

**Assessing the parameters affecting sighting detection rates of the Bottlenose  
Dolphin in the Cardigan Bay Special Area of Conservation, Wales**

**Amrit Melissa Dencer-Brown**

**Student #: 2813171**

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Supervisors: Dr. Kerry Lock, Daphna Feingold and Dr. Peter Evans

Project in association with the Sea Watch Foundation

## **DECLARATION AND STATEMENTS**

This work has not been previously accepted in substance for any degree and is not being concurrently submitted for any degree or programme.

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TUTOR: DR.KERRY LOCK

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**Assessing the parameters affecting sighting detection rates of the Bottlenose Dolphin in the Cardigan Bay Special Area of Conservation, Ceredigion, West Wales.**

**Amrit Melissa Dencer-Brown**

**Oxford University Department of Continuing Education, Rewley House,  
Wellington Square, Oxford, OX1 2JA**

**ABSTRACT**

Abundance and density data on the semi-resident population of bottlenose dolphins in New Quay, Cardigan Bay is integral to the conservation measures employed in this Special Area of Conservation. Responsive behaviour of the bottlenose dolphin *Tursiops truncatus* to vessels in the area may have an effect on abundance and density data leading to positive or negative bias in the numbers recorded. The present study's main aim was to see whether responsive behaviour of *Tursiops truncatus* to vessels occurred, at what distances this behavioural response took place and whether this behaviour occurred before the observer on board the vessel had detected the bottlenose dolphin(s). The study period ran from the 24<sup>th</sup> June to the 31<sup>st</sup> July 2012. Bottlenose dolphins were tracked from the cliff-top and behaviour prior to interaction with vessels was noted as well as any behavioural changes. Observers onboard vessels also recorded the presence of bottlenose dolphins and the data was compared. Responsive behaviour occurred in 38% of total observations (n=95). However this was not significant with the type of vessel, group size and composition of the bottlenose dolphin or distance between the bottlenose dolphin and the vessel (Chi-squared tests,  $P>0.05$ ). Comparison

of data between the observer on the vessel and the cliff-top observer showed that responsive behaviour occurred in 43% of cases, all displaying behaviour away from the vessel. This change in behaviour was detected by the cliff-top observer before the observer on the vessel in 66% of observations, however sample size was very low (n=7). This study suggests that responsive behaviour of *Tursiops truncatus* may occur and that this occurrence may happen before the animal is detected by the observer onboard the vessel. This has important implications with regards to abundance and density estimates of *Tursiops truncatus* in the Cardigan Bay SAC and subsequent conservation measures implemented within the area.

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# 1. INTRODUCTION

The main objective of this study was to look at which parameters affect the rates at which the bottlenose dolphin, *Tursiops truncatus*, is detected by observers on vessel-based observation platforms on research vessels. Populations of animals may fluctuate in terms of size and distribution overtime due to a variety of factors (Evans and Hammond, 2004). Monitoring any changes in population dynamics and identifying their causes forms the basis of conservation research. Abundance and density estimates may not be accurate if bottlenose dolphins respond to the vessel, either moving towards or away from it, which can cause bias in abundance estimates (Buckland *et al.*,2004). It is important to ascertain whether this behaviour is occurring and at what distance to the vessel. Abundance and density data are extremely important in understanding the ecology of populations of cetaceans and have strong implications in the conservation of marine mammal species.

## 1.1 The bottlenose dolphin, *Tursiops truncatus*

The bottlenose dolphin was first described by Montagu in 1821 as *Delphinus truncatus*. The genus was changed to *Tursiops*, meaning ‘dolphin-like’ by Gervais in 1855 (Wells and Scott, 1999). It is a member of the family ‘Delphinidae’, one of the most diverse cetacean families, also consisting of other species such as the orca or killer whale, long-finned pilot whale, Atlantic white-sided dolphin,, common dolphin and Hector’s dolphin (Evans, 1984).

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### CLASSIFICATION

<b>KINGDOM</b>	Animalia
<b>PHYLUM</b>	Mammalia
<b>CLASS</b>	Chordata
<b>ORDER</b>	Cetacea
<b>FAMILY</b>	Delphinidae
<b>GENUS</b>	<i>Tursiops</i>
<b>SPECIES</b>	<i>T. truncates</i>

**Table 1.** Phylogeny of the bottlenose dolphin; *Tursiops truncatus* (Montague, 1821).

## ***1.2 Feeding habits of *Tursiops truncatus****

The bottlenose dolphin has a varied diet including cephalopods and benthic, pelagic, solitary and schooling fish (Wilson *et al.*, 1997). They are opportunistic feeders and individuals may switch particular prey species as availability changes particularly with area and season.

Common prey of bottlenose dolphin in Scottish waters include cod, whiting, saithe and haddock, as well as sprat, salmon, sandeels, flatfish and cephalopods (Santos *et al.*, 2001). Bottlenose dolphins in Welsh waters have been observed feeding upon species such as sea bass, salmon, garfish, conger eel, sandeel and some small species of shark (Pesante *et al.*, 2008; Sea Watch, unpubl data).

The semi-resident population of bottlenose dolphins in Cardigan Bay have been observed forming small groups close to the coast during the summer months, frequently diving and feeding either close to or directly off the seabed (Pesante *et al.*, 2008; Sea Watch, unpubl. data). They have also been observed to feed on pelagic prey such as herring and mackerel situated offshore and around estuaries like the Teifi.

Larger groups have been observed during the winter and spring months in North Wales feeding on species such as sea bass, herring, whiting and mackerel (Sea Watch, unpubl. data).

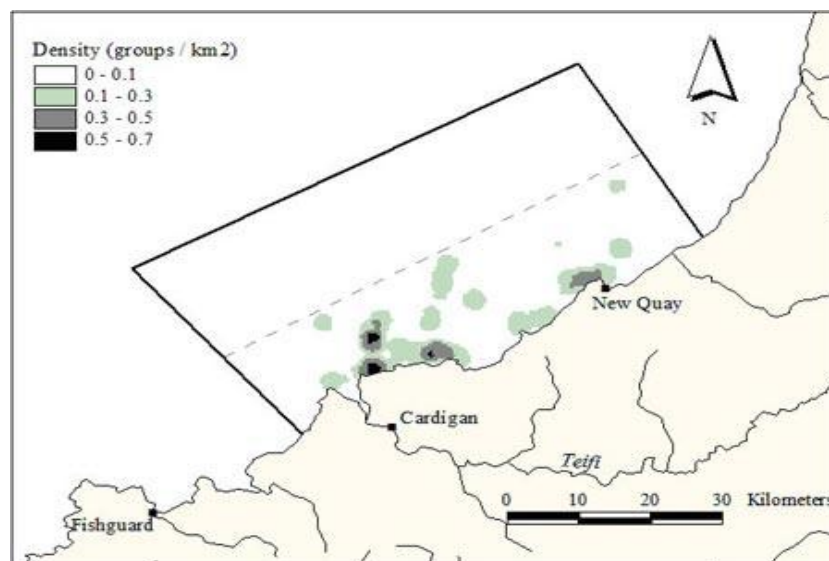
## ***1.3 Global distribution of *Tursiops truncatus****

The bottlenose dolphin (*Tursiops truncatus*) has a worldwide distribution, found throughout tropical seas and temperate oceans (Shane, 1990). This species of dolphin occupies a variety of marine habitats, from shallow coastal areas to deep seas, as well as inshore lagoons and estuaries (Leatherwood and Reeves, 1990). Coastal populations of bottlenose dolphins have been studied extensively over recent decades, and have been seen to exhibit periodic residency, seasonal migrations, home ranges, repeated residency and long-range movements (Wells and Scott, 1999). Bottlenose dolphin populations have fission-fusion societal structures, with changes in group composition, high levels of cooperation and complex relationships (Holobinko and Waring, 2009).

### ***1.4 Distribution of Tursiops truncatus in UK waters***

*Tursiops truncatus* has a wide distribution in UK waters, ranging from the English Channel and Irish Sea (particularly Cardigan Bay), to South-West Scotland, North-East Scotland (especially areas such as the Moray Firth and Firth of Forth), to Western Ireland (Shannon estuary and Galway Bay in particular) (Evans, 1992; Hammond *et al.*, 1995; Berrow *et al.*, 1996; Pollock *et al.*, 2000., Lahaye and Mauger, 2000; Pineau *et al.*, 2000; Evans *et al.*, 2003).

There are two known semi-resident populations of *Tursiops truncatus* in UK waters. Cardigan Bay holds the largest population of semi-resident bottlenose dolphins in UK waters (Pesante and Evans, 2008), with approximately 150-250 individuals (Baines *et al.*, 2002; Ugarte and Evans, 2006; Pesante *et al.*, 2008b; Feingold *et al.*, 2011) followed by the Moray Firth population (Wilson *et al.*, 1997; Thompson *et al.*, 2005).



**Figure 1.** Density of bottlenose dolphins in Cardigan Bay SAC during the months of May to July. Sea Watch Foundation, 2012.

Residency has been observed with smaller populations around Scottish islands such as Islay, Tiree, Mull and Coll as well as Skye in Western Scotland.

The species also occurs offshore in the eastern North Atlantic (often in association with long-finned pilot whales), as far north as the Faroe Islands and even Svalbard (Evans,

1992; Bloor *et al.*, 1996; Pollock *et al.*, 2000).

### ***1.5 Responsive Behaviour of *Tursiops truncatus* to vessels***

Coastal waters and estuaries are home to dense human populations and marine tourism and recreation has become an incredibly lucrative and popular industry over recent decades (Mattson *et al.*, 2005). A decade ago, it was found that commercial whale-watching tours were available in almost 90 countries world-wide and the industry was worth 1 billion USD (Hoyt, 2001). Now, after years of media attention, nature documentaries and films about cetaceans, marine tourism is burgeoning. This can have good implications, such as raising awareness about conservation measures and educating the general public on protection of the ocean; an ever-more important issue in current times with the global problems the oceans are facing due to climate change.

