Effects of tourism on dusky dolphins at Kaikoura

Kirsty Barr and Dr Elisabeth Slooten
University of Otago
PO Box 56
Dunedin

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1. Introduction

Dusky dolphins are found in nearshore waters off New Zealand south of about 37 degrees latitude (Baker 1983). The size of the New Zealand dusky dolphin population is unknown. No population surveys have yet been conducted. Likewise, the distribution of dusky dolphins around New Zealand is poorly understood, although Kaikoura appears to be the stronghold of the local population. Dusky dolphins are clearly much less common in other parts of New Zealand waters.

Off Kaikoura, dusky dolphins can be found throughout the year (Cipriano 1992) in pods that usually range in size from 6 to 300 individuals. During daytime in summer, they frequently come within 1 to 3 km of shore to socialise, rest and feed. Most feeding appears to occur during the evening and night in deep water, around the near shore Kaikoura Canyon (Wursig *et al.* 1991, 1996). Dusky dolphins mainly eat lantern fishes and squid that migrate vertically to within 50-100 m of the surface at night (Cipriano 1985, 1992).

Historically, dusky dolphins at Kaikoura have lived with low to moderate boat traffic for many years, mainly from fishing boats. Over the past seven years, however, Kaikoura has experienced an increase in commercial and non-commercial boating activity. The first New Zealand commercial tours to view and swim with dolphins began in Kaikoura in 1989. At present dusky dolphins are regularly approached by boats during the summer, and recently commercial trips have become regular during the winter months. Three commercial companies are licensed to take tourists out to view dolphins. Private boats also approach the dolphins, and fishing boats are active daily in the area where the dolphins are present. Two of the commercial companies are licensed to allow tourists to enter the water to swim with the dolphins. Whale Watch Kaikoura is also permitted to swim with dolphins, but so far has not actioned this.

The purpose of the Marine Mammals Protection Regulations (MMPR, 1992) is to:

"make provision for the protection, conservation, and management of marine mammals" and "regulate human contact or behaviour with marine mammals either by commercial operators or other persons, in order to prevent adverse effects on and interference with marine mammals" (Section 4, Purpose).

Disturbance to dusky dolphins could potentially have both short- and long-term effects. For example, close contact with humans may alter behaviour of individuals or pods of dolphins in the short-term. Stress may manifest itself through avoidance of humans or aggression towards humans (Tyack 1987). Repeated and prolonged contact with humans could result in a disruption of "critical behaviours" such as feeding, rest and reproduction, which in turn may threaten the long-term health and growth of the population (Richardson *et al.* 1995).

2. Aims of this report

1. This report summarises the main findings of the first thorough study on dolphin watching at Kaikoura and its effects on the behaviour and movement patterns of dusky dolphins (Barr 1997).

2. We also answer a set of questions posed by the Department of Conservation about the implications of this research for the management of dolphin viewing at Kaikoura. The Department is considering whether or not to allow any greater level of dolphin watching effort at Kaikoura. DOC would also like advice on which modifications to current dolphin viewing operations or to the dolphin watching regulations might be most effective at avoiding, remedying or mitigating adverse effects.

3. Research methods

3.1 FIELDWORK

Several techniques have been used by researchers to assess the impacts of whale and dolphin watching (IFAW 1995). Observations from whale and dolphin watching boats or planes themselves are not ideal, because the observer is on board a source of potential disturbance. A thorough assessment of the effect of boats on dolphin behaviour requires observations with and without boats present. If the animals are too far offshore to allow the use of observation sites on land, observations should be made from a separate boat, plane or other platform that stays at a distance at which it has little or no effect on dolphin behaviour.

Observation sites on shore or other stationary platforms are ideal, because they remove the possibility of observer disturbance and allow the comparison of dolphin behaviour in the presence and absence of boats. The only disadvantage is that behaviour observations are less detailed from a distance.

Kirsty Barr observed dusky dolphins from Ota Matu Lookout Point (73 m high, 42° 29' 029" S, 173° 31' 711" E), 19 km south of Kaikoura Peninsula (Fig. 1). Data were collected on 118 days from December 1993 to April 1994 and October 1994 to April 1995, when dolphins were within 10 km of the coast during the day. This period covers the main season of commercial dolphin watching tours. Observations were made over a total of 443 hours and 39 minutes (average = 3 hrs, 46 mins per day). There was no significant difference between the first and second field season in the time spent observing dolphins each day and each month ($F_{3,90} = 0.26$, $p = 0.851$).

Theodolite tracking

Dolphin and boat movements were tracked using a Leitz-Sokkisha digital theodolite with 30x monocular, connected to a computer for data storage (Wursig *et al.* 1991; Mayo & Goodson 1993). A theodolite (surveyor's transit) measures vertical angles relative to gravity and horizontal angles from a selected reference point. The horizontal zero of the transit was repeatedly checked and reset throughout the day. Positions were automatically entered into a computer in the field.

Theodolite tracking was done continuously for periods lasting ten minutes each, with a maximum of four periods completed per hour of observation. Boat movements within 500 m of focal dolphin pods were tracked. During each period, the size of a focal pod, pod dispersion, group envelope, and the activity of human swimmers were recorded. Pod dispersion was recorded by rapidly recording theodolite fixes of opposite ends of the dolphin pod (Cipriano 1992). Group envelope was described using four main categories: 1) "closed" (closely spaced dolphins moving as a unit); 2) "open" (loose collection of dolphins spread over 100 m to 500 m with haphazard dolphin movement); 3)" widely scattered" (individuals and small subgroups spread over a wide area (>1 km^2) and moving independently); and 4) "extended" (tightly spaced dolphins spread in a long, narrow line or wedge (>500 m long) moving as a unit).

Surface activity levels

Surface activity was recorded to determine whether it increased or decreased in the presence of boats. A "clean leap" describes a dolphin leaping into the air and making a clean head-first re-entry. A "slap" describes a dolphin partially or completely leaping out of the water and hitting the water surface on its side, back or belly, creating a splash on re-entry (Ostman and Folkens, in prep.).

The number of leaps and slaps was recorded in scans of the whole dolphin group. Each observation of surface activity consisted of three scans made over one minute, looking from one side of the dolphin pod to the other. Scanning in one direction ensured that observations were not biased towards repetitive behaviours of a few dolphins, but effort was spread evenly over the whole pod. A maximum of three surface activity observations were made per hour.

The size of the focal pod, the number and type of boats present, and the activity of swimmers within 300 m were also recorded during every set of scans. The number of clean leaps and slaps per 100 dolphins was used for comparisons between dolphin pods with and without boats present, observations with different boat types, etc.

Environmental conditions

At the start of each hour of observations, the following environmental conditions were recorded: Beaufort Sea state (0 = flat calm, 1 = surface broken by ripples, 2 = small wavelets, 3 = scattered white caps, 4 = many white caps) (Lamont 1994), percentage cloud cover (how much of the sky was obscured by clouds), and an arbitrary scale of dolphin visibility (1 = excellent, 2 = good, 3 = poor). Observations began at sunrise and ended when the dolphins had moved too far from shore to be seen accurately. In good weather, this was usually when the dolphins had moved farther than 7 km from the study site. Data were not collected when wind strength exceeded Beaufort 3, or in rain or fog as these conditions obscured dolphins, making theodolite tracking inaccurate.

Daily summary

Each day that dolphins were observed, the following were calculated: total observation time, number and type of boats that approached within 300 m of a dolphin pod, and percentage of time boats were present within 300 m of the dolphin pod. Boats were defined as "present" when within 300 m of a dolphin pod as this is the distance used to regulate boat activity in the MMPR (1992). Boats were classified into one of three" use-class" categories: 1) commercial (whale and dolphin watching boats), 2) fishing (commercial fishing boats that worked daily in the area), and 3) private (predominantly recreational boats but also including research boats, DOC and professional photographers).

Ten minute summary

Dolphins and boats were tracked for ten minute periods in the presence and absence of boats. Occasionally, it was not possible to record the positions of boats and dolphins exactly at the end of ten minutes. Therefore, a range from seven to thirteen minutes was allowed for summarising data into groups.

