TENERIFE WHALE AND DOLPHIN CONSERVATION PROJECT

TRW

Tenerife, Canary Islands

Picture by Jennifer Shaw (RA)

TRW Phase 172 Science Report

1 April 2017 – 11 June 2017

Natasha Wallis, Macarena Blanco, Thomas Insje

Staff Members

Guy Bezant (GB)	**Project Manager (PM)**
Natasha Wallis (NW)	**Assistant Research Officer (ARO)**
Macarena Blanco (MB)	**Assistant Research Officer (ARO)**
Thomas Insje (TI)	**Assistant Research Officer (ARO)**

Contents

1. General Introduction

The Canary Current and the coastal upwelling from the African coast promote wide marine biodiversity in the Canary Islands. Such biodiversity includes 730 native fish species, four species of marine turtles and twenty-eight cetacean species (Francisco-Ortega et al., 2009). Although most of the cetacean species are migrant or seasonal, some of them are resident in the Archipelago. This is the case for short-finned pilot whales (*Globicephala macrorhynchus*), sperm whales (*Physeter macrocephalus*) and bottlenose dolphins (*Tursiops truncatus*) (Francisco-Ortega et al., 2009). This biodiversity has provided a unique opportunity for a multimillion dollar ecotourism industry in Tenerife – in 2008 whale watchers spent $56,527,500- making it an important sector of the local economy.

Short-finned pilot whales and bottlenose dolphins are the main attraction for ecotourists to the Canary Islands, hence the whale watching industry in the South of Tenerife (Hoyt, 2001). Tenerife accounts for 58% of all whale watching companies and 75% of the whale watching tourists in the Canary Islands (Elejabeitia et al. 2004). In an effort to control and minimise any negative effects of these ecotourism activities, a Code of Conduct has been set out in the Canary Islands for whale watching boats to follow and a specific flag is flown by those who adhere to this Code of Conduct (Elejabeitia and Uriquiola, 2009). The industry has grown exponentially in recent years, with last year's revenue numbers worldwide at $2 billion in 2009 (International Whaling Commission, 2009) and was expected at that time to grow by as much as 10% every year. This has led to blurred lines between tourism and disruption as many international Codes of Conduct for viewing the species have been breached (International Whaling Commission 2013).

External disturbances can have great impacts on the stress levels of both captive and wild animals, and it is vital to be able to identify ways to measure their welfare (Dawkins 2004; Cagienard et al. 2005; Parker et al., 2012). This is especially important in the case of scientific investigations of vulnerable species (Moll et al., 2009). There have been several papers that indicate a significant correlation between behaviour and stress (Dawkins 2004; Cagienard et al., 2005).

The aims of this project are to look for solutions to several problems with the local cetacean tourism industry. There are national guidelines in place but these are poorly regulated and it has led to several issues including jet skis approaching whales and dolphins, people trying to swim with dolphins, or unaccredited whale-watching boats causing disturbance to the cetaceans. The current project objective that works towards achieving this aim is to establish a long-term cetacean monitoring programme studying abundance and distribution of cetaceans, habitat use of different species, effect of boat encounters on behaviour and the effect of group composition on cetacean behaviour during encounters.

2. Training

2.1. Briefing sessions

Briefing sessions and presenters are summarised in table 1.

2.1.1. Risk Assessments

Volunteers were explained the risks associated with the house, life on the Island and with the project. The immediate risk assessment was given within the first hour of arrival.

2.1.2. General Introduction

Volunteers were introduced to the Organisation by being explained Frontier's mission statement, objectives and projects. Main geographical and cultural aspects of Tenerife were also explained, and some species of flora and fauna found in the Island were highlighted. Life on camp including duties, schedules and optional activities were clarified.

2.1.3. Cetaceans in Tenerife

Local cetacean biology, ecology and diversity were described. Volunteers were trained in the identification of cetacean species in Tenerife, with specific focus on short-finned pilot whales and bottlenose dolphins.

2.1.4. Introduction to TRW project

Aims and objectives of the project, as well as the methodology for data collection and data entry were explained.

Table 1: Briefing sessions conducted during phase 172.

Briefing session	Presenter
Risk Assessments	TW/MB
General Introduction	TW/MB
Cetaceans in Tenerife	TW/MB
Introduction to TRW project	TW/MB

2.2. Field work training

Cetacean behaviour and a species identification quiz was conducted at the end of the project briefing. Initial data collection and data entry experience were supervised by a staff member.

3. Survey areas

The project was carried out in the south of the island of Tenerife (Canary Island, Spain). Tenerife camp is located in the village of Oroteanda (Guargacho), belonging to the province of Arona (28° 02' 41.1''N 16° 38' 11.9'' W) as shown in figure 1. Field work was carried out on board whale-watching boats leaving from the ports of Los Cristianos (province of Arona, 28.0489° N, 16.7116° W) and Puerto Colon (province of Costa Adeje, 28.0785° N, 16.7355° W) as shown in figure 2. Survey areas covered by boat journeys are shown in figure 3.

Figure 1: The village of Oroteanda and the location of the field house as indicated by the red arrow (Google maps, 2017).

