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Bottlenose dolphins around Aberdeen harbour, north-east Scotland: a short study of habitat utilization and the potential effects of boat traffic

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The aim of this study was to investigate the factors that affect the patterns of occurrence and habitat utilization of bottlenose dolphins around Aberdeen harbour, on the north-east coast of Scotland (UK), and their responses to boat traffic. Land-based surveys were conducted over a period of nine weeks, between early May and late July, 2002. During this time 83 sightings of bottlenose dolphins were recorded. Dolphins occurred more frequently around midday and early afternoon, while their abundance was greater around high tide and late afternoon. Foraging was the most commonly observed activity.

Dolphins were usually concentrated around the entrance of Aberdeen harbour. Their responses to boats varied considerably according to boat size, activity and speed, but there is evidence of habituation to boat traffic.

INTRODUCTION

The degradation of coastal habitats due to the expansion of human developments is known to have important effects on cetacean populations. This is especially true for species such as the bottlenose dolphin (*Tursiops truncatus*, Montagu, 1821), which mainly inhabits coastal areas, where human activity is concentrated.

Once known to occur throughout the European coasts, the distribution of bottlenose dolphins has contracted over the last century, and they are thought to have deserted certain areas, such as the Tejo estuary in Portugal (dos Santos & Lacerda, 1987) and most parts of the North Sea (Evans, 1992). In most cases anthropogenic factors, such as increases in pollution levels, various forms of disturbance (e.g. boat traffic, dredging, seismic exploration, development and production of oil and gas), as well as the direct or indirect effects of fishing (namely directed kills, entanglement in fishing nets and depletion of food resources), have been considered as the main causes for these changes in distribution and abundance (Evans, 1980; Curran et al., 1996).

Protection of a population of free ranging cetaceans, such as bottlenose dolphins, requires a sound understanding of the way these animals utilize different areas throughout their distribution range, and identification of the factors that need to be managed to ensure their viability.

In particular, especial concern has been expressed over the status of the Moray Firth population of bottlenose dolphins on the north-east coast of Scotland, the low abundance of which (approximately 129 ±15 individuals, according to Wilson et al., 1999), and apparent geographical isolation, render this population prone to extinction. Recognized to be at the northern extreme of the species' range (Curran et al., 1996), living in a highly disturbed environment, this population is considered to be of both national and international importance and an area of the inner Moray Firth has been recently designated as a marine Special Area of Conservation (SAC) with the purpose to conserve this species (Wilson et al., 1997).

However, the distribution range of the Moray Firth dolphins extends beyond the boundaries of the Moray Firth. Photographic-identification studies have confirmed the presence of these dolphins in the Aberdeenshire region (Weir & Stockin, 2001), and off the coastal waters of Fife (Wilson et al., 2004). Along the coast of Aberdeenshire, dolphins are predominantly observed in the region of Aberdeen harbour, with a peak in the occurrence of sightings between February and May (Weir & Stockin, 2001).

Aberdeen harbour is Europe's largest centre of support for the exploration and production of oil and gas in the North Sea. Furthermore, it is an important port for the fisheries industry, and also serves as a tourist gateway. It is therefore apparent that bottlenose dolphins in this area are exposed to high levels of boat traffic.

The primary aim of this study was to determine the patterns of occurrence and habitat utilization of bottlenose dolphins occurring in the coastal waters of Aberdeen over the summer months, to identify and quantify how their abundance, distribution and behaviour is being affected by several environmental factors, and in particular how they respond to the high level of boat traffic in the harbour area.

MATERIALS AND METHODS

The study area

The study was carried out at the mouth of Aberdeen harbour, located in the estuary of the River Dee, north-east Scotland, approximately 200 km from the designated

