An Ethogram for the Bottlenose Dolphin (*Tursiops truncatus*) Population in Cardigan Bay, Wales

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

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Abstract

Ethograms, or organised lists of behavioural events, are valuable research tools in the study of animal behaviour and are critical for a thorough knowledge of a species' behavioural ecology. A species' behaviour may be defined, monitored, and compared across populations using specific definitions of activity state categories and behavioural event types. Based on sighting data gathered between 2007 and 2022 in Cardigan Bay, Wales, we offer the first ethogram for wild bottlenose dolphins (*Tursiops truncatus*) inhabiting Welsh waters. Six activity states and 47 behavioural events make up the ethogram. Using the created ethogram in this study, activity state budgets were calculated for the years 2011 to 2019 and compared. Approximately 85% of the time, when bottlenose dolphins were observed in Cardigan Bay, they displayed travelling behaviour, and in 7% of the sightings, the first behaviour seen was feeding. No significant difference was seen in the percentage of time the bottlenose dolphins spent in each activity state between years, group size, or presence of calves. This indicates that there has not been a change in behaviour seen during encounters and, since 2011, the same amount of time has been spent by dolphins in each activity state per year.

Keywords: ethogram, activity status, *Tursiops truncatus*, bottlenose dolphin, Cardigan Bay, Special Area of Conservation

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Introduction

Dolphins are of ecological importance because they are top-level or apex predators that keep the environment in balance (Connor et al., 2000). Bottlenose dolphins have been recognised as sentinels of coastal marine ecosystems because they consume a range of fish and squid and absorb poisons when pollution levels are high. Therefore, dolphins can be ecological indicators or biological indicators of the health of the marine ecosystem for scientists to assess the condition of the marine environment (Evans, 2020). Dolphins are significant to humans because we are still searching for and learning about our animal predecessors. Humans and dolphins share numerous characteristics that apes do not. We can identify and stop some concerns that may damage the ocean biome, such as pollution or diseases that are spreading to fish populations, because of their behaviour and well-being and identifying changes (Horsburgh et al., 2020).

The bottlenose dolphin is one of the most-studied cetaceans, and as a result, its surface behaviour has been the subject of a substantial amount of research and scholarly writing (Shane et al., 1986; Krützen et al., 2004) . Numerous published studies focus on relationships, such as those between mothers and calves (Mann & Smuts, 1999), foraging (Sargeant & Mann, 2009), or interactions with conspecifics, such as social contacts (Shane, 1990). Ethograms are typically derived from captive studies of dolphins (von Streit, 2011; Hill et al., 2016; Huettner et al., 2021); however, where this is not the case, they are often limited to describing only the broad categories of activity states (Karniski et al., 2015; Huettner et al., 2021). Baker et al. (2017) established the first ethogram for bottlenose dolphins within the Shannon Estuary population in Ireland. As the closest population of dolphins where an ethogram has been created to Cardigan Bay it will be a good comparison for behaviours that could be identified.

In addition to coastal bays, bottlenose dolphins inhabit a variety of tropical and temperate habitats, including harbours, rivers, lagoons, and estuaries as well as occurring far offshore. The range of this species appears to be constrained by temperature, either indirectly or directly via the distribution of prey (Baines & Evans, 2012). This species of dolphin is by far the most common, and its range appears to support a large population (Pesante, Evans, Anderwald, et al., 2008; Pesante, Evans, Baines, et al., 2008; Pierpoint et al., 2009). Cardigan Bay in West Wales has become well-known due to the presence of the large populations of this species which has persisted there for an extended period. In addition to permanent residents, it is anticipated that transient animals make up a sizeable portion of the population

(Feingold & Evans, 2014; Lohrengel et al., 2018). Approximately 250 dolphins reside in the Cardigan Bay Special Area of Conservation (SAC) (Lohrengel et al., 2018).

Bottlenose dolphins range between small groups and larger groups both of which may change in composition and behaviour. (Krützen et al., 2004; Tsai & Mann, 2013). Group size may be influenced by both the environment and gender. The social structure is comprised of numerous groupings of males and females, interactions between males, and mother-calf pairings. Females prefer larger groups when having young calves less than three months old for protection and/or foraging aid (Lamb, 2004). According to the results of a few specialists, larger groups provide advantages in terms of feeding in pelagic habitats and protection from predators in the open ocean (Barros et al., 1998; Gazda et al., 2005; Wells & Scott, 2009).

Cetaceans are highly intelligent animals capable of demonstrating a wide variety of behaviours and modes of interspecies communication. Additionally, they share some similarities with humans. The high level of cerebral cortex encephalization in the brains of delphinid cetaceans provides an explanation for this phenomenon (Reiss & Marino, 2001). For the development of their species-specific complex behaviours and social structures, a high degree of "social intelligence" is necessary for many delphinid creatures. It is hypothesised that higher EQ and larger brain sizes are associated with a high "social intelligence" level in these animals (Reiss & Marino, 2001). The communication between pods is a vital component of the complex social structure possessed by the bottlenose dolphin population. This structure, referred to as a "fission-fusion structure," is distinguished by its high level of social complexity (Connor et al., 2000; Connor, 2007; Tsai & Mann, 2013).

