TEMPORAL CHANGES IN SITE USAGE BY BOTTLENOSE DOLPHINS (*Tursiops truncatus*) IN NEW QUAY BAY, WALES.

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DECLARATION

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ABSTRACT

Bottlenose dolphin *Tursiops truncatus* population is found in significant proportions in the southern zone of Cardigan Bay, which has been established as a Special Area of Conservation (SAC). Within the SAC, New Quay Bay is recognised as an important area for their population in the Welsh waters, with records dating back to the 1920s. Despite the fact that New Quay Bay is part of the Cardigan Bay SAC, the increasing boat activities in the area and their possible effects on the presence and behaviour of bottlenose dolphins are presently a great concern. Therefore, this study aimed to investigate the changes in bottlenose dolphin presence in New Quay Bay over time, as well as to establish any temporal changes in site usage for recognisable individuals. The population of bottlenose dolphin in New Quay Bay was largely found to be non resident. This may be because the area chosen for analyses was not within the core area of an individual's home range zone. The change in occurrence of individuals can be related to the purpose of their visits to the bay, which is believed to be both a feeding and breeding area for bottlenose dolphin. Depending upon their reproductive status (reflected in particular characteristics such as gender, age, mother or presence of calves), some individuals will use some zones more than others or may use New Quay Bay either early or later in the summer. Even though the present study observed a neutral reaction towards the presence of boats as a frequent behavioural pattern, studies of reactions towards boats are still quite subjective, since bottlenose dolphins are mostly underwater, which makes it very difficult to determine the behaviours and reactions under the water. Therefore, presence of boats and it's effects upon the dolphins should be analysed in more detail as it could be that an increase in boat activity is causing some individuals to spend less time in New Quay Bay,which encourages more individuals to be transient. If this is the case, further management actions should be taken in the area to fully protect the bottlenose dolphins.

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ABBREVIATIONS

ANOVA	Analysis of Variance
BND +ve	Bottlenose dolphin positive
%	Percentage
cSAC	Candidate Special Area of Conservation
SAC	Special Area of Conservation
G-test	Goodness of fit test
IUCN	International Union for Conservation of Nature
CCW	Countryside Council for Wales
CCC	Ceredigion County Council
Km	Kilometres
Km^2	Square kilometres
UK	United Kingdom
NE	North East
°C	Centigrade
ID	Photo-Identification
GPS	Global Position System
°	Degree
’	Minutes
”	Seconds
SWF	Sea Watch Foundation
sp	Specie
N	North
W	West
PO	Primary observers
IO	Independent observer
hp	Horse power
RIB	Rigid Inflatable Boat
ArcGIS	Geographical Information System

1. Introduction

Following the taxonomic classification, which is still changing based on molecular and genetics analysis, the marine mammal Order Cetacea, (whales, porpoises and dolphins) contains two suborders, classified on the basis of their morphology: Mysticeti or baleen whales, and Odontoceti or toothed whales. This order includes approximately 90 species, in which except for four species of freshwater dolphins, all are marine animals. In this large group, the range size varies markedly from the vaquita and Commerson's dolphin at a little over a metre length, to the blue whale at around 30 metres, which is recognised to be the largest animal ever to have existed on earth. Twenty-eight of these species have been recorded in British waters, whilst fifteen of these have been recorded in the last 20 years in Welsh waters.

1.1 The Bottlenose dolphin

The bottlenose dolphin *Tursiops truncatus* (Montagu, 1821) belongs to the sub-order Odontoceti and to the family *Delphinidae*. Evidence of the existence and knowledge about the bottlenose dolphin as a marine mammal dates back to the ancient Greeks and Romans, which together with the fact that they are used in marine parks and research programmes, are the reason why nowadays this species is recognised as the best known of all cetaceans (Wells & Scott, 1999).

1.1.1 Morphology

Dolphins display a great number of physical characteristics different from the ones that are seen in terrestrial mammals, such as lack of external ears, hair and hind limbs. Particularly, bottlenose dolphins can be differentiated from other members of the *Delphinidae* family by specific morphological characteristics such as a robust fusiform body with light to dark grey colour on the back and flanks and lighter colour in the ventral side (Jefferson, Webber & Pitman, 2008), but without any intricate pattern (Wells & Scott, 2002). The body of an adult bottlenose dolphin varies from 1.9 to 3.8 metres, with males slightly larger than females (Jefferson *et al.*, 1993). Depending on the geographical location of the bottlenose dolphin population, both size and colour can vary, European bottlenose dolphins being larger and browner than those from tropical waters (Wilding & Avant, 2009).

1.1.2 Feeding habits

Bottlenose dolphins are mainly opportunistic feeders taking a variety of fish, mainly demersal but also pelagic species; their diet can also include shrimps, cephalopods, and even small Chondrichthyes (cartilaginous fish) such as rays and sharks. The individuals of this species display a range of feeding behaviours, depending mainly upon the ecology and behaviour of the prey. These include cooperative foraging on schooling fish, individuals chasing fish onto mudbanks, and feeding behind shrimp trawlers, as well as other fishing operations (Jefferson *et al*., 1993). Bottlenose dolphins have also been found feeding in areas where the compression of a watercourse generates tidal races, which at the same time seems to make easier the process of catching the fish prey (Connor *et al*., 2010). Previous studies have shown that the presence of inshore populations of bottlenose dolphins can be related, and therefore predictable, to tidal state, because this factor will determine better foraging conditions (see, for example, Wilson *et al*., 1997). Many studies of bottlenose dolphin populations have shown a trend in foraging behaviour in the early morning and later in evening, whilst socialising has been seen in the afternoon, with travelling increasing between the afternoon and evening (Saayman *et al*., 1973; Hansen & Defran, 1993; Bräger, 1993; Bearzi *et al*., 1999). Feeding behaviour can vary daily or seasonally, which is related to prey availability, distribution and to movements; if prey availability is high, this will decrease the travel time that dolphins will need to seek for fish, allowing feeding time to increase as well. In addition, previous studies have shown that many fish species move with the tides, searching also for food resulting in the movements of the dolphins corresponding to those seen in their prey (Würsig & Würsig, 1979; Berrow *et al*., 1996). During winter, the density and abundance of fish may vary, and, therefore, dolphins have to search a longer time for their prey, causing them to switch to other prey such as cephalopods and crustaceans (Bräger, 1993). The tidal state that varies daily can also affect the travel behaviour of the bottlenose dolphins (Lamb, 2004). If individuals are swimming with the currents and not against it, less energy is needed.

1.1.3 Life History

Based on tooth sample analysis, the life expectancy of bottlenose dolphin has been estimated at 40-45 years for males, whilst females live longer, exceeding 50 years (Wells & Scott, 1999). Age at physical and sexual maturity has been determined to change, depending upon the region and sex; males, for example, reach sexual maturity between 10 and 13 years old, when they are approximately 2.45-2.6 metres length, whilst females reach it at a younger age, between 5 and 13 years old, when reaching 2.2-2.35 metres length (Wells & Scott, 1999). At sexual maturity, females start breeding. During summer, when temperatures increase, calving reaches a seasonal peak. The gestation period lasts for 12 months resulting in the birth of a single offspring measuring between 0.8 and 1.4 metres (Wells *et al*., 1987). Previous studies have found that before reaching three years of age, approximately 44% of the calves die due to natural causes (Barragán-Barrera, 2010). Calves that survived complete most of their growth between 1.5 and 2 years of age, during what is called the breast-feeding season (Ridgway & Harrison, 1999). Afterwards, calves stay for a long period with their mothers, learning survival techniques. Females can still reproduce up to an age of approximately 48 years old, at calving intervals of 3 to 6 years (Wells *et al*., 1987).

1.1.4 Social Structure

Bottlenose dolphins live socially in groups between 2 to 25 individuals, although sometimes aggregations may occur, numbering in the tens or even low hundreds (Reid *et al*., 2003). Group size can vary depending upon the season, activity state, group composition and habitat heterogeneity. In addition, previous studies have found that populations that are inhabiting nearshore waters can be found living in an open society, with individuals moving from one group to another, triggering a change in the population composition as well as a change in their behaviour (Connor *et al.*, 2000). Social structure has been found to vary hourly, daily, or weekly (Connor *et al*., 2000). Previous studies have demonstrated that, frequently, males join together to establish a group or alliance that can last as long as 14 years (Connor *et al*., 2000); some other evidence shows that the strongest bond can be seen between mothers and calves, the duration of which depends upon the population (Reynolds *et al*., 2000).

1.1.5 Distribution

The bottlenose dolphin is a cosmopolitan species, distributed in all oceans around the world, except in waters at the highest latitudes (Reeves *et al*., 2002). In most parts of the world, the species is not found in latitudes beyond 45º north or south but in the UK and other parts of northern Europe, bottlenose dolphins can occur up to around 60º north (Jefferson *et al.*, 1993) (

Figure 1. **1**). Based on this idea, bottlenose dolphins can occupy a range of habitats, from deep waters off the edge of the continental shelf to bays, lagoons, harbours, estuaries and rivers (Wells & Scott, 1999). Although populations of this species can inhabit both offshore and inshore waters, it is the latter that are the most studied due to their closeness to the coast and easy accessibility. In addition, whereas offshore populations have an extended area range, the inshore ecotype has been discovered to display different movements on a temporal scale, resulting in populations with specific home characteristics known as resident with a small home range and travelling short distances; semi-residents with a larger home range, travelling many kilometres; and transients where little information exists about the area and kilometres covered by them (Speakman *et al*., 2006). This terminology can also apply to re-sighting patterns, both in times seen and years of sightings, therefore transient individuals are those seen once or twice between one or two years, semi-residents are those seen 4 and 11 times between three and six times, and residents are those seen more than 12 times, between seven and twelve years, in the studied area. Examples of these cases can be seen worldwide, for example the resident populations of bottlenose dolphin in Galveston Bay, Texas (Brager, 1993), the Shannon Estuary dolphins in western Ireland (Berrow *et al*., 1996), and in UK waters, the semi-resident populations of the Moray Firth in Scotland and Cardigan Bay in Wales (Wilson *et al*., 1997; Evans *et al*., 2003; Reid *et al*., 2003; Evans & Hammond, 2004; Hammond *et al*., 2012).

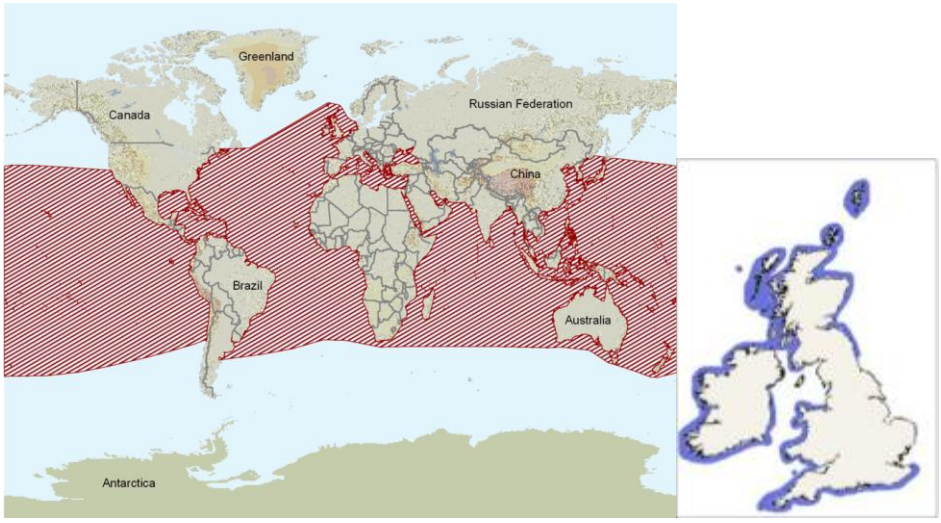

Figure 1. 1. Global distribution of bottlenose dolphin, defined by red area (IUCN, 2009) and bottlenose dolphin area in UK and Irish waters defined by blue area (MarLIN, 2010).

1.1.6 Habitat

Habitat selection of bottlenose dolphins is a result of the heterogeneity of the environment around them. Whilst some areas can offer a higher abundance in prey availability, others can be more beneficial to avoid predation (Ballance, 1992). Therefore, as the different habitats are characterised by many abiotic factors (water temperature, salinity, depth and substratum) and this in time will determine also the change in presence of fish or other prey, the distribution of dolphins will be affected as well, leading to a change in the amount of usage of an area and in the activity or behaviour shown in the different zones, which may also be related to the time of the year, reproductive season, tidal state, time of day, and habitat type (Wells & Scott, 2002).

Most cetacean species, although very mobile, use a specific home range to fulfil their normal activities, such as mating, caring for young, and foraging (feeding). Bottlenose dolphins exhibit a variety of home ranges during their lives, the location and size of the area that they use as home range varying according to characteristics such as sex, age, season and presence of calves (Burt, 1943). Nonetheless, the study and definition of the home range of a bottlenose dolphin population is difficult to determine due to the great movements of this species, and therefore, the variety of environmental variables such as depth, substrate, prey availability and tidal state that they encounter.

1.2 Conservation status and Threats

Presently, based on our current knowledge of bottlenose dolphins, the International Union for Conservation of Nature (IUCN) has classified this species in its Red List as of "Least Concern" (IUCN, 2009), which refers to the fact that populations around the world appear not to be threatened. Nonetheless, it is important to bear in mind evidence of the human pressures that bottlenose dolphins face worldwide (Jefferson *et al*., 1993). Individuals of this species, particularly those living in coastal areas, often show a negative impact to their health as well as to the dynamics of the population all around the world (Wells & Scott, 1999), caused by different anthropogenic impacts such as hunting, boat traffic, pollution (both litter and quality of the water and animal prey within it), noise, by-catch, habitat deterioration, prey depletion, climate change and tourism activities.

1.3 Photo Identification

Identification of specific individuals of bottlenose dolphins is possible based on specific marks or patterns located on the body, particularly on the dorsal fin, which can act in the same way as fingerprints do in humans (Verme & Iannacone, 2011). These may be caused by anthropogenic activities (such as collision with boats, propeller cuts) or from bites or tooth rake marks between individuals. Photo-identification methods using mark and recapture techniques, and other analyses of the natural marks in the dorsal fin were used first upon cetaceans back in the 1950s by David and Melba Caldwell and subsequently, in the 1970s, by Bernd Würsig (Würsig & Jefferson, 1990; Mann *et al*., 2000). The implementation of this new photo identification, non-invasive, technique helped to re-formulate mark-recapture methods that had been used in terrestrial mammals until the 1950s. Based upon this method, some other species characteristics can be determined. Examples include migratory movements, associations, population size, time of residence within an area, population dynamics, distribution patterns, and birth and mortality rates inclusive (Hammond, Mizroch & Donovan, 1990). Consequently, photo identification has achieved many different objectives around the world, increasing our knowledge of the species and thus achieving more effective management and conservation plans (Hammond *et al*., 1990; Evans & Hammond, 2004; Weir *et al*., 2008). As a result, several organizations engaged in the study of bottlenose dolphins have created identification

catalogues; the information that a catalogue contains can form the basis for the conservation of the species and the establishment of future studies that include environmental education as well as eco-tourism management (Reynolds *et al.*, 2000; Evans & Hammond, 2004).

Earlier studies based on photo identification have shown that coastal bottlenose dolphin populations tend to be either year-round or seasonal residents. It can be demonstrated whether dolphins are present or absent during a specific period of time based on the variability in the number of individuals encountered during a survey, within and across years (Arnold, 2000). Furthermore, inferences can be made for those cases in which dolphins may be transient in specific areas, based on the premise that no dolphins are seen over a period of time that those areas have been surveyed. Resident bottlenose dolphin populations, on the other hand, are more likely to be found in those places where protective measures take place, due to their better managements of threats, although other factor may be involved; for, example, group size tends to increase as depth increases (Shane *et al*., 1986). However, preferences for specific habitats can vary in bottlenose dolphin populations around the world, affecting dolphin range, foraging strategy and social structure dependent upon a number of environmental factors (Arnold, 2000).

1.4 Bottlenose Dolphin in Welsh Waters

In Welsh waters, where bottlenose dolphins are inhabitants, photo identification techniques have also been used over a number of years. Baseline surveys and routine monitoring have formed the basis for the designation of the Special Area of Conservation (SAC) in Cardigan Bay (2001) and Pen Llyn a´r Sarnau (2004), and reporting of whether the species is at Favourable Conservation Status. Conservation studies of cetaceans, particularly of bottlenose dolphin, have been undertaken by the marine research charity, Sea Watch Foundation, since the 1990s, which until then had been studied only from dead animals such as strandings or direct human exploitation. Within Cardigan Bay, west Wales, a more framework for surveillance was established in 2001, as part of a monitoring contract with the Countryside Council for Wales (CCW), with emphasis upon the semi-resident population of bottlenose dolphin within the designated Cardigan Bay SAC (Baines *et al*., 2002; Pesante & Evans, 2008; Pesante *et al*., 2008; Feingold & Evans, 2014a, b).

These two SACs have been established as part of the Natura 2000 network within the EU Habitats Directive with the idea of providing spatial protection for the bottlenose dolphins. The bottlenose dolphin population of Cardigan Bay is described to be semi resident (Feingold & Evans, 2014a, b). A detailed analysis of bottlenose dolphin residency patterns in the southern portion of Cardigan Bay, and specifically of New Quay Bay, should reveal which inhabitants are resident, transient or simply occasional visitors, and whether differences can be related to gender or reproductive status, and if there have been any changes over time.

Fifteen percent of the Cardigan Bay population corresponds to individuals that have never been seen outside of the SAC, whereas some others clearly have larger home ranges or are occasional visitors to the SAC (Feingold & Evans, 2014a, b). Long-term monitoring of individuals has provided data on the locations and movements of dolphins within the population; during the summer, the population is located mainly in coastal waters of Cardigan Bay, whilst in winter the individuals disperse mainly northwards into North Wales (Anglesey and north-east mainland Wales) or beyond (Feingold & Evans, 2012, 2014a, b). Some hypotheses have been put forward to explain this seasonal movement. These include changes in prey availability, alterations in water temperature, and changes in anthropogenic activities such as scallop dredging (which may cause an impact on the habitats of bottom-dwelling fish) and marine recreation (that can cause disturbance).

1.5 Aims and Objectives

A significant portion of the Cardigan Bay population inhabits the southern SAC, some of them potentially residing there year-round (Feingold & Evans, 2014a, b). Within this SAC, a particularly important area for the Welsh bottlenose dolphin population appears to be New Quay Bay; it is apparent that a proportion of the resident bottlenose dolphin population in Cardigan Bay SAC is recently decreasing (Pierpoint *et al.*, 2009), and yet there is a stable abundance within Cardigan Bay overall, showing that perhaps the population is resident in some other parts of the SAC during the summer season. A possible explanation is that whilst visiting the SAC, individuals of bottlenose dolphin are visiting New Quay Bay area more than other areas. Therefore, it may be necessary to introduce further management strategies to help to support and protect the overall bottlenose dolphin

population in New Quay Bay which perhaps supports the bottlenose dolphin population in the entire bay.

Nonetheless, some animals are semi-resident, and others may have changed their residency patterns. To try to understand the cause of such movements, researchers have focused their studies on factors such as time of day, tidal state and season, etc. In addition, based upon photo identification techniques, it is well known that individual site fidelity may vary annually (Bristow & Rees, 2001), and this could be related to shifts in site usage and/or the presence of calves (Feingold & Evans, 2013), as evidenced by the presence of some females using the Cardigan Bay SAC at least partly for nursery purposes (Bristow & Rees, 2001; Pesante et al., 2008; Feingold & Evans, 2014a, b).

Within Cardigan Bay, in many areas along the coast, bottlenose dolphins can easily be seen, leading to specific land-watch studies in areas such as Ynys Lochtyn, Aberporth, Mwnt, New Quay Head and pier (Stone, 2006; Pierpoint *et al*., 2009). These last two locations have been recognised as areas of particular importance for the occurrence of dolphins as they are areas where they may come into conflict with boat activity during the summer (Pierpoint *et al*, 2009; Feingold & Evans, 2014a).

Many studies worldwide have focused upon analysing the effects of boat traffic on dolphin presence. Despite this, the presence of animals around New Quay appears to be still increasing, showing tolerance to this anthropogenic activity, although more studies need to be done to evaluate the range of variables that can affect the presence of individuals. In New Quay Bay, approximately 150 individuals have been recorded since 2001, showing a significant increase in site usage through the years studied (Lambert *et al*., 2013).

Therefore, the aims of this project were to investigate any changes over time in bottlenose dolphin presence and site usage in New Quay Bay, to establish whether any changes have affected some individual dolphins more than others, and if so, what factors might be determining this. Also, it seeks to investigate if the conservation measurements in Cardigan Bay SAC are adequate to protect the individuals that are present in New Quay Bay or if the individuals are becoming tolerant to the different anthropogenic activities in the area.

Based on those previous ideas, this research in New Quay Bay aimed to address the following hypotheses:

- Some part of the population of bottlenose dolphins in New Quay Bay is confined to this area.
- There is an annual turnover of bottlenose dolphin individuals in New Quay Bay each year.
- Variation in occupancy within New Quay Bay can be related to particular characteristics of the individual (sex, age, presence of a calf, etc).
- Bottlenose dolphin individuals that used New Quay Bay in the past are no longer there at the present.
- The protection measures of New Quay Bay are adequate to fully protect bottlenose dolphins.
- Some individuals use some areas of New Quay Bay more than others.
- Particular individuals use New Quay Bay either early or later in the summer.
- The population of bottlenose dolphins in New Quay Bay is semi-resident.

2. Methodology

2.1 Study area

2.1.1 Cardigan Bay

- Physical description

Covering an area of approximately 5500 km^2, Cardigan Bay is the largest bay in the UK (Baines *et al.*, 2000). It encompasses over 100 km from Saint David's Head at the southernmost point to the Llyn Peninsula and Bardsey Island at the northernmost end. It is a shallow bay with gentle slopes that do not exceed 60 metres (Figure 2. 2), becoming deeper from east to west. Limited in the north by the Llyn Peninsula and west Pembrokeshire in the south, it forms part of the Irish Sea, and is located NE of the northern Celtic Sea Trough (Baines *et al.*, 2000).

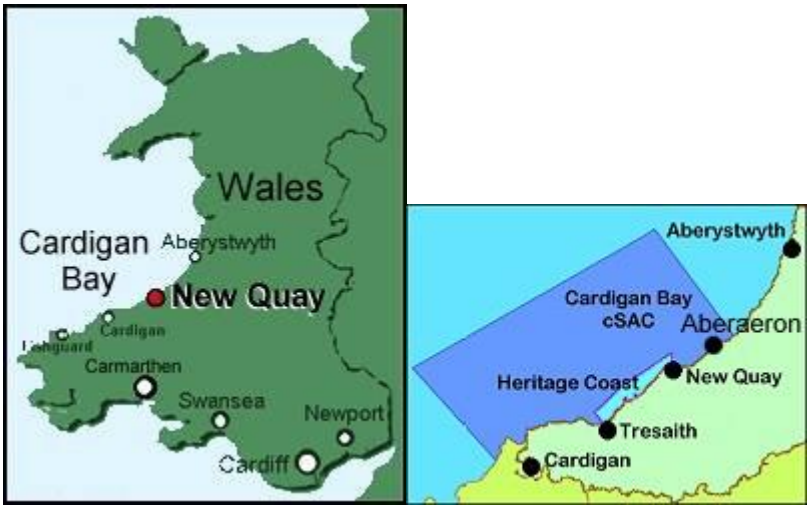

Figure 2. 1 Map of the location of Cardigan Bay within UK (Taken from http://www.newquay-westwales.co.uk) and the Cardigan Bay SAC (Taken from www.aberaeron-westwales.co.uk)

The substratum in Cardigan Bay varies from fine sand and broken shell to gravel, shingle and muddy sand, which shows an extremely heterogeneous seabed (Figure 2. 3). Tidal strength and currents shape the sediments, so that when the current is strong, more gravel is present and when the current is weak the sediments become muds. Nonetheless, Cardigan Bay has predominantly weak tidal currents, with a maximum value of reaching just 1.8 knots, the strongest currents being near headlands and estuaries, whilst the weaker currents are in the north-easternmost sector, increasing towards south and west (Evans, 1995). As elsewhere, the tides display four phases during 24 hours: two low tides and two high tides, with nearly six hours between them. The area is continually exposed to winds coming

mainly from south-west and west, where gales can occur often during the period between October and March. These gales can cause significant swells, and this may be a reason for some northwards bays such as Mwnt, Ynys Lochtyn and New Quay providing shelter for bottlenose dolphins during parts of the year (Nichols *et al.,* 1992; Ceredigion County Council *et al.,* 2001).