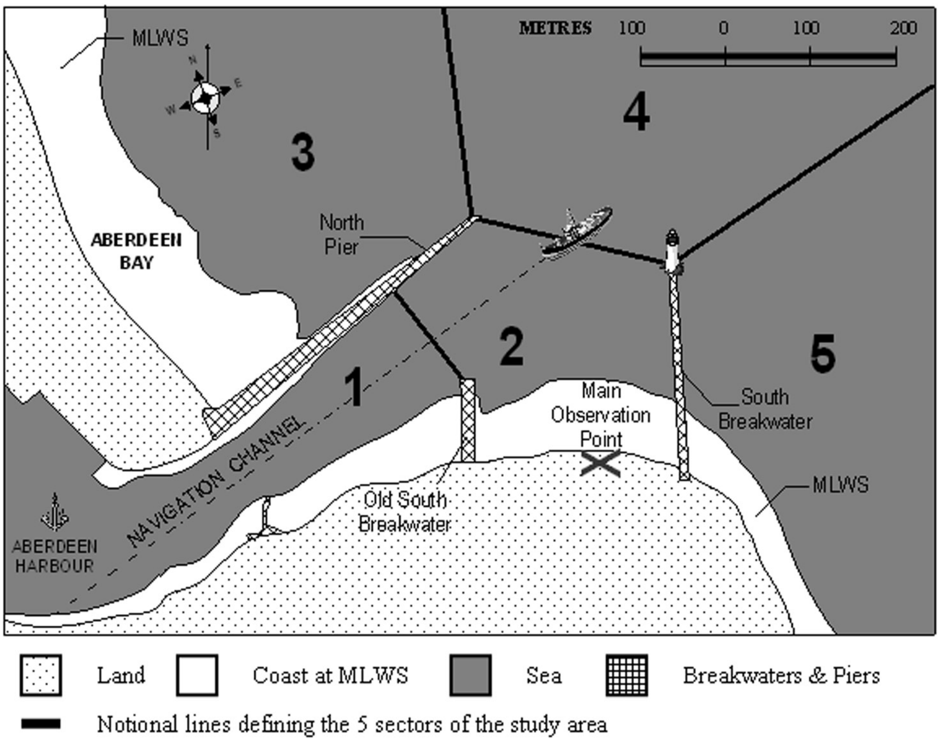

Figure 1. Map of the study area showing the five sectors and the observation point.

Table 1. *Behavioural categories used during field observations.*

Behavioural category	Description of observed activity
Forage	Repetitive prolonged dives in one location, erratic movements or splashes, prey pursuit and fish tosses, or apparent capture and ingestion of prey
Aerial displays	Any activity, such as leaping or breaching, exposing at least half of the dolphin's body
Normal swim	Steady movement, with regular and constant surfacing, within the same area
Milling	Slow, non-directional movements within the same location, usually, staying close to the surface, but showing no surface behaviours and no apparent physical contact between individuals
Other	Including socializing, travelling and individual behaviours

SAC. At the entrance of the harbour, the navigation channel has a maximum width of approximately 75 m and a maximum depth of 10.30 m at mean high water spring tide (MHWS). Outside the channel average depth is approximately 20 m until 2 km off-shore. The waters both inside the navigation channel and in the surrounding area are considered to be relatively free of pollution.

Data collection

Data were collected by means of regular, standardized land-based observations over a period of nine weeks (13 May 2002 to 13 July 2002). Surveys were conducted on a daily basis, weather permitting, between 0900 and 2000 h (British Summer Time, BST). Data obtained at reduced visibility (i.e. <1 km) and Beaufort sea state >3, were not included in the presented analysis.

All samples were taken from a single observation point (at 14 m height above sea level at MLWS), located adjacent to the southern part of the navigation channel, with a northward orientation (Figure 1).

Primary data set

The primary data set incorporates all information recorded regarding the behaviour, distribution and abundance of dolphins.

Samples were taken in the form of 5-min scans at preselected time intervals (i.e. every half hour), to allow tracking of changes during a day, even within the same sighting. During the sampling period the whole study area was carefully scanned from south to north using Minolta Autofocus 10×25 5.2 hand-held binoculars. Samples taken in the absence of dolphins were characterized as negative scan samples, while those taken in the presence of dolphins (i.e. during a dolphin sighting) were characterized as positive scan samples. This way it was possible to monitor the frequency of dolphin occurrence (i.e. on the basis of presence/absence data), and also obtain an instantaneous sample of the abundance, distribution and behaviour of all individuals present. Environmental conditions (i.e. sea state, wind force and direction, swell height, cloud coverage and visibility) were recorded every 15 min. The study area was divided into five sectors as shown in Figure 1.

For the purpose of this study five discrete behavioural categories were chosen (Table 1).