The mean speed, pod dispersion, and number of directional changes made by dolphin pods were also calculated for each observation period. To minimise errors associated with non-linear travel, travel speeds were calculated using two successive theodolite positions recorded within 240 seconds of each other. These individual speed estimates were used to calculate the mean speed for each period. The mean numbers of directional changes were calculated for each period using the same successive theodolite positions. A change in direction was defined as a change in orientation of 245 ° by a focal pod. Dolphin density was calculated by dividing the number of dolphins by the mean dispersion of the pod.

3.2 ANALYSIS

From the sighting station's position, its height above the sea surface (corrected for tidal fluctuations), and the position of a landmark used to zero the horizontal scale, each theodolite position was translated into x and y co-ordinates on a map using TTrak (Theodolite-Tracking data analysis program; Cipriano 1990). This allowed the exact location of dolphin pods and boats to be determined. Under good sighting conditions and with the dolphin pod within 5 km of the observation site, this system provides position accuracy within 5 m (Wursig *et al.* 1991). Successive positions were used to calculate speed of travel, direction of movement, distances of dolphins and boats from shore and from each other, and changes in orientation. See Wursig *et al.* (1991) or Mayo & Goodson (1 993) for more complete descriptions of theodolite tracking techniques.

Cipriano (1992) found that some dusky dolphin behaviours changed in relation to time of day. To account for the effect of time on dolphin behaviour, data for each day were divided into two-hour time blocks, beginning at sunrise and continuing through all daylight hours.

To document the exposure of dusky dolphins to human activities, the level of boat activity around dolphins and the types of boats that visited them were quantified. Tests were carried out to determine whether boat activity varied among the summer and autumn months and during the day. General linear models were used to investigate differences among months and between seasons for each of the following variables: percentage of observation time that boats were present, number of boats, number of commercial, fishing and private boats, and time spent observing dolphins.

The effects of time of day on dolphin behaviour were studied using general linear models. The effect on dolphin behaviour of boats and swimmers, the number of boats, and type of boats were also investigated using general linear models. The effect of these factors on the spacing of dolphins within a pod (pod envelope) was studied using chi-square tests and log-linear analysis.

All data were analysed using Version 6.10 of the SAS statistical software package (SAS Institute, Cary, North Carolina). All statistical tests are at the 95% significance level (i.e. $p < 0.05$).

4. Main findings

4.1 BOAT ACTIVITY

A high level of boat activity was observed south of Kaikoura over the study period from December 1993 to April 1994 and October 1994 to April 1995. One or more boats were present within 300 m of the dolphin pod under observation for 72% of the observation time (average across both seasons). There was a significant increase in the proportion of time boats were present, from 65.23% of observation time in the first field season to 78.28% in the second field season (Fig. 2). This difference was statistically significant (general linear model: $F_{1,92} = 3.97$, $p = 0.049$).

This large proportion of time is due, in part, to extensive communication between commercial skippers, fishing boats, and commercial aircraft about the position of dolphin pods. This means that boats leaving a dolphin pod are soon replaced by other boats which do not have to search for dolphins themselves.

Boats were observed to approach within 300 m of a dolphin pod on a total of 949 occasions during the study period. Once dolphins were located at dawn, their movements and positions were almost continuously followed until dusk by commercial whale and dolphin watching skippers. It is possible that the arrival and departure of vessels is as potentially disruptive as vessels remaining continuously with the group. Of 776 ten-minute blocks of observation time, 34% contained either a vessel arrival or departure.

On average, eight boats approached within 300 m of the dolphins each day of observations (about two boats per hour of observation), an average of seven commercial boats and one private boat. The mean number of boats observed per day increased significantly from 7.1 per day in the first field season to 9.0 in the second field season ($t = -14.27$, $DF = 97$, $p < 0.001$). As there was no significant difference in observation time between the first and second field season and observations ceased when sea conditions exceeded Beaufort sea state 3, the increase in the mean number of boats present was not the result of better dolphin watching conditions but reflects a real trend. Time of day also significantly affected the mean number of boats approaching dolphins, with the highest number of boat approaches during mid to late afternoon ($F_{5,770} = 3.68$, $p = 0.003$).

Commercial dolphin and whale watching boats made up 84.4% (793 boats) of all boats present. Fishing boats made up 5.4% (52 boats), and 9.4% (104 boats) were private boats. The number of commercial and private boats that visited the dolphins per day increased significantly from the first to the second field season (Fig 3; $F_{1,89} = 7.71$, $p = 0.007$ and $F_{1,89} = 6.19$, $p = 0.015$ for commercial and private boats respectively). Tour operators have noticed that the number of private boats visiting dolphins and the number of people wanting to take commercial tours has continued to increase since this study was done. Tourist demand is expected to continue increasing.

4.2 BREACHES OF THE MARINE MAMMALS PROTECTION REGULATIONS 1992

Under the MMPR (1992) no more than three boats and/or aircraft are permitted within 300 m of a dolphin pod. The maximum number of boats present with dolphins at one time exceeded three during 8.2% of observations during which boats were present. In 95% of these observations, commercial and private boats were present. When three boats were already with the dolphins, most additional boats waited beyond 300 m until one boat left.

There were 70 instances (7.4% of total approaches) when boats did not abide by the conditions governing behaviour around dolphins set out under the MMPR 1992. Commercial fishing boats are exempt from the regulations and so are not included in this figure, but their behaviour within 300 m is included in this section. These behaviours fell into three categories: 1) boats crossing in front of a dolphin pod, 2) boats driving fast within 300 m of a dolphin pod, and 3) boats driving through a dolphin pod.

Private boats were more likely to cross in front of a dolphin pod than any other boat type.

Fishing boats were more likely to drive fast within 300 m of a pod (Fig. 4). No obvious responses to these fishing boats were observed. This may be due to the predictability of their movement. Commercial fishing boats have been active in the area since before dolphin watching operations began. Their movements are generally in a straight line from one net or crayfish pot to the next, or between the fishing grounds and Kaikoura. Some whales and dolphins appear to habituate to certain kinds of noise, particularly repetitive and predictable noise (Thorpe 1963; Jones & Swartz 1984; Watkins 1986). Janik & Thompson (1996) found that bottlenose dolphins did not show significant changes in behaviour to boats that passed through the study area in a predictable straight line. It is also possible that the dolphins recognise individual boats and learn which boats will follow them and those that ignore them (Irvine et al. 1981).

Commercial whale watching boats were observed to drive through and move around within a dolphin pod more often than other types of boats (Fig. 5).

Over the course of the study, several film crews visited Kaikoura to film dusky dolphins. Film crews often spent several hours at a time with dolphin pods, sometimes for several days on end. Competition among film makers means that they are seeking ever more impressive images. This often involves driving the boat amongst dolphin pods for close up shots and therefore not abiding by the MMPR.This applied to professional photographers also. Film and photographic crews were included in the "private" boat category. There were too few to form a separate category.

There were also times when aircraft were flying over the dolphins and three boats were present. It became apparent that tour operators were either not aware that this was against the regulations or were ignoring the regulations.

4.3 GENERAL DOLPHIN BEHAVIOUR

Dusky dolphins at Kaikoura appear to rest and socialise in shallow waters during the day and move further from shore in the late afternoon. Dolphins moved rapidly when they first came inshore in the morning (mean = 2.0 m/s) and slowed down by midday (mean = 1.63 m/s). They then swam faster during the afternoon. Cipriano (1992) also found that dusky dolphins in Kaikoura were engaged in slow swimming more often during the middle of the day. Slow swimming is an indication that dolphins are resting (Norris & Dohl 1980a; Wursig & Wursig 1980; Cipriano 1992), suggesting that dusky dolphins at Kaikoura spend more time resting during the middle of the day.