Sea surface temperatures in Cardigan Bay vary due to the influence of the season, the shallow seabed and input of freshwater coming from rainfall and rivers. Sea surface temperatures are lowest between February and March, with values ranging from 5° to 8.5°C, rising during August and September to between 14° and 16°C in offshore waters and 20°C in inshore waters (Baines *et al.,* 2000). The seasonal variation in sea temperatures in coastal waters tends to follow that of the offshore waters (Reichelt, 2002).

The influence of saltwater coming from the Atlantic and freshwater from the different rivers can be seen in the salinity of the waters in Cardigan Bay which is approximately 34 parts per thousand, diminishing towards the coast, and showing an increase during summer months (Ceredigion County Council *et al.,* 2008).

- Biological description

Due to its physical characteristics, Cardigan Bay displays a wide variety of marine habitats, that includes estuarine, littoral, sub-littoral, and other offshore habitats that will depend on the depth and the substratum of the area. Therefore, Cardigan Bay supports an abundant and rich fauna and flora, including a diversity of species of marine invertebrates, fish, seabirds, and marine mammals. Bottlenose dolphins have long been present in the bay, with records going back at least to the 1920's. (Evans and Scanlan, 1989; Lamb, 2004; Pierpoint *et al.,* 2009).

2.1.2 Cardigan Bay SAC

In 1992, due to concern for the conservation status of the bottlenose dolphin, Atlantic grey seal, river and sea lampreys, as well as its reefs, sandbanks and sea caves the UK Government proposed to add the southern part of Cardigan Bay as a candidate Special Area of Conservation (cSAC). These were all features listed in Annex II of the EU Habitats & Species Directive, requiring special protective measures. Later in 2004, the area was given

the full status of SAC by the European. Its area extends approximately 22 km offshore, encompassing the zone from the coast of Aberarth in the north to Cemaes Head in the south.

Following the management plan, the main objectives have been to protect marine habitats and communities and provide education towards a better knowledge and therefore better management of the ecosystems. Therefore the management plan involves the conservation of bottlenose dolphins among other sea mammals and their habitat. In order to fulfil the objectives of protecting seals, bottlenose dolphins and porpoises, a Marine Code of Conduct has been developed. This code recommends that boaters should not approach marine mammals within a distance of 100 metres and, during any approaches, they should avoid steering directly towards the animals, or to change speed or course in a sudden or erratic manner. It also recommended that people should not feed, touch or swim with the animals and should avoid any unnecessary noise around them; in particular, boaters need to be especially careful when the animals have young with them.

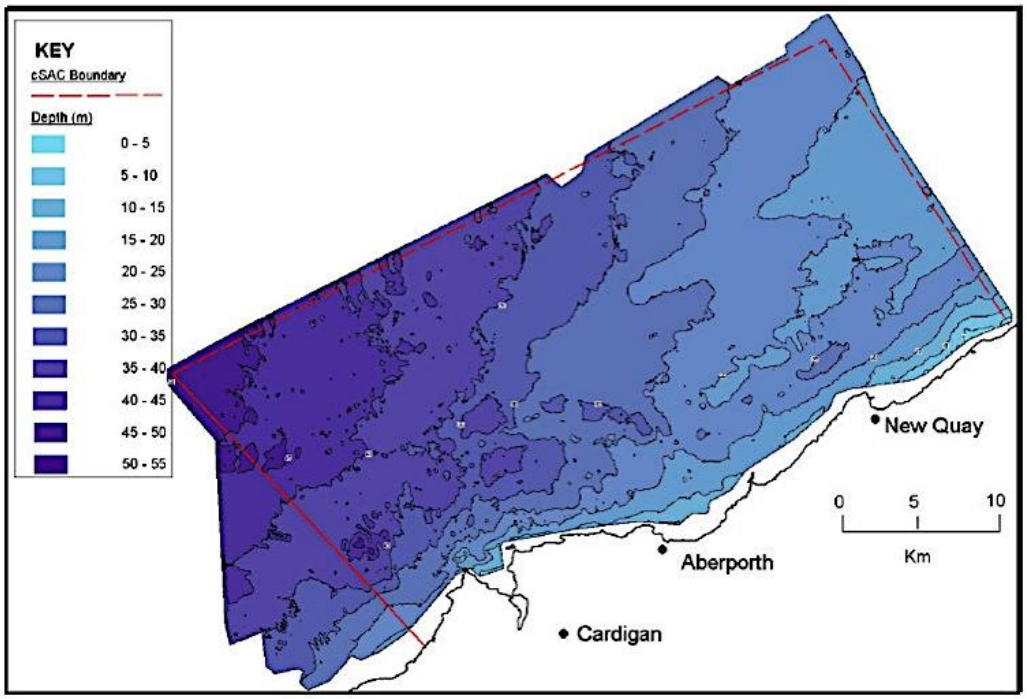

Figure 2. 2 Depth of Cardigan Bay SAC (taken from Cardigan Bay Special Area of Conservation Management Plan, 2008)

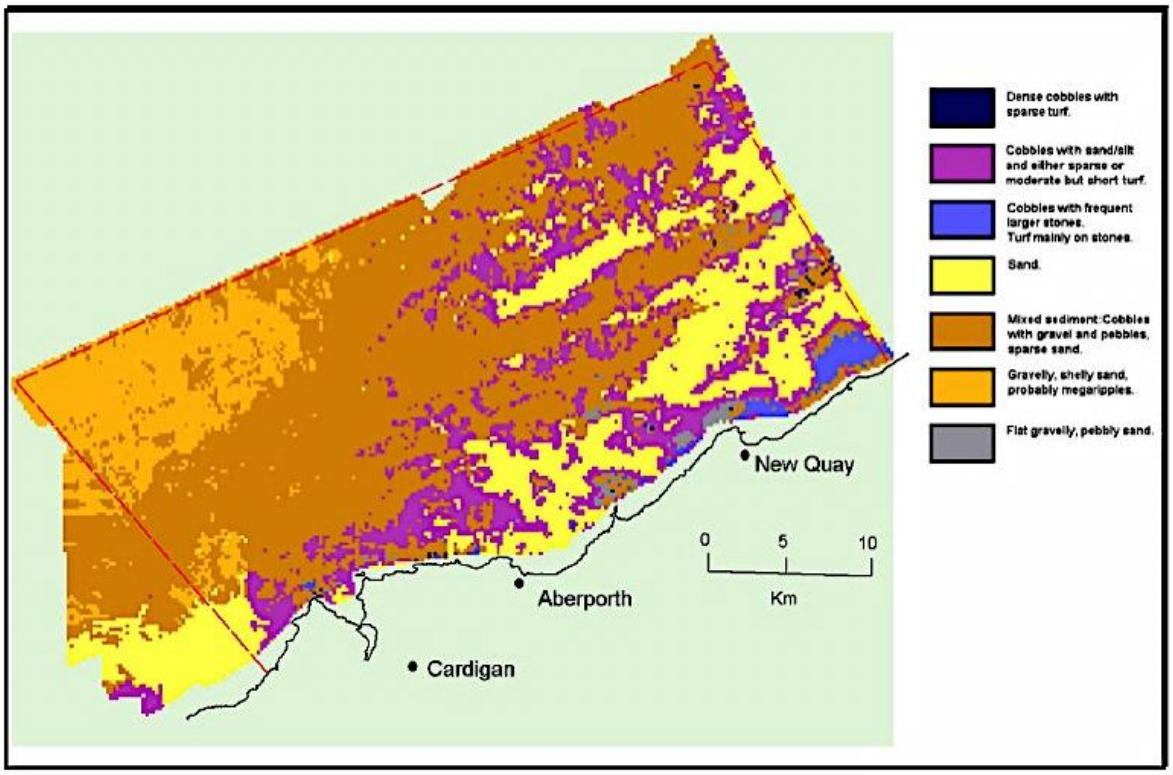

Figure 2. 3 Substrates and communities in Cardigan Bay SAC (taken from Cardigan Bay Special Area of Conservation Management Plan, 2008

2.1.3 New Quay Bay

Based on the idea that bottlenose dolphins in Cardigan Bay are mostly a coastal population, and adding that photo ID techniques are easier to develop from land in places where dolphins are seen within a couple of hundred metres of shore, land based studies have been developed, in which New Quay Bay plays an important role. Therefore, in 2004, due to the recognition of the importance of New Quay Bay for dolphins and the great amount of boat traffic that were using New Quay harbour during the summer, New Quay Bay was added to the Ceredigion County Council (CCC) studied zones and therefore Sea Watch Foundation started watches overlooking New Quay Bay from the pier.

New Quay Bay is located at Latitude 52º13’ N, and Longitude 4º21’05” W (Figure 2. 4). It is a shallow, mostly sandy bay, with depth not exceeding 15 metres, that faces north-west. On the eastern side of New Quay Bay there is a reef called Llanina Reef that extends about 600 metres offshore and which is believed to be of great importance as foraging and

feeding area for bottlenose dolphins (Stone, 2006) for its high abundance of fish species such as mackerel (*Scomber scombrus*) and bass (*Dicentrachus labrax*). On the western side, called New Quay Head, a fish-processing factory can be found. This fish factory discharges *Buccinum undatum* (whelk) shells directly into New Quay Bay waters, reaching approximately 2000 tonnes per year (Pierpoint and Allan, 2004). Recently, shells and other organic matter are being discharged, which is believed to be causing effects upon the local biodiversity. In 1836, a harbour wall was built and placed in New Quay Bay in order to protect the area; in recognition of the good view of the whole bay that it provides, this wall is nowadays the observation point for the Sea Watch Foundation land surveys that are established there to collect the data to fulfil the different research projects with distinct marine mammals of the area.

In the study site other species of animals have been seen, such as grey seal (*Halichoerus grypus*), common seal, (*Phoca vitulina*) guillemots (*Uria aalgae*), kittiwakes (*Rissa tridactila*), sea gulls (*larus* sp.), razorbills (*Alca torda*), shags (*Phalacrocorax aristotelis*) and cormorants (*Phalacrocorax carbo*), which use the cliffs in the area for breeding. Also the most common boats that frequent the area are motor boats, speed boats and sail boats.

2.1.4 Study Site

Since 2004, Sea Watch Foundation and volunteers have conducted regular systematic watches in New Quay Bay, recording the presence of dolphins and boats in the bay, along with their behaviours, and examining the effects of the boats on those activities. Although boats could cause disturbance to bottlenose dolphin behaviour, dolphins often appear to show a high level of tolerance towards boats (Lamb, 2004). Nonetheless, detailed information regarding how bottlenose dolphins use New Quay Bay and their habitat use is still largely lacking. The aim of this study was therefore to use data collected between 2001 and 2013 from both vessel based and land based observations, to describe and explain any observed temporal changes in site usage of New Quay Bay by bottlenose dolphins.

The focal area for this study was New Quay Bay, defined as the area lying between the following coordinates: north-west point - 52º13’2500 N, 4º21’52.32” W; north-east point -

52º13’2500 N, 4º20’04.94” W; south-east point - 52º12’55.78 N, 4º20’04.94” W; and south-west point - 52º13’8.84 N, 4º21’52.32” W (Figure 2. 4), covering a rectangular area of approximately 3.8 km^2, and believed to be of particular importance to the local bottlenose dolphin population (Pesante *et al*., 2008; Pierpoint *et al*., 2008; Feingold and Evans, 2014).

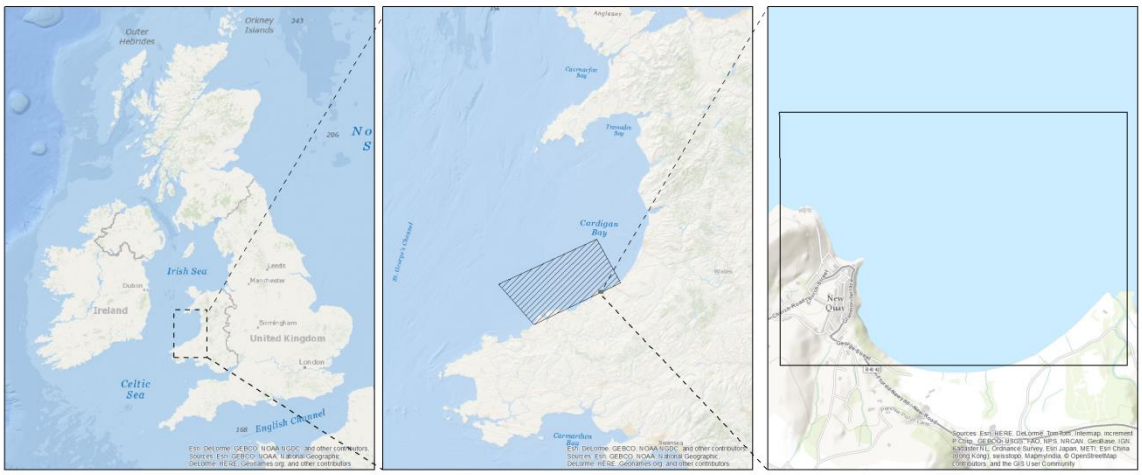

Figure 2. 4 New Quay area, used for the present study within Cardigan Bay SAC and UK

2.2 Data collection

The research of bottlenose dolphins in this area will include three field data collection phases: boat survey, land survey, and photo identification.

2.2.1 Boat based surveys

Data were collected from boat surveys from 2001 until 2013, covering all the area of Cardigan Bay, including the SAC and also New Quay Bay. A number of persons, previously trained for the data collection process, from the Sea Watch Foundation have been involved in collecting the data over the years and all the files from effort and sightings have been kept archived in a computer database available from the SWF office in New Quay. The trips were conducted in sea state Beaufort scale three or less, with swells less than 2 metres, in the presence of good light and visibility, and if rain was present, with no more than moderate strength. In cases where t the weather conditions were greater than the

ones mentioned, the survey was cancelled because this could affect visibility and therefore detection rates.

The data collection process during a single trip was taken by a minimum of five people onboard:

- Two primary observers (POs), on the roof of the vessel, who were searching for bottlenose dolphin from 90° on their side to 10° on the opposite side. They looked for animals with the naked eye, using binoculars to confirm the presence of animals or species ID. When a sighting was made, details were recorded on a standard "Sighting Form" (Figure 2. 5). The data recorded on the sighting form included sighting reference number, time, location (latitude and longitude), angle between the bow of the boat and the centre of the group seen, estimated distance of the individuals from the boat, boat course, species, group size and composition, cue used to recognised the species, associated behaviours, and the reaction of the individuals towards the boat and researchers.
- At least one independent observer (IO), stood either at the back or the front of the boat, depending upon the type of vessel and the number of crew available. IOs were looking at the sea surface, continuously scanning with binoculars. IOs were trained not to have any contact with the POs. In case of a sighting that the POs missed, IOs reveal this until the individual(s) were abeam so as to avoid influencing them. The observations from IOs were recorded on a standard "Independent Observer Form" (Figure 2. 6).

Both the sighting form and the independent observer form recorded distance and angle of the sightings. The distance was estimated by eye, usually by the more experienced PO, although all observers were previously trained with known distances of different objects, in order to be able to record distances more accurately during the survey. The angle was estimated using an angle board.

- The person collecting effort was responsible for recording the effort information on the "Effort form" (Figure 2. 7) every 15 minutes or every time one or more of the environmental variables changed or when the boat changed speed or course. There

were four different types of effort recorded during the surveys: 1) line transect, which was conducted following a predefined transect route based on the pre-established linear transects and all the observers locate in strategic positions looking for marine mammals; 2) dedicated search with the boat not following any line transect but all the observers positioned to be able to observe the animals; 3) casual watch, when weather or other conditions were not favourable for dedicated searching; and 4) photo-identification which was carried out if a sighting provided suitable conditions, by following the individuals and taking close pictures of them. The effort data recorded included time, location (latitude and longitude), boat activity in the surrounding area, boat speed and course, glare intensity, precipitation type, visibility and sea state When a marine mammal was seen, a specific sighting reference number was given, which had to be the same one as used on the sighting form.

- The person collecting Behaviour information was in charge of recording all the dolphins' activities every 3 minutes on a "Behaviour Form" (Figure 2. 8). In order to differentiate properly the behaviours, the recorded data were taken when the animals were 100 metres or less from the boat. If the distance was greater and the behaviour was hard to determine even with binoculars, then the data were recorded as unknown or uncertain. The person recorded behaviour throughout the encounter, as well as interactions with other species, and any reactions to the survey vessel. This activity also included the number of individuals seen, group formation and composition, surfacing mode and directionality. The behaviour collection ended when all the individuals were photographed from both sides, or if the animals appeared to be disturbed, or after 40 minutes period under the terms of the licence. The behaviour recorded was within the categories of normal, slow or fast swim, suspected feeding, observed feeding, leaping, resting/milling, socialising, bow riding, other or unknown.
- Photo identification techniques were recorded as photographs, taken by a researcher with a digital SLR camera with a zoom telephoto lens. The aim was to take pictures of both sides of the body of all individuals in order to be able to identify them properly.

The relative ages of individuals were recorded, using four age classes: adult, juvenile, calf and newborn. Individuals with body length between the range of 2.5 to 4 metres and that often had nicks and marks on the dorsal fin, were classified as adults. Individuals that were approximately two-thirds of the size of an adult and were usually found swimming independently were identified as juveniles. Individuals around half the length of an adult, with a clean dorsal fin and that were found swimming in a close association with a physically mature individual, were classified as calves. Those individuals with a small size, showing foetal folds along the body and displaying a small dark dorsal fin, who were found swimming next to an adult, were identified as newborns.

SIGHTING FORM
Date:________________ Type of trip: LT ☐ NLT ☐ Page:___of___ Entered into PC ☐ Checked by ____________
GMT or BST

Sight #	Time (hh.mm)	Lat (min.sec)	Long (min.sec)	Effort type	An. Ang (deg)	Boat course (deg)	Dist (m)	Species		Tot num	A	J	C	NB	Cue	Beh Dir	Reac. to Boat		Seen by
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	
		N52°	W004°					BND	HP								A	T	
								GS									U	N	

Type of trip LT = line transect surveys, NLT = other than line transect surveys GMT=Greenwich Mean Time, BST=British Summer Time Effort type LT, DS, CW, ID Species BND=bottlenose dolphin, HP=harbour porpoise, GS=grey seal A=adult, J=juvenile, C=calf, NB=newborn Cue HE=head, F=fin/fluke, L=leaping, S=splash, B=blow, BA=back, BI=bird, R=reflection, O=other, U=unknown. Behaviour For BND and HP SS=slow swim, NS=normal swim, FS=fast swim, SF=suspected feeding, FF=feeding (fish seen), L=leaping, B=bowriding, R=resting/milling, S=socializing, O=other, U=unknown, N=not recorded. For GRS H=hauled out, W=in the water Reaction to boat A=swimming away, T=swimming toward us, U=unknown, N=none.

Figure 2. 5 Sighting form

INDEPENDENT OBSERVER FORM

Date:________________ Type of trip: LT ☐ NLT ☐ Page:___of___ GMT or BST

Entered into PC ☐ Checked by ____________

IO #	Time (hh.mm)	Lat (min.sec)	Long (min.sec)	An. Ang. (deg)	Boat course (deg)	Dist (m)	Species	Ind. #	Cue	Effort type	Seen by prim.platform?	If yes, sighting #	Seen by	Comments
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			
		N52°	W004°				BND HP GS			LT DS	Y N			

Type of trip LT = line transect surveys, NLT = other than line transect surveys; GMT=Greenwich Mean Time, BST=British Summer Time; Species BND=bottlenose dolphin, HP=harbour porpoise, GS=grey seal Cue F=fin/fluke, L=leaping (body out of water), S=splash, B=blow, BA=back, BI=bird, R=reflection, O= other, U=unknown. Effort type LT=line transect, DS=dedicated search.

Figure 2. 6 Independent observer form

EFFORT FORM

Boat: ____________ Person responsible for data ______________ Crew: __________________________________ Page ___of ___

Date: __________________ Time start ___________ Time end ___________ GMT or BST Type of trip: LT ☐ NLT ☐

Time hh.mm	Lat. (min.sec)	Long. (min.sec)	Transect	Leg num.	Tran. point	Boat act.	Speed knots	Course Deg.	Glare degrees	Effort type	Precipitation Type	Precipitation Int.	Visibility (km)	Sea state B	Sea state S	Sigh. ref.	Comments
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				
	N52°	W004°		S C E					0 1 2 3	CW DS LT ID	N R F	I C L M H	<1 1-5 6-10 >10				

Type of trip LT = line transect surveys, NLT = other than line transect surveys; Leg S=start, C=continuation, E=end; Boat activity NB=none, YA=yatch or sailing, RB=kayak, JS=jet ski, SB=speed boat, MB=motorboat, FI=fishing boat, Fe=ferry, LS=>30m; Glare 0=no glare, 1=mild, minimal impact on sightability, 2=moderate, 3=severe Effort type CW=casual watch, DS=dedicated search, LT=line transect, ID=photoid; Precipitation type N=none, R=rain, F=fog, I=intermittent, C=continuous, L=light, M=moderate, H=heavy; Sea state B=sea state in Beaufort scale, S=swell presence and height (L= <1m, M= ≥1 and <2, H ≥ 2m). Entered into PC by _____________ Checked by_____________________

Figure 2. 7 Effort form

Date _____ sight # _____ from _____ Line _____

set	Time	Lat N	Long E	sea st	Group form: a	l	l	d	s	p	dis	surf mode: q	p	u	Direct.: no	po	st	Main Behaviors: ss	ns	fs	ff	sf	b	r	s	o	u	other: ab	pb	Group comp: a	j	c	n	Tot	bird	Dep	Boat dist	Skin swab	Time swab	note #
	:	52	004																																				:	1
	:	52	004																																				:	2
	:	52	004																																				:	3
	:	52	004																																				:	4
	:	52	004																																				:	5
	:	52	004																																				:	6
	:	52	004																																				:	7
	:	52	004																																				:	8
	:	52	004																																				:	9
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	:	52	004																																				:	28
	:	52	004																																				:	29
	:	52	004																																				:	30

Group form: a: single, t: tight, l: loose, d: dispersed, s: subgroups, p: patchy **dis**: dolphins in sight **surf mode**: Q: quiet, P: peppy, U: uncertain
Direction: no: none, po: poor, st: straight **Behaviors**: SS: slow swim, NS: normal swim, FS fast swim, FF feeding, SF: suspected feeding
AB: aerial behavior, PB: percussive behavior, B: bow-ride, R: resting/milling, S: socializing, O: other, U: unknown, NR: not recorded
Birds: A:0, B:2-5, C:6-10, D:>10 **Group Composition**: A: adults, J: juveniles, C: calves, N: newborns
Boat Dist: A:<5, B: 5-30, C:30-100, D: >100 meters

Note #

Figure 2. 8 Behaviour form

Different types of vessels have been used, including commercial vessels and research vessels, in order to fulfil the distinct boat surveys, in which two types of observations or sampling method have been developed, line-transect and *ad libitum* surveys (Feingold & Evans, 2014).

The vessels used for the data analysed in this study were:

- Ermol V: this is a 11.5 metres length vessel, powered by a twin 128hp diesel engine. A New Quay wildlife tour operator owns this; it travels for 2 hour long coastal trips, covering the Heritage coast. SWF volunteers have joined these trips in order to collect data and pictures to be able to gather information about the presence and distribution of the marine mammals in the area.
- Ermol VI: this vessel has a length of 10.9 metres, powered by a 350hp diesel engine. As Ermol V vessel, this one is owned by a New Quay wildlife tour operator, it travels for 1 hour long coastal trips, covering the Heritage coast. SWF volunteers have joined these trips in order to collect data and pictures to be able to gather information about the presence and distribution of the marine mammals in the area.
- Dunbar Castle II: this is a 9.7 metres vessel, powered by a 120 hp inboard diesel engine. The vessel was moored in New Quay, where trips always started and ended. On the roof of the boat there was a bench to allow the primary observers a clear view, making observations at 3.5 m above the sea level. All the surveys were established with a minimum of 5 observers in order to cover all aspects of data collection: 2 primary observers, 2 independent observers and one person collecting effort.
- Gallois: this is a 5 metres length RIB, powered by a 60hp petrol engine. It was used for *ad libitum* surveys, in which effort and sightings were recorded and in the event of dolphins sighted close to the RIB, pictures were taken for photo ID purposes.
- Islander: this is a 7 metres length vessel, powered by a twin 60hp petrol engine. It was used for *ad libitum* surveys, in which effort and sightings were recorded and in the event of dolphins sighted close to the boat, pictures were taken for photo ID purposes.