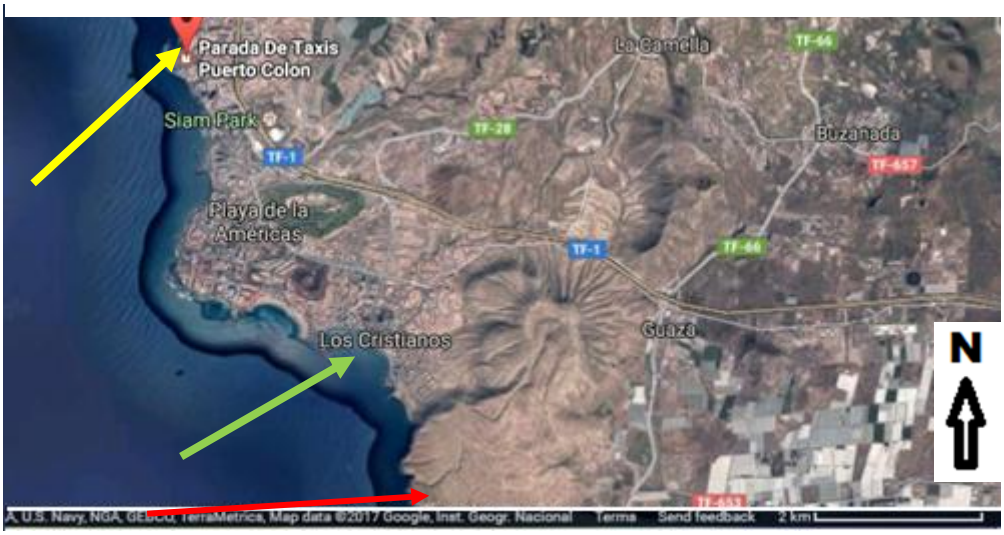

Figure 2: Ports of Los Cristianos (indicated by green arrow) and Puerto Colon (indicated by yellow arrow). (Google maps, 2017). Coastal survey site indicated by red arrow

Figure 3: Survey areas in the south of Tenerife covered by the whale-watching boats as indicated by yellow boxes (Google maps, 2016).

Coastal surveys were conducted on the cliffs of Los Cristianos (figure 2), belonging to the Mountain of Guaza. The GPS coordinates for the coastal site are 28.035709, -16.709022.

4. Project: "Proximity of cetacean sightings to fish farms and comparison of behaviour of bottlenose dolphins observed from both coastal and boat surveys"

4.1. Introduction

Bottlenose dolphins around Los Cristianos are often spotted around the fish farms nearby. It is thus believed that they use this location as a feeding area. It is from the cliffs above the fish farms where coastal surveys are conducted every week. A larger number of feeding events are expected to be recorded when surveying cetaceans from the cliff in comparison to those recorded from the boats, although other behaviours have also been recorded from coastal surveys.

To investigate whether the type of behaviour of bottlenose dolphins differs depending on the location and survey method, behavioural states were compared between survey methods (boats and coastal surveys).

The group sizes of coastal bottlenose dolphins generally range between 2 to 15 individuals (Grigg and Markowitz, 1997). However, the number of individuals recorded varies in each encounter. The number of individuals present in the sightings is here hypothesised to affect the types of behaviour performed. In addition, the number of

individuals recorded was compared between survey methods in order to study whether bottlenose dolphins tend to visit the fish farms in larger or smaller groups.

4.2. Materials and methods

4.2.1. Species

4.2.1.1 Resident

Common bottlenose dolphin (*Tursiops truncatus*) (figure 4)

The 'typical dolphin' light to dark grey colour, robust body with short thick beak. Length: 2-4m, males usually slightly larger than females. Weight: 135 – 635kg. Lifespan: males 40-45 years, females 50 years. Diet: fish, squid, invertebrates – generalists. Behaviour: commonly found in groups of 2-15. Reproduction: gestation ~12 months, nursing ~6-8 months.

Figure 4: A bottlenose dolphin (*Tursiops truncatus*) (Frontier volunteer)

Short finned pilot whale (*Globicephala macrorhynchus)* (figure 5)

Bulbous melon head with no discernible beak and black or dark brown colour with a large grey saddle behind the dorsal fin. Length: females ~3.7m, males ~5.5m (max 7.3m). Weight: 1000 – 3000kg. Lifespan: males ~45 years, females ~60 years. Diet: primarily squid, also octopus and fish, in moderate – deep water. Behaviour: often in groups of 25-50, males have multiple mates with groups 1 male to 8 females, matriarchal societies. Reproduction: gestation ~15 months, nursing ~2 years

Figure 5: Two adult pilot whales and a juvenile (*Globicephala macrorhynchus)* (Frontier volunteer)

4.2.1.2 Migratory

Atlantic spotted dolphin *(Stenella frontalis)* (figure 6)

Calves are unspotted, adults dark grey and heavily spotted. Length: 1.6-2.3m. Weight: 100-140kg. Lifespan: unknown. Diet: small fish, cephalopods. Behaviour: usually seen in groups <50, but sometimes in hundreds. Reproduction: may nurse for 1-5 years.

Figure 6: An adult Atlantic spotted dolphin *(Stenella frontalis)* (Frontier volunteer)

Common dolphin *(Delphinus delphis)* (figure 7)

‘Hourglass’ pattern on each flank with yellow forward and paler behind. Length: 2.7m. Weight: 200kg. Lifespan: about 35 years. Diet: schooling fish, cephalopods. Behaviour: often in large social groups of hundreds of individuals. Reproduction: gestation 10-11 months, nursing about 4 months.

Figure 7: An adult common dolphin *(Delphinus delphis)* (Frontier volunteer)

Striped dolphin (*Stenella coeruleoalba)* (figure 8)

The distinct and striking coloration pattern with a complex of bold thin stripes that extend from the eye to the flipper and another set of stripes down the side of the body to the anal region is the origin of their name. Weight: 150-160kg. Length: 2.4-2.7m. Lifespan: 50 years. Diet: Schooling fish, squid and octopus. Behaviour: usually found in tight, cohesive groups of about 25-100 individuals; often observed breaching.

