Research Proposal – Lauren Rose

Title

Behavioural impact of vessel activity on short-finned pilot whales (*Globicephala macrorhynchus*) in South Tenerife, Canary Islands.

Abstract

The expanding human population has increased both the severity and frequency of interactions between cetaceans and humans. As boat traffic encroaches further into areas inhabited by marine life, detrimental effects will become more prevalent and severe. Short-finned pilot whales are resident and relatively abundant in the South-east waters of Tenerife. An increased demand for whale-watching activities and other shipping services have undoubtably had an impact on the local whale population and their behaviour, yet the exact influence remains unclear. This study analyses data collected by the AWdF and its volunteers to assess whether boat traffic is having a detrimental effect on short-finned pilot whales. It aims to establish which aspects of boat traffic have the largest or most influential impacts; potentially highlighting priorities for enforcement by the Barco Azul.

Introduction

Directly or indirectly, the largest issue affecting conservation efforts today is anthropogenic change (Dirzo, *et al.,* 2014). The Anthropocene has driven biodiversity loss by habitat degradation, exploitation and pollution; all of which can be traced back to human activity, and often whose impacts can be reduced or avoided with effective and researched management (Barnosky *et al.*, 2011; Panti *et al.,* 2019; Pereira *et al.*, 2012). Since the mid-nineteenth century, the conservation movement began to pick up momentum and the first National Park, Yellowstone, was established in 1872 (Frost & Hall, 2009). Since then, stakeholders have gradually begun to acknowledge how essential ecosystem health is to the economy, human health and wellbeing. For the marine environment however, conservation and management has presented further challenges due to their interconnectivity, vastness and difficulties with enforcement.

The global human population is predicted to exceed 9 billion by 2050 and consequently, boat traffic has increased majorly in recent decades (Tournadre, 2014; UN, 2015). Between 1992 and 2002 ship traffic increased by over 400% (Tournadre, 2014) and it is predicted to rise by 240-1,290% by 2050 (Sardain *et al.,* 2019). Boosted tourism, over-exploitation and increased shipping causes further marine noise, pollution and disturbance; the expanding human population causes activities to encroach further onto areas inhabited by marine wildlife. Together with this expansion, advances in technology and changes in the environment have allowed areas previously inaccessible to be reached. For example, in an increasingly ice-free Artic, more marine mammal species are going to be at risk of increased boat traffic (Hauser *et al.,* 2018). Additionally, tourism has increased exponentially in recent years, with over 700 million international tourists arriving in 2000 to 1.4 billion in 2019; placing further direct and indirect impacts on the marine environment (Gössling, 2002; UNWTO, 2019).

Human impacts have been escalated due to rapid population growth, industrialisation and technological advances, commercialisation of resources and the development of luxury markets (Lotze *et al.,* 2006). Approximately 66% of the oceans now show evidence of increased human impact and commercial species' populations have been diminished to under 10% of what they were originally (Halpern *et al.,* 2015; Lotze *et al.,* 2006). Fish abundance has also decreased by almost 40% in 40 years and essential marine habitats such as mangroves and seagrass beds have diminished by over 65% (Hutchings *et al.,* 2010; Lotze *et al.,* 2006). Furthermore, human activity has resulted in an increase in atmospheric carbon dioxide which has, and will continue to reduce ocean pH (Caldeira & Wickett, 2003).

These plethora of impacts have accelerated biodiversity loss and exasperated dwindling populations of many marine species. Current extinction rates are estimated to be 10-1000 times greater than proposed background extinction rates, supporting scientist who believe the Anthropocene is the sixth mass extinction (Pimm *et al.,* 1995; Barnosky *et al.,* 2011).

The species that are most at risk are long-lived mammals, such as cetaceans. Due to their life history traits, it is a greater challenge to recover from detrimental anthropogenic impacts (Constantine *et al.,* 2015). Recent literature has brought to light the impacts that marine noise, plastics pollution, boat collisions and being caught as bycatch or exploited in the exotic meat trade pose on cetacean populations. Climate change will also continue to alter sea surface temperatures, affecting many deep-diving cetacean genera, including *Globicephala* (Whitehead *et al.,* 2008).

62 species of cetacean have been found in the Atlantic islands of which 28 have been sighted in the Canary Archipelago (Hoyt, 2005). Due to upwellings, Tenerife harbours the perfect environment for cetaceans (Sebastián *et al.,* 2004). 24 species have been recorded in Tenerife waters; making its cetacean fauna the most diverse in the Canary archipelago (Carrillo *et al.,* 2010). Of these 24 species, 4 are resident: the short-finned pilot whale (*Globicephala macrorhynchus*), bottlenose dolphin (*Tursiops truncatus*), sperm whale (*Physeter macrocephalus*) and Risso's dolphin (*Grampus griseus)* (Francisco-Ortega *et al.,* 2009).

Short-finned pilot whales, *Globicephala macrorhynchus,* are the most commonly encountered cetacean in the South-eastern waters of Tenerife, with an estimated population of approximately 1000 individuals; primarily composed of resident individuals and some transient groups (Bowler, 2018; Carrillo *et al.,* 2010; Soto *et al.,* 2008). They are amongst countless species negatively impacted by expanding human practices and still, very little is known about their spatial and temporal patterns and global distribution (Minton *et al.*, 2018). In addition to anthropogenic noise pollution, short-finned pilot whales in Tenerife are increasingly vulnerable to ship collisions (10% of recorded boat strikes involve short-finned pilot whales) as they rest on the surface of the water during day (Ritter, 2010; Jensen, *et al.,* 2011).

