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Changes in Coastal Site Usage by Bottlenose Dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales

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Abstract

A shore-based study has been conducted for over 14 years of a coastal population of bottlenose dolphins (*Tursiops truncatus*) that frequent New Quay Bay. Analysis of year-round observations for the years 1997, 2001, and 2002 are presented for the first time and are set in context with results from the years 1989-1996 and 1998-2000, which were the subject of earlier papers. The annual frequency of dolphin sightings in days per year were comparable with previous studies. The results for 1997 are in line with observations made in the period 1989 to 1999, both in terms of group size frequency distribution, average monthly group size, and number of sightings of groups with small calves. The results for 2001 and 2002 confirm the significant decline in dolphin group size first noted in the year 2000, with a steep decline in both average monthly group size and monthly maximum group size. In addition, there was a corresponding decline in the incidence of groups containing small calves. In 2002, the number of recognised individuals seen was also reduced.

Key Words: Cardigan Bay, bottlenose dolphin, *Tursiops truncatus*, shore-based monitoring

Introduction

Bottlenose dolphins (*Tursiops truncatus*) (Montagu) have a worldwide distribution, using a range of coastal habitats, including lagoons, estuaries, and open coastal waters, as well as the open ocean in temperate and tropical seas (Kenney, 1990; Shane, 1990). Although highly mobile, they favour inshore locations where they occur with some regularity. Of at least six favoured locations around northwestern Europe, one is the southern part of Cardigan Bay, Wales, notably off the small fishing port of New Quay. Anecdotal evidence from local fishermen indicated that dolphins have frequented this location since the 1920s. The location was designated a candidate Special Area of Conservation (cSAC) for this species, listed in Annex II of the EU Habitats Directive (Council Directive 92/43/EEC).

Because these dolphins often come close to land, they can readily be seen by observers on shore, enabling relatively long-term shore-based studies of the dolphin population. Between 1989 and 1997, a year-round shore-based study was made of bottlenose dolphins in New Quay Bay. Although the bay was but a small part of the foraging range of the dolphins, systematic recording confirmed that they frequented this bay throughout the year. Records of group size, group composition, and characteristically marked individuals helped determine the site fidelity of individuals and groups on a seasonal and yearly basis. When the findings from the years 1989 to 1996 were reported (Bristow & Rees, 2001), data for 1997 had yet to be analysed. A second year-round study that took place between 1998 and 2002 used the same methods as the earlier study, with data generated by a team of ten local, trained volunteers, supported by the observer from the first study and two co-ordinators. When the findings for 1998 to 2000 were reported (Bristow et al., 2001), data for the year 2000 showed significant changes in dolphin numbers and changes in site usage and activity. The unpublished data for 1997 and the data from 2001 and 2002 have now been analysed, making it possible to report both how changes seen in 2000 have progressed, and an overview of 14 years of year-round observations.

Materials and Methods

The location for the study was New Quay Bay (Lat. 52° 13' N, Long. 4° 21' W). The small fishing port of New Quay faces NNW, with steep terraces of houses overlooking the harbour and New Quay Bay. Observations were made from properties which overlooked the bay; from the quay, where dolphins often came within 10 m of the harbour wall; or from a rocky promontory at New Quay Head (Figure 1). In good conditions, dolphins were detectable by eye or by scanning with 10 x 50 binoculars. Positions were estimated

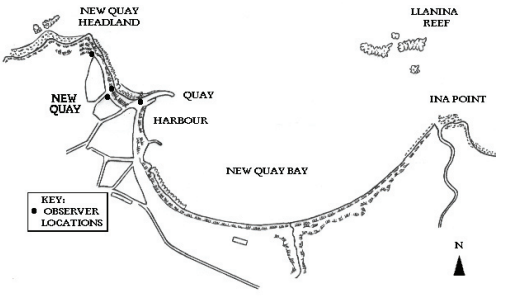

Figure 1. Study location

to the nearest 100 m in relation to reference points in the bay, with temporary summer buoys aiding distance estimates. Observations were made for between four and seven h per day. The core observation times were 0730-0930, 1030-1100, 1230-1400, 1500-1530, 1730-1830, and, during summer, 1930-2130 h. Times were maintained whether Greenwich Mean Time or British Summer Time prevailed. In 1997, observations were made on 284 days by a single observer, which compared with between 355 and 360 days per year in 1989-1996 by the same observer (Bristow & Rees, 2001). In 2001 and 2002, observations were made on 300 and 232 days, respectively, by the original observer, two project co-ordinators, and four of the same volunteers from the 1998-2000 all year-round study (Bristow et al., 2001).