Figure 8: A striped dolphin (*Stenella coeruleoalba)* (WDC, Whale and Dolphin Conservation, 2017)

Sei whale *(Balaenoptera borealis)* (figure 9)

One ridge of the top of the head. Long body with a small sickle shaped dorsal fin 2/3rds of the way along the back. Throat pleats under their jaw. Darker grey on top and paler underneath. Length: 14.5m. Weight: 45,000kg. Lifespan: 50-70 years. Diet: plankton, small schooling fish, and cephalopods. Behaviour: usually observed singly or in small groups of 2-5 animals.

Figure 9: A Sei whale *(Balaenoptera borealis)* (Frontier volunteer)

Bryde’s whale *(Balaenoptera edeni)* (figure 10)

Large, sleek, dark grey body with white underside. Three ridges on the top of the head. Weight: 40,000 kg. Length: 13-16.5 m. Lifespan: unknown, but sexually mature at 8-13 years. Diet: plankton, crustaceans, schooling fish. Behaviour: usually sighted individually or in pairs.

Figure 10: A Bryde’s whale *(Balaenoptera edeni)* (Frontier volunteer)

Fin whale (*Balaenoptera physalus*) (figure 11)

Large, streamlined body. Back and sides of the body are black or dark brownish-grey, and the underside is white. Asymmetrical colouring. Weight: 36,000-72,000kg. Length: 22-26 m. Lifespan: 80-90 years. Diet: krill, small schooling fish and squid. Behaviour: found in social groups of 2-7 whales; fast swimmers; little is known about their social and mating systems.

Figure 11: A Fin whale (*Balaenoptera physalus*) (Frontier volunteer)

Dense beaked whale *(Mesoplodon densirostris)* (figure 12)

Strongly arched lower jaw. Prominent forward tilting teeth in males. Long beak. Dark blotched body with paler underside. Small dorsal fin. Weight: 820-1,030 kg. Length: 4.5-6 m Lifespan: unknown, but they reach sexual maturity around 9 years. Diet: small fish and cephalopods. Behaviour: deep divers like other beaked whales, usually found in small social groups of about 5.

Figure 12: A female dense beaked whale *(Mesoplodon densirostris)* (Frontier volunteer)

Rough toothed dolphin *(Steno bredansis)* (figure 13)

Tall dark fin. Conical head. Dark narrow 'cape' with white or pale pink underside and white 'lips'. Weight: 100-150kg. Length: 2.4m. Lifespan: Unknown. Diet: Fish and squid. Behaviour: seen in groups of 10-20 individuals but occasionally seen in groups of several hundred.

Figure 13: A rough toothed dolphin *(Steno bredansis)* (Sailhawaii.com, 2017)

4.2.2. Survey protocol

4.2.2.1. *Boat surveys*

Data collection was carried out by pairs of voluntary research assistants whilst on board accredited whale-watching boats, including our main partner boat 'Peter Pan'. Boat trips went out twice a day from the Puerto Los Cristianos.

Each encounter was assigned a unique ID code, consisting of a prefix of the first three letters of the boat name followed by a three-digit encounter number in chronological order. To standardise data collection, all volunteers were trained in data collection requirements before their first boat journey and paired with more experienced volunteers or staff members. Data was collected in field notebooks as seen in table 2. To aid data collection in the field, notebooks were equipped with keys listing abbreviations of species names and definitions of behavioural states and events (Appendix I and II). The initial behavioural state was defined as the behaviour being exhibited at the start of the encounter, and could fall into one of five categories: travelling, socialising, feeding, resting and milling. The number of boats present during each interaction

was also recorded, not including the one holding the observers. Boats were identified as legal or illegal based on their display of the "Blue Boat" emblem on a yellow flag. Boats not displaying the flag were assumed to be unauthorised whale-watching companies. Boat Response could be separated into three possible outcomes: Avoidance, Interaction or No Response. This field was only filled out at the end of the interaction. There were nine possible behavioural events that could take place: "approach", "scout", "bow ride", "spy hop", "dive", "breach", "tail slap", "belly up" and "surf" (see Appendix I and II for definitions), with an additional option of writing an unlisted behaviour as "Other" with further details being described in the notes. To be able to study group composition, observers noted down the presence of adult males, adult females, juveniles and calves. The former two categories were mainly useful for pilot whales, where adult males have a distinctly concave fin and can therefore be differentiated from immature males and adult females. Juveniles and calves were distinguished by the presence of foetal folds on the calves' sides. Finally, the encounter method was the method of finding the cetaceans. If cetaceans were found as a result of the observer boat following other whale-watching boats, the method was defined as "Boats". Similarly, if the cetaceans were found through searching with the naked eye or binoculars, the method was "Search"; and finally, if the captain had used the radio to communicate with other boats about cetacean sightings the method was "Radio".

Table 2: Format of data collection forms in the field notebooks for each encounter.

Date	
Boat Name	
Research Assistants	
Event number	
Start time	
End time	
GPS co-ordinates	
Species	
Behavioural State	
Boats (Illegal, Legal, Jet skis)	
Boat Response	
Behavioural Events	
Number of individuals (Male, Adult, Juveniles, Calves, Total)	
Encounter Method (Search, Radio, Boats)	

Notes	

In addition to the variables listed, weather conditions including sea state, visibility and cloud cover were also recorded. To determine sea state, the Beaufort scale was used. Visibility was similarly on a scale from zero to five, with five being a clear view of the horizon and visibility decreasing down the scale. Cloud cover was measured as a percentage of the area immediately above the observer boat; consequently, percentages could only be from zero to ten percent.

