Diurnal Behaviour of

Bottlenose Dolphins (*Tursiops truncatus*)

in Cardigan Bay, Wales

A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science (MSc) in Marine Environmental Protection

Diurnal Behaviour of Bottlenose Dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales

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Submitted in September, 2021.

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For submission to Marine Mammal Science

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ABSTRACT

Behavioural understanding of species is vital in individually recognisable species, such as bottlenose dolphins. It was hypothesised that there will be a greater number of behaviours exhibited by bottlenose dolphins in winter than in summer, and also that groups in southern Cardigan Bay will display a greater number of behaviours than those in northern Cardigan Bay. Data was sorted and analysed using Microsoft Excel and R. Analysis of hypothesis 1 found that, rather than dolphins displaying more behaviours in winter than in summer, there was actually a larger variety of behaviours displayed in summer compared to in winter. An ANOVA analysis of hypothesis 2 produced a p-value of 0.064, meaning the null hypothesis that there is no difference in the number of behaviours exhibited between groups of dolphins northern and southern Cardigan Bay. These variations of behaviour are unique to Cardigan Bay. Due to bottlenose dolphin's complex social structures, environmental and anthropogenic factors influence populations in different ways for each habitat.

KEYWORDS

bottlenose dolphin, behaviour, tursiops truncatus, cardigan bay, wales

1 INTRODUCTION

The common bottlenose dolphins (*Tursiops truncatus*) population biology and social ecology has been studied in many locations globally (Connor *et al.*, 2000). They can be found anywhere from deep and coastal waters and temperate and tropical climates (Reynolds *et al.*, 2000). Both males and females of the species can live up to 40-50 years, reaching maturity between 5-13 years old in females and 8-13 in males. They will also only give birth to single calves after a gestation period of 12 months (Connor *et al.*, 2000). Due to their 'slow' life histories, long life spans and intervals between births, they are 'K' selected (Votier, 2010; Goodall, 1986).

Bottlenose dolphins are an individually recognisable species, therefore understanding their behaviour is key to scientific understanding of their species. Quantitative and systematic study of bottlenose dolphins is achieved through detailed quantification, descriptions and definitions of behaviours (Martin & Bateson, 1986).

Bearzi *et al.* (1999) produced a table of behavioural definitions for Bottlenose Dolphins in the Adriatic Sea. The behaviours of bottlenose dolphins in different European areas have also been studied, though not as extensively as they were by Bearzi *et al.* (1999).

Bottlenose dolphins are social animals, Alexander (1974) states that social animals will interact with one another in order to maintain harmony and cohesion among group members, this facilitates the survival of participants. Social relationships facilitate information and disease transmission, which is vital for the success of a population. This transmission of information aids the population in adapting to their environment (Krause *et al.*, 2009).

The study of society is a vital part of getting insight into the ecology of a species, along with their behaviour. A society is made up of three parts that are interrelated; social organisation, mating system, and social structure. The social organisation is what characterises the society's demographics, this is done by finding the sex ratio, age composition, spatiotemporal cohesion, and size of the society. The social structure is the social interaction and relationship patterns among members of the society regardless of the size of the group, their age and their sex. Finally, the mating system is described by the genetic and behavioural aspects of reproductive interactions within the society (Kappeler and van Schaik, 2002).

While usually found in groups of around 2-15 individuals, groups of hundreds have also been found in offshore waters (Wells & Scott, 1994). Populations living in coastal waters are often known to form smaller groups (Augusto *et al.*, 2012).

In species like bottlenose dolphins, their behaviours are influenced by decisions that affect their fitness (McGraw and Caswell, 1996). Influences such as intra-specific competition and prey availability (Lusseau *et al.,* 2004; Connor *et al.*, 2001) lead to complex social structures and behaviours within groups (Lusseau, 2004). Complex social behaviours are behaviours that arise from 'selective forces in other bottlenose dolphin populations' (Connor *et al*., 1999). While similarities may arise between populations, association patterns vary between populations and locations (Moreno and Acevedo-Gutierrez, 2016). With their social behaviour being complex, it is comparable in relative brain size to the great apes (Marino, 1998).

Bottlenose dolphins have well defined home ranges while also engaging in long-distance movement (Shane *et al*., 1986; Wells *et al*., 1999). Whether the dolphins use the home range throughout the year or shift between areas over seasons depends on the individual (Shane *et al.*, 1986). Bottlenose dolphins have been found in many coasts of the UK, these include; Devon, the Hebrides, Cornwall, including a resident population in the Shannon Estuary in Ireland (Norman *et al.*, 2015).

Cardigan Bay is home to one of the two semi-resident bottlenose dolphin populations in the UK's territorial waters. Bristow and Rees (2001) confirmed that the bottlenose dolphins were sighted year-round in the waters off the coast of New Quay in Cardigan Bay. Using photo ID, they found that already recognised individuals were sighted seasonally and throughout the year, with some also being seen irregularly. The second population resides in the Moray Firth, Scotland. (Wilson *et al.*, 1997). The semi-resident population in Cardigan Bay is also the largest of the two. In Cardigan Bay there are currently two established Special Areas of Conservation (SACs). These SACs were established to conserve the bottlenose dolphin populations that reside in those areas using spatial protective measures which are required within the Annex II of the EU Habitats and Species Directive. Bottlenose dolphins are also listed for strict protection measures under Annex IV. Spatial management, which includes the implementation of protected areas, has been proven to be an effective tool for the protection of marine environments (Edgar *et al.*, 2014)

Of all the species found in Welsh waters, bottlenose dolphins are the second most recorded species, being found predominantly in coastal waters (Baines & Evans, 2012). While there is a semi-resident population there, they also use Cardigan Bay as a breeding ground during the summer, making Cardigan Bay a significantly important area for the species. This is confirmed by Bristow and Rees (2001), who found that, with the large number of sightings of adults and calves, along with site fidelity, there was a strong indication that the shallow waters of Cardigan Bay were being used as a nursery area. The exact breeding season for bottlenose dolphins is unknown, as they have an extended breeding season with calves being sighted throughout the year. However, there is usually a peak in calf births in July and August, which consist of 76% of births year-round. (Baines & Evans, 2012). Between 2001 and 2014, a robust open population model ranged the population of bottlenose dolphins that use the SAC in Cardigan Bay from 77 (2002) to 168 (2012), with a recent estimate showing a high probability of dolphins remaining outside of the SAC and high emigration rates (Norman *et al.*, 2015).