Secondary data set: reactions to boat traffic

Boat traffic as well as the reactions of individuals/groups of dolphins towards the boats, were recorded on a separate data sheet.

When boats were first observed, the number of dolphins, their initial position, and individual behaviour were recorded, by means of a fast 2-min scan, along with information regarding the number, size, speed and direction of boats. As soon as a reaction towards the boat was detected, the number of dolphins showing a response and the type of reaction were recorded.

Three categories of vessels were defined: small: <15 m in length, including small fishing boats, sailing boats and coastguard vessels; medium: 16–30 m in length, including larger fishing or sailing boats and some small supply vessels; and large: >30 m in length, including ferries and large supply boats. Validation of boat size was made possible through the use of Lloyd's Register (2002). In addition, three types of boat activity were recorded: entering or exiting (the harbour) and variable (i.e. moving in random directions). Finally, three speed categories were defined: slow: boats moving at a speed of less than 5 km/h; normal: boats moving with a speed of approximately 5 km/h; and fast: boats moving considerably faster than 5 km/h.

With regard to the behaviour of dolphins towards the operating vessels, three types of behaviour were recorded, on the basis of short-term surface reactions: positive reactions: dolphins that approach, follow, surf, bowride, breach or leap within a distance of 10 m from the boat; negative reactions: dolphins observed actively swimming away from the boat, exhibiting prolonged dives, changing position or being displaced over a distance greater than 30 m; and neutral reactions: dolphins that showed no change of activity or position throughout the time that a boat was present.

On most occasions, boat sightings occurred over time periods of up to 10 min, because boat activity was usually limited to exiting or entering the port. However, if boats were active within the area for prolonged periods (i.e. more than 10 min), data were collected every 5 min and were treated as independent samples. Although this is a very short inter-sample interval, the phenomena studied (i.e. reactions to boats) took place over a time-scale of seconds to minutes.

If a boat sighting continued into the designated sampling period used for the collection of the primary data set, the 5-min scan was transferred 2 min after boat traffic had ceased. This was done because: (a) when boats were around it was not possible to get a good estimate of the number of dolphins present at that time in the area; and (b) reactions to boats were not considered to form part of the normal behaviour of dolphins. Incorporating such information in the primary data set would therefore lead to a biased result regarding the normal activities and behaviours of dolphins, at times of no apparent disturbance.

Data processing and statistical analysis

To enable statistical analysis further grouping of some of the variables was necessary. Group size was divided into four categories (i.e. 1–5, 6–10, 11–15, 16+); time of the day was separated into six time intervals [morning (0900–1100), midday (1100–1300), early afternoon (1300–1500), late afternoon (1500–1700), early evening (1700–1900) and late evening (1900–2000)]; finally, tidal state was divided into high, ebb, low and flood.

To analyse the patterns of dolphin occurrence and abundance over the nine weeks, the median number of sightings recorded per week, as well as the median number of dolphins recorded per week were utilized accordingly, and Kruskal–Wallis (H) tests were conducted in order to test for differences. To determine whether there was any consistent upward or downward trend in dolphin numbers, the association between week number and total number of dolphins recorded per week was analysed using Spearman's rank-order correlation (r_s).

Diel and tidal data were used to identify patterns in daily movements, abundance and behaviours. Relative frequencies of positive scans (i.e. scan samples taken while dolphins were present) were compared using χ^2-tests, while average numbers of dolphins present were compared using Kruskal–Wallis tests. To separate the effects of time of day and tidal state the Friedman (S) test was performed.

Finally, χ^2-tests were also used to compare the different sectors of the study area in relation to dolphin occurrence and behaviour, as well as to investigate the relative frequency of occurrence of the various dolphin reactions in relation to the different categories of boat size, activity and speed.

RESULTS

Patterns of occurrence, abundance and behaviour

Over a period of nine weeks, 52 land-based surveys were conducted. Bottlenose dolphins were sighted on 45 out of the 52 days, with a total of 83 dolphin sightings and 456 positive scan samples. Duration of sightings ranged from 5 min to 11(+) h, with the majority terminating within 2 h (see Table 2 for a summary of the sampling effort and data collected).