The popularity of bottlenose dolphins has led to an increase in 'dolphin-watching' trip boats operating in coastal waters around the world, however, the presence of high levels of boat traffic can cause disturbance to populations of bottlenose dolphins, including changes in behaviour (Constantine *et al.*, 2002; Mattson *et al.*, 2005; Nowacek *et al.*, 2001). The use of coastal habitats by bottlenose dolphins makes this species of cetacean particularly susceptible to anthropogenic activity.

Resting behaviour of *Tursiops truncatus* has been shown to decrease with high levels of boat traffic in the Bay of Islands, New Zealand (Constantine *et al.*, 2002). Both the direction of movement and changes in behaviour of *Tursiops truncatus* occurred with increased boat traffic off Hilton Head Island, South Carolina, USA (Mattson *et al.*, 2005). Boat traffic has been shown to possibly suppress the use of sites at New Quay harbour, Cardigan Bay by bottlenose dolphins (Pierpoint *et al.*, 2009).

The type of vessel may also cause a different response by bottlenose dolphins, depending on the size of the engine, speed of the vessel and whether the course is steady or erratic. Underwater noise caused by vessel engines may affect communication of bottlenose dolphins through acoustic activity, as well as detection of prey and the orientation of the animals (Tyack, 1999).

Long-term impacts of vessel activity on bottlenose dolphins situated off Shark Bay, Australia showed that the presence of tour vessels contributed more to a decrease in population size compared to research vessels in the area (Bejder *et al.*, 2006). Studies on the responsive behaviour of *Tursiops truncatus* to boat traffic have revealed how important it is that strict marine codes of conduct regarding vessels are implemented in high-use areas for bottlenose dolphins.

### **1.6 Variation in detection rates**

Variation in cetacean detection rates due to particular parameters such as vessel platform height and speed, observer experience, field of view, and sea state can all greatly affect abundance and density estimates. Addressing such potential biases in cetacean surveying techniques is critical.

Responsive behaviour of cetaceans to a vessel is a potentially serious factor in detection rates. They may be attracted to or move away from the approaching vessel, which can be a source of bias in estimates of cetacean abundance using line transects. This form of bias may lead to negative abundance/density estimates if the animal moves away from the vessel, or positive estimates if it moves towards it.

Normally, large vessels try to account for this possibility by having double platforms - primary and independent observers on platforms of differing height on the vessel. The higher platform should allow the observer to scan ahead at a greater distance, to try and detect the animals before they respond (Evans and Hammond, 2004).

### **1.7 Objectives of the study**

This project looks at responsive behaviour of bottlenose dolphins to small vessels. The effects of motor sound should be limited on a small vessel. However, its low platform height makes it more difficult to determine whether responsive behaviour has taken place or not.

This study aims to compare the ranges at which dolphins are detected from the vessel, with measurements taken using an electronic theodolite on the cliff-top from the dolphin to the vessel. It can then be seen at what ranges any changes in behaviour occur and whether the observer on the vessel has detected the animal before or after this change in behaviour. (If the vessel-based observer does not see the dolphin(s) until

after a change in behaviour, then this may create bias in abundance estimates, as the animal may move towards or away from the vessel).

Another problem with abundance estimates on line transect surveys is availability bias. As the dolphins will only be surfacing for short periods of time, observers can only record dolphins which they can see. The amount of time the dolphins stay at the surface may depend upon the group size and the type of activity. When there is a high sea state, perception bias is particularly introduced, so both of these together pose a large potential error in estimating abundance of cetaceans from the boat.

### ***1.8 Research questions for assessing the parameters affecting detection rates***

**1: Do bottlenose dolphins exhibit responsive behaviour in the presence of a small vessel?**

**2: If bottlenose dolphins exhibit responsive behaviour in the presence of a small vessel; at what ranges does this occur?**

**3: Do bottlenose dolphins respond to the vessel by moving towards the vessel or away from it?**

**4: Do the primary observers onboard the vessel detect the bottlenose dolphins before they respond to the vessel?**

**5: If not, to what extent does this bias affect the abundance/density estimates of bottlenose dolphins and harbour porpoises?**

**6: Is responsive behaviour affected by group size?**

**7. Is responsive behaviour affected by group composition?**

**8. Is responsive behaviour affected by sea state?**

**Table 2: Research questions for the study.**

## ***1.9 Hypotheses***

- Ho: Bottlenose dolphins do not exhibit responsive behaviour in the presence of a small vessel or responsive behaviour will occur after the primary observer has detected the animals (so at closer range).
- Ho: There is no significant difference in the estimate of density and abundance estimates from the primary observer and the land-based observer using a theodolite to track the actual ranges of the animals.
- Ho: This form of bias is not significant since if responsive behaviour did occur, it would be after the bottlenose dolphin(s) had been detected.
- Ho: There is no significant effect on responsive behaviour of *Tursiops truncatus* by sea state.
- Ho: There is no significant effect on responsive behaviour of *Tursiops truncatus* with group size.
- Ho: There is no significant effect on responsive behaviour of *Tursiops truncatus* with group composition.

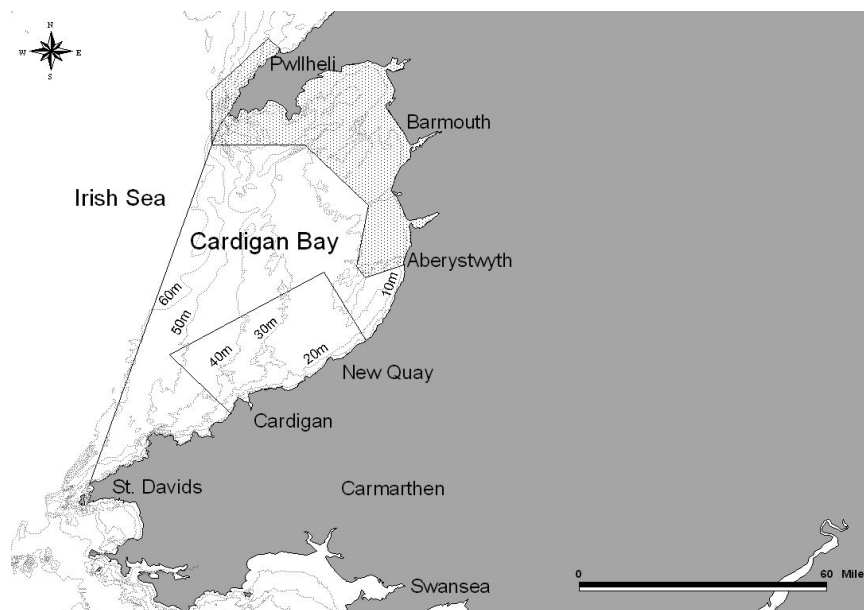


## 2.0 MATERIALS AND METHODOLOGY

### 2.1 Study Area

This project was carried out from the 24<sup>th</sup> June to the 31<sup>st</sup> July 2012 at Cardigan Bay, Ceredigion, West Wales. Cardigan Bay is the largest bay in the British Isles and covers an area of approximately 5500km<sup>2</sup> (Gregory & Rowden, 2001). In 1992, the voluntary Ceredigion Marine Heritage Coast was established, which led to Cardigan Bay being put forward as a Special Area of Conservation (SAC) under the EU Habitats and Species Directive (94/43/EEC).

In 2004, the southern region of the bay was granted SAC status (Ceredigion County Council et al., 2008). This region covers approximately 1000km<sup>2</sup> and is home to a semi-resident population of bottlenose dolphins (*Tursiops truncatus*) (Pesante et al., 2008; Ugarte and Evans, 2006; Veneruso and Evans, 2012).

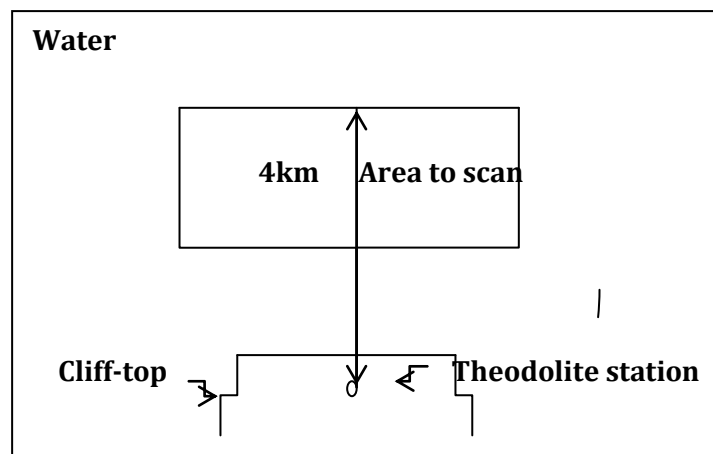


**Figure 2.** Cardigan Bay SAC (Pesante et al., 2008).

Bottlenose dolphins are listed under Annex II of the EU Habitats Directive and the Cardigan Bay population is most abundant during the months of April to October (Pesante et al., 2008; Ugarte et al., 2006; Veneruso and Evans, 2012). A significant proportion of the population then migrates northwards around November to the waters

off Anglesey, the Isle of Man and probably beyond, where they remain until the following April (Veneruso and Evans, 2012; Pesante *et al.*, 2008).

Cliff-top observations were conducted from a research station on the New Quay headland, with the SAC at GPS co-ordinates: 52°13.040'N, 04°21.871'W ± 5m. The area out to sea from this vantage point is very broad and it is possible to spot and track dolphins several kilometres away. For this investigation, an area of 9km<sup>2</sup> was allocated, which corresponds to a horizontal distance of 4km out from the theodolite research station.



**Figure 3:** Diagram of research area

This area was gridded off into smaller sections and displayed as a map, which was used by the cliff-top observers to locate a group/individual animal when an interaction with a vessel and a bottlenose dolphin(s) occurred. The map was marked with the initial sighting of the bottlenose dolphin(s) and of any vessels in the area. Whilst the focus was on the vessel with the Sea Watch observers, a note was made of any other vessels in the area and any interaction that had occurred (see Appendix 1).