Using previously observed variations in observations and behaviour, assumptions can be made for the data used in this study in order to find any correlations. For example, seasonal differences have been observed in the populations of bottlenose dolphins in Cardigan Bay, such as in the summer the dolphins are generally spotted in smaller groups compared to in winter where they form larger groups moving northwards.

1.1 HYPOTHESES

There are two hypotheses being looked into in this paper;

1. There will be a greater number/variation of behaviours exhibited by bottlenose dolphins in winter than in summer.

2. Groups of bottlenose dolphins in southern Cardigan Bay will display a larger number of surface behaviours than groups in northern Cardigan Bay.

2 MATERIALS AND METHODS

2.1 STUDY AREA

Cardigan Bay is a shallow bay in West Wales, with a total area of 4986.86km^2, its most western point measures around 100 km across. Its deepest point reaches 60m deep (Evans, 1995). The Bay extends from St David's Head (51˚ 54' 10'' N, 005˚ 18' 54'' W) to the Llŷn Peninsula (52˚ 47' 45'' N, 004˚ 46' 00'' W) (Norman *et al.*, 2015). A map of Cardigan Bay, including the locations of both SACs in the area can be seen in Figure 1.

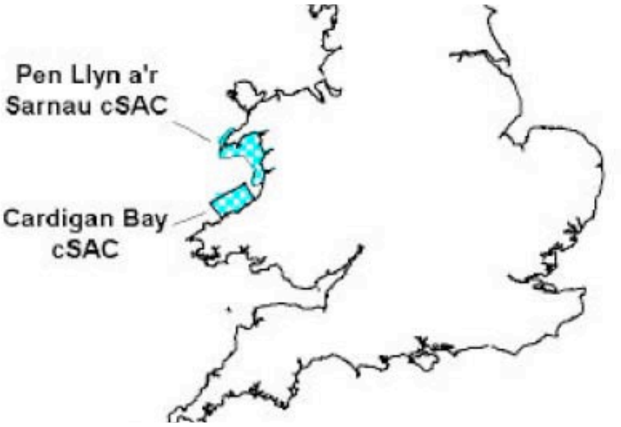

FIGURE 1. The locations of the Cardigan Bay Special Area of Conservation (SAC) and Pen Llyn a'r Sarnau SAC shown on a partial map of the UK (Ceredigion County Council, 2011).

2.2 SURVEYS

The Sea Watch Foundation (SWF) gather data from both dedicated and non-dedicated surveys, with a majority of the data coming from non-dedicated surveys. The non-dedicated surveys took place on tourist boat trips which occur multiple times every day. These tourist boats follow relatively the same course for every trip, with accommodations being made for weather and the locations of any animals encountered. Observations were taken from a variety of different boats.

From 2000 – 2019, 30010 bottlenose dolphin sightings were compiled from these surveys. Observations were often taken by trained volunteers or interns.

Dedicated surveys followed line-transects. During non-dedicated opportunistic surveys, observers were placed on vantage points on the boats. These vantage points were generally on the roof of the boat. In order to maintain safety, each observer was required to wear a life vest while on the boat.

Surveys were separated into 15-minute time slots. Every 15 minutes, the effort was recorded. The effort includes; latitude, longitude, sea state, boat speed (knots), time, direction of heading, visibility (km), swell height, boat activity, and precipitation. GPS devices were used to track latitude, longitude, boat speed and heading direction.

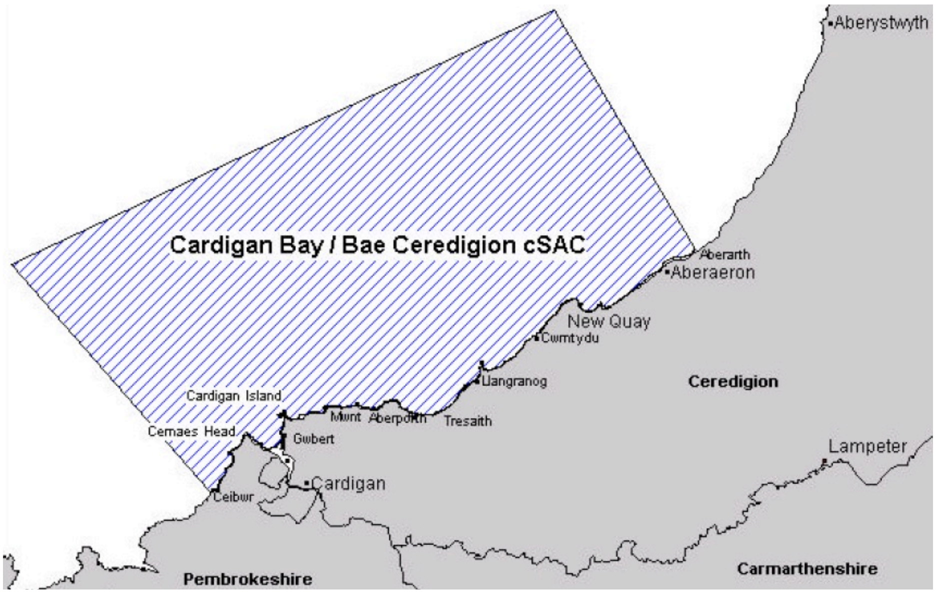

FIGURE 2. A map showing the Cardigan Bay Special Area of Conservation (Ceredigion City Council, 2001)

2.3 DATA ANALYSIS

Data from 2000-2019 was compiled into one Excel document. This included effort and sightings data for every type of survey carried out by the SWF over this time. Excel version 2019 was used. To start, the bottlenose dolphin sightings, 'BND' in the sheet, were separated from the rest of the data as that is the only species being used. For testing both hypotheses, the data needed to be separated from the already extracted BND data into two sheets. Any sightings that did not include identifiable behaviours were also removed from the data.