Dolphins engage in several behaviours, including aerial and percussive ones, as well as frequent encounters with other aquatic species. There have been instances of dolphins interacting with kelp (Shane et al., 1986; Baker et al., 2017) and barrel jellyfish (Bel'Kovich et al., 1991; Kuczaj & Eskelinen, 2014), or "playing" with them. It has been established that feeding has a substantial effect on the geographic distribution of bottlenose dolphins (Hastie et al., 2004; Cheney et al., 2013; Horsburgh et al., 2020). Dolphins are believed to have evolved behavioural characteristics that make the process of capturing extraordinarily agile prey more effective and successful (Barros et al., 1998; Gazda et al., 2005). This is because capturing exceptionally nimble prey is difficult. Percussive behaviour is one of the best-known instances, yet it is just one of many (Shane, 1990; Miller et al., 2010). Feeding behaviour is assumed to be opportunistic when there is a limited quantity of prey. Solitary and cooperative group foraging, tracking solitary or schools of prey across the water column, hunting prey buried in the sediment, and pursuing prey near the water's surface are examples of these behaviours. (Hastie et al., 2004; Gazda et al., 2005). Feeding behaviours include 'fish kicks,' in which a dolphin propels a fish vertically into the air with its tail fluke, possibly to aid digestion, and 'surface tail slaps,' in which the dolphin raises its tail fluke above and below the water's surface to create suction, which can be useful in fish capture but can also indicate aggressive behaviour in other situations. (Shane, 1990; King et al., 2016). It has been established that pods of bottlenose dolphins may cooperate to herd schools of fish, including the division of responsibilities among pod members (Simon et al., 2010). When predators are present, the anti-predator response is essential to the survival of the pod, especially of young calves. This is especially true when the pod is threatened by a large number of predators. Mother and calf synchronise behaviour to give maternal protection over the calf (Mann & Smuts, 1999; Sargeant & Mann, 2009) and collective synchronisation of behaviours in response to anthropogenic threats, such as the arrival of a vessel (Gregory & Rowden, 2001; Koroza, 2018; Berrow et al., 2021).

To provide scientific baseline data for a wide range of research endeavours, it is essential to have a solid understanding of the repertoire of behaviours that a species possesses. It is necessary to standardise the terminology and categories used in behavioural research to conduct valid comparisons across multiple study sites (Connor et al., 2000; Masatomi, 2004; Bearzi et al., 2009; von Streit, 2011). The comprehensive descriptions, taxonomies, and quantitative analyses of behaviour have the potential to serve as a useful foundation for future systematic and quantitative research on bottlenose dolphin behaviour, particularly in populations in the wild that have received little attention (Arso Civil et al., 2019). An ethogram is a significant study method that has been used for decades to examine behaviour. It is a systematised presentation of categorical definitions and specific behaviours belonging to each category (Lehner, 1997). Ethograms are meant to represent the entire behavioural repertoire of a species (within the habitat that is the subject of the study), and they can serve as the basis for research that advances the understanding of and conservation efforts for the species that is the subject of the study (Lamb, 2004; Hill et al., 2016). They are required for the gathering and analysis of high-quality scientific data, and the creation and execution of an ethogram can aid in the uniformity of data recording and interpretation (Baker et al., 2017).

To varying degrees, surface behaviours have been explored at several European study sites (Evans & Hammond, 2004; Díaz López & Shirai, 2008; Genov et al., 2008; Augusto et al., 2012; Baker et al., 2017). However, there has not been a great deal of research on the behaviour of dolphins inhabiting the temperate waters of the northeast Atlantic. Researchers have used broad categories to explain the behaviour of bottlenose dolphins in the Moray Firth and Cardigan Bay (Gregory & Rowden, 2001; Hastie et al., 2004; Pesante, Evans, Anderwald, et al., 2008; Pesante, Evans, Baines, et al., 2008; Feingold & Evans, 2012, 2014; Lohrengel et al., 2018; Mason, 2021), but little has been published on specific instances of behaviour within these populations' activity state categories. Few articles have documented the frequency of activity states in cetacean populations, despite the importance of this information for understanding the life cycles of species which may influence conservation management (Evans et al., 2012, 2014; Evans, 2020). Even fewer studies incorporate behavioural event data that characterise and quantify the various surface behaviours of wild bottlenose dolphins and attempt to explain the context and function of these observed surface behaviours (Hastie et al., 2004; Masatomi, 2004; Baker et al., 2017), despite the fact that the collection of behavioural data is essential for understanding animal population dynamics and behaviour.

The goal of this study is to create a detailed ethogram of wild bottlenose dolphins in Cardigan Bay, as well as analyse quantitative data on the frequency of various activity states and behavioural occurrences. This study seeks to serve as a resource for future research on bottlenose dolphin behaviour by exposing the behavioural repertoire and activity budget of the Bay's bottlenose dolphins, as well as discovering regular and distinctive behaviour patterns. Understanding bottlenose dolphin behaviour can help to conserve and manage the species in the UK (particularly within SACs) and across its range.

Methods

Study area

The research for this study was carried out within the Cardigan Bay SAC for bottlenose dolphins, a 959 km^2 EU Habitats Directive site established in 2004 (EEC, 1992) on Wales's west coast between the Llŷn Peninsula in the north and Saint David's Head in the south (Table 1, Figure 1). Cardigan Bay is a shallow (reaching a maximum depth of 50 m), gently sloping inlet with a varied substrate that includes fine sand and shell pieces as well as gravel, shingle, and muddy sand (Barne et al., 1995).