Dolphin speed and direction changes increased towards the end of the day, indicating an increase in activity. Hawaiian spinner dolphins also move more rapidly in late afternoon as they move offshore to feed at night (Norris *et al.* 1994). Behaviour is also significantly influenced by a diurnal rhythm in other free-ranging dolphin species (Saayman *et al.* 1973;Wursig & Wursig 1980).

4.4 EFFECTS OF HUMAN ACTIVITIES ON DOLPHIN BEHAVIOUR

The purpose of the Marine Mammals Protection Regulations (MMPR, 1992) is to protect, conserve and manage marine mammals, and to regulate marine mammal tourism in such a way as to "prevent adverse effects on and interference with marine mammals". Harassment is defined in the Act as any act that "Disrupts significantly or is likely to disrupt significantly the normal behavioural patterns of any marine mammal". Therefore, this study examined whether there were any changes in dolphin behaviour due to human activities.

Presence of boats and swimmers

Studies of other dolphin species have shown that dolphin pods tend to be more closely packed when resting, and in response to the presence of boats (Norris *et al.* 1978; Irvine *et al.* 1981; Au & Perryman 1982; Blane & Jackson 1994). This is thought to be an attempt to improve communication among pod members, and is also used by some dolphin species in predator defence and avoidance.

Dusky dolphin pods at Kaikoura became more compact during the morning and early afternoon (Figs 6a, 6b). During mid afternoon, groups became more dispersed (higher dispersion, lower density) in the absence of boats. But in the presence of boats, groups remained compact (Figs 6a, 6b). This difference was not statistically significant. Power analyses were carried out to determine how large behaviour differences had to be, to reach statistical significance.These analyses indicate that fairly large changes could have gone undetected (Table 1). The low level of statistical power (in part due to the large proportion of time boats were present) underscores the need for a precautionary approach.

There were no significant effects of swimmers on mean pod dispersion, dolphin density, speed, and number of directional changes. The influence of swimmers on surface activity and group envelope could not be assessed due to small sample sizes.

It was also beyond the scope of this study to assess whether the presence of swimmers altered individual dolphin behaviour. It is possible that a ten minute observation period is too long to assess the effect of swimmers on a focal pod, as responses may be more immediate and therefore not detectable. A boat-based study similar to Constantine (1995) would be useful to describe individual dolphin responses to swimmers.

There were some substantial changes in aerial behaviour, but again these were not statistically significant. After mid-morning dolphins made between twice and seven times as many clean leaps when boats were present (Fig. 6e) and more than twice as many slaps (Fig. 6f). In some species, an increase in aerial activity reflects disturbance behaviour and agitation. For example, Baker *et al.* (1983) found that the frequency of occurrence of aerial behaviour in humpback whales was significantly correlated with the presence of large ships and with close approaches of boats. An increase in aerial activity may also improve communication between individuals by visual and acoustic means (Norris & Dohl 1980b; Wursig & Wursig 1980; Heimlich-Boran 1988; Norris 1991; Norris *et al.* 1994; Corkeron 1995) when boat noise is produced close to pods. This response may also reflect an increase in the excitement or motivation levels of dolphin pods (Lockyer 1978; Norris & Dohl 1980b; Wursig & Wursig 1980; Black 1994; Slooten 1994).

Whether an increase in aerial activity in the presence of boats is a disturbance reaction, improves acoustic or visual communication, or results from increased excitement is not yet clear. Dusky dolphins spend the day resting, socialising and occasionally feeding, and then move offshore to feed at night (Cipriano 1992). Increased activity at a time when dolphin pods are normally least active may prevent dolphins from resting. If dolphins do not rest enough during the day and have a higher energy consumption through increased aerial activity, they may not gain enough energy for feeding at night or may have to feed for longer. In this case, it would help if operators were to reduce boat activity in the afternoons.

Researchers and tourist operators have noted that dusky dolphins at Kaikoura appear to rest during the midday to mid afternoon period, and are concerned that dolphin watching may disrupt normal resting behaviour. The beginning of this "sensitive period" appears to be around 11 am. The end of the period is less clear. More data on behaviour and responses to boats during the mid to late afternoon would help answer this question.

Data were also collected before, during and after boat visits to dolphin groups, to control for the effects of individual pods, time of day, and other confounding variables (see also Gordon et al. 1992). Mean pod dispersion, dolphin density, pod speed, and number of directional changes did not change significantly when boats arrived or when boats left.

However, there were few opportunities to observe dolphins pods before, during and after the presence of boats as boats were present for a high proportion of the observation time. This severely compromised our ability to detect changes. For example, with our current sample sizes a 70% change in dolphin density after boats left could have gone undetected. A larger sample size, and especially a larger amount of time without boats present, is needed to allow more sensitive tests of behaviour changes.

Effect of different numbers of boats

There was no significant effect of increasing numbers of boats on dolphin behaviour. Again, differences in behaviour had to be fairly major to be detectable statistically. For example, we can be 95% sure that dolphin density did not change by more than 53% between observations made in the presence of different numbers of boats (Table 2). Until more information is gathered, the three boat regulation seems to be appropriate.

Boat type

Comparisons of dolphin behaviour were made between observations made in the presence of a) commercial whale and dolphin watching boats only, b) a combination of commercial boats with fishing and/or private boats and c) fishing and/or private boats. The presence of different types of boats had no significant effect on mean pod dispersion, dolphin density, speed, or number of slaps. However, the number of directional changes and clean leaps made by dolphin pods were significantly affected by boat type, and these responses changed during the course of the day. Dolphins made more directional changes in the early afternoon (Fig. 7) and a higher number of clean leaps during midday and the early afternoon (Fig. 8), when a combination of commercial with fishing and/or private boats were present.

The dolphins' response to a combination of commercial boats with fishing and/or private boats suggests that dolphins are sensitive to vessel behaviour and uncertainty in vessel behaviour. Commercial and private boats are manoeuvred to bring them close to the dolphins, often with multiple changes in speed and direction. These boats usually follow a dolphin pod for a large proportion of the observation period. In comparison, fishing boats normally drive past dolphin pods without stopping. Private boats show a range of different behaviours.

A combination of commercial boats with private or fishing boats appears to cause the highest level of disturbance. This may be a situation in which it is difficult for the dolphins to predict the behaviour of individual boats.

Several other studies have observed differences in whale and dolphin responses to different types of boats. Gray whales make more deviations from their migration course in response to boats, with significantly more deviations in the presence of private boats compared to commercial whale watching boats (Bursk 1983). Bursk (1983) commented that some private operators have little experience with gray whale migration and inadvertently move too fast and approach too close when whale watching. Swartz & Cummings (1978) found that gray whales at San Ignacio Lagoon generally avoided fishing boats. They observed that commercial operators use more discretion when choosing whale to boat distances and throttle speeds, presumably to ensure that the whales' behaviour remains predictable. Burgan & Otis (1995) also observed differences in boat behaviour between commercial and non-commercial boats but they found no relationship between this and killer whale behaviour.

An increase in the number of directional changes may indicate that dolphins are avoiding boats by continually adjusting their direction of swimming away from boats. This behaviour may also reflect a degree of indecision as to what direction to swim when several different types of boats are surrounding the pod and moving in different ways. Several studies have observed dolphins and whales moving erratically and making more directional changes in response to the presence of boats (Bursk 1983; Acevedo 1991; Baker & MacGibbon 1991). This is usually interpreted as an attempt to move away from the source of disturbance (Wursig & Wursig 1980; Au & Perryman 1982; Baker & Herman 1989; Hawke 1989; Polacheck &Thorpe 1990; Acevedo 1991; Constantine 1995; Ritter 1996).

Time of day modified the influence of boat type on the number of directional changes and clean leaps. Dolphins may be more susceptible to disturbance from early afternoon, as they normally enter a more restful state at that time of day. Alternatively, dolphins may become less tolerant of boats later in the day in response to continued exposure during the day.

5. Case studies

Of the total boat approaches 1.6% were followed by obvious changes in dolphins behaviour.

Case 1:
On 17 November 1993, an active geological exploration vessel *(L'Atalante)* came inshore, south of Kaikoura Peninsula. The sounds of the swath mapping sonar could be heard through an underwater hydrophone well before the boat was seen. The dolphins and whales in the area quickly moved offshore as the boat moved inshore.