Dolphins were seen throughout the study area, although for 76% of the positive scan samples dolphins were seen within 300 m of the harbour entrance, and for 65% of the positive scan samples dolphins were present within the navigation channel. Dolphins were seen most frequently in Sectors 2 (during 51% of positive scans), 4 (46%) and 5 (46%) and less often in Sectors 1 (6%) and 3 (11%), (χ^2=388.810, df=4, P=0.001). The total number of individual dolphins present within the study area at a given time ranged from 1 to 30+. In most cases (86%) dolphins appeared in groups of 2–5 or 6–10 (i.e. 44% and 42% respectively). A solitary individual was sighted

Table 2. *A monthly summary of the overall sampling effort and the data collected. Figures represent total numbers unless otherwise stated. Daily surveys were divided into 5-min scan samples, recorded every 30 min.*

	May	June	July	Overall
Days in the field	17	23	12	52
Hours of observation	178	234	128	540
Sightings	28	36	19	83
Mean sighting duration (h)	3.6	2.2	1.8	2.5
Standard error	3	1.5	1.8	2.22
Scans	369	486	265	1120
Positive scan samples*	214	168	74	456
Mean number of dolphins per positive scan	6.4	7.5	5.6	6.8
Standard error	3.2	4.1	4.6	3.8
Range	1–17	1–17	1–30	1–30

*, Scan samples taken while dolphins were present.

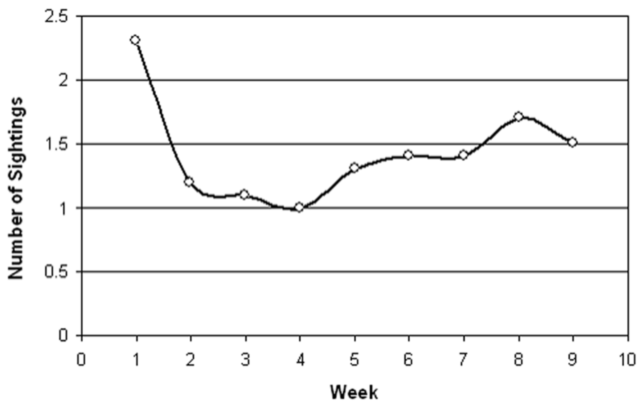

Figure 2. Number of sightings per unit effort (where effort is the number of days on the field).

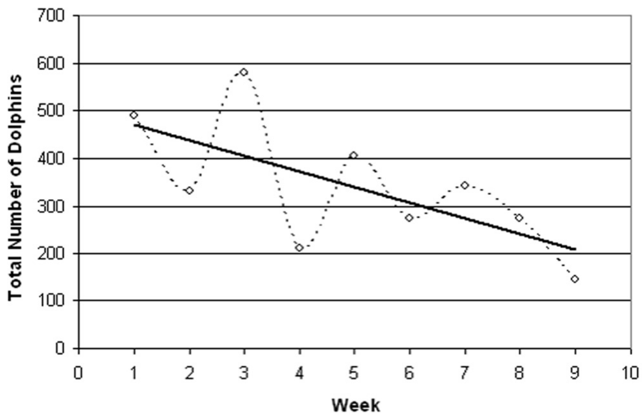

Figure 3. Total number of dolphins recorded per week.

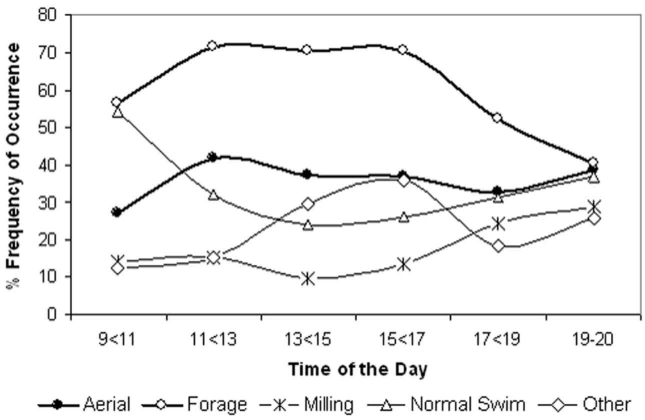

Figure 4. Frequency of occurrence of the different behaviours in relation to time of day.

only once, while an aggregation of approximately 30 individuals was also a unique event.