**Figure 4:** Study area from the research station: Amrit Dencer-Brown

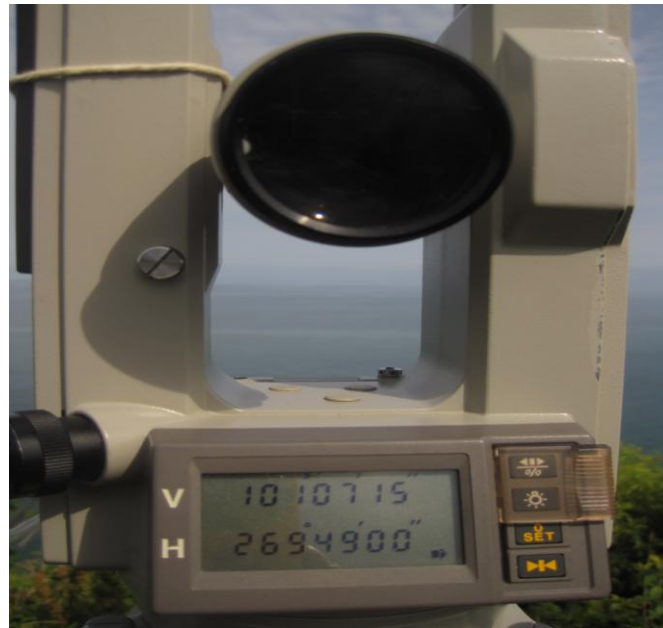
The time, direction, behaviour of the bottlenose dolphin(s), and any behavioural change was noted. This method follows also the same protocol as the land watches conducted by Sea Watch Foundation.

## ***2.2 Survey Design***

The horizontal reference point was a weather station at geographical co-ordinates: 52°12.865'N, 4°22.536'W ±5 m. Co-ordinates of bottlenose dolphins were measured using a 30x magnification Sokkia electronic digital theodolite.

The theodolite was set to the reference point, so giving a horizontal reading of 0°00'00". The presence of bottlenose dolphins was recorded every 15 minutes over a period of two hours, followed by a 15-minute break. One observer tracked the direction, behaviour, group size and composition of the dolphins using the theodolite, and the other observer took down the horizontal and vertical readings from the theodolite as the dolphins were being tracked. A third observer, when present, was able to assist in searching for and tracking the dolphins, when there was more than one dolphin individual or group in the area and/or more than one vessel. Changes in behaviour were recorded as either movement away from the vessel, movement towards the vessel, diving down for long periods or neutral behaviour (no change). Every 15 minutes,

effort was taken. This consisted of recording the sea state, wind direction, visibility, swell height, tidal height, and whether or not there was a sighting (see Appendix 2).



**Figure 5:** 30x magnification Sokkia electronic digital theodolite. V corresponds to the vertical reading and H to the horizontal reading: Amrit Dencer-Brown.

It was sometimes the case that an observer from the vessel had already seen a dolphin or group before the vessel had entered the target area. In this case, possible responsive movement could not be determined as it may have already occurred. In those situations, the vessel was tracked primarily on its way back to the harbour. The observer on the theodolite continually marked locations of the vessel and bottlenose dolphin(s) during the interaction, noting the time and any behavioural change by the dolphin(s), and by the vessel. This information was then used to compare with observations made by the observer(s) on the vessel, where the same vessel was involved in the same recorded interaction in the target area.

### 2.2.1 Categories of vessels

Vessels in the study area were categorised according to their type and size.

BOAT TYPE		LOG	BOAT TYPE		LOG
Smb	Recreational motor boat <15m		RB	Row boat, kayak	
Mmb	Recreational motor boat 15-30m		JS	Jet Ski	
SB	Racing type speedboat or RIB		R	Cetacean Research Boat	
YA	Any boat under sail		FE	Ferry	
FI	Fishing Boat		LS	Ship >30m	
VPB	Visitor Passenger Boat				

**Table 3:** Vessel log to record vessels tally and type within the study area.

The *Ermol V* and *VI* visitor passenger boats operate scheduled departures from New Quay on a daily basis, weather permitting. Prior to any trip, it was ascertained whether a Sea Watch observer would be going on the vessel, and at what time. Radios were used to check whether boat tours were going ahead so that the cliff-top observers could set up and start scanning the target area for dolphins and possible encounters. The vessel *Islander* did not have definite departure times so this was also checked in advance by radio.

The Sea Watch research vessel, *Dunbar*, went out occasionally for line-transect surveys, depending upon the weather. When this occurred, only the primary investigator of this project could be present on the cliff-top as all volunteers were required on survey. Depending on the line-transect chosen to survey, *Dunbar* sometimes came into the

study area. Although it was difficult to track the bottlenose dolphins and take down co-ordinates, the use of a voice-recorder was set up so that the cliff-top observer did not have to take down the co-ordinates immediately and risk losing track of the bottlenose dolphins.

Occasionally, the RIB Gallois was taken out for photo-identification of *Tursiops truncatus*. During these times, the vessel was given R status (cetacean research boat).

### **2.2.3 Comparison of vessel-based and cliff-top based data**

A positive identification of the same group/individual could be made by comparing the time of sighting and location taken from the handheld Garmin GPS 60 device on the vessel. An angle board was used by the observer on the vessel to derive an angle to the sighting and this assisted the accurate identification of the same group/individual dolphin. When a dolphin was detected, the observer on the vessel immediately contacted the cliff-top observer. The cliff-top observer would then simultaneously take a fix on the dolphin using the theodolite, and the co-ordinates used to calculate the distance of the dolphin to the boat. During times when the radio did not work; the vessel-based observer would raise their hands to indicate a sighting. The cliff-top observer took down the locations of the vessel with the theodolite also to confirm location when comparing data.

Other vessels without observers were also recorded, and the same measurements taken from the cliff-top since those data could still be used to note behavioural changes of the dolphins and of the vessels.

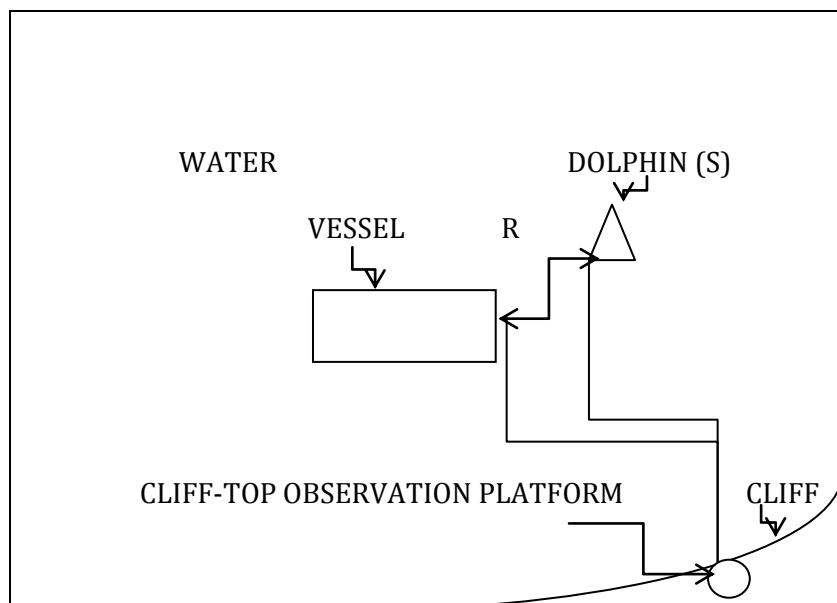
### **2.2.4 Sea state and visibility**

The sea state was categorised according to the Beaufort Scale (see figure 12). Dolphins are difficult to spot and track when the sea state is 3 or above, so for this study, data was collected only when the sea was state 2 or less. Sometimes the sea state would change during the day, so it was checked every 15 minutes (see Appendix 1). The theodolite was not used if there was any precipitation. Visibility was also taken down as effort every 15 minutes on a scale of 1-4, where 1 corresponded a visibility of <1km, 2=1-5km, 3=6-10km and 4=>10km.

### 2.2.5 Distance calculations

The distance of the vessel to dolphins, as recorded from the cliff-top, was calculated using a series of trigonometric formulae inputted into an Excel spreadsheet created by Meier, 2010. The vertical and horizontal readings from the theodolite were converted into distances between vessels and the dolphins. It was made sure that all of the trigonometric formulae and calculations were understood, and co-ordinates of *Tursiops truncatus* and vessels were verified on Google Maps.

For the correct distances to be calculated, the accurate height above sea level of the theodolite was needed for this calculation. The height of the cliff was calculated using the rod method (Frankel and Yin, 2009) by Meier, 2010. Since the tidal height can alter the distances calculated with the theodolite to a significant degree, a rock was marked at 0.5m intervals from the lowest tide of the season. This is referred to as the Reference Tidal Mark (RTM). This was then checked every 15 minutes. This was then used to determine at what distance the dolphins responded to the vessel and whether their behaviour changed.



**Figure 6:** Diagram of interactions with *Tursiops truncatus* and vessels. R= distance between vessel and *Tursiops truncatus*.

Total theodolite height was calculated as: Total theodolite height= Reference station Altitude + Theodolite Eye Height -/+ Tidal Height (above/below the RTM)



**Figure 7:** Target rock being painted at 0.5m intervals in order to calibrate tidal height as part of calculations for distances between *Tursiops truncatus* and vessels. (RTM = 0.7m above chart datum).

#### 2.2.6 Group size, composition and behavioural states of *Tursiops truncatus*

A group of dolphins has been defined as ‘a number of dolphins in close association with one another, often engaged in the same activity and remaining within approximately 100m of each other’ (Shane, 1990; Bearzi *et al.*, 1997). During the observations, as well as group size being noted, the group composition of *Tursiops truncatus* was recorded as taken from Bearzi *et al.*, 1997 (see below).

- **ADULT:** A dolphin that appears fully-grown (approximately 2.5-4m long).
- **NEW-BORN:** less than ½ adult length. Constantly in close association with the adult. Dorsal fin typically low and rounded. Visible fetal creases.
- **CALF:** About ½ size of adult, in clear association with adult, light grey colouration, usually with lighter vertical stripings left by fetal creases.
- **JUVENILE:** About 2/3 size of an adult, usually swimming in association with an adult, but sometimes independently, coloration generally lighter than an adult.