Case 2:
On 28 December 1993, at 9:56, a pod of about 200 dolphins was observed swimming slowly at 0.66 m/s. One of the commercial dolphin watching boats drove fast though the middle of the pod, which immediately started swimming faster at 2.14 m/s in the same direction.

Case 3:
On 28 December 1993, at 11:39, a pod of dolphins (same pod as in Case 2) was swimming slowly (0.36 m/s) beside one of the commercial dolphin watching boats and among swimmers. A small private boat drove straight through and around the pod. The dolphins began swimming in several directions and became more spread out.

After the private boat had gone, the dolphins started moving faster (1.35 m/s) and resumed their original direction.

Case 4:
On 30 December 1993, at 13:15, a pod of about 600 dolphins was swimming slowly (0.56 m/s) as a closed pod, with all individuals moving in the same direction. Two private boats drove on either side of the pod from the back to the front and then across the course of the pod. The dolphins changed direction away from the boats and the pod scattered. At 13:17 the dolphins were swimming faster (1.16 m/s) in a different direction from that before the boats arrived.

Case 5:
On 14 January 1994, a pod of about 400 dolphins was swimming at 2.57 m/s with little surface activity. At 12:15 one of the commercial whale watching boats was driving 2 km from the observation site and stopped to scan for the dolphins that were about 300 m away, swimming with little aerial activity. Then several dolphins made leaps that the skipper of the boat most likely saw, as the motors were immediately revved audibly and white water could be seen around the boat. At the same time as the motors were heard revving, the dolphins took off, making long horizontal leaps, with about 200 dolphins in the air at once. The pod continued to travel very fast, porpoising about 300 m for about 30 seconds while the boat slowly moved closer. By 12:17 the boat was stationary, with the dolphin pod then swimming slowly (1.71 m/s).

Case 6:

On 11 February 1994, as one of the commercial dolphin watching boats approached the front of a pod of about 550 dolphins, the dolphins took off fast and travelled away from the boat.

Case 7:

On 12 February 1994, a pod of about 300 dolphins was resting with slow swimming and no aerial activity until a private small runabout approached the pod at high speed. The dolphins took off fast in the opposite direction to the runabout.

Case 8:

On 23 March 1994, an open pod of about 60 dolphins appeared to be feeding from 9:19 to 10:20. The dolphins were mingling, making many clean leaps and birds were diving into the water among the dolphins. This behaviour stopped when one of the commercial dolphin watching boats approached the pod within 300 m and the dolphin pod began swimming in the same direction as the boat.

Case 9:

On 8 April 1994, a pod of about 750 dolphins appeared to be feeding from 9:56 to 10:08, being quite active with birds diving among them. This behaviour stopped when one of the commercial dolphin watching boats approached. The boat stayed with the pod, which did not resume feeding.

Case 10:

On 15 November 1994, at 14:41, a nursery pod (consisting of equal numbers of adult and juvenile dolphins; with juvenile dolphins being about half the size of adults and each swimming predominantly by the side of one adult) was seen swimming in a tight pod for six minutes until two of the commercial dolphin watching boats drove within 20 m of the pod. The pod then dispersed. At 14:53 the pod was still dispersed and was becoming difficult to follow by theodolite. Nursery pods are normally observed in fairly tight pods.

Case 11:

On 17 November 1994, a pod of about 200 dolphins was travelling in a tight pod when a fishing boat drove fast through the middle of the pod at 8:58. The dolphins immediately split into two groups. At 9:04, one half of the pod was swimming towards the other dolphins.

Case 12:

On 7 December 1994, a pod of about 250 dolphins was resting as a tight pod for at least 15 minutes with no aerial activity and swimming slowly. At 10:12, one of the commercial dolphin watching boats approached the dolphins. When swimmers entered the water among the dolphins, the dolphins became noticeably more active.

Case 13:

On 24 January 1995, a pod of about 250 dolphins was swimming at 1.47 m/s at 12:19. One of the commercial whale watching boats approached the dolphins relatively fast (there was still a clear wake behind the boat) within 300 m at 12:20. The pod increased speed and scattered. At 12:21 the boat was moving among the dolphin pod, which had split in two. At 12:22 one half of the pod was moving fast towards the other dolphins. By 12:29 the pod had rejoined and was swimming at 1.0 m/s.

Case 14:

On 2 February 1995, a pod of about 250 dolphins had been moving slowly with a fishing boat stationary within 500 m of the pod for half an hour. The boat suddenly started moving away from the area at high speed and at the same time the pod became more active, with 6 leaps in the air at once. After a couple of minutes the pod became quiet again.

Case 15:

On 3 March 1995, a pod of dolphins was swimming at 3.88 m/s when one of the commercial whale watching boats approached and started driving around within the pod. The dolphins slowed down to 1.23 m/s and changed direction during this time. By 12:06 the boat had left the dolphins, which were then swimming at 1.06 m/s.

These case studies indicate that occasionally dolphins were clearly disturbed by the activities of boats. Typical behaviours were dolphin pods splitting, scattering, stopping with dolphins swimming in different directions, and changing direction and speed. Most of these observations were made when boats failed to abide by the conditions governing behaviour around marine mammals as set out under the MMPR 1992. Numerous other studies have found that rapid movements of boats, with fast shifts in speed or direction, are particularly disturbing to whales and dolphins (Watkins 1981, 1986; Baker & Herman 1989; Beach & Weinrich 1989; Kruse 1991; Baker & MacGibbon 1991). The biological significance of these behaviour changes is unknown, but it is likely to depend on age, reproductive state, and general health of the dolphin(s) concerned, as well as the amount of boat and swimmer activity.

On several occasions resting pods of dolphins showed a change in behaviour when they were approached by boats. Dolphins showed an increase in aerial activity and speed, and pods became more dispersed. Dolphins also appeared to feed for long periods until boats approached, then subsequently interrupted feeding behaviour. Neither resting nor feeding behaviour was resumed once the boat had left the pod. Although dusky dolphins were seen feeding in the daytime, it is not known how often it occurs or how important daytime feeding may be for energy gain. In order to minimise the risk of disturbing dolphins, it may be appropriate to prevent boats from approaching resting pods (slow swimming with little aerial activity) or feeding pods (generally characterised by dolphins moving erratically and making lots of high clean leaps, often with birds diving into the water among them).

6. Summary

- Dolphins are accompanied by boats for a large proportion of the daylight hours, and this proportion increased significantly from the first (65% of observation time) to the second season (78%) of the study.

- For 8.2% of the time more than three boats were present (average of two seasons), and the proportion increased significantly from the first to the second field season.

- Until recently, dolphin watching took place only in summer. Winter trips are now becoming more popular.

- Violations of the dolphin watching regulations occurred during 7.4 percent of all boat approaches.

- Several substantial changes in behaviour were noted, some of which were statistically significant. For example: The numbers of leaps and slaps were greater in the presence of boats from late morning. Dolphin pods are more compact (higher dolphin density) in the presence of boats during mid to late afternoon. The number of leaps and number of directional changes were significantly higher when a mix of different boat types (commercial whale and dolphin watching boats plus private and/or fishing boats) was present after mid morning.

- Statistical power for detecting differences was low in most cases, partly because of the large proportion of time dolphins were accompanied by boats.

- All substantial changes in behaviour occurred after late morning, suggesting that dolphins were more sensitive to disturbance in the afternoon.

- Case studies of noticeable changes in dolphin behaviour in response to boats indicated that these responses were more likely when the dolphin watching regulations were not adhered to.

7. Questions and answers

This section answers specific questions posed by the Department of Conservation and issues raised by tourist operators.

1. *What adverse effects on dusky dolphins at Kaikoura have been demonstrated to be directly attributable to dolphin viewing?*

The numbers of leaps and of directional changes were significantly higher when a mix of different boat types (commercial whale and dolphin watching boats plus private and/or fishing boats) was present after mid morning. This may disrupt normal resting behaviour.

