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DISTRIBUTION OF BOTTLENOSE DOLPHIN IN GALICIAN REGION (NW SPAIN). THE IMPACT OF MUSSEL FARMING ON SPECIES

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Abstract: The spatial and seasonal distribution of common bottlenose dolphin and possible links with environmental conditions were studied at the Galician continental shelf. Data was collected between June 2019 and July 2019 during opportunistic surveys onboard fishing boats. Modelling results indicated that the number of common dolphin sightings per unit effort was higher further in the outer ria in shallow waters. Shellfish farming is an expanding segment of marine aquaculture, but the impact of this industry on bottlenose dolphins is only beginning to be considered. Over a period of 1 month spent in the field, 11 daily boat surveys and 53 common bottlenose dolphin encounters were done. Results of this research confirm that bottlenose dolphins prefer areas relating to such factors as sea surface temperature and prey availability. Moreover, there is an overlap between distribution of the dolphins and mussel production as mussel farming rafts cover 17% of Ria de Arousa. However, it

was revealedbottlenose dolphins are not avoiding the area of mussel production and can be outside the mussel rafts the same amount of time as inside. This research provides new insight into the mussel farming impact on the common bottlenose dolphins in Galician waters showing that this limiting factor is not major in the area.
Keywords: common bottlenose dolphin, Tursiopstruncatus, Galicia, shellfish farm, mussel rafts

1. INTRODUCTION

The common bottlenose dolphin Tursiopstruncatushas been studied intensively in numerous locations around the world, and today is one of the best known of the 85+ living cetacean species (Wells and Scott, 1999). In Galician region, NW Spain modern cetacean field studies started only in 1993 (Dacosta and López, 1993) and relatively little is yet known about bottlenose dolphins in the region.

The bottlenose dolphin is a cosmopolitan species found throughout the temperate and tropical oceans of the world (Leatherwood and Reeves, 1983). Bottlenose dolphin qualified as 'Least Vulnerable' according to the International Union for Conservation of Nature (IUCN) Red List criteria.

Previous studies of bottlenose dolphin populations have shown the species to have a fluid and dynamic social structure known as a fission-fusion society (Wursig and Wursig, 1979). Diet of bottlenose dolphins along the Galician coast have been described in previous studies (e.g. González et al., 1994) and statedthe most important prey of bottlenose dolphin are blue whiting and hake (Merlucciusmerluccius).

Galicia region is famous for its mussel farming production which represents half of the world production of mollusk, placing Spain foremost among world leaders in aquaculture. According to Perez Camacho (1987), the extraordinary extent of mussel culture in Galicia can be linked to several factors: the relatively low cost of the rafts, their high production, the price of mussels (making even the exploitation of a single raft a lucrative business), the abundance of seed, which can be collected from the rocks by the mussel farmer himself, and low operating costs.

The potential conflict between marine animals and mussel aquaculture is of a global nature. Further, due to the ongoing and growing demand for aquaculture and potential expansion into offshore areas, interactions are likely to continue and even increase into the future.

Interactions of cetacean species with aquaculture operations may occur as a result of an overlap between the spatial location of aquaculture operations and habitat space. Interactions may be direct, including fatal and non-fatal entanglements, damage to gear, collisions, and depredation, in which an animal feeds on captured fish or stock from nets, and/or biological, including habitat loss or degradations and reduced wild food supply (Read, 2008). Direct interactions between cetaceans and mussel farms, particularly entanglements, not only have the potential to negatively impact the animal and populations involved, but also the mussel industry by direct damage to gear and possibly decreased harvest.

Results of this study revealed a significant upward trend in density of bottlenose dolphins, preferences for a coastal area where human pressure and particularly aquaculture impact is higher. The observed link between human activities and changes in common bottlenose dolphin behaviour aim to contribute to a better understanding of the ecology of a marine top predator and its interaction with mussel farming in Galician waters. This in turn can provide some of the needed baseline data, from which effective management and conservation strategies can be designed.

2. METHODOLOGY

1. Study area

Galicia is situated in the North-west corner of the Iberian Peninsula and has almost 1500 km of coastline with a relative narrow continental shelf (with width of about 27 km on average).The Galician continental shelf and the Galician rías (coastal fjords) lie at the northern edge of one of the major upwelling areas in the world, which results in nutrient enrichment of the area (Blanton et al., 1984) and this area is among the most productive oceanic regions of the world. High biodiversity of fishes among the waters which is mainly depends on depth and hydrographic structure as, in general, density, biomass and species richness all decrease with increasing depth, reflecting the general phenomenon that species with more restricted depth ranges tend to occur in the shallowest waters (Smith & Brown, 2002). Galician waters are also an important area for marine mammals, including 16 cetacean and four pinniped species. Resident cetaceans in Galicia is the bottlenose dolphin (Tursiopstruncatus) which is seen all along the Galician coast, although with different geographical patterns of local abundance (López et al., 2004).