The information recorded included date, time, duration of sighting, species, total number, adult, juvenile, large calf and small calf numbers, known individuals, activity and behaviour, distance from shore, boat activity within 100 m of dolphins, and any associated sea birds. Data on weather conditions, sea state, wind strength and direction, air and sea temperatures, and times of high water were recorded throughout the study.

A sighting was defined as a single event, whether a dolphin or a group remained visible in the study area for only a few minutes or for several hours. If an additional group of dolphins was seen, with the original group still in sight, this was treated as a new sighting. When no dolphins were seen for 20 min, a subsequent sighting was treated as a new one. In addition to close groupings, two or three large adults traveling parallel, as much as 100 m apart, were treated as a single group, as were split groups forming an arc for feeding, or when a single large adult seemed to flank or lead a closer group. Body size estimates, assisted by behaviour and colour, were used to categorise animals as small calves (< 1.5 m), large calves (1.5-2.0 m), juveniles (2.0-2.5 m), or adults (3-4 m). Observers provided drawings, photographs, or video footage of dolphins with distinctive markings, and these were compared with the catalogue from the previous studies. Dolphin activities and behavioural categories were as defined previously (Bristow & Rees, 2001).

Results

Sightings Frequency and Group Sizes

The frequency of dolphin sightings in 1997, 2001, and 2002, expressed as a proportion of observation days, were compared with values obtained in each year of the earlier studies (Figure 2). In 1997, dolphins were recorded on 48.9% of observation days, which fits the upward trend in sightings seen over the years 1989 to 1996. The peak years for sightings were 1995 to 1999, when dolphins were present on between 41.1% and 49.3% of observation days. The frequency figures for 2001 and 2002, 40.0% and 33.6% of observation days, respectively, were below those of the peak years, and appear to follow the pattern of reduced sightings seen in 2000; however, lower figures were observed in the earlier years 1989-1992.

Group size data for 1997, 2001, and 2002, were collated by months and average group sizes determined. Data for monthly average group size and monthly maximum group size were compared with results from the whole 14-year range of group size data (Table 1). While the results for 1997 were comparable with results from 1991-1999, data for 2001 and 2002 showed a decline in monthly average group size and monthly maximum group size similar to that first observed in 2000.

The frequency distributions of the sightings by group size, from 1 to 17+, across all 14 years of the study, were analysed. The distributions for all years were skewed towards small groups; however, the proportion of sightings of the smallest groups (1-2 dolphins) when compared to larger groups (3-10 dolphins) began to change in 1998 and became much more marked in the years 2000,

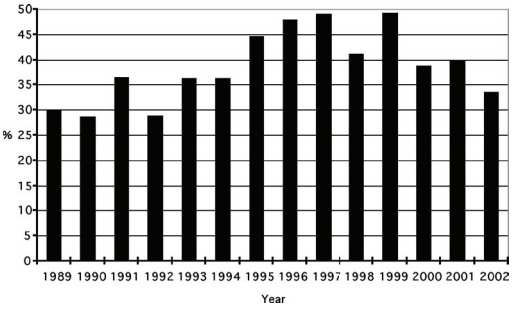

Figure 2. Annual frequency of dolphin sightings at New Quay Bay as a percentage of observation days, 1989-2002

Table 1. Average and maximum group size of bottlenose dolphins seen in New Quay Bay in 1997, 2001, and 2002