To minimise confounding factors, only the records of encounters that met the following criteria were included in the study: (1) encounters with cetaceans identified to species level; (2) encounters with the initial behavioural state recorded; (3) encounters with at least one behavioural event recorded; (4) encounters with demographic information recorded and (5) encounters with the final boat response recorded. Additionally, anomalous data such as records where the encounter appears to have taken place at night or where the encounter time was recorded to last several hours were deleted.

4.2.2.2. Coastal surveys

Coastal survey is carried out from Los Cristianos on the cliffs of Montana de Guaza. The GPS location is 28.035709, -16.709022 with an elevation of 600m. A minimum of two people collect the coastal data. In ideal circumstances, two RAs conduct a cetacean scan, two RAs collect boat traffic data and a member of staff writes down the data (recorder) in the prepared tables shown in table 3. Before any scans are conducted, the recorder notes down the date, researchers, visibility, sea state and cloud cover.

The cetacean scan is conducted in 5 minute intervals. Using binoculars, two observers begin scanning the ocean for cetaceans. The scan begins where the waves break in front of the most southern point in Tenerife and should end where the waves break in Las Americas. The observers scan from left to right and should not go back once they have passed a point. When they have been scanning for 2.5 minutes, the staff member should inform the observers that they are half way through their scan. If a cetacean is sighted, the observer who spotted the cetacean should stop the scan and continue observing the cetaceans. The other observer should continue the scan until it is completed or they encounter a different group of cetaceans. Of the cetaceans sighted the observer should tell the recorder; the distance from the horizon, the bearing, the species, the number of individuals, the behavioural state and whether there are any boats present. After the scan, the observers have a 5 minute break and then begin the scan again.

The boat traffic data is collected over a period of 20 minutes. The observers record the distance, bearing, type and speed of the boat and whether there are any cetaceans near it. They record every boat seen in the coastal survey area in the 20 minutes period. The only exceptions are those which are less than 5mm from the horizon-for clarity of boat type, and those without an engine i.e. kayaks. Distance is measured using a ruler,

placing 0 on the horizon and measuring the distance from the horizon in mm. Bearing is taken using a compass.

Cetacean Survey - to be conducted once every 5 minutes							
Time	Distance (mm)	Bearing	Species	Total	Behavioural State	Boats Present (Y/N)	Boat Details

Boat types: Fish Farm (FF), Fishing (F), Whale-Watching (WW), Jet skis (J), Other (O), Unidentified (U)						
Boat Survey - to be conducted once every 30 minutes						
Time	Boat No.	Distance (mm)	Bearing	Type	Fast/Slow	Cetaceans near

Table 3 Coastal survey format of data collection forms

4.2.3. Compliance with Ethical Standards

All data collection was conducted on authorised tourist whale-watching boats flying the "blue boat" emblem (see figure 14). This emblem is only awarded to boat companies that have fulfilled all of the permit requirements and that are therefore legally obliged to follow the legal code of conduct for cetacean activities in the Canary Islands (Carlson, 2012).

Figure 14: Picture of the Blue Boat emblem carried by all authorised whale-watching companies in Tenerife.

4.2.4. Behavioural Observations

A total of 184 encounters with bottlenose dolphins were recorded from the 22nd of September 2016 to the 9th of June 2017. Only data collected on board of Peter Pan (87 encounters) and from coastal surveys (96 encounters) were analysed to be able to compare both methodologies, which were carried out in the same area of Los Cristianos. It is hypothesised that the feeding behaviour will be seen significantly more frequently from the coastal survey and travelling would be seen significantly more frequently from the boats. It is also hypothesised that the larger the group of cetaceans, the more likely they are to be socialising.

Counts of the behavioural state recorded from each encounter were visually compared between survey methods.

In order to study the influence of group size on the type of behavioural states, the number of individuals were classified into three groups: 1 to 4; 5 to 10 and more than 11 individuals.

Because a larger number of encounters corresponded to the first size group (118/183), and a smaller number corresponded to the third group (14/183), counts were standardized within each group by the number of encounters of the correspondent group. Behavioural states between groups were then visually compared.

4.2.5. Proximity of cetacean sightings to fish farms

Observation point at GPS position 28.035709, -16.709022 at elevation 600m above sea level.

Using the distance from the horizon and the bearing of each group, the cetaceans could be plotted onto a map of the coastal survey area. The distance in mm that was recorded was transferred to the map as the same distance from the black curve representing the

horizon. The degrees noted along the horizon curve on the map were used to mark the bearing. For any cetaceans seen by a fish farm well, the number of the well was recorded rather than the bearing and the distance. This was possible because the fish farms are stationary and do not change location. The species was also recorded. Any cetaceans that were not identified down to species level have not been included in the map. Any cetaceans seen not during the official cetacean scans by observers were not recorded on to the map.

As part of the coastal data collection described in section 4.2.2.2 during cetacean scans, the location of each group of cetaceans is recorded. The distance from the horizon and the bearing on the compass enable the location of the cetaceans to be recorded. It is hypothesised that pilot whales would be seen closer to the horizon and only bottlenose dolphins would be recorded as near a fish farm well. The aim of the study is to find out how different species of cetacean use the fish farms

4.2.6. Statistical analyses

All data was analysed using the statistical software R version 3.2.4 (R Core Team, 2016). Prior to statistical analyses, every variable was tested for heterogeneity of variances and normality by conducting Levene tests and Shapiro Wilk normality tests, respectively. The significance level was set at $p < 0.05$.

A One-way analysis of variance (ANOVA) was performed in order to analyse the differences in the mean number of individuals between behavioural states. Post-hoc comparisons in the analyses of variance were conducted using Tukey's Honestly Significant Difference test (Tukey HSD) in order to account for type I error from multiple testing.

The number of individuals recorded in each encounter was also compared between the two survey methods by a One-way ANOVA.

