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# Effects of Boat Traffic on the Behaviour of Bottlenose Dolphins *(Tursiops truncatus)*

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## Abstract

Boat traffic is widely believed to cause disturbance and physical injury to cetaceans and is frequently cited as an important threat to their welfare and conservation. As a result, numerous codes of practice have been proposed which restrict the movement of boats in the vicinity of cetaceans. There are, however, relatively few quantitative studies on the behaviour of cetaceans in the presence of boats. Here, we report on a study of bottlenose dolphins (*Tursiops truncatus*) in Teignmouth Bay, UK. We show that the presence of dolphins in the study area was unrelated to the number of boats present. When boats were stationary, the behaviour of dolphins did not differ significantly between boat classes; however, there was a highly significant difference in the response of dolphins to different classes of boats in motion. Speedboats and jet skis were associated with aversive behaviours, even when boats were not directly approaching the dolphins.

**Key Words:** bottlenose dolphin, disturbance, boat traffic, behaviour, conservation, *Tursiops*

## Introduction

Although dolphins frequently ride the bow waves of ships, benefiting from economical high-speed travel (Williams et al., 1992), there is mounting evidence that marine traffic poses a major threat to cetaceans. Collisions cause direct physical injury and death (Nowacek et al., 2001b; Wells & Scott, 1997), and boat engines produce high levels of underwater noise, resulting in behavioural changes, short- or long-term displacement, masking of echolocation signals, and physiological stress (Evans et al., 1992; Richardson, 1995; Richardson & Würsig, 1997).

Studies on both spinner dolphin (*Stenella longirostris*) and spotted dolphin (*S. attenuata*) groups showed that in all cases the dolphins' response to boats were to move away from an approaching ship; in fact, they responded even when the vessel was still on the horizon (Au & Perryman, 1982). Early responses to avoid an oncoming vessel have also been noted in many other species, including Arctic beluga whales (*Delphinapterus leucas*) (Blane & Jackson, 1994; Richardson, 1995), harbour porpoises (*Phocoena phocoena*) (Evans et al., 1994), and killer whales (*Orcinus orca*) (Kruse, 1991). Fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaengeliae*), and sperm whales (*Physeter macrocephalus*) have all demonstrated shorter surface periods and fewer blows in response to whale-watching craft (Notarbartolo di Sciara et al., 1996). A recent study by Hastie et al. (2003), demonstrated a significant relationship between breathing synchrony in bottlenose dolphins (*Tursiops truncatus*) and the presence of boat traffic.

Despite long-term exposure to high levels of marine traffic, bottlenose dolphins in Sarasota Bay, Florida, continued to demonstrate short-term behavioural changes, showing decreased inter-animal distance, increased swimming speed, and increased directional changes in response to an approaching vessel (Nowacek et al., 2001a). Acevedo (1991) found that bottlenose dolphins altered their behaviour as a boat approached by moving away from the vessel and eventually resumed their previous behaviour elsewhere.

Those studies in which cetaceans appear to tolerate, or are unaffected by, the presence of boats suggest that they have habituated to the presence of boats. This has occurred in areas of relatively light boating traffic, or where particular vessels maintain a predictable course such as passenger ferries (Gregory & Rowden, 2001; Janik & Thompson, 1996; Shane, 1990).

Bottlenose dolphins form both large transient pelagic groups and smaller resident coastal populations (Shane, 1990). Although these coastal groups are usually sheltered, they are at high risk from anthropogenic disturbance, in particular from the increasing number of recreational boats in coastal waters. Within the UK, there are two main resident groups of bottlenose dolphins: one in the Moray Firth, Scotland (Thompson et al., 2000; Wilson et al., 1997), and one in Cardigan Bay, Wales (Bristow & Rees, 2001; Evans, 1992; Gregory & Rowden, 2001). In addition, there are more widely dispersed groups around the coasts of Cornwall, Devon, Somerset, and Dorset (Tregenza, 1992; Williams et al., 1996; Wood, 1998). The southwest population consists of a group of about 45 individuals (Simmonds et al., 1997), comprising groups of both resident and transient individuals. The groups that remain within coastal waters throughout the year travel between sites along the north and south coasts (Evans, 1992; Williams et al., 1996). While they maintain an extensive home range, they frequently spend long periods of time in particular bays such as Teignmouth Bay, and TorBay, Devon (Wood, 1998). In such enclosed locations, boat traffic is more frequent; therefore, the dolphins may be at greater risk of anthropogenic disturbance. Anecdotal reports of harassment and injury to bottlenose dolphins are well-documented (e.g., Simmonds, 2000), but there are few quantitative studies (Hastie et al., 2003). The primary aim of this study was to quantify the level of disturbance caused by boats and to relate the dolphins' behavioural responses to the number and type of boats within Teignmouth Bay.