Several substantial, but not statistically significant, changes were noted. For example: The number of leaps and slaps was greater in the presence of boats from late morning. Dolphin pods were more compact (higher dolphin density) in the presence of boats during mid to late afternoon.

Case studies of noticeable changes in dolphin behaviour in response to boats indicate that these responses were more likely when the dolphin watching regulations were not adhered to.

2. What adverse responses are considered to be significant in terms of the ecology and behaviour of dusky dolphins at Kaikoura and why?

A comprehensive answer to this question would require more information on the ecology of dusky dolphins at Kaikoura, in particular their population size, movements, survival, and reproductive rate. The changes in dolphin behaviour in the presence of boats show that although dolphin pods have been exposed to boats for a long time they still react to boat activity. They have not completely habituated to tourism despite several years of frequent exposure. The biological significance of these behavioural changes, in terms of changes to the size or distribution of the dusky dolphin population at Kaikoura, is still unknown.

Some of the results of this study are cause for concern. For example, the increased activity levels when boats are present could interfere with the dolphins' normal patterns of activity and rest. Dusky dolphins at Kaikoura appear to rest during the day. When boats are absent, aerial activity decreases from late morning. Activity levels are higher in the presence of boats. A reduction in the amount of rest may lead to reduced energy for feeding at night. Further research on this question is needed to determine the biological significance of these behaviour changes. This would mean gathering more data on the behaviour of dolphin groups with and without boats, and following dolphins during the night (using a boat, nightscope and hydrophones). The use of dolphin vocalisations as an indicator of feeding activity and success should be investigated. Vocalisations have been used as an indicator of feeding activity for sperm whales in a study of the effects of whale watching at Kaikoura (Gordon et al. 1992). To carry out such a study for dusky dolphins would be a major undertaking.

The large proportion of time that dolphins are accompanied by boats is cause for concern, and makes it very difficult to determine the effects of dolphin watching on the dolphins. To provide clearer answers on behaviour changes and their biological significance requires longer periods without boat activity. This could be achieved by voluntary or regulated "time off" periods for the dolphins, during which their natural behaviour could be studied. It is very difficult to determine whether boats and swimmers affect dolphin behaviour when periods without boats and swimmers are so few and so brief.

From a statistical point of view, the ideal experimental design would have boats present for no more than 50% of the time. The "boats absent" periods would need to occupy a representative range of daylight hours, and would be long enough to allow the dolphins to return to "normal" behaviour. If dolphins take several hours to return to "normal" behaviour after a boat visit, then almost all of the observations reported here represent modified behaviour. A research design of a whole week or day with tourist boats, followed by a week or day without, would have a much better chance of determining the effects of dolphin watching.

3. What dolphin viewing activities elicited noticeable adverse responses from dolphins? How might these be mitigated?

a) The effect of boats on aerial activity and density (see question 1) could be mitigated by reducing boat activity during late morning and early afternoon.

b) Dolphins made more directional changes and more clean leaps when a combination of different boat types was present (fishing and/or private boats at the same time as commercial dolphin watching vessels). It may be difficult for dolphins to predict boat movements when several different types of boats are present. More consistent and predictable boat behaviour would help to avoid and mitigate this effect. In addition, regulations could be developed to direct the second and third boats approaching dolphin pods to the same side of the pod (perhaps excluding widely scattered pods) as the first boat. This would avoid pods being surrounded by boats and may reduce disturbance.

c) Discussions with tourism operators have led to the proposal to have a "time off" period when dolphins appear to spend more time resting. On the basis of the data gathered in this study, we recommend that this period be from 11 am to 2 pm each day. This should apply to private boats as well. DOC may also wish to consider extending this to approaches by planes and helicopters. Further research is needed to improve data on the most appropriate starting point, and in particular the most appropriate end point of the "time off" period.

4. More generally, what additional management measures could be introduced to the existing dolphin watching industry at Kaikoura which could help mitigate any significant adverse effects on dusky dolphins?

- A reduction, or at the very least no increase in the number of boat trips.
- A reduction (no increase) in the number of swimmers in the water at any one time.
- Stricter adherence to (and policing of) the regulations (3 boat rule, speeds, boat movements relative to dolphin group, etc.).
- More policing of boat activity during public holidays when private boats numbers are high.
- Continued training of tourist guides and skippers is essential. An accreditation course for marine mammal tourist operators is in the planning stages. The course will be taught by staff from DOC and the Universities of Otago and Auckland, and will run for the first time in 1999. The aim is to provide recent research results and other biological information directly to tour guides and skippers, to ensure they have access to the most up-to-date and accurate information for their education programmes. The course will also allow exchange of skills and information among tourist operators, and between tourist operators and researchers. Researchers have a great deal to learn from operators as well as the other way. A small group of tourist operators have so far been involved in the design of the course. During the second half of 1998, we will circulate a draft course outline to a wider group for comment.

- More education of private boat operators about how to behave around dolphins. This is complicated by the fact that drawing attention to dolphin watching may increase the number of private boats going out to find the dolphins. An extensive education programme could result in a larger number of (better behaved) dolphin watchers in private boats.

- It may be worthwhile to implement a different set of rules for private boats (e.g. encouraging them to stay further away from dolphins). This may encourage tourists to go on a commercial dolphin watching trip, with a trained skipper, rather than taking their chances at finding and approaching dolphins themselves. Two different sets of regulations, however, would be more difficult to police.

5. What elements of the study demonstrate that additional dolphin viewing effort at Kaikoura could or could not be sustained and why?

- Dolphins are already accompanied by boats for a large proportion of the daylight hours (72% of observation time on average). For 8.2% of the time more than three boats were present.

- The number of boats visiting the dolphins each day already increased significantly from the first to the second field season. This trend appears to be continuing.

- Until recently, swim-with-dolphin activities took place only in summer, from November to April. However, in the past two to three years there has been an increase in commercial dolphin watching during winter months. It now appears that the industry will be operating year round, although with reduced frequency in winter. Long-term photographic identification studies are needed to determine whether the same dolphins are targeted by commercial tours throughout the year. If they are the same individuals, the cumulative summer and winter effects of human disturbance should be considered.

- DOC controls the number of commercial permits, but has no control over the number of private boats, and little control over their movements and behaviour around dolphins. The presence of commercial dolphin watching boats makes it much easier for private boats to find dolphins. An increase in the amount of time dolphins are accompanied by commercial boats would probably lead to an increase in the number of visits by private boats.

- Enforcement of regulationswould be more difficult; 7.4 percent of all boat approaches violated the regulations.

- While outside the scope of this research, tourists may not appreciate seeing several other boats (and at times aircraft also) out with the dolphins. It is possible that the "social sustainability" level has already been reached. Some social science research in this area would help DOC in its decision making.

The "no boat" periods were relatively short and scattered throughout the day, rather than in one continuous period at a predictable time of day. This has two important implications:

a. This makes it extremely difficult to determine the effects of dolphin watching on the dolphins. Subtle changes in behaviour, which could be important long-term, were not detectable by this study because dol phins were accompanied by boats for most of the observation time. Several behaviour changes were noted in this study, and the biological significance of these behaviour changes is not yet known. More boats will make it even more difficult to study the effects of dolphin watching.

b. If dolphin watching modifies dolphin movements or behaviour in ways that are biologically important, having boats accompany dolphins for such a high proportion of the time increases the risk of adverse effects such as dolphins leaving the area, avoiding boats, or becoming aggressive towards swimmers.

Any increase in the level of dolphin watching activity would, of course, increase risk further. The economic and educational value of dolphin watching underscores the need to make precautionary decisions about boat numbers and boat activity.

In summary, none of the findings of this study suggest that additional dolphin-viewing effort could be sustained without risk. This study shows that current activity levels change dolphin behaviours and present risks to the dolphin population. More boat approaches would increase that risk. The results of this study certainly do not justify an increase in commercial dolphin-watching effort

6. How might additional dolphin viewing effort be managed so as to avoid, remedy and mitigate adverse effects on dusky dolphins?