4.3. Results

4.3.1. Behavioural observations

The number of encounters in which feeding behaviour was recorded did not seem to differ between the boat or coastal surveys (figure 15). A higher number of milling behaviours were recorded from coastal surveys, whereas socialising and travelling behaviours were more commonly seen from the boat.

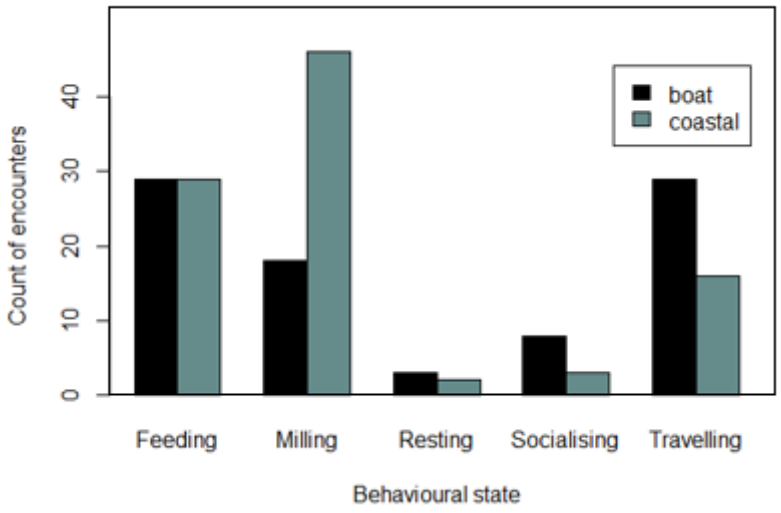

Figure 15: Count of behavioural events performed by bottlenose dolphins (Tursiops truncatus) during boat and coastal surveys.

Milling behaviour appeared to be shown more often by smaller groups, whereas socialising appeared to occur more often when more individuals were encountered (figure 16). No clear trends were found for the rest of behavioural states. Similar trends were found when analysing the differences in the number of individuals in the encounter between behavioural states (figure 17). Statistical differences were found between socialising and milling behaviours, which appeared to be performed by larger and smaller groups, respectively (ANOVA: $F_{4, 184} = 2.473$, $p < 0.05$; Tukey HSD $_{\text{socialising-milling}}$: $p < 0.05$)

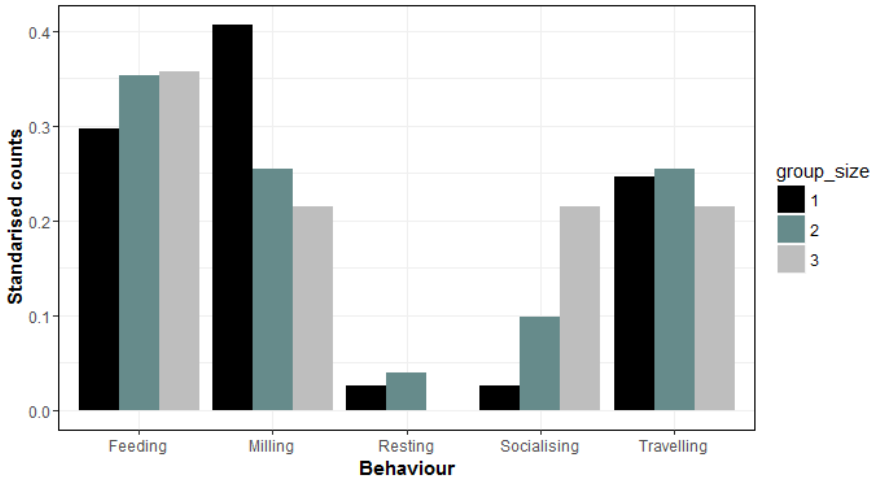

Figure 16: Count of behavioural events standarised by the number of encounters of each group category performed by Bottlenose dolphins (Tursiops truncatus). Group size categories correspond to groups with 1 to 4 individuals (group 1), 5 to 10 individuals (group 2) and more than 11 individuals (group 3).

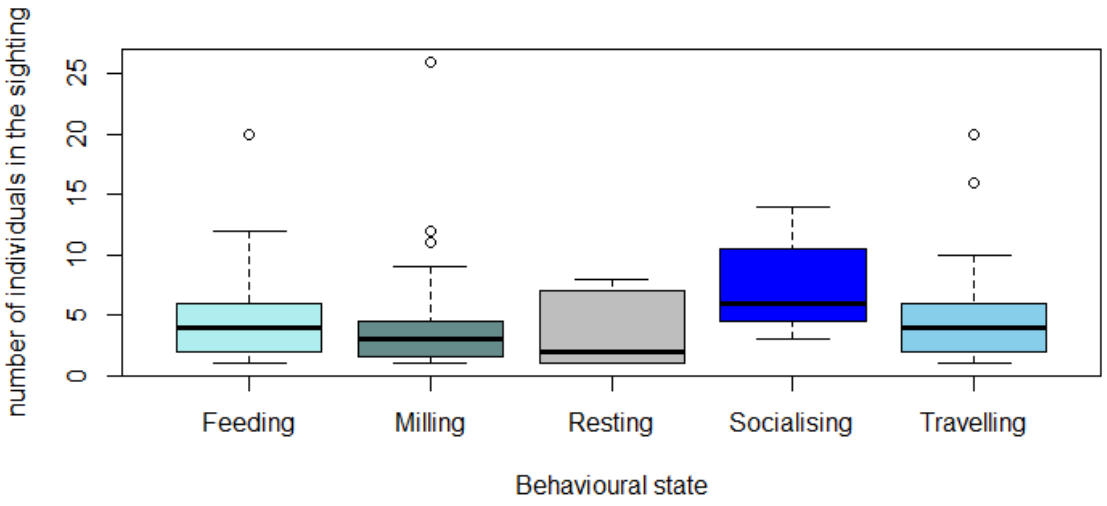

Figure 17 – Mean and variation of the number of Bottlenose dolphins (Tursiops truncatus) recorded during different behavioural events. Milling behaviour appeared to be shown more often by smaller groups in comparison to socialising, which appeared to occur more often when more individuals were encountered.