Table 1. Coordinates of the Special Area of Conservation in Cardigan Bay, Wales (EEC, 1992).

Latitude	Longitude
52 13.90 N	005 00.0 W
52 04.70 N	004 45.9 W
52 25.25 N	004 23.1 W
52 15.25 N	004 13.5 W

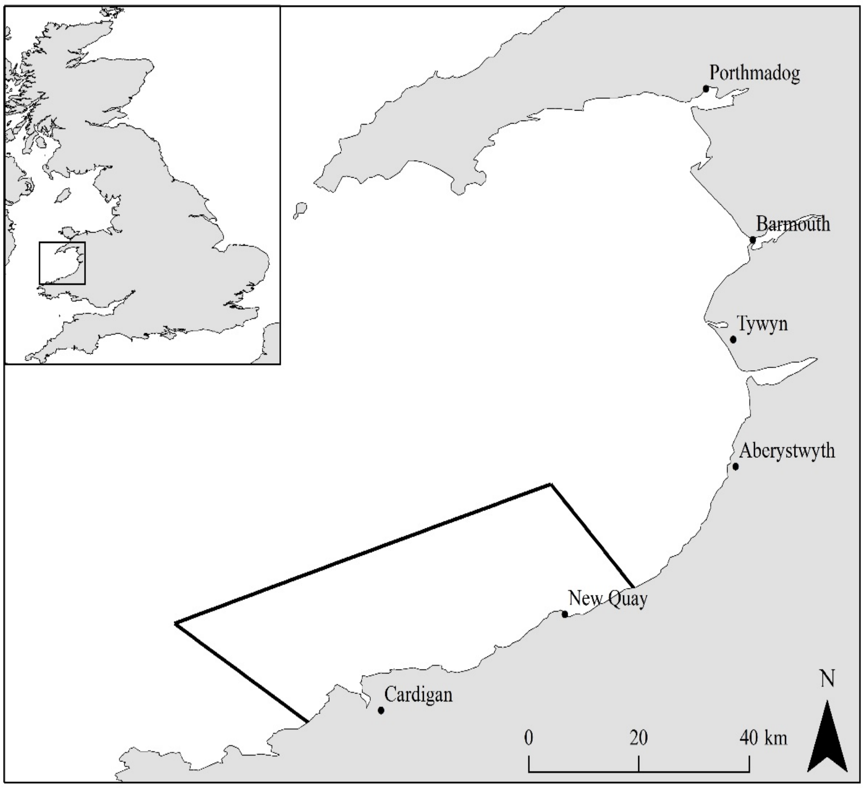

Figure 1. Location of Cardigan Bay SAC (outlined by a continuous line), the main study area (Esri Inc., 2020).

Vessel Surveys

Long-term photo-identification studies of bottlenose dolphins in Cardigan Bay have been conducted since 2001 by Sea Watch Foundation (Pesante et al., 2008; Feingold & Evans, 2012, 2014; Lohrengel et al., 2018). Between April and October, vessel-based surveys were conducted inside Cardigan Bay SAC, from 2011-2022 with an average of 2-4 surveys a week. Throughout those years, several vessels and volunteers have gathered data, and both sightings and effort have been logged in the Sea Watch Foundation's national computer database. The following vessels based in New Quay were used for this investigation in 2022: *Dreamcatcher* (a nine-metre motor vessel with twin 250-hp outboard diesel engines) and *Dunbar Castle 2* (a ten-metre motor vessel with a 100-hp inboard diesel engine). The data used in this study were gathered between May 2011 and August 2022.

A crew of trained volunteers and at least one experienced researcher or research assistant conducted the vessel surveys. All vessel surveys were conducted in sea state Beaufort three or less, with swells of less than one metre, good light, and visibility. If the sea state rose over three or the visibility was decreased by severe rain or fog, the survey trip was cancelled due to the low likelihood of valid observations and of capturing images that might be used for photo-identification (Pesante, Evans, Anderwald, et al., 2008; Pesante, Evans, Baines, et al., 2008; Feingold & Evans, 2012, 2014; Lohrengel et al., 2018). Two primary observers were stationed on the roof or front of the vessel, constantly monitoring the front 180 degrees with an emphasis on the track line. Two independent observers were stationed elsewhere on the vessel, using binoculars to constantly monitor the track line and forward 90 degrees.

When a survey was started, the time, position (latitude and longitude in degrees and decimal minutes), vessel name, and names of observers were noted on the effort form. An entry was made or amended during the survey period depending on effort status, change in course and/or environmental conditions, start of photo-identification, or otherwise at every 15-minute interval.

When an animal was sighted, it was approached to a distance of at least 50 metres under licence from Natural Resources Wales, to get photographs, location information, and behavioural data. The animals were followed for a maximum of forty minutes, or until all the animals were photographed, or until the animals were out of sight. Sighting reference number, time, species, group size and composition, the angle between the group's centre and the bow of the vessel, distance from the vessel, associated behaviours, the cue used to detect the animal(s), and the animal's reaction to the study vessel were all recorded (Pesante, Evans, Anderwald, et al., 2008; Pesante, Evans, Baines, et al., 2008; Feingold & Evans, 2012, 2014; Lohrengel et al., 2018).