Behaviours of *Tursiops truncatus* were categorized as resting/milling (R), Travel (T), Socializing (S), Feeding (FF), Suspected Feeding (SF), Long Dives (DIV), Aerial Behaviour (AB), Percussive Behaviour (PB), Bow-riding (B) and Unknown (U).



<b><u>Behaviour of bottlenose dolphin</u></b>	<b><u>Description</u></b>
<b>Resting/milling (R)</b>	Dolphins engaged in very slow movement as a tight group (Constantine <i>et al.</i> ,2004). Non-directional, slow movement (Shane, 1990).
<b>Travel (T)</b>	Continuous movement in one general direction (Bearzi and Politi, 1999).
<b>Socializing (S)</b>	Dolphins observed leaping, chasing, observed in body contact with each other. Aspects of play and mating with other dolphins (Constantine <i>et al.</i> ,2004).
<b>Suspected Feeding (SF)</b>	Dolphins in an effort to capture and consume prey, however, no visible prey observed.
<b>Long dives (DIV)</b>	Diving for long periods of time, thought to be foraging at depth (Shane, 1990).
<b>Feeding (FF)</b>	Prey seen being captured and consumed
<b>Aerial Behaviour (AB)</b>	Dolphins clear the water with all or most of their body
<b>Percussive Behaviour (PB)</b>	Dolphin hits the water with any part of its body
<b>Bow riding (B)</b>	Riding bow waves produced by ships and boats
<b>Unknown (U)</b>	Behaviour not recognised.

**Table 4:** Behaviours of *Tursiops truncatus* used for the study.

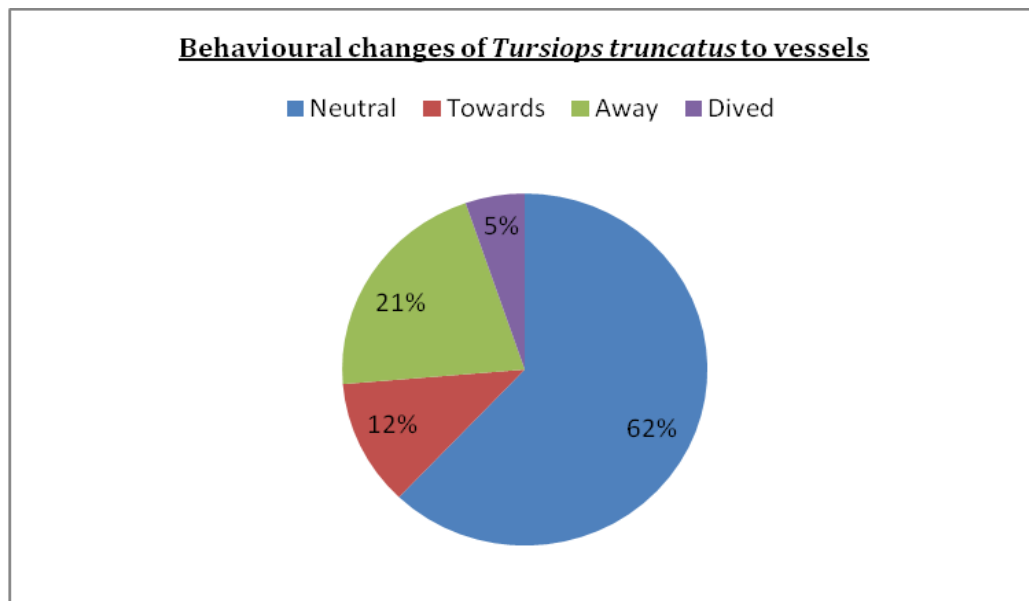
### 3. RESULTS

Analysis of results were carried out using Excel 2010. Non-parametric tests (Chi-squared) were used to test for significance of hypotheses. A total of 73 hours of effort

was taken over the study period, resulting in 18.25 hours of observations of interactions with bottlenose dolphins and vessels. A total of 95 observations of interactions with bottlenose dolphins and vessels were recorded during the study period. The weather during the study period was very changeable and many days the sea state reached 4 in the study area, with high north/north-westerly and westerly winds. There was a high amount of precipitation in the initial fortnight of the study period which meant that the electronic theodolite could not be used, due to its high-sensitivity.

### 3.1 Responsive Behaviour

Out of the 95 observations of *Tursiops truncatus* and vessels in the study area; 36 showed a change in behaviour in the presence of vessels and the remaining 59 showed no response. Behavioural changes consisted of movement towards the vessel (12%), movement away from the vessel (21%) and diving down for long periods (5%).



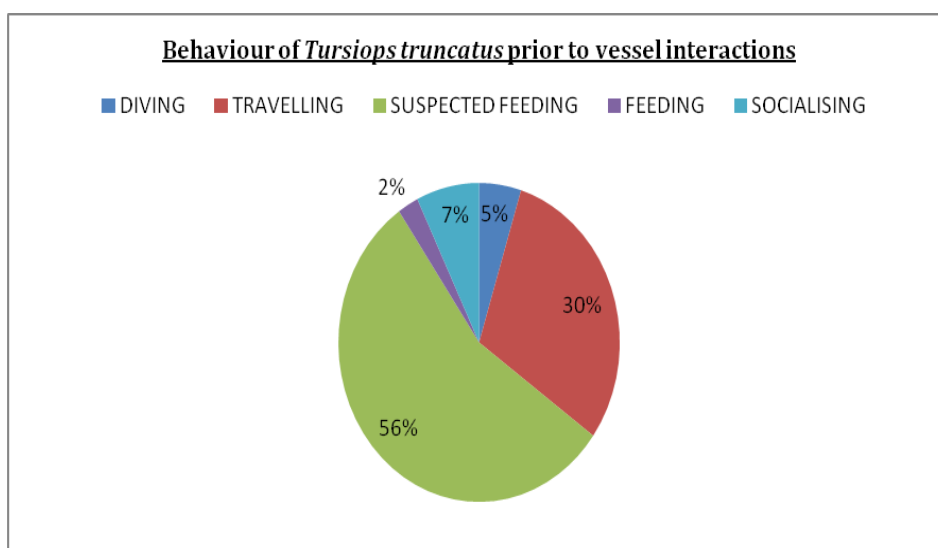
**Figure 8:** Pie-chart displaying behaviours of *T. truncatus* in the presence of vessels (%). Response to vessels was neutral (no response), towards the vessel, away from the vessel or diving down for long periods.

BEHAVIOUR	Neutral	Towards	Away	Dived
# OBSERVATIONS	59	11	20	5
PERCENTAGE (1 D.P)	62.1	11.6	21.0	5.3

**Table 5:** Behaviour of *T. truncatus* in the presence of vessels. Behaviour, number of observations and conversion to percentages are shown.

### 3.2 Behaviour of *Tursiops truncatus* prior to interactions with vessels

Bottlenose dolphins engage in a wide-range of activities and can display multiple types of behaviour (see table 4). Observed behaviours prior to interactions with vessels in the study area showed *Tursiops truncatus* engaging in 5 different types of behaviour: diving, travelling, suspected feeding, feeding and socialising. Of these, the majority of recorded behaviour was suspected feeding (56%), followed by travelling behaviour (30%), diving (7%) socialising (5%) and feeding (2%).



**Figure 9.** Pie-chart displaying types of behaviour exhibited by *T. truncatus* before exposure to vessels

BEHAVIOUR	DIVING	TRAVELLING	FEEDING	SUSPECTED FEEDING	SOCIALISING
# OBSERVATIONS	4	25	2	46	6

**Table 6.** Behaviour of *T. truncatus* prior to interactions with vessels. Total number of behaviours observed was 83.

#### 3.2.1 Suspected feeding and feeding

Over half of observed behaviours were suspected feeding. The study area encompassed 3 feeding grounds, the westerly edge of the study area contained Bird's Rock, the

easterly edge is situated close to the shellfish factory (see discussion) and a central part of the area is Target Rock (see figures 4 & 7), where *Tursiops truncatus* was frequently observed in suspected feeding or feeding behaviour.

### **3.2.2 Travelling**

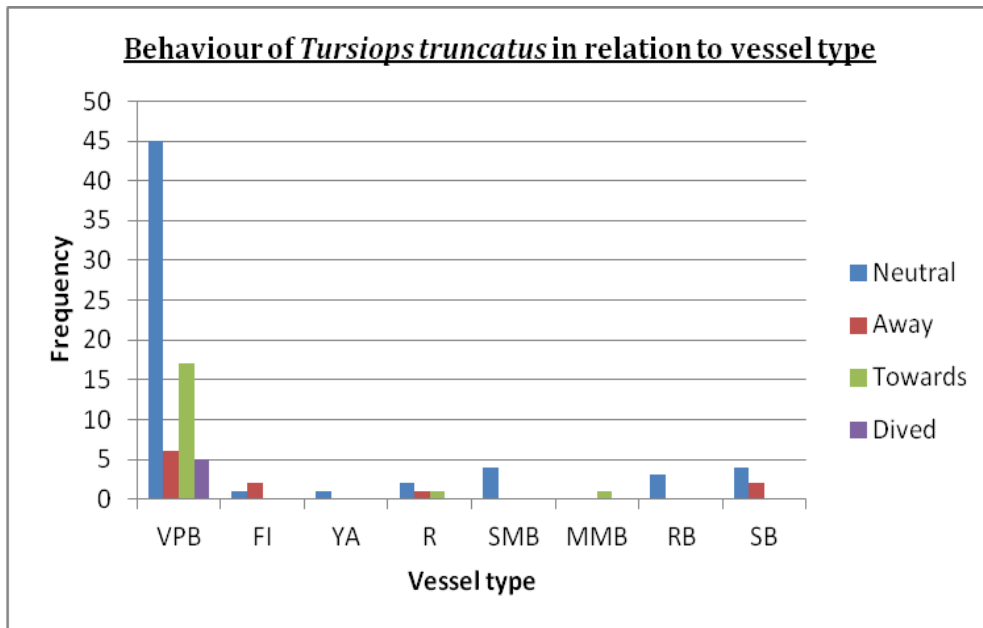
30% of the observed behaviours of *Tursiops truncatus* were of travelling. Bottlenose dolphins have frequently been observed travelling from New Quay Bay, through the study area and down to Ynys Lochtyn (Lewis and Evans, 1993).