Additional dolphin viewing effort should not be considered.

7. Notwithstanding questions 5 and 6, in your professional opinion, what additional commercial dolphin viewing effort should be permitted at Kaikoura and why?

We do not support additional dolphin viewing effort. Current dolphin watching modifies some aspects of dolphin behaviour. More research is required to determine whether these behaviour changes are biologically significant. Meanwhile, a precautionary approach would be appropriate.

8. As a result of the research, or otherwise, in your opinion what amendments need to be made to Regulations 18-20 of the Marine Mammals Protection Regulations 1992 to give better protection to dusky dolphins and why?

The "3 boats and/or aircraft" rule needs to be made clearer. Some operators seem to interpret this rule as meaning that the limit is 3 boats plus 3 aircraft.

This interpretation would allow a very high level of interaction with the one dolphin pod, which is undesirable from the point of view of the tourists as well as the dolphins. The effect of aircraft on dolphins is a separate issue and needs to be addressed in future research.

It would be useful to clarify the regulations on approaching "juvenile dolphins". More information specifying the relative size (e.g. less than half of the size of the adults) would help. Without some clarification, skippers are likely to develop their own definition of what is a juvenile dolphin or a nursery pod. This could result in little if any protection for breeding females and their young calves.

It may be appropriate to include fishing boats under the control of the Marine Mammals Protection Regulations, to prevent fishing boats from driving straight through dolphin pods. Since this study was completed, regulations for film makers have been changed. Film makers are now required to use a boat driven by a permitted operator.

Any changes that would enhance the chance of people who breach the regulations being apprehended and successfully prosecuted would be desirable. A legal expert should be approached to help with this.

8. Management implications

Dolphin responses to approaches by boats and swimmers could potentially be managed or reduced by:

- Reducing boat activity from late morning
  Discussions with tourism operators have led to the proposal to have a "time of" period from late morning, to cover the period when dolphins appear to spend more time resting. We recommend that dolphins not be approached by any boats (including private boats) from 11 am to 2 pm each day.

- Ensuring there is no increase in dolphin tourism
  Dolphin tourism has the potential to increase within the limits of current dolphin watching permits, as most of the operators are not operating to the capacity of their permit. For example with increasing tourist demand, the tourist season is lengthening into the winter months.

  It would be prudent not to grant any further permits for dolphin watching, and not to allow any increases in the number of boat trips allowed per day or the number of swimmers allowed in the water at any one time. There is a need for forward planning, setting a limit on the number of commercial boat trips now rather than waiting until serious problems arise.

There may be some scope for reducing the number of boat trips, without economic losses, by increasing the number of tourists per boat trip. Within reason, it may be possible to achieve this by using larger boats.

- Clarification and better policing of regulations
  Better adherence to and more policing of the dolphin watching regulations would be beneficial. This would require more resources for education and policing. The "3 boats and/or aircraft" rule and regulations on approaching "juvenile dolphins" need to be made clearer. It may be appropriate to include fishing boats under the control of the Marine Mammal Protection Regulations.

- More training for tourist operators
  An accreditation course for marine mammal tourist operators is in the planning stages. It would be advantageous for new and existing permit applicants to participate in this course, to ensure a consistently high level of training.

- More education of private boat owners
  Private boats are much more prone to breaking the regulations than professional tourism operators. Education about how to behave around dolphins could help.

9. Conclusion

Dusky dolphin tourism at Kaikoura is very successful. We are hopeful that with careful management it will be sustainable, and will have educational and conservation as well as economic benefits. The research and management recommendations made in this report are aimed at providing a basis for sound management of dolphin tourism in New Zealand. We hope they will also be of benefit to researchers and managers elsewhere.

10. Acknowledgements

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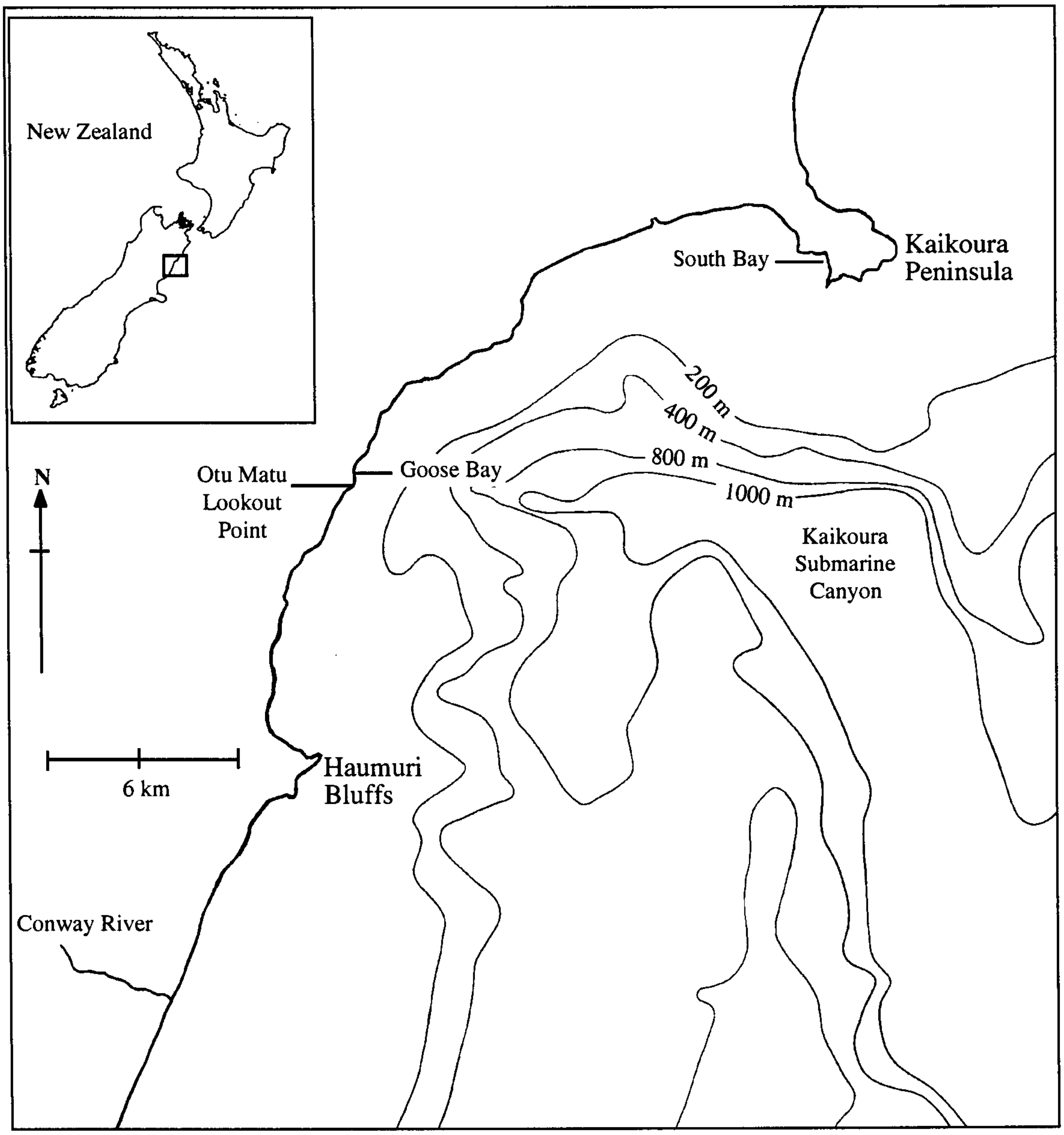

Figure 1 . Map of the Kaikoura study site showing Ota Matu Lookout Point (where behavioural observations of dolphin pods were made) and water depth contours.