Between-week fluctuations in the median number of sightings were not statistically significant (H=5.87, df=8, P=0.662; see Figure 2), but between-week variation in mean dolphin abundance was significant (H=51.77, df=8, P=0.001). There was no significant association between the median number of dolphins recorded and week of survey (r_s = −0.024, P=0.606; see Figure 3). There was significant variation in the median duration of sightings over the nine weeks (H=17.26, df=8, P=0.028). Sightings lasted for longer time intervals over the first three weeks. After week 4, however, duration of sightings dropped markedly and remained relatively constant for the remainder of the study period (mean=1.8 h).

Frequency of occurrence was independent of tidal state (χ^2=6.101, df=3, P=0.107). However, there was significant variation in the abundance of dolphins in relation to tidal state (H=8.20, df=3, P=0.042), with the highest number of dolphins recorded around high tide and fewest during flood tide. Furthermore, dolphins occurred most frequently around midday and in the early afternoon (1100–1500) (χ^2=27.304, df=5, P=0.001), although abundance reached a peak in late afternoon (1500–1700) (H=15.51, df=5, P=0.008.). To separate the effects of the diel and tidal cycles on the patterns of dolphin occurrence, the Friedman test was used. The median value of dolphin occurrence was found to be the same at all tidal states (S=1.65, df=3, P=0.648) and during all times of the day (S=4.25, df=5, P=5.14).

The different types of behaviour were analysed in relation to tidal state and time of the day. None of the behaviours was found to be affected by the tidal cycle (χ^2=8.352, df=12, P=0.759). The patterns of occurrence of all behaviours in relation to time of the day are illustrated in Figure 4. The most common types of behaviour at all times were foraging (average frequency, a.f.=61%), and aerial displays (a.f.=36.2%), the relative frequency of which did not vary significantly over the day (χ^2=10.401, df=5, P=0.065 and χ^2=6.092, df=5, P=0.297, respectively). Normal swimming (a.f.=30%), was found to be most frequent during the morning hours (i.e. 0900–1100), reached a minimum value during early afternoon (i.e. 1300–1500), and showed a slight recovery over the rest of the day (χ^2=19.775, df=5, P=0.001). Milling (χ^2=16.424, df=5, P=0.006) and other behaviours (χ^2=12.380, df=5, P=0.03) were also found to be associated to time of day. Milling was the least frequent behaviour (a.f.=16.4%), observed at less than 30% at all times of the day. Other behaviours were also quite rare, with an average frequency of 23%; however, they showed an overall increase in their frequency over the afternoon hours (i.e. 1300–1700).

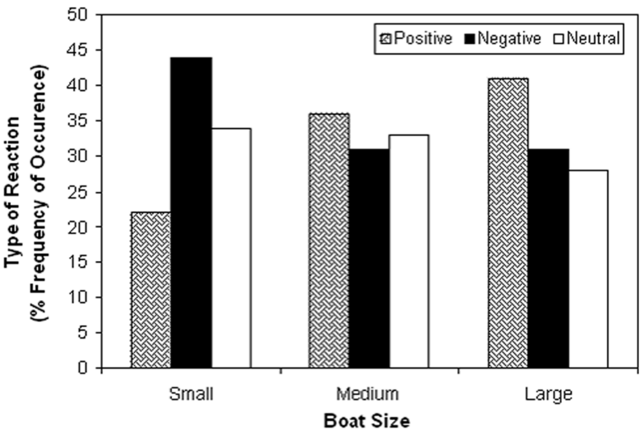

Figure 5. Frequency of occurrence of different types of reaction in relation to boat size.

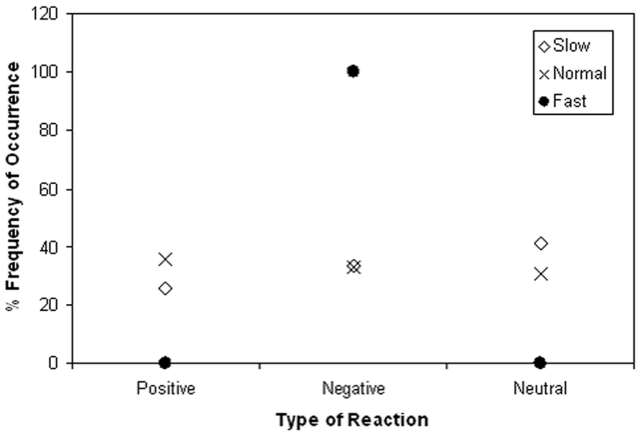

Figure 6. Frequency of occurrence of different types of reaction in relation to speed of boat.