Age groups

Dolphins' ages were determined in the wild based on their body size and distinguishing traits. The animals were divided into four groups based on their age: *Newborns, Calves, Juveniles,* and *Adults*. *Newborns* were distinguished by their small size, less than half that of an adult, their proximity to adults, the existence of evident foetal folds, and a short, dark, and occasionally floppy dorsal fin. *Calves* were normally half the size of adults, swam closely with adults, and had foetal folds down their sides and a clean dorsal fin. *Juveniles* were around two-thirds the size of adults and swam largely alone, though they would occasionally swim alongside adults. *Adults* were described as having a body length of 2.5 to 4 metres and having nicks or marks on the dorsal fin. Because it was difficult to place certain animals in the appropriate age category, newborns and calves were combined and labelled as calves for this study.

Data Analysis

Prior to analysis, the data were processed using a variety of criteria. Observations from both primary and independent observers that were repeated, were deleted. Sightings within 15 minutes of one another with the same group size and makeup were counted as a single sighting. *Travel* comprised all forms of movement from one place to another and *Feeding* included both suspected and directly observed feeding or foraging while *Socializing* grouped sexual, aggressive and play behaviour. *Resting* included resting and milling behaviour, while *Other* covered all other actions not included in the basic behaviours, such as bow riding.

One of the research's two principal goals was to assess the bottlenose dolphins' behavioural budget to evaluate the amount of time the animals spent in various activity states over the length of the 12-year study period. The behavioural budget is the percentage of sightings each activity state comprises from the total amount of sightings for each category of analysis. To guarantee independent samples, just one behavioural sample was chosen at random for budget development and subsequent statistical analysis of each encounter.

The total budget was created by combining each activity state for all 12 years and looking at each year separately. The budget for each year was examined to see whether there were any changes in budget coverage over the 12-year research period. The budget was divided into two seasonal periods to see if it varied during the research season for all years combined. The first half of the season began on April 1 and ended on July 15, with the second half of the season commencing on July 16 and ending on October 29. The budget was also examined in relation to group size to see if different group sizes dedicate a different amount of their time to different activities. The animal groups were divided into the following sizes: one animal, two to four, five to seven, eight to ten, 11 to 20, and 20+ animals. The budget was then calculated separately for groups with and without calves.

The significance between observations on behaviour was assessed using a Kruskal-Wallis rank-sum test for multiple factors and a Mann-Whitney U test for two factors if the data were normally distributed. The Kolmogorov Smirnov normality test was used to do preliminary testing for data normality. If the P-value was less than 0.05, the data were considered not normally distributed, and a two-sided Wilcoxon signed rank test was applied. This was done to identify if there was a significant difference in the number of sightings seen for each individual activity state across the different categories. Appropriate statistical analyses were carried out using the statistics application SPSS 27 (IBM Corp., 2020)

Results

Summary of Data Collection

Sea Watch Foundation started surveying Cardigan Bay in 2001 and collected almost 24 h of video footage between 2007 and 2018. Between the years 2011 and 2019, a total of 2,073 sightings (261 surveys) were made on multiple tour vessels; due to the Covid pandemic, surveys could not be undertaken in 2020 and 2021.

Bottlenose Dolphin Ethogram

The ethogram for bottlenose dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales was created based on the ethogram of Baker et al. (2017) and modified while watching 23h and 37 min of video footage from 2007 – 2018 in addition to 23.5h of physical data collection on vessel surveys conducted in June 2022. The ethogram contains codes and descriptions for six activity states and 47 behavioural events (Tables 2 to 7). The first section describes all activity states (Table 2) followed by five separate behavioural event sections detailing foraging/feeding, resting, social, travel, and other behaviours respectively (Tables 3-7). *Slow travel* was the behaviour most seen within the *Travelling* activity state. While *Fluke* and *Peduncle dive* were seen most during *Foraging/feeding* and *Head out* for *Resting*. Mostly aerial behaviour was seen within the *Social* activity state and *Bow riding* was the main behaviour seen under *Other*.

Table 2. Activity states for bottlenose dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales, including a description for each activity state.

Unit	Code	Name	Description
Activity status	FF	Foraging/Feeding	Indications of searching for prey, prey capture, or feeding behaviours
	RE	Rest	Slow, steady activity in absence of other identifiable activities
	SO	Social	All active interactions with conspecifics, including body contact, chasing/ following, sexual and aggressive behaviours
	TR	Travel	Regular directional movement, including zigzag and meandering movement
	UN	Unknown	Activity cannot be defined
	OT	Other	The observed activity is clear but does not fit any other definition and in all cases during which dolphins interact with a vessel

Table 3. Travel behaviours for bottlenose dolphins in Cardigan Bay, including a description for each behavioural event

Unit	Code	Name	Description
Travel	DS	Dorsal surface	Moving at a steady pace and just the dorsal part of the body is visible at the surface
	FTR	Fast travel	Directed movement at a speed of over 10 km/h
	PP	Porpoising	Repeated leaps in a straight direction
	SR	Surface rush	Fast movement breaks the surface causing a flurry of white water on either side of the animal
	STR	Slow travel	Directed movement at a speed of under 10 km/h

Table 4. Foraging/feeding behaviours for bottlenose dolphins in Cardigan Bay, including a description for each behavioural event.