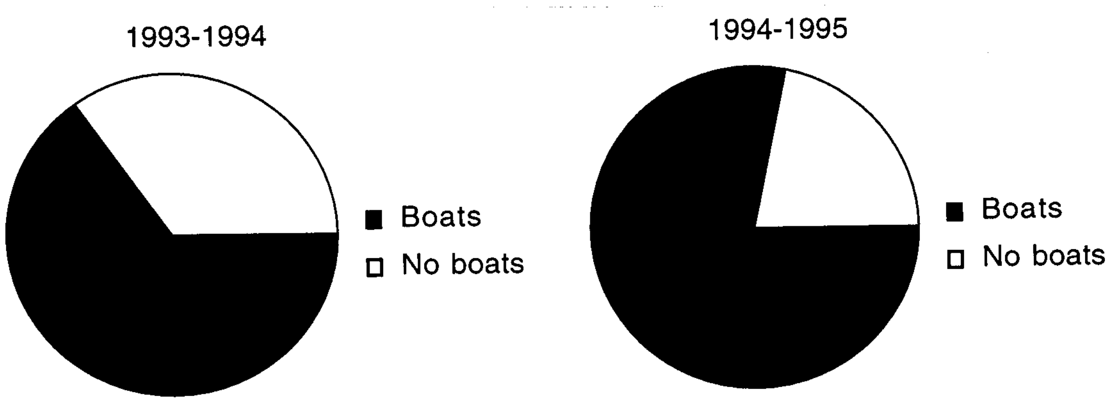

Figure 2 . Proportion of total observation time that boats were present and absent within 300 m of a focal dolphin pod during the first and second field season.

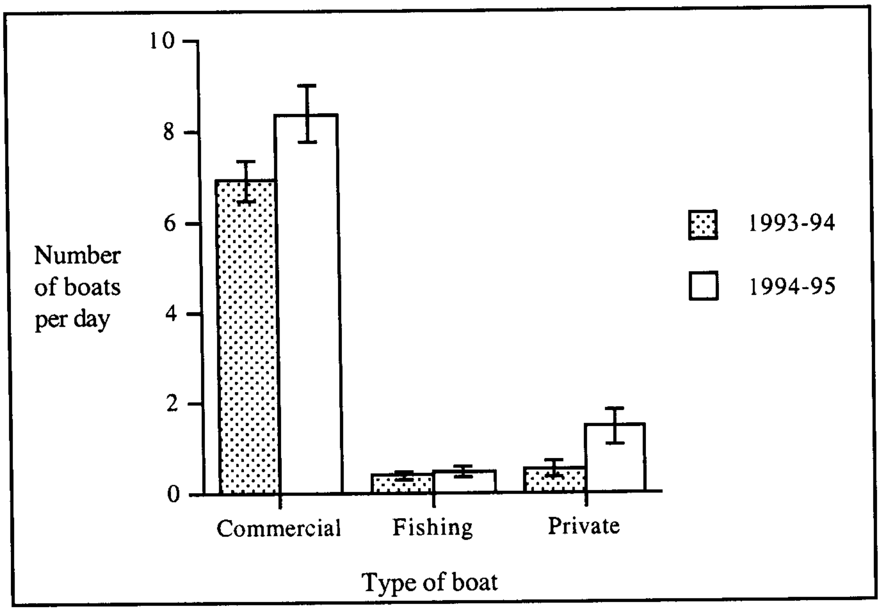

Figure 3. Mean number of commercial dolphin and whale watching, fishing and private boats that approached within 300 m of a focal dolphin pod per day during the first (Dec 93 - Mar 94) and second (Dec 94 - Mar 95) field seasons. Error bars are standard errors of the mean. P values represent the probability of the difference occurring by chance. NS = not statistically significant.

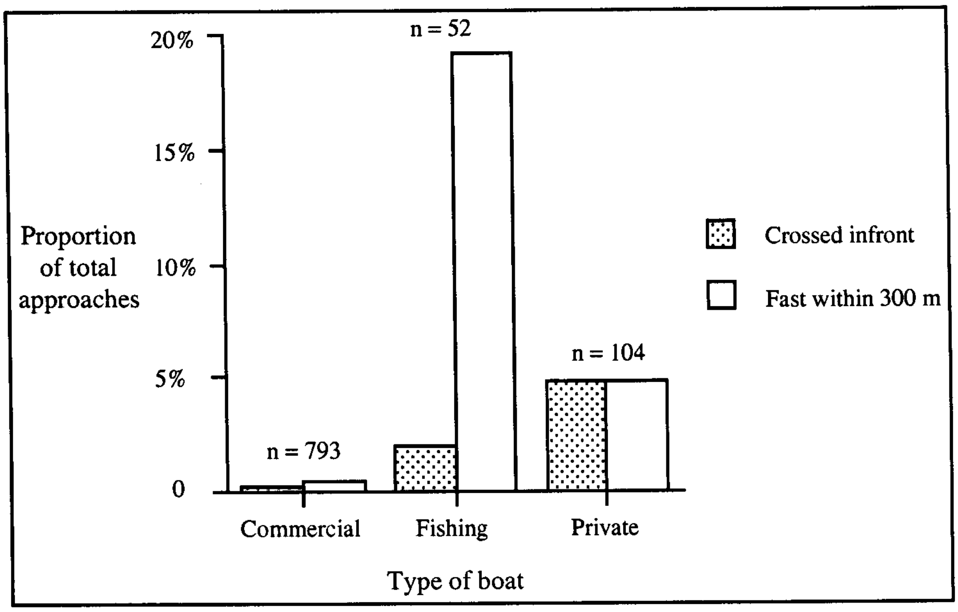

Figure 4. Proportion of total approaches that commercial dolphin and whale watching, fishing and private boats crossed in front of a dolphin pod or drove fast within 300 m of a dolphin pod.

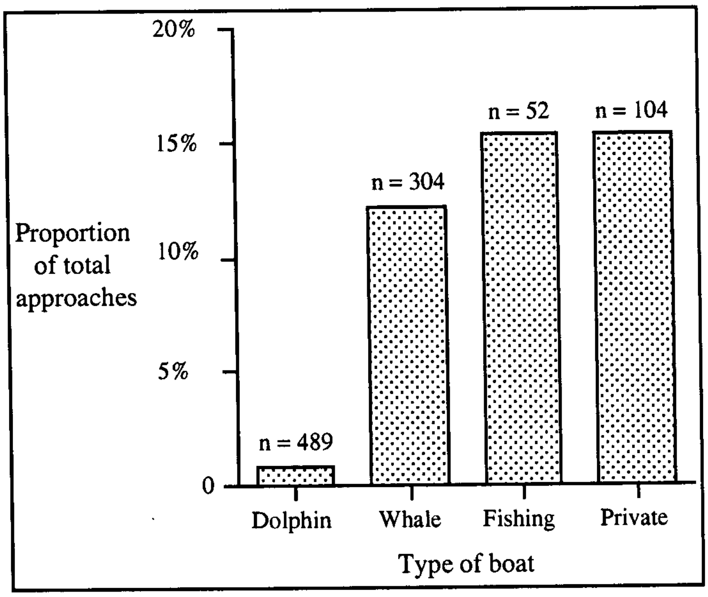

Figure 5. Proportion of approaches on which boats drove through a dolphin pod for each type of boat.

Table 1. Summary of the differences detectable (with 95% power) in dolphin behaviour between observations made in the presence and absence of boats. 'Detectable differences given as an absolute value due to use of different methods for back-transforming to the original scale.

Behaviour	Detectable difference
Dispersion (m)	58%
Dolphin density	59%
Speed (m/s)	21%
Number of clean leaps/100 dolphins	29%
Number of slaps/100 dolphins	1.83*
Number of directional changes	≥1*

Table 2. Summary of the differences detectable (with 95% power) for changes in dolphin behaviour between observations made in the presence of different numbers of boats. * Detectable differences given as an absolute value due to using different methods for back-transforming to the original scale.

