from Norway to the south of Spain (Giralt Paradell *et al.*, 2019; López *et al.*, 2002, 2003; Mirimin *et al.*, 2009).

As a result of their wide distribution, as well as their tendency to have low rates of both residency and site fidelity (Caputo *et al.*, 2020; Evans, 1994; Jefferson *et al.*, 2008), common dolphins have a variety of feeding habits, including small mesopelagic fishes, cephalopods, and others such as clupeoids (Perrin, 2008), that can vary seasonally as well as regionally (Evans, 1994).

D. delphis can be seen in large groups with 50-400 individuals, on average (Caputo *et al.*, 2020; Evans, 1994; Perrin, 2008). These large group sizes could be related to two factors: (1) to take advantage of their numbers to prey on schools of fish (Ambrose *et al.*, 2013; Caputo *et al.*, 2020; Neumann, 2001); (2) to avoid attacks from predators in areas with high predation pressure (Acevedo-Gutiérrez, 2008; Caputo *et al.*, 2020). Usually, *D. delphis* groups have 20-30 individuals (Evans, 1994; Perrin, 2008). It is also possible to find common dolphins in association with other cetaceans' species, such as pilot whales (*Globicephala spp.)*, Atlantic spotted dolphins (*Stenella frontalis)* and striped dolphins *(Stenella coeruleoalba*) (Cecchetti *et al.*, 2018; Evans, 1994; Frantzis & Herzing, 2002; Perrin, 2008).

7.1.4.3 Conservation Status and Major Threats

Marine life is under constant threat due to man-made impacts. For cetaceans, the major threats are associated with vessel traffic, exploration of ocean resources, pollution and marine debris (Olaya-Ponzone *et al.*, 2020). In addition, populations of species living in coastal environments may be further affected by ship strikes and by-catch (Parsons & Jefferson, 2000).

While many local populations have experienced dramatic declines, much of the impact on *D. delphis* does not appear to be leading to a global decline (Braulik *et al.*, 2021). According to the IUCN Red List of Threatened Species, *D. delphis* was listed as "Least Concern" in 2008, and that classification remains unchanged today.

7.1.4.4 Regulations and Legislation

Common dolphins, along with other cetaceans, are legally protected by several legislations that can be applied worldwide. Between international agreements to national laws, the extent of the protection and the degree of enforcement varies.

7.1.4.4.1 International Convention and Agreements

All international agreements constitute a set of binding instruments that can serve as guidelines to the Member States. For marine mammals, the objective is to develop a set of actions to ensure the conservation and management of species that are or may be at risk.

There are four major international conventions with important policies for common dolphins. According to Article 65 of the United Nations Convention on the Law of the Sea (1982), "states shall, in particular, cooperate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management and study". The Convention on the Conservation of Migratory Species of Wild Animals - CMS (1979), which provides for the protection and conservation of migratory species, strengthens this position. The CMS lists the populations of common dolphins from the North and Baltic Seas in Appendix II. Furthermore, the Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES (1973) establishes rules to prevent trade in species listed in the agreement in manner that does not adversely affect the species' survival. In addition, the Convention on the Conservation of European Wildlife and Natural Habitat (1979) has included North Atlantic common dolphins in Appendix 2 as "strictly Protected Fauna Species", which means that numerous activities are prohibited, like deliberate capture or killing.

The Agreement on the Conservation of Small Cetaceans of Baltic, Nort East Atlantic, Irish and North Seas (1992), commonly known as ASCOBANS, and the Agreement on the Conservation of Cetaceans of Black Sea, Mediterranean Sea and Contiguous Atlantic Area (1996) (ACCOBANS) have important conservation and management strategies for various cetacean populations. Article 2 from the ACCOBANS states that "parties shall take co-ordinated measures to achieve and maintain a favourable conservation status for cetaceans. To this end, parties, shall prohibit and take all necessary measures to eliminate, where this is not already done, any deliberate taking of cetaceans and shall cooperate to create and maintain a network of specially protected areas to conserve cetaceans".

7.1.4.4.2 European Regulations

Under European regulations, *D. delphis* is protected through the Habitat Directive (Council Directive 92/43/EEC of 21 May 1992). This legal instrument is responsible for the preservation of endangered and endemic biodiversity. According to article 12, "Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting: (a) all forms of deliberate capture or killing of specimens of these species in the wild; (b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernations and migrations; and (d) deterioration or destruction of breeding sites or resting places". Annex IV corresponds to a list of "Animal and Plant Species of Community Interest in Need of Strict Protection", where *D. delphis* is included.