A Friedman test showed that the median values for the frequency of occurrence of the most common behaviour (i.e. foraging) were the same at all times of the day (S=8.43, df=5, P=0.134) regardless of the tidal state and at all tidal levels regardless of the time of the day (S=1.35, df=3, P=0.717).

To look at the frequency of occurrence of the different behaviours in relation to the different sectors of the study area, the relative number of occurrences of each behaviour in different sectors was utilized. Foraging occurred with the greatest frequency in Sector 2 (92%) and Sector 4 (52%) (χ^2=266.864, df=4, P=0.001). Aerial displays were also most common in Sectors 2 (42%) and 4 (29%) (χ^2=68.917, df=4, P=0.001). Normal swimming (36%; χ^2=48.535, df=4, P=0.001), milling (36%; χ^2=26.875, df=4, P=0.001), and other behaviours (39%; χ^2=39.595, df=4, P=0.001) were most common in Sector 5.

Reactions towards boat traffic

Boat activity was recorded during 40% of the positive scan samples, with a maximum of six boats present during any given sample. A total of 505 boats was sampled and 625 dolphin reactions were recorded.

Reactions in relation to boat size

Out of the total sample, 33% of observations of dolphins in the presence of boats involved dolphin reactions to small boats (N=175), 9% to medium-sized vessels (N=53) and 58% to large vessels (N=276). There was some association between boat size category and type of reaction (χ^2=18.992, df=4, P=0.001; see Figure 5). In most cases dolphins showed a negative reaction towards small boats, while positive reactions were the most frequent response towards medium and large boats. Neutral reactions occurred with approximately the same frequency towards all types of boats.

Reactions in relation to boat activity

Thirty-five per cent of the sample involved reactions to vessels entering the harbour (N=181), 54% to vessels exiting (N=281) and 5% to boats that were moving in no consistent direction (N=43). There was a significant association between type of reaction and boat activity (χ^2=32.7454, df=4, P=0.001). All dolphin responses occurred with more or less the same frequency towards boats that were entering or leaving the harbour, while 80% of the responses to boats moving in variable directions involved negative reactions; no positive reaction was recorded towards this type of boat activity.

Reactions towards boats moving at different speeds

Approximately 6% of the total sample involved reactions to slow-moving vessels (N=30), 90% to vessels travelling at intermediate speeds (N=455), and 3% towards fast-moving vessels (N=20). A significant association was found between type of behaviour and speed of boat (χ^2=45.738, df=4, P=0.001). For vessels moving at intermediate speeds, all types of reaction were observed with almost the same frequency (30–36%). For slow moving boats, more neutral and negative than positive reactions were recorded (41%, 33% and 25% respectively). When boats were moving fast, only negative reactions were observed (100%; see Figure 6).

DISCUSSION

Frequency of occurrence, abundance and behaviour

The management of a protected population becomes increasingly difficult when dealing with highly migratory animals whose home range and distribution may change over time. Stranding records indicate that during the early part of the 20th Century bottlenose dolphins were continuously distributed along most parts of the British and Irish coasts (Evans, 1980). Today, they are only locally abundant, with resident groups being present off the west coast of Ireland, Cardigan Bay (Wales) and the Moray Firth (Evans, 1992; Curran et al., 1996). Elsewhere in the North Sea, they are known to exist in relatively small numbers (Evans, 1992).

However, the population of the Moray Firth utilizes areas outside the existing SAC. Within the Moray Firth, dolphins show a peak in abundance between May and September (Wilson et al., 1997); around the coast of Fife the main concentration occurs between July and August (Cumming, 1997–2000 in Weir & Stockin, 2001), while around the Aberdeenshire coast, dolphins are known to occur throughout the winter, reach a peak in spring (i.e. March–April) but are relatively scarce during the summer months (Weir & Stockin, 2001). Between 1992 and 2001 only 50 sightings had been reported over the summer season for the entire Aberdeenshire region, out of which 17 were recorded between 1999 and 2001.