### **4.2.3 Socialising and diving**

7% of behaviour was comprised of socialising. Bottlenose dolphins are highly social animals and are frequently seen in pods of varying size. Diving behaviour (5%) indicates that the bottlenose dolphins were foraging at depth.

## **3.3 Interactions with vessels**

Interactions of bottlenose dolphins with different types of vessel showed that visitor passenger boats (dolphin-watching boats for tourists) made up 77% of the total, followed by speedboats (6%), research vessels (4%), , rowing boats (4%), fishing boats (3%), small motor boats (4%), medium motor boats (1%) and yachts (1%). (See table 3 for descriptions of types of vessel).



**Figure 10.** Response of *T. truncatus* to different types of vessels. Response is categorized as neutral (no response), towards, away or dived. See table 3 for categories of vessel.

A chi-squared analysis was conducted on vessel type and behaviour and showed no significant differences between vessel type and behaviour. Chi-squared=24.16345, degrees of freedom= 21, P= 0.205207.

### 3.3.1 Observers on the vessel

There were seven occasions when the observer aboard the vessel was in the study area and had an encounter with one or more bottlenose dolphins. On four out of seven of those occasions, the response was neutral indicating no change in behaviour, and on the remaining three occasions, there was movement away from the vessel. In 2/3 cases, the behaviour occurred before the observer aboard the vessel had spotted the bottlenose dolphins. For five out of seven of the responses, the observer was on a visitor passenger boat, and for the remainder, on a research boat. All movements away from the vessel occurred on the visitor passenger boats. (See table 7).

OBS #	VESSEL	DISTANCE	BR	R	TIME	DATE	SEA STATE	# & COMP
1a	ERMOL VI	183.12	SF	1	12.1	21/07/2012	1	1 A
1b	ERMOL VI	154.37	SF	1	12.1	21/07/2012	1	1 A
2b	GALLOIS	240.56	SF	1	12.3	21/07/2012	1	6 5(1)
2a	GALLOIS	253.56	SF	1	12.3	21/07/2012	1	6 5(1)
3b	ERMOL VI	88.71	T, SF	3	11.05	21/07/2012	1	1 A
3a	ERMOL VI	90	SF	1	11.06	21/07/2012	1	1 A
4b	ERMOL VI	128.08	SF, T	1	11.16	26/07/2012	1	5 A
4a	ERMOL VI	112.11	T	1	11.17	26/07/2012	1	5 A
5b	GALLOIS	476.35	T	1	11.39	26/07/2012	1	4 3(1)
5a	GALLOIS	320	T	1	11.39	26/07/2012	1	4 3(1)
6b	ERMOL VI	71.73	T	3	11.46	26/07/2012	1	3 2(1)
6a	ERMOL VI	103.83	T	3	11.46	26/07/2012	1	3 2(1)
7b	ISLANDER	307.37	T	3	16.28	26/07/2012	1	2 A
7a	ISLANDER	304.79	T	3	16.29	26/07/2012	1	2 A

**Table 7.** Comparison of data collected from vessel-based observations and cliff-top observations. Rows labelled 'a' refer to vessel-based data, rows labelled 'b' refer to cliff-top based data. Column 1= Observation number, column 2=Name of vessel, 3= Distance of vessel to dolphin(s) at the time of observation, 4=Behaviour of dolphin(s) prior to presence of vessels, 5= Response of dolphin(s) (where 1=neutral, 2=towards, 3=away and 4=dived), 6=Time of observation, 7=Date of observation, 8=Sea state and 9= Group size and composition of dolphin(s) (where A = adult and bracketed number= calf).

Observation number 3 showed that the observer on the vessel recorded a neutral reaction, although the bottlenose dolphin had already moved away prior to the observer on the vessel noticing it. All other observations showed the same recorded response of the dolphin(s).

### 3.3.2 Visitor passenger boats

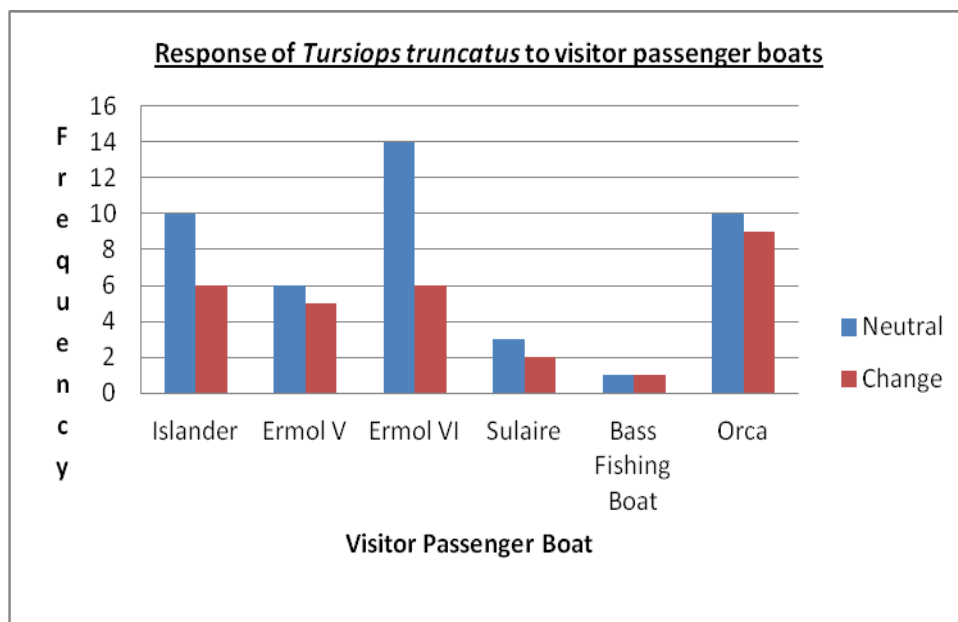
Regular trips during the summer months take place from New Quay harbour and head past the study area in a westerly direction. Most trip boats (Ermol VI, Islander, Sulaire and Orca) are approximately 1 hour in duration. Ermol V is a two-hour passenger boat, which travels in a westerly direction towards Ynys Lochty. Boat trips commenced at approximately 10.30a.m and continued throughout the day (weather dependent) until approximately 4.30p.m. Islander occasionally conducted a sunset tour at approximately

7.30p.m. The Ermols had fixed departure times, whereas Islander departed when there were enough visitors to fill the vessel, so was less frequent than the Ermols.

	N	A	T	D	Total
ISLANDER	10	2	2	2	16
ERMOL VI	15	4	1	1	21
ERMOL V	6	3	0	1	10
SULAIRE	3	1	1	0	5
BASS FISHING BOAT	1	0	0	1	2
ORCA	10	7	2	0	19
TOTAL	45	17	6	5	73

**Table 8.** Visitor passenger boats and response of *T. truncatus* to the vessels, where N=Neutral, A=Away, T=Towards and D=Dived.

A chi-squared analysis of the different types of visitor passenger boat and the response of the dolphin showed no significant difference chi-squared = 14.49304, degrees of freedom = 15, P = 0.488512.



**Figure 11.** Response of *T. truncatus* to visitor passenger boats. A change in behaviour corresponds to bottlenose dolphins moving either towards the vessel, away from the vessel or diving down for long durations.

### **3.3.3 Estimates of abundance and density**

*Ho: There is no significant difference in the estimate of density and abundance estimates from the primary observer and the land-based observer using a theodolite to track the actual ranges of the animals.*

Estimates of abundance and density were not calculated during this study; however, the number of bottlenose dolphins and the composition of the group were recorded. Table 7 shows the size of the group and composition (columns 9 and 10). In 100% of cases, the group size and composition recorded by the observer on the vessel and the observer on land was the same.

*Ho: This form of bias not significant since if responsive behaviour did occur; it would be after the animal had been detected.*

On the three occasions that responsive behaviour did occur, two of these were before the animal was detected and one at the same time (see table 7). The responsive behaviour that occurred was movement away from the vessel in all 3 cases. The remaining 4 cases showed a neutral or no response of the bottlenose dolphin(s) to the vessel. There was a very low sample size in the vessel-based observer data. This was due to adverse weather conditions during the study period, which meant that the trip boats did not run or only went in the area of the bay, which was outside of the study area.

### **3.3.4 Sea state and responsive behaviour**

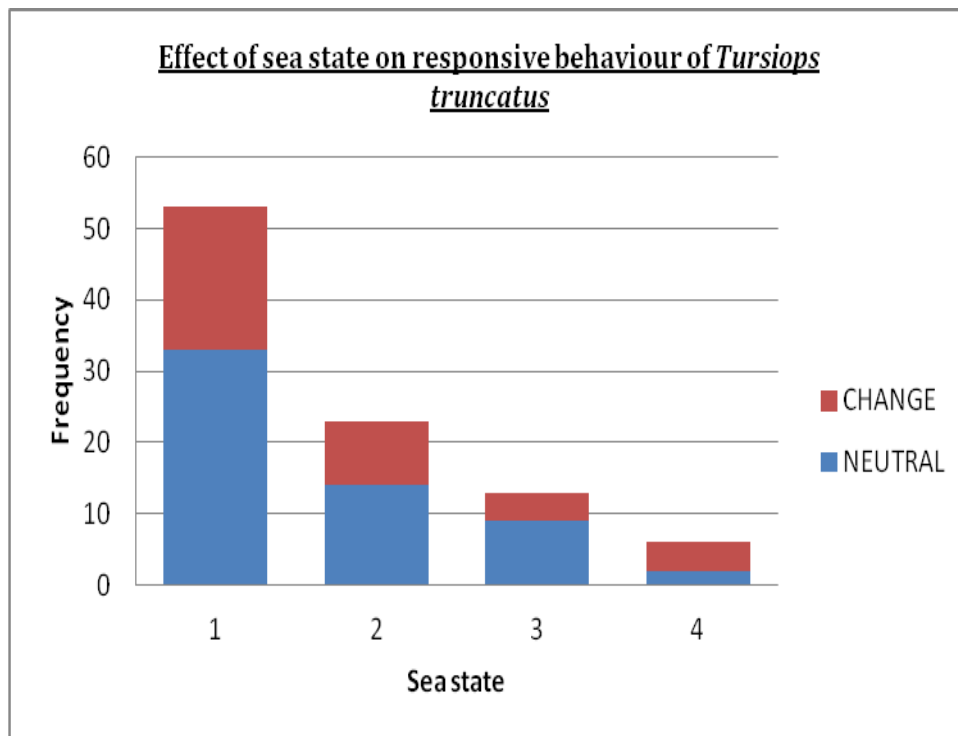
*Ho: There is no significant effect on responsive behaviour by sea state.*

High sea states can cause the observers not to spot dolphins even though they may be present. This form of availability bias can cause lower abundance and density estimates, which can affect the implementation of conservation measures.