- Sulaire: this is a motorboat used between 2003 and 2004 to conduct line transect surveys, where effort and sightings data were recorded and pictures were taken when the animal were close to analyse them for photo ID commitments.

2.2.1.1 Line Transect surveys

Line-transect surveys are a distance sampling method used to study cetaceans. They have been conducted by the Sea Watch Foundation in previous studies throughout Cardigan Bay SAC, aiming to estimate the number of individuals of different species of marine mammals. In order to do so, a large effort was required to obtain reliable estimates; therefore, with the idea of maximising sample size, a grid of systematically spaced lines was superimposed on the area of the SAC. At the same time, the area of the SAC was divided into two zones, inshore, at approximately 11 kilometres from the coast and offshore at about 23 kilometres from the coast. The limit between the two zones is given by the line that crosses the coordinates 52.15°N, 4.89°W and 52.33°N, 4.31°W (Pesante *et al.,* 2008). In both zones, pre-defined routes have been established, called transects, which at the same time are divided into legs, each having a starting and ending point known as transect points (Figure 2. 9).

Each survey transect was chosen at random, before leaving the harbour. In case of bad weather, insufficient time or some other factor preventing the survey to be completed that day, it was continued during the next survey.

In addition, the pre-selected transect was travelled by the vessels at the same speed of approximately 8 knots. All the data were collected on the respective forms. In case of a movement away from the transect, to follow the sighting or to conduct photo-identification, it was always followed back, resuming at the point where the line was left before.

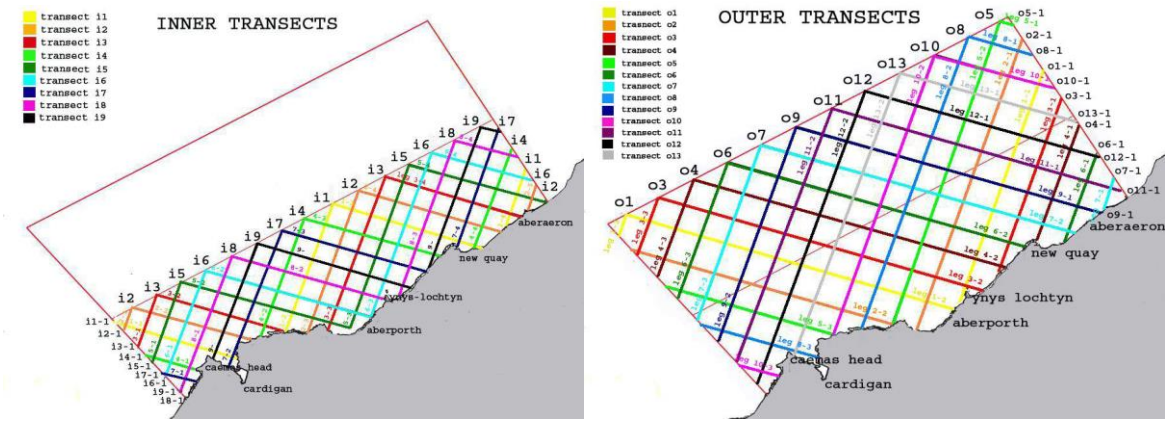


Figure 2. 9 Inner and outer zones, with the respective line transect numbers, legs and points.

2.2.1.2 Non-Linear Transect surveys

Ad libitum surveys were performed in addition to line transects. During these random direction journeys, effort and sightings data were recorded as described above (Section 2.2.1).

It is well known that bottlenose dolphins are seen in some specific zones within Cardigan Bay with higher frequencies, and therefore, in order to be able to get an estimate of the occurrence, distribution and movements of the individuals of this species throughout Cardigan Bay, a wider area encompassing both Llyn a'r Sarnau and Cardigan Bay SACs as well as other parts of the bay were surveyed.

The *ad libitum* or non-linear transect surveys included "Dedicated Search" and "Casual Watch". As mentioned before, Dedicated Search was conducted with the boat not following a pre-determined line transect; nonetheless all the observers were positioned to be able to observe the animals and collect the data needed. Casual Watch took place when weather or other conditions were unfavourable for systematic survey. In addition, one- and two-hour trips were conducted by the New Quay wildlife tour operator along the coast, with one to two SWF volunteers aboard these platforms of opportunity to collect effort and sightings data and ID pictures of any marine mammals encountered. These usually involved Dedicated Search but at times were interrupted either for photo ID or some other activity

2.2.2 Land based surveys

Given that the pier in New Quay provides a good viewpoint of almost all of New Quay Bay, trained volunteers from all around the world conducted observations from that point. New Quay surveys were performed between 2001 and 2013, from April to early November, covering the summer season, during daylight hours, weather and light permitting, between 7am and 9pm, divided in two hours shifts, each one being covered by two volunteers that were looking for bottlenose dolphins with naked eye as well as with binoculars. At the same time, each shift was divided in 8 successive 15-minute intervals, where all sightings data and effort information were taken on the standard "Land based survey form" (Figure 2. 10) where time, weather conditions, sea state, group size, group composition, travel direction and behaviour were recorded. When a sighting was made, dolphin movements were followed using binoculars, and where possible, photographs were taken in an attempt to identify the individuals. In addition, a mapping system with 8 identic maps was added to the sightings, where the bottlenose dolphin individuals seen were plotted on a specific map of the area, where each map corresponds to each 15 minutes interval effort (Figure 2. 11). Therefore, location, time, group size and behaviour were recorded, rather when the 15 minutes interval started or when the encounter was made. Presence of calves was important to be recorded since New Quay area is believed to be a breeding area. In order to accurately plot the position of dolphins and their movements in New Quay Bay, each map had three sets of marker buoys, to use as reference points. Also, during the sighting, the presence of boats was recorded, adding information such as type of boat, position, direction and reaction of the dolphins towards the vessels.

NEW QUAY LAND WATCH: EFFORT Name: **Date:**

Map	Effort time (GMT/BST) Start	End	Sea state	Wind direction	Visibility	Sighting?	Boat enc no.	Notes
A								
B								
C								
D								
E								
F								
G								
H								

Number of boats seen

BOAT TYPE		Log	Total	BOAT TYPE		Log	Total
sMB	Recreational motor boat <15m			RB	Row boat, kayak or other paddled craft		
mMB	Recreational motor boat 15-30m			JS	Jet Ski		
SB	Racing type speedboat or RIB			R	Cetacean research boat		
YA	Any boat under sail (including windsurfer)			FE	Ferry		
FI	Fishing boat			LS	Ship >30m		
VPB	Visitor passenger boat						

NEW QUAY LAND WATCH Name: **Date & watch start time:** **Page…..of…..**

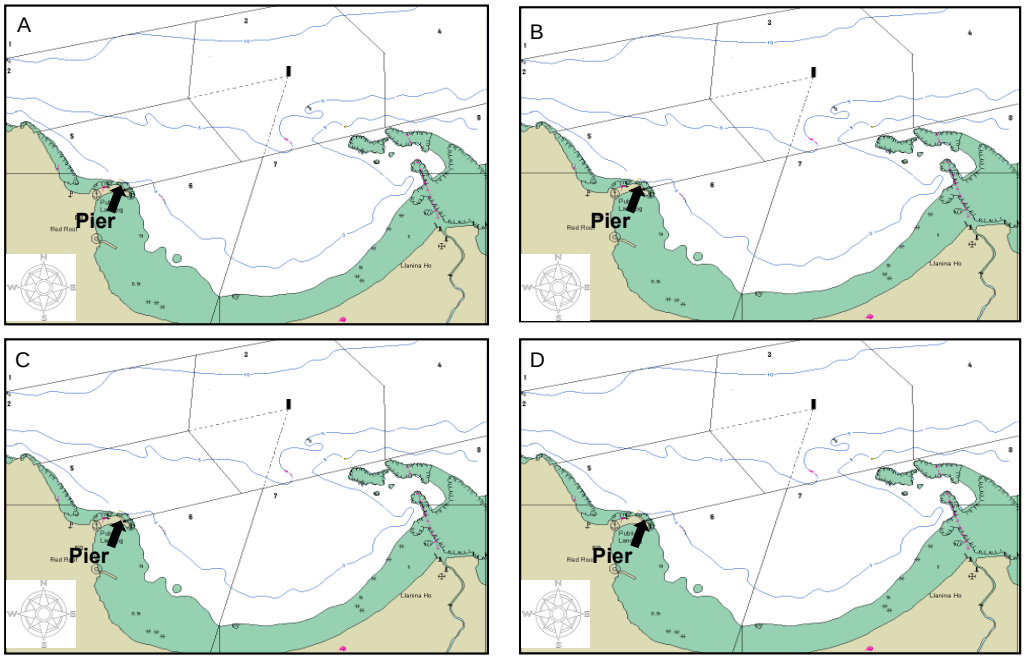
Boat encounters

Boat enc. number	Boat type	Boat Name	No boats <300m	Distance to animals	Boat behaviour	Cetacean behaviour	Reaction to boat
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U
							A T N U

Behaviour: R-Resting/milling, SURF-Surfacing, NS-Normal swin (3-6 kn), FS-Fast swim (>6 kn), S-Socializing, SF-Suspected feeding, DIV-Long dives, thought to be forgaing at depth, FF-Feeding (fish seen), AB-Aerial behaviour: non percussive, dolphins clear water with whole or majority of their body, PB-Dolphin hits water with any part of body, U-Unknown, O-Other, B-Bowriding, GS-Group splits, disperses, GF-Form close, tight group, NC-No change: applies only to boat encounter when there is no change in animals original behaviour. **Boat's closest distance to cetaceans: A-** Distance is less than 50 metres, B- Distance is between 50 and 100 metres, C- Distance is between 100 and 200 metres, D- Distance is between 200 and 300 metres. **Boat behaviour: Y1-** No wake speed & no erratic changes in course when passing cetaceans, Y2- Slowed down and gradually stopped, N1-Too fast: bow/wake speed, white water visible, N2- Erratic course to approach to avoid/follow cetaceans, N3- Attempted to touch/feed/swim with cetaceans, N4- Exceeded 8 kn inside yellow buoys. Boat names: E6-Ermol VI, E5-Ermol V, DUN-Dunbar, KAT-Katherine Arden (big blue FI), AB2-AB2 (red & black FI), SUL-Sulaire (blue & white passenger boat), ISL-Islander, SAC-SAC boat, KIR-Kirsty Ann (large yellow FI), GAL-Boat Gallois (SWF RIB). Reaction to boat: A-Away, T-Towards, N-Neutral, U-Unknown.

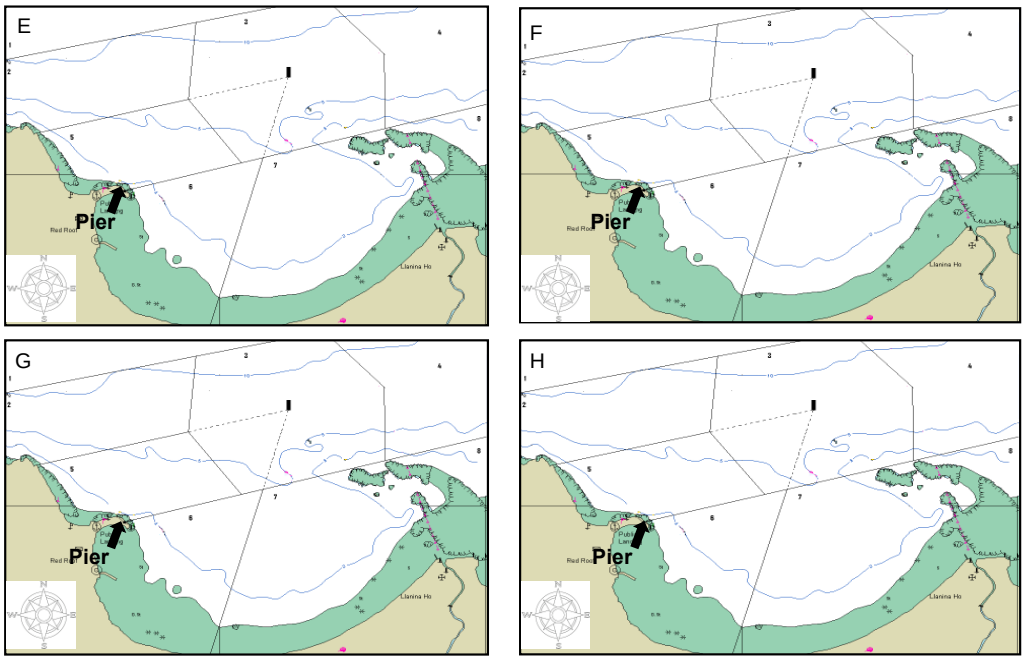
Figure 2. 10 Land based form for effort and sightings

NEW QUAY LAND WATCH **Name:** **Date & watch start time:**



Write the species, number animals & behaviour in the correct location on the map. Note the heading direction with an arrow if there is one. Also add boats that involved in an encounter with a 'X' & boat name/type.

NEW QUAY LAND WATCH **Name:** **Date & watch start time:**



Write the species, number animals & behaviour in the correct location on the map. Note the heading direction with an arrow if there is one. Also add boats that involved in an encounter with a 'X' & boat name/type.

Figure 2. 11 Land based form. Each map represents one 15-minute interval.

2.2.3 Photo-Identification

During line transect surveys, *ad libitum* surveys, and land based surveys, covering both Llyn a'r Sarnau and Cardigan Bay SACs, as well as other parts of Cardigan Bay, photos were taken of each individual seen, concentrating upon the dorsal fin, with pictures of both right and left sides taken if possible. In order to obtain appropriate pictures that could be analysed and compared, a camera equipped with a high quality zoom lens was used, settling it to the speed priority program of 1/1000 sec. In addition, pictures taken by other people or organisations were added to the analysis, resulting in the SWF catalogue that now holds at least 380 recognised individuals, where 248 are "well-marked" (dolphins that have nicks on the dorsal fin or visible marks or pigmentations on both sides of the fin and therefore can be recognised from both sides, using even a poorer quality picture), and at least 132 "slightly-marked" (individuals with nicks or marks that are minor and therefore to confidently identify the individual, medium or high quality pictures were needed) (Feingold & Evans, 2014) (Figure 2. 12). In the latter case, images of individuals are divided into "right" where individual identification is based on the right side of the dorsal fin only, and "left" where identification is based on the left side of the dorsal fin only. Thus some individuals may be represented in both "left" and "right" catalogues but these need to be treated separately. In order to identify the individuals and match the pictures taken, analyses in Adobe Photoshop 7.0 and/or ACDSee Pro were conducted. Only high quality pictures were used to confirm the identity of an individual, which was also checked by a second person, avoiding false positive or false negative matches. Since the 1990s, SWF has been taking pictures of the Cardigan Bay bottlenose dolphin population, which has allowed the catalogue to be enriched over time with more individual observations, as well as with a greater area of survey coverage. Also, an additional item has been added to the land surveys in the past couple of years, the digiscope system. It includes a tripod in which a camera together with a telescope are mounted, allowing to take a better quality pictures from far distances, that can be afterwards identify better and more accurate for photo ID purposes. This means that in a particular encounter where dolphins were far from New Quay pier, a normal picture with the zoom of the camera was difficult to be analysed and therefore the identification of the individual(s) could not be possible, nonetheless, using the disgiscope increased the details in the picture and therefore the identification process was more feasible.

Figure 2. 12 Four identified bottlenose dolphin individuals, two well-marked above and two slightly-marked below

2.3 Data analysis

2.3.1 Compiling the data

Since this study involves a temporal analysis of the data collected from 2001 to 2014 (from April until June), and in order to get familiar with the data collection procedure as well as with the previous information recorded in those years, for a two months period during the summer of 2014, boat based surveys and also land based watches were performed.

In order to understand the data collection on boats, surveys on Dunbar Castle II, Ermol V and on Ermol VI were completed. Line transect as well as dedicated search and 1 and 2 hour trips were finished, all of them covering Cardigan Bay area, a wider area of New Quay Bay.

Based on that, surveys on Dunbar Castle II, started early at 5 in the morning in order to be out on the field until the afternoon and being able to collect data and analyse if time of day was related to the presence of bottlenose dolphins. Since Dunbar was following the line transect method, all the activities on board were developed in a rotation model, collecting data in the respective forms as primary observer, independent observer, effort and behaviour collector and photo ID person as well, which gave a minimum of 6 persons on board.

In the other hand, trips in Ermol V and Ermol VI from the local tour operator company were conducted in 2 and 1-hour trips respectively. Since the company organises many trips in a day during the summer season, the survey was chosen to be in the moment where the weather was more appropriate for the sightings, allowing recording data at different times of the day. In this case the data collection was in charge of just one person, who had access to binoculars and GPS and the respectively standard forms. Therefore, this person was recording all the effort data, sightings data and in the event of an encounter, photo ID and behaviour information as well.

During land watches, SWF has a rotation model also, in which volunteers rotate the time of their watch and day as well. Therefore, as part of this rotation, land watches were conducted in a 2-hours period, at different times of day in different days, weather dependent. From the beginning of the shift all the effort information was recorded every 15 minutes. In the moment of dolphins presence the maps were used, recording on them the species, the number of individuals, the direction, the behaviour they were presenting and in case of any boats in the vicinity, the reaction of the animals toward those. At the same time, pictures were taken, trying to cover both right and left side of the fin if possible. The animals where followed using binoculars, whilst recording all the time their behaviour until they left the area and were no longer seen from the pier or until the person for the new shift could take place.

After the surveys, the information collected was transfer into computers in order to systematise all the data and save in the SWF database. In this way, the data collection process was known, the forms where understood and the previous years data were more

accessible. Emphasis in data were made in those variables that were used in the present study such as behaviour, presence of vessels, and the reaction of the individuals towards these boats and group composition emphasised in mother and calves presence besides time of the day and date.

2.3.2 Analytical approaches

After all the previous years data were copied from the SWF database, encompassing all the surveys made in different vessels and from land watches also, the first step into the analysis of it was to choose only the information between 2001 to 2013, which was recorded in a standard method that would allow the proper analysis. Afterwards, the first filter was grouping the data for bottlenose dolphin sightings, this because SWF studies involve the bottlenose dolphins but also other cetacean species as well as other marine mammals. Therefore, the following analysis was encompassing the data concerning to only those sightings that were made in New Quay area, used for the present study. Therefore ArcGIS was used to filtered latitude and longitude of the sightings. Once this was done, having the information of bottlenose dolphin sightings in the study site, the data were fixed and ready for the present purpose.

In the other hand, for data concerning marked individuals of bottlenose dolphins, after coping the data for the database, the sightings made between 2001 and 2013 were compiled and later were geographical analysed with ArcGIS, to find out those that were made in New Quay study area.

In this way, both, general bottlenose dolphin sightings and marked individuals sightings data were properly arranged for the analysis towards answering the aims and hypotheses of this study.

For the purposes of analysing how season, month and time of the day are related with bottlenose dolphins presence, season categories were established by First half of Early summer: 20th May - 7th June; Second half of Early summer: 8th - 26th June; First half of Mid summer: 27th June - 15th July; Second half of Mid summer: 16th July - 3rd Aug; First half of Late summer: 4th - 22nd Aug and Second half of Late summer: 23rd Aug - 10th Sept. Parallel to this, time of the days categories were established as 1: 06:00-07:59; 2:

08:00-09:59; 3: 10:00-11:59; 4: 12:00-13:59; 5: 14:00-15:59; 6:16:00-17:59; 7: 18:00-19:59 and 8: 20:00-21:59.

In addition, to analyse habitat use, a grid system with 6.47 arc seconds segment grid was performed over the study site map containing all the sightings. Based on that, the number of times that each square was used by bottlenose dolphins could be analysed.

2.3.3 Statistical analysis

Using IBM SPSS Software, different statistical tests were conducted depending on the appropriate one to fulfil the objectives of interest. Therefore ANOVA test was used to determine whether there are differences in site usage of New Quay Bay and presence of bottlenose dolphins according to presence of a calf, boat traffic, behaviour, time of day, time of the month and season, and Mann-Whitney test as well as pairwise comparison and correlation were used in other analysis cases, where further detail was needed to see where was the larger sample size of those evaluated variables.

3. Results

In order to investigate the changes in bottlense dolphin presence in New Quay Bay over time, as well as to establish temporal changes in site usage of individual bottlenose dolphin, data were collected from 2001 to 2014 (from April until June) from land- and vessel-based surveys in their respective forms. Analyses included examing the factors that influenced dolphin presence in the bay such as year, month, season, time of the day and vessel presence. In order to analyse site usage of particular individuals, marked animals were also analysed on a temporal scales, evaluating their behaviour in the area. In addition to this, presence of mothers and calves were also analysed related to the previous mentioned factors. Statistical analyses were run using IBM SPSS Software.

3.1 Boat surveys

From boat surveys, between 2001 and 2014, there were 1230.25 hours of effort in New Quay Bay, with 198.75 hours when bottlenose dolphins were seen in the study area. The number of hours of effort is presented in Table 3. 1. The effort in each day, month and year was not equal across time due to bad weather conditions or due to the availability of volunteers to collect the data.

Table 3. 1 Number of hours of data collection for the years of the study

Year	Effort Hours
2001	30.75
2002	46.5
2003	60.5
2004	33.75
2005	52.25
2006	67
2007	29
2008	92.25
2009	205
2010	133.25
2011	215.75
2012	131.25
2013	113.5
2014	19.5

3.1.1 Bottlenose dolphin Presence

Over the sampled period, the change in presence of bottlenose dolphins was analysed in terms of year and month. A significant difference in presence of *Tursiops truncatus* was found to happen across the different sampled years (One-way ANOVA: $F_{1,26}$= 4.22, p<0.001) (Figure 3. 1) as well as in the months (One-way ANOVA: $F_{1,12}$= 4.75, p= 0.007). In addition, a pairwise comparison was evaluated, which indicated that April was the month with fewer bottlenose dolphins sightings whilst July had the highest number of sightings (Pairwise comparison: p=0.015). In the same way, even though the effort every year was found to be unequally distributed, the number of bottlenose dolphins positive (BND +ve) hours of sightings was found to be related to both year and month as well (Figure 3. 2**Error! Reference source not found.**). In addition, during the surveys made by the Sea Watch Foundation, there was a change in the methodology of the data collection during 2006, which could create this big jump that is seen between 2007 and 2008 in dolphins presence in New Quay study area (Figure 3. 1).

The low number of sightings during 2014 is due to the fact that the data analysed in this study encompasses only the information collected on the survey only until June and therefore the other summer months are missing, which will give a greater sample size.

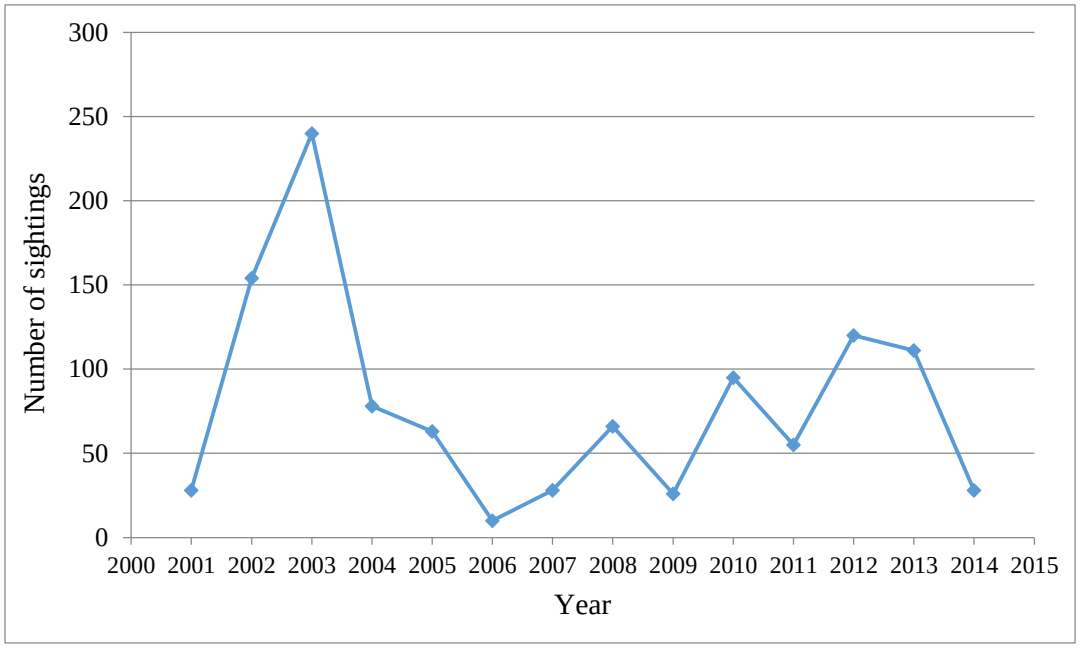


Figure 3. 1 Number of sightings per year in the study area

Table 3. 2 BND +ve hours of sightings for the years of the study.

