

**CETACEAN SITE USE & BOAT TRAFFIC ON THE  
CEREDIGION MARINE HERITAGE COAST,  
WEST WALES**

**1994-99**

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April 2000

## **CETACEAN SITE USE & BOAT TRAFFIC ON THE CEREDIGION MARINE HERITAGE COAST, WEST WALES 1994-99**

### **SUMMARY**

Observations of cetaceans and boat traffic were recorded at four sites on the coast of Ceredigion, West Wales, from 1994-99. Fieldwork was carried out between July 1<sup>st</sup> and September 30<sup>th</sup> each year, with over 200 volunteers from local communities participating. Observer effort totalled 4695h. The data provided information on the relative abundance and site use by bottlenose dolphins on the Ceredigion Heritage Coast and within the Cardigan Bay Special Area of Conservation. Dolphin occurrence was assessed using sighting rates, standardised for variation in sea state. Sightings were made in approximately 50% of 2h watches at New Quay and at Mwnt, and between 25-30% of watches at Ynys Lochtyn and Aberporth. Expressed as the average number of animals recorded per hour ( $\pm$  95% CI), sighting rates were: 3.2 (2.8 - 3.5) at New Quay; 3.2 (2.4 - 3.9) at Mwnt; 2.1 (1.6 - 2.7) at Ynys Lochtyn; and 1.1 (0.9 - 1.3) at Aberporth. Groups of 10 or more animals were recorded at each site. The highest simultaneous count at all sites was 19 animals, although this is only a minimum estimate of the number of dolphins present in the coastal strip at one time. From 1995-99 no significant trends in dolphin abundance were detected at any site. The inclusion of additional data did suggest that site use at New Quay declined between 1994 and 1998. However, as no data were available from this site in 1999 when sighting rates at Mwnt and Ynys Lochtyn increased sharply from the previous year, this result should be interpreted with caution. Sightings peaked each year in early to mid-August, and a comparison of weekly rates suggested local variation in abundance within the summer field season.

Some differences in habitat use were identified between sites: average group size was lower at Aberporth than at other sites, and transiting behaviour was recorded more frequently here than elsewhere. Dolphins tended to occupy the study site at New Quay for longer periods than other sites. The 2h watches were scheduled to begin daily at 11:00h, 13:00h, 15:00h and 17:00h. When average sighting rates were compared across the four watch times, consistent patterns were found for the two northern and the two southern sites. Sightings at New Quay and Ynys Lochtyn tended to peak early in the day and occurred less frequently during the late afternoon and evening. At Aberporth and Mwnt, sightings peaked during the first and last watches of the day. Differences in site use suggest that our understanding of local bottlenose dolphin ecology would benefit from more detailed investigation of habitat resources at different sites, and the movements of individually recognisable animals and groups.

Interaction between dolphins and boats was examined with the aim of assessing the impact of codes of conduct introduced to reduce the likelihood of disturbance to dolphin behaviour. Ceredigion County Council provided a code of conduct for recreational boat users since the early 1990s. Visitor passenger boat (VPB) operators later adopted a similar voluntary code. These codes offer guidelines on appropriate boat-handling when in the vicinity of dolphins. They emphasise that boat operators should not attempt to approach and pursue bottlenose dolphins too closely or at speed. Ideally, boats should stop when in the vicinity of dolphins, allowing the animals themselves the choice of whether or not to initiate close interaction.

Analyses focussed on the separation distance between dolphins and the nearest boat during encounters; the frequency with which boats stopped when in the vicinity of dolphins; and on dolphin behaviour recorded during encounters with different types of boat. No indication was found to show that the behaviour of recreational motor boat and speedboat users had changed over the study period. There was no trend for separation distances to increase, the frequency of very close approaches occurred at a similar rate and boats did not stop more frequently during encounters. In contrast however, separation distances for encounters between passenger boats and dolphins increased during the project and were significantly greater after the introduction of the boat operators' code than before. These boats were stopped more frequently when close to dolphins than motor boats or speedboats. The relative frequency with which observers recorded dolphins heading away from passenger boats decreased after self-regulation, and the relative frequency of 'staying' (milling or surfacing repeatedly around the same location) increased. Changes in the occurrence of these behaviours were not statistically significant. However, the adoption of a code of conduct appeared to have reduced the likelihood that passenger boats would displace or otherwise adversely affect the behaviour of bottlenose dolphins.

Dolphin behaviour observed in the presence and absence of boats was summarised, and compared for encounters with different types of boat at various separation distances. Dolphin behaviour with passenger boats was also compared for encounters when boats stopped and when they continued moving. Overall, the most commonly recorded behaviours were 'staying', 'leaping' and 'transiting' (which included movements towards and away from boats). 'Staying' was found to occur more frequently with VPBs and 'tail-slapping' occurred more frequently with canoes, than would be expected if no boats were present. 'Bow-riding' occurred disproportionately more with sailing boats and fishing boats than other vessels, and 'heading away' occurred more with speedboats, fishing boats and canoes. In the presence of VPBs, 'leaping' generally occurred more often when vessels were stationary. Heading away from VPBs was recorded least often when the boats were stationary, especially when close to dolphins. Dolphins were most likely to approach VPBs when the boats were moving, but again when very close (within 50m) dolphins were more likely to approach stationary boats. The data lend support to the idea that if boats do not attempt to approach or pursue dolphins closely, interaction is often initiated by dolphins themselves.

Most encounters between boats and dolphins (over 60% of 1439 encounters) took place at New Quay, even though no observations were carried out at this site in 1999. Levels of boat use were higher at New Quay than at other sites: approximately 3-4 times higher at New Quay than at Aberporth and Ynys Lochlyn, and 5-6 times than at Mwnt. Forty percent of boat encounters at New Quay involved VPBs. Sailing boats, motor boats and speedboats were recorded relatively frequently throughout the study area. Sailing boats and commercial fishing boats formed a greater proportion of traffic at Mwnt than elsewhere. No evidence was found to suggest that the use of powered recreational boats increased over the duration of the project.

The available data on military range activity at DERA Aberporth was insufficient to make a satisfactory assessment of impacts on dolphins in southern Cardigan Bay. However, there was found to be no significant difference in sighting rates for periods when the range was inactive and when firing had recently taken place.

This project incorporated the efforts of the local community and tourist industry to monitor the presence of bottlenose dolphins. A substantial baseline of data was established for four important sites and interaction between dolphins and boats examined objectively. Suggestions are made for research that may improve our understanding of bottlenose dolphin ecology in the region.

## CONTENTS

<b>SUMMARY</b> .....	2
List of Figures .....	6
List of Tables .....	7
 <b>INTRODUCTION</b>	
a. Aims and objectives .....	8
b. Data collection.....	9
c. Impact on public awareness .....	9
d. Management measures .....	10
 <b>METHODS</b>	
a. Data collection.....	11
b. Standardisation of data collected under different sighting conditions.....	12
c. Derivation of sighting rates .....	12
d. Analysis.....	13
 <b>RESULTS</b>	
<b>1. Overview</b>	
a. Observer effort .....	15
b. Sighting data .....	15
c. Sighting conditions .....	15
d. Boat data.....	17
 <b>2. Variation in Sighting Rates of Bottlenose Dolphins</b>	
a. Differences between sites .....	17
b. Differences between years.....	18
c. Other comparisons between sites	
(i) Group size .....	20
(ii) Site occupancy .....	21
(iii) Time of day .....	22

(iv) Behaviour .....	23
d. Weekly variation in sighting rates .....	23
<b>3. Boat Use</b>	
a. Variation in the types of boats using different sites .....	24
b. Levels of boat traffic recorded in 1994, 1998 and 1999 .....	25
<b>4. Interaction Between Boats and Bottlenose Dolphins</b>	
a. Comparison of average separation distances between dolphins and boats	
(i) ... Visitor Passenger Boats (VPB) .....	28
(ii) .. Speedboats & Motor boats .....	29
(iii) . Other boat types .....	29
(iv) . Differences between sites .....	30
(v) .. The frequency of close approaches (<50m).....	31
b. The frequency with which boats stop during encounters.....	33
c. Dolphin behaviour recorded during encounters with boats	
(i) ... Dolphin behaviour in the presence of different types of boats .....	34
(ii) .. Dolphin behaviour recorded with stationary and moving boats .....	36
(iii) . Overall comparison of behaviour recorded during boat encounters before and after the introduction of codes of conduct for boat operators .....	38
<b>5. Activity at the DERA Aberporth Military Range .....</b>	<b>38</b>
 <b>DISCUSSION</b>	
a. Sighting rates and site use.....	40
b. Boat traffic .....	41
c. Boat / dolphin interaction .....	42
d. Military range activity at DERA Aberporth.....	44
 <b>ACKNOWLEDGMENTS .....</b>	<b>45</b>
 <b>APPENDIX</b>	
A1 Example of a completed recording form .....	46
A2 Code of Conduct for recreational boat users.....	47
A3 Code of Conduct for passenger boat operators .....	49

## List of Figures

Figure 1. The location of the study sites in Ceredigion, West Wales .....	14
Figure 2. Mean sighting rate ( $\xi D$ ) and observer effort for watches carried out with different sea conditions.....	16
Figure 3. Frequency distribution of wind direction during observation periods .....	16
Figure 4. The proportion of 2h watches in which bottlenose dolphins were recorded at Aberporth, New Quay, Mwnt and Ynys Lochtyn .....	17
Figure 5. Sighting rates of bottlenose dolphins ( $\xi D$ ) at Aberporth, New Quay, Mwnt and Ynys Lochtyn.....	18
Figure 6. Inter-year variation in pW at each site .....	18
Figure 7. Sighting rates ( $\xi D$ ) 1995-99.....	19
Figure 8. Sighting rates ( $\xi Est$ ) 1994-99 .....	20
Figure 9. Frequency distribution of dolphin counts during sightings at all sites .....	21
Figure 10. Sighting rate ( $\xi D$ ) variation throughout the day.....	22
Figure 11. Mean weekly sighting rates .....	24
Figure 12. Total boat traffic at study sites in 1994, 1998 and 1999 .....	25
Figure 13. The relative frequency of different types of boat in 1994, 1998 & 1999: the number of boats per 2h watch / number of watches .....	27
Figure 14. Mean separation distance during visitor passenger boat encounters with bottlenose dolphins.....	28
Figure 15. Mean separation distance during speedboat and motor boat encounters with bottlenose dolphins .....	29
Figure 16. Mean separation distance during sailing boat and commercial fishing boat encounters with bottlenose dolphins .....	30
Figure 17. Site differences for speedboat and motor boat encounters .....	30
Figure 18. Variation in mean separation distance for speedboat & motor boat encounters, at Aberporth, New Quay and Ynys Lochtyn .....	31
Figure 19. The proportion of encounters between Visitor Passenger Boats (VPB) and bottlenose dolphins each year, for which the closest point of approach was 50m or less and 51-200m .....	32
Figure 20. The proportion of 15min intervals each year when Visitor Passenger Boats, motor boats and speed boats were recorded as having remained stationary .....	33
Figure 21. The behaviour of dolphins in the presence of different boat types.....	35

Figure 22. The frequency with which 'staying' and 'leaping' were recorded during encounters with Visitor Passenger Boats: moving and stationary vessels.....	36
Figure 23. The frequency with which 'approaching' and 'heading away' were recorded during encounters with Visitor Passenger Boats .....	37
Figure 24. Sighting rates for periods when Aberporth military range had, or had not been active prior to the observations carried out .....	39

### **List of Tables**

Table 1. Observer effort 1994-99 .....	15
Table 2. Comparison of the average number of animals present during encounters, 1995-99.....	21
Table 3. Comparison of periods of occupancy during watches in which dolphins were recorded at least once .....	22
Table 4. The percentage of observations for which different behaviours were assigned .....	23
Table 5. Closest vessel during dolphin-boat encounters.....	25
Table 6. The relative frequency with which different types of boat are recorded at each site .....	26
Table 7. Comparisons of behaviour and boat type.....	35
Table 8. Dolphin behaviour recorded during encounters with VPBs: comparison of observed and expected frequencies recorded in 1997-99 .....	38



## INTRODUCTION

In 1991, a petition was received from the community of New Quay asking Ceredigion Council to consider extending the boundary of the Heritage Coast between New Quay and Tresaith one mile seaward. A study of the bottlenose dolphin population over a six-year period had discovered an increasing impact from human activities on the local coastal area and its marine mammals<sup>a</sup>.

Following the establishment of the Marine Heritage Coast (MHC) in 1992, discussions with other organisations raised the need to assess the level and type of boating activity and to monitor the effects of disturbance on marine mammals during the main summer season.

In 1993, a survey was carried out in July and August and covered 155.5 hours over 48 days. Timed watches of New Quay, Llangrannog, Tresaith and Aberporth recorded the number and type of craft launched during the time period, and the number and type of craft at sea within the survey area. Sightings of bottlenose dolphin, harbour porpoise and grey seal were also recorded (CDC, Marine Heritage Coast 1993).

It was not possible to draw conclusions on typicalness of boating activity from one year's data, so it was agreed to extend the survey period for a further three years, with a review on the need for a further extension at the end of that period.

### a. Aims and objectives

The aims and objectives of the survey were considered within the context of the overall objectives of the MHC, which are:

- o to protect and enhance marine habitats and communities;
- o to provide interpretation and educational facilities that will generate interest, appreciation and commitment for marine conservation;
- o to manage recreational activities in a way compatible with nature conservation interests;
- o to support sustainable forms of tourism.

In order to achieve these objectives, it has been recognised that further information is needed to increase our knowledge and understanding of the marine environment. It is also recognised that recreational use will continue in the area, and could potentially increase in the future. Therefore, activities with a potential to damage need to be monitored and assessed regularly, and good practice supported at all times.

The issue of what constitutes disturbance to dolphins is, however, an emotive subject locally. Opinions vary between those who believe that all boats are a threat to the animals and should be banned, to those who believe that all boating activity is a positive delight to the dolphins with many tales of bow riding being told. Any attempt to introduce management measures in 1994 against this climate of varied opinion, and in the

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<sup>a</sup> Arnold, H. (1993). Distribution, abundance, and habitat use of bottle-nosed dolphins in Cardigan Bay, Wales, 1992. *European Research on Cetaceans - 7*. Proceedings of the seventh annual conference of the European Cetacean Society, Inverness, 1994, 306pp.

absence of any hard scientific information, was considered at the time to be unwise. Somehow the community had to arrive at a consensus on this issue, and the only way this could be achieved, we concluded, was to undertake our own study.

The aims and objectives of the survey were, therefore:

- o to build on local community interest and support for the MHC by actively involving them in producing their own science;
- o to raise public awareness of the issue and to influence local behaviour whilst at sea;
- o to obtain further information that would help guide future management.

b. Data collection

Volunteers were recruited via posters, word of mouth and the local media. Volunteers also included those registered with the Ceredigion Heritage Coast. In 1994, a meeting was held at the start of the survey period where the volunteers were given guidance on how to use the survey forms, and advice on how best to observe the animals. This was followed up by site visits during the survey period to ensure that no problems were being encountered. At the beginning of August 1994, another meeting was called with all the volunteers. Holly Arnold gave an illustrated talk about bottlenose dolphin characteristics and behaviour as part of the volunteer training programme.

In June of every subsequent year, meetings were held to review the previous year's efforts and to provide information on arrangements for that year.

In 1995, the idea of local co-ordinators was introduced by a shop-owner in Aberporth. The idea being that forms could be distributed and collected from a central point, and a rota for the site could be kept locally. This idea was developed in New Quay and Llangrannog and was maintained until the survey ended.

c. Impact on public awareness

There can be little doubt that the survey stimulated considerable debate on the issue of marine mammal disturbance during its six-year period. The role of the co-ordinators was particularly important in this, as they provided a focal point for discussions. The fact that it was primarily local people who undertook the data collection meant that attention became more focused on exactly what was happening at sea, and opinions on the issue became more temperate accordingly.