	Av. 1997	Av. 2001	Av. 2002	Range 1989-2002	Max. 1997	Max. 2001	Max. 2002	Range 1989-2002
January	6	0	5	2-8	6	0	12	2-14
February	5	2	1	1-5	10	3	1	1-10
March	2	2	2	1-5	4	4	2	1-7
April	5	2	2	1-5	15	5	4	3-15
May	4	2	2	2-5	7	5	5	4-18
June	4	2	3	2-4	8	7	7	5-13
July	4	2	2	2-4	10	7	4	4-10
August	4	2	2	2-4	9	6	3	3-10
September	5	2	3	2-7	12	8	8	6-26
October	4	2	3	2-6	6	6	6	6-16
November	7	1	4	1-7	30	1	9	1-30
December	6	5	0	2-10	12	8	0	3-13

2001, and 2002 (Figure 3). The deviations in the observed frequency distributions in 1998 and 1999 were not significantly different from 1989-1997, but the deviations in 2000, 2001, and 2002 were significant at $\alpha = 0.05$ (critical value 26.296). For 1998-1999, $\chi^2 = 14.09$, and for 2000-2002 $\chi^2 = 48.10$.

The decrease in sightings of groups of three to ten dolphins led to a reduction in the proportion of sightings that contained small calves (< 1.5 m). The percentage of sightings that included small calves in 1997, 2001, and 2002 were 42%, 10%, and 10%, respectively. Across all years of the study, 88.6% of sightings of small calves occurred in groups of three to ten dolphins.

The largest group of dolphins seen in 1997, 2001, and 2002 was a single sighting of 30 dolphins seen between 400 m and 1,200 m of the shore on 1 November 1997. The relative rarity of inshore sightings of large groups of dolphins in the New Quay Bay area is confirmed by the fact that over a 14-year period, the only comparable event was a single group of 26 dolphins seen in September 1993. The next largest sighting was a group of 18 dolphins in May 1999.

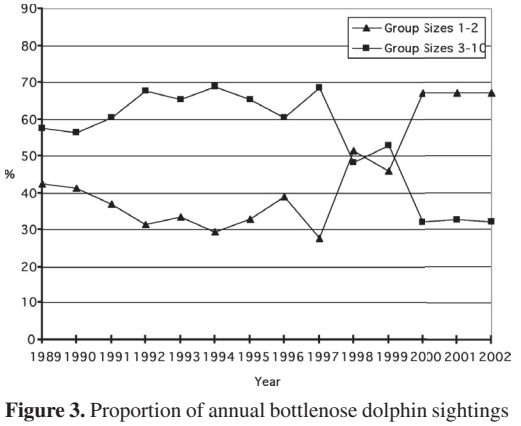

Figure 3. Proportion of annual bottlenose dolphin sightings by group size at New Quay Bay, 1989-2002

Identifiable Individuals

In this location, dolphins came within 10 m of the quay and the rocky promontory below New Quay Head, allowing the identification of individual dolphins with large and distinctive natural dorsal fin markings on a regular basis (Bristow & Rees, 2001). Over 14 years, 20 adult dolphins were recognised from their fin markings (dolphins A to T), and some of these individuals showed a high degree of site fidelity. Observations of these dolphins, their associates, and their behaviour, singly, in groups, or with accompanying calves, indicated that three of them, dolphins B, I, and R, were probably adult males and the remaining 17 were probably adult females. On average, 50% of the recognised adults thought to be females were seen in the course of a year to have a calf. Dolphins A and E were seen with accompanying small calves for three periods over the 14 years of the study. Dolphins C, D, F, M, and P were seen for two periods with accompanying small calves. Dolphins G, H, N, and O were only seen for one period with accompanying small calves, while K and S were only seen to be accompanied by large calves. For the identified individuals, it was possible to plot the years in which they had accompanying small calves, and in three cases, show progression of these calves through to juveniles. In four cases, the loss of calves after one year was indicated when the dolphins returned the following year without their calves.

The range of recognised individuals seen in any one year in earlier studies was seven to 14. In 1997 and 2001, seven and eight recognised individuals were seen respectively, but in 2002, only four previously recognised individuals were seen.

Even so, the regular appearance of some dolphins in the area for the whole 14-year period confirms the long-term site fidelity of individual bottlenose dolphins in the bay, even in times of decreasing site usage.

From the ratio between the identifiable individuals and the unmarked or unidentified ones, a rough minimum population estimate of 51 dolphins was derived for the immediate New Quay Bay part of Cardigan Bay.