Tenerife is the largest (2,026km^2), and most populous (approximately 950,000 inhabitants) of the Canary islands, located off the north-west coast of Africa (28°29'N, 16°63'W) (Eurostat, 2020; Rodríquez *et al.,* 2008). Located in the sub-tropics, Tenerife offers pleasant temperatures year-round (14°C – 28°C); attracting approximately 5 million tourists annually (Bowler, 2018). Tenerife relies heavily on Mariculture and so industries such as eco-tourism are already well-established on the island.

From an expanding human population and an increased demand from tourism, boat traffic has subsequently increased considerably. With whale-watching trips attracting more than 700,000 people annually, it would be anticipated that boat-cetacean collisions would also increase (Aguilar *et al.,* 2001; Carrillo, *et al.,* 2010). Through recent literature, cetaceans have been seen to respond to boat presence in a variety of ways; many noting avoidance behaviour (Aguilar *et al.,* 2001; Mallard, 2019; Matear *et al.,* 2019; Vieria *et al.,* 2018).

Numerous cetacean species have been adversely affected by boat traffic either through direct collisions, habitat degradation or pollution (chemical, physical and noise). Other odontocetes have adjusted their behaviour to increased boat traffic by substituting resting behaviour for more erratic behaviour, increased swimming speed or avoiding the vicinity altogether (Allen & Read, 2000; Constantine, *et al.,* 2004; Lusseau, 2003; Stensland & Berggren, 2007). It is suspected that South-eastern Tenerife waters may be a calving ground for short-finned pilot whales and so groups born in this area may have become habituated to local vessel traffic (Carrillo *et al.,* 2010).

Without extensive research, the impacts of boat traffic on short-finned pilot whales are still unclear. Currently, it is expected that increased boat traffic will impact a populations health long-term, particularly if resting or feeding behaviours are disrupted significantly (Constantine *et al.,* 2003; Stensland & Berggren, 2007).

Hypothesis

Main question:
Does boat traffic impact the behaviour of short-finned pilot whales?
i.e. Does the number of boats present, direction of approach or speed of approach effect the group behaviour or formation or the length of the interaction? I expect to find there is a correlation here.

Other questions that may be answered in the results or debated in the discussion:

Are these changes in behaviour linked with a physiological impact, such as increased stress? Will compare to similar, previous studies.

Is there evidence of habituation (When comparing data temporally)? I expect to see some evidence of this.

Is the behaviour effected by any of the following: calves present, oceanic cloud cover, Beaufort scale of sea state, location (GPS co-ordinates), other species present or the number in group? I expect these to have an impact to an extent – especially calves present.

Methodology

I will first create an ethogram of behaviours (according to how the AWdF defines them)

I will require the following data on shirt-finned pilot whales:

- Boat speed and direction of approach
- Number of boats present
- Interaction location and duration
- Group behaviour and formation
- Group size
- Cloud cover
- Beaufort scale of sea state
- Whether calves or other species were present

Using R-studio, I will first ensure that the data used conforms to the assumptions of normality.
I will create linear mixed-effects models (LMM) and compare the outcomes using likelihood ratio tests (LRT).

The duration of the interaction or group behaviours observed will be included as response variables. The number of boats present and the boat speed and direction of approach will be included as explanatory variables. The models will also account for the effect of cloud cover, waves, calf or other species presence and size of the group. Each recording will be included as a random factor.

An example of R code I would use to compare the effect of **boat number** on **interaction duration**:

```
MODEL1<-lmer(interactionduration~boatno+boatspeed+boatdirection+cloudcover+waves+year+calf+
groupsize+(1|recording),data=AWdF)
MODEL2<-lmer(interactionduration~boatspeed+boatdirection+cloudcover+waves+year+calf+groupsize+(1|recording),data=AWdF)
lrtest(MODEL1,MODEL2)
```

Conclusion and justification

There remains a large knowledge gap on the acute and chronic effects of boat traffic on cetacean behaviour (Constantine, *et al.,* 2004). Many papers in this literature review have investigated effects on such odontocetes as bottlenose dolphins but very few explore the effects on short-finned pilot whales. They are the most prevalent cetacean in Tenerife and therefore, data collected here will be numerous and allow for extensive statistics and analysis.

Short-finned pilot whales are currently listed as Data Deficient on the IUCN redlist and so, although categorized as 'Least Concern' globally, the lack of precise data on their distributions, populations and behaviour will put them at a great risk over the coming decades. For this reason, and those mentioned above, further, more specific, research is essential to ensure conservation practices effectively preserve our cetacean species.

Already in Tenerife there is a legally recognised code of conduct; the 'Barco Azul/Blue Boat'. It aims to reduce disturbance to cetaceans by whale watching boats although its effectiveness is limited due to poor enforcement (Duprey *et al.,* 2008). This research may help to target the most detrimental factors to short-finned pilot whale behaviour and so suggest aspects of control that should be prioritised in order to maximise the effectiveness of the Barco Azul.

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