Through posters, word of mouth, articles in the *Cambrian News*, *Western Mail* and *Teifi side* newspapers, and interviews for *Radio Ceredigion*, word soon spread and many local people came forward to volunteer their services. Many volunteers helped with the survey over the entire six year period, whilst others helped over shorter time scales. It is estimated that, in total, some two hundred people have helped with the survey since its inception.

In 1995, a campaign to raise public awareness, and promote marine conservation in Ceredigion was launched by the former Ceredigion District Council. A boat users guide was distributed; information panels sited at the main launching sites; Marine Heritage Coast Code of Conduct details included in the Ceredigion Tide Tables, and Ceredigion

*Marine Friendly* T-shirts and stickers were produced. The newsletter '*Ar lan y mor*' was also re-introduced, and two of the local co-ordinators on the survey contributed articles about the experiences of working on the previous year's survey. '*Ar lan y mor*' has continued to be the main vehicle of ensuring that volunteers are kept informed of developments. This campaign, coupled with the wide involvement of local people in the survey, has meant that public awareness of the issue has been raised considerably.

d. Management measures

A number of additional management measures were introduced during the survey period. A speedboat zone was created off New Quay for the benefit of those boats wanting to travel at speed in the area safely. The area was chosen because it:

- o is outside the bye-law speed limit areas;
- o is sheltered from the prevailing winds;
- o encourages people to travel north of New Quay rather than towards the area of Marine Heritage Coast.

However, the area is not an ideal site, as there are a number of fishing pots located in the vicinity.

The other management measure introduced, in 1997, was the Commercial Passenger Boat code for the New Quay and Aberaeron operators. It had become apparent during the survey that it was the Visitor Pleasure Boat type that was having the greatest number of encounters with the animals. Therefore, it was considered necessary to introduce, in conjunction with the boat operators, a code of conduct specifically for this type of activity. The boat operators themselves welcomed the code, which highlighted in more detail the more sensitive areas, rather than the more general information carried in the Marine Heritage Coast code of conduct. It is intended that this code be reviewed regularly with the boat operators

## METHODS

### a. Data collection

Fieldwork was carried out each year from 1994-99, from the beginning of July to the end of September. Voluntary workers collected observations of bottlenose dolphins and of boat activities at four coastal sites on the Ceredigion Heritage Coast within the Cardigan Bay Special Area of Conservation (SAC) (Fig. 1). Data were collected at Aberporth and at Ynys Lochtyn (Llangrannog) from 1994-99, New Quay from 1994-98, and Mwnt in 1998 and 1999. Observers were instructed to record sightings of bottlenose dolphins, information on boat traffic and a range of environmental parameters. Watches were 2h duration and were scheduled to begin daily at 11:00h, 13:00h, 15:00h and 17:00h. Sighting data were collected by continuously scanning the study area, alternating between low power binoculars and unaided vision. The approximate height of observation positions above sea level was 60m at Mwnt and Ynys Lochtyn, 50m at New Quay and 30m at Aberporth. Data were recorded onto forms. For each sighting, the time at which groups of dolphins appeared and were last seen, and the number of animals in view was recorded. Estimates of the number of dolphins present were given as either 'actual' or 'estimated' depending on the certainty of the observer. A best estimate was later extracted from these using an 'actual' count if available, or else the 'estimated' count. Observers recorded the presence of young animals (small calves that were substantially smaller and lighter coloured than accompanying adults, perhaps with foetal folds visible). Further discrimination of age groups was not attempted. Incidental sightings of harbour porpoises, grey seals, basking sharks and sunfish were also made.

Information was recorded in a slightly different manner in 1994 than in subsequent years. In 1994, each sighting of dolphins was described in detail; from 1995-99 codes were used to objectively categorise surfacing behaviour (see Appendix 1). In 1995-99 watches were divided into eight 15min intervals and, when dolphins were present, multiple codes were used to summarise consecutive intervals.

Whenever boats and dolphins were both present at the study site<sup>b</sup>, the number of boats of different types were recorded. The closest distance between boats and dolphins during encounters was estimated<sup>c</sup>. Distances were estimated by eye and recorded in metres. The closest boat type and distance was recorded for each distinct encounter in 1994, and for each 15min interval during encounters from 1995-99. Additional data on dolphin / boat interaction was collected from 1995 onwards: observers recorded whether or not the closest boat was moving or remained stationary in each 15min. Behaviour codes for 'heading away' and 'approaching' were included to describe the direction of movement of dolphins in relation to the closest boat. Data on dolphin encounters were also recorded directly from passenger boats in some years. A comparison of how some encounters were viewed from land and sea was carried out in 1997<sup>d</sup>. The present report focuses solely on observations carried out from land.

In 1994, 1998 and 1999, the number of boats of different types was tallied over each 2h observation period independently of whether bottlenose dolphins were or were not

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<sup>b</sup> Here termed an 'encounter' regardless of whether or not any interaction was apparent.

<sup>c</sup> This distance is referred to in this report as the 'separation distance'.

<sup>d</sup> Anon, 1998. *A Report on Marine Mammal Disturbance 1994-97*. Report by the Director of Environmental Services & Housing to Cyngor Sir Ceredigion Planning Committee.

present. From these data, a relative measure of boating activity was derived and comparisons made between different sites and years.

The following environmental data were recorded, once for each watch in 1994 and at 15min intervals from 1995-99: air temperature, general weather, Beaufort value and wind direction. Observers were instructed to base Beaufort values on sea surface criteria, rather than wind speed, and therefore provided a direct measure of sea state<sup>e</sup>. A key to other codes used to determine these parameters is given on the example sighting form in Appendix 1.

b. Standardisation of data collected under different sighting conditions

Sea conditions are thought to be the most important factor affecting the probability with which dolphins are seen and counted accurately. However, the effects of sea state are complex and modified by factors including group size and behaviour. In poor conditions, large groups and animals leaping clear of the water are probably more likely to be seen than small groups and animals behaving less energetically. In calm conditions and good visibility, dolphins are often sighted at greater range.

During the project, sighting rates were highest in calm conditions (Beaufort 0-1) (Fig. 2). In order to reduce any negative effects resulting from the inclusion of data collected in poor conditions, data from watch periods in which the median Beaufort value exceeded 4 were removed from the dataset prior to analyses of sighting rates. Data from a total of 131 watches were thus excluded (i.e. 5.4% of 2417 watches). There was little appreciable difference in sighting rates between Beaufort 2-4 (Fig. 2). Beaufort 4 is a 'moderate breeze' of 11-16kt, with sea conditions characterised by small waves and fairly frequent white-caps<sup>o</sup>. This was judged to be an appropriate threshold value in this case as effects due to poor sighting conditions were reduced, but a high proportion of the data could still be used. Bottlenose dolphins are relatively large animals that are often seen in groups and whose surfacing behaviour makes them relatively easy to spot compared to some smaller cetaceans. In standardising sighting rates for the effects of sea state on the sightability of harbour porpoises, for example, a lower threshold may prove more appropriate.

c. Derivation of sighting rates

A range of sighting rates for bottlenose dolphins were calculated. Some describe site use, based on the presence and absence of dolphins during watch periods. Others account for the number of animals seen and give average rates at which dolphins were recorded per unit effort. Some rates allowed the inclusion of data from 1994 that were collected under a slightly different protocol. The various sighting rates used are defined below:

(i) *pW (proportion of watches in which dolphins were recorded)*

This is the proportion of 2h watch periods in which bottlenose dolphins were observed. Based upon species presence or absence, the number of animals recorded is not taken into account. It gives a measure of the frequency with which dolphins occupied a

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<sup>e</sup> Her Majesty's Stationary Office 1983. *Meteorological Office state of sea booklet*. HMSO, London.

particular site. It also functions as a predictor, indicating probability of seeing dolphins during watches at different locations. It allows comparisons to be made between data collected using different but compatible protocols.

(ii)  $\xi D$  (*average number of dolphins per unit effort*)

From 1995 onwards, counts of the number of dolphins in view were made for successive 15min periods (intervals):  $\xi D$  is the mean number of dolphins recorded per 15min interval in each watch period. The standard deviation is employed as a measure of variation between intervals. Sighting rates were summarised over longer time periods by calculating the average  $\xi D$  for a series of watches and presenting the standard error or 95% confidence interval as a measure of the variability between watches. Unlike pW, this index is sensitive to variation in the number of animals present. However, it is only applicable to data collected as a series of 15min counts (1995-99).

(iii)  $\xi Est$  (*average estimate of the number of individual dolphins recorded per watch*)

This is the average estimate of the total number of individual animals observed over each entire watch period. It allowed comparisons to be made between data collected in 1994 and data collected under the 15min count protocol used in later years. To estimate the total number of individual animals recorded during each watch, the highest number of animals in view at any one time was used (i.e. the maximum 15min count for watches in 1995-99, and the highest single count of dolphins made during watches in 1994). As all individual animals observed over the period of a watch might not have been present at the same time, the maximum count is only a *minimum* estimate of the total number of dolphins seen. Unlike  $\xi D$ , this index provides no information regarding the proportion of watch duration that dolphins were present, nor the variation in the number of animals in view at any one time.

d. Analysis

Observations recorded on forms in the field were transferred at the end of each year into digital format as tables in an Access 97 database (Microsoft). Additional data were incorporated by reference to the original data sheets. Data were extracted for analyses in Excel 97 (Microsoft) and summary statistics derived for each observation period using routines written in Visual Basic for Applications. Statistical analyses were carried out using StatsDirect statistical software version 1.601 (Iain E. Buchan).

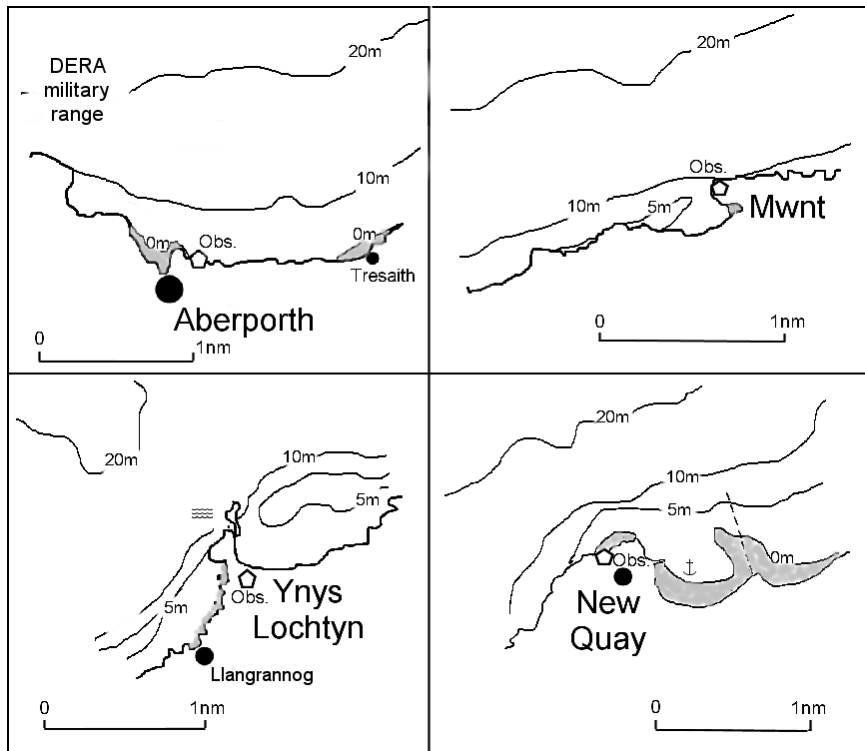
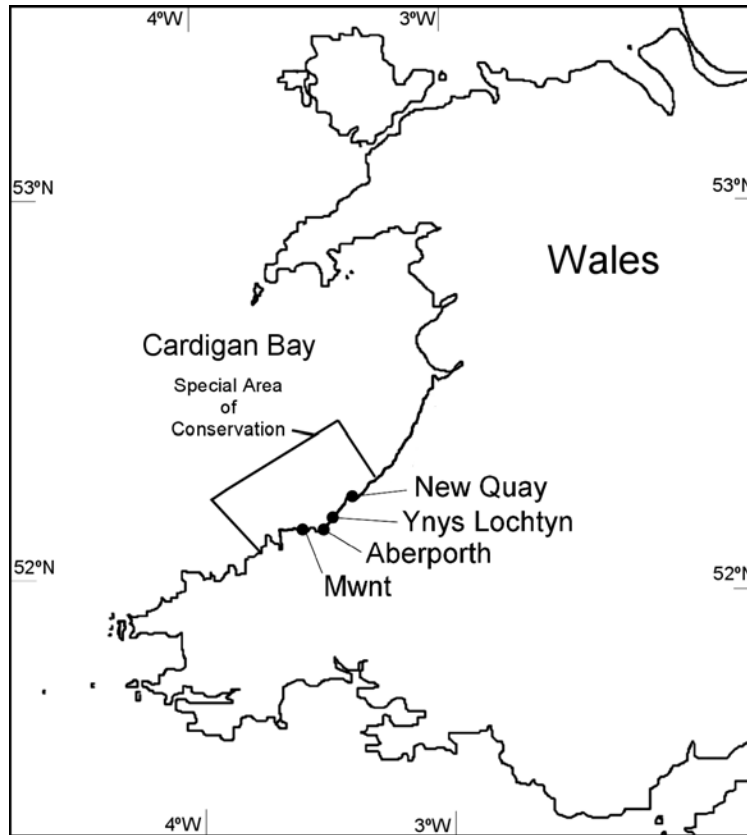
Analyses focused on three broad areas:

- o bottlenose dolphin ecology and variation in occurrence at four study sites;
- o levels of boat traffic and interactions between dolphins and boats;
- o effects of military range activity on dolphin sighting rates.

Investigations of data from dolphin / boat encounters specifically aimed to determine:

- o whether commercial and recreational boat operators modified their activity following the introduction of codes of conduct;
- o whether bottlenose dolphins in general, behaved similarly in the presence of different types of boat;
- o whether the introduction of codes of conduct affected the observed behaviour of dolphins during encounters with boats.

Figure 1. The location of the study sites in Ceredigion, West Wales.



## RESULTS

### 1. Overview

#### a. Observer effort

Observer effort is summarised in Table 1. A total of 2390 observation periods (watches) were completed, spanning 914 days. Watches were usually 2h long, although occasionally shortened, in periods of bad weather for example. From 1994-99, observer effort totalled 4695h.

Table X. Observer effort 1994-99.

Site	Days	Watches	Hours	Years
Aberporth	300	816	1578	1994-99
Mwnt	72	192	375	1998-99
New Quay	290	914	1845	1994-98
Ynys Lochtyn	252	468	897	1995-99

#### b. Sighting data

During the first field season in 1994, there were 134 sightings of bottlenose dolphins at three sites. From 1995 onwards sightings data were collected as a series of counts made over successive 15min intervals and dolphins were recorded in a total of 2854 intervals. Overall, dolphins were present in 887 (41%) watches completed in good sighting conditions (Beaufort 4 or less).

The largest group of dolphins observed was 16, recorded at Ynys Lochtyn in July 1996. The highest number of animals recorded simultaneously at multiple sites was at least 19<sup>f</sup> (0 at AB, 9 at NQ, 10 at YL) in August 1996. This represents the minimum number of animals in the coastal strip between AB and NQ at this time, as other animals may have been present between sites. Groups of 10 or more animals were recorded at all sites during the course of the project.

Data on bottlenose dolphin calves was not collected with sufficient consistency to warrant further analysis; a sub-set of data from Mwnt in 1999 however, confirmed the presence of calves thought to be less than 1 year of age in the coastal strip. Up to 2 calves were reported from watches at Mwnt on 16 days from 11<sup>th</sup> July to 6<sup>th</sup> September.