## Materials and Methods

*Study Site*

Teignmouth (50° 32' N, 3° 29' W) is situated on the western side of Lyme Bay, Devon, UK. Teignmouth Bay is bordered by two rocky outcrops, which were used to delimit the study area of approximately 2.5 $km^2$. The seabed of the study site is gently sloping, with rock and sandy patches down to 10 m, below which the substrate becomes a mixture of mud, fine sand, pebbles, and broken shells. The River Teign flows into the western side of the bay, frequently creating strong currents across the estuary mouth.

Marine traffic in Teignmouth Bay consists of a wide variety of boats, from large commercial tankers and fishing boats to recreational powerboats, yachts, and rowing boats. During May to September, there is a marked increase in boat numbers, in particular sailing boats, canoes, and tour boats.

*Dolphin-Boat Interactions*

The study was conducted throughout July and August 1999 for a total of 281 h of observation. Daylight hours were divided into three watch periods: 0800-1100 h, 1330-1600 h, 1730-2100 h. All watches were conducted from a land-based station on the seafront (observation height, 4 m), eliminating any potential effect of the two observers on dolphin behaviour or boating activity. In the analysis, we consider each watch as a separate, independent data point. During each watch, the following data were recorded: date, start time, time and height of high tide, sea state, air temperature, cloud cover, and wind direction. The bay was scanned every 15 min using binoculars to record the number of boats. For analysis, boats were categorised as displacement-hulled boats (e.g., ships, tankers, large motor vessels, motor yachts, fishing boats), planing-hulled boats (e.g., small motor vessels, speed boats, pleasure craft, jet skis, water skiers, wave skis), or non-motor boats (e.g., sailing yachts, canoes, rowing boats, wind surfers). When dolphins were present (over 54 h in total), their behaviours were continuously recorded. Group size was recorded as the maximum number of individuals seen at the surface. As there was only ever one group in the bay, if dolphins were observed surfacing separately from the main group, they were included in the total. The mean group size was seven. This was verified using photo-identification images which were later compared to the *Tursiops* catalogue for the English and French coast. The group was observed throughout the entire watch period or until they left the study area, whichever was greater. During this time, dolphin behaviour was recorded using an ethogram of nine behaviours in three classes: positive (approach, bow ride, rub alongside vessels), neutral (feeding, tail slap, uninterested), and negative (move away, change direction, dive greater than 5 min) (see Heimlich-Boran & Osborne, 1998; Lockyer, 1987). All behaviours were recorded using one-zero sampling. All interactions between dolphins and people or boats were recorded. An interaction occurred if the distance between the two was less than 100 m (Simmonds et al., 1997). This distance was estimated using fixed points with known distances within the bay (i.e., the end of the pier, the position of a number of fixed oceanographic buoys, rocky outcrops, and headlands). Although both theodolite and range finding binoculars had been tested, both were deemed unsuitable due to dolphin movement and observation height. The interactions between dolphin-boat (dolphin approaching boat) and boat-dolphin (boat approaching dolphin) were separated by noting the boat's course and direction of movement. If a boat obviously altered course to the dolphins' last known position, it was recorded as a boat approach. If, however, the boat maintained its original course regardless of dolphin movement, and yet the dolphins were next sighted beside the boat, it was deemed that the dolphins approached the boat.

## Results

The presence or absence of dolphins in the bay was not significantly affected by the total number of boats ($t_{98}$ = 1.83, $p$ = 0.070). Dividing the boats into classes gave similar results: displacement-hulled boats ($t_{98}$ = 1.54, $p$ = 0.127), planing-hulled boats ($t_{98}$ = 0.58, $p$ = 0.565), and nonmotor boats ($t_{98}$ = 1.79, $p$ = 0.077) (Figure 1).