There were 95 observations during the study period. The median sea state was 1. 56% of observations took place during this sea state.

The number of observations declined as the sea state increased, however, the effect of sea state on responsive behaviour was not significant. Chi-squared = 2.3374942, degrees of freedom = 3, P = 0.9849393. Null hypothesis accepted.



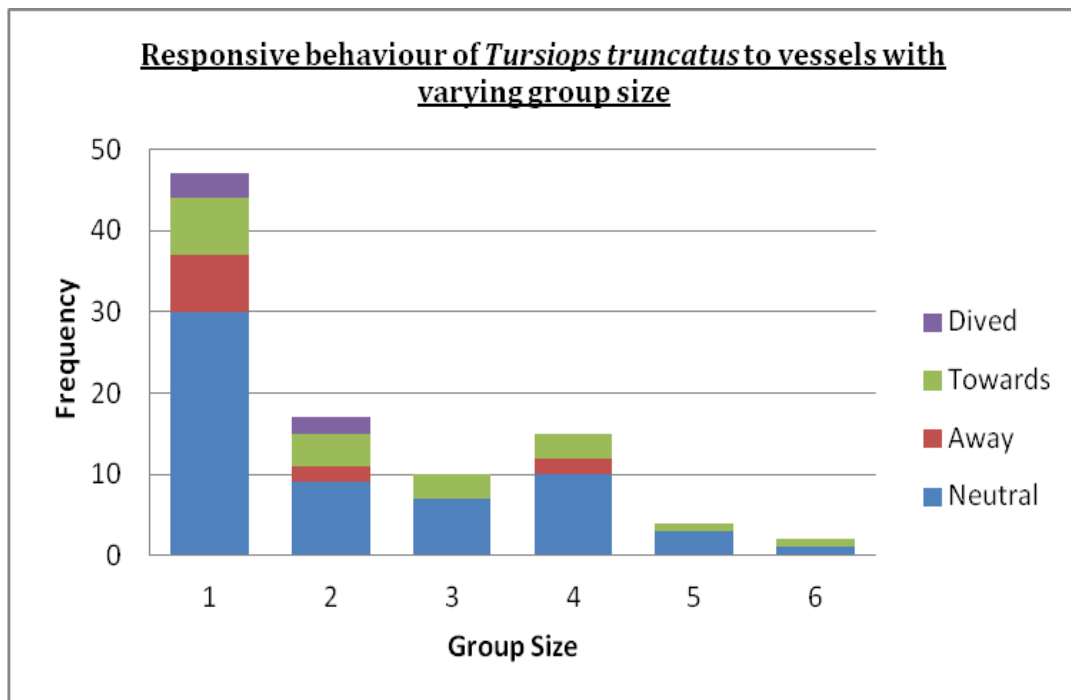


**Figure 12.** The effect of sea state on responsive behaviour of *T. truncatus*. Where 1=Ripples without crests 2=Small wavelets 3= Large wavelets, scattered whitecaps.4=Small waves with breaking crests, frequent whitecaps (based on the Beaufort Scale) "[National Meteorological Library and Archive Fact sheet 6 — The Beaufort Scale](#)"

### 3.3.5 Effect of responsive behaviour on group size

*Ho: There is no significant effect on responsive behaviour with group size.*

The group sizes of *Tursiops truncatus* during the study period ranged from one individual adult to a group size of 6 individuals. Mean group size was 2.14 individuals. Median group size was 1. Chi-squared= 8.14284089, degrees of freedom=15, P=0.912219. Null hypothesis accepted.



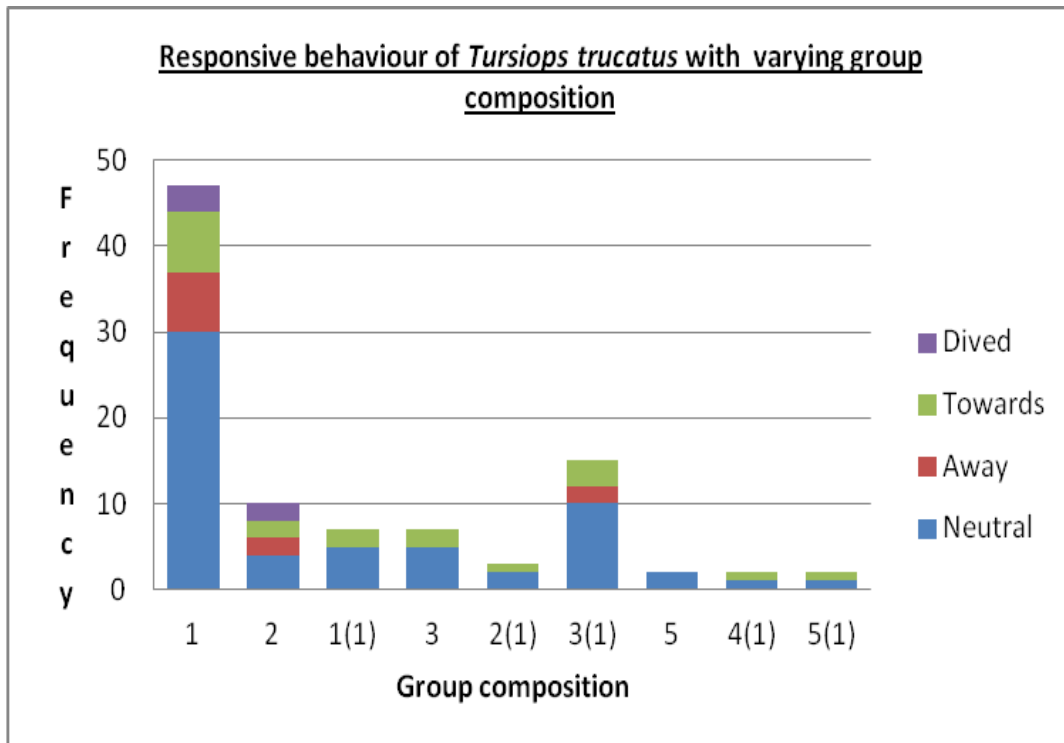
**Figure 13.** Responsive behaviour of *T. Truncatus* to vessels with varying group size.

The mode of group size was 1. Groups of sizes 1 and 2 displayed all 4 types of behavioural response, groups of sizes 3, 5 and 6 displayed a neutral response and movement towards the vessel.

### 3.3.6 Effect on responsive behaviour with group composition

*Ho: There is no significant effect on responsive behaviour with group composition.*

Group composition consisted of either individual adults or a group with 1 calf present. Chi-squared=15.189, degrees of freedom =24, P = 0.915, null- hypothesis accepted. The modal value for group composition was 1 adult. 63% of all responses were neutral regardless of group composition. Movement away from the vessel was observed with a group composition of 1 adult, 2 adults and a group of 3 adults with 1 calf.



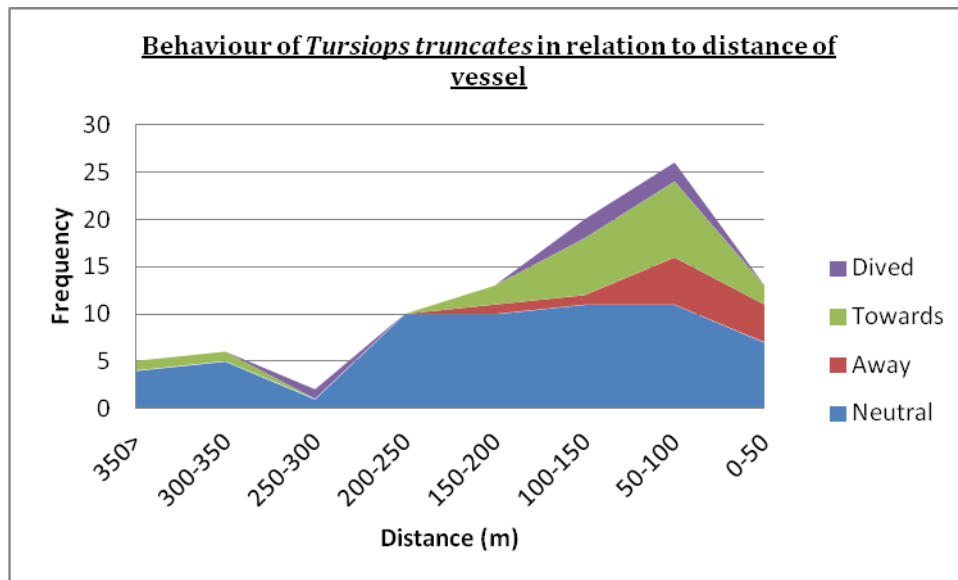
**Figure 14.** Responsive behaviour of *T. Truncatus* to vessels with varying group composition. Calves are numbered in parentheses.

### 3.3.7 Distance and behaviour

The distance of *Tursiops truncatus* to vessels was constantly tracked and any changes in behaviour noted. At distances of 350 metres or greater, down to 250 metres, there was a small amount of recorded behaviour (13.7%). 27% of total observations occurred between distances of 50-100 metres and 21% of total observations occurred between distances of 100-150 metres.

	N	T	A	D	TOTAL
350>	4	0	0	1	5
300-350	5	0	0	1	6
250-300	1	0	0	0	1
200-250	10	0	0	0	10
150-200	10	1	0	2	13
100-150	11	1	0	6	20
50-100	11	5	0	8	26
0-50	7	4	0	2	13
<b>TOTAL</b>	<b>59</b>	<b>11</b>	<b>0</b>	<b>20</b>	<b>95</b>

**Table 9.** Responsive behaviour of *T. truncatus* to vessels with distance. Total number of observations=95. Distance in metres. Responsive behaviour was recorded as N (Neutral), T (Towards), A (Away) and D (Dived).