#### c. Sighting conditions

Observers were requested to record the prevailing environmental conditions. Sea state was recorded as Beaufort values, based by sea surface criteria. Using data collected at 15min intervals between 1995-99, the modal Beaufort value during observations was 1. The mean sea state overall was 2.09 (sd = 1.37), varying between 1.83 ± 1.26 (in 1997) and 2.41 ± 1.55 (in 1998). Of 14925 intervals for which sea state was recorded, 68% of observations were carried out in Beaufort 2 or less, 94% in Beaufort 4 or less.

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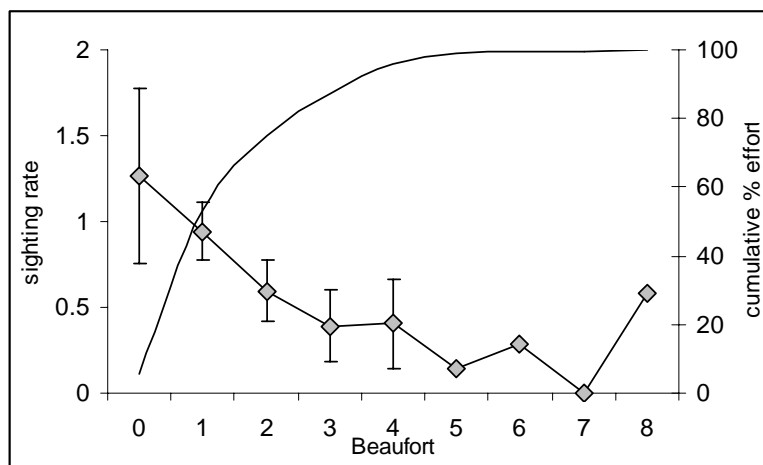
<sup>f</sup> Two animals were present at Aberporth earlier in the same watch. As it would not have been possible for these dolphins to have been included in counts made soon afterwards at other sites, their inclusion would raise the minimum estimate to 21 animals.



The frequency distribution of wind directions recorded during observations in 1995-99, is shown in Fig. 3. The most frequent wind directions were SW (25%), NW (20%) and W (17%).

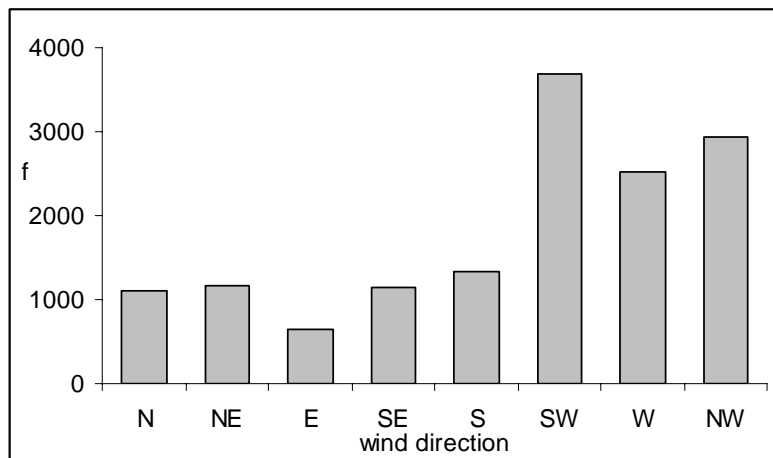
The modal weather class recorded was 2 'sunny' (49% of 15min intervals) and the modal temperature class was 3 'warm' (39% of data; a further 29% was collected in 'moderate' conditions).

Figure 2. Mean sighting rate ( $\xi D$ ) and observer effort for watches carried out with different sea conditions. 95% confidence intervals are shown for data with more than 20 watches. The cumulative number of watch periods is shown as a percentage.



NB. In order to reduce possible effects due to seasonal variation in dolphin abundance, sighting rates were calculated from data collected in weeks 6-8, during which the peak numbers of dolphins were recorded each year.

Figure 3. Frequency distribution of wind direction during observation periods ( $f = 15\text{min}$  intervals, 1995-99).



d. Boat data

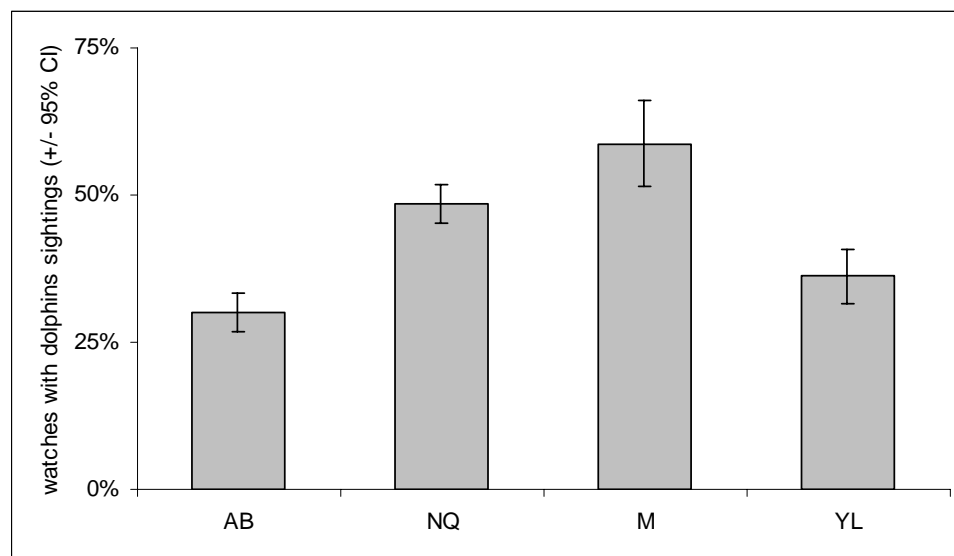
When boats and dolphins were both present at a study site, observers were instructed to record information on the closest boat to the dolphins. From 1995 onwards, the type of boat, its minimum distance from dolphins ('separation distance'), and whether the boat was stationary or moving, were recorded for each 15min period. In 1994, the type of boat and the minimum separation distance were recorded once only for each sighting. Data were available for a total of 1439 encounters between dolphins and different categories of boat. The total number of encounters for each boat type boat were: 'visitor passenger boat' (406), 'speedboat' or 'water-skiers' (244), 'motor boat' (284), 'commercial fishing boat' (111), 'sailing boat' (319), 'canoe' (46), 'jetski' (1) and 'other' (28).

## 2. Variation in the Sighting Rate of Bottlenose Dolphins

a. Differences between sites

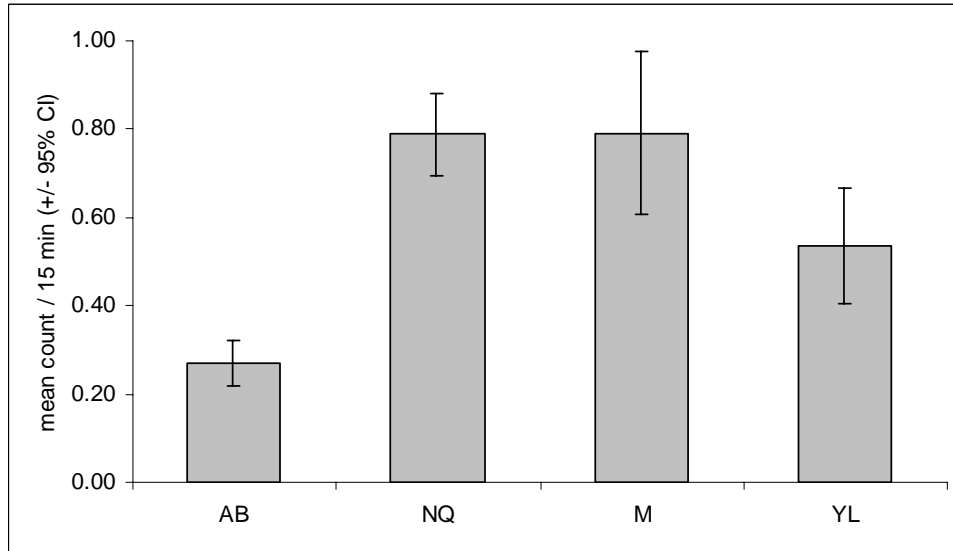
Bottlenose dolphins were frequently present at all four study sites. Sightings were made in approximately 50% of 2h watches at New Quay and at Mwnt, and between 25-30% of watches at Ynys Lochtyn and Aberporth (Fig. 4).

Figure 4. The proportion of 2h watches in which bottlenose dolphins were recorded at Aberporth, New Quay, Mwnt and Ynys Lochtyn (1994-99). N = 2180 2h watches.



Overall sighting rates of individual animals ( $\bar{x} \pm D$ ) were highest at New Quay and Mwnt. Lower rates were recorded for Ynys Lochtyn and Aberporth (Fig. 5). Expressed as the average number of animals recorded per hour ( $\pm$  95% CI), sighting rates were: 3.2 (2.8 - 3.5) at New Quay; 3.2 (2.4 - 3.9) at Mwnt; 2.1 (1.6 - 2.7) at Ynys Lochtyn; and 1.1 (0.9 - 1.3) at Aberporth.

Figure 5. Sighting rates of bottlenose dolphins ( $\xi$ D) at Aberporth, New Quay, Mwnt and Ynys Lochtyn (1995-99). N = 1808 15min intervals.

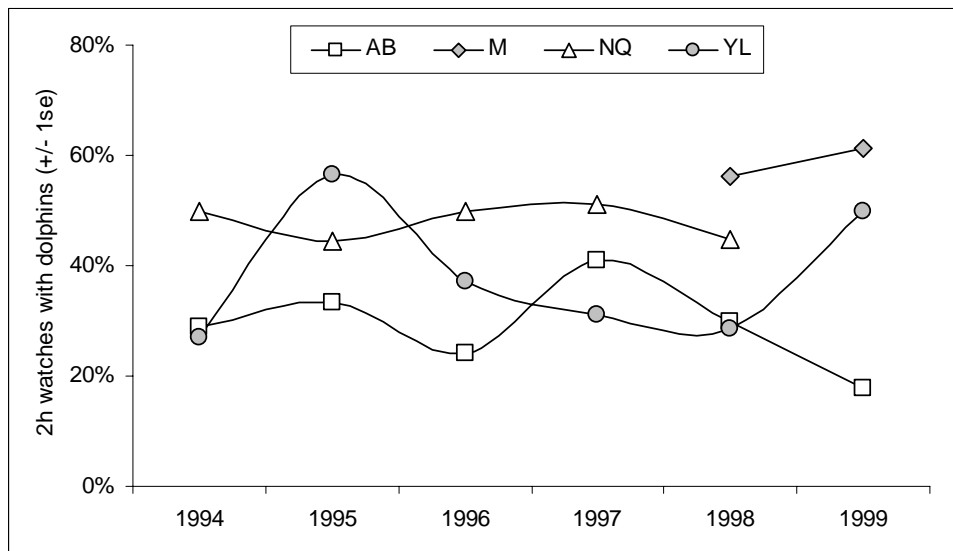


Ranked in terms of dolphin presence and sighting rate, therefore, site use was highest at New Quay and Mwnt, followed by Ynys Lochtyn and then Aberporth. The analyses that follow compare year to year variation at these sites. The data are also investigated for indications of whether other aspects of dolphin ecology may vary between the four locations.

b. Differences between years

Variation in sighting rates between years is shown in Figs. 6 to 8. The proportion of 2h watches in which dolphins were seen (pW) varied little at New Quay and ranged between 45-51%. Greater inter-year variation was evident at Ynys Lochtyn (range = 34%) in particular, and at Aberporth (range = 23%).

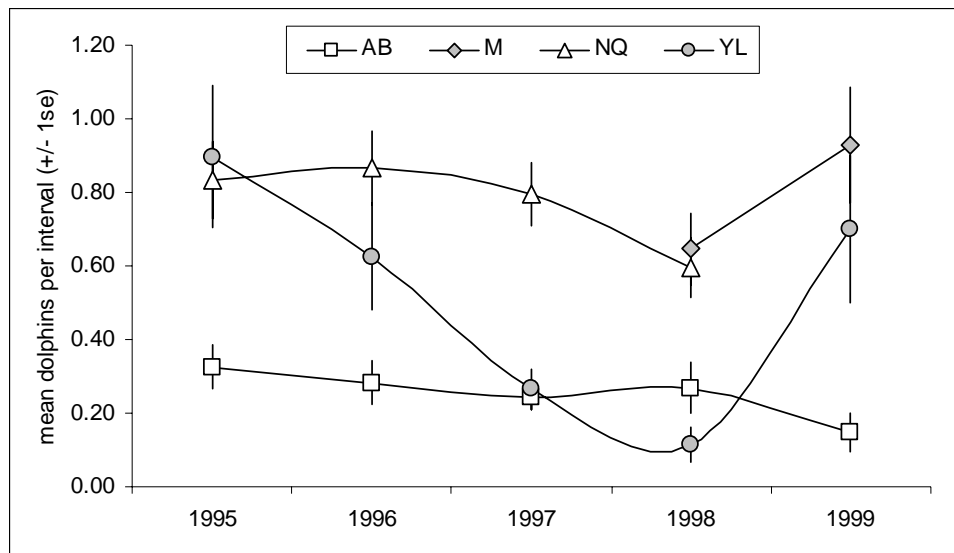
Figure X. Inter-year variation in pW at each site.



Between 1995-99, the sighting rate  $\xi D$  remained relatively stable at Aberporth, although lower in 1999 than in previous years (Fig. 7). In most years dolphins were recorded less frequently at Aberporth than at other sites. At Ynys Lochtyn, sighting rates showed a steep decline from 1995 until 1998, when particularly low rates were recorded. In 1999 however, a higher  $\xi D$  was again recorded.

Sighting rates at New Quay were consistently higher than at both Aberporth and Ynys Lochtyn, except in 1995 when a similarly high sighting rate was recorded at the latter site. Rates at New Quay declined annually from 1996 to 1998, the last year for which data were available. Sighting rates at Mwnt in both 1998 and 1999 were amongst the highest recorded at the four sites. As at Ynys Lochtyn, a markedly higher rate was observed in 1999 compared to the previous year.

Figure 7. Sighting rates ( $\xi D$ ) 1995-99.



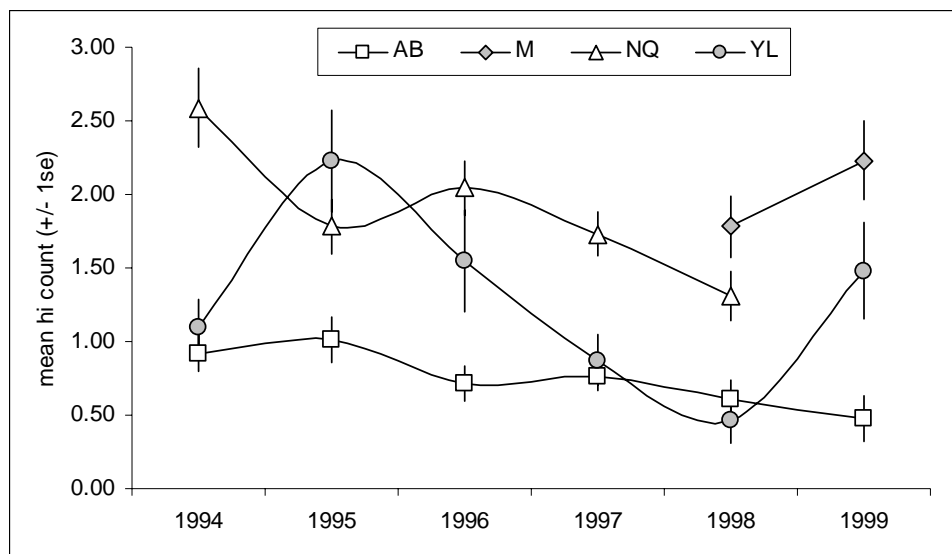
The inclusion of data from 1994 enabled comparisons to be made over a slightly longer time series. As data were recorded in a different way in 1994<sup>9</sup>, comparisons were made using  $\xi Est$  rather than  $\xi D$ ; annual trends were similar for both these indices from 1995 onwards. Over a six-year series, low rates at Ynys Lochtyn in 1997 and 1998 appear to fall within the normal variation in sighting rates recorded at this site (Fig. 8). The additional data do however, suggest that sighting rates at New Quay and at Aberporth declined slowly, but steadily, over the duration of the project.