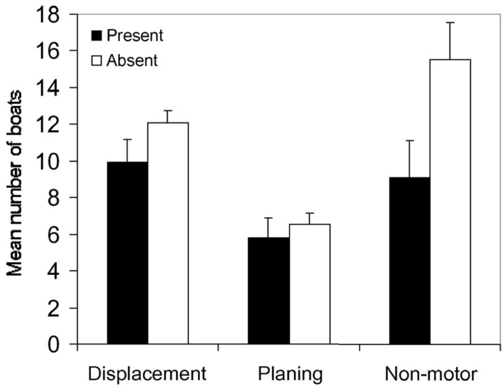


**Figure 1.** The mean number of boats (± SE) of three different classes during watches when *Tursiops truncatus* were present and watches when dolphins were absent from the study site

During watches when dolphins were present, the proportion of time that dolphins spent in the bay was not statistically significantly correlated with the total number of boats ($r^2$ = 0.01, $F_{1,24}$ = 0.22, $p$ = 0.644). Similar results were found for the three different classes of boat: displacement-hulled boats ($r^2$ = 0.003, $F_{1,24}$ = 0.06, $p$ = 0.806), planing-hulled boats ($r^2$ = 0.001, $F_{1,24}$ = 0.01, $p$ = 0.914), and nonpower boats ($r^2$ = 0.02, $F_{1,24}$ = 0.40, $p$ = 0.534).

The frequency of positive, negative, and neutral behaviours (Figure 2) did not differ significantly among the three classes of boats when they were stationary ($G_4$ = 8.74, $p$ = 0.067), but there was a highly significant difference between boat classes when they were moving ($G_4$ = 30.82, $p$ < 0.0001) (Figure 3). In particular, dolphins frequently showed negative behaviours (move away, change direction, dive greater than 5 min) in the presence of moving planing-hulled boats.

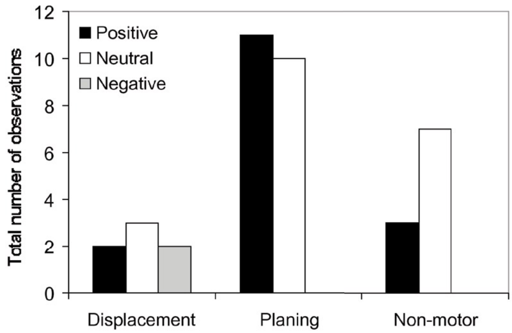


**Figure 2.** The total number of positive (approach, bow ride, rub alongside vessels), neutral (feeding, tail slap, uninterested), and negative (move away, change direction, dive) behaviours displayed by *Tursiops truncatus* in the presence of stationary boats of three different classes

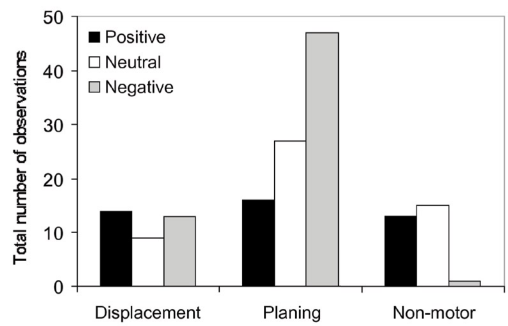


**Figure 3.** The total number of positive (approach, bow ride, rub alongside vessels), neutral (feeding, tail slap, uninterested), and negative (move away, change direction, dive) behaviours displayed by *Tursiops truncatus* in the presence of moving boats of three different classes

## Discussion

There is an increasing threat to inshore groups of cetaceans because the number of boats in coastal waters grows. Therefore, it is important to understand the way in which increased marine traffic is likely to affect cetaceans. Our study demonstrated that the level of boat traffic might be a poor measure of disturbance. The total number and category of boats did not affect the presence/absence of dolphins or the amount of time they spent in the bay. Stationary boats did not significantly affect dolphin behaviour. There was, however, a highly significant effect of boat type when the boats were in motion. A greater number of negative reactions were recorded in the presence of moving planing-hulled boats compared with moving displacement-hulled and nonmotor boats.

Although studies have highlighted boat-avoidance behaviour in cetaceans, it is unclear whether this is caused by the physical presence of the boat, the underwater noise generated, or their interaction. Previous studies (Blane & Jackson, 1994; Evans et al., 1992, 1994) suggested that the noise generated during motion is likely to be an important factor. Evans et al.. (1992) concluded that when boat engine noise rose gradually above ambient levels, the response of bottlenose dolphins was less marked than when the noise level rose over a short period of time. Hence, a large fishing boat had less of an effect on dolphins than jet skis, which have the ability to approach and change direction very quickly.

This study highlights the disturbance of bottlenose dolphins by fast-moving planing-hulled boats such as speedboats and jet skis. While dolphins appear to tolerate high numbers of boats, both here and in Sarasota Bay (Nowacek et al., 2001a), adverse interactions frequently occur even when boat users do not intend to approach the dolphins. The dramatic increase in numbers of aversive behaviours by dolphins in the presence of fast-moving boats suggests that codes of practice relating to boat traffic in the vicinity of cetaceans must include recommendations about maximum speed, as well as amount of distance between the animals and the boats.

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