Mussel farming in Galician waters is extremely important. The declared production is 130 kg per $1m^2$ of raft which is 98% of the total Spanish production, approximately 50% of the European production and almost 13% of the world mussel production. This Spanish region is the third largest mussel producer in the world behind China and Thailand (Diaz Lopez, Menthion, 2017). To have such high production rate rafts has to cover huge territory: in the Ria de Arousa the mean surface area of the rafts (bateas) is $369m^2$(17% of the whole ria), and it increased by almost 25% since 1974 (Pérez Camacho et al., 1991).

The mean number of ropes per raft is 455m with rope length being about 5.6m. According to Marifio et al. (1982), ropes used in mussel culture consist of two parts; an upper or lashing rope which is fastened to the grid, and is hung as deep as 1 m below the water surface, and the rope where the mussels are tied. The second rope is totally submerged and has wooden or plastic pegs 30 cm long which are inserted at 40-cm intervals. The purpose of dividing the ropes into two parts is to make them last longer, as the upper part, which is exposed to air and sunlight, has a shorter life (2.4 years) than the part of the rope which is underwater (5.8 years).

2. Data collection

Data for this study were collected as part of an internship in study of common bottlenose dolphins inhabiting the Galician coast. We conducted boat-based surveys in the Ría of Arousa between June 2019 and July 2019 using a 12 m vessel, powered by two 180 hp inboard engines

The study area was monitored during daylight hours at a constant speed around 6-8 knots, with at least two experienced observers scanning 360º of the sea surface in search of bottlenose dolphins (with the naked eye and/or binoculars, 10x50). Boat-based observations were done when the visibility was not reduced by rain or fog, and sea conditions were < 3 on the Douglas sea scale (approximately equivalent to the Beaufort wind force scale). The survey area and track were selected based on sea conditions and time constraints on each day. Surveys were attempted to equally cover all parts of the study area, although the geographic distribution of effort could vary according to weather conditions(DíazLópez 2006).On each boat survey, the time, position, speed (knots), presence of dolphins, and environmental and anthropogenic data were recorded every 20 minutes (following DíazLópez 2017). These 20 min sets were used to summarize field conditions and distribution of the survey effort irrespective of dolphins' presence.

When bottlenose dolphins were encountered, searching effort (on-effort) concluded and the vessel slowly manoeuvred towards the bottlenose dolphins to photograph the dorsal fin of every individual present in the group. A suite of data including, the initial time, location, the group size, and group composition were recorded for each bottlenose dolphin group encounter. Group size and composition were assessed based on the initial count of different individuals observed at one time in the area. Upon sighting a group of bottlenose dolphins, searching effort ceased and the vessel slowly manoeuvred towards the group in order to minimise disturbance during the approach. During observation sessions, bottlenose dolphin groups were monitored for extended periods of time, often during the course of several hoursAfter the end of an encounter, the searching effort generally continued along the previously planned route.The sighting continued until the focal group changed composition or was lost; a group was considered lost after 15 min without a sighting.

3. **Data analysis**

Bottlenose dolphins were identified by using photographs of both sides of their dorsal fins and surroundingarea as unique natural markers. All photographs of the dorsal fin of every adult bottlenose dolphin identified were graded for quality and degree of distinctiveness in order to minimise both misidentification and heterogeneity in capture probabilities.

For spatial analysis all 9 years of survey data were included into a geographic information system (GIS) using the software QGIS (http://www.qgis.org). The study area was divided into 1 nm2 cells by creating a polygon grid and the number of times the research vessel crossed each cell searching for dolphins (on-effort) was used to summarize the distribution of the survey effort irrespective of dolphins' presence. Thus, in order to minimise bias from uneven allocation of survey effort in space a relative index defined as Sighting per Unit of Effort (SPUE) was calculated as:

SPUE =Ec/Sc

Where, Ec is the number of bottlenose dolphin encounters in each cell of the grid and Sc is the total number of surveys on-effort monitoring each cell. By calculating SPUE we reduced effort-related bias from derived distribution patterns arising from an uneven survey effort, caused by time and weather restrictions.

To understand the influence of some factors Chi-squared Test was done. The Test of Independence assesses whether an association exists between the two variables by comparing the observed pattern of responses in the cells to the pattern that would be expected if the variables were truly independent of each other. Calculating the Chi-Square statistic and comparing it against a critical value from the Chi-Square distribution allows the researcher to assess whether the observed cell counts are significantly different from the expected cell counts. The formula below was used:

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

Where f_o = the observed frequency (the observed counts in the cells) and f_e = the expected frequency if NO relationship existed between the variables

3. RESULTS

In all, 11 daily boat surveys over a period of 1month were spent in the field in the period from 1th of June until 29th of June 2018. During this period 111 instantaneous sets were recorded every 20 min: 53 sets (47%) searching for dolphins (on effort) and 58 (53%) with the group of dolphins (off effort).