**Figure 15.** Behaviour of *T. Truncatus* in relation to distance of vessels.

A chi-squared analysis of distance and behaviour was carried out; chi-squared=30.618, degrees of freedom=21, P=0.08025. Null hypothesis accepted.

## 4. DISCUSSION

### 4.1 Responsive Behaviour

Out of the 95 observations of *Tursiops truncatus* and vessels in the study area, 62% showed no response of the bottlenose dolphins to the vessels. The remaining 38% of observations consisted of movements towards vessels (12%), movement away from vessels (21%) and long dive duration (5%). The majority neutral response is consistent with previous observations of dolphin behaviour and vessel activity in New Quay harbour. Veneruso *et al.*, 2011 analysed 2977 encounters between bottlenose dolphins and vessels at New Quay harbour between 2005 and 2010, where an encounter is defined as 'the presence of a dolphin or group of dolphins within 300 metres of a vessel'. Of these, 82% of responses were neutral or no response and the remaining 19% resulted in a change in behaviour. Negative responses (movement away from the vessel) occurred in 13% of total observations and 6% resulted in a positive response to the vessel (movement towards the vessel) (Veneruso *et al.*, 2011).

Gregory and Rowden, 2001 looked at the behavioural response of dolphins to various factors including boat traffic in Cardigan Bay (including New Quay) recorded a neutral response of bottlenose dolphins to vessels in 62% of cases, 16% showed a positive response, and the remaining 22% of behaviour was recorded as negative.

This study also recorded a longer dive duration as a form of responsive behaviour. It has been noted that this behaviour occurs in the presence of vessels as a form of avoidance behaviour (Evans *et al.*, 1992; Nowacek *et al.*, 2001). Mother-calf pairs have been observed to increase their dive duration in the presence of vessels (Nowacek, 1999). During this study, it was difficult to ascertain whether the bottlenose dolphin(s) stayed under as an avoidance behaviour, or engagement in foraging behaviour, therefore this behaviour was recorded as a separate response instead of being included in a neutral response or movement away from the vessel.

## ***4.2 Response to different types of vessel***

The majority of interactions between bottlenose dolphins and vessels were with visitor passenger boats (77%). A chi-squared analysis was conducted on vessel type and behaviour and showed no significant differences between vessel type and behaviour. Chi-squared =7.981614, degrees of freedom=7, P= 0.334218.

It may be possible that the bottlenose dolphin population of New Quay have to some extent become habituated to the presence of vessels in the area, thereby not responding to the presence of vessels. This was suggested by Gregory and Rowden, 2001. However, sample size was fairly low during this study (95). This was mainly due to adverse weather conditions during the study period during which the electronic theodolite could not be used. High sea states also inhibited the study, making it very difficult for the cliff-top observer to spot and track bottlenose dolphins. Visitor passenger boats tended not to go out during high sea states also, so further reducing any possible recordings of interactions with bottlenose dolphins and these types of vessels. On many occasions, the visitor passenger boats did not venture into the study area and remained within the bay, where there was more shelter from the wind.

Previous studies have indicated that there is a significant difference in the response of bottlenose dolphins to different types of vessels in Cardigan Bay. Veneruso *et al.*,2011 found that speed boats caused the most behavioural change, with motor boats, such as visitor passenger boats causing the least behavioural change. A positive response towards visitor passenger boats was recorded by Gregory and Rowden, 2001 and a negative response towards kayaks was also recorded (abbreviation: RB see table 3). No positive response was recorded for speedboats in this study, which is consistent with Gregory and Rowden, 2001.

The behaviour of the vessels has been shown to have an effect on bottlenose dolphin behaviour. Erratic approaches of vessels to *Tursiops truncatus* and an increase in the speed of vessels can cause a change behaviour and direction of movement (Mattson *et al.*,2005; Ng and Leung, 2003). There is a strict marine code of conduct in New Quay. It has been recorded that the compliance levels of vessels were highest (90%) here in comparison with other locations in the Cardigan Bay SAC (Pierpoint & Allan, 2006). Compliance behaviour was not recorded as part of this study, however, it was noted

when vessels approached bottlenose dolphins at high speeds and with erratic movement.

Speedboats were observed to comply the least with the code of conduct during the study period. 33% of the interactions between speedboats and bottlenose dolphins resulted in movement away from the vessel, however, the sample size was very low (N=6) to draw any valid conclusions here.

A chi-squared analysis of the different types of visitor passenger boat and the response of the dolphin showed no significant difference. Chi-squared =14.49304, degrees of freedom = 15, P= 0.488512.

The number of observations of visitor passenger boats and interactions with bottlenose dolphins was relatively low (N=73). Although the results were not significant, it could be seen that a change in behaviour occurred with all visitor passenger boats. Responsive behaviour occurred with Orca during 47% of interactions. Of these, 78% showed movement away from the vessel and 22% towards the vessel (see table 8).

### ***4.3 Behaviour prior to vessel interaction***

The observed behavioural budget during the study period prior to interactions with boats comprised of feeding, travelling, socialising and diving behaviour (see figure 9.). No resting behaviour was recorded. This is in line with the recorded behavioural budget from line transect surveys conducted in 2011 in Cardigan Bay SAC (Veneruso and Evans, 2012). From surveys conducted since 2005 in the area, bottlenose dolphins have rarely been recorded resting. Other bottlenose dolphin populations have shown higher resting behaviours such as the Bay of Islands population, New Zealand, where resting behaviour was observed in 11% of observations (Constantine *et al.*, 2004).

Lamb (2004) observed that resting behaviour occurred at night in New Quay bay and that bottlenose dolphin presence throughout the day varied inversely with boat traffic.

It has been observed that the New Quay headland is an important feeding ground for bottlenose dolphins. Strong tidal currents around this headland make it an ideal feeding ground due to the concentration of prey in this area (Pesante *et al.*, 2008).

In addition to the environment of the New Quay headland making it an ideal feeding ground for *Tursiops truncatus*; there is a shellfish processing factory here, the main product of which is the common whelk (*Buccinum undatum*). The factory disposes of the whelk shells through a chute onto rocks and the bay below (Denton, 2011). The disposal of the shells may attract small fish to the area, which in turn may attract bottlenose dolphins due to increased prey abundance. A positive relationship was found between the amount of discard and the abundance of bottlenose dolphins in the area (Denton, 2011).

During this study, bottlenose dolphins were observed suspected feeding in this area on a daily basis. The location of the study area meant that the cliff edge obscured the view of the shellfish factory and bottlenose dolphins could only be tracked if they moved further out. Vessels went past this area and many interactions with bottlenose dolphins and vessels occurred here. Hastie *et al.*, 2004 found that the distribution of bottlenose dolphins was linked to foraging behaviour. The New Quay headland represents important potential feeding grounds for bottlenose dolphins, which makes it imperative that the marine code of conduct be adhered to at all times.

#### **4.4 Observers on the vessel**

One of the main objectives of this study was to observe if responsive behaviour of *Tursiops truncatus* to vessels occurred and if so, whether it was before or after the observer on the vessel recorded the presence of the bottlenose dolphin(s). Due to adverse weather conditions, it was only possible to record this information on 7 occasions. Although the observers went out on the vessels regularly, in many instances they had either already spotted the bottlenose dolphins before they came around the headland (so any responsive behaviour could not be noted by the cliff-top observer), or there were no bottlenose dolphins in the area when the vessels passed the study area. At times of adverse weather, the trips either did not run or stayed in the bay, where the sea was calmer.

Of the 7 observations of behaviour of *Tursiops truncatus* in the presence of vessels; 4 behaviours were recorded as a neutral response by the cliff-top observer, and the remaining 3 were recorded as movement away from the vessel. The observer onboard the vessel recorded one of the movements away as a neutral response. On this occasion,



the cliff-top observer had already spotted the bottlenose dolphin and recorded movement away from the vessel before the observer onboard the vessel had spotted it. On the 2 out of 3 occasions where responsive behaviour did occur, the observer onboard the vessel spotted the dolphin after the behaviour had occurred. With such low sample sizes, nothing can be concluded here, however, more investigation is required in order to see whether responsive behaviour does occur before the observer onboard the vessel spots the dolphin(s). This has large implications regarding abundance and density estimates. If in most cases this behaviour does occur and it is a form of negative behaviour, then abundance estimates may be lower than previously estimated.

#### ***4.5 Sea state and responsive behaviour***

The number of observations declined as the sea state increased, however, the effect of sea state on responsive behaviour was not significant. Chi-squared = 2.3374942, degrees of freedom = 3, P = 0.9849393. The modal sea state was 1, which corresponds to ripples without crests. Sea states <2 are ideal for spotting bottlenose dolphins. High sea states make it very difficult for observers to distinguish between the crests of the waves and the dorsal fin of the bottlenose dolphin, this is reflected in the results as the number of observations decreased as the sea state increased (see figure 12.). During the times where there was an observer on the vessel, the sea state was recorded as 1, so no perception bias was detected on these occasions, however the sample size was very low (n=7). As high sea states are not the best viewing conditions for bottlenose dolphins, visitor passenger boats are less likely to go out during these times, therefore it is difficult to ascertain whether sea state has an effect on responsive behaviour due to perception bias.

#### ***4.6 Group Size and Composition***

The size of groups of bottlenose dolphins during the study period ranged from 1 to 6. On some occasions groups were observed splitting up and rejoining. The size of the group did not give any significant results in relation to responsive behaviour. This is in line with the results found by Gregory and Rowden, 2001.

It has been observed that mother-calf pairs of bottlenose dolphins show increased dive duration in the presence of boats ( Nowacek, 1999), however the results in this study were not significant regarding group composition and responsive behaviour (P=0.915).