Group Composition and Estimated Calf Production

Throughout the study, the composition of groups of dolphins was noted. When the numbers of adults, juveniles, large calves, and small calves in a group were plotted out over a particular month, it was clear that different groups were observed on different days. For example, in July 1995, a small calf was associated with a group of three adults and a large calf on four days of the month. A small calf associated with just two adults was noted on five different days, three of them consecutive, in the same month. These were probably two different groups. Allowing the fact that group associations were somewhat fluid, and the situation was more complex than a single coherent "resident" group staying in the New Quay area, it was possible by repeating this exercise in the period July-October each year to make an estimate of annual small calf production. Allowances were made for what appeared to be smaller groups combining, particularly in the autumn, when the composition of larger groups exactly matched that of two smaller groups seen on other days or times in the same month. The analysis was made easier when there were repeated sightings of groups containing identified individual adult dolphins accompanied by a small calf. Estimated annual calf production in the New Quay Bay area over 14 years varied from two to five (Figure 4). Although small calves have been produced in all years, the years 1990-1997 appear to have been more prolific.

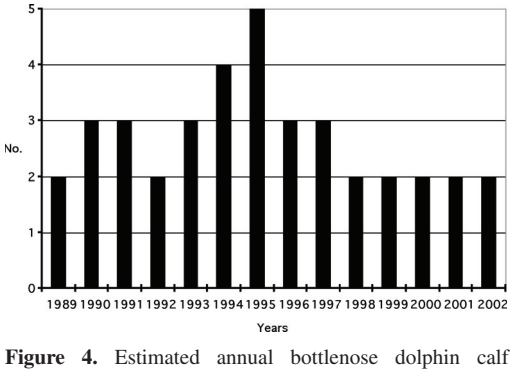

Figure 4. Estimated annual bottlenose dolphin calf production at New Quay Bay, 1989-2002

Dolphins and Boats

Encounters between groups of dolphins and boats were recorded for boats that came within 100 m. Over the study period, encounters increased from eight per year to 100 per year. The dolphin responses were recorded and assessed as positive, negative, or no response according to definitions used previously (Bristow & Rees, 2001). Bow-riding was regarded as a positive response; disturbance or avoidance reactions were regarded as negative responses. Disturbance included curtailed feeding or curtailed social activity in the presence of boats, tail-slapping (rarely seen in New Quay), or apparent attempts by single dolphins to "decoy" boats away from a "mother" and calf. Avoidance involved a dolphin submerging to the sea bed for several minutes in the presence of boats then heading offshore, or a dolphin laying to one side to obscure the dorsal fin or hide a calf in the presence of a boat. In 1989, there were just two cases of disturbance; the incidence had risen to 11 by 1996, and in 1999 there were 24 cases of disturbance. The 24 cases of disturbance in 1999 all occurred between June and September, at the height of the season for recreational boating activity and visitor pleasure craft, and represented disturbance on 32% of the days that bottlenose dolphins were present. The cases of disturbance in 2002, however, were no worse than in 1999 and represented 29% of the days between June and September when dolphins were present.

Sea Surface Temperature

Over the 14 years of the study there were 3,082 sightings of bottlenose dolphins, and 90% of these occurred between the months of April and December. Sightings were consistently far less frequent in January, February, and March.

In the period 2001-2002, there were two months (January 2001 and December 2002) when there were no sightings of dolphins in the bay. This had only occurred three times before, in February 1990, March 1992, and March 2000. In 1990 and 1992, frequent persistent stormy conditions limited the number of days suitable for observing dolphins and almost certainly accounted for the lack of sightings. Stormy conditions did not account for the lack of sightings in March 2000, and the possible effect of sea surface temperature was considered. It was again considered for the months of January 2001 and December 2002. A correlation between the frequency of dolphin sightings and sea surface temperature, and temperature related changes in dolphin behaviour were revealed in the first study (Bristow & Rees, 2001). The relationship between monthly sightings frequency and monthly mean sea surface temperatures for the ten years 1991-2000 is shown in Figure 5, the