A larger number of individuals was recorded from the boat in comparison to that recorded from coastal surveys (figure 18) (ANOVA: $F_{1, 184} = 343.7$, $p < 0.001$).

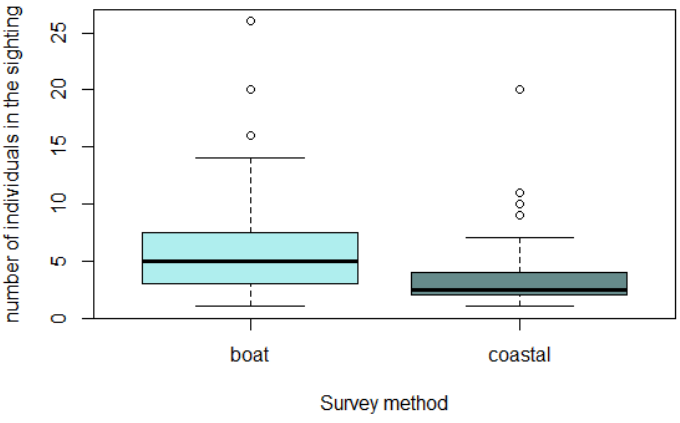

Figure 18: Mean and variation of the number of Bottlenose dolphins (Tursiops truncatus) recorded during both boat and coastal survey methods. Larger groups are more often encountered from boats in comparison to coastal encounters.

4.3.2. Proximity of cetacean sightings to fish farms

110 groups of cetacean were recorded in an eleven-month period from 10/07/2016 to 09/06/2017 (figure 18). Of these, 96 groups were Bottlenose dolphins. Around the fish farms there were only Bottlenose dolphins observed. 48% of all cetacean observations were within the fish farms. No Pilot whales were observed near the fish farm wells. All but one group of Pilot whales were recorded less than 25mm from the horizon. The only two non-resident species were recorded on the coastal survey were the Fin whale and the Spotted dolphin and both were only observed once. Of the cetaceans not seen in the fish farms, 68% were seen beyond the half way mark- bearing 241 degrees or more.