Trends in sighting rates were tested statistically, for both  $\xi D$  and  $\xi Est$ . No significant downward trend in sighting rates was found at Aberporth (Cruzick's Trend Test (one-sided),  $P = 0.148$ ), New Quay ( $P = 0.263$ ) or Ynys Lochtyn ( $P = 0.077$ ), from 1995-99 using  $\xi D$ .

<sup>9</sup> Best estimates of the number of animals present were recorded for each sighting in 1994. From 1995-99, counts of the number of animals in view were made each 15min.

Using  $\xi$ Est and a six-year series, a significant downward trend was again not detected at Aberporth ( $P = 0.126$ ) and Ynys Lochtyn ( $P = 0.351$ ). The decline in sighting rates at New Quay over five years, however, was found to be statistically significant ( $Z = -2.36$  (adj.),  $P = 0.009$ ), a result clearly influenced strongly by a high rate recorded in 1994. The proportion of watches in which dolphins were present at New Quay (pW) varied little between 1994 and other years, and showed no evidence of a decline in dolphin occurrence (Fig. 6). The decrease in  $\xi$ Est may therefore have resulted from a reduction in the number of animals visiting the site, rather than a decline in species occurrence at New Quay.

Figure 8. Sighting rates ( $\xi$ Est) 1994-99.



The present data raise the hypothesis that sighting rates at this site are in decline. It is unfortunate however, that data were not collected from this site in 1999, as in this year sighting rates at Ynys Lochtyn and at Mwnt increased sharply from those recorded in 1998. A corresponding increase at New Quay may have yielded a non-significant trend at this site also.

Variation in the relative abundance and distribution of dolphins in Cardigan Bay as a whole have not yet been quantified and trends in sighting rates reported here should not be extrapolated for the region as a whole.

d. Other comparisons between sites

(i) *Group size*

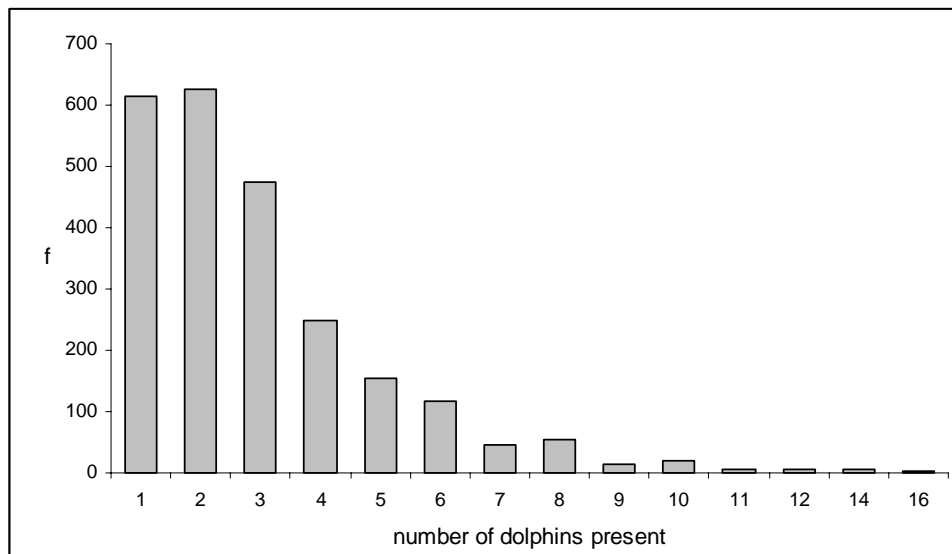
Group size here refers to the total number of animals in view at any one time. In reality, smaller social units or sub-groups may be present. Equally, all animals at one site may constitute part of a larger aggregation of animals dispersed over a wider area. For the present data, the average number of dolphins present during sightings (i.e. the average of non-zero counts) has been compared between sites (Table 2). As sea state increases, it becomes more difficult to assess group size accurately; comparisons have therefore been made for data collected in Beaufort 2 or less only.

Table 2. Comparison of the average number of animals present during encounters, 1995-99.

Site	n (counts)	Max	Mean	sd
Aberporth	456	12	2.18	1.49
Mwnt	291	11	3.27	2.25
New Quay	1255	12	3.10	1.98
Ynys Lochtyn	382	16	3.21	2.67

The null hypothesis was tested that when dolphins were present, the average number of animals in view was similar at all sites. However, significant differences were found between the median values each location (Kruskal-Wallis  $T = 99.6$  (adj.),  $P < 0.001$ ). Pairwise comparisons showed that the average number of animals present was lower at Aberporth than at Mwnt ( $P < 0.001$ ), at New Quay ( $P < 0.001$ ) and at Ynys Lochtyn ( $P < 0.001$ ). At Aberporth, sighting rates were lower than those recorded at other sites; the present data indicate that when dolphins were seen, there were on average fewer animals present at Aberporth than elsewhere. Large groups of 10 or more dolphins were however, recorded at all four sites over the course of the project. The overall frequency distribution of counts (group size) is shown in Fig. 9.

Figure 9. Frequency distribution of dolphin counts during sightings at all sites ( $n = 2384$  counts,  $\xi = 3.0$  dolphins,  $sd = 2.1$ ,  $Md = 2$ ,  $max = 16$ ).



(ii) *Site occupancy*

Occupancy does not refer to medium or long-term residency or to patterns of movements of individual dolphins; the term is applied here to describe the amount of time that the species was present at study sites, during watch periods in which they were recorded at least once. The aim of the analysis was to determine whether the average amount of time that dolphins spent at sites varied. A low proportion of time present may indicate a tendency for groups to transit through a site, rather than to remain and use resources at the site for longer periods. The amount of time in which dolphins were in view was summed for each 2h watch, and the mean number of minutes that the site was occupied was compared between sites.

Table 3. Comparison of periods of occupancy (minutes) during watches in which dolphins were recorded at least once.

Site	n (counts)	Max	Mean	sd
Aberporth	167	120	38.3	34.5
Mwnt	103	120	32.1	31.1
New Quay	330	120	49.7	33.8
Ynys Lochtyn	116	120	39.4	33.8

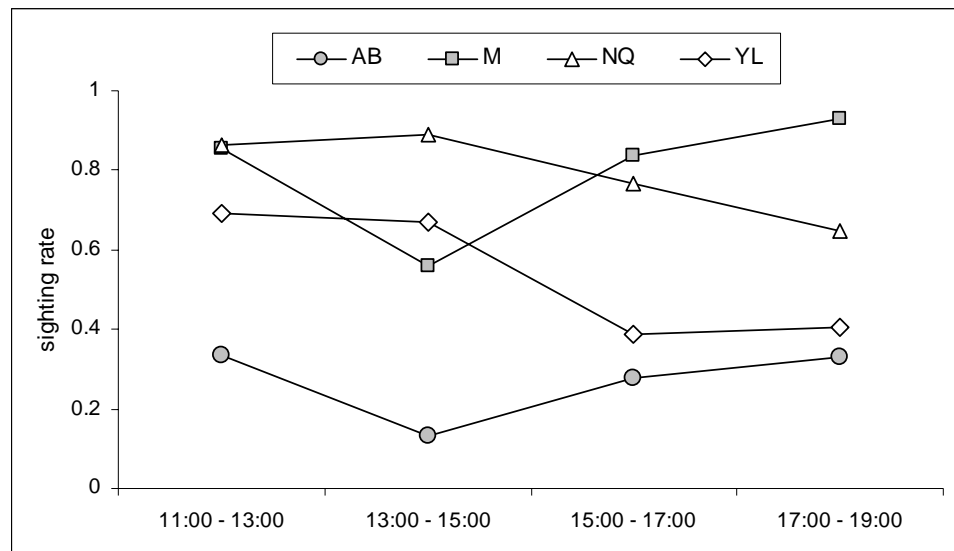
A significant difference was found between the mean number of minutes that dolphins occupied each site (One-way ANOVA,  $F = 9.458$ ,  $P < 0.001$ ). On occasions that dolphins present at New Quay, animals occupied the site for longer periods than at Aberporth (Tukey pairwise comparison,  $P < 0.001$ ), Mwnt ( $P < 0.001$ ), New Quay ( $P < 0.001$ ) and Ynys Lochtyn ( $P < 0.001$ ). No significant differences were found between the other three sites.

This result may be due to individual dolphins staying at the site for extended periods. It may also result from a greater turnover of animals visiting this site than elsewhere. Photo-identification studies may clarify the situation. The data again highlight the relative importance of habitat resources for bottlenose dolphins at New Quay.

(iii) *Time of day*

The data were examined to determine whether sighting rates for dolphins varied at different times of day. Rates ( $\xi D$ ) were compared for watch numbers 1-4<sup>h</sup> at each site (Fig. 10).

Figure 10. Sighting rate ( $\xi D$ ) variation throughout the day.



The data suggest different trends for northern and southern sites. Sighting rates at New Quay and Ynys Lochtyn appeared to fall during the late afternoon and evening (watches

<sup>h</sup> Watch times: W1 = 11:00-13:00; W2 = 13:00-15:00; W3 = 15:00-17:00; W4 = 17:00-19:00.

3 and 4). At the more southern sites, Aberporth and Mwnt, sighting rates were lowest in the early afternoon and peaked during the first and last watches of the day.

When average values were compared for watches at each site, statistically significant differences were found at Aberporth only (Kruskall-Wallis  $T = 12.12$ ,  $P = 0.07$ ). At this site, the median sighting rate for watch 2 was significantly less than that of watches 1 ( $P = 0.05$ ) and 4 ( $P = 0.008$ ). Observers were most likely to see dolphins at Aberporth during the morning and evening. The coincidence of the times at which highest and lowest sighting rates were recorded at northern and southern sites, may warrant further investigation focusing on the daily movements of individual animals.

(iv) *Behaviour*

The most frequently recorded behaviours at all sites were 'staying at approximately the same location', 'leaping' and 'heading away'. Observers were instructed to assign the behaviours 'heading away' and 'approaching' to describe the response of dolphins to boats. It is clear however, that these behaviours were also used to record the direction of dolphins relative to the observation position. In Table 4, 'heading away' and 'approaching' have been combined as 'transiting' to describe the movement of animals around or through and from the study site in the absence of boats. The table gives the percentage of 15min intervals in which each behaviour was recorded.

In general, the range of behaviour were generally recorded with similar frequency at different sites. The percentage of 'staying' (milling) was very similar at New Quay, Mwnt and Ynys Lochtyn, but markedly lower at Aberporth. Repeated surfacing at the same location may be indicative of a range of different activities, including foraging over a small area of seabed, resting or social interaction. A higher percentage of 'transiting' was also recorded at Aberporth than elsewhere. Aberporth was the only site for which 'transiting' ranked more highly than 'staying'.

Table 4. The proportion of observations (%) to which different behaviours were assigned (1995-99) in the absence of boats.

	<b>Aberporth</b>	<b>Mwnt</b>	<b>New Quay</b>	<b>Ynys Lochtyn</b>
Bow-riding	2	1	4	1
Staying	25	39	37	38
Leaping	27	21	23	31
Transiting	32	19	27	18
Tail-slapping	<1	7	1	2

The results suggest that behaviour in which dolphins are observed milling about the same location occur less frequently at Aberporth than at Mwnt, New Quay and Ynys Lochtyn. Dolphins appeared more likely to transit through and around central Aberporth Bay, than to remain surfacing at the same location for extended periods.

A comparison of dolphin behaviour recorded in the presence of different types of boat is carried out in section 5d.

e. Weekly variation in sighting rates and site use by bottlenose dolphins

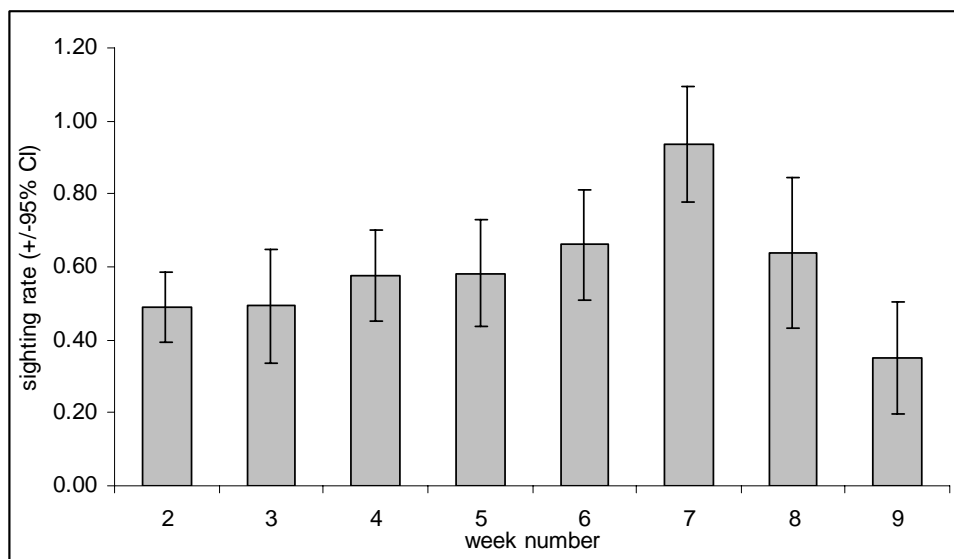
Each watch period was assigned a week number. Week 1 began 1<sup>st</sup> July, and observations extended to Week 13, which began 23<sup>rd</sup> September. Mean weekly sighting



rates ( $\xi D$ ), for watches carried out in Beaufort 4 or less (1995-99) are shown in Fig. 11. Confidence intervals reflect variation between years. Only those weeks with means based on 5 years data are shown; few or no data were available for Weeks 1 and 10-13 in most years.

For the period 8<sup>th</sup> July to 1<sup>st</sup> September, mean sighting rates tended to rise gradually until Week 7 (beginning 12<sup>th</sup> August), before falling again (Fig. 11). Peak sightings occurred in Week 6 or Week 7, early and mid-August, every year. These data suggest temporal variation in bottlenose dolphin occurrence at the study sites, within the summer field season.

Figure 11. Mean weekly sighting rates.



### 3. Boat Use

#### a. Variation in the types of boats involved in dolphin encounters at different sites

The presence of boats in the vicinity of bottlenose dolphins was recorded in 1439 15min intervals from 1995-99. Most encounters were observed at New Quay (61%), even though no observations were carried out at this site in 1999. Encounters observed at Aberporth, Ynys Lochtyn and Mwnt represented 18%, 13% and 8% of all encounters respectively.

The types of boat most commonly recorded in encounters with bottlenose dolphins varied between study sites. Most passenger boats operate from New Quay, and most records of Visitor Passenger Boats (VPB) were therefore made at the New Quay study site (n = 355). There were fewer observations of VPBs at Ynys Lochtyn (40), and these again mostly involved boats based at New Quay. Dolphin encounters with VPBs were recorded only infrequently at Aberporth (11) and Mwnt (4).

Overall at New Quay, VPBs were recorded as the closest boat in 40% of encounters. The second most frequently recorded boat type, sailing boats, were present in 22% of

encounters. At Aberporth there were a total of 253 encounters, mostly involving motor boats (36%), speedboats (23%) and sailing boats (21%). Of 187 encounters at Ynys Lochtyn, the predominant boat types were motor boats (26%) and VPBs (20%). At Mwnt, most encounters involved sailing boats (37%). Commercial fishing boats were recorded in a greater proportion of encounters at Mwnt (16%) than elsewhere (Table 5).