Unit	Code	Name	Description
Foraging/Feeding	BF	Bubble feeding	Corralling or displacing fish using bubble bursts
	CF	Catch fish	A dolphin catches a fish
	FD	Fluke dive	The dolphin dives and the tail is visible
	FJ	Fin jerk	Abrupt movement of the dorsal fin, indicating possible prey capture
	FS	Fish seen	A fish is seen next to a dolphin, in the water or air, with no evidence of a fish toss
	FSW	Fast swim	Dolphin moves quickly through the water, presumably in pursuit of fish
	FT	Fish toss	The dolphin throws fish into the air from its mouth
	LF	Leap feeding	Many dolphins are leaping, presumably in pursuit of fish
	PD	Peduncle dive	The dolphin dives and the peduncle is visible but its tail is not

	WF	With fish in mouth	Dolphin has fish in its mouth

Table 5. Rest behaviours for bottlenose dolphins in Cardigan Bay, including a description for each behavioural event

Unit	Code	Name	Description
Rest	HO	Head out	Head and rostrum emerge above the water surface and re-enter water smoothly
	LOG	Logging	The body is stationary and horizontal; the dorsal part of the body is visible at the surface

Table 6. Social behaviours for bottlenose dolphins in Cardigan Bay, including a description for each behavioural event. *Halfway = to the dolphin's belly button but the genital slit is not visible above water.

Unit	Code	Name	Description
Social	AT	Attack	Attacking or killing other species
	AP	Aggressive pursuit	Dolphin in an aggressive pursuit with a possibility of infanticide
	BB	Belly to Belly	Dolphins are swimming belly to belly
	BEL	Belly roll	The body rotates c. 180° in water so that the light ventral underside of the animal becomes visible
	BKS	Backslap	The body exits halfway* out of the water and falls against the dorsal surface
	BR	Breach	Body exits water over halfway* and vertically and then falls horizontally creating white water
	BST	Backstroke	The body is horizontal, and the ventral part of the body is visible above the surface with both pectoral fins extended
	CHF	Chuff	Strong, audible exhale from the blowhole
	CNS	Chin slap	The body exits halfway* out of the water and falls against the ventral surface
	CT	Calf Tossing	The tossing of a calf out of the water with a possibility of infanticide
	GEN	Genital slit / Genitals	Pink genital area or erect penis observed
	GT	Genital touch	Gentle contact between the pectoral fin or rostrum of one dolphin and the genital areas of another
	LP	Leap	The body exits water entirely in an arcuate path and re-enters water smoothly
	NUR	Nursing	Calves nursing from their mothers
	ONS	On side	The body rotates c. 90° in water
	PEC	Pec out	The pectoral fin is extended above the water surface
	PET	Pet	Gentle contact between the pectoral fin of one dolphin and the body of another
	PR	Pec rub	One dolphin rubs along another's pectoral fin
	RAM	Ramming	Dolphin ramming into another dolphin
	RUB	Rub	Gentle to vigorous body-body contact

	SDS	Side slap	The body exits halfway* out of the water and falls against the flank
	SPL	Splash	Water splash caused by movement of dolphin(s), but action cannot be defined
	SPY	Spy hop	The head and rostrum emerge vertically from the water, and the dolphin appears to view its surroundings
	TO	Tail out	The tail is exposed above the water surface
	TS	Tail slap	Flukes raised above the water surface and then lowered making a strong, audible impact

Table 7. Other behaviours for bottlenose dolphins in Cardigan Bay, including a description for each behavioural event.

Unit	Code	Name	Description
Other	BO	Bow riding	Dolphin is bow riding the vessels waves
	DEF	Defaecation	Faeces are emitted from the body
	WB	With bird	Dolphin interacting with sea birds – grabbing and pulling under birds on the water
	WJ	With jellyfish	Dolphin interacting with jellyfish—in its mouth or draped over its dorsal fin, body, or fluke
	WS	With seaweed	Dolphin interacting with seaweed—in its mouth or draped over its dorsal fin, body, or fluke

Activity Status Budget

Using our ethogram, behavioural events observed in this bottlenose dolphin population were categorized into activity states and quantified. Activity states were recorded for 261 surveys from 2011 to 2019, and activity state budgets were calculated (Figure 2). These were then compared between each year (Figure 3) and grouped at the beginning and end of the research season (Figure 4). *Travelling* was a predominant activity state in 85% of all sightings between 2011 and 2019, with *Feeding* only being seen in 7% of the sightings. Comparing each individual activity state throughout the years indicated no significant difference for each activity state for the different years (Kruskal–Wallis rank-sum test, $p > 0.05$) or the first half vs second half of the research season (Mann-Whitney U test, $p > 0.05$). All tests were run again excluding *Travelling* as this was the most dominant behaviour identified but, again, no significant difference was found.