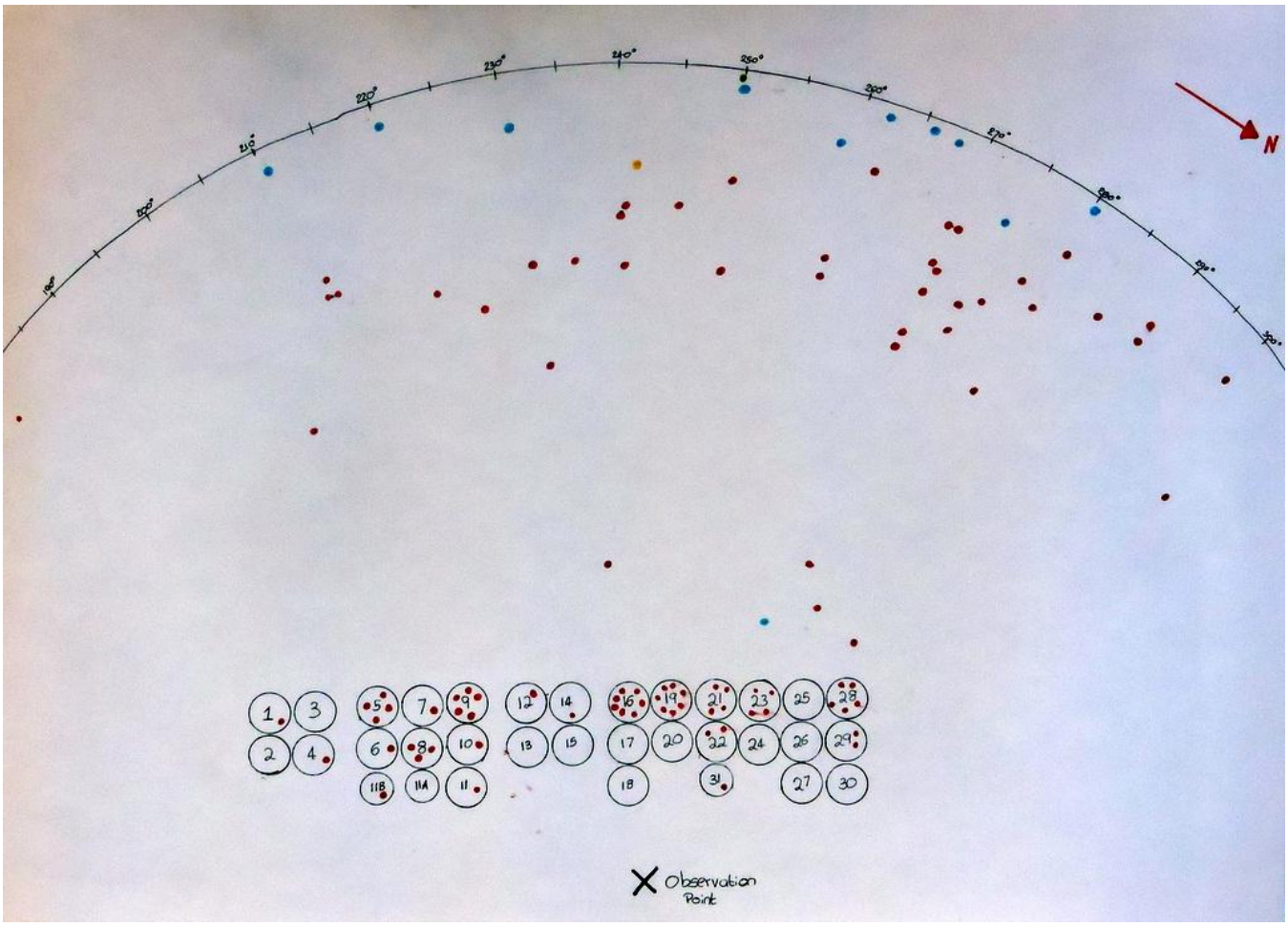

Figure 18: Surveyed area from coastal surveys. Red- Bottlenose dolphins, Blue- Pilot whales, Green- Spotted dolphins, Yellow-Fin whale. Dark curve symbolises the horizon. Angle from observation point measured in degrees. Numbered circles indicate fish farm well.

4.4. Discussion

4.4.1. Behavioural observations

During coastal surveys feeding behaviour is among the most frequent behaviours recorded. It is likely that feeding is the main purpose of the dolphins when they come to the fish farms as food availability is the one of the most important factors that determines Bottlenose dolphin movements (Shane et al., 1986). Dolphins recorded travelling or milling were most likely travelling to and from the feeding grounds or milling, waiting for feeding opportunities. In the fish farms, there is no need for the dolphins to use group fishing techniques, such as those observed offshore, and this could be the reason why less individuals are often recorded around them. Grigg and Markowitz (1997) also found that Bottlenose dolphin use different habitats for different functions. Bottlenose dolphins observed resting were most often in pairs. Very few dolphins were observed resting because they typically rest during darkness (Lyamin et al., 2007). If an ill dolphin needed to rest during the day or a calf needed a rest, another dolphin would stay with them to help look out for potential dangers and mothers do not leave calves unless in extreme circumstances (Mann and Smuts, 1997) so may be observed resting with the calf.

4.4.2. Proximity of cetaceans to fish farms

Bottlenose dolphins often being observed around stationary and local fishing gear is not unique to the south coast of Tenerife. Rocklin et al. (2009) found that Bottlenose dolphins in the Bonifacio Strait Natural Reserve (France) were a common occurrence. However, in France, the dolphins would attack the nets to get access to the fish. In Tenerife, the dolphins are not known to take the fish from within the fish farms but take any that escape and catch wild fish that have gathered around the fish farms. The wild fish are attracted to eat any artificial fish food that has fallen through the nets (Local fish farmers). This means that with the current situation dolphins have no need to enter the fish farm well or cause any damage to them. This likely means the resident dolphins in Tenerife will have long term access to this source of food as the fish farm owners do not lose any revenue due to the presence of the dolphins. However, in France the dolphins do attack the nets and have a significantly higher catch per unit effort when the nets are destroyed. If it was found that the bottlenose dolphins in Tenerife are highly dependent on the fish farms as a source of food heightened by the current rate of decline of wild fish stocks (Hernandez-Milian et, al., 2008), the Tenerife bottlenose dolphins may also begin to attack nets to increase their catch per unit effort in the short term. This may prove detrimental in the long term as the fish farm owners would lose revenue because of the dolphins and would no longer allow the dolphins access to the fish farm for feeding.

There are several possible reasons for Pilot whales not being observed around the fish farms. Pilot whales hunt at night and this coastal survey is only done during the day for health and safety reasons. Secondly, the preferred food of the resident Pilot whales is the giant squid (*Architeuthis dux*)**.** The waters around the fish farms are too shallow for the giant squid to inhabit as they need the water pressure of greater than 101Psi, only attainable at 1000m. All but one group of Pilot whales were seen less than 25mm from the horizon.

The Fin whale and Spotted dolphins are migratory species. As Fin whales are baleen whales that consume large numbers of small fish or krill in one engulfment, and can grow up to 25.9m (Goldbogen et, al., 2017) they would struggle to manoeuvre between the fish farm wells and the catch per unit effort would be much lower than the open ocean. It is likely that the individual observed was migrating either to or from feeding grounds and had no need to feed off the waters of Tenerife.

As no other species of Odontocete has been observed around the fish farms, future studies could consider whether being a residential species allows an advantage in knowing the feeding areas where there will be the best catch per unit effort.

4.5. Conclusion

This is the first study to be conducted solely on the behaviour and distribution of the Tenerife cetacean population around the fish farms. As such, no comparisons can be made to previous studies, only to studies conducted elsewhere in the world in similar conditions. The hypothesis that only Bottlenose dolphins would be found in the fish farm has been supported by this study. This study has shown that Bottlenose dolphins are more commonly seen feeding in fish farms than any other cetacean species. It has also shown that milling is the only behaviour that is more commonly seen at the coastal site than out on the boats. The hypothesis that the feeding behaviour will be seen significantly more frequently from the coastal survey was not supported by this study. The hypothesis that travelling would be seen significantly more frequently from the boats than the coastal survey site was supported by this study as was the hypothesis that the larger the group of cetaceans, the more likely they are to be socialising. Feeding was observed at the same frequency from the boats and coastal site which may counter the suggestion that Bottlenose dolphins may be becoming dependant on feeding at the fish farms. In the future, a study could be conducted into the catch per unit effort for off shore and coastal feeding and success rate of feeding at the two different sites to see if dolphins are using fish farms to compensate for declining wild fish stocks.