Table 5. Closest vessel during dolphin-boat encounters. Total encounters are given for each site and as percentages for each type of boat involved. NB. C = canoe; CF = commercial fishing boat; MB = motor boat; O = other; SB = speedboat; SCY = sailing boat, under sail; VPB = visitor passenger boat. 'Other' types included tugs and other vessels employed on Aberporth military range.

Site	%C	%CF	%MB	%O	%SB	%SCY	%VPB	ξ
Aberporth	7	6	36	2	22	21	4	253
Mwnt	4	16	14	14	13	37	2	118
New Quay	2	8	12	0	16	22	40	881
Ynys Lochtyn	4	5	36	2	17	17	20	187

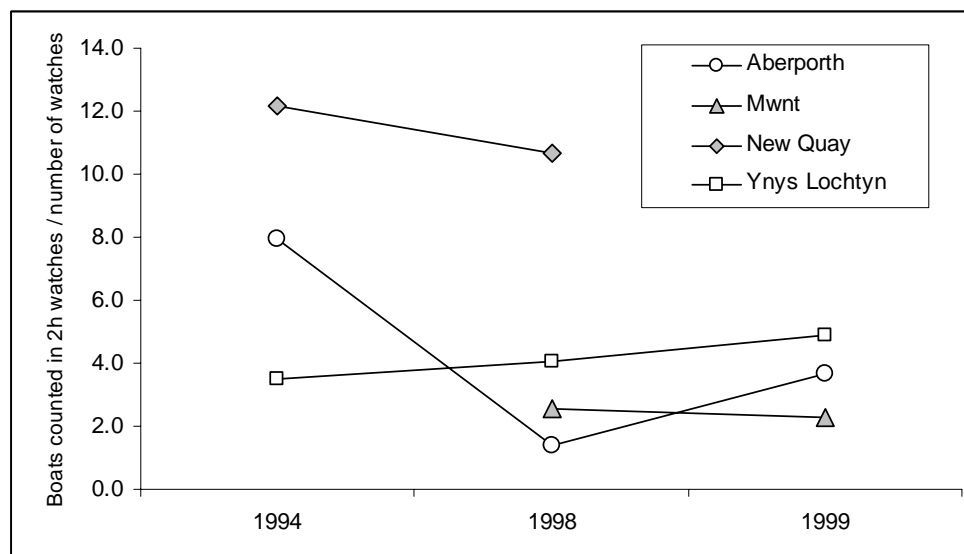
A jetski was recorded as the nearest vessel in 1 encounter only, at Aberporth in 1994.

b. Levels of boat traffic in 1994, 1998 and 1999

Counts of the number of boats of different types were made for 2h watches in 1994, 1998 and 1999. These data allowed comparisons to be made of levels of boat use at the study sites over the duration of the project.

An index of the relative levels of boat traffic was calculated by dividing the total number of boats counted in 2h watches by the number of watches completed at each site. These data confirm that New Quay was 'busiest' site for boats, with approximately 3-4 times as much boat traffic recorded than at Ynys Lochtyn and Aberporth and 5-6 times as much as at Mwnt (Fig. 12). There is clearly poor correlation between dolphin site use and the relative number of boats that use each site: observers at New Quay and Mwnt, the sites with highest sighting rates of dolphins, recorded the highest and the lowest levels of boat traffic respectively.

Figure 12. Total boat traffic at study sites in 1994, 1998 and 1999.



Differences in the most commonly recorded types of boat are shown more clearly in Table 6. Sailing boats, motor boats and speedboats were frequently recorded at all sites. The most common boat types at both Aberporth and Ynys Lochtyn were sailing boats and motor boats. Commercial fishing boats and sailing craft made up a higher proportion of boat traffic at Mwnt than at other sites, and speedboats were less common here than elsewhere. Boat traffic at New Quay was dominated by four types of vessel: sailing boats, speedboats, motor boats and VPBs. Passenger boats accounted for approximately 20% of traffic at New Quay and 10% of traffic at Ynys Lochtyn, but did not frequently visit other sites.

Table 6. The relative frequency with which different types of boat are recorded at each site.

<b>Boat type</b>	<b>AB</b>	<b>M</b>	<b>NQ</b>	<b>YL</b>
sailing boat	35%	46%	37%	25%
speedboat	14%	12%	18%	16%
visitor passenger boat	1%	1%	18%	10%
motor boat	23%	19%	15%	31%
commercial fishing boat	1%	19%	8%	9%
canoe	14%	2%	3%	6%
water skier	5%	0%	1%	2%
other	4%	2%	1%	2%
jetski	3%	0%	< 0.5%	< 0.5%

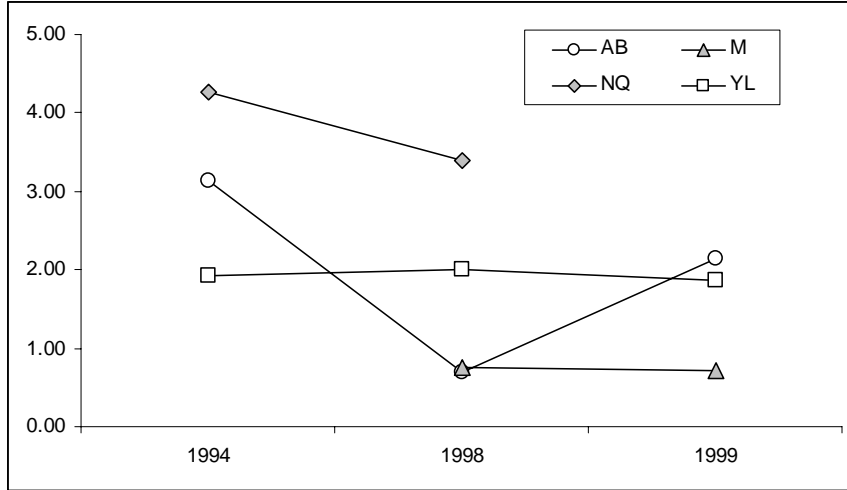
The relative frequency with which the most common types of boat were recorded in 1994, 1998 and 1999 is shown in Fig. 13. The data indicate that the number of motor boats and speedboats recorded at most sites remained fairly consistent each year, although site use by these types of boat was more variable at Aberporth than elsewhere. There was no evidence to suggest that the use of recreational motor-driven boats increased over the duration of the project. The rates at which sailing boats were recorded showed similar variation. There was however, an increase in VPB traffic at New Quay from 1994-98, and at Ynys Lochtyn from 1994-99.

The use of jet-skis was relatively uncommon at all sites in 1998 and 1999. Jet-skis were recorded more frequently in 1994 at Aberporth, however, when they were present almost daily from 22<sup>nd</sup> July – 1<sup>st</sup> August, with up to six skiers in the Bay on one occasion. The overall rate at which jet-skis were recorded at this site in 1994 remained relatively low at less than 0.25 per watch.

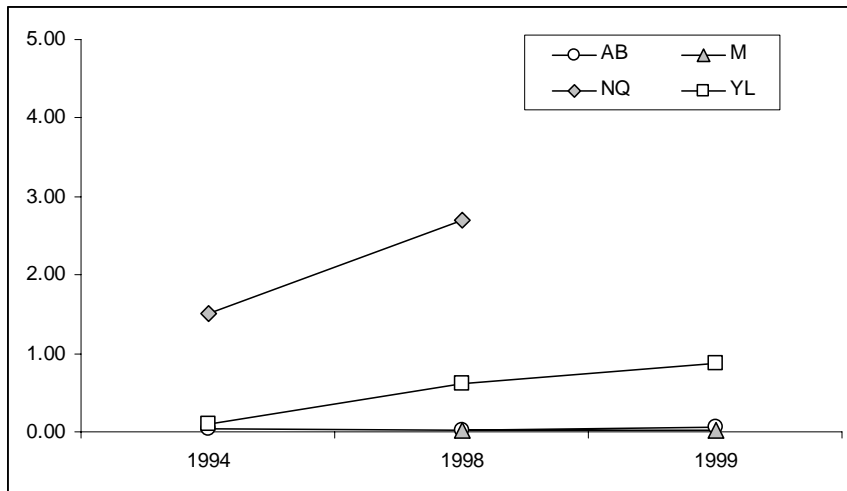
The rate at which canoes were recorded ranged annually between 0.20 and 0.35 at Ynys Lochtyn and New Quay. Canoes were rarely recorded at Mwnt. Levels of use at Aberporth were again more variable than at other sites and canoeists were recorded relatively frequently here in 1994, at an overall rate of approximately 1.2 boats per watch.

Figure 13. The relative frequency of different types of boat in 1994, 1998 & 1999: the number of boats per 2h watch / number of watches.

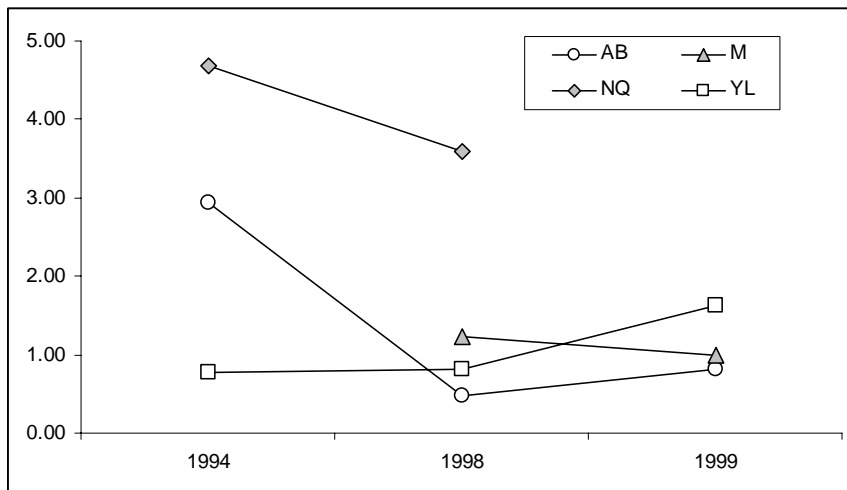
a. Motor boats, speed boats and water skiers



b. Visitor passenger boats



c. Sailing boats (includes yachts and dinghies under sail and windsurfers)



#### 4. Interaction between boats and bottlenose dolphins

##### a. Average separation distances between dolphins and boats

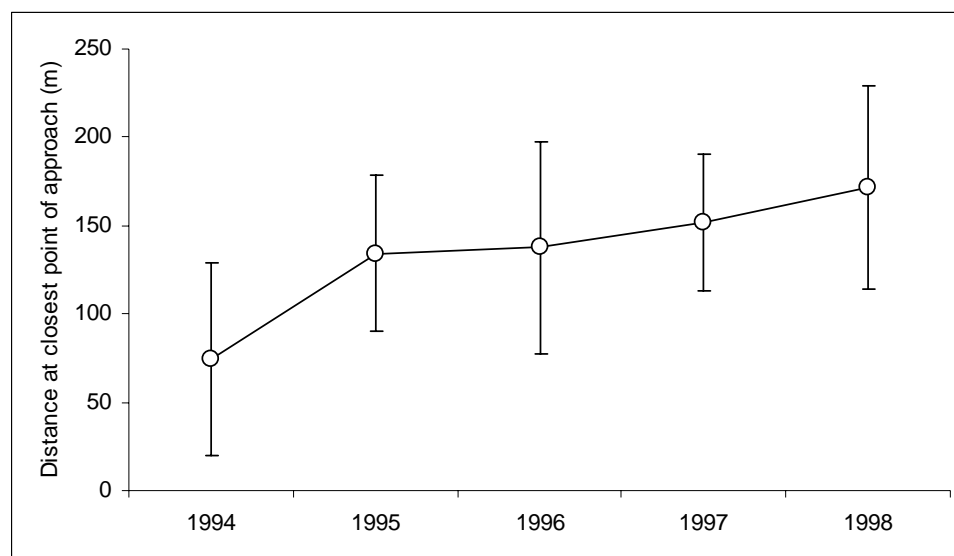
The average separation distance<sup>i</sup> between dolphins and boats was compared for encounters involving different types of boat. These data were collected during 118 encounters in 1994, and in 964 15min intervals from 1995-99. The following analyses were therefore carried out with a total of 1082 data for which the closest distance was recorded.

Differences between years and type of boat were investigated to determine whether boat operators heeded codes of conduct, introduced after the 1996 season. Both a voluntary code of practice for VPB operators, and a similar code of conduct for recreational boat users, requested boat-handlers not to approach groups of dolphins closely and to stop when dolphins were close.

##### (i) *Visitor Passenger Boats (VPBs)*

Figure 14 shows the mean separation distance recorded during VPB encounters for 1994-99. There was a significant trend for separation distance to increase over this period (Cuzick's trend test:  $Z = 2.4722$  (adj.), 1-sided  $P = 0.007$ ). The median distance recorded 1994-96 (md = 50,  $n = 190$ ) was found to be significantly less than the median distance for 1997-99 (md = 100,  $n = 131$ ) (Mann-Whitney  $U = 9131.5$ ,  $P < 0.001$ ). The data suggest that VPB operators did not attempt to approach dolphins as closely in 1997-99 as prior to the introduction of the code of conduct.

Figure 14. Mean separation distance during visitor passenger boat encounters with bottlenose dolphins (1994-99). Error bars indicate 95% CI.

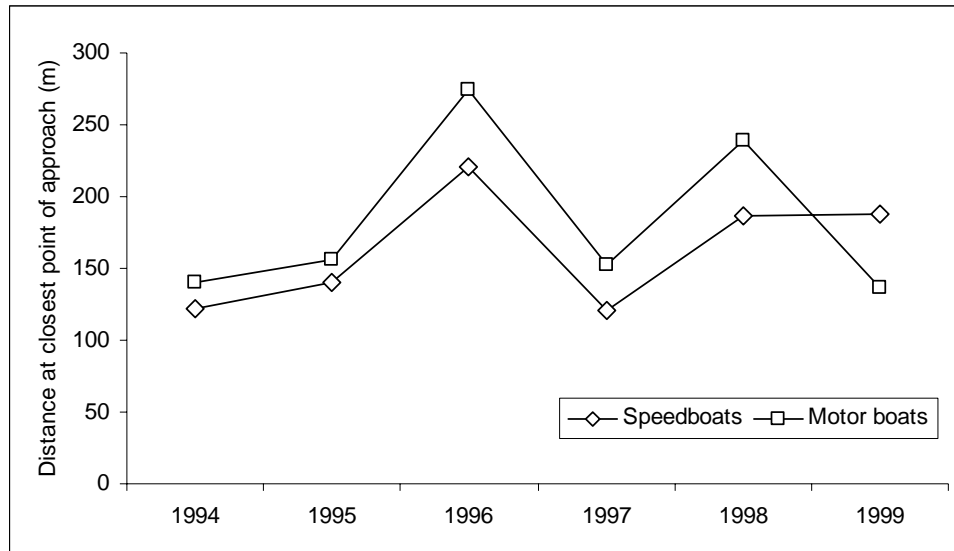


<sup>i</sup> Separation distance refers to the closest distance between boats and dolphins recorded during encounters.

(ii) *Speedboats & Motor boats*

Figure 15 shows the mean separation distance between dolphins and speedboats and motor boats.

Figure 15. Mean separation distance during speedboat and motor boat encounters with bottlenose dolphins (1994-99). Error bars have been omitted for clarity.



There was no significant trends in separation distance for either speedboats (Cuzick's trend test:  $Z = 0.3864$  (adj.), 2-sided  $P = 0.700$ ) or motor boats ( $Z = -0.2615$  (adj.), 2-sided  $P = 0.794$ ). It is interesting however, that the two data sets show similar patterns of variation from year to year, with greater mean distances recorded in 1996 and 1998 than in other years.