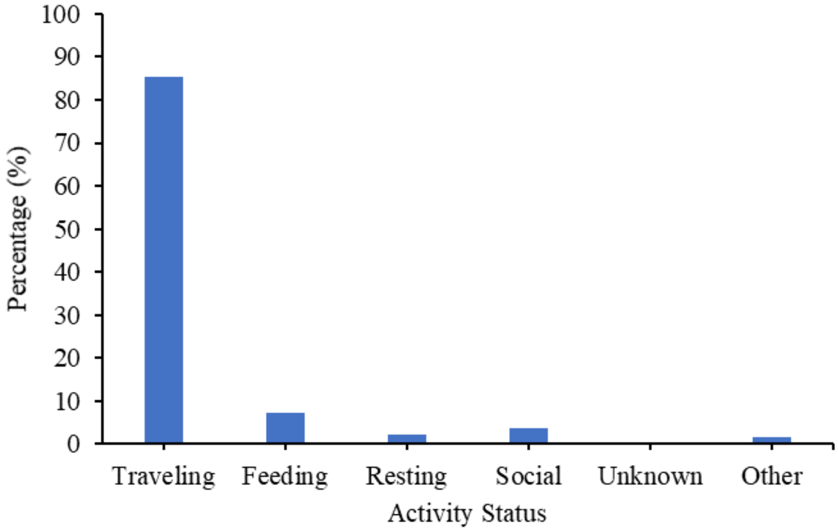

Figure 2. Combined activity status budget for bottlenose dolphins in Cardigan Bay from 2011-2019.

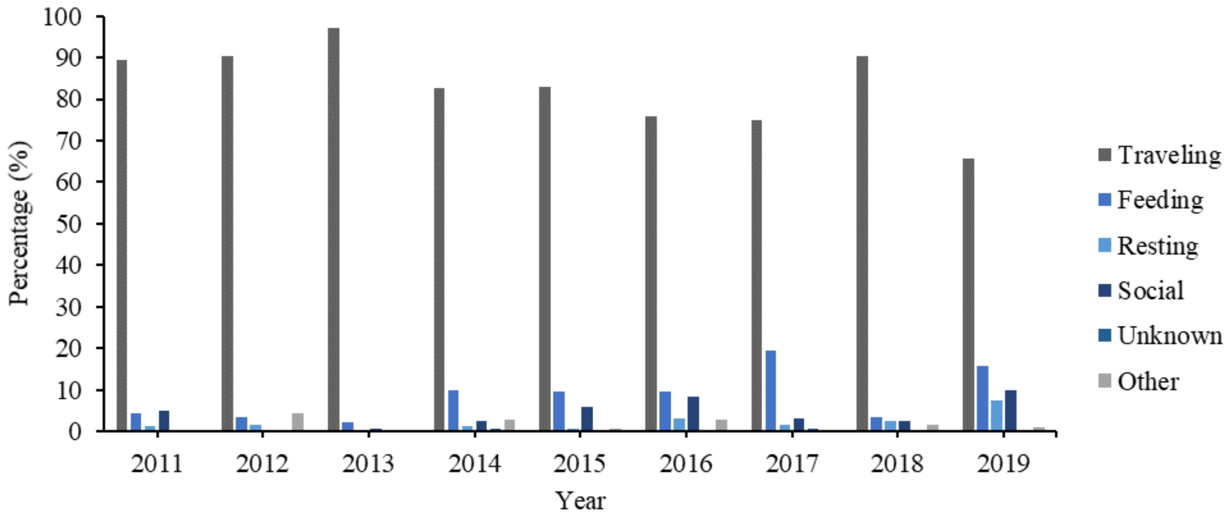

Figure 3. Activity status budget for bottlenose dolphins in Cardigan Bay per year from 2011-2019.

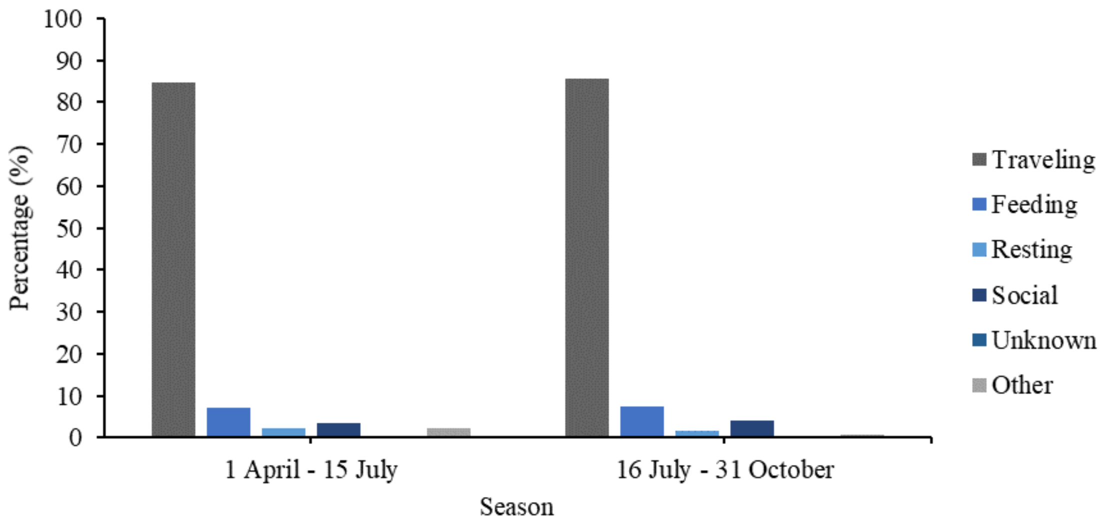

Figure 4. Combined activity status budget for bottlenose dolphins in Cardigan Bay from 2011-2019 during the beginning and end of the research season.