During the current study neither the number of sightings nor the number of dolphins were found to change dramatically over the nine weeks, although the mean duration of sightings showed a decline. Out of a total of 83 sightings over the whole study period, 55 sightings were achieved between June and July. Furthermore, over the same period, opportunistic boat-trips, as well as data collected by the Sea Watch Foundation South Grampian Regional Group give additional evidence to support the findings of the present study (S.J.C., personal observation). Bottlenose dolphins were frequently sighted along the coastline of Aberdeenshire, while a sighting of an aggregation of 30(+) bottlenose dolphins around Aberdeen harbour, suggests that possibly more than one group of dolphins frequented the coastal waters of Aberdeenshire during the summer months of 2002. Thus, the numbers used in the present analysis should be treated with caution, since they were taken from just one region, and by no means reflect the abundance of bottlenose dolphins along the rest of the Aberdeenshire coast.

Nevertheless, the current study has provided evidence that dolphins are present in significant numbers and spend considerable time in the vicinity of Aberdeen harbour between late May and early July. It is possible that such contrasts in the reported results of different studies reflect, in part, the variation in sampling effort. However, the possibility of an actual increase of dolphin abundance around the Aberdeenshire region should not be dismissed. Further investigation over a longer temporal scale is required, in order to confirm the trends in abundance and distribution presented in this study. Such information could be of great significance during future population estimates and management options, especially since this habitat is known to form part of the home-range of a highly vulnerable population (Weir & Stockin, 2001). Furthermore, the regular use of the Aberdeenshire coastline, an area well outside the existing SAC, by substantial numbers of bottlenose dolphins also raises questions about the adequacy of the protection afforded by the SAC.

The movements and abundance of cetacean species are thought to be primarily influenced by the temporal and spatial availability of food resources (e.g. Davis et al., 1998). Previous studies have revealed that bottlenose dolphins around Scotland commonly take salmon (*Salmo salar*) (e.g. Wilson et al., 1997; Santos et al., 2001) and the hypothesis that dolphins are targeting salmon in the River Dee requires further investigation.

The River Dee has been characterized as one of the most exceptional salmon rivers in Scotland, and spawning migrations of salmon are known to occur both during spring and to some extent also during summer (Smith & Smith, 1997). Since the timing of spawning varies greatly between different rivers, Weir & Stockin (2001) hypothesized that the decline in the number of bottlenose dolphins during the summer months may partly be related to an increase in salmonids in other regions of Scotland.

In the current study, dolphins were found to be present in the area around Aberdeen harbour during all times of the day and at all tidal states, although there was a significant increase in their frequency of occurrence during midday and early afternoon and a peak in abundance during late afternoon and high tide. Moreover, foraging was found to be the most common activity at all times of the day and at all tidal states, indicating the significance of the area as a foraging habitat. Since dolphins were regularly observed throwing large fish in the air, which at most times were identified as salmon (M.I.S., personal observation), it is possible that the occurrence and abundance of dolphins are, to some extent, related to the up-estuary movements of salmon prior to river entry during the summer months in the River Dee, as described by Smith & Smith (1997). However, more surveys are required to validate this hypothesis. Nevertheless, a great diversity of feeding techniques was recorded during the present study, ranging from lone foraging in shallow areas, to co-operative chase and herding of prey. This may indicate that bottlenose dolphins in this area take a wide variety of prey species. As is also suggested by stomach contents analysis (Santos et al., 2001), cod (*Gadus morhua*), whiting (*Merlangius merlangus*), saithe (*Pollachius virens*), sandeel (*Ammodytes* spp.), several species of flatfish, as well as various crustaceans, are some examples of potential prey items, which according to local fishermen are commonly found in the waters surrounding Aberdeen harbour. We therefore suggest that further studies are required to look at the type, abundance and distribution of potential prey species in the area, as well as to investigate the importance of salmon as a potential prey resource.

Dolphins were most commonly observed in groups of 5–10 individuals, which is considered to be characteristic for coastal populations of bottlenose dolphins (Shane et al., 1986). Once around the harbour, individuals would typically separate into smaller dynamic groups that would occupy different areas of the study site and perform different types of behaviour. At most times, dolphins were located within a distance of 300 m from the entrance to the harbour, while in 65% of the samples dolphins were observed within the navigation channel (i.e. <10.30 m depth).