There was no significant difference between the median separation distance for motor boats and dolphins in 1994-96 (md = 53.2,  $n = 128$ ) and 1997-99 (md = 75.0,  $n = 63$ ) (Mann-Whitney,  $U = 4000.5$ ,  $P = 0.930$ ). There was also no significant difference between the median separation distance for speedboats and dolphins in 1994-96 (md = 100,  $n = 125$ ) and 1997-99 (md = 100,  $n = 87$ ) ( $U = 5248.5$ ,  $P = 0.666$ ).

These data suggest that the provision of a code of conduct for recreational boat users did not reduce the distance to which speedboats and motor boat operators approached groups of dolphins.

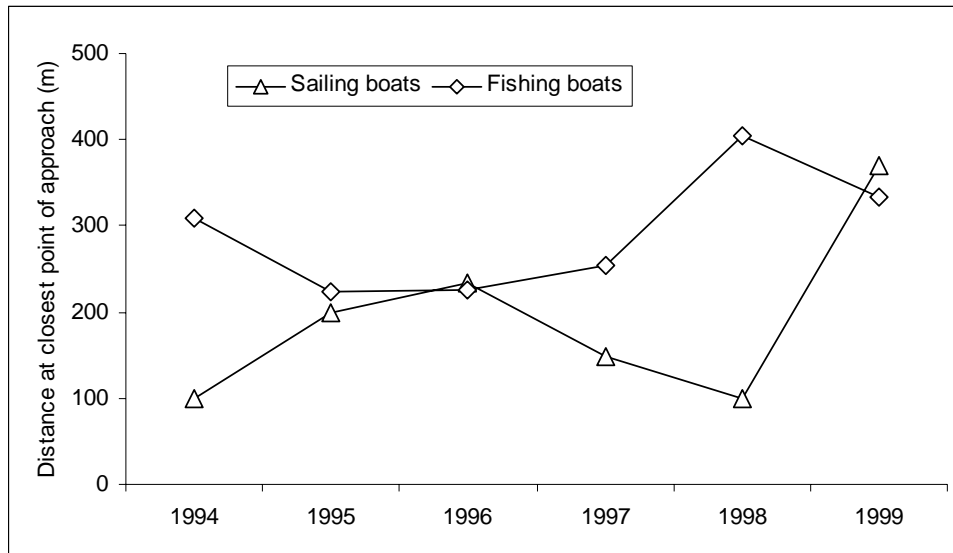
(iii) *Other boat types*

The mean separation distance recorded during encounters between dolphins and sailing boats and commercial fishing boats is shown in Fig. 16.

There was no significant trend in separation distance for either sailing boats (Cuzick's trend test:  $Z = 1.007$  (adj.), 2-sided  $P = 0.314$ ) or fishing boats ( $Z = 1.215$  (adj.) 2-sided  $P = 0.224$ ). There was no significant difference between the median separation distance for sailing boats and dolphins in 1994-96 (md = 100,  $n = 114$ ) and 1997-99 (md = 50,  $n = 89$ ) (Mann-Whitney,  $U = 4733$ ,  $P = 0.930$ ). Neither was there a significant difference

between the median separation distance for fishing boats and dolphins in 1994-96 (md = 200, n = 38) and 1997-99 (md = 300, n = 19) ( $U = 278.5$ ,  $P = 0.162$ ).

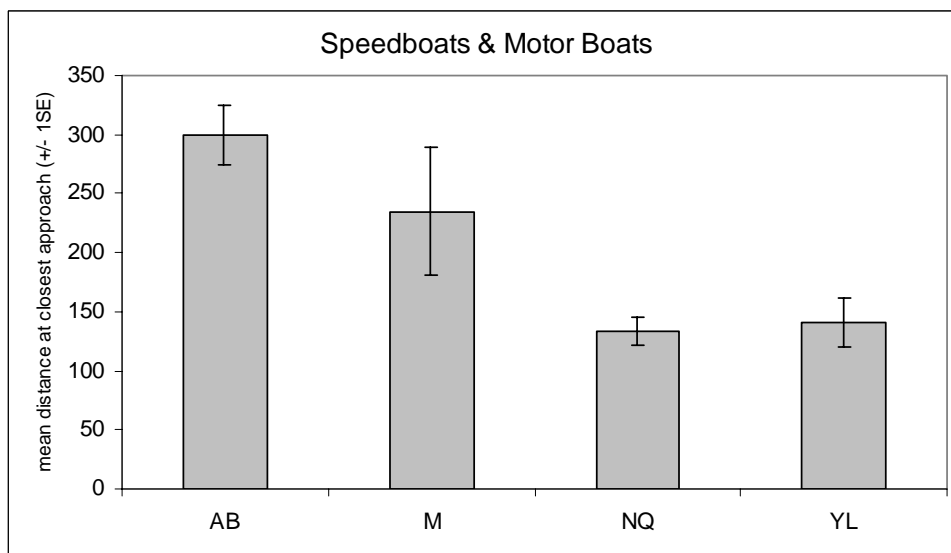
Figure 16. Mean separation distance during sailing boat and commercial fishing boat encounters with bottlenose dolphins (1994-99). Error bars have been omitted for clarity.



(iv) *Differences between sites*

Average separation distances for speedboat and motor boat operators were compared between study sites to see whether the introduction of a code of conduct had been more successful at some locations than others (Fig. 17).

Figure 17. Site differences for speedboat and motor boat encounters.

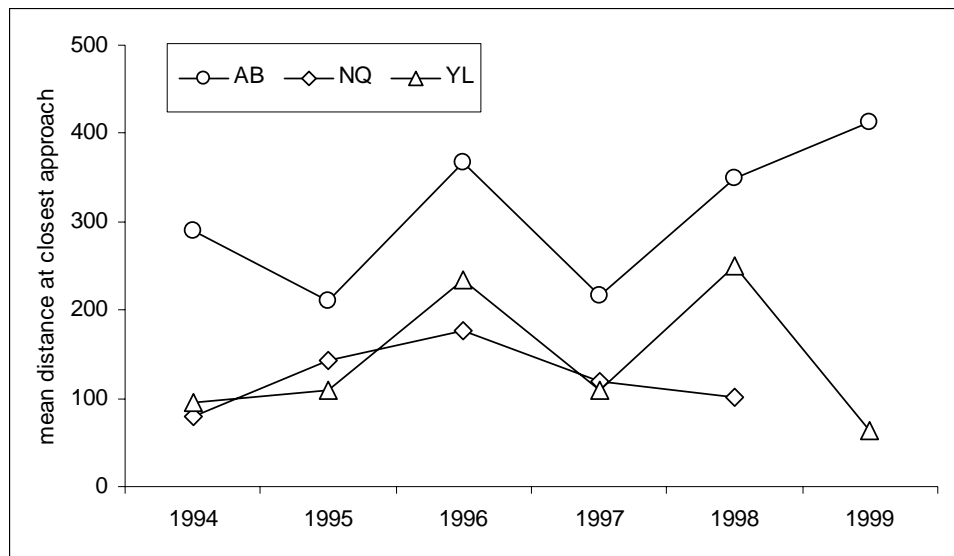


There were significant differences between average separation distances at the four sites (Kruskall-Wallis,  $T$  (adj.) = 38.9,  $P < 0.001$ ). Pair-wise comparisons identified that these differences lay between data from Aberporth & New Quay ( $P < 0.001$ ); Aberporth & Ynys Lochtyn ( $P < 0.001$ ); New Quay & Mwnt ( $P = 0.036$ ). Ynys Lochtyn & Mwnt were found not different at the 95% level of significance ( $P = 0.06$ ).

Speedboats and motor boats therefore, tended to approach dolphins more closely at New Quay and Ynys Lochtyn than at Aberporth in particular, and also Mwnt. These differences may be due in part to the proximity of boat launching and other high use boating areas, to areas frequently used by dolphins. Dolphins are frequently observed close to the busy harbour entrance at New Quay for example. Similarly, sightings at Ynys Lochtyn are often made close to the headland in a stretch of water through which boats often transit or stop to fish. At these sites, site use factors may habitually tend to bring dolphins and boats into closer contact. In contrast, at Aberporth dolphins often appear to disperse over a wider area and at greater distance from local launching sites. Boats must travel greater distances to reach Mwnt where there is no nearby public slipway.

Despite differences between sites, a significant trend for increasing distance was not detected at any site (Fig. 18).

Figure 18. Variation in mean separation distance for speedboat & motor boat encounters at Aberporth, New Quay and Ynys Lochtyn. NB. The mean for Aberporth in 1999 was based on 4 data only.



(v) *The frequency of close approaches (<50m)*

Distance at sea is notoriously difficult to estimate by eye. Data quality is affected by sea state, target size and by variation in the experience and skills of individual observers. Sometimes range-finding equipment (e.g. reticule binoculars or theodolites) may be used to improve accuracy. Observer training and calibration experiments are recommended whenever possible. In this case, the number of different observers participating in the project prohibited training in distance estimation. However, workers benefited from several factors:

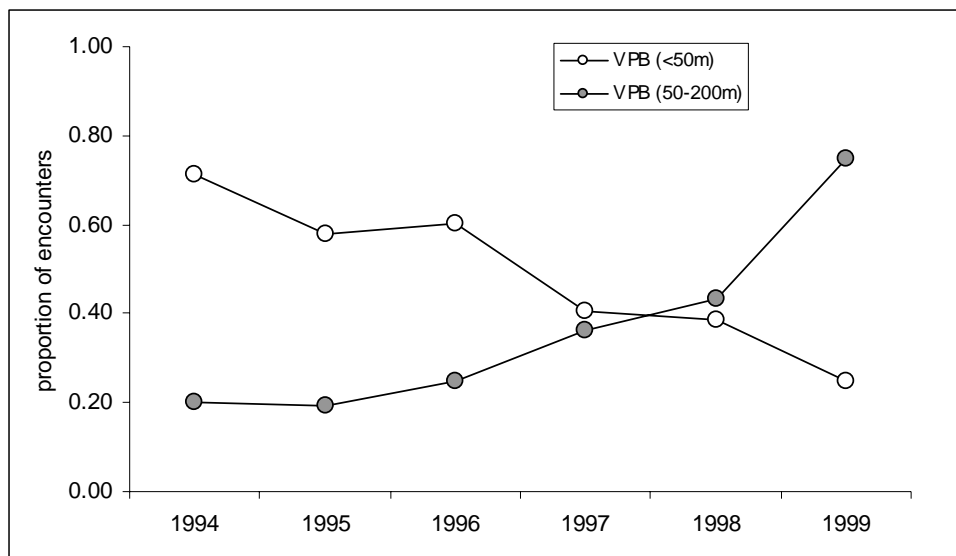


- o estimates were made from a steady platform (cliff-top positions rather than the bridge of a ship);
- o knowledge of distances between coastal landmarks was a useful guide to distances between adjacent objects in the sea;
- o observers were able to 'project' ranges during encounters, from the approximate length of boats involved.

The data however, show clear indications of 'heaping' or rounding of distance estimates to the nearest 10m (at distances of between 50 and 200m), 50 or even 100m (for more distant encounters). Because of the lack of certainty in the precision of estimates, further analyses were carried out using counts of the number of encounters in the following classes: within 50m; 51-100m; 101-200m; 201-400m; 401-800m; greater than 800m.

In Section 4a, comparisons were made using average separation distances. Here, the frequency of very close interaction is examined. The proportion of encounters for which a separation distance of 50m or less was recorded, was compared between years for different boat types. The only statistically significant trend was for VPBs: the proportion of very close approaches decreased over the study period (Cruzik's Trend Test,  $Z = -2.108$ , 1-sided  $P = 0.017$ ). Trends for other boat types were not significant ( $P > 0.05$ ).

Figure 19. The proportion of encounters between Visitor Passenger Boats (VPB) and bottlenose dolphins each year, for which the closest point of approach was 50m or less and 51-200m.



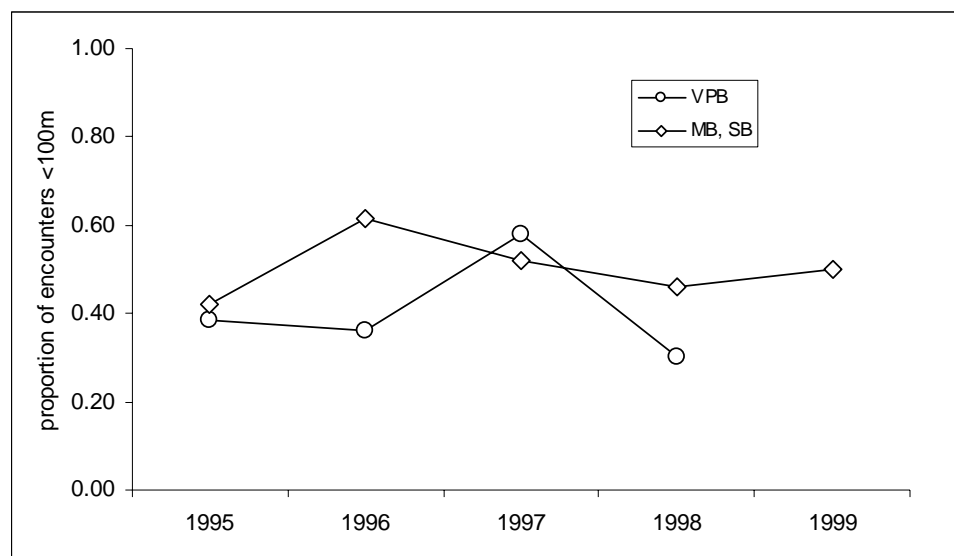
During the study period, the proportion of encounters within 50m of all VPB encounters decreased and a corresponding increase in the proportion of encounters between 51-200m was also recorded. Although separation distance was determined by the behaviour of dolphins as well as boat operators, these data again suggest that VPB skippers attempted to close on dolphin groups less frequently after the introduction of a code of conduct. No significant changes in the actions of other types of boat were recorded.

b. The frequency with which boats stop during encounters

Boat operators were encouraged to stop when in the vicinity of groups of dolphins, rather than to closely pursue them if they choose to move away. The data were therefore investigated to determine whether there was an increase in the frequency at which boats stopped when with dolphins after the introduction of a code of conduct. From 1995 onwards, observers were asked to record whether boats were stationary or moving when dolphins were present. During encounters, this information was recorded at the end of each 15min interval, for the closest boat to dolphins only. Overall, 1040 data were recorded for boats within 800m of dolphins. For VPBs the annual percentage of 'stationary intervals' ranged from 23% (in 1998) to 47% (in 1997). The majority of VPB data were recorded at New Quay, and as observations were not carried out at this site in 1999, there were insufficient data overall to include this year in comparisons.

Both recreational boat users and commercial VPB operators were requested to stay stationary only when close to dolphins, so a subset of encounters were examined for which the closest point of approach was 100m or less (Fig. 20).

Figure 20. The proportion of encounters (recorded at 15min intervals) each year when Visitor Passenger Boats, motor boats and speedboats were recorded as having remained stationary. Data for encounters with dolphins in which the closest separation distance was less than 100m.



The data for both boat types varied relatively little between years. There was no evidence of significant changes during the study period, although there was an increase in VPB compliance in 1997, the season following the introduction of the voluntary code of conduct.

For encounters with a separation distance of 50m or less, VPB stopped overall for 40% of intervals. Motor boats / speedboats stopped in 35% of intervals although this was more variable between years: the 'worst' year for motor / speedboats was 1995, when boat drivers stopped on only 9 of 46 occasions (20%); the following year these boats stopped on 12 of 24 occasions (50%).

The data show that overall, motor boats and speedboats stopped a little more frequently than VPBs when within 100m of dolphins. However, VPBs appear more likely to remain stationary than other boat types when dolphins were closer than 50m. There was little variation between years for either boat type. However, the lowest proportion of stationary data (20% of 15min intervals), recorded for motor boats and speedboats during the first season that these data were collected, was not repeated in subsequent years.

c. Dolphin behaviour recorded during encounters with boats

Dolphin behaviour was recorded as a series of codes summarising surface activity during 15min intervals. Behaviour was recorded for 1970 intervals (69% of intervals in which bottlenose dolphins were present, 1995-99). As multiple codes were often used, 2571 data were available to describe dolphin behaviour with and without boats present.