For the first hypothesis, the month, average group size and primary behaviour were extracted. Average group size was used instead of maximum and minimum group size seen in the sightings because it provides a singular number which is better to analyse while still remaining accurate to the sightings. For the second hypothesis, the latitude and longitude (decimal degrees) and primary behaviours were extracted. The rest of the data was excluded from this analysis because it was not relevant to the hypotheses stated, therefore would only be problematic when analysing the data in R. These were then converted into a '.csv' file and extracted into R. The R version used was 'R x64 3.6.3'.

Once loaded into R, the following R packages were installed; 'tidyverse', 'readr', and 'reshape'. Using these, the data was sorted and analysed, then made into graphs for visual representation. Graphs were edited using Excel to adjust their design. ANOVA was used to find if there is significant difference in the data.

Cardigan Bay is split into two; southern Cardigan Bay and northern Cardigan Bay. These areas were divided by latitudinal decimal degrees. Sightings within <52.5 decimal degrees were seen as in southern Cardigan Bay and sightings within 52.5-53.0 decimal degrees were in northern Cardigan Bay, with any higher than 53.0 decimal degrees being in North Wales/northern Irish Sea. These decimal degrees are the latitudes stated. With the already sorted data, it was further separated into southern Cardigan Bay sightings and northern Cardigan Bay sightings.

3 RESULTS

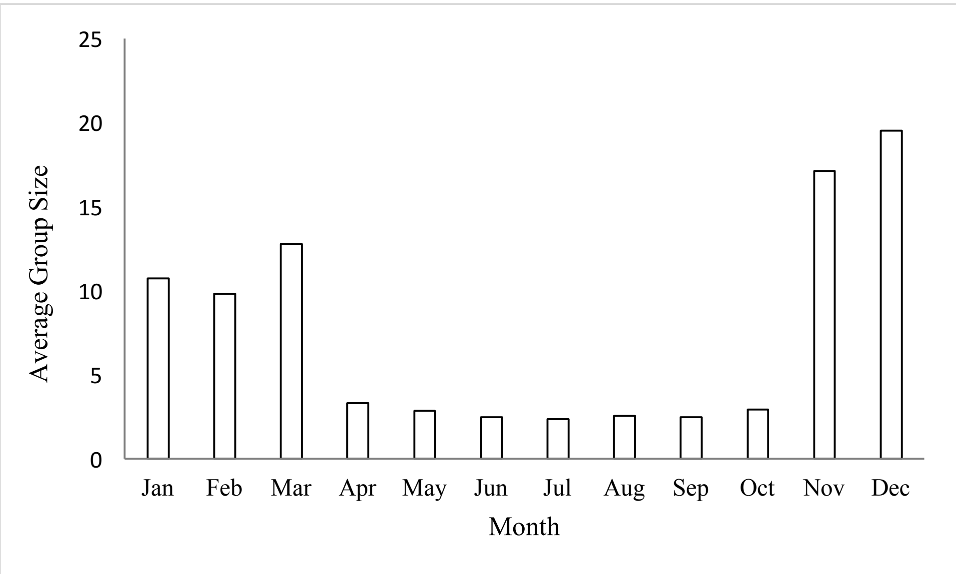

Figure 3. A graph showing the average group size of dolphins over each month of the year in Cardigan Bay, Wales, from 2001- 2019.

For the purpose of this paper, only the primary behaviours observed have been used for the data analysis. Figure 3 shows a graph of the average group size of bottlenose dolphins observed over each month of the year. From the months of April – October, the average group size is less than 5 for each month, a large difference compared to the rest of the months. From November – March the average group size stays above 10, with a maximum of 20.

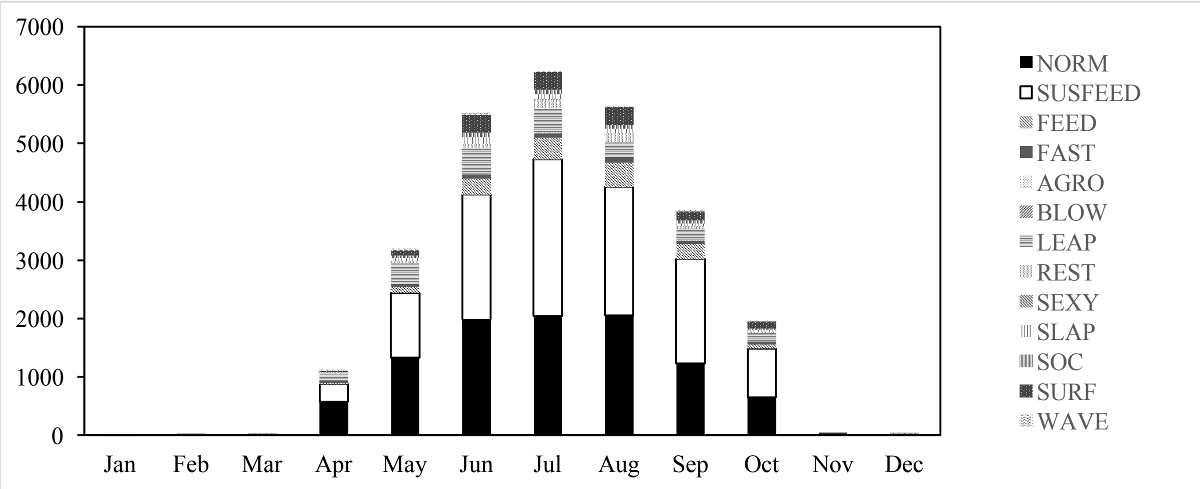

FIGURE 4. A graph showing the number of times each behaviour was observed over every month of the year. Different behaviours are indicated by separate patterns.

Figure 4 shows the count of observations for every behaviour listed in the Sea Watch Foundations data. The large difference in the number of behaviours observed is due to the number of observations being larger in April – October. Visually, it appears that 'SUSFEED' was the most observed behaviour, with 'NORM' being the second.