7.1.4.4.3 National Legislation

In Portugal, the common dolphin is fully protected since 1981 by the Decree-Law No 263/81, from September 3rd, which include the prohibition of hunting, fishing, or killing of marine mammal species in estuaries and in the continental exclusive economic zone was stipulated here. Additionally, in 2006, the regulation of whale watching for mainland Portugal was defined by the Decree-Law No 9/2006, from January 6th. Here, a code of conduct is established, and all whale-watching companies and recreational vessels are required to follow near cetaceans.

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7.2 Annexe II – Complementary information regarding the land-based observations

The land-based observations could only occur if certain weather conditions were accomplished. The conditions were continuously assessed by the observer and noted, every hour in a specific spreadsheet. Furthermore, during the hourly assessment report, the number of vessels present in the study area was counted and assigned to one of the following categories: fishing vessels, tourism vessels and others (see Annexe III).

During the land-based observations, a set of variables were recorded when dolphins were present. To provide additional information, the study area was divided into 7 sectors (defined through visible reference points inland) and these sectors were used to define dolphins' location (Figure 7.1). Also, information regarding the group's composition (adults and calves), presence of seabirds, group's cohesion, predominant direction, aerial behaviour events, and other complementary observations were collected (see Annexe IV).

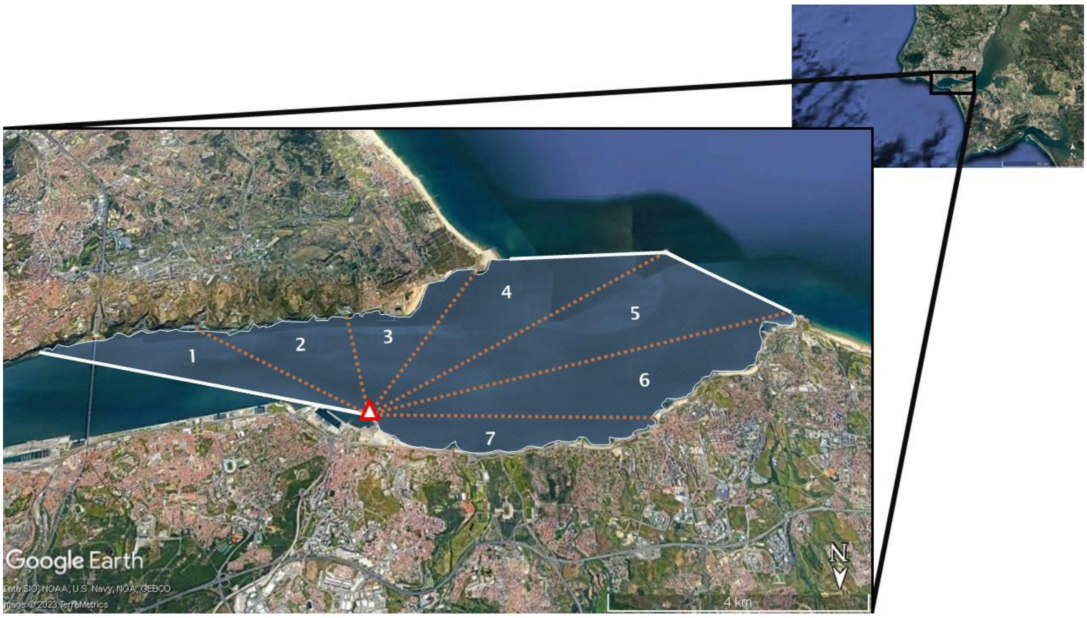

Figure 7.1 - Map of the study area. The red triangle represents the VTS tower, where land-based observations were carried out. The dash orange line is the division of the sectors and the white line correspond to the limits of the study area.

7.3 Annexe III – Record sheet for the weather conditions

Data	Hora	Observadores	Maré (Encher/ Vazar)	Bft Scale	Glare		Barcos			Observações
					Sim/ Não	Setor	Pesca	MTs	Outros	

7.4 Annexe IV – Record Sheet for Land-Based Observations

SAÍDA Nº		H INÍCIO		BM	METEO	REGISTOS
DATA		H FIM		PM		
		T ESFORÇO				

HORA	ESPÉCIE	LOCALIZAÇÃO	AZIMUTE	TAMANHO GRUPO	ATIVIDADE DOMINANTE	EMBARCA-ÇÕES (Nº)	EMBARCA-ÇÕES (TIPOLOGIA)	REAÇÃO A EMBARCAÇÕES	OBSERVAÇÕES (elementos aéreos, aves, presas à vista e outras infos relevantes)
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	
					A BP D S R			- 0 +	

7.5 Annexe V – Record Sheet for video analysis

Dia	Hora	Duração do vídeo	Posição			Espécie	Tamanho do grupo	Padrão de Atividade	Observações	Qualidade do Vídeo
			Setor	Azimute	Próximo à Margem Sul					