Year	BND +ve hours sightings
2001	7
2002	18
2003	28.5
2004	14.5
2005	12.75
2006	2.25
2007	6.75
2008	15
2009	5.75
2010	19.75
2011	10.75
2012	27.75
2013	23.75
2014	6.25

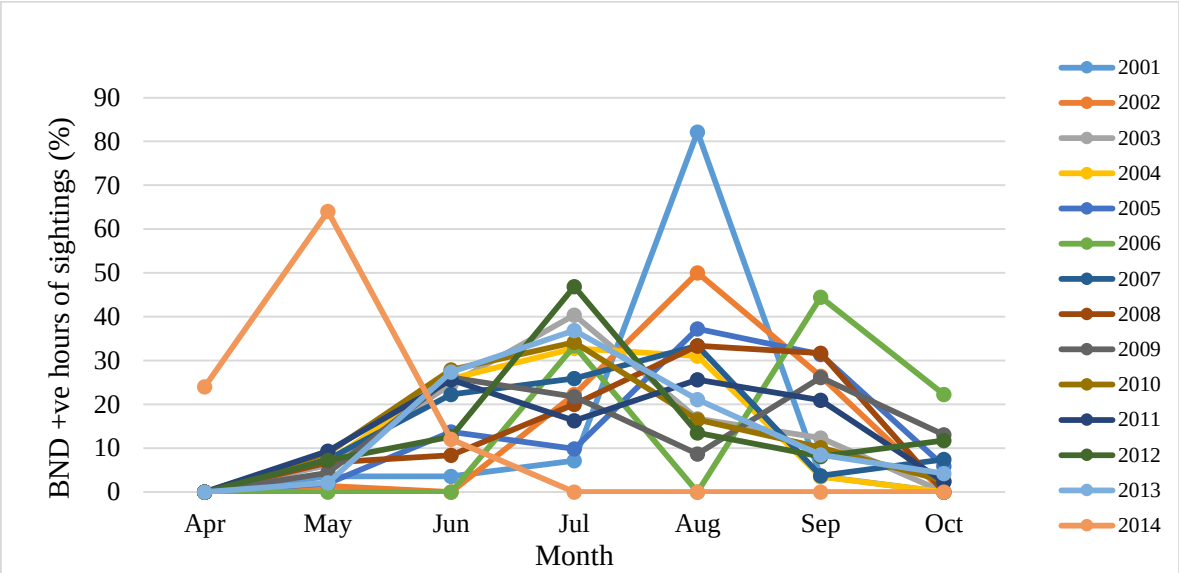


Figure 3. 2 BND +ve hours of sightings per month for the years of the study

3.1.2 Behavioural patterns

In order to being able to analyse how bottlenose dolphin presence changes in New Quay Bay and to see how the animals use the bay over time, each behaviour was calculated for the years of data collection (Table 3. 3). Some other behavioural patterns such as socialising, resting, breaching or milling occurred at low frequency and therefore are not considered further for this analysis.

Table 3. 3 Most frequent behavioural patterns seen in bottlenose dolphin in New Quay Bay study area

Behaviour	Frequency (%)
Feeding/Suspected feeding	52.90
Normal swimming	28.77
Foraging	1.63
Traveling	1.36
Fast swimming	1.36

Most frequent behavioural patterns were found to be significantly different (p=0.034) but previous analysis of those showed that the difference lay in the low sample size of feeding and foraging behaviours (Mann-Whitney W= 30.5, p= 0.004). Data were analysed monthly (Table 3. 4), in order to see if the bottlenose dolphin activities in the bay change depending upon the season. Nevertheless, from April until October, actual feeding behaviour was the most frequent activity undertaken by the bottlenose dolphins (Figure 3. 3). The second most

frequent behavioural pattern was foraging. However, there was no significant difference in the amount of time spent travelling and foraging (Pairwise comparison, p= 0.83).

Table 3. 4 Monthly variation in frequency of the most seen behavioural patterns

	Feeding and suspected feeding (%)	Foraging (%)	Traveling (%)
April	100	0	0
May	86.36	0	13.64
June	93.97	3.45	2.59
July	92.61	5.42	1.97
August	95	1.88	3.13
September	100	0	0
October	100	0	0

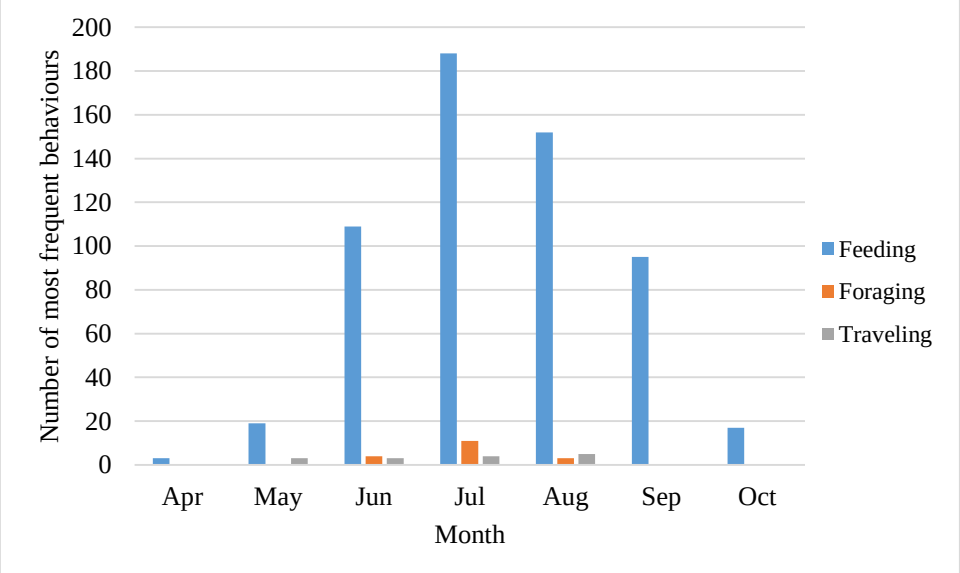


Figure 3. 3 Most frequent behavioural patterns by month

3.1.3 Boat interactions

During the vessel based surveys from 2006 until 2014, 377 boat interactions were seen between bottlenose dolphins and vessels that were close to the animals in the study area. The majority of the interactions were neutral or none towards the boat presence (84.08%), but positive and negative responses were similarly low (9.55% and 6.37% respectively) (Figure 3. 4). The proportions of the reactions of these responses are significantly different from each other (One-way ANOVA $F_{1,4}$= 7.70, p=0.026) although the greatest difference was between neutral and negative responses (p=0.038).

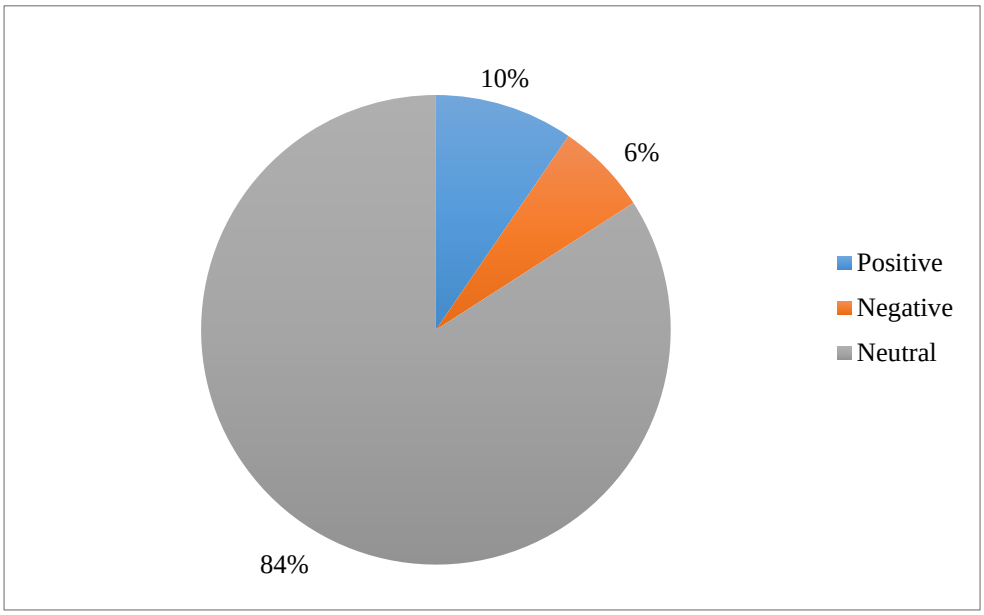


Figure 3. 4 Behaviour reaction due to presence of boats in New Quay Bay study area between 2006 until 2014

In addition, the interaction between bottlenose dolphins and boats was analysed annually (Figure 3. 5), showing that the responses vary highly significantly (One-way ANOVA: $F_{3,26}$= 2.97, p< 0.001), which can be seen also in the daily variation in the interactions (One-way ANOVA: $F_{3,28}$= 2.94, p= 0.005), showing a general increase in tolerance towards the presence of boats (Figure 3. 6).

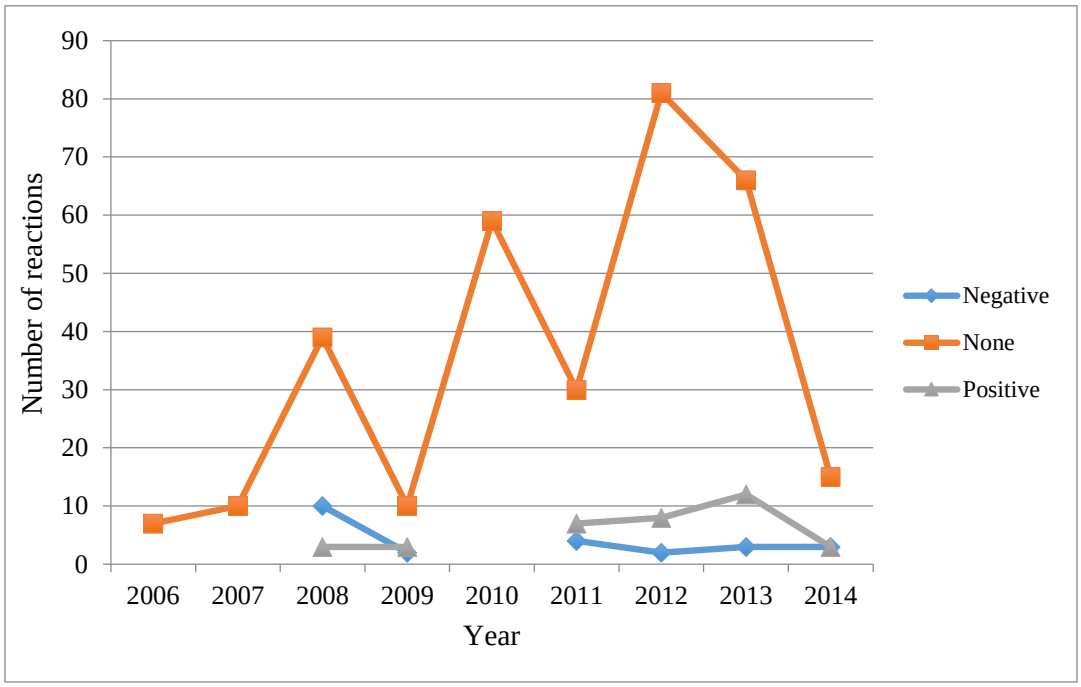


Figure 3. 5 Behavioural reactions due to presence of boats between 2006 and 2014

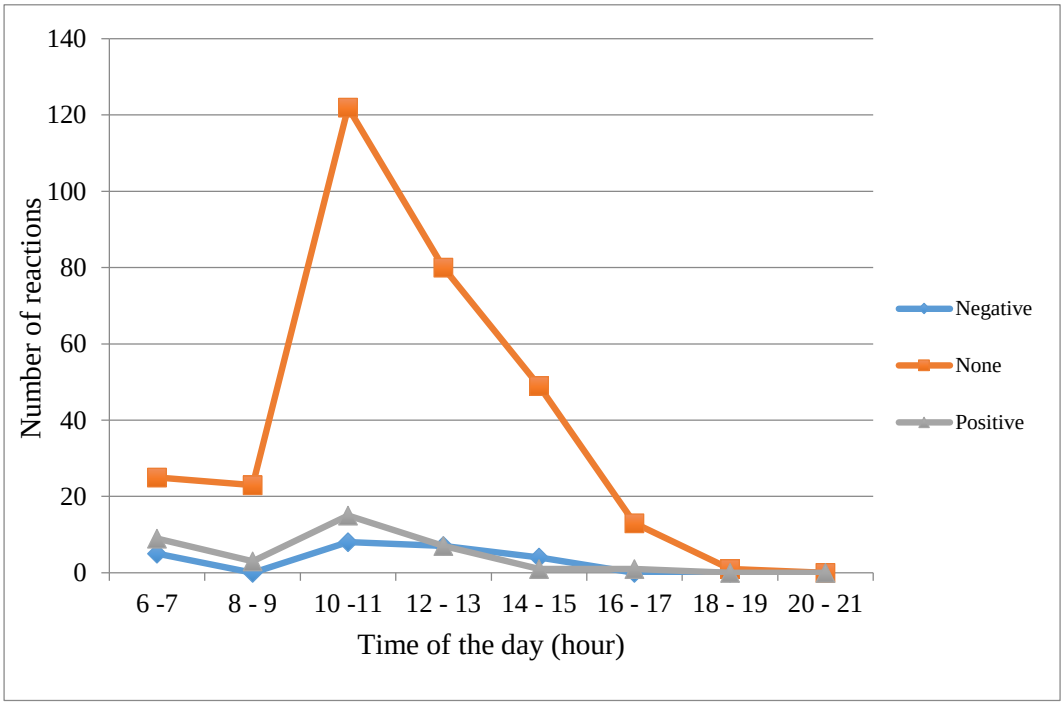


Figure 3. 6 Behavioural reactions due to presence of boats in different times of the day

3.1.4 Habitat use

In order to be able to analyse bottlenose dolphin habitat use in New Quay Bay, a 6.47 arc seconds segment grid was overlaid on top of the study area (see **Error! Reference source not found.**). To determine bottlenose dolphin presence, as well as habitat use in the area, a grid colour coded by percentage was made to establish those grids that were used most by the individuals. The activities that bottlenose dolphins showed, as total use and feeding, foraging and travelling are not all present with the same frequency and extent in New Quay Bay study area (G-test $p<0.001$).

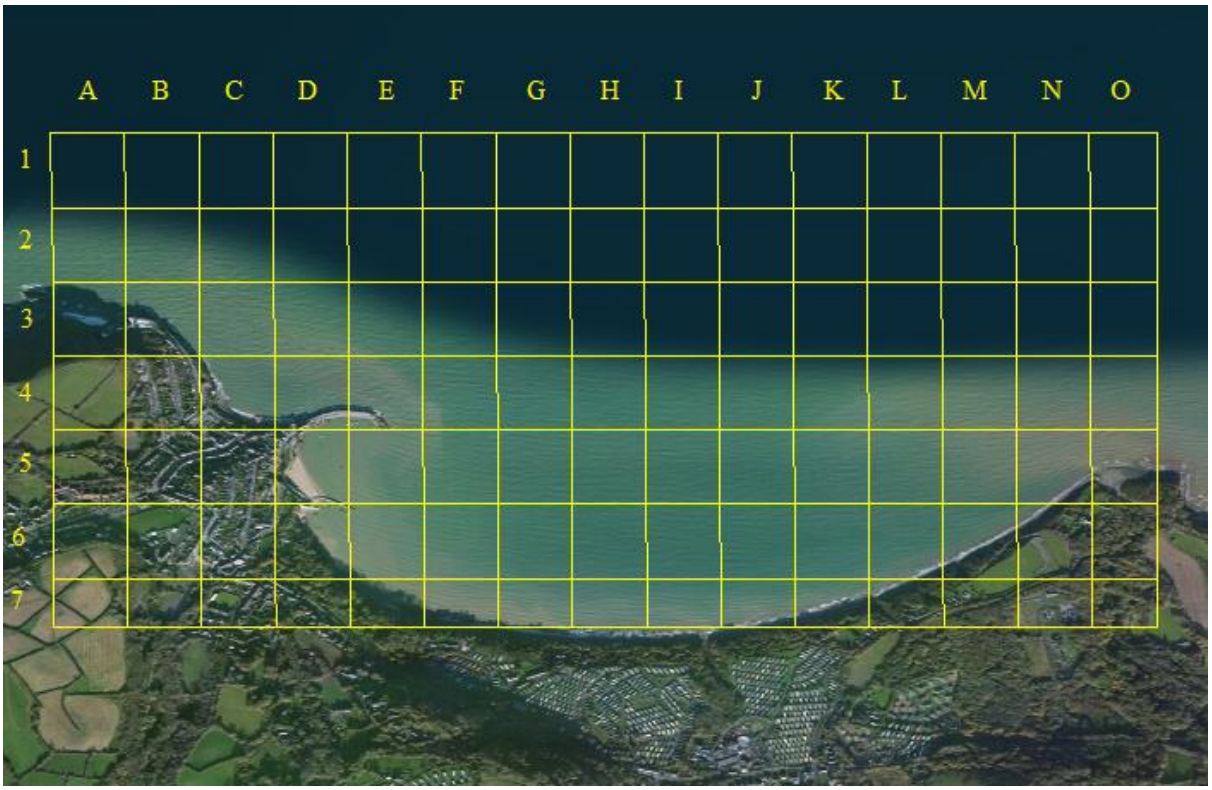


Figure 3. 7 A grid system of 6.47 arc seconds segment grid overlays in New Quay study area

Table 3. 5 Grid colour coded by percentages for total use of the study area

% of Use	Colour
0	
0.1 - 1	
1.1 - 3	
3.1 - 5	
5.1 - 7	
7.1 - 9	

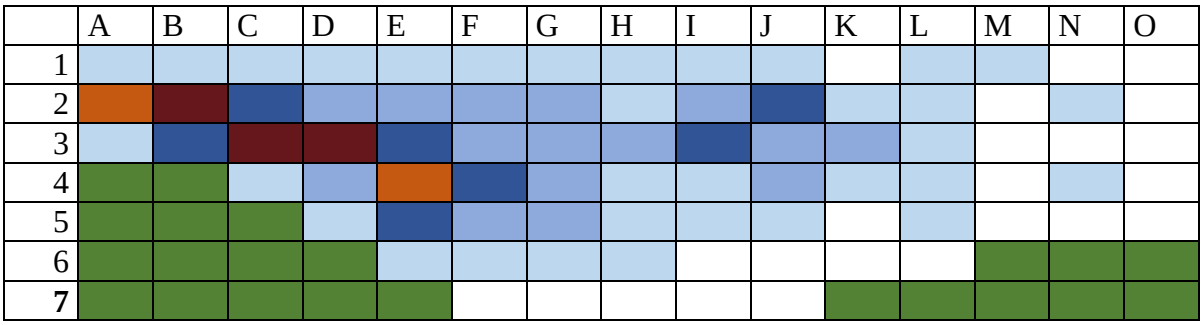


Figure 3. 8 Total use of the study area base on the grid colour code

Table 3. 6 Grid colour coded by percentages for feeding and suspected feeding behaviour in the study area

% of Use	Colour
0	
0.1 - 1	
1.1 - 3	
3.1 - 5	
5.1 - 7	
7.1 - 10	

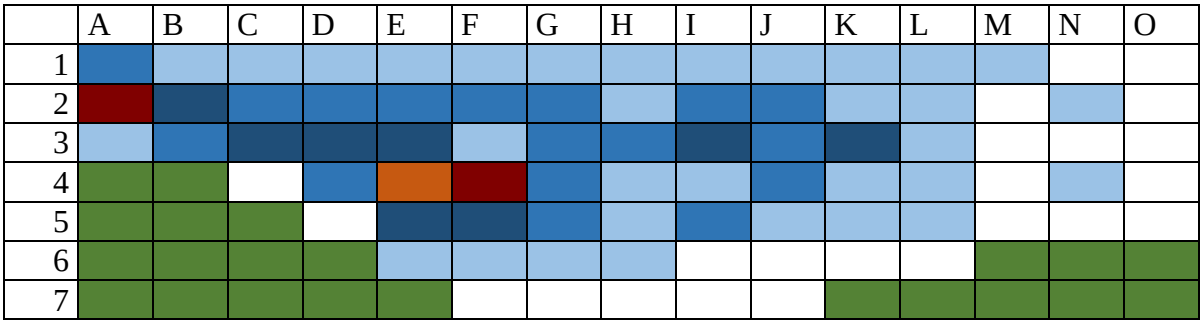


Figure 3. 9 Feeding and suspected feeding behaviour in the study area base on the grid colour code

Table 3. 7 Grid colour coded by percentages for foraging behaviour in the study area

% of Use	Colour
0	
5.1 -10	
10.1 - 15	
15.1 - 20	

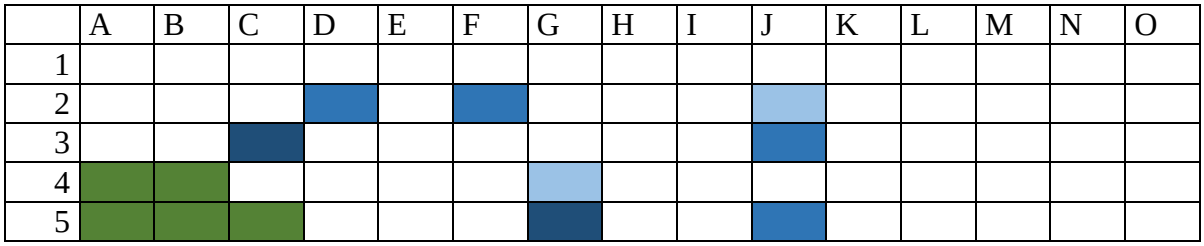


Figure 3. 10 Foraging behaviour in the study area base on the grid colour code

Table 3. 8 Grid colour coded by percentages for traveling behaviour in the study area

% of Use	Colour
0 - 13	
13.1 - 17	
17.1 - 21	
21.1 - 25	
25.1 - 30	

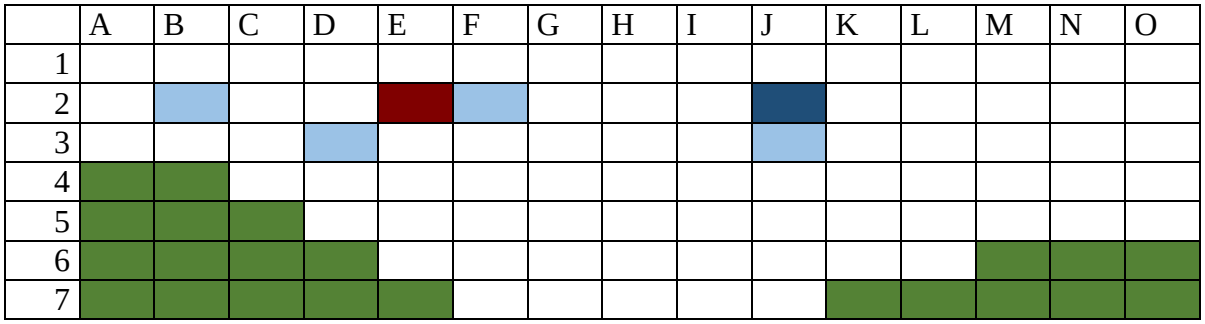


Figure 3. 11 Traveling behaviour in the study area

Based on the previous figures and the percentages of area used (Figure 3. 8, Figure 3. 9, Figure 3. 10, Figure 3. 11), it can be seen that the area most commonly used is found to be between grids A – E and 1 -4. In addition, feeding behaviour is concentrated in that same zone, probably because of the presence of Llanina Reef in the neighbourhood of grid K3, whilst foraging also is found close to this area; nonetheless traveling behaviour more often occurs in the deepest areas of the bay.

3.2 Marked - Identified individuals

Boat-based and land-based surveys were conducted from 2001 to 2013, resulting in a total of 81 individuals identified from 752 sightings in the delimited study area of New Quay Bay within Cardigan Bay SAC. 39% (81/207) of the individuals that were seen in Cardigan Bay SAC, were recorded in New Quay Bay.

There has been a general increase in bottlenose dolphin presence since 2007 (Figure 3. 12), in which both year and month have an influence (Year = One-way ANOVA: $F_{1,26} = 4.25$, $p < 0.001$; Month = One-way ANOVA: $F_{1,14}=4.60$, $p= 0.0016$). Moreover, a monthly analysis shows that the peak in which marked individuals are seen the most is between June, July, August and September (**Error! Reference source not found.**).