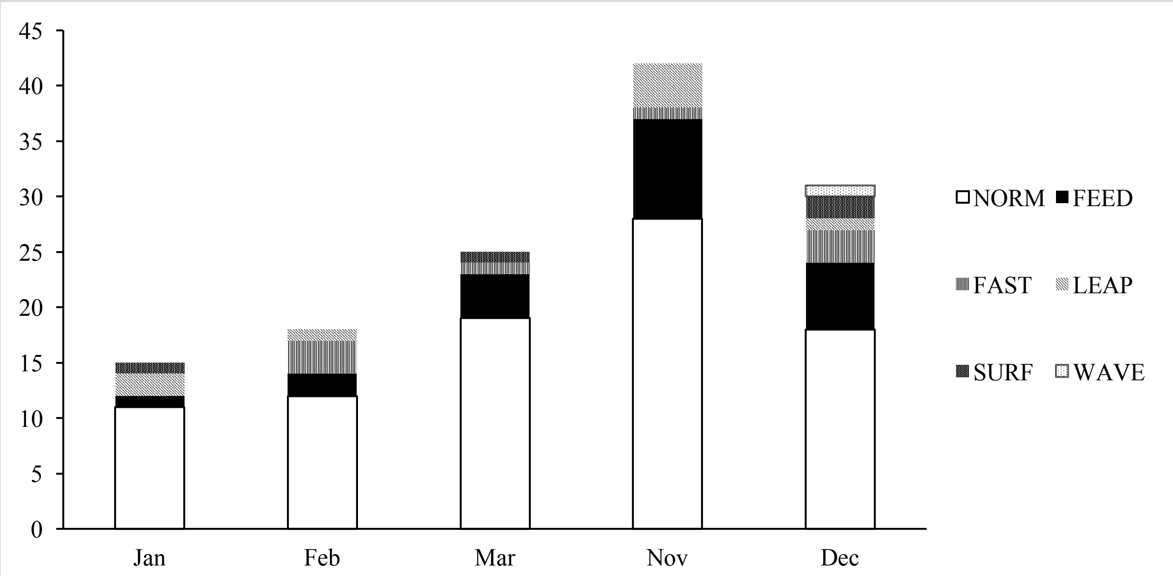

FIGURE 5. A graph showing the count of each time a behaviour was observed over the months January – March and November – December.

Figure 5 was made to show a closer look at the months that were difficult to interpret in figure 4. The number of observations in these months were significantly lower than the numbers for the rest of the year. The behaviour ‘NORM’ was observed most frequently, with ‘FEED’ being the second most observed behaviour generally.

Below is a table showing the codes used in the data for each behaviour and the corresponding behaviour it indicates.

Table 1. A table showing the code, behaviours and descriptions for each behaviour and how the subsequent behaviours are identified.

Code	**Behaviour**	**Description**
NORM	Normal Swim	Directed movement at a speed of under 10km/h
SUSFEED	Suspected Feeding	Indication of feeding with no confirmation
FEED	Feeding	Dolphin is seen catching fish or with a fish in their mouth
FAST	Fast Swim	Directed movement at a speed of over 10km/h
AGRO	Aggressive	Aggressive behaviour; such as attacking other dolphins
BLOW	Blow	Audible exhale out of the blowhole
LEAP	Leaping	Body exiting the water entirely with an arcuate path, reentering the water smoothly
REST	Resting	Slow activity, no other identifiable activities
SEXY	Sexual Behaviour	Sexual interactions between dolphins

SLAP	Tail Slap	Audible impact of flukes on the surface of the water
SOC	Social Behaviour	Active interactions with other dolphins; including chasing, contact, sexual interactions
SURF	Surface	Movement at the surface that causes a flurry of white water at either side of the dolphin.

Definitions for behaviour are adapted from Baker's (2016) ethogram of bottlenose dolphin behaviours.

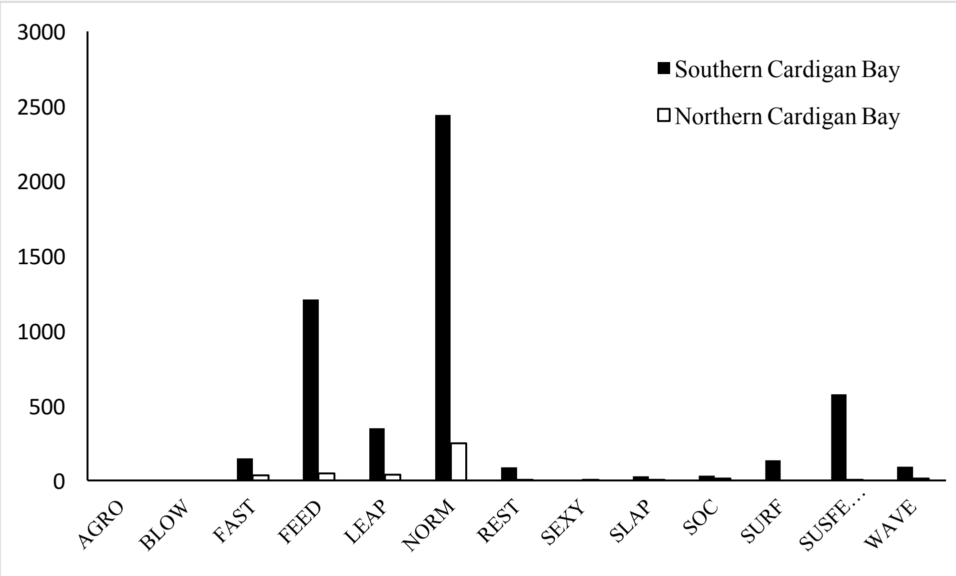

Figure 6. A graph showing the count of each behaviour observed in bottlenose dolphins in southern Cardigan Bay and northern Cardigan Bay. Southern Cardigan Bay is represented by a solid black bar and northern Cardigan Bay is represented by a white bar with a black outline.

Figure 6 shows the distribution of behaviours observed in southern and northern Cardigan Bay. In order to run a statistical analysis of the data, it had to be converted into numerical form. For this, the When running an ANOVA test, a p-value of 0.064, meaning the results are not statistically significant.