In addition to comparing activity budgets between time frames, the activity budgets were compared for different group sizes (Figure 5), and when calves were present or not (Figure 6). Group sizes were categorised into a single individual, two to four, five to seven, eight to ten, 11 to 20, and groups with more than 21 individuals. Comparing each individual activity state for different group sizes indicated no significance in any activity state for the different groups (Kruskal–Wallis rank-sum test, $p > 0.05$) or the presence or absence of calves (Mann-Whitney U test, $p > 0.05$). All tests were run again excluding Travelling as this was the most dominant behaviour identified and again no significant difference was found.

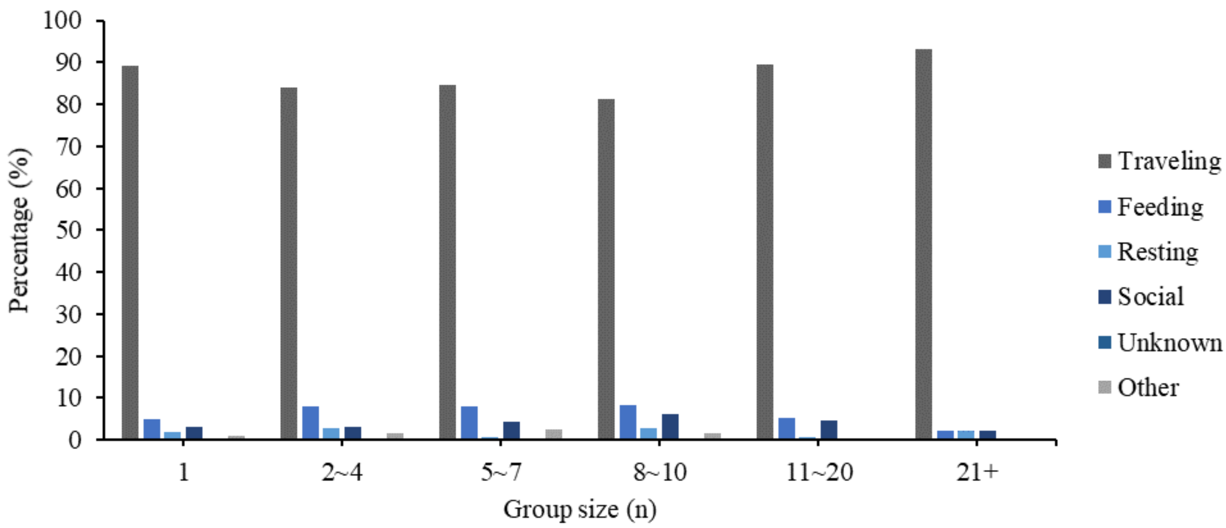

Figure 5. Combined activity status budget for bottlenose dolphins in Cardigan Bay from 2011-2019 per group size.

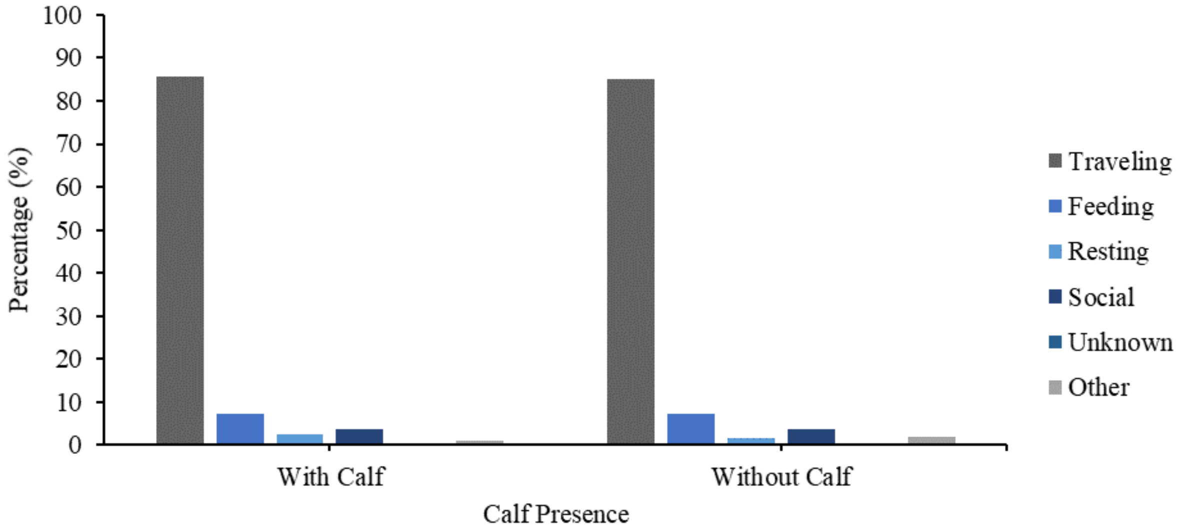

Figure 6. Combined activity status budget for bottlenose dolphins in Cardigan Bay from 2011-2019 with and without calves.