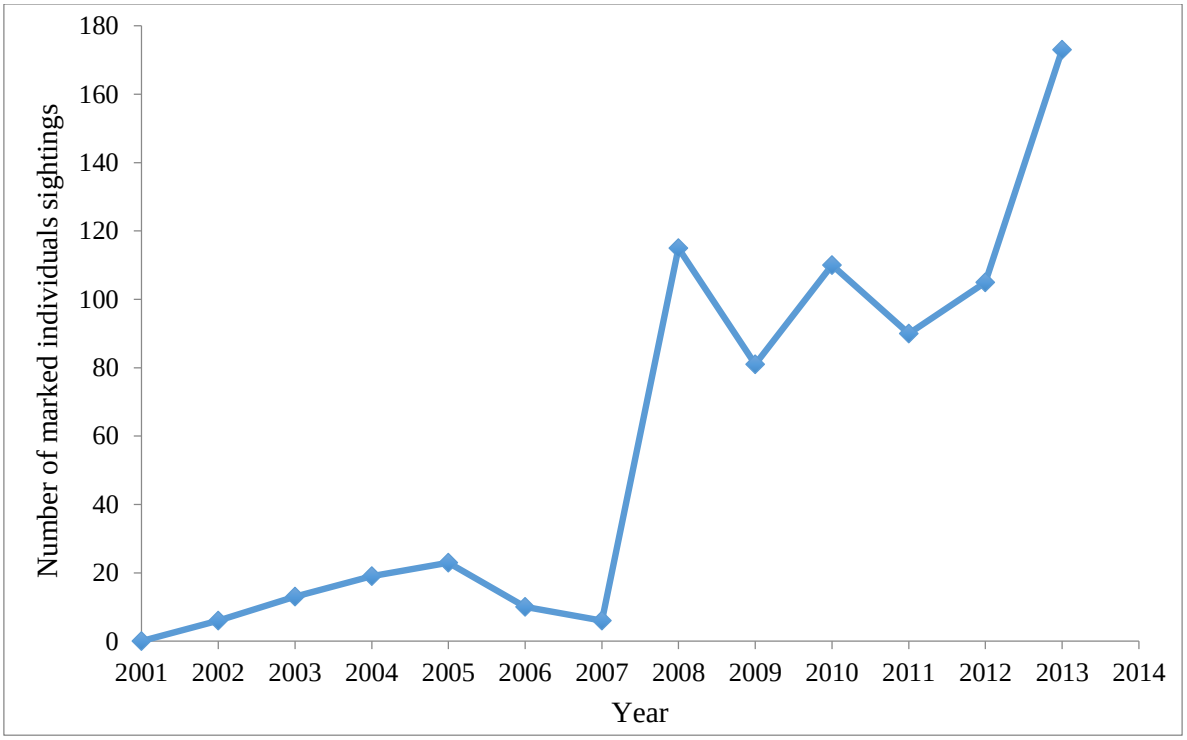


Figure 3. 12 Marked individuals visiting New Quay Bay (study area) from 2001 to 2013

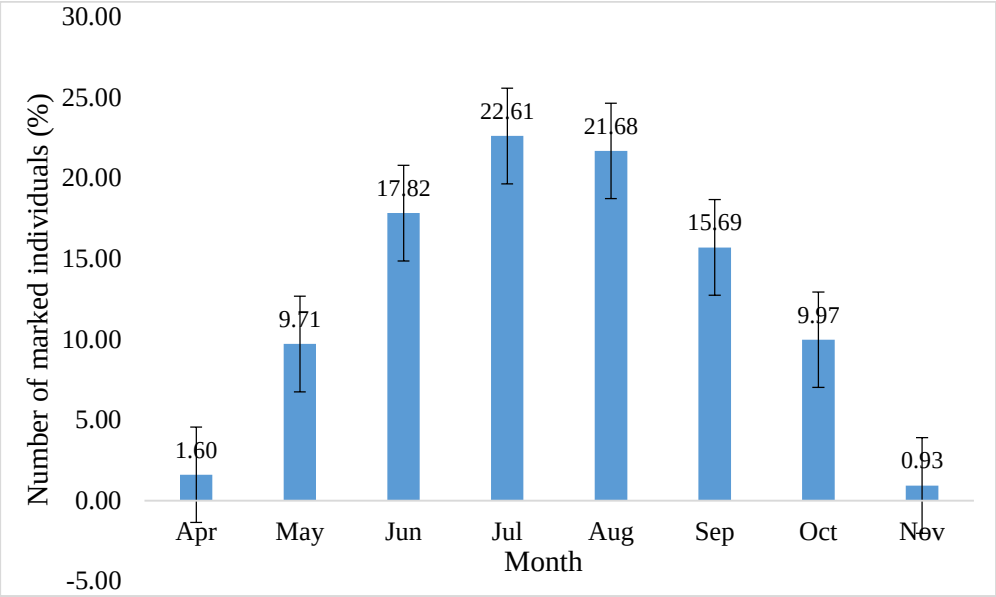


Figure 3. 13 Frequency of marked individuals seen in each month from 2001 to 2013 in New Quay Bay study area

Based on the months with the most sightings - June to September as shown in Figure 3. 13, and in order to be able to analyse the presence of dolphins during the different seasons of the year, day categories were established as follows in Table 3. 9

Table 3. 9 Season by day categories

Season	Date
First half of Early summer	20th May - 7th June
Second half of Early summer	8th - 26th June
First half of Mid summer	27th June - 15th July
Second half of Mid summer	16th July - 3rd Aug
First half of Late summer	4th - 22nd Aug
Second half of Late summer	23rd Aug - 10th Sept

Marked individuals showed a significant seasonal peak between 16th July and 22nd August as seen in Figure 3. 14, proving that season variation influences the presence of marked individuals (One-way ANOVA $F_{1,10}$= 4.96, p= ,0.001).

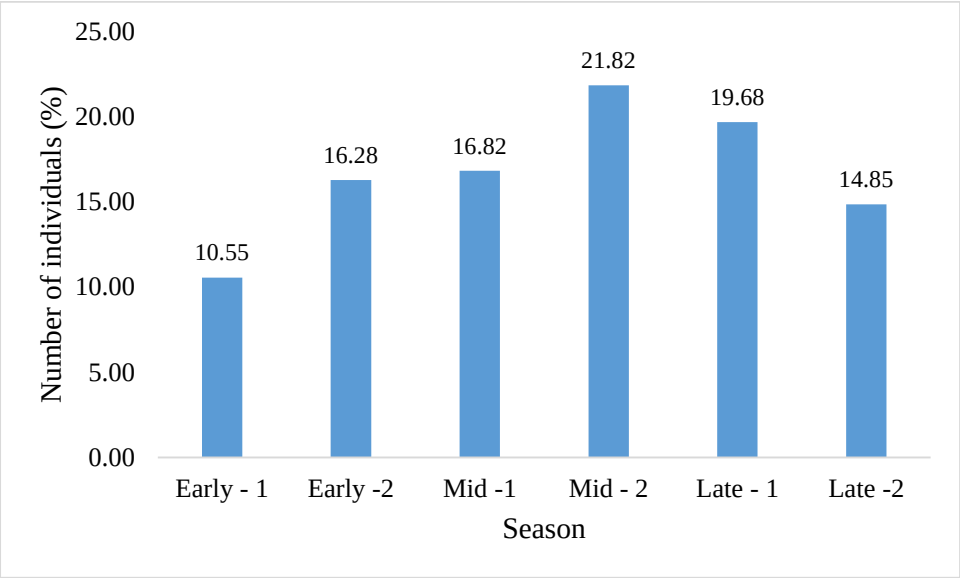


Figure 3. 14 Frequency of marked individual seen in each season category, from 2001 to 2013 in New Quay Bay study area

Using only the months June to September, with the higher percentages of sightings, the analysis of the times of the day showed that this actually influences the presence of the marked individuals (One-way ANOVA $F_{4,35}$= 2.64, p=0.03). It can be seen that whilst months go by, the time of the day where bottlenose dolphins are seen the most varies (Figure 3. 15), which is also related to the seasonal changes that influence their presence. Therefore the following categories were made to visualise the change, as shown in Table 3. 10

Table 3. 10 Time of Day categories

Category	Time
1	06:00-07:59
2	08:00-09:59
3	10:00-11:59
4	12:00-13:59
5	14:00-15:59
6	16:00-17:59
7	18:00-19:59
8	20:00-21:59

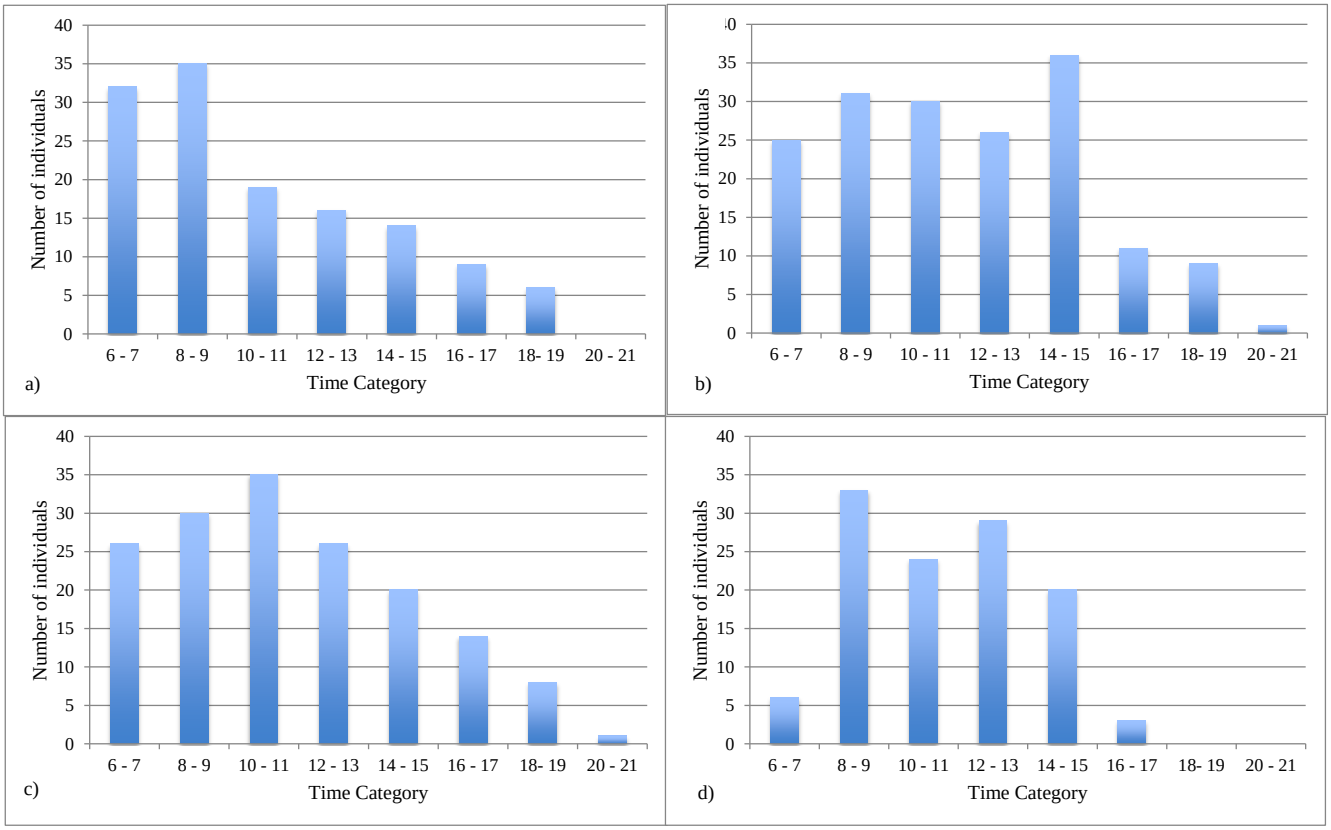


Figure 3. 15 Frequency of marked individuals seen at different times of day by month, from 2001 to 2013 in New Quay Bay study area a) June, b) July, c) August, d) September

3.2.1 Habitat use of identified individuals

From the 753 sightings of identified individuals, the habitat use was also studied, in order to see the temporal change in site usage of marked individuals, which allows more detailed information, such as age and gender analysis.

Table 3. 11 Grid colour coded by percentages for marked individuals' total use of the study area

% of Use	Colour
0	
0.1 - 2	
2.1 - 4	
70	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3															

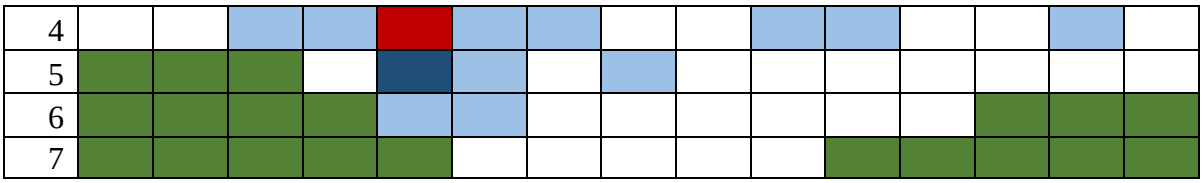


Figure 3. 16 Marked individuals' total use of the study area by grid colour coded

As the habitat use analysis from boat based surveys revealed previously in section 3.1.4, habitat use of marked individuals is seen with greater frequency in the area between A – E and 1 – 3, even though the distribution is found spread over most of the area, which may be explained by the presence of Llanina Reef (Grid K3), as well as the fact that the fish factory is found off New Quay Headland (Grid C4) (Figure 3. 16).

3.2.2 Presence of Mothers

From both land and boat surveys, a total of 81 identified individuals were seen in the New Quay study area. From that number, 17 individuals were recognised to be mothers that frequent the study area. Nonetheless, only three mothers (Table 3. 12) were seen repeatedly, allowing analysis to be done.

Table 3. 12 Frequency of different identified bottlenose dolphin mothers in the study area

Individual number	Frequency of sightings (%)
004-90W	54.31
017-03W	29.21
193-07S	16.48

- Individual 004-90W

Individual 004-90W was first photographed and identified in 1990. During boat based surveys this individual was seen in company of calves during 2008 and 2010. Variation in the presence of this female occurs in relation to year (One-way ANOVA $F_{1,14} = 4.60$, $p = <0.001$), month (One-way ANOVA $F_{1,12} = 4.74$, $p= 0.03$), season (One-way ANOVA $F_{1,10} = 4.96$, $p< 0.001$) and time of day (One-way ANOVA $F_{1,14}= 4.60$, $p= 0.01$), all depending upon the usage and purposes she gives to the study area (FiguresFigure 3. ***17***,Figure 3. ***18***,Figure 3. ***19***,Figure 3. ***20***,Figure 3. ***21***)

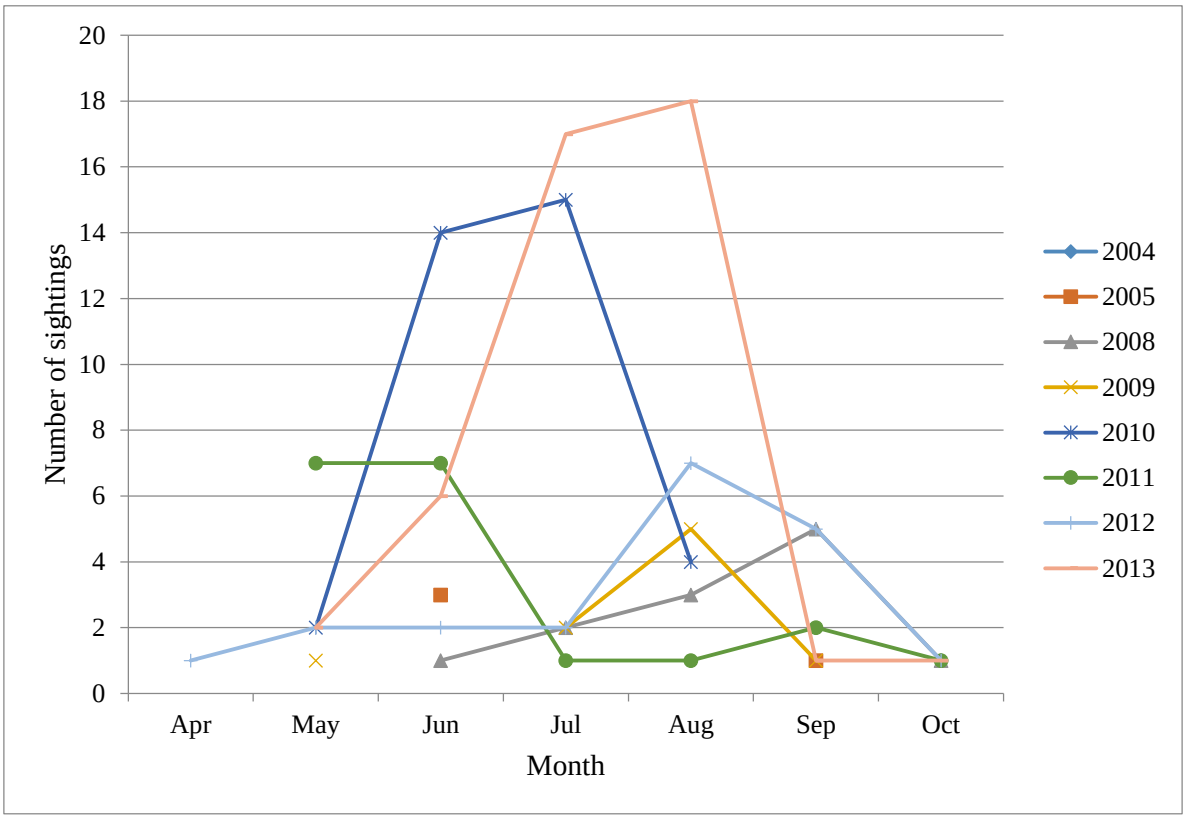


Figure 3. 17 Monthly and annual variation in presence of individual 004-90W in New Quay Bay study area

Table 3. 13 Season by day categories

Season	Date
First half of Early summer	20th May - 7th June
Second half of Early summer	8th - 26th June
First half of Mid summer	27th June - 15th July
Second half of Mid summer	16th July - 3rd Aug
First half of Late summer	4th - 22nd Aug
Second half of Late summer	23rd Aug - 10th Sept

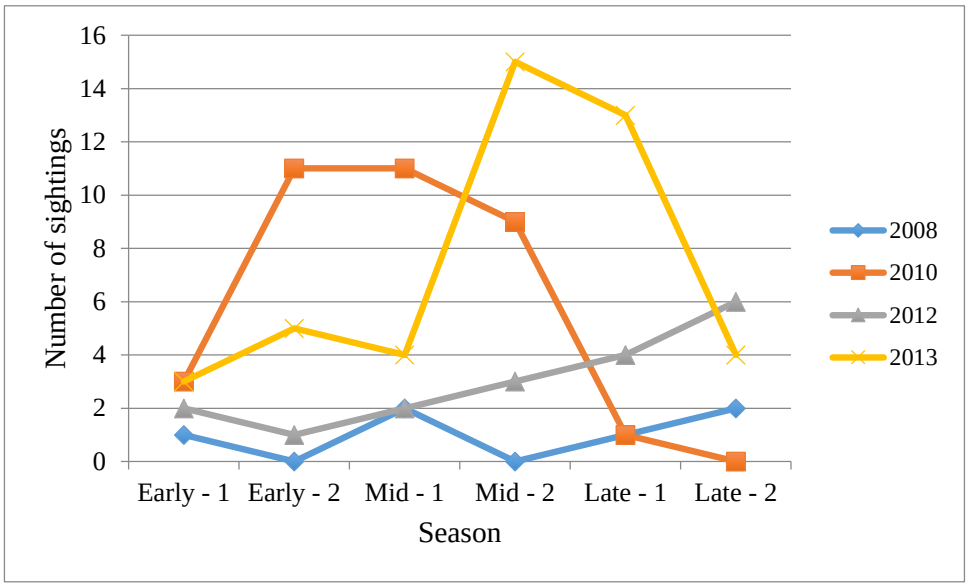


Figure 3. 18 Seasonal variation in presence of individual 004-90W in New Quay Bay study area per each year

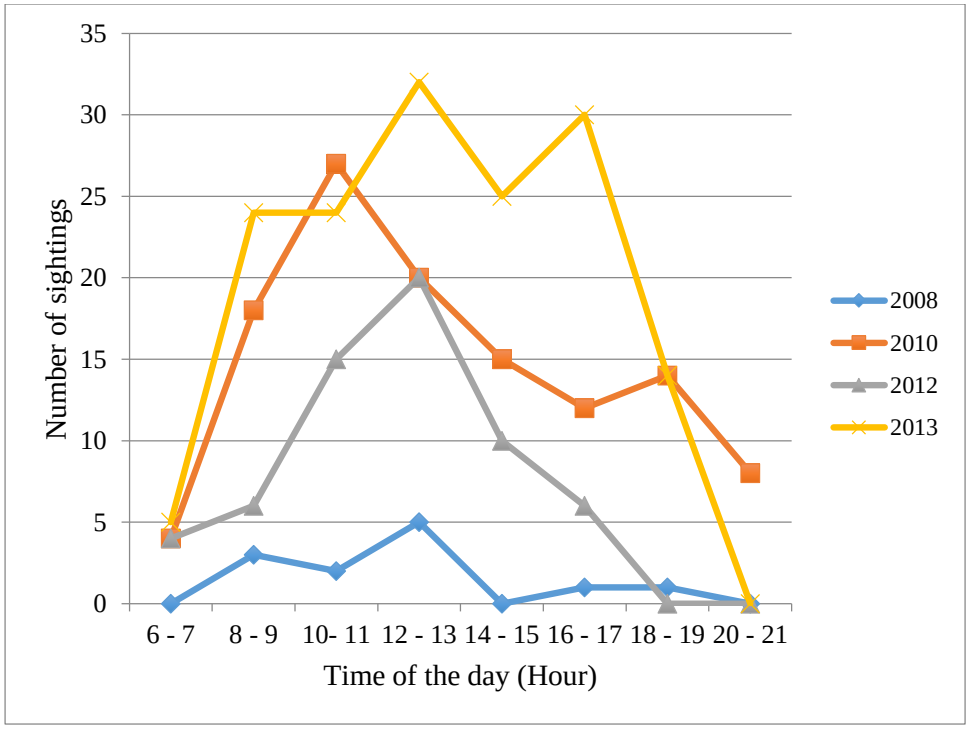


Figure 3. 19 Diurnal variation in the presence of individual 004-90W in New Quay Bay study area per each year

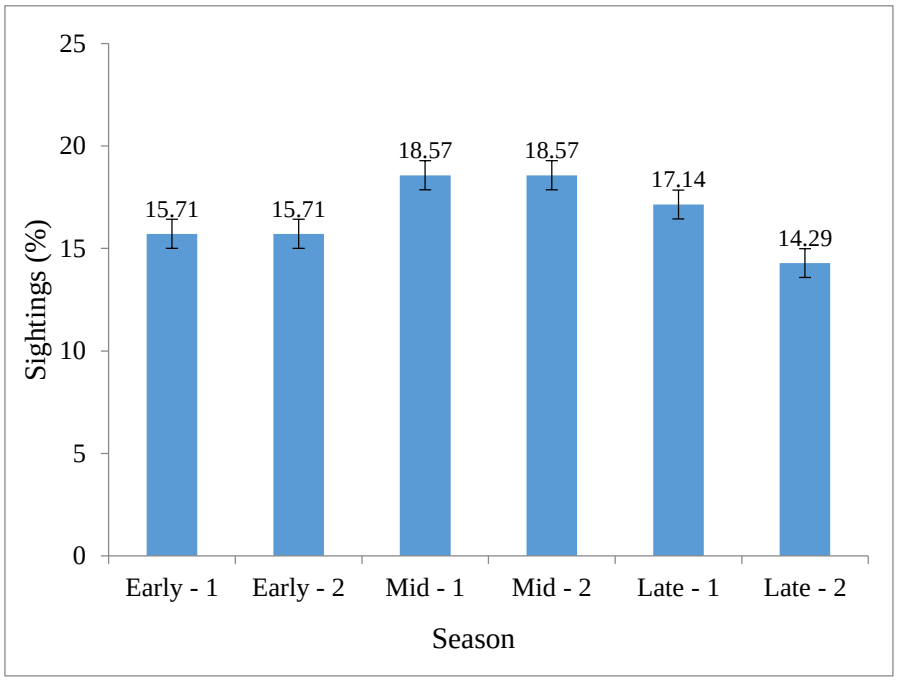


Figure 3. 20 Seasonal variation in presence of individual 004-90W in New Quay Bay study area

Table 3. 14 Time of Day categories

Category	Time
1	06:00-07:59
2	08:00-09:59
3	10:00-11:59
4	12:00-13:59
5	14:00-15:59
6	16:00-17:59
7	18:00-19:59
8	20:00-21:59

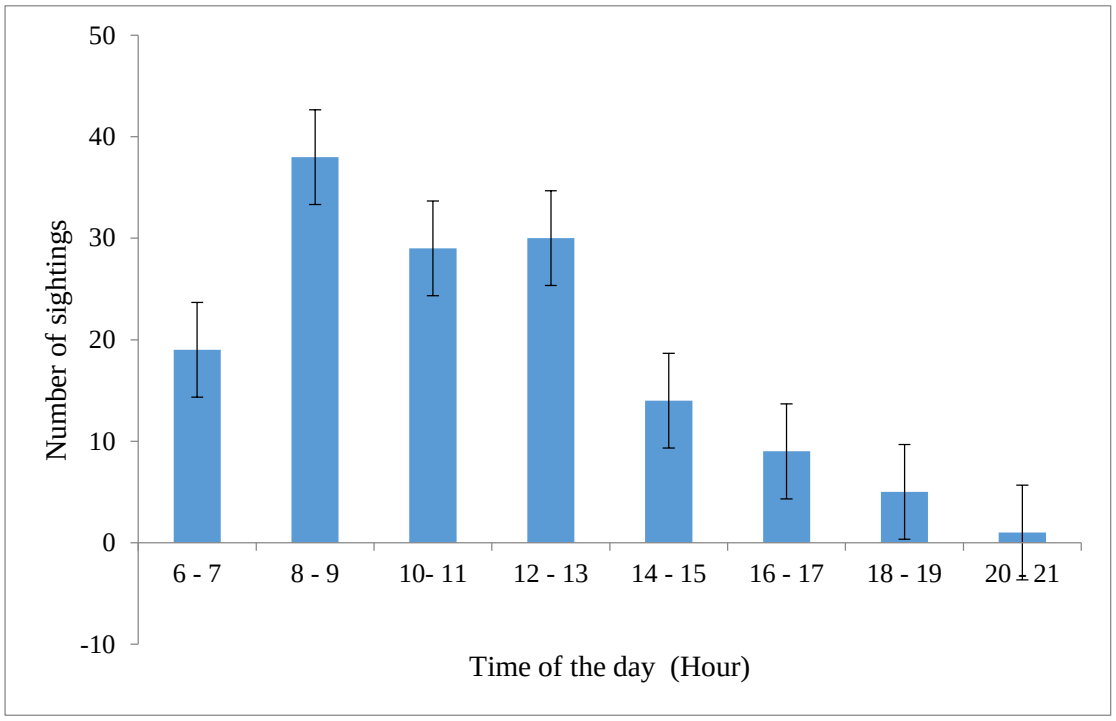


Figure 3. 21 Diurnal variation in the presence of individual 004-90W in New Quay Bay study area

Individual 017-03W

This female bottlenose dolphin was first seen in 2003. In that same year and later in 2007 she was seen with a calf. The change in her presence and behaviour in New Quay Bay study area is related to the year (one-way ANOVA $F_{1,18}$= 4.41, p= <0.001), month (one-way ANOVA $F_{1,10}$= 4.96, p= 0.04) and season (one-way ANOVA $F_{1,10}$= 4.96, p< 0.04); nonetheless, time of day did not seem to influence the presence of this individual in the area (one-way ANOVA $F_{1,14}$= 4.60, p= 0.06) (Figures Figure 3. ***22***,Figure 3. ***23***,Figure 3. ***24***).