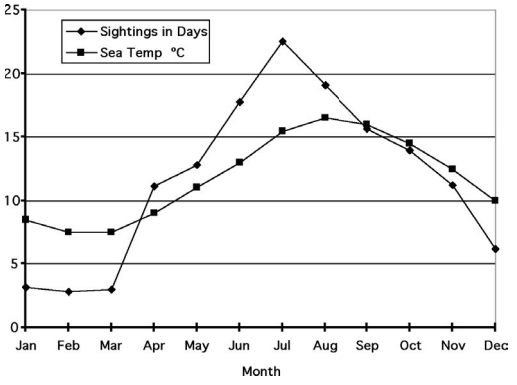

Figure 5. 10-year average monthly sightings of bottlenose dolphins and average monthly sea surface temperatures at New Quay Bay, 1991-2000

correlation coefficient was r = 0.895 (critical value r = 0.576 at 0.05 level of significance). In general, sea surface temperatures decline to 10º C close to the end of December. From the data for the last four years, 1999-2002, it was seen that in December 1999, sea temperature was below 10º C by 14 December, two weeks earlier than the other years, and yet there were five days of sightings in December and 8 days in January 2000. In January 2001, there were no sightings, and yet average sea surface temperature at 7.5º C was the same as January 2000, so this can probably be ruled out as a factor. Similarly, the lack of sightings in December 2002 cannot be explained in terms of sea surface temperature because this did not fall to 10º C until 30 December in that year.

Discussion

The analysis of the observations of bottlenose dolphins in New Quay Bay for a further three years has been a valuable check on the findings reported in two earlier studies and also allows a perspective on a continuous 14-year data set containing over 3,000 observations. The regular year-round patterns of site usage and behaviour of dolphins in the bay were established by the 1989-1996 study (Bristow & Rees, 2001), and changes in that pattern were noted in the 1998-2000 study (Bristow, et al., 2001). The results for 1997 in terms of average group size per month and maximum group size per month were similar to those seen in 1995 and 1996, the years of greatest dolphin activity in the bay. The corresponding results for 2001 and 2002 are similar to those seen in 2000, the year when deterioration of dolphin activity in the bay first became significant. In terms of group size frequency distribution, the results for 2001 and 2002 mirrored those of 2000, when statistically significant change was first noted. The other parameters measured—numbers of sightings with small calves, estimated annual calf production, and in 2002, frequency of sightings of recognised individuals—confirm the decline seen in 2000. Overall, a pattern of site usage and site fidelity that had been stable or slightly improving over 11 years has in just three years become markedly changed.

It has been noted that the number of dolphins in a particular area, the average group size, and residence patterns with respect to a particular site appear to be flexible parameters. Estimated numbers of bottlenose dolphins in a particular area vary both between and within locations. In Texas, in a 75 km² area off the coast, numbers varied between 30 in spring and 98 in winter (Ballance, 1990), while off San Diego, population size for bottlenose dolphins was between 173 and 240. Group size also varied considerably between locations, with the number of individuals per group varying from 1 to over 100, but usually averaging between 2 and 15. The mean school size for the Sarasota community on the west coast of Florida was 7.0 dolphins, which is felt to be typical of dolphins studied in other areas (Scott et al., 1990). In a study of historical sightings records from two shore-based locations in coastal California, group size ranges of 1 to 139 and 1 to 82 were noted, with mean group sizes of 19.5 and 18.0, respectively (Hansen, 1990). The results from the New Quay Bay study may therefore indicate that this bottlenose dolphin population, although not untypical, was on the low side for a coastal community in terms of population and average group size, even before the changes seen in the years 2000-2002.

The results are of particular concern because the location of this prolonged study is within a candidate Special Area of Conservation (cSAC). The Management Plan for the Cardigan Bay cSAC states that the conservation objectives are to maintain within their natural variation the distribution and abundance of the cSAC bottlenose dolphin population (Ceredigion County Council, 2001). The measure of their "condition" has so far relied on minimum population estimates from intermittent boat-based photo-identification studies in the wider bay. These studies yielded estimates of between 44 and 131 bottlenose dolphins in Cardigan Bay in 1990-1993 (Grellier et al., 1995).