Discussion

Bottlenose Dolphin Ethogram

The study project processes and published literature searches for surface behaviour ethograms resulted in a broad array of behavioural terms and descriptions for bottlenose dolphins in Cardigan Bay (Gregory & Rowden, 2001; Pierpoint et al., 2009; Mason, 2021). As a baseline, this ethogram was created using Baker et al.'s (2017) first complete ethogram for bottlenose dolphins in the Northeast Atlantic. All the behaviours seen in this study were added to the current ethogram, along with detailed descriptions, allowing them to be compared to behaviours observed in other investigations.

Behavioural occurrences that have not been observed or documented in Cardigan Bay have been described in other related studies. Foraging activities such as strand feeding (surging out of the water in unison onto sand banks to feed on small fish), and benthic feeding approaches have been seen in other populations (Jiménez & Alava, 2015; Quigley et al., 2022). During this study in Cardigan Bay, the social activities known as "jaw clap" (a dolphin slapping its lips at the surface without anything within) or "headbutt" (two dolphins jump simultaneously and hit their heads together) have not been seen (Lusseau et al., 2006; Steiner, 2011). As with any catalogue of activities, the ethogram produced should be seen as a dynamic document rather than a comprehensive collection of the actions of Cardigan Bay bottlenose dolphins.

Activity Status Budget

In this study, bottlenose dolphins in Cardigan Bay spent most of their time travelling, a moderate amount of time feeding, and the least amount of time socialising and resting when they were first observed. After re-running all activity budgets and removing travelling behaviour as this could have influenced the data by being so prevalent, still no significant differences were found for any of the categories. These proportions are somewhat similar to other studies on activity budgets. Baker et al. (2017), for example, found that dolphins spent 52% of their time travelling and 28% of their time foraging. Since dolphins must travel to find prey and conspecifics, travelling may also relate to feeding behaviour. The majority of an animal's budget is devoted to searching for food, thus when foraging, it must be able to travel to areas with abundant food.

In this study, splashing, belly-to-belly views, physical/sexual contact, and aggressive behaviour were all identified as indicators of social behaviour among animals. Socializing and eating are frequently mistaken for one another. This is because splashing can occur during both social and eating behaviour, whereas tail slaps are employed during both feeding and aggressive/warning behaviour. Another behaviour that may be misinterpreted as sluggish travel is resting. Due to the possibility that an activity state may not be seen in certain years, behavioural budgets should be approached with caution. It must be noted that some level of disruption by the survey vessel itself can significantly diminish the amount of time spent resting or the capacity to observe resting animals.

Limitations

Although measuring the behavioural budget allows researchers to acquire a better understanding of how a population spends its time on certain activities and how circumstances such as seasonality and the presence of calves impact their budgets, such data have limitations in interpretation. The budget is determined at any given time by the recorded behaviour, and it may differ from the real behavioural budget. Surface behaviours, as previously indicated, determine the state of activity. Cetaceans spend almost all of their time underwater. We can only glimpse a limited portion of their body at a time when we do see them. As a result, surface behaviours may be misconstrued or recorded as a single behaviour observed at the surface, despite the animal engaged in another underwater behaviour that is not visible. Researchers will interpret hidden behaviours differently even when using the strictest procedures. Several people have contributed to the collecting of these data during the last 12 years. Despite the limitations of this strategy, surface behaviours may be useful for developing a daily budget.

Vessel surveys are useful for studying cetaceans in their native habitat, but they do not offer a full picture. Bottlenose dolphin viewing is only permitted during daylight hours and in excellent weather. As a result, the budgets shown here only reflect the daily budget for these animals, rather than the entire budget. This is critical for analysing these data since they would most likely change greatly if the animals were tracked for 24 hours. Because there are few alternatives for observations, caution should be used while analysing the budget. Nonetheless, the budget may be used to compare the quantities of time spent on different behaviours. The findings of this study were often gathered in the early morning when the weather was good to fair. Furthermore, there is some disruption created by the study vessel itself, particularly during a behavioural examination. Behavioural data were obtained during the initial dolphin observation before any vessel disturbance might have an effect.

Recommendations

The material used in this article was obtained during a short period, largely during the summer. As a result, comparing behaviour across seasons would be interesting. To answer questions about how group behaviour varies over time, continuous research is necessary throughout the year. Furthermore, rather than focusing just on surface activity, an underwater study would almost certainly provide a larger repertoire of dolphin behaviour. Finally, behavioural data collected only by trained staff and research assistants might reduce variability in recordings by performing inter-observer validity and reliability assessments.

Conclusions

This study aimed to define and quantify activities in bottlenose dolphins in Cardigan Bay, develop the species' first ethogram for this area, and establish behavioural budgets. The ethogram generated 47 behavioural characteristics and six activity levels. The quantified ethogram behaviours of dolphins in Cardigan Bay were each recorded at least once for the results, which were based on 12 years of observational data. We predict that our ethogram will change over time when bottlenose dolphins are spotted in Cardigan Bay, including some of the behaviours that have been described for bottlenose dolphins elsewhere. The behaviours detailed here are some of the most common that bottlenose dolphins perform in diverse natural circumstances.

After quantifying activity states and behavioural occurrences in Cardigan Bay, an activity status budget for this population of bottlenose dolphins was created. Bottlenose dolphins in Cardigan Bay spend more time travelling and less time eating and resting when compared to other populations. Overall, this study provides the framework for future research on the behaviour of the Cardigan Bay bottlenose dolphin population, as well as systematic comparisons with other populations, to better understand the complicated lives of these social creatures.

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