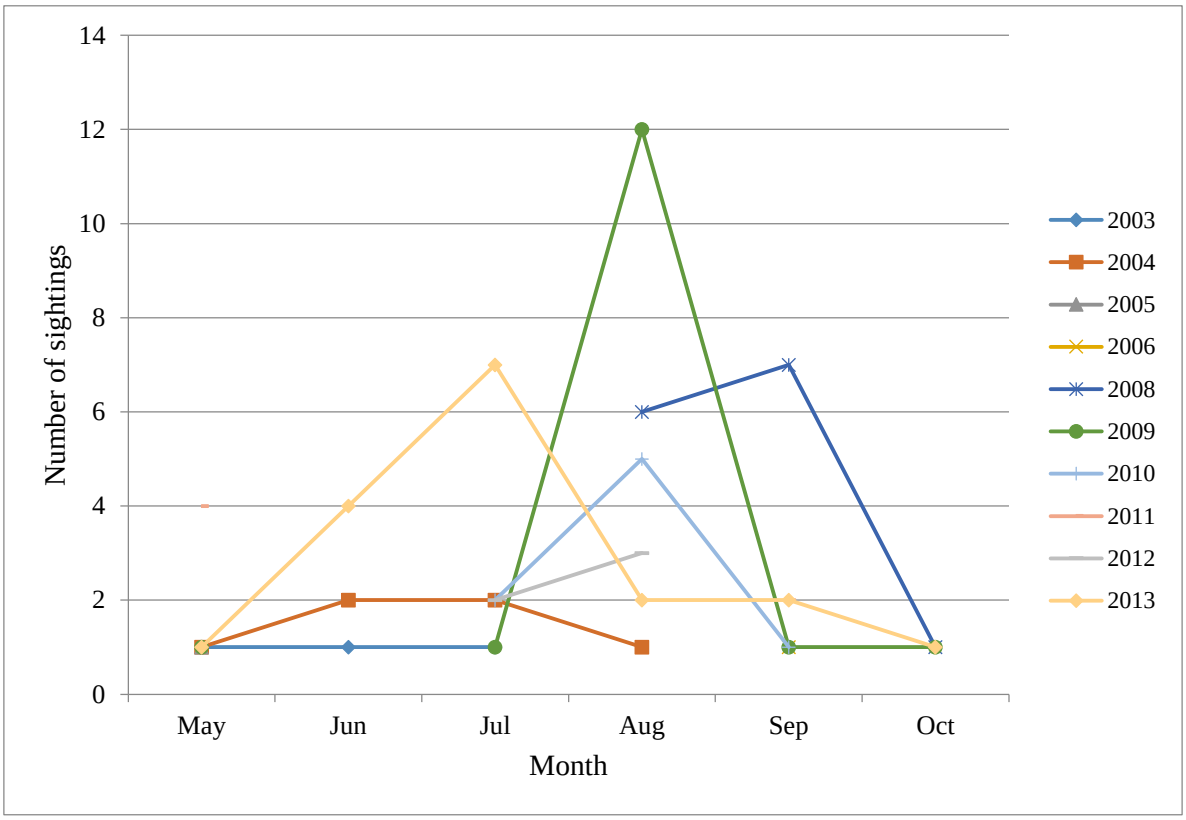


Figure 3. 22 Monthly and annual variation in presence of individual 017-03W in New Quay Bay study area

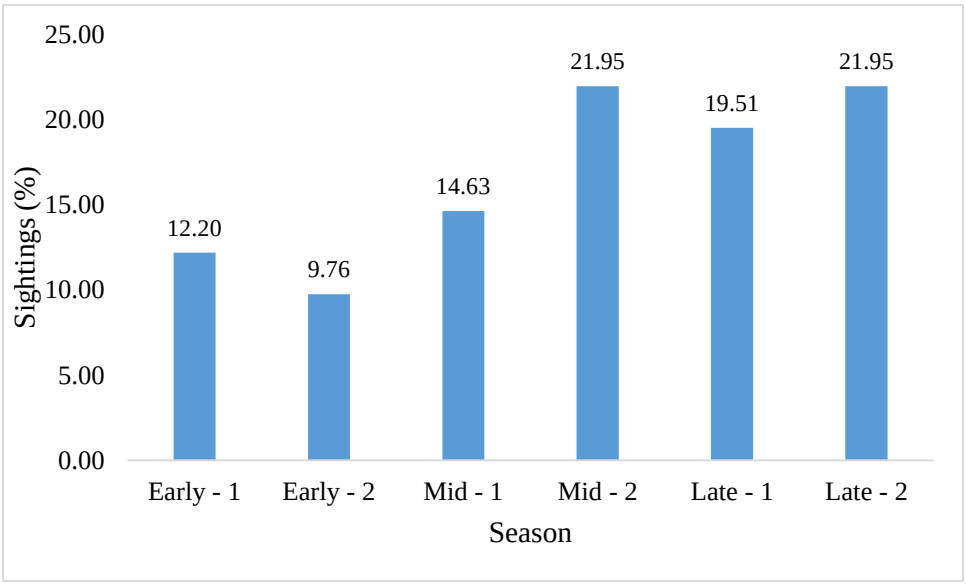


Figure 3. 23 Seasonal variation in presence of individual 017-03W in New Quay Bay study area

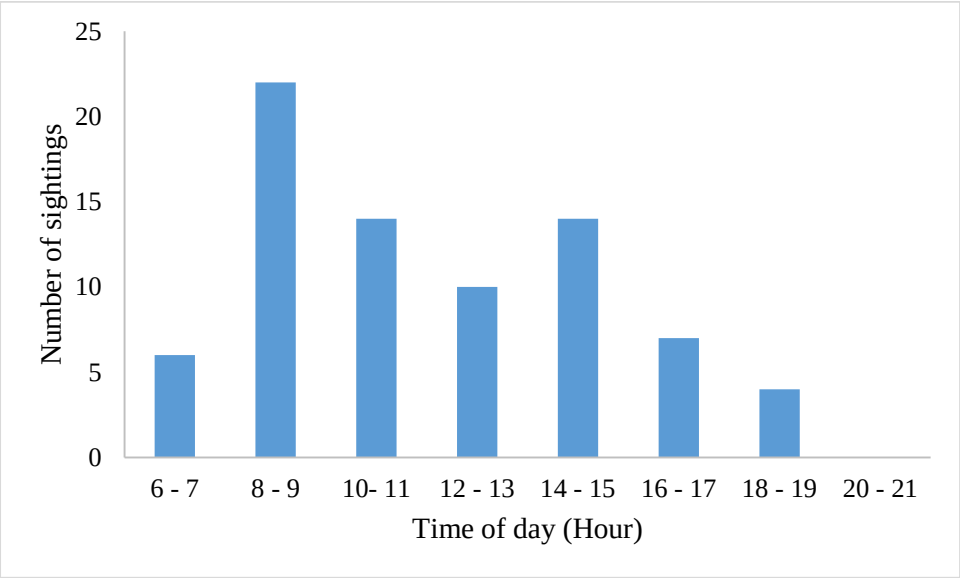


Figure 3. 24 Diurnal variation in the presence of individual 017-03W in New Quay Bay study area

Individual 193-07S

Individual 193-07S was first seen in 2007, and in that same year it was photographed with a calf. Its presence varied significantly with year (One-way ANOVA $F_{1,4}$=7.70, p<0.001) but month, season and time of day were not related to her presence in New Quay Bay (Month = One-way ANOVA $F_{1,12}$ = 4.74, p = 0.7; Season = One-way ANOVA $F_{1,10}$ = 4.96, p = 0.07; Time of day = One-way ANOVA $F_{1,14}$ = 4.60, p = 0.6) (FiguresFigure 3. ***25***,Figure 3. ***26***,Figure 3. ***27***).

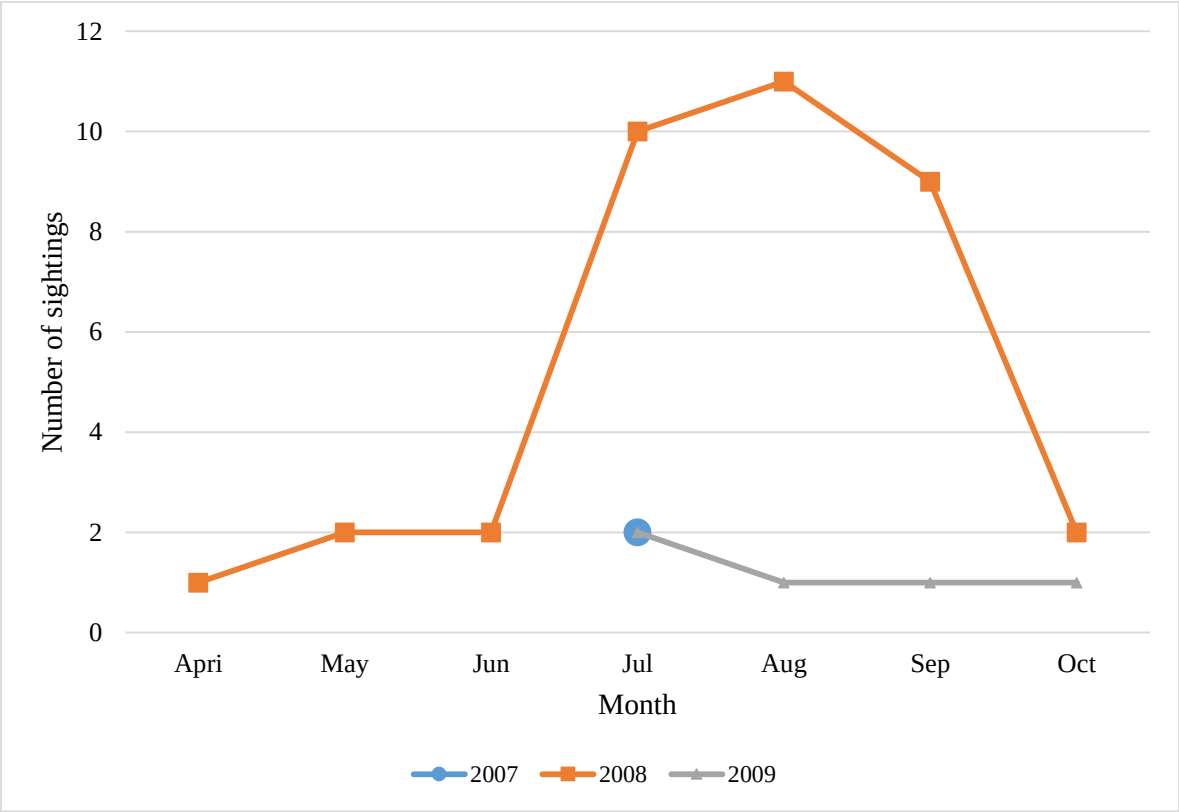


Figure 3. 25 Monthly and annually variation in presence of individual 193-07S in New Quay Bay study area

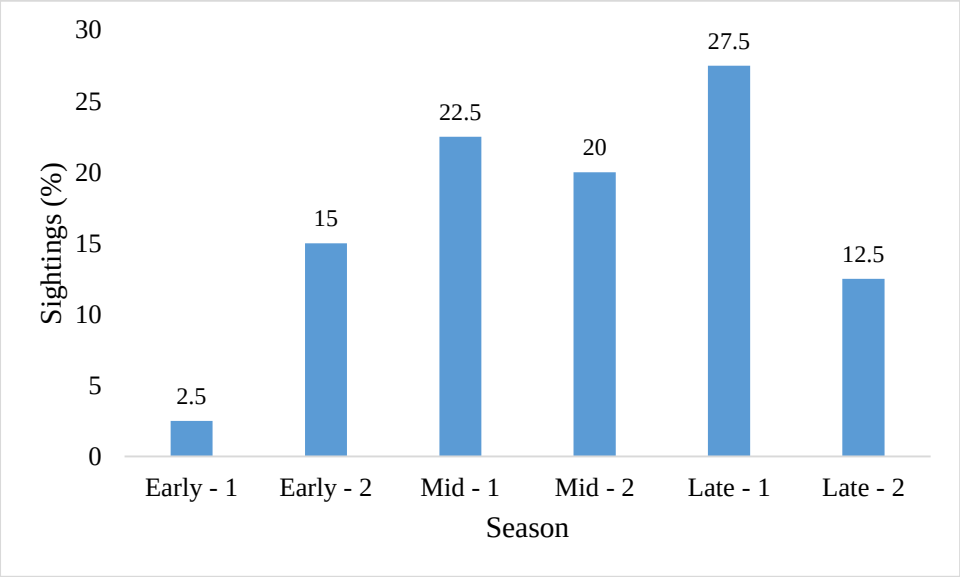


Figure 3. 26 Season variation in presence of individual 193-07S in New Quay Bay study area

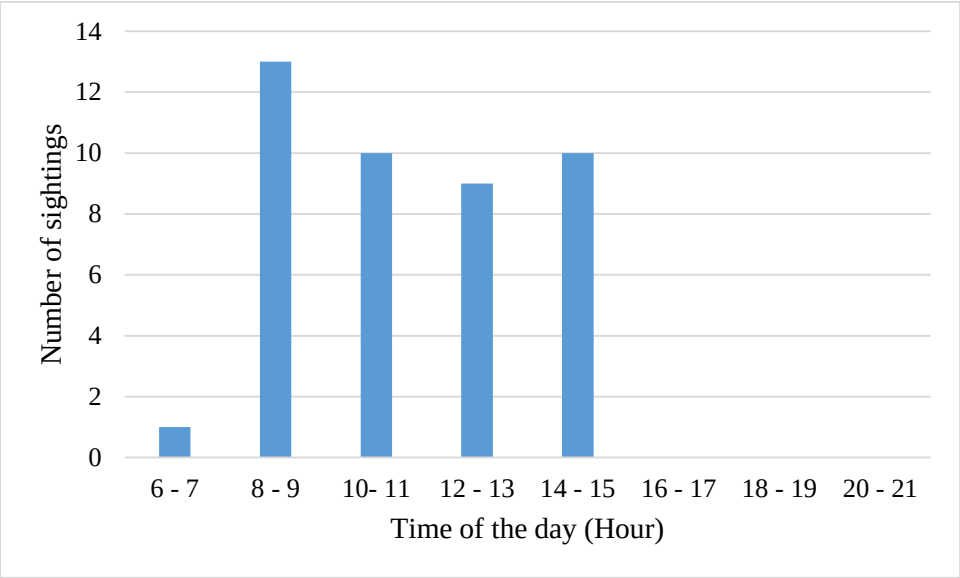


Figure 3. 27 Daily variation in the presence of individual 193-07S in New Quay Bay study area

3.2.3 Presence of calves

The number of calves present during the encounters was also recorded. Calves were usually absent between April and June and their presence was most obvious during July and August, which shows the strong influence that the month has on the presence of the young (One-way ANOVA $F_{3,24}$=3.01, p= 0.001) (Figure 3. 28).

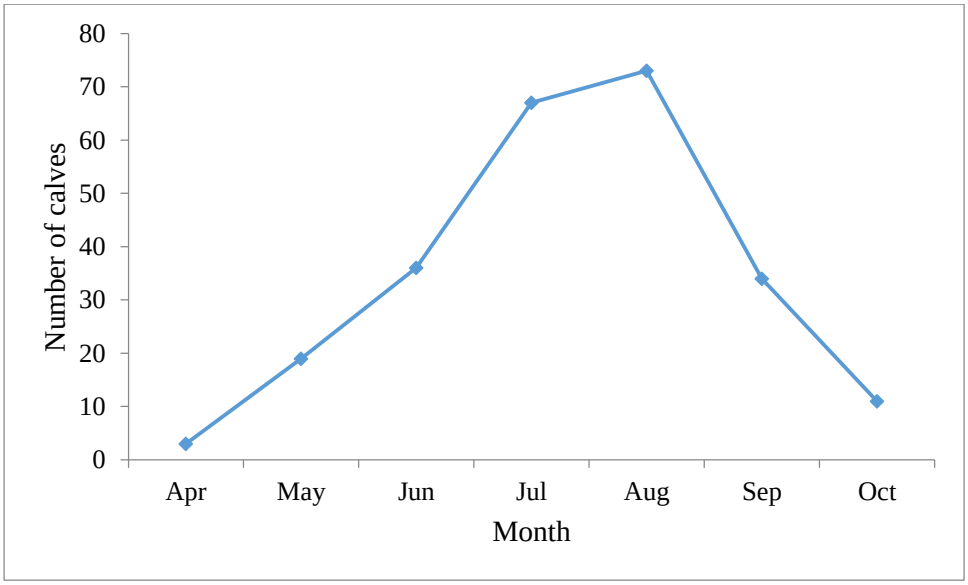


Figure 3. 28 Month variation in presence of calves in New Quay Bay study area

3.2.4 Resident, transient, and occasional individuals

In the waters of Cardigan Bay SAC, many boat-based surveys have been conducted in order to collect more information about the bottlenose dolphin individuals that inhabit there, as well as to record their behaviour and trends in usage of the area. As part of that study, an analysis of the bottlenose dolphin population in the area has provided a general overview of the resident population that can be found within Cardigan Bay SAC, in which few individuals are occasional and even less are transient (Table 3. 15 and Figure 3. 29a). If comparison is made of the number of times that marked individuals have been seen in the New Quay Bay study area, the population here does not have the same characteristics that are found in the wider Cardigan Bay SAC (One-way ANOVA $F_{2,6} = 5.14$, $p = 0.3$). Animals in New Quay Bay study area could be referred to as a transient population, given that most of the marked individuals are transient, whilst occasional and even residents are much fewer in number (Table 3. 16 and Figure 3. 29b).

Table 3. 15 Frequency of transient, occasional and resident individuals in Cardigan Bay SAC from 2001 to 2013

	Number individuals	Proportion (%)
Transient	2	2.47
Occasional	20	24.69
Resident	59	72.84

Table 3. 16 Frequency of transient, occasional and resident individuals in New Quay Bay from 2001 to 2013

	Number individuals	Proportion (%)
Transient	49	60.5
Occasional	27	33.3
Resident	5	6.17

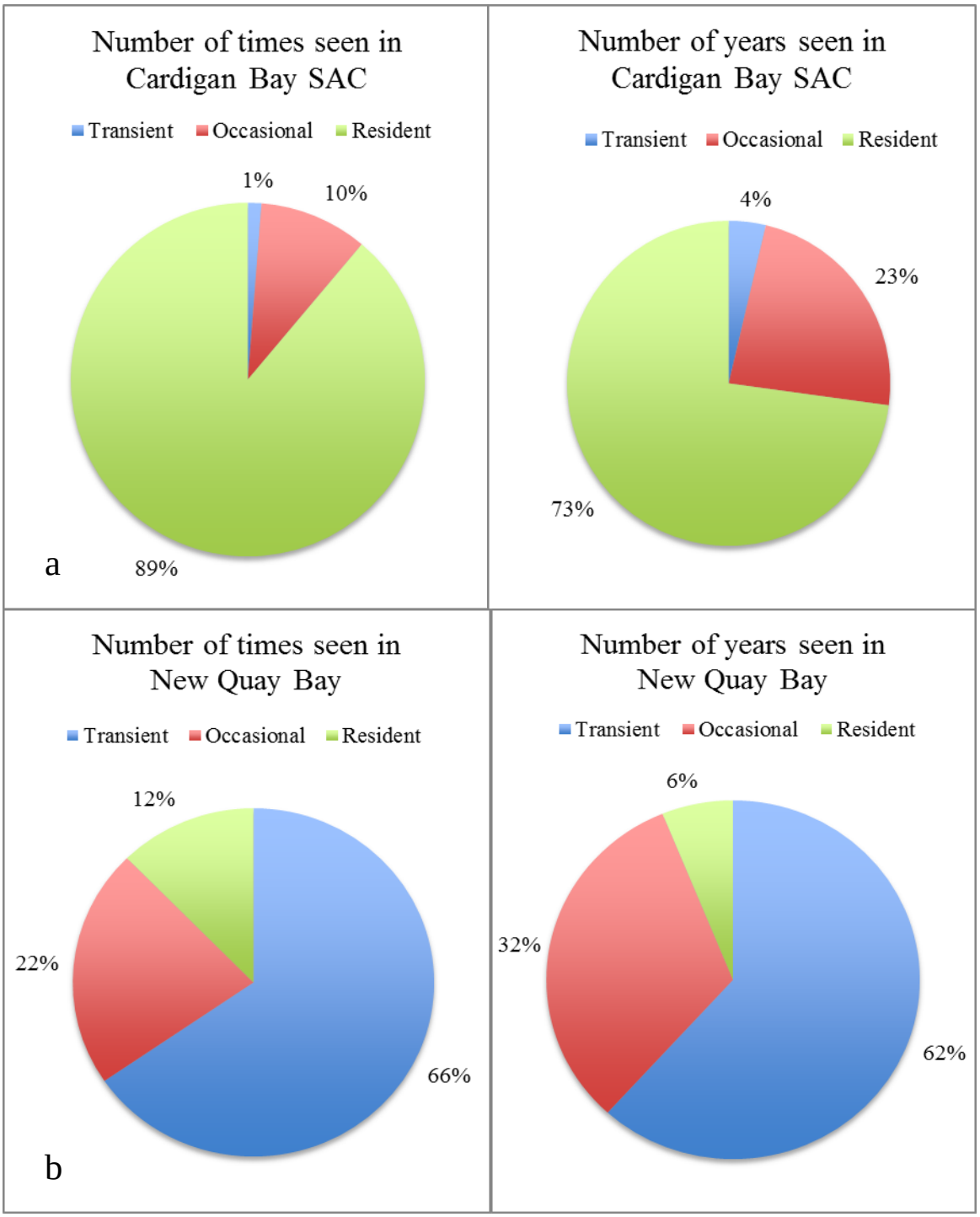


Figure 3. 29 Frequency of times and years that marked individuals have been seen from 2001 to 2013 in a) Cardigan Bay SAC (above) and b) in New Quay Bay study area (below)

3.2.5 Frequently observed individuals

Based on the analysis of marked individuals, and in order to analyse whether there is an annual turnover of bottlenose dolphin individuals in New Quay Bay each year, the most frequently observed individuals were analysed separately. These showed that whereas year influences their presence in the area (One-way ANOVA $F_{4,55}$=2.53, p<0.001), month is not related to change in their presence (Kruskal-Wallis H= 12.3, df= 5, p= 0.03).