As previously mentioned, foraging was the main activity at all times and involved a great variety of feeding strategies. However, it occurred more frequently in Sectors 2 and 4. More specifically, foraging was most commonly observed on either side of the South Breakwater, at the tip of the North Pier, or in a dispersed manner between the two (i.e. along the notional boundary between Sectors 2 and 4 in Figure 1). This preference of certain areas for foraging has also been reported by Weir & Stockin (2001), and is probably related to the fact that in enclosed areas, tidal currents tend to channel water in certain locations, which could increase the chances of prey capture (Lewis & Evans, 1993).

Reactions to boat traffic

The frequent occurrence of dolphins within the narrow strip of the navigation channel and around the harbour mouth, which are the areas of most intense boat activity, indicates two main things: (a) the estuarine area of the

River Dee is of great importance to the dolphins; and (b) the dolphins are exposed to—and apparently habituated to—high levels of boat traffic.

During the observation period it was not clear to what extent the dolphins were affected by the presence of boats, since reactions varied considerably. Approaching or following a boat, as well as initiating bowriding, surfing, leaping or breaching around the vessel (all classified as positive reactions), were relatively common reactions, while in some cases the dolphins were observed to cease normal activity and 'wait' for the approaching boat to start bowriding.

Sometimes when a boat passed through the area, the dolphins would perform long dives, followed by intense splashing and breaching within the wake of the boat; occasionally fish were thrown into the air during this time. This activity was mostly observed after large boats had passed, and it is likely that the dolphins were foraging on organisms stirred up by the propeller's wash (as also observed by Shane, 1990). Finally, on two occasions, a dolphin was observed catching a large fish while engaged in bowriding. In both cases the dolphin stopped bowriding immediately and started foraging. This observation indicates that dolphins may actually take advantage of the approaching vessel, in order to chase startled fish.

On the other hand, reactions that were classified as negative, e.g. prolonged dives followed by intense coughing (defined as heavy, fast respiration), active avoidance and transition to a different location of the study area were also observed with equal frequency. Nevertheless, departure from the whole study area was observed in only a few cases of intense and prolonged boat traffic.

Although based on a relatively small sample size, the overall results of the current study have shown that boat traffic affects dolphin behaviour, but in a complex way. In relation to boat size, dolphins would most commonly stop normal activity and would exhibit some type of reaction. Large boats generally attracted positive reactions while small boats elicited the most negative reactions. Furthermore, dolphin behaviour was found to be strongly related to both boat activity and speed. When boats were following the standard route through the navigation channel (i.e. entering or exiting the harbour), all reactions occurred with almost the same frequency. However, when boats where manoeuvring inside or outside the harbour, dolphins would exhibit a negative response much more frequently than a neutral one, while positive reactions never occurred. Similarly, when boats were travelling at slow or intermediate speeds, all types of responses occurred with the same frequency, whereas only negative reactions were observed when boats were travelling at a high speed. Small boats, moving fast and in variable directions may of course simply be perceived as more of a threat by dolphins.

Given that in most instances dolphins did show a change of their normal activity when boats were present, but rarely left the area, it is suggested that endurance or tolerance are the most suitable words to describe the state of these animals, which seem to utilize this area for food.

Previously reported behavioural reactions of dolphins towards boats include changes in foraging habitat selection (Allen & Read, 2000), diving duration (Evans et al., 1992), and surfacing patterns (Janik & Thompson, 1996) or, as in this study, tolerance (Acevedo, 1991). Short-term interruptions of normal activity could have long-term adverse effects on a population of dolphins, through reductions in the time available for foraging or resting, abandonment of favoured habitats, disruption of social bonds, or through physiological effects of stress (Thompson, 1992). Such long-term effects are most likely to take the form of subtle decreases in reproductive success and survival (Curran et al., 1996), and are therefore difficult to detect. To enhance our understanding of these long-term consequences, future investigations might focus on the potential effects of boat traffic on the energy budgets/requirements and foraging efficiency of these animals. At the same time, future management schemes should acquire a precautionary approach towards this form of disturbance, especially since these animals show a preference towards this particular habitat.

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