Each group was observed during an average of 36 minutes. Group size ranged from 1 to 17 individuals (mean = 7). Compositionshowedthat 87% of individuals were adults and 13% were inmatures.

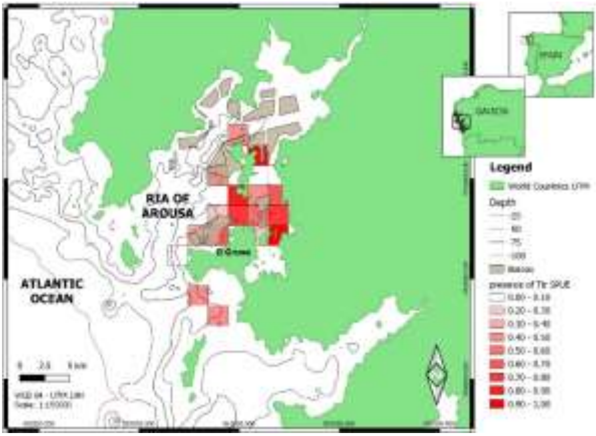

Figure 1. The distribution of bottlenose dolphin showed in red. Bateas (mussel rafts) are brown.

Analysis of collected data showed that dolphins use inner riamuch less frequently than the outer ria (Figure 1).Moreover, they prefer areas with depth equal 25m and less. Besides, there is clearly an overlap between mussel rafts and dolphins' habitat moreover dolphins are not avoiding the area.

Trying to analyze the impact of mussel production on the bottlenose dolphin in the study Chi-squared Test was done to compare the duration of sighting inside/outside the bateaswith total numbers of surveys inside/outside the bateas with the aim of minimizationrandomness of the results.The test showed that Chi-square Value is less than Critical Chi-square which means there is no quite difference between two factors. In other words, dolphins can be as long outside the bateas as inside them.

Chi-square	0,102587
uareValue	0,00317

Table 1. The results of Contingency Table Chi-squared Test.

4. CONCLUSIONS

Dolphins have been recorded in all parts of the survey area, but in much higher numbers and more frequently, in the outer ria. According to Giovanni Bearzi(2008) there are a few factors related to the preferred area of the population: habitat characteristics, local availability of prey and the nature of bottlenose dolphin communities.Schneider (1999) reported that bottlenose dolphins' habitat use selection is highly related to changes of sea surface temperature as they prefer the warmest water. Thus, the distribution of the dolphins in the study area confirms those statements:the dolphins are predominantly found close to the coast occurring with most frequency in areas with depths not exceeding 25 m where the water is clearly warmer. Shallow waters are known for concentrating cetaceans due to their abrupt topography which are characterized by shelf breaks, steep slopes, canyons, shallow banks and islands which can cause currents to change pattern creating small eddies and fronts (Bailey & Thompson, 2010). These features are highly productive resulting from upwelling-driven nutrients available (not to mention the area is situated in one of the major upwelling areas in the world(Blanton et al., 1984))which in turn aggregate different prey species attracting top predators.

Another aim of this work was to analyze mussel farming impact on common bottlenose dolphin. The production in Galicia is done using mussel rafts or bateas. The previous studies showed that these kinds of rafts can have a negative influence on dolphins' population. Studies in New Zealand revealed that mussel farms lie across seasonal migratory routes of large and in historic calving areas (Brian D. Lloyd, 2003), while another study in Australia concluded that bottlenose dolphins were excluded from parts of their home range where long-lines mussel farms were (Mann 1999;). In Ria de Arousaarea of mussel rafts overlap with the frequently utilized by common bottlenose dolphins area which means there is an overlap and the impact should be huge. However, this research demonstrated bottlenose dolphins are not avoiding the area of mussel production probably feeding as there are big aggregation of fish around mussel rafts. Another conclusion is that dolphins can be outside the bateas for the same amount of time as inside which means the impact of mussel farming on the common bottlenose dolphins in Galician waters is not that of a limiting factor.

This study provides further insight into the understanding of how shellfish aquaculture influences common bottlenose dolphins' distribution and habitat use within the study region.

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SOCHI IS A TREASURE TROVE FOR THE TRAVELLER

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Abstract: the impressions of the October trip to Sochi and the Black Sea are presented.

Keywords: Sochi, 22nd Winter Olympics, the Black Sea, the Olympic village

A lot of Chinese knows this beautiful and warm city. But «Sochi is the city that had hold the 22nd Winter Olympics in 2014» was my