The modal value for group composition was 1 adult. During this study, it was observed that individual adult dolphins differed in their behaviour to vessels. In some cases, the individual did not respond to the vessel and continued in their engaged activity. Other individuals avoided vessels very obviously. Veneruso *et al.*, 2011 found that bottlenose dolphins observed in New Quay harbour had a significant response to boat traffic depending on the type of activity they were engaged in. Dolphins engaged in foraging behaviour were least likely to be affected by boat traffic, whereas dolphins engaged in resting behaviour were most likely to be disturbed. As identification of individual dolphins was not part of this project, it cannot be said whether the responsive behaviour observed during this study is dependent upon the individual.

#### **4.7 Distance of the vessel to *Tursiops truncatus***

48% of responsive behaviour of *Tursiops truncatus* to vessels occurred between distances of 50-150 metres. At 250 metres and above, only 13.7% of total recorded behaviour was observed. Detection probability decreases with increasing distance (Veneruso and Evans, 2012), so although responsive behaviour may be occurring at long distances between the vessel and the bottlenose dolphin(s), the probability of the observer on board the vessel detecting the bottlenose dolphin(s) is reduced. At 250 metres, the detection probability of bottlenose dolphins drops to 0.75. At 400 metres, it is at 0.5 (Veneruso and Evans, 2012). This can affect abundance estimates in a negative manner as there maybe animals present at large distances from the vessel, but they will not be detected, so giving a negative bias to the estimates of abundance, density and distribution.

The P-value for the chi-squared analysis of distance of *Tursiops truncatus* to the vessel was 0.08. The sample size was small during this study (n=95) and so more data is required to be collected to conclude whether there is a significant relationship between responsive behaviour and distance of *Tursiops truncatus* vessels or not. It has been observed previously that bottlenose dolphins in Cardigan Bay show responsive behaviour at a distance of 150-300 metres in a negative manner (making longer dives and moving away from the vessel) (Evans et al., 1992).

#### **4.8 Limitations of the study**

As previously mentioned, the adverse weather conditions during the study period severely hindered the amount of data collection available. The study period could not be extended due to other commitments. It is recommended that this study should be carried out for an 8 week duration at least.

#### **4.9 Study location**

The study area was an exposed cliff-top of co-ordinates GPS 52°13.040'N, 04°21.871'W. Although the study area was broad, due to the specific foraging and feeding activities of bottlenose dolphins at the boundaries of this area, possible interactions with vessels and bottlenose dolphins could not be recorded as the areas where the majority of foraging and feeding activity occurred (near to the shellfish factory) were obscured by vegetation on the cliff. Due to the nature of the study area, which was open and exposed to the elements, there were numerous occasions when the visitor passenger boats, which accounted for 77% of total observations did not enter the study area, thereby reducing the amount of potential data collection. Also, as responsive behaviour to vessels may have occurred before the bottlenose dolphins were detected (for example by the shellfish factory, or in New Quay Bay), any interactions with vessels coming into the study area from the bay could not be recorded. Only when *Tursiops truncatus* was detected in the study area and the behaviour noted prior to vessels approaching, could data be recorded and collected.

It is suggested that for future studies of responsive behaviour of bottlenose dolphins to vessels, that the study area be altered so that the shellfish factory site and surrounding area can be visible, and that the study period be extended so that more data can be collected when the observers are aboard the vessels.

#### **4.10 Observer inaccuracy and bias**

Use of the electronic theodolite, including setting up and tracking the behaviour and movements of *Tursiops truncatus* across a large study area took some amount of training in order for the user to be skilful and accurate. Although there was only one trained observer on the cliff who tracked with the theodolite, initially there may have

been some inaccuracies or missed interactions of *Tursiops truncatus* with vessels as the cliff-top observer was learning how to use this equipment effectively.

Observers onboard the vessel also received training, however there were different observers onboard on a daily basis and different observers on the cliff-top assisting with the sightings and trackings of *Tursiops truncatus*. This may cause inaccuracies and observer bias which could alter the results. It is not thought that during this study that any bias and inaccuracies would have affected any of the results, but for future study, it is recommended that at least one other cliff-top observer is trained in use of the electronic theodolite and /or the user has plenty of training before the data is collected.

## **5.0 CONCLUSION**

Despite a small sample size and limitations of the study, some useful observations were obtained during this study. Responsive behaviour of *Tursiops truncatus* to vessels in New Quay, Cardigan Bay was detected. It was found that the majority of responsive behaviour occurs at distances of 50-150 metres, however, detection probability decreases with increasing distance.

The type of vessel was not significant to whether responsive behaviour of *Tursiops truncatus* to vessels occurred, however the sample size was low. 62% of behaviour of *Tursiops truncatus* in the presence of vessels was neutral. This could be due to due habituation of the bottlenose dolphins to the vessels, as the majority were visitor passenger boats, many of which had regular departure times from the bay.

Of the instances where there was an observer on board the vessel, responsive behaviour occurred in 43% of cases. Responsive behaviour was negative during all of these interactions and it occurred before the observer had detected *Tursiops truncatus* in 66% of cases. The sample size was very low (n=7) and so it is recommended that this study is carried out for a duration of at least 8 weeks.

During the summer months, boat traffic in the area is high. It has been found that bottlenose dolphin sighting rates decreased when there were a high number of vessels present in the area (Pierpoint *et al.*, 2009). Between the years of 2006-2011, it has been observed that an increase in boat traffic is occurring in locations where sightings have

decreased (Veneruso and Evans, 2012). More data is required in relation to boat traffic and sighting detection rates of bottlenose dolphins in the area.

The study area boundaries are important feeding grounds for *Tursiops truncatus*. Erratic changes in the speed of vessel and direction can alter the behaviour of bottlenose dolphins with possible long-term effects regarding population dynamics (Tyack, 1998; Bejder *et al.*,2006). This study was hindered in the fact that data was not able to be collected in important feeding grounds due to obscurity by vegetation on the cliff-top. It is suggested that the study area is altered in order to encompass this area also.

The Cardigan Bay SAC was created in part due to the presence of a semi-resident population of bottlenose dolphins. It is critical that any changes in population size and structure as well as distribution are constantly monitored. This study has shown that there may be potential observer error in abundance estimates by observers onboard vessels due to responsive behaviour occurring before the observer has detected the dolphin(s).

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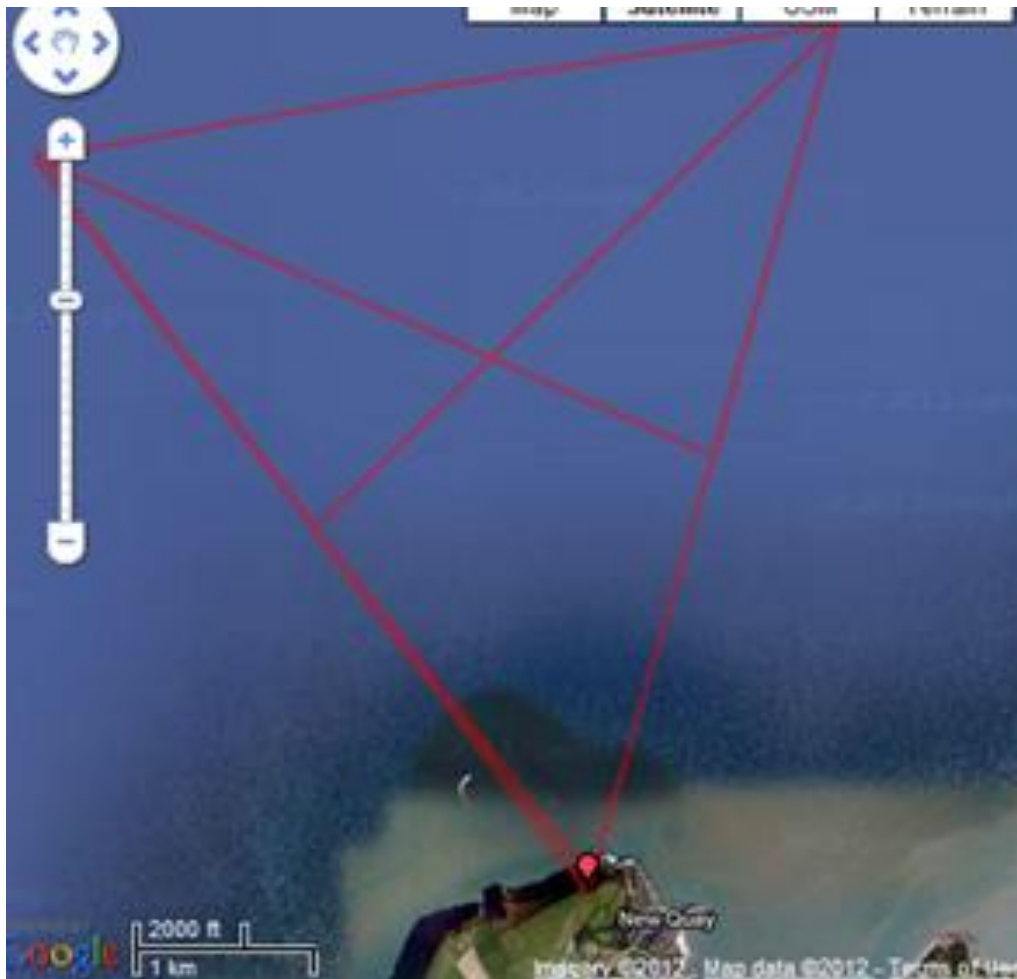
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**APPENDIX 1.**

**Gridded map of area to be surveyed for interactions of bottlenose dolphins and vessels. Adapted from Google Maps. Accessed on 26<sup>th</sup> June 2012.**



**APPENDIX 2.Template for cliff-top observations, effort form, marking effort and vessel type.**

**CLIFF-TOP OBSERVATION NEW QUAY:EFFORT**  
**NAME: \_\_\_\_\_ DATE: \_\_\_\_\_**

MAP	TIME		SEA STATE	WIND DIR	VISIBILITY	SIGHTING	BOAT ENC #	NOTES
	START	END						
A								
B								
C								
D								
E								
F								
G								
H								

BOAT TYPE		Log	Total	BOAT TYPE		Log	Total
Smb				RB			
Mmb				JS			
SB				R			
YA				FE			
FI				LS			
VPB							