Observers were instructed to record the occurrence of these activities: bow-riding boats (B), leaping clear of the surface (L), repeated surfacing at approximately the same position (S), approaching boats (A), heading away from boats (H), tail-slapping (T). Two additional codes were available to record the presence of birds (BS) and fish (F). The use of codes was introduced after the 1994 season to replace full text descriptions, and data collected in 1994 is not included here.

(i) *Dolphin behaviour in the presence of different types of boats*

Dolphin behaviour recorded for animals within 400m of boats was compared with dolphin behaviour recorded in the absence of boats. Activities likely to occur independently of the presence of boats were 'staying' (S), 'leaping' (L) and 'tail-slapping' (T). These were recorded with similar frequency with or without boats respectively: S (36%, 34%); L (24%, 27%); T (2%, 2%). There seemed therefore, to be no clear differences in the occurrence of these behaviours when boats were absent or within 400m.

Behavioural data recorded in the presence of different types of boat are shown in Fig. 21 below. It should be borne in mind however, that only data for the closest boat to dolphins was recorded each 15min. Whether observed behaviour included response to more distant boats of different types is not known (e.g. to a fast moving speedboat at 150m rather than a visitor passenger boat at 80m from the animals).

These data were tested to determine whether there were statistically significant differences in the relative frequency of behaviour recorded for different boat types. Chi-squared procedures were used to test whether the frequency with which behaviours were recorded were different from that which would otherwise be expected (Table 7). Expected frequencies of 'staying', 'leaping' and 'tail-slapping' were calculated from the relative frequencies of these behaviours when no boats were present. Expected frequencies of the interactive behaviours 'bow-riding', 'heading away' and 'approaching' were calculated for different boat types using the relative frequency of these behaviours overall when boats were present.

No significant difference between the frequency of 'leaping' when boats were present and when no boats were present (goodness of fit,  $\chi^2_5 = 3.55$ ,  $P > 0.05$  ns). However, there were significant differences between the observed and expected frequencies of 'staying' ( $\chi^2_5 = 12.0$ ,  $P < 0.05$ ) and 'tail-slapping' ( $\chi^2_5 = 20.1$ ,  $P < 0.01$ ). These results

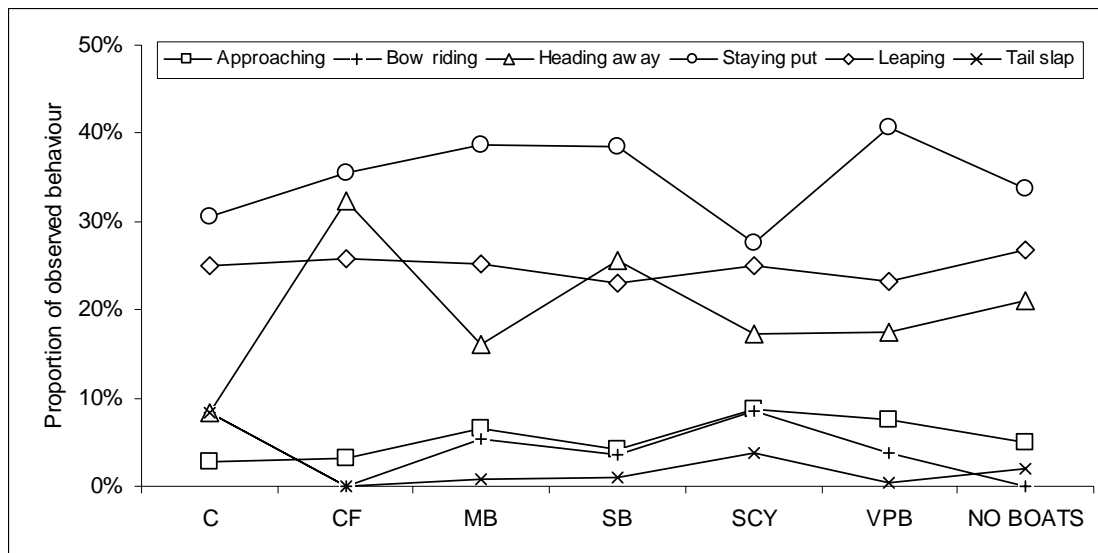
were attributed to the relatively high occurrence of 'staying' in the presence of VPBs, and the raised incidence of 'tail-slapping' when canoes were the closest boats respectively.

Of behaviours requiring boat interaction ('heading away', 'approaching', 'bow-riding'), there was found to be no significant difference between the frequency that dolphins approached different boat types ( $\chi^2_5 = 6.11$ , ns). There were however, significant differences between boat types for 'bow-riding' ( $\chi^2_5 = 12.0$ ,  $P < 0.05$ ) and 'heading away' ( $\chi^2_5 = 14.6$ ,  $P < 0.05$ ). The boat types with the highest individual  $\chi^2$  components for 'bow-riding' were sailing boats and commercial fishing boats. The boat types with the highest individual  $\chi^2$  components for 'heading away' were speedboats, commercial fishing boats and canoes.

Table 7. Comparisons of behaviour and boat type. The level of significance ( $P$ ) is shown for each behaviour (ns = not significant at 95% level); the contribution of individual  $\chi^2$  scores may be compared across boat types. NB. C = canoe; CF = commercial fishing boat; MB = motor boat; SB = speedboat; SCY = sailing boat, under sail; VPB = visitor passenger boat.

	C	CF	MB	SB	SCY	VPB	$\chi^2$	$P$ (5df)
Staying	0.11	0.05	1.85	1.25	3.12	5.62	<b>12.0</b>	0.05
Leaping	0.04	0.02	0.21	0.99	0.31	1.97	<b>3.55</b>	ns
Tail-slapping	7.39	1.22	1.92	0.88	4.01	4.65	<b>20.1</b>	0.01
Approaching	0.83	1.13	0.02	1.99	1.78	0.36	<b>6.11</b>	ns
Heading away	2.12	5.86	1.08	4.70	0.38	0.49	<b>12.0</b>	0.05
Bow-riding	0.72	3.18	0.03	0.90	5.89	1.28	<b>14.6</b>	0.05

Figure 21. The behaviour of dolphins in the presence of different boat types. The data are expressed as the proportion of all behaviour recorded in the presence of each boat type.



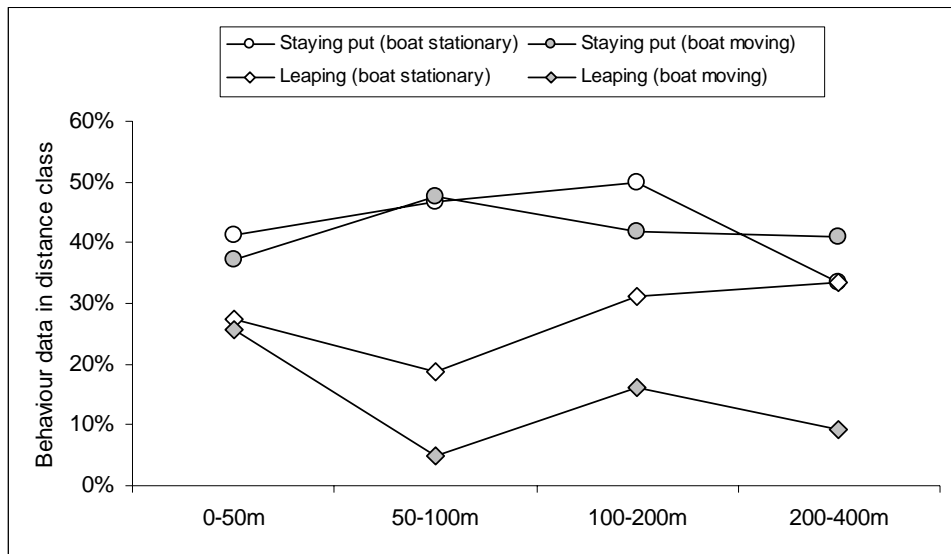
In summary, dolphins appeared more likely to stay at the same location when passenger boats were present and tail-slap when canoes were close, than would otherwise be expected if no boats were present. Also, the data suggest that dolphins would bow-ride sailing boats and fishing boats, and head away from speedboats, fishing boats and

canoes more than would be expected if these behaviours were performed to the same degree with all boat types.

(ii) *Dolphin behaviour recorded with stationary and moving boats*

The frequency with which different behaviours were recorded was compared for encounters with VPBs, when the closest boat was either moving or stationary. In Fig. 22, the frequency with which each behaviour was recorded is expressed as a percentage of all intervals with behaviour data in each distance class.

Figure 22. The frequency with which 'staying' and 'leaping' were recorded during encounters with Visitor Passenger Boats: moving and stationary vessels.



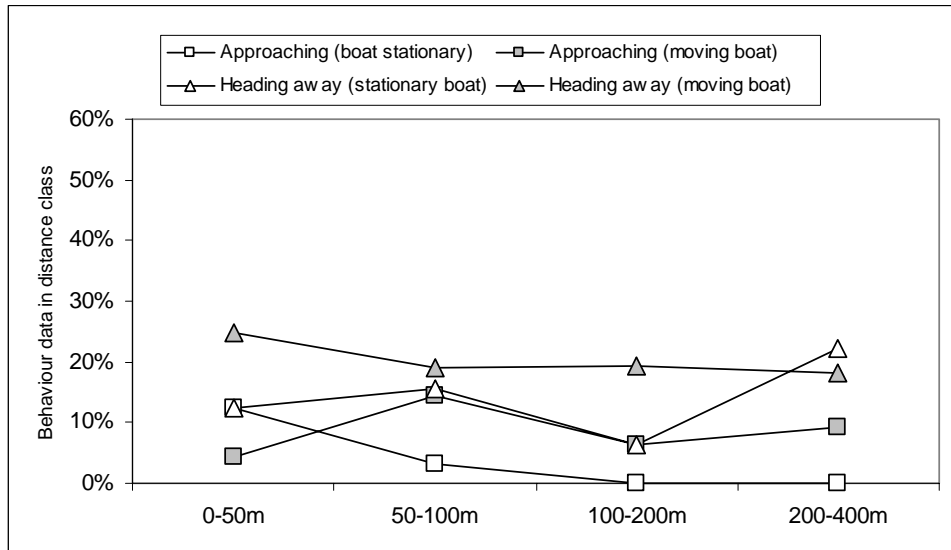
'Staying' was recorded with similar frequency when the closest VPB was moving or stationary. This behaviour was, however, recorded with the greatest relative frequency when VPBs were stationary and approached to a range of not less than 100m. The data suggest that whether VPBs stopped or not had little effect on whether dolphins continued surfacing the same location.

'Leaping' occurred with similar frequency for moving and stationary boats during encounters at 50m or less. However, in general, 'leaping' was recorded less frequently when boats were moving. 'Leaping' during encounters with moving boats occurred relatively more often at close range (50m or less) than when the boats were further away, but was recorded with similar frequency at distances up to 400m for stationary boats.

Both 'heading away' and 'approaching' were recorded less frequently during encounters with VPBs than 'staying' or 'leaping'. In general, dolphins approached moving boats more frequently than stationary boats, although at distances of 50m or less the opposite was true. Dolphins only rarely approached stationary boats at distances of more than 50m. They would however, approach moving boats with similar frequency at distances of 50m to 400m. In general therefore, dolphins seemed more attracted to moving boats than stationary boats, except during close interaction.

'Heading away' was recorded more frequently than 'approaching', and dolphins tended to head away from moving vessels more often than they would stationary vessels (Fig. 23).

Figure 23. The frequency with which 'approaching' and 'heading away' were recorded during encounters with Visitor Passenger Boats.



In summary, it appears that 'heading away' behaviour was recorded least frequently when VPBs stopped during encounters, particularly when at close range. Dolphins were however, more attracted to moving than stationary boats. During the closest encounters though, dolphins appeared more likely to approach VPBs if these boats were stopped.

(iii) *Behaviour recorded during boat encounters before and after the introduction of codes of conduct for boat operators*

A voluntary code of conduct was introduced by VPB operators mid-way through the project. Dolphin behaviour was therefore compared between years up to and including 1996, and years after 1996, to see whether changes occurred in the relative frequency with which different behaviours were recorded.

Table 8. Dolphin behaviour recorded during encounters with VPBs: comparison of observed (O) and expected (E) frequencies recorded in 1997-99. Percentage of all recorded behaviour are given. Individual chi-squared components of test described below are shown for each behaviour.

	O95-96	%95-96	O97-99	%97-99	E97-99	$\chi^2$
Approaching	14	8%	11	8%	10.3	0.046
Bow-riding	9	5%	3	2%	6.6	-
Heading away	41	23%	21	16%	30.2	2.796
Staying	76	42%	62	47%	56.0	0.653
Leaping	42	23%	35	27%	30.9	0.537
Tail-slapping	0	0%	2	2%	0.0	-

Although the relative frequency with which most behaviours varied little between 1996-97 and 1997-99, there was a reduction in the occurrence of 'heading away'. There was also an increase in the frequency with which 'staying' and 'leaping' were recorded (Table 8).

The number of times that each behaviour would be expected to have been recorded after the introduction of the code of conduct (i.e. 97-99) was calculated, based on the frequency that each was recorded in 1995-96. A chi-squared (goodness of fit) test was used to determine whether the frequency with which behaviours were actually observed differed significantly from those expected. This was not found to have been the case: there was no significant change in the relative frequency of recorded behaviours before and after the introduction of the code of conduct ( $\chi^2_3 = 4.03$ ,  $P > 0.05$ )<sup>j</sup>.

## 5. Activity at the DERA Aberporth Military Range

When the military firing range at Aberporth is active, missiles or artillery shells are either fired from the DERA facility on Aberporth Head or from aircraft operating over the range. A number of targets are located several miles offshore in central Cardigan Bay. The facility tests propulsion and navigation systems and live war-heads are rarely used. Some rounds are detonated in mid-air, others drop into the sea. Potential biological impacts may include injury to dolphins in the vicinity of detonations; displacement of dolphins as a direct result of disturbance from detonations; habitat degradation due to the displacement of prey species. Relative sighting rates at coastal sites were used to test whether firing range activity affected the relative abundance of dolphins locally.

DERA provided a list of dates and times in which Aberporth Range was engaged in firing or dropping missiles or stores into the sea for 1994-97 and for 1999. Firing events were identified as either ground-based or from aerial activity. Impacts from ground-based activity (shells and some missiles) generally occurred closer to shore than devices released from aircraft which may impact anywhere within Range Danger Area. The number of shells or missiles fired during these periods was available for 1999 only. There were no data on whether explosions occurred in air or on impact with the sea. The precise locations of impacts on the sea surface were also not available.

The relative acoustic impact of periods of firing and the distance of impacts from the study sites could not be estimated, and consequently all range activity was treated as a single dataset. Sighting rates of bottlenose dolphins were calculated for watch periods when the military range had been recently active. These watch periods were carried out after firing had taken place that day (either before or during the watch), or at anytime on the previous day. The average sighting rate during these watches was then compared to the average sighting rate for watches on days when no firing had taken place on that or the previous day (Fig. 24). Data were selected for observation periods carried out between week numbers 2-8, to avoid effects that may have been due to background seasonality of dolphin occurrence.