5. Additional projects

The photo ID catalogue is continually updated so family units may be identified in the future and a population size can be estimated for the resident Bottlenose dolphins and the resident Pilot whales. As of 10/06/2017 there were 326 individual Pilot whales identified and 103 individual Bottlenose dolphins.

6. Proposed work programme for next phase

- Continuation of photo ID programme
- Continuation of data collection of location, group composition, population size, behavioural changes, interactions with boats, behavioural state, behavioural events and how the boats locate the cetaceans.
- Continue coastal surveys of cetacean and boat activity
- Flyering at Tenerife South airport asking tourists to only use boat companies that are part of the blue boat scheme

7. References

Cagienard, A., Regula, G. & Danuser, J., 2005. The impact of different housing systems on health and welfare of grower and finisher pigs in Switzerland. *Preventive Veterinary Medicine*, 68(1), pp.49–61.

Dawkins, M.S., 2004. Using behaviour to assess animal welfare. *Animal Welfare*, 13(SUPPL.), pp.3–7.

Elejabeitia, C. & Servidio, A. 2004. Estudio de Seguimiento de las Actividades de Observación de Cetáceos en Tenerife. *Dirección General del Medio Natural de la Consejeria de Medio Ambiente y Ordenación Territorial del Gobierno de Canarias*

Elejabeitia, C. & Urquiola, E., 2010. Whale watching in the Canary islands. Independent researcher & consultant - Santa Cruz de Tenerife.

Goldbogen, J., Cade, D., Calambokidis, J., Friedlaender, A., Potvin, J., Segre, P. and Werth, A. (2017). How Baleen Whales Feed: The Biomechanics of Engulfment and Filtration. Annual Review of Marine Science, 9(1), pp.367-386.

Grigg, E. & Markowitz, H. 1997. Habitat use by bottlenose dolphins (Tursiops truncatus) at Turneffe Atoll, Belize. *Aquatic Mammals*, 23.3, pp. 163-170.

Hernandez-Milian. G, Goetz. S, Varela-Dopico. C, Rodriguez-Gutierrez. J, Romon-Olea. J, Fuertes-Gamundi. JR, Ulloa-Alonso. E, Tregenza. NJC, Smerdon. A, Otero. MG, Tato. V, Wang. JJ, Santos. MB, Lopez. A, Lago. R, Portela. JM, Pierce. GJ, (2008), "Results of a short study of interactions of cetaceans and longline fisheries in Atlantic waters: environmental correlates of catches and depredation events", HYDROBIOLOGIA, 612, 251-268.

Hoyt, E., 2001. Whale watching 2001 worldwide tourism numbers, expenditures and expanding socioeconomic benefits. *International Fund for Animal Welfare*

Lyamin, O., Pryaslova, J., Kosenko, P. and Siegel, J. (2007). Behavioral aspects of sleep in bottlenose dolphin mothers and their calves. Physiology & Behavior, [online] 92(4), pp.725-733. Available at: http://www.sciencedirect.com/science/article/pii/S0031938407002429 [Accessed 10 Jun. 2017].

Mann, J. and Smuts, B. (1998). Natal attraction: allomaternal care and mother–infant separations in wild bottlenose dolphins. Animal Behaviour, [online] 55(5), pp.1097-1113. Available at: http://www.sciencedirect.com/science/article/pii/S0003347297906370

[Accessed 10 Jun. 2017].

Moll, R.J., et al., 2009. Physiological stress response of captive white-tailed deer to video collars. *Journal of Wildlife Management*, *73*(4), pp.609-614.

Parker, M.O., Millington, M.E., Combe, F.J. and Brennan, C.H., 2012. Housing conditions differentially affect physiological and behavioural stress responses of zebrafish, as well as the response to anxiolytics. *PloS one*, *7*(4), p.e34992.

Rocklin. D, et al. (2009), "Changes in the catch composition of artisanal fisheries attributable to dolphin depredation in a Mediterranean marine reserve", ICES JOURNAL OF MARINE SCIENCE, 66, 699-707.

Sailhawaii.com. (2017). Rough-toothed dolphins in Hawaii, pictures facts. [online] Available at: http://sailhawaii.com/steno.html [Accessed 19 Apr. 2017].

Shane, S., Wells, R. and Wursig, B. (1986). ECOLOGY, BEHAVIOR AND SOCIAL ORGANIZATION OF THE BOTTLENOSE DOLPHIN: A REVIEW. Marine Mammal Science, 2(1), pp.34-63.

Whales and Dolphins of Tenerife. (2017). *Atlantic Spotted Dolphin*. [online] Available at: http://whalesanddolphinsoftenerife.org/whales/atlanticspotted.html [Accessed 24 Mar. 2017].

WDC, Whale and Dolphin Conservation. (2017). *Striped dolphin*. [online] Available at: http://us.whales.org/species-guide/striped-dolphin [Accessed 19 Apr. 2017].

8. Appendices

Appendix I

Behavioural state

- TRAVELLING – sustained movement in one direction
- SOCIALISING – splashing, breaching, close together
- FEEDING - sea bird activity, repeated surface acceleration
- RESTING – slow movement or stationary as a tight group, usually all facing the same direction
- MILLING – surface in constantly varying directions in relation to each other but group remains in one area

Appendix II

Behavioural events

- APPROACH – moving and remaining closer to the boat
- SCOUT – brief approach close to the boat then moving away
- BOW RIDE – swimming in waves at front or back of boat
- SPY HOP – animal vertical and raising head out of water
- DIVE – definite change of body position to dive deeper
- BREACH – any leap/jump bringing most of the body out

- TAIL SLAP – lifting tail and slapping on the water surface
- BELLY UP – rolling to expose underside
- SURF – swimming quickly in the waves