The value of a prolonged study, even if it is very localised, is to show trends in areas within the bay favoured by dolphins. Young & Peace (1999) stated that, if conducted on a regular basis, shore-based surveys of coastal cetaceans can be used to track local population trends over time. It took ten

years of the present study before significant deterioration was detected. While it may be that change seen in 14 years in a long-lived species, the bottlenose dolphin, is part of a longer term cycle, the prolonged downturn in site usage by mothers and calves surely indicates the possibility that some environmental factor could be amiss. Increasing recreational boating, the dumping of shells within the bay, or other unrecorded activities outside the area, all could contribute to what appears to be a long-term decline in bottlenose dolphin activity in New Quay Bay. The effect of boating and increased boat-dolphin encounters is reported in this paper. Gregory & Rowden (2001), in a one-month study in Cardigan Bay in August 1999, reported that even kayaks had the potential to disturb dolphins. An acoustic study of Pacific humpback dolphins (*Sousa chinensis*) in southeast Queensland (Van Parijs & Corkeron, 2001) indicated that mother and calf pairs appeared to be most disturbed by transiting vessels, while groups with no calves were less affected. This would have relevance in the New Quay Bay area where for most years of this study a high proportion of mother and calf pairs were present. It may, however, not be boat type but the human occupants that are the problem. As noted in a previous paper (Bristow & Rees, 2001), boats such as fishing vessels and yachts, with people going about their business and ignoring the dolphins, have little or no impact on the dolphins. It is worrying that the lead authority for the management of the cSAC has recently revealed plans to promote greater use of this part of the bay for recreational boating activity, with a scheme for eight launch sites along the coast, and a three-year budget of £250,000 (Ceredigion County Council, 2003). This would appear to be completely inappropriate for a designated conservation area.

The licensed dumping of shell waste from a whelk (*Buccinum undatum*) processing plant below New Quay headland into the conservation area was reported previously (Bristow et al., 2001). A correlation, but no causal link, with declining dolphin site usage was noted. Beginning in 1997 and in 1999, 1,000 tonnes of shell waste were discharged to the sea at New Quay Head. In 2000, over 1,000 tonnes were discharged in the period between February and July. This licensed dumping activity (licensed by the Department for Environment, Food and Rural Affairs, Marine Consents and Environment Unit) has and will continue at a rate of 2,000 tonnes per year until at least 31 January 2006. The European approach to marine protected areas is for small "Special Areas of Conservation." These SACs are generally multiple use, and their area is almost certainly insufficient to meet the stated objectives, namely, to maintain within their natural variation the distribution and abundance of the cSAC bottlenose dolphin population. The individuals favouring New Quay Bay, although showing a high degree of site fidelity, have been observed ranging along the coastline outside the confines of the SAC. To permit the large-scale dumping of shell waste in the small area defined to preserve the dolphins risks making the area unfavourable for dolphins, thereby making a mockery of the SAC concept.

It has been pointed out that many studies in marine protected areas or reserves often employ designs which cannot unequivocally deliver a verdict on whether they work (Gell & Roberts, 2003). Because changes over time may be due to habitat or background environmental changes, Gell & Roberts stress the importance of studies with data collected at intervals before and after protection, so that the effects of protection can be separated from those of habitat. Although their comments are related to marine reserves in a fisheries context, they are equally valid in the case of managing the Cardigan Bay cSAC.

The Cardigan Bay cSAC should become a fully managed conservation area in 2004. If the conservation objectives are indeed to maintain the current status of the bottlenose dolphin population, then "before" data, such as the present 14-year study, will be important for making judgements on the progress of the scheme; however, if changes in the local environment continue and habitat degradation is permitted, the conservation scheme could be undermined from the outset.

In this location, dedicated continuous monitoring can provide much needed information. Scott et al. (1990) noted that conclusions based on short-term data tend to be simplistic and transitory, adding that collecting data for only two or three years is unlikely to give a complete picture of a complex society of long-lived animals. It is arguable that this 14-year shore-based study of dolphin site usage and site fidelity in New Quay Bay has enabled a "picture" to emerge and given a timely warning of significant changes.

Acknowledgments

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