Behaviour	Detectable differences
Dispersion	48%
Dolphin density	53%
Speed	16%
Number of directional changes	≥1*
Number of clean leaps/100 dolphins	200%
Number of slaps/100 dolphins	1.39*

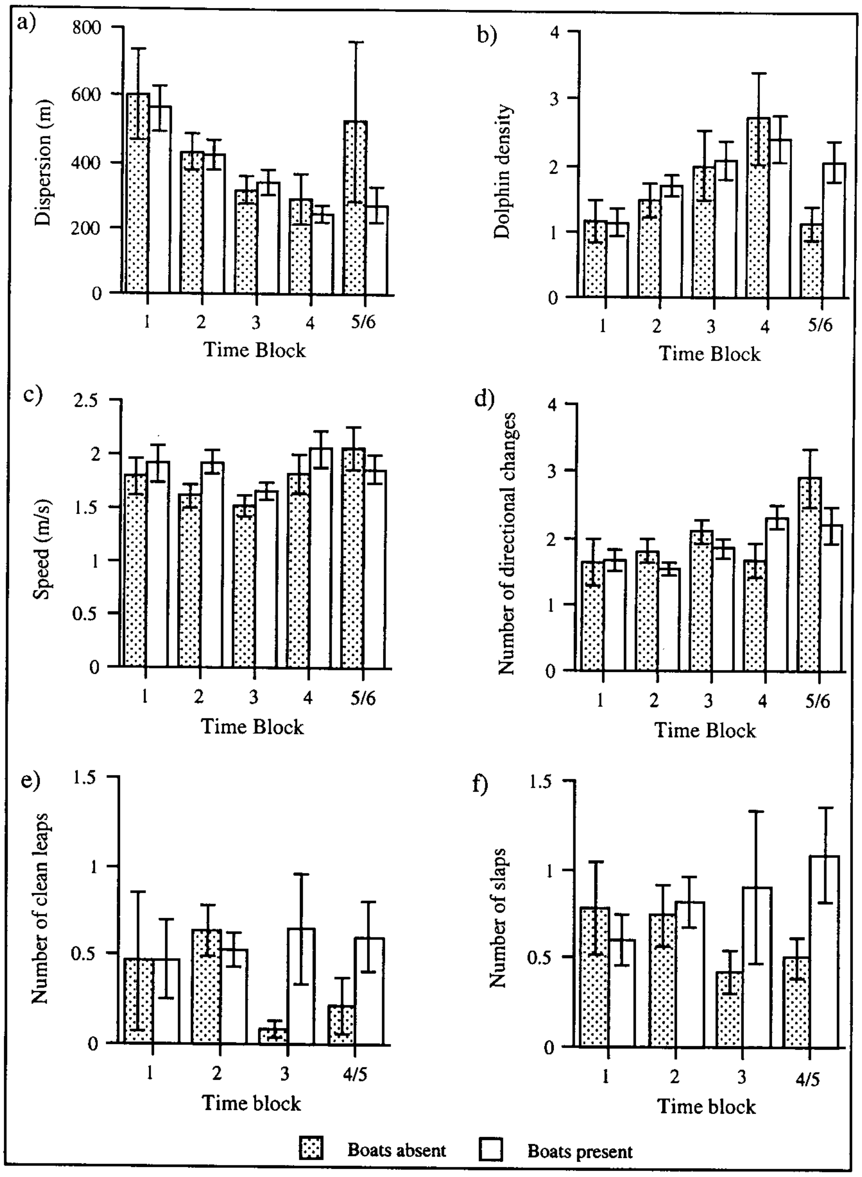

Figure 6. Dolphin behaviour (a) pod dispersion, b) dolphin density (number of dolphins per m2), c) speed (m/s), d) number of directional changes, e) number of clean leaps per 100 dolphins and f) number of slaps per 100 dolphins) in the presence and absence of boats during different time blocks. Each time block represents a two-hour period with the first block beginning at sunrise. Time blocks 5 and 6 are combined for a) to d) and time blocks 4 and 5 are combined for e) and f). Error bars represent standard error of the mean.

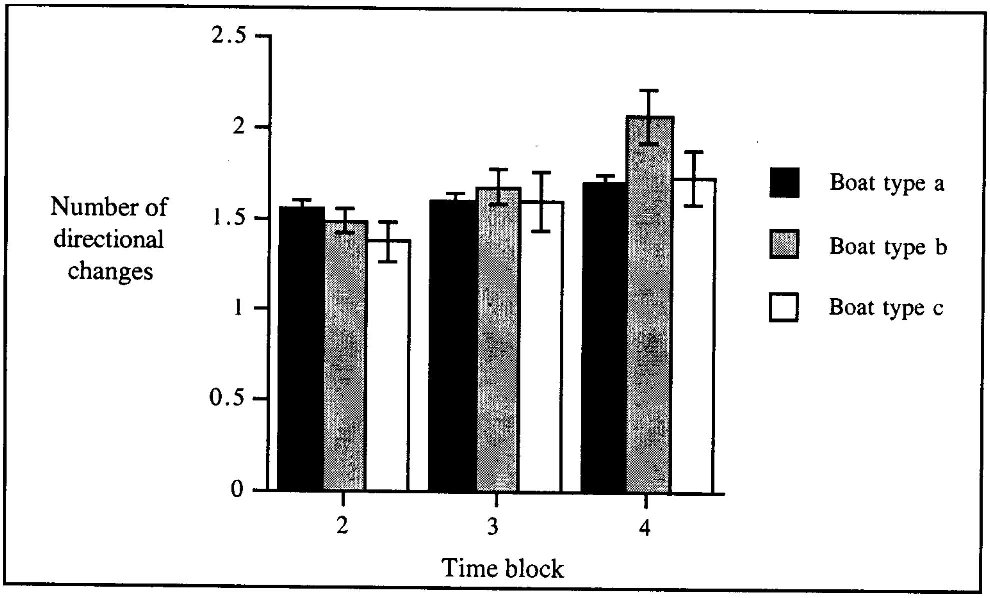

Figure 7. Mean number of directional changes made by dolphin pods during different time blocks in the presence of different types of boats (a = commercial boats only, b = commercial boats and fishing and/or private boats and c = fishing or private boats only). Error bars represent standard error of the mean.

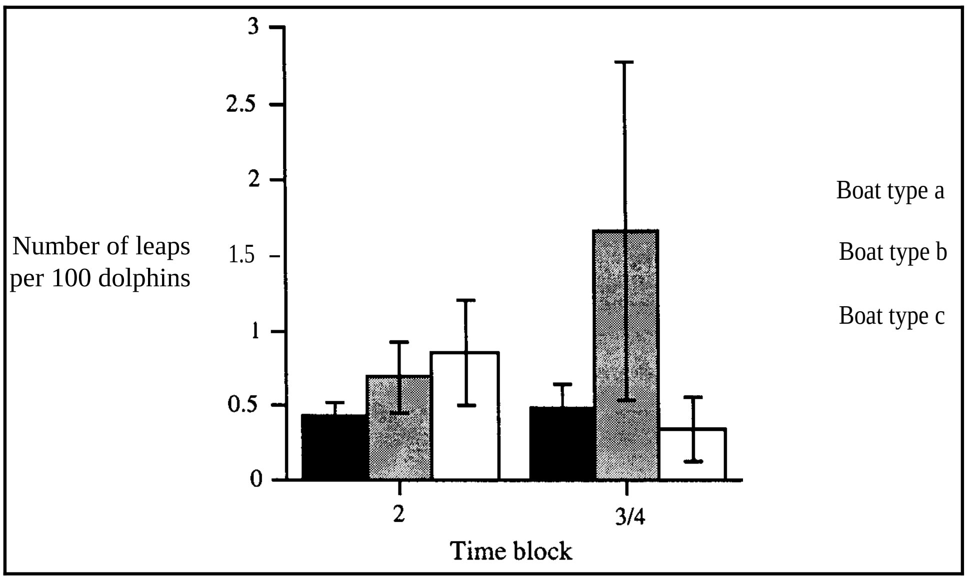

Figure 8. Mean number of clean leaps per 100 dolphins during different time blocks in the presence of different types of boats (a = commercial boats only, b = commercial boats with fishing and/or private boats and c = fishing or private boats only). Time blocks 3 and 4 are combined. Error bars represent standard error of the mean.