4 DISCUSSION

As can be seen in figure 3, the average group size of bottlenose dolphins is drastically smaller from April-October than November-March. April – October are the months where the majority of the observational data occur, which could be due to many reasons. Potentially, this could be due to there simply being more surveys in these months, therefore more data is being gathered. This seems the most likely contributing factor to the sheer difference in numbers during these months compared to the winter months in November - March. There is a stark difference in group size during the summer and winter months. The summer months referring to April – October and the winter months referring to November – March, though these are not exclusively summer and winter months, for ease of understanding they will be referred to as these.

A majority of the behaviours observed were defined as 'NORM'. Observations were done from a vantage point on the boats used, meaning observers were only able to see behaviours the dolphins exhibited on the surface, as it would be difficult, or even impossible, to see what the dolphins are doing below the surface. Bottlenose dolphins will often surface for to breathe, so regular movement being spotted the most often is plausible.

There were two types of feeding behaviour recorded in the results; 'SUSFEED' and 'FEED', standing for 'suspected feeding' and 'feeding' respectively. Suspected feeding was used when the dolphins' exhibited behaviours associated with feeding, such as deep diving, but were not seen with food whereas dolphins seen with food were recorded as feeding. Deep diving was indicated by the dolphin diving with the fluke being visible during the dive.

Bottlenose dolphins are one of many mammal species that are known to hunt in groups (Kitchen & Packer, 1999). Therefore, we would presume that dolphins observed in larger groups will display more feeding behaviours. This, however, is not shown in the results. During the months of April - October, when the group sizes were, on average, at their lowest there was a much larger proportion of feeding behaviours occurring compared to the rest of the months of the year. While this may be due to the lack of observations available for the rest of the year, from what has been observed there is still proportionately less observations of feeding behaviour in these groups in comparison. Suspected feeding is, on average, the most or the second-most observed behaviour during April-October. While suspected feeding is more common, definite feeding observations appear more often during the rest of the year, which would include the larger groups of dolphins.

Foraging behaviours are known to be unique to research sites, populations, and even individuals (Sargeant *et al.*, 2005). Therefore, any studies into populations outside of Cardigan Bay may be inapplicable to the population there, though similarities may be found between populations in comparison. For example, Sargeant *et al* (2005) found that dolphins in Shark Bay, Western Australia, were exhibiting a unique behaviour 'beach hunting'. Beach hunting is defined as 'frequent fast swims in shallow water (less than 3m from shore), creating a trail of water off the dorsal fin, as dolphins chase individual fish, parallel to and then onto the beach surface'. Other examples of unique population behaviours are; fish schools being stranded on mud banks in Florida populations (Lewis and Schroeder, 2003), crater feeding in Bahamas populations (Rossbach and Herzing, 1997) and Brazil dolphin populations cooperating with fishermen (Pryor and Lindbergh, 1990). This is a demonstration of how some behaviours can differ and are unique between populations of bottlenose dolphins.

Deliberate associations are a necessary part of a society's social structure (Whitehead *et al.,* 2005). Gero *et al.* (2005) found that some dolphins demonstrate preferred associations within behavioural states, meaning they mainly associate with certain individuals while socialising and foraging. These dolphins were divided into three categories; affiliates, acquaintances and behavioural associates. Behavioural associates form preferred associations in at least one behavioural state, affiliates demonstrated preferred associations across all behavioural states on a consistent basis, and acquaintances associated in a behavioural state but did not show preferred associations. This study found that a large number of individuals demonstrated preferred associations. These associations are beneficial for foraging, socialising and even protection against predators. Smaller groups of dolphins may be displaying more behaviours as they are only associating with other individuals that they have preferred associations with, which may explain why there were a larger number of surface behaviours observed in summer.

Association variations between locations and populations has already been documented. For example, in the Moray Firth, Scotland, the populations of dolphins tend to demonstrate short-term associations a majority of the time with no obvious strong alliances (Lusseau *et al.*, 2006). Whereas, in Shark Bay, Australia, there tends to be strong alliances between 2-3 males

(Connor and Whitehead, 2005). The Moray Firth and Shark Bay populations are relatively opposite examples of associations. Another example is the dolphins residing in Doubtful Sound, New Zealand, which have a large number of long-lasting, inter- and intrasexual associations that are thought to be caused by the variable productivity and isolation of the area (Lusseau *et al*., 2003).

Social structure variations between bottlenose dolphins have many drivers, these include prey availability, rates for resource encounters, resource predictability, any costs or benefits for forming associations, habitat features and immigration and emigration rates (Lusseau *et al.,* 2003; Karczmarski, 2005; Wiszniewski *et al*., 2009; Gowan *et al*., 2008). Despite knowledge of these drivers, examination of the interactions between them has proven to be difficult (Moller, 2006).

Cardigan Bay also has a lot of boating activity, with many tourist boats making multiple trips daily and fishing boats that also use the bay. While it is not the only area with high boat activity, it is important to acknowledge that this will likely affect the behaviours displayed by bottlenose dolphins in the area. Behaviours could be in reaction to the boats or adapted over time because of the frequent presence of them. In order to minimise disturbance from boats in the area, the Cardigan Bay SAC has specific rules for dolphin encounters that all boats must follow. Dolphins may not be approached by boats and speed must be decreased when dolphins are in the area. There is also a time limit for boats to stop and observe dolphins before they must move on. Even with the rules being followed, the dolphins will still be affected by boat activity, though the restrictions in place aim to minimise the disturbance. The bottlenose dolphins are also a semi-resident population there, so any dolphins living there are likely used to the boats and do not see them as a threat. It is also a breeding area, so calves are raised around this level of activity. However, it is still important to acknowledge this potential outside influence on the behaviour of the bottlenose dolphin population in Cardigan Bay.

Dolphin's responses to anthropogenic disturbance are difficult to assess, with impact assessments in general focussing on if animals are displaced from areas exposed to anthropogenic disturbance (Nowacek *et al*., 2007). Boat activity can affect dolphins in a multitude of ways. For example, acoustic communication and foraging may be made more difficult due to noise from engines (Van Parijs and Corkeron, 2001). This is due to the anthropogenic noise affecting the detection of signals used in echolocation (Pirotta *et al*., 2014). These changes may also not be limited to the dolphin's behaviour, it could be in response to changes in fish behaviour (Engas *et al*., 1995).