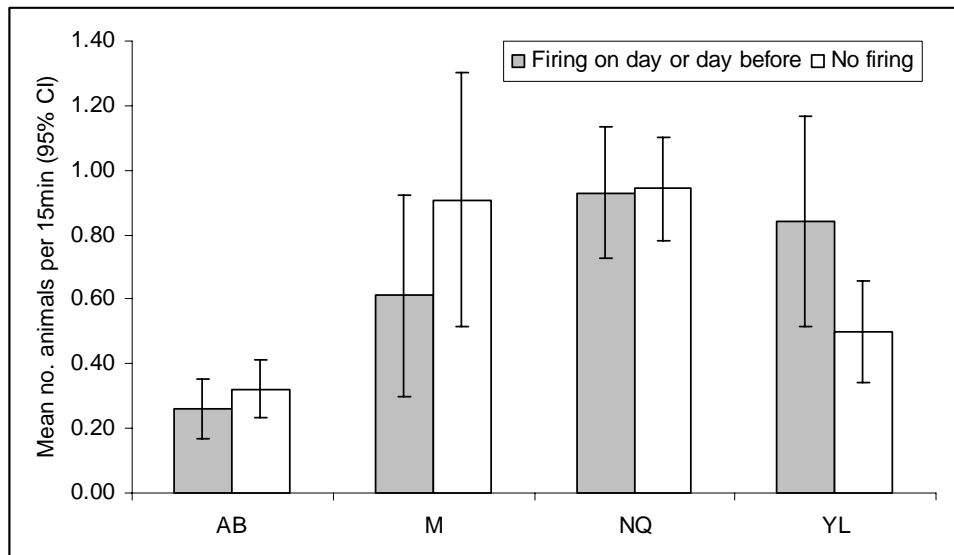
Average sighting rates were compared for each of the four sites in turn, using a Mann-Whitney (two-sided) test. No significant differences were found between average

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<sup>j</sup> Statistical significance was tested with 3 degrees of freedom (n-1) as there were sufficient data available in four behavioural classes only.

sighting rates for periods of range activity and inactivity at any of the coastal study sites: Aberporth ( $U = 21845$ ,  $P = 0.590$ ); Mwnt ( $U = 433$ ,  $P = 0.821$ ); New Quay ( $U = 26212$ ,  $P = 0.685$ ); Ynys Lochtyn ( $U = 6626$ ,  $P = 0.988$ ).

Figure 24. Sighting rates for periods when Aberporth military range had, and had not been active prior to the observations carried out (data from weeks 2-8, 1995-99 only).



There was therefore, no evidence to support the hypothesis that military activity at DERA Aberporth affected sighting rates of dolphins at these sites. However, more satisfactory comparisons may be made if additional details of range activity were available, i.e. whether explosions occurred in air or in the sea; the distance from the area of impact to dolphin study sites; the relative intensity of firing during periods when the range was active.



## DISCUSSION

### a. Sighting rates and site use by bottlenose dolphins

Sighting rates for bottlenose dolphins were calculated from data collected in 2390 watches (standardised 2h observation periods), carried out over a six-year period. The data describe site use by dolphins at four sites in Cardigan Bay between 1994 and 1999. In terms of the regularity with which bottlenose dolphins were present and the rate at which individual animals were sighted, the most highly ranked sites were New Quay and Mwnt. Sighting rates were generally lower at Ynys Lochtyn although more variable, and sightings were made less frequently in Aberporth Bay. Bottlenose dolphins were however, observed regularly at all sites: in 50-55% of watches each year at New Quay and Mwnt, and between 25-35% of watches at Aberporth and Ynys Lochtyn. Expressed as the average number of animals recorded per hour ( $\pm$  95% CI), sighting rates were: 3.2 (2.8 - 3.5) at New Quay; 3.2 (2.4 - 3.9) at Mwnt; 2.1 (1.6 - 2.7) at Ynys Lochtyn; and 1.1 (0.9 - 1.3) at Aberporth. Groups of 10 or more animals were observed at all sites. The largest group of dolphins recorded was 16 animals, at Ynys Lochtyn in 1996. The highest count for multiple sites was 19 animals, although this is a conservative estimate of the number of dolphins present in and between sites in the coastal strip, and represents the maximum simultaneous count. Sightings of young animals believed to be less than 1y old were also recorded.

Initially, a five-year series of sighting data were compared at Aberporth and Ynys Lochtyn and a four-year series at New Quay. No significant trends were found in annual sighting rates at any site. The dataset was then expanded to include data from the first field season in 1994, that were recorded under a slightly different protocol. These data suggested that sighting rates at New Quay may have declined between 1994-98. This poses a hypothesis for further work at the site. However, the results of this analysis should be interpreted with caution: high rates recorded in 1994 were shown to have strongly influenced the significance of the result, and no data were available for 1999 when sharp increases from the previous year were recorded at Mwnt and Ynys Lochtyn. If a similar increase in sighting rate was observed at New Quay in 1999, it is unlikely that a significant downward trend over six years would have been identified.

Other differences between the four sites were examined. On occasions when dolphins were recorded, lower numbers of animals tended to be present at Aberporth than elsewhere. A relatively high frequency of transiting behaviour and a lower frequency of 'staying' (which is milling or repeated surfacing at approximately the same location) were also observed at Aberporth than at other sites. In contrast, dolphins tended to occupy habitat at New Quay for significantly longer periods than at the other sites, an average of 50min of each 2h watch in which they were recorded. The regularity of sightings at New Quay, the high sighting rates of individual animals and the high proportion of observation time that dolphins were present, highlight the importance of habitat at this site.

The most frequently recorded behaviours overall were 'staying', 'leaping', and 'transiting' which includes movements towards and away from boats. The relative frequency of behaviours recorded at all sites was similar, except for the aforementioned prevalence of 'transiting' at Aberporth and a correspondingly low incidence of 'staying' relative to other sites.

Observations were carried out during four pre-scheduled 2h periods of the day only. Sighting rates for each of these watch periods were compared between sites. Two, partly contrasting, patterns were evident for the two more northern and southern sites respectively. Sighting rates at the southern sites, Mwnt and Aberporth tended to peak in the first watch (beginning 11am) and the last watch of the day (beginning 5pm). Sighting rates at the northern sites, New Quay and Ynys Lochdyn, also peaked early in the day, but fell steadily from mid-afternoon to evening. Differences in rates for the four watches were only statistically significant at Aberporth. The data suggest however, that daily patterns of movement of individual animals and groups deserve further investigation.

Although the annual field spanned a period of three months only, from the beginning of July until the end of September, sighting rates were compared for successive weeks. Using data from all sites combined, sighting rates gradually increased through July to peak in early to mid-August. Peak rates were recorded at this time every year, although dolphins were present during the whole of each field season. Seasonality in relative abundance at these sites suggests an influx of dolphins to the region during the summer and may indicate temporal variability in the importance of habitat resources. Prey availability for bottlenose dolphins may increase at the study sites towards mid-summer. Equally, aggregation of animals in southern Cardigan Bay may be driven by social or reproductive factors. The abundance of bottlenose dolphins in Cardigan Bay outside the field season from late autumn to late spring is widely believed to be considerably lower than during the summer. There are few comparable data available however<sup>k</sup>.

Data from the project establish baselines for future shore-based monitoring, but variation in the abundance and the distribution of bottlenose dolphins in Cardigan Bay as a whole, and the relative importance of habitat at the four study sites remain unquantified. Present results highlight some differences in site use on the Ceredigion coast. These data suggest that detailed investigation of habitat and prey resources at these sites, habitat utilisation by dolphins, and the movements of individual animals, would improve our understanding of the local ecology of bottlenose dolphins.

#### b. Boat traffic

Levels of boat use were monitored in 1994, 1998 and 1999, independently of the presence of dolphins. Levels of boat use were higher at New Quay than at other sites: approximately 3-4 times higher at New Quay than at Aberporth and Ynys Lochdyn, and 5-6 times than at Mwnt. The most common types of boat use also varied between sites. In general, sailing boats, motor boats and speedboats were recorded frequently at all sites. Visitor passenger boats (VPBs) however, accounted for approximately 20% and 10% of boat traffic at New Quay and Ynys Lochdyn respectively, but did not feature significantly elsewhere. Sailing boats and commercial fishing boats made up higher proportions of boat traffic at Mwnt than at other sites.

Data on boat encounters with dolphins were collected systematically throughout the project. Encounters were recorded between bottlenose dolphins and a wide range of boats including motor-driven recreational craft, VPBs, sailing boats, fishing boats and

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<sup>k</sup> Baines, M.E., Pierpoint, C.J.L. and Earl, S.E. (1997). *A Cetacean Sightings Database for Wales and an evaluation of impacts on cetaceans from the Sea Empress oil spill*. Report to the Sea Empress Environmental Evaluation Committee. The Countryside Council for Wales. 70pp.

canoes. In general the types of boat most commonly recorded at each site were involved in a high proportion of encounters with dolphins. Over sixty percent of all (881 of 1439) encounters occurred at New Quay, the busiest site, even though no observations were carried out there in 1999. At New Quay, 40% of encounters involved VPBs. A further 22% involved sailing boats. Motor boats accounted for 15%, and speedboats 12% of all encounters.

At Ynys Lochtyn, and at Aberporth where less VPB activity was recorded, motor boats and speedboats were recorded in a proportionally higher number of encounters (34% and 38%, and 20% and 22% of encounters respectively). At Mwnt sailing boats and commercial fishing boats were recorded as the closest vessels to dolphins in 40% and 20% of encounters.

c. Boat / dolphin interaction

The primary aim of this project was to examine interactions between dolphins and boats. The project itself was initiated by local concern over possible disturbance to dolphins by boats. Ceredigion County Council introduced a code of conduct for recreational boat users in the early 1990s. Passenger boat operators later introduced their own similar code. The codes of conduct aimed to reduce disturbance of bottlenose dolphin behaviour. Skippers were requested not to closely pursue groups of dolphins or to approach at speed. They were asked to stop their boats if possible, before approaching too closely, thereby allowing dolphins to choose whether or not to approach and initiate close interaction. The present data were analysed to determine whether or not the introduction of codes of conduct had had a positive impact on boat activity at the four sites.

On average, the separation distance between VPBs and dolphins was greater after the introduction of the boat operators' voluntary code than it had been previously. There was a significant trend for the separation distance (at closest point of approach) to have increased over the study period. The proportion of very close encounters (within 50m) also fell. The data suggest that VPB operators, in abiding by the guidelines, did not attempt to approach dolphins as closely from 1997 onwards. In this respect it appears that under self-regulation, VPB operators have reduced the likelihood that they will interrupt the behaviour of the dolphins.

No corresponding trend was recorded for motor boat and speedboat operators however. Neither the average distance to which these boats approached dolphins nor the frequency of very close approaches changed significantly over the study period. No positive changes were observed at any of the four sites. The average separation distance was lower for encounters with dolphins at New Quay and at Ynys Lochtyn than at Aberporth and Mwnt. This may be due to the proximity of high-use boat areas and preferred dolphin habitat, but suggests that action at the former sites should be prioritised when targeting recreational boat users with information on how to reduce disturbance to dolphins.

No trend was found to indicate that either VPBs or other types of boat now stop more often when in the vicinity of dolphins. Motor boats and speedboats stopped when within 50-100m of dolphins marginally more frequently than VPBs, although each type stopped in approximately 33-45% of encounters. When within 50m of dolphins however, VPBs stopped more frequently than motor and speedboats.

Dolphin behaviour around boats was investigated, to see whether different behaviours were more or less likely to be recorded in the presence of boats or different types of boat. Analyses were also carried out to determine whether any measurable changes in dolphin behaviour during encounters with VPBs had been observed since operators introduced their code of conduct.

It was found that 'staying', 'leaping' and 'transiting' were recorded with similar frequency when boats were within 800m, and when boats were absent from the field of view. Behaviour was then divided into two classes: behaviour applicable to situations with or without boats present ('staying', 'leaping' and 'tail-slapping') and behaviour that described interaction with boats ('bow-riding', 'approaching' and 'heading away'). The relative frequency of these activities was compared for different types of boat.

'Staying' (repeated surfacing at the same location) was found to occur more frequently with VPBs (i.e. when VPBs were the closest boat to the dolphins), and 'tail-slapping' occurred more frequently with canoes, than would be expected when no boats were present. For the purely interactive group of behaviours, there were significant differences between the observed frequency of both 'bow-riding' and 'heading away' than would be expected if these behaviours were recorded with the same frequency for all boat types. 'Bow-riding' occurred more with sailing boats and fishing boats, and 'heading away' occurred more with speedboats, fishing boats and canoes.

For VPBs, 'staying' was recorded more than other behaviours and was observed with similar frequency when boats were stationary or moving. 'Staying' was most likely to be recorded when the vessel was stationary and 100-200m from the dolphins.

In general 'leaping' occurred more often when VPBs were stationary, except when the boats were within 50m. During these close encounters, there was a raised incidence of 'leaping' with moving boats; as a result, the behaviour was recorded with the same frequency for moving and stationary boats. It is difficult to explain why dolphins should leap more in the presence of stationary boats than moving boats at ranges of 50-400m. Jumping clear of the surface may be performed in a range of behavioural contexts (e.g. aggressive display, other high-key social interaction or when feeding). The data suggest that the frequency of 'leaping' is suppressed however, in the presence of moving boats except when the boats are very close. One hypothetical explanation is that dolphins are able to track moving boats acoustically more easily than stationary boats. Dolphins may therefore 'leap' in order to gauge the proximity of stationary boats visually. If this were true, dolphins may be expected to begin leaping immediately after VPBs stopped. At close range leaping may result from the excitement of close interaction and therefore take place relatively frequently with both stationary and moving boats.

'Heading away' from VPBs was recorded least often when these boats were stationary, especially when the vessel was close to the dolphins. Conversely, dolphins were more likely to approach VPBs when they were moving, but again when very close (within 50m) dolphins were more likely to approach stationary boats. This lends support to the idea that if boats do not attempt to approach dolphins to within 50m, close interaction is often initiated by dolphins themselves.

Based on data for VPBs therefore, the present codes of conduct therefore provide useful guidelines for boat users wishing to watch dolphins without displacing animals or

otherwise adversely affecting their behaviour. The VPB operators' guidelines for example, advise that boats should reduce speed at 300m from dolphins and that boats should then stop or cruise by at 100m (Appendix 3). In the present study, dolphins were most likely to approach moving boats at this range, and stationary vessels during closer interaction. Stopping minimised the incidence of 'heading away', especially during close encounters. 'Leaping' was also observed more often in encounters with stationary boats.

The behaviour of dolphins in the presence of VPBs was compared before and after the introduction of the code of conduct. The most marked differences were an increase in 'staying' and a decrease in 'heading away' (23% -16% of recorded behaviour in 1995-96 and 1997-99 respectively). These changes were not however, statistically significant.

d. Military range activity at DERA Aberporth

Concerns have been raised over the impact of military range activity on bottlenose dolphins in Cardigan Bay. The present data allowed the issue to be addressed, but only in a relatively superficial manner. DERA provided information on range activity during the duration of the project and sighting rates of dolphins were compared at each site for periods when the Aberporth range had and had not been, recently active. To reduce background variation due to seasonal variation in dolphin occurrence, data were selected for the six week period in which most sightings were made each year.

Average sighting rates were compared for periods with no range activity and periods when firing had occurred during or before the watch or on the previous day. No significant difference in sighting rates for active and non-active periods were observed at any site. There was therefore no evidence to suggest that range activity affected the local abundance or distribution of dolphins. Additional data concerning the nature of range activity would be required, if a more satisfactory assessment of the potential impacts of military weapon testing were to be made. For example, it was not known whether explosions occurred in air or on impact with the sea. The location at which missiles or shells entered the sea and the distance from the study sites was also not known and information on the intensity of firing was available for 1999 only.

## **ACKNOWLEDGMENTS**

We would like to thank Holly Arnold, not only for comments on earlier drafts of this report, but for support and expertise provided throughout the six years of this project.

Thanks also to Alison Davies for providing data on behalf of DERA, for Aberporth range.

The completion of this project owes everything to the enthusiasm and participation of the many observers who took part.

Appendix 1. Example of a completed recording form.

Appendix 2. Code of Conduct for recreational boat users.



Appendix 3. Code of Conduct for passenger boat operators