- 004-90W

This individual was seen in almost all of the sampled years with peaks in July and August (Figure 3. 30), and showing an heterogenious distribtuion in the study area (Figure 3. 31).

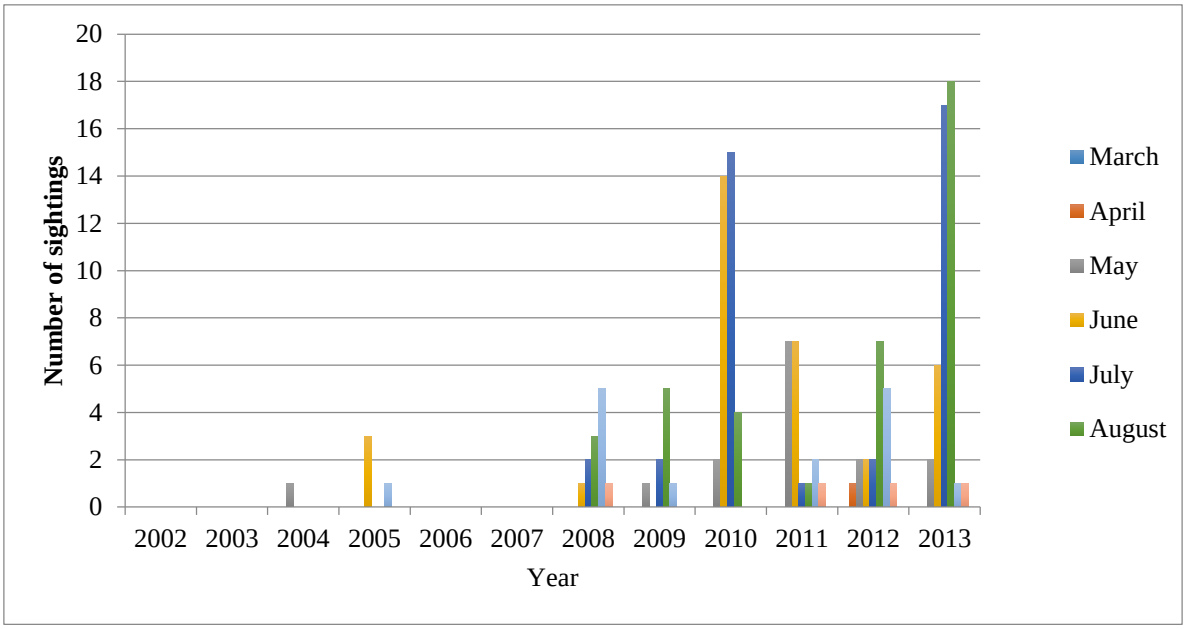


Figure 3. 30 Number of sightings of individual 004-90W, between 2001 and 2013 in New Quay Bay study area.

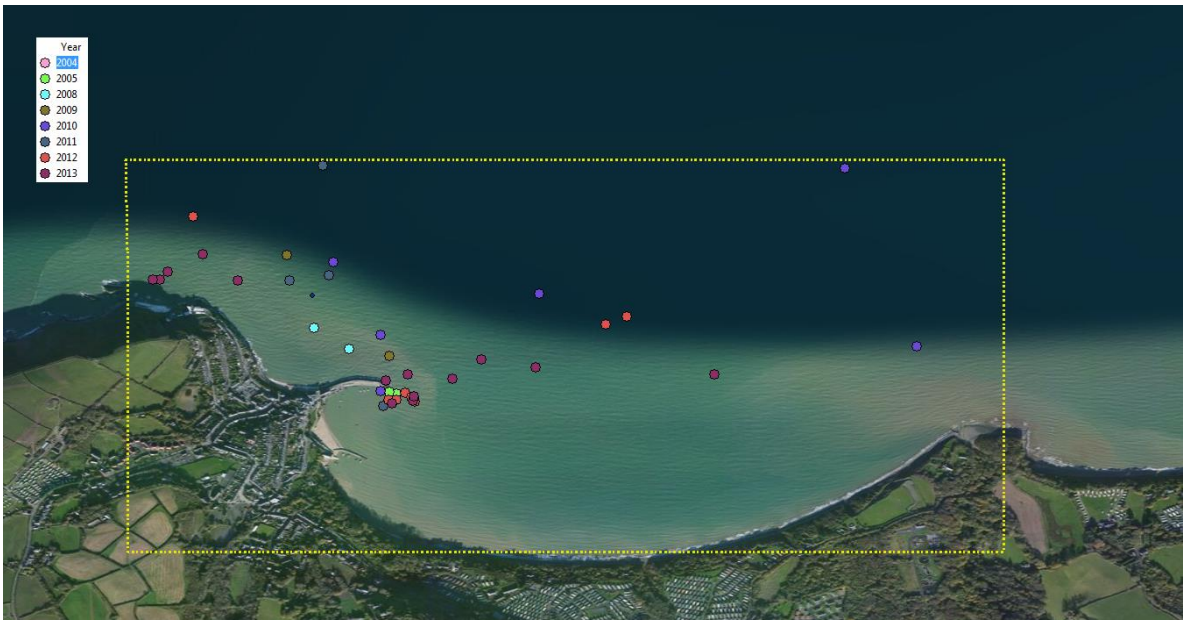


Figure 3. 31 Sightings of individual 004-90W, between 2001 and 2013 in New Quay Bay study area

- 074-03W

With an heterogenious distribution in the study area (Figure 3. 33), this individual has been seen ever since 2003 (Figure 3. 32)

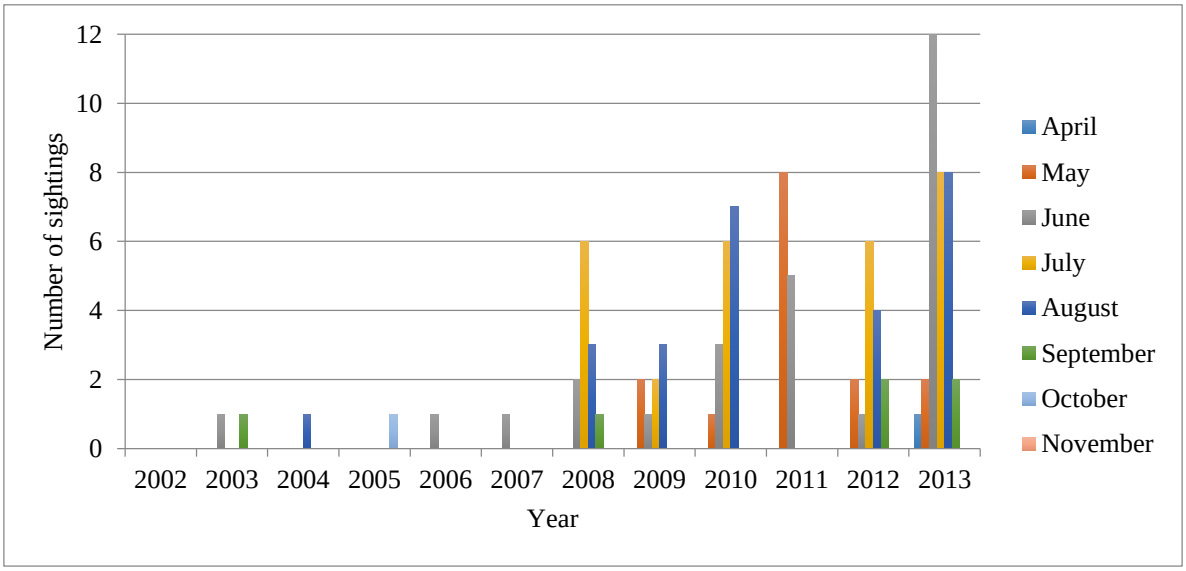


Figure 3. 32 Number of sightings of individual 074-03W, between 2001 and 2013 in New Quay Bay study area

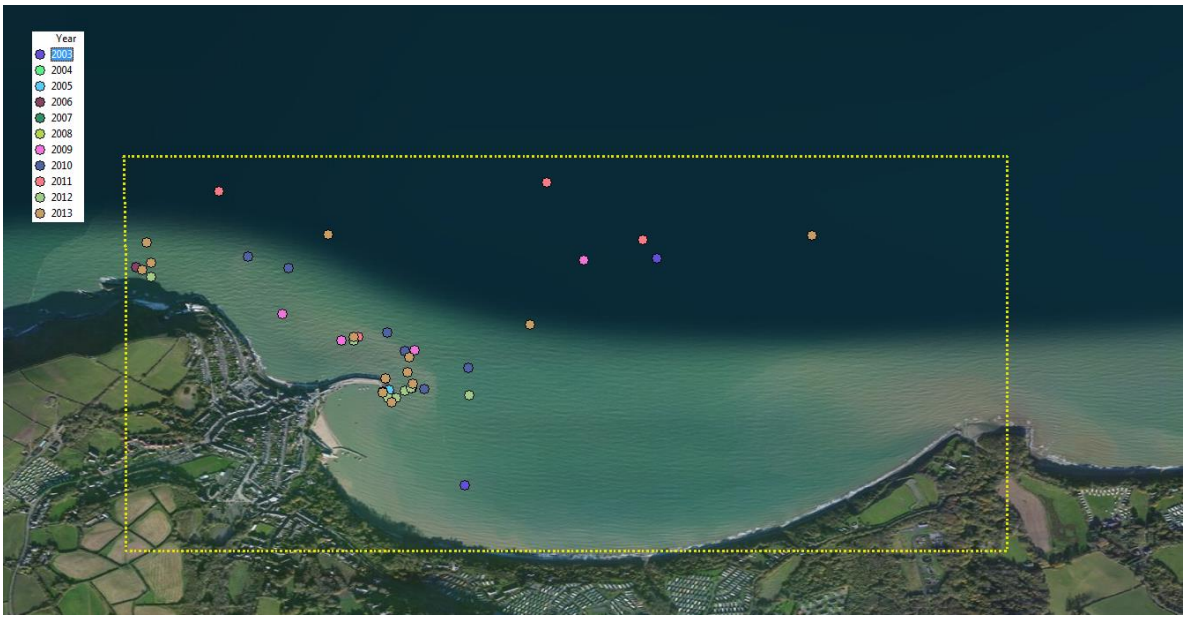


Figure 3. 33 Sightings of individual 074-03W, between 2001 and 2013 in New Quay Bay study area

- 017-03W

This individual has been present in the area most of the years (Figure 3. 34), simming the inshore waters close to the pier (Figure 3. 35).

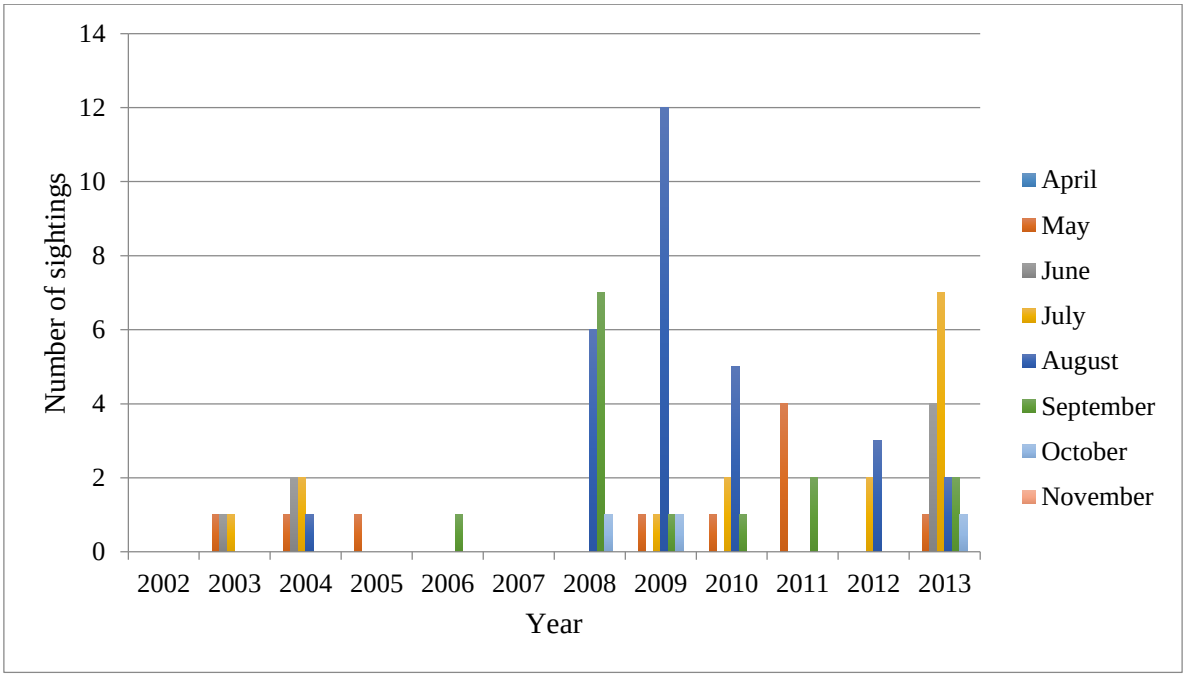


Figure 3. 34 Number of sightings of individual 017-03W, between 2001 and 2013 in New Quay Bay study area

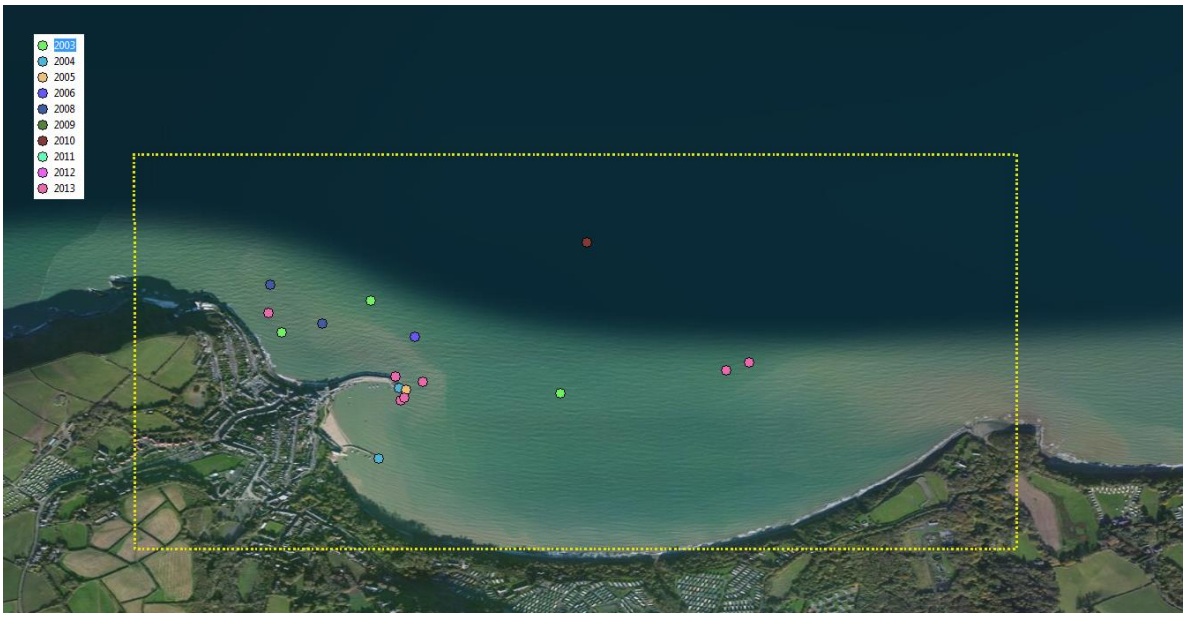


Figure 3. 35 Sightings of individual 017-03W, between 2001 and 2013 in New Quay Bay study area

- 207-07S

Individual 207-07S has been seen ever since 2008 (Figure 3. 36), either close to the pier or in deeper waters (Figure 3. 37)

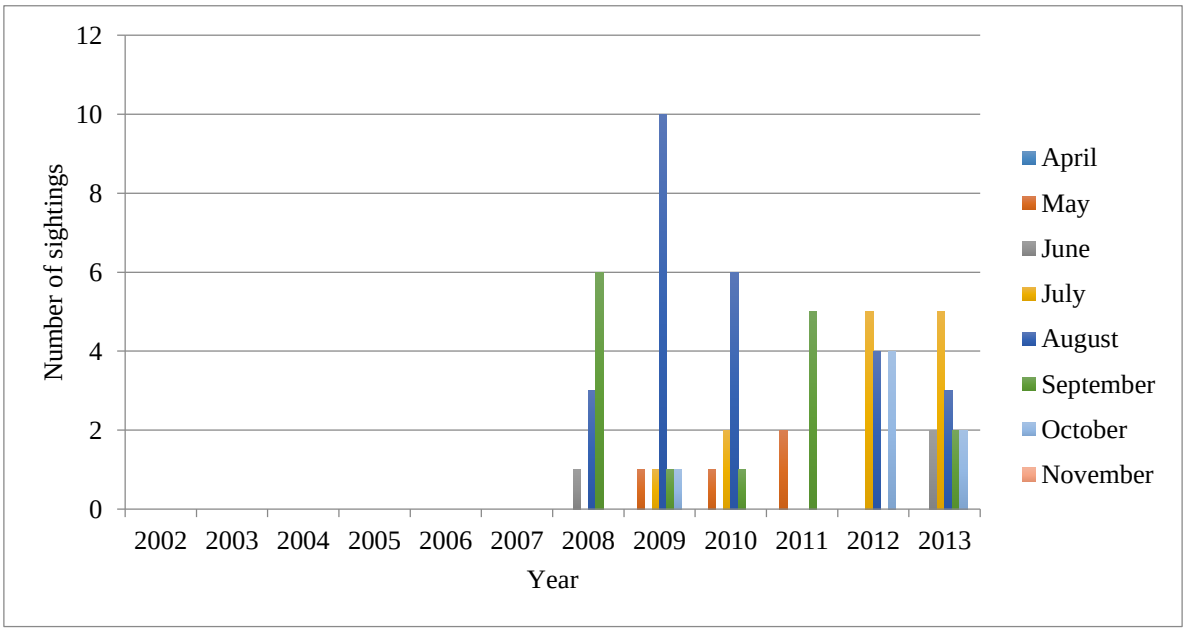


Figure 3. 36 Number of sightings of individual 207-07S, between 2001 and 2013 in New Quay Bay study area

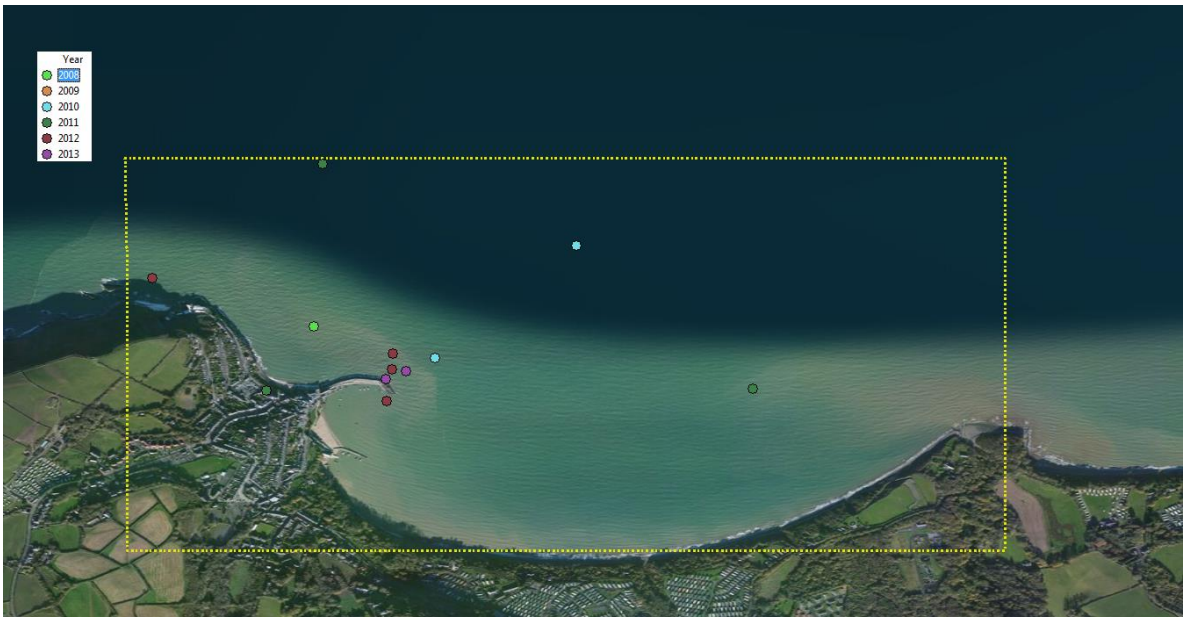


Figure 3. 37 Sightings of individual 207-07S, between 2001 and 2013 in New Quay Bay study area

3.3 Land-based surveys

Land watches from New Quay Bay pier were conducted from 2005 to 2014, giving a total of 8,351.75 of BND+ve hours of sightings, with a mean value of 2.13 sightings/hour. Bottlenose dolphin encounters from land were not related to years (One-way ANOVA $F_{1,18} = 4.41$, $p = 0.1$) as it can be seen in Figure 3. 38, probably due to the influence of other environmental variables such as bad weather (precipitation, visibility and sea state), or even to variable availability of volunteers to collect the data during all the seasons in each year of sampling. Monthly and weekly analysis of the presence of bottlenose dolphins in the area have been previously analysed, showing the significance relationship of those variables in the presence of *Tursiops trucantus* (Stone, 2006) and therefore nor further details will be given in this study

Table 3. 17 Bottlenose dolphin sightings between 2005 and 2014 from land watches

Year	BND Sightings
2005	1189
2006	1314
2007	839

2008	1036
2009	2345
2010	2093
2011	2468
2012	2390
2013	1996
2014	1570

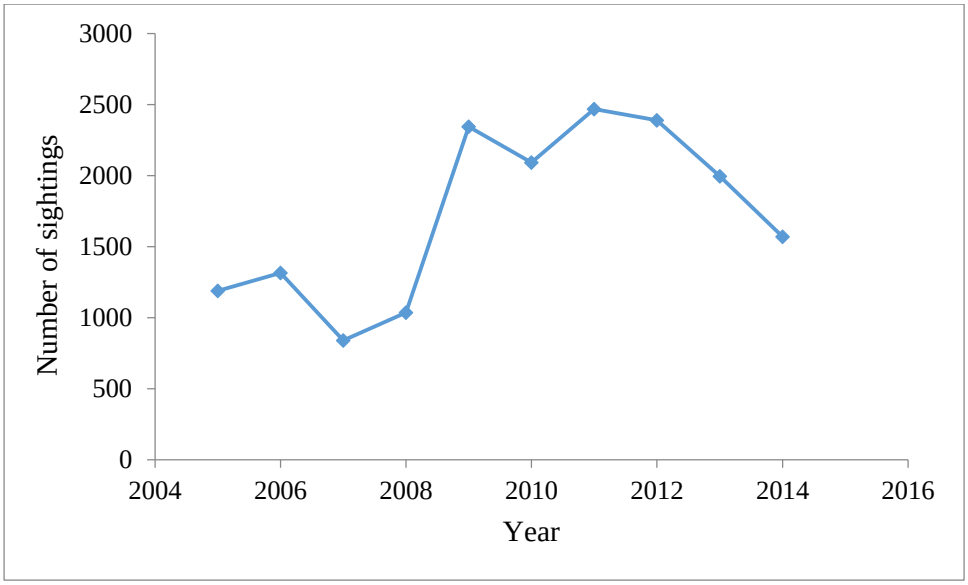


Figure 3. 38 Number of sightings made from land watches, between 2005 and 2014.