Pirotta *et al.* (2014) found that while noise level exclusively didn't affect foraging activity, the presence of boats in the area was also insufficient enough to affect a change in activity. Noise is what enables animals to perceive an approaching risk, which may be what contributes to the threatening effect of approaching boats (Frid and Dill, 2002). It was concluded that the interaction between the noise and presence of a boat and its behaviour around the dolphins is what affects the risk perception in the animals which determines the behavioural response (Ellison *et al.*, 2012). Boats operating in the Cardigan Bay SAC, as stated before, are limited in their interactions with the bottlenose dolphins by heavy restrictions put in place. As a result of these restricted interactions, in combination with fishing and tourist boats being present in the area for a long time, the population may have a reduced response to boating activity.

Dolphins spend most of their time underwater, so any behavioural observations are going to be based on surface events, unless there is investment in underwater observers/cameras. This makes documenting any impacts on behaviour from outside influences, such as anthropogenic activity, more difficult than it would for land animals (Hastie *et al*., 2003).

Delphinids, like many other primate, carnivore, and ungulate species, exhibit what is known as a fission-fusion society. A fission-fusion society is described as when a group of animals will change in size and composition as they move through environments, as well as when time passes (Aurelli *et al.,* 2008). Ecological and social contexts are tightly linked in this type of society. Sex-specific patterns are common in this type of society because of the main limiting resource for productivity in each sex, this is mates for males and food for females (Connor and Whitehead, 2005). Male harassment a large factor in the segregation that occurs in some bottlenose dolphin populations (Fury *et al.*, 2013), which could be related to why there are smaller groups in the summer months when the breeding season occurs, with dolphins having to protect their calves from potentially aggressive males. The quality and quantity of social relationships in cetaceans influence fitness measures, for example reproduction, survival, and aging (Smith *et al.*, 2016).

Dolphins will usually hunt in groups as they have been known to have different roles in groups during hunting/feeding. Gazda *et al.* (2005) state that dolphins that hunt in groups will, while herding fishes, engage in two types of behaviours. In groups of 3 – 6 dolphins there will be what is described as a ‘driver’ which will herd the fish in circles, aside herding them towards the group, known as ‘non-driving’ dolphins, that will be grouped together tightly, less than one body-length apart. Tail slaps may be performed by the ‘driver’. This method will lure fish to the surface where they will leap into the air, sometimes being caught by the other dolphins regardless of role. These behaviours were observed in Cedar Key in Florida, therefore may be different to behaviours seen in dolphins in Cardigan Bay, however, there may be similarities in the behaviours observed. The larger number of confirmed feeding behaviours displayed by dolphins in winter may be because larger groups may have more dolphins able to efficiently carry out these roles, whereas in smaller groups, individuals may have to take on more responsibility while hunting, potentially lowering efficiency

Societal roles are not only seen during feeding in dolphins, they can be present in their daily lives, as well. Groups of animals need to come to a consensus between individuals in order to survive successfully as a group (de Waal, 2000; Conradt and Roper, 2005). Social structure and behaviour, which emerge from various outside influences, are what facilitate the decision-making processes needed to reach this consensus. The size of the groups may influence these roles and behaviours. Larger groups may experience more conflict between individuals, making it harder to work together. Whereas with smaller groups of dolphins, there are less individuals to conflict with, making the decision-making process potentially easier. The larger variation of behaviours displayed by the bottlenose dolphins, which are predominantly in smaller groups, in summer could be caused by individuals having to take on more roles within their groups, or that they are able to act more freely without the influence of many other animals to conflict with.

Potential threats to coastal populations of dolphins are usually associated with the urbanization of areas (Jefferson *et al.*, 2009), so the Cardigan Bay SAC protects the dolphin populations’ there to a certain extent in regards to urbanization. Therefore, study of this population may be used as a comparison for areas where bottlenose dolphin populations may not be protected from anthropogenic changes.

With both hypotheses, the large difference in numbers of surveys between summer and winter will likely affect the results. This could be due to many of the surveys being opportunistic on tourist boats which may not run as often in the winter. The inconsistencies in survey numbers could negatively impact accuracy of results. For more accurate representation of behaviour statistics, an equal number of surveys would be taken over the entire year. This would require dedicated, structural surveys that would occur along line-transects.

It was hypothesised that there will be a greater number of behaviours engaged in by the bottlenose dolphins in winter than in summer. This hypothesis can't be accepted, however the null hypothesis, that states that there is no difference in the number/variation of behaviours observed between summer and winter, which should technically be accepted in this situation is also wrong. The reason the null hypothesis could also not be accepted is because there is an obvious difference in the number/variation of behaviours between summer and winter, however the issue is that there is more variation in summer than in winter, meaning the opposite of the original hypothesis is true. However, this may also only be visually acceptable, therefore more analysis into this could be carried out in order to prove the opposite.

With a p value of >0.05, the null hypothesis for hypothesis 2 is accepted. This means that there is no significant difference between the number of surface behaviours displayed between groups of bottlenose dolphins in southern and northern Cardigan Bay.

Long-term studies into the social dynamics and individual behaviour syndromes are, as stated before, extremely important for the understanding of species. Personalities can affect life history, behaviour, and fitness of individuals; such as reproductive success, dispersal capacity, survival or habitat divergence (Diaz Lopez, 2020). Conservation for behavioural processes should incorporate social dynamics in these socially complex, long-lived species (Smith et al., 2016). However, due to the nature of these species, detailed long-term studies are difficult and would potentially require expenses that may not be readily available.

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SUPPLEMENTARY INFORMATION

FIGURES

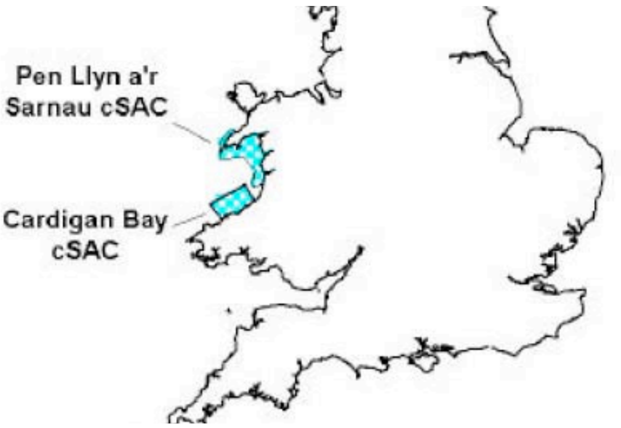

FIGURE 1 - The locations of the Cardigan Bay Special Area of Conservation (SAC) and Pen Llyn a'r Sarnau SAC shown on a partial map of the UK (Ceredigion County Council, 2011).

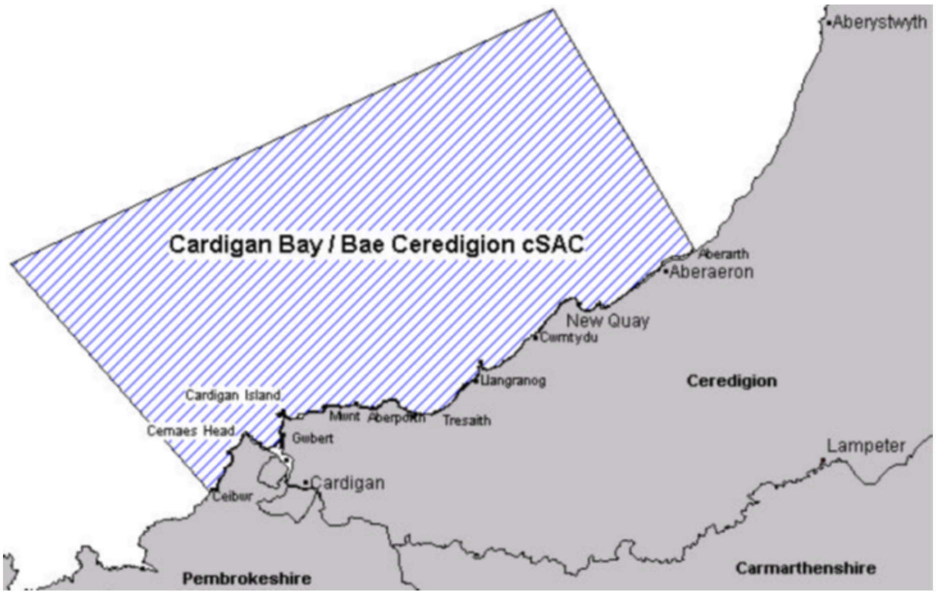

FIGURE 2 - A map showing the Cardigan Bay Special Area of Conservation (Ceredigion City Council, 2001)

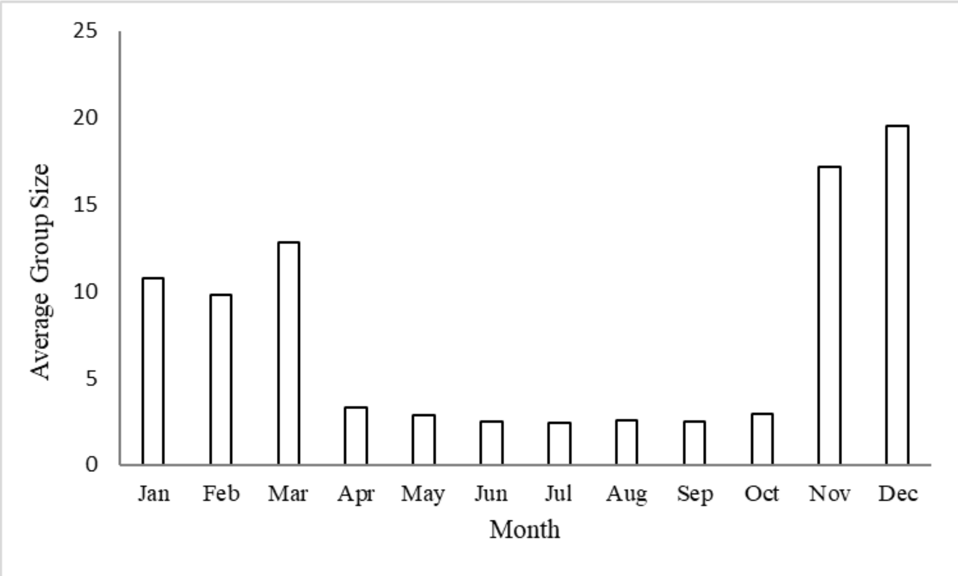

FIGURE 3 - A graph showing the average group size of dolphins over each month of the year in Cardigan Bay, Wales, from 2001- 2019.

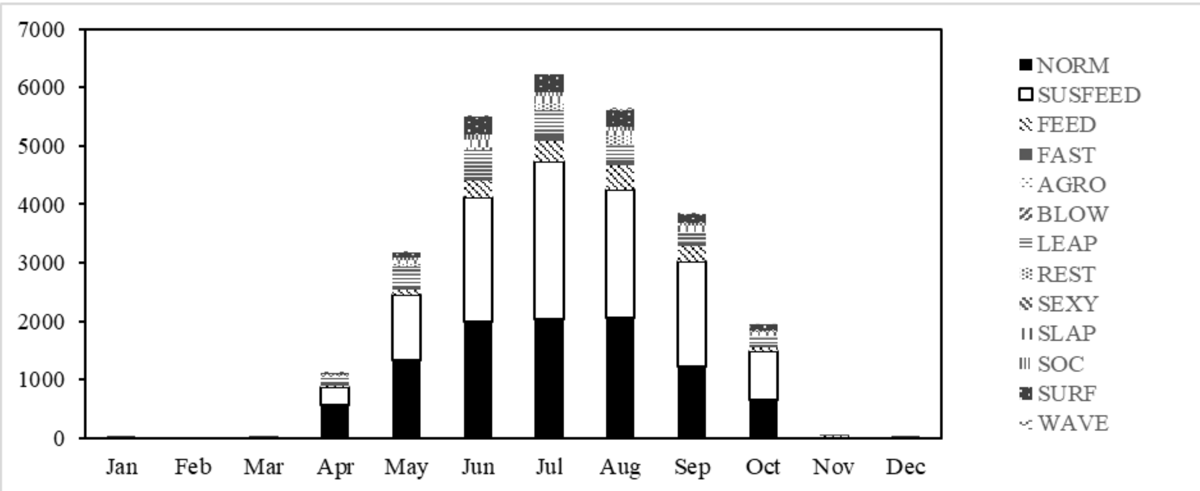

FIGURE 4 - A graph showing the number of times each behaviour was observed over every month of the year. Different behaviours are indicated by separate patterns.