4. Discussion

The bottlenose dolphin population inhabiting Cardigan Bay SAC has long been known to use mainly its coastal waters in summer (Baines *et al*., 2002; Ugarte & Evans, 2006; Pesante *et al*., 2008; Feingold & Evans, 2014). Favoured locations have included waters adjacent to Ynys Lochtyn, Aberporth, Mwnt, New Quay Head and New Quay harbour (Stone, 2006; Pesante *et al*., 2008*;* Pierpoint *et al*., 2009; Feingold & Evans, 2014).Vessel-based surveys and land watch have combined to evaluate the presence of different individuals, their characteristics (such as gender, age and presence of calves) their distribution and habitat use, site fidelity and the impact of anthropogenic activities and how these factors might change over time (see Feingold & Evans, 2014 for a recent review). One area receiving particular attention has been New Quay Bay. Observations from 2001 until 2014 of the bottlenose dolphins recorded both from vessel and land based surveys in New Quay Bay were therefore analysed in detail for this study.

4.1 Bottlenose dolphin presence

Previous studies have examined a variety of environmental factors (month, time of the day, tidal state, depth, weather and sea state) and anthropogenic activities in order to see how those influence the presence of dolphins (Gregory & Rowden, 2001; Lamb, 2004; Pesante *et al.*, 2008*;* Meatcher, 2010; Denton 2012; Feingold & Evans, 2014).

Annual, monthly and daily variation

In the present study, bottlenose dolphin presence was found to vary on a daily, monthly and yearly basis. As a natural environment, with constant changes and under the influence of many environmental variables that can shape it, New Quay Bay is not a stable shallow bay, and differences in usage of the Bay was shown to occur between 2006 and 2008, possibly due to a shift in the distribution of pelagic fish species (Meatcher, 2010). Prey availability may change over time leading to bottlenose dolphins changing their behaviour and site usage in response. This may in turn lead to sightings of individuals in areas not normally occupid or conversely fewer sightings in areas were the species was seen regularly in the past. Another cause for changes in the occurrence of bottlenose dolphins during the years of the study might be due to anthropogenic boat activities. It is believed that although boat

activities can have a major impact on the behaviour of bottlenose dolphins, they can also habituate to particular vessels with which they become familiar (Papale *et al*., 2012), This may be the case in New Quay Bay, although Pierpoint *et al*. (2009) found an inverse relationship between dolphin sighting rates and vessel encounter rates around New Quay.

Although bottlenose dolphins are found in New Quay Bay all year round, with different population densities each year, their presence and usage of the New Quay harbour area also changes seasonally, with numbers greatest between April and September, particularly July and August (see Pesante *et al*, 2008; Feingold & Evans, 2014). The present study also found a greater presence of the species during the second half of the midsummer and first half of the late summer periods (spanning the days from 16th July until 22nd August). This peak in occurrence of individuals is probably determined by other variables such as presence of prey, which will likely also influence their behaviour. In addition, an increase in presence of boats might alter the number of individuals of bottlenose dolphins that occur in the bay.

New Quay Bay is visited by different fish species throughout the year; it is known that species such as mackerel (*Scomber scombrus*), salmon (*Salmo salar*) and sea trout (*Salmo trutta*) visit the area during different periods of time in the year, mostly during summer, whilst other species like plaice (*Pleuronectes platessa*), dogfish (*Scyliorhinus canicula*), brill (*Scophthalmus rhombus*), small turbot (*Psetta maxima*), dab (*Limanda limanda*), skate (*Raja clavata*) and mullet (*Liza ramanda*), may be found all year round (Bristow, 1999; Baines *et al*., 2000; Kosarew, 2003). In summary, the richness of the area makes New Quay Bay an excellent place for bottlenose dolphin to feed and rear calves during the summer season.

Monthly and annual variation in the presence of bottlenose dolphin can also be analysed in relation to water temperature. During the summer months, due to solar heating, the water temperature in New Quay Bay reaches its maximum between July and August, which is at the same time that calving reaches a peak in the area (Feingold & Evans, 2014). Bottlenose dolphin neonates have a relatively thin blubber layer, and therefore their insulation properties against low temperatures are poor (Dunkin *et al.,* 2005). In order to develop a proper insulation layer before the winter arrives, newborn individuals have to take

advantage of the high water temperatures, which translates into breeding during those warmer months in the New Quay area (Meatcher, 2010), when food availability is also likely to be rich. In addition, the presence of calves has been found to coincide with that of male individuals showing fresh wounds in their skin, suggesting strong interactions with other males. This seasonal peak in the presence of bottlenose dolphins in New Quay Bay may therefore also be related to socialising for mating purposes (Lott, 2004).

Bottlenose dolphins may show diurnal variation in behaviour (Pesante *et al*., 2008), although Shane *et al* (1986) found that movements and presence of bottlenose dolphins were likely to be related less to time of day than to prey availability. The deployment of acoustic click detectors (T-PODs) between 2004-06 at ten sites (including two in New Quay Bay) within Cardigan Bay SAC capable of monitoring dolphin activity throughout 24 hours, revealed strong diurnal (and seasonal patterns), with peaks in occurrence early in the morning and again in the late afternoon to early evening (Pesante *et al*., 2008).

4.2 Resident, transient, and occasional individuals

In the case of marked individuals seen in the study area, the same relationships as mentioned before applied to variation in their presence by day, month, and year. Some individuals such as 004-90W, 074-03W and 017-03W have been seen in the bay almost every year from 2003 and so may be regarded as resident. However, others were not necessarily seen from year to year. Around 60% of the population recorded in the Bay in fact were seen between one and three times or only for one or two years, and therefore should be classified as transients. Those 49 individuals are clearly non-residents, suggesting that the study site is not part of their main home range, as others have found in previous bottlenose dolphin studies (Wells *et al*., 1987; Würsig & Würsig, 1997; Quintanna-Rizzo & Wells, 2001). On the other hand, one reason for the relatively high frequency of transient individuals could be lack of good photo-ID coverage in the Bay, since photography from vessels is discouraged in front of the harbour. For the present, the conclusion is that only a few individuals are using New Quay Bay on a regular basis, and therefore site fidelity is relatively low. This contrasts with an earlier conclusion that bottlenose dolphin individuals in New Quay area were increasing in their site fidelity, resulting in the recommendation that the management zone should be widened, and that maybe other management strategies

should be added (Bristow & Rees, 2001). The present study indicates that only a small number of individuals are site faithful, the majority forming part of a population that ranges more widely, using the area on an opportunistic basis. This is supported by the mark-recapture analyses conducted across Cardigan Bay SAC and Cardigan Bay in general (Feingold & Evans (2014).

4.3 Boat presence

New Quay is a busy touristic please and for this reason, during the warmer months, particularly the school holidays, there is a substantial increase in the number of people that come to the town to enjoy the summer. This in turn is reflected in a great increase of boat activities. An analysis of dolphin-boat interactions showed that responses varied depending upon the year and the month, which basically was related to the amount of boats present in the bay, which increases during summer and during weekends (Pierpoint & Allan, 2004; Pierpoint e*t al*., 2009). Nonetheless, studies of reactions towards boats are still quite subjective, since bottlenose dolphins are mostly all the time underwater and only travel to the surface in order to breathe, which makes it very difficult to determine the behaviours and reactions under the water. Lamb (2004) suggested that in New Quay Bay there was evidence of an increase in tolerance towards boats. Nonetheless, the fact that positive interactions are occurring, means a change in the behaviour of the individuals, even if it is travel towards the vessel. This still has an impact upon the bottlenose dolphins, and therefore further analysis is recommended to see if the management plan is fulfilling all the requirements for the species. Parallel to this, there is some evidence that boat occurrence strongly impacts upon the presence of calves (Walker, 2005), hence even though some individuals remain in the Bay for a number of years, the impact might be occurring upon newborns and calves. This can be evidenced from analysis of whistle rates and dive durations (Hastie *et al*., 2003). Walker (2005) suggested that mothers and calves might be avoiding New Quay Bay and could be visiting other zones of the Cardigan Bay SAC looking to get away from the high presence of boats

4.4 Behavioural patterns

In order to analyse the usage of New Quay Bay by some individuals, a behaviour analysis must first be conducted. Previous studies have recorded that traveling, feeding and socialising are the most common behaviours present (Bristow & Rees, 2001; Beddia, 2007; Pesante *et al*., 2008; Feingold & Evans, 2014). Since bottlenose dolphins spend most of their time underwater, behaviour studies are hard to undertake, and analysis of the activities that individuals show are limited to those seen at the surface. Therefore, in order to fully analyse patterns in the behaviours, some other variables have to be analysed and conclusions or speculations should be avoided. In this study, feeding and suspected feeding were the most common behavioural patterns shown by the bottlenose dolphin individuals in New Quay Bay, which as mentioned before, is probably related to prey availability. A lower frequency of foraging and travel were found, both behavioural categories that are also linked with feeding. The highest peak in these three behaviours coincides with the peak period of prey richness in the bay, between June and August (Bristow, 1999; Baines *et al*., 2000; Kosarew, 2003), which suggests there is a relationship between these three behaviours.

Travel and foraging behaviour should be present with greater frequency suggesting that the study area might not be an important part of the home range for the Cardigan Bay bottlenose dolphin population, except for a small number of individuals.

In addition, seasonal changes in the presence of identified individuals is related either to their behaviour or to their use of the bay, hence it can be concluded that particular individuals visiting New Quay Bay are not always coming for the same purposes so their presence and use of the zone is not constant, which means that New Quay Bay area is used at different times by different individuals.

Mothers and calves

Some identified mothers appeared to be absent or less frequent in some years, which may be due to the fact that they are not accompanied by newborns or calves (Bristow & Rees, 2001).

Three mothers were seen on repeated occasions in New Quay Bay, and not only in the years that they were first seen with their calves. This suggests that, even though females may be using the study area as a breeding zone, this is not the only purpose for which it is used. Previous studies have suggested that there is no particular preference for New Quay Bay, and that mothers can visit wider areas (Lamb, 2004).

4.5 Habitat use

Habitat use and behaviour are related to specific characteristics of the individuals, such as gender, age, or presence of calves. As mentioned before, males can visit the area with the aim of mating, whilst older females may come to the bay for breeding or nursery purposes. Therefore, these particular characteristics will determine their occupancy within New Quay Bay. As a recognised feeding area, more activity is found close to the fish factory and the Llanina Reef (K3 grid), which are likely to provide a greater amount of prey for the dolphins. Therefore, even though the individuals are not confined to one specific area of the study site, they do use the deepest areas (close to the A-E a nd 1-4 grids) more often, both in terms of total site usage and for specific behaviours.

4.6 Effects of anthropogenic activities - Conservation management

Even though New Quay area is embedded within Cardigan Bay SAC, and therefore it would be expected that the Conservation Management Plan, together with the Ceredigion Marine Code of Conduct, should protect the bottlenose dolphin population at least in the coastal zone, a large amount of boats travel in and out of the harbour, and this might be having a greater impact than expected, also causing underwater noise. In fact it could be that an increase in boat activity is causing some individuals to spend less time in New Quay Bay, thus encouraging more individuals to visit the bay in less occaccions, which in turn would be seen as more presence of transients individuals, as was found in this study, and which has also been found from the photo – ID proccess that is carry out in the whole Cardigan Bay SAC (Feingold & Evans, 2014). Therefore, boat traffic as well as other anthropogenic activities such as scallop dredging, should be evaluated in more detail, and the protective measures expanded to provide full protection of the population of bottlenose dolphins in New Quay Bay

5. Limitations and Recommendation for Future Studies

During both boat and land surveys, data collection was only recorded under good visibility conditions and during day light, and therefore records during the night were confined only to acoustic monitoring. However, T-POD studies support visual observations indicating that bottlenose dolphins occur in New Quay Bay particularly in the early morning and evening. It is assumed that the dolphins change their behaviour partly to avoid daily boat activities, which are lowest at those times.

General trends and conclusions for the population within the study area may not be typical of the wider region if the area of the study was largely outside the home range of many of the individuals. Nevertheless, 81 individuals were recorded within this small area, highlighting the fact that a significant portion of the Cardigan Bay population uses New Quay Bay at one time or another. Further studies could be made to compare usage of neighbouring sites such as Aberporth Bay, Ynys Lochtyn, Mwnt, and the Teifi Estuary. This would allow one a better understanding of the degree of site fidelity for sections of the population in different habitats

The data analysed in this study were from the summer months only. Since acoustic monitoring shows that dolphins can be found in New Quay Bay in all months of the year, despite a large part of the Cardigan Bay population migrating out of the region, it would be interesting to determine whether particular individuals are so site faithful that they remain there year round.

New Quay Bay is believed to be a feeding area with a high fish species richness upon which bottlenose dolphin may feed, but the species that dolphins prefer are largely unknown and therefore, given that New Quay Bay is a shallow area, some underwater surveys could be carried out, which at the same time might provide more details of specific underwater behaviours.

6. Conclusions

Bottlenose dolphin records in New Quay Bay date back to at least the 1920s. Nowadays, the area is recognised as of great importance for the population of this marine mammal species. Even though the area is part of the Cardigan Bay SAC, the increasing boat activities in the area and their possible effects on the presence and behaviour of bottlenose dolphins are presently a great concern. Therefore, this study aimed to investigate the changes in bottlenose dolphin presence in New Quay Bay over time, as well as to establish any temporal changes in site usage for recognisable individuals.

- Presence of bottlenose dolphin was found to change within the years sampled, and was found to peak during the summer months, particularly between 16th July and 22nd August.
- Total use of the study area was found to vary, but with deeper waters being favoured. In addition, feeding behaviour was found to be the most frequent activity, a probable reason for the higher frequency of use close to the fish factory and around Llanina Reef, both location known to be rich in potential fish prey.
- Most of the individuals analysed were transient individuals that do not visit the bay each year, but instead whose occurrence might change either seasonally or between years; however, a small number have been recorded regularly over several years.
- The change in occurrence of individuals may be related to the purpose of their visits to the bay. New Quay Bay is believed to be both a feeding and breeding area for bottlenose dolphin, and, therefore, some individuals will use some zones more than others, depending upon their reproductive status (reflected in particular characteristics such as gender, age, mother or presence of calves).
- Following on from this, and depending upon the particular individuals, animals may use New Quay Bay either early or later in the summer, depending upon the type of prey they are seeking, whether they are nursing a calf, or perhaps when water temperature increases (if they are coming to give birth).
- The population of bottlenose dolphin in New Quay Bay was largely found to be non resident, although this may be an artifact if the area chosen for the analyses was not

within the core area of an individual's home range zone. This probably explains why some portion of the population is not confined to New Quay Bay.

- Further analysis of the presence of boats and its effects upon the dolphins should be made. It could be that an increase in boat activity is causing some individuals to spend less time in New Quay Bay, thus encouraging more individuals to be transient. If this proves to be the case, then further management actions should be taken in the area to fully protect the bottlenose dolphins.

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- **Appendix 1** Percentage of BND +ve hours of sightings per month for the years of the study

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	24
May	3.57	1.39	6.14	6.90	1.96	0	7.41	6.67	4.35	8.86	9.30	7.21	2.11	64
Jun	3.57	0	24.56	25.86	13.73	0	22.22	8.33	26.09	27.85	25.58	12.61	27.37	12
Jul	7.14	22.22	40.35	32.76	9.80	33.33	25.93	20	21.74	34.18	16.28	46.85	36.84	0
Aug	82.14	50	16.67	31.03	37.25	0	33.33	33.33	8.70	16.46	25.58	13.51	21.05	0
Sep	3.57	26.39	12.28	3.45	31.37	44.44	3.70	31.67	26.09	10.13	20.93	8.11	8.42	0
Oct	0	0	0	0	5.88	22.22	7.41	0	13.04	2.53	2.33	11.71	4.21	0

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- Cardigan Bay SAC

- **Appendix 2** Identified “transient” individuals seen in Cardigan Bay SAC from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
160-05W	Unknown	2005				■								
241-11S	Unknown	2011												■

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- **Appendix 3** Identified “occasional” individuals seen in Cardigan Bay SAC from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
001-03S	Unknown	2003		■					■					
018-03S	Unknown	2003			■									
021-02W	Unknown	2002		■						■				
058-04W	Possible male	2004									■			
103-06S	Unknown	2006					■							
111-01S	Unknown	2001									■		■	
139-91S	Male	2003									■	■		
155-05S	Female	2005										■		
193-07S	Female	2007						■	■	■				

195-07S	Unknown	2007												
199-07S	Unknown	2007												
207-07S	Unknown	2007												
212-08S	Possible female	2008												
216-08S	Unknown	2008												
227-08S	Unknown	2009												
233-09S	Possible female	2010												
234-09S	Unknown	2009												
238-10S	Unknown	2010												
251-11S	Unknown	2011												
252-07S	Unknown	2007												

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- **Appendix 4** Identified "resident" individuals seen in Cardigan Bay SAC from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
004-90W	Female	2003												
005-90W	Possible male	2001												
012-89W	Possible male	2001												
014-94W	Unknown	2001												
016-01W	Unknown	2001												
017-03W	Female	2003												
019-02S	Female	2002												
023-03W	Possible male	2003												
024-05S	Female	2005												
025-01W	Female	2002												
029-02W	Possible male	2002												
030-05S	Female	2005												
033-06S	Female	2006												

036-06W	Possible male	2006								■			■	
047-90W	Unknown	2001		■	■			■						
048-90W	Female	2001								■	■			
049-89S	Unknown	2002									■			■
060-01W	Possible male	2001		■	■	■			■			■		
062-06W	Unknown	2006								■			■	■
064-01W	Male	2001	■											
067-01S	Female	2001	■											
070-06S	Unknown	2006					■		■				■	■
073-03S	Unknown	2003								■		■	■	■
074-03W	Male	2003		■	■	■	■	■	■	■	■	■	■	■
075-03W	Possible male	2003										■		
081-01S	Female	2001										■		
082-01W	Female	2001	■	■										
083-01W	Female	2001		■		■					■		■	
085-03W	Male	2003					■	■	■			■	■	■
086-06W	Male	2006												■
091-90W	Female	2003					■				■	■		
096-90W	Possible male	2005				■			■			■	■	■
099-905S	Female	2005									■			
101-05W	Female	2005								■			■	
102-02S	Possible female	2002					■			■				
105-03W	Possible male	2003										■	■	■
107-91S	Unknown	2003												■
108-01W	Unknown	2001										■		
109-92W	Possible male	2001		■		■			■	■	■	■	■	■
110-01W	Possible male	2001									■			

112-01S	Female	2001												
115-01W	Unknown	2001												
118-02W	Possible male	2002												
128-02S	Unknown	2002												
132-03W	Female	2003												
142-01W	Unknown	2001												
151-05S	Unknown	2005												
158-05W	Unknown	2005												
159-03W	Possible male	2005												
163-05S	Male	2005												
165-07S	Unknown	2006												
176-90W	Unknown	2005												
181-06W	Possible male	2006												
186-05S	Unknown	2005												
188-07W	Unknown	2007												
192-07S	Unknown	2007												
194-07W	Unknown	2007												
196-07W	Possible male	2007												
220-03S	Female	2003												

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- New Quay Bay

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- **Appendix 5** New Quay Bay Transient identified individuals seen in the study area from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
001-03S	Unknown	2003												
005-90W	Possible male	2001												
012-89W	Possible male	2001												
019-02S	Female	2002												

018-03S	Unknown	2003			■										
021-02W	Unknown	2002		■						■					
025-01W	Female	2002	■												
030-05S	Female	2005										■	■		
033-06S	Female	2006							■			■			
036-06W	Possible male	2006								■			■		
048-90W	Female	2001								■	■				
049-89S	Unknown	2002									■			■	
058-04W	Possible male	2004									■				
064-01W	Male	2001	■												
067-01S	Female	2001	■												
075-03W	Possible male	2003										■			
081-01S	Female	2001										■			
082-01W	Female	2001	■	■											
086-06W	Male	2006												■	
099-05S	Female	2005									■				
101-05W	Female	2005								■			■		
102-02S	Possible female	2002					■			■					
103-06S	Unknown	2006					■								
107-91S	Unknown	2003												■	
108-01W	Unknown	2001										■			
110-01W	Possible male	2001									■				
111-01S	Unknown	2001									■		■		
112-01S	Female	2001										■			
115-01W	Unknown	2001	■												
118-02W	Possible male	2002					■							■	
128-02S	Unknown	2002											■	■	

139-91S	Male	2003												
151-05S	Unknown	2005												
155-05S	Female	2005												
158-05W	Unknown	2005												
159-03W	Possible male	2005												
160-05W	Unknown	2005												
163-05S	Male	2005												
165-07S	Unknown	2006												
186-05S	Unknown	2005												
195-07S	Unknown	2007												
199-07S	Unknown	2007												
216-08S	Unknown	2008												
233-09S	Possible female	2010												
234-09S	Unknown	2009												
238-10S	Unknown	2010												
241-11S	Unknown	2011												
251-11S	Unknown	2011												
252-07S	Unknown	2007												

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- **Appendix 6** New Quay Bay Occasional identified individuals seen in the study area from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
014-94W	Unknown	2001												
023-03W	Possible male	2003												
024-05S	Female	2005												
029-02W	Possible male	2002												
047-90W	Unknown	2001												
060-01W	Possible male	2001												

062-06W	Unknown	2006								■			■	■
070-06S	Unknown	2006					■		■				■	■
073-03S	Unknown	2003								■		■	■	■
083-01W	Female	2001		■		■					■		■	
085-03W	Male	2003					■	■	■			■	■	■
091-90W	Female	2003					■				■	■		
096-90W	Possible male	2005				■			■			■	■	■
105-03W	Possible male	2003										■	■	■
132-03W	Female	2003							■			■		■
142-01W	Unknown	2001			■	■			■	■	■	■	■	
176-90W	Unknown	2005								■	■	■		
181-06W	Possible male	2006									■	■	■	■
188-07W	Unknown	2007							■	■			■	■
192-07S	Unknown	2007						■		■	■	■	■	■
193-07S	Female	2007						■	■	■				
194-07W	Unknown	2007										■	■	■
196-07W	Possible male	2007							■	■			■	
207-07S	Unknown	2007							■	■	■	■	■	■
212-08S	Possible female	2008										■	■	■
220-03S	Female	2003			■		■		■	■			■	■
227-08S	Unknown	2009								■	■			■

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- **Appendix 7** New Quay Bay Resident identified individuals seen in the study area from 2001 to 2013

Catalogue name	**Gender**	**First seen**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
004-90W	Female	2003			■	■			■	■	■	■	■	■
016-01W	Unknown	2001		■	■	■	■		■	■	■		■	■

017-03W	Female	2003																					
074-03W	Male	2003																					
109-92W	Possible male	2001																					

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- **Appendix 8** Monthly summary for total number of days that marked individuals were seen in New Quay Bay study area from 2001 to 2013

Year	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**	
	April	0		April	6		April	0		April	0
	May	0		May	0		May	1		May	1
	June	0		June	0		June	5		June	3
	July	0		July	0		July	4		July	11
	August	0		August	0		August	1		August	2
	September	0		September	0		September	2		September	0
	October	0		October	0		October	0		October	2
	November	0		November	0		November	0		November	0
2001	**Total**	0	2002	**Total**	6	2003	**Total**	13	2004	**Total**	19
Year	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**	
	April	0		April	0		April	0		April	1
	May	1		May	1		May	0		May	4
	June	3		June	2		June	3		June	11
	July	0		July	0		July	3		July	23
	August	0		August	0		August	0		August	30
	September	3		September	4		September	0		September	38
	October	9		October	3		October	0		October	8
	November	7		November	0		November	0		November	0
2005	**Total**	23	2006	**Total**	10	2007	**Total**	6	2008	**Total**	115
Year	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**		**Year**	**Number of days**	
2009	April	0	2010	April	0	2011	April	0	2012	April	2

	May	8		May	5		May	22		May	14
	June	6		June	21		June	30		June	3
	July	15		July	36		July	11		July	21
	August	36		August	28		August	5		August	21
	September	10		September	12		September	19		September	19
	October	6		October	9		October	3		October	25
	November	0		November	0		November	0		November	0
	Total	81		**Total**	111		**Total**	90		**Total**	105

Year	**Number of days**	
	April	3
	May	16
	June	47
	July	46
	August	40
	September	11
	October	10
	November	0
2013	**Total**	173

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