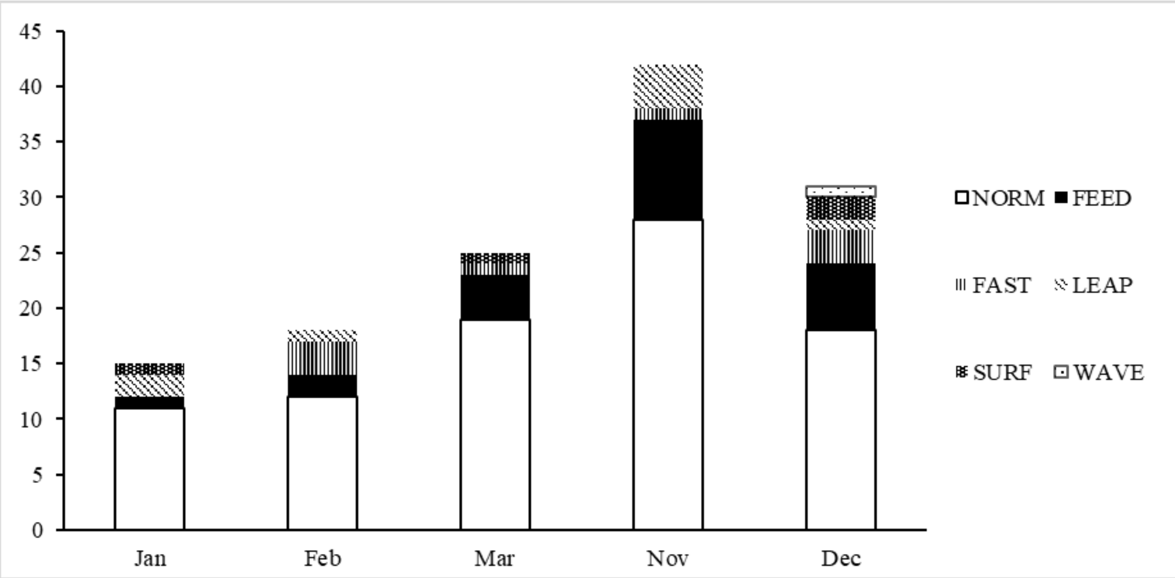

FIGURE 5 - A graph showing the count of each time a behaviour was observed over the months January – March and November – December.

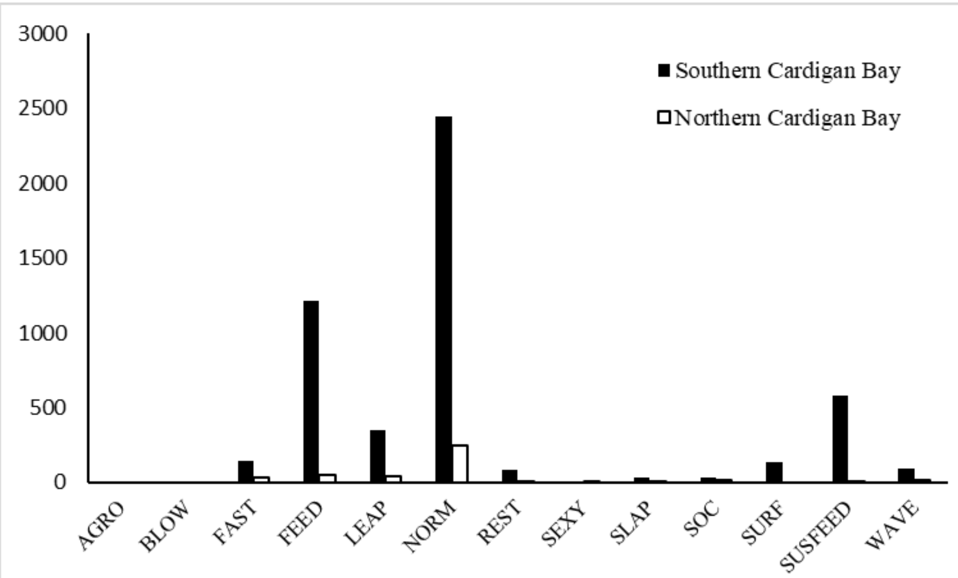

FIGURE 6 – A graph showing the count of each behaviour observed in bottlenose dolphins in southern Cardigan Bay and northern Cardigan Bay. Southern Cardigan Bay is represented by a solid black bar and northern Cardigan Bay is represented by a white bar with a black outline.

TABLES

TABLE 1 - A table showing the code, behaviours and descriptions for each behaviour and how the subsequent behaviours are identified.

Code	**Behaviour**	**Description**
NORM	Normal Swim	Directed movement at a speed of under 10km/h
SUSFEED	Suspected Feeding	Indication of feeding with no confirmation
FEED	Feeding	Dolphin is seen catching fish or with a fish in their mouth
FAST	Fast Swim	Directed movement at a speed of over 10km/h
AGRO	Aggressive	Aggressive behaviour; such as attacking other dolphins
BLOW	Blow	Audible exhale out of the blowhole
LEAP	Leaping	Body exiting the water entirely with an arcuate path, reentering the water smoothly
REST	Resting	Slow activity, no other identifiable activities
SEXY	Sexual Behaviour	Sexual interactions between dolphins
SLAP	Tail Slap	Audible impact of flukes on the surface of the water
SOC	Social Behaviour	Active interactions with other dolphins; including chasing, contact, sexual interactions
SURF	Surface	Movement at the surface that causes a flurry of white water at either side of the dolphin.

SOFTWARE VERSIONS

Microsoft Word - version 2019

Microsoft Excel - version 2019

R - version x62 3.6.3

RStudio – version 3.6.3