Effects of tourism on behavioural ecology of bottlenose dolphins of northeastern New Zealand

DOC SCIENCE INTERNAL SERIES 153

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Published by
Department of Conservation
PO Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed.

Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are listed in the DOC Science Publishing catalogue on the website, refer http://www.doc.govt.nz under publications, then Science and Research.

ISSN 1175-6519

ISBN 0-478-22527-X

In the interest of forest conservation, DOC Science Publishing supports paperless electronic publishing. When printing, recycled paper is used wherever possible.

This report was prepared for publication by DOC Science Publishing, Science & Research Unit; editing and layout by Lynette Clelland. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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ABSTRACT

A study of the behaviour of bottlenose dolphin (*Tursiops truncatus*) in the Bay of Islands, Northland, New Zealand showed that the dolphins were affected by the presence of the permitted dolphin-watching boats beyond the effect of any other type of boat (i.e. recreational or non-permitted commercial boats). In particular, resting behaviour decreased and milling behaviour increased when the permitted boats were present. The change from 'discrete' to 'staggered' boat departures and an increase in the number of permitted operators has resulted in an increase in interaction time. This has resulted in further decreases in dolphin resting behaviour. Dolphin response to swim attempts is affected by swimmer placement, and avoidance behaviour has increased over time. The 'line abreast' placement results in the fewest avoidance responses, and it is recommended that swimmers only be placed in the water 'line abreast' of the dolphins' path of travel. Examination of the spatial distribution and habitat use of dolphins in the Bay of Islands showed that there was a difference in the frequency of behavioural states observed in four zones, but all areas in the Bay of Islands were important. Although these results demonstrate impact, no threshold on the number of permits can be recommended. Nonetheless, to minimise the effects of the permitted boats on dolphin behaviour, it is recommended that no further permits should be issued. A change in the current operating times of the existing tours would reduce the effects of the permitted operators' boats.

Keywords: Human–dolphin interaction, bottlenose dolphins, *Tursiops truncatus*, tourism, Bay of Islands, human impact, boat impacts, swim-with-dolphins, habitat use, New Zealand.

Constantine et al. 2003: Effects of tourism on behavioural ecology of bottlenose dolphins of northeastern New Zealand. *DOC Science Internal Series 153*. Department of Conservation, Wellington. 26 p.

1. Introduction

Cetaceans are charismatic animals with a wide appeal for many people. Bottlenose dolphins (*Tursiops truncatus*) are readily found in coastal waters around the world (Jefferson et al. 1993) and are therefore readily accessible to many people. This has resulted in financially viable businesses being set up, based on taking tourists to see them (IFAW 1999). The combination of these factors has led to the rapid growth in cetacean-based tourism both overseas (Hoyt 2000) and in New Zealand (Constantine 1999).

In New Zealand, the 1978 Marine Mammals Protection Act was passed to protect all marine mammals in New Zealand waters. In 1990, the Marine Mammals Protection Regulations were drafted to provide a series of guidelines for issuing permits and for regulating human behaviour around marine mammals (Donoghue 1996). These Regulations were reviewed in 1992, in response to the rapid increases in recreational vessels targeting marine mammals and in commercial operators applying for permits to conduct tours to watch and / or swim with marine mammals.

The purpose of the 1992 Marine Mammals Protection Regulations is:

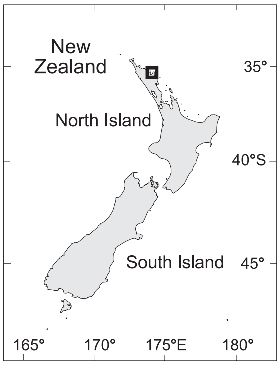
… to make provision for the protection, conservation, and management of marine mammals and, in particular,

(a) To 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:

(b) To prescribe appropriate behaviour by commercial operators and other persons seeking to come into contact with marine mammals.

In 1993, the Northland Conservancy of the Department of Conservation (DOC) investigated the possibility of initiating research on the potential impacts of the expanding swim-with-dolphin tourism industry in the Bay of Islands (Fig. 1). Research on bottlenose and common dolphins (*Delphinus delphis*) began in 1994 and resulted in preliminary findings on the distribution and habitat use of these species, and the effects of boats and swimmers (Constantine 1995; Constantine & Baker 1997). Constantine's (1995) research showed that the species most frequently exposed to tourism was the bottlenose dolphin, and key areas of concern have been highlighted (Constantine & Baker 1997). The decision was made by DOC to continue research specifically on bottlenose dolphins and the potential long-term impacts of tourism. Ph.D. research was initiated in late 1996 by R. Constantine, and population size, ranging patterns, life history parameters, habitat use, and the potential impacts of swimmers and boats on bottlenose dolphin were studied.

The questions addressed in this report were compiled by Northland Conservancy at the completion of the research, so some management questions were unable to be comprehensively answered. The present report is based primarily on R. Constantine's Ph.D. research, which was concluded in March 2000 (Constantine 2002). The questions relating to commercial swim-with-dolphin activities have also included data collected from 1994 to 1995 (Constantine 1995; Constantine & Baker 1997), which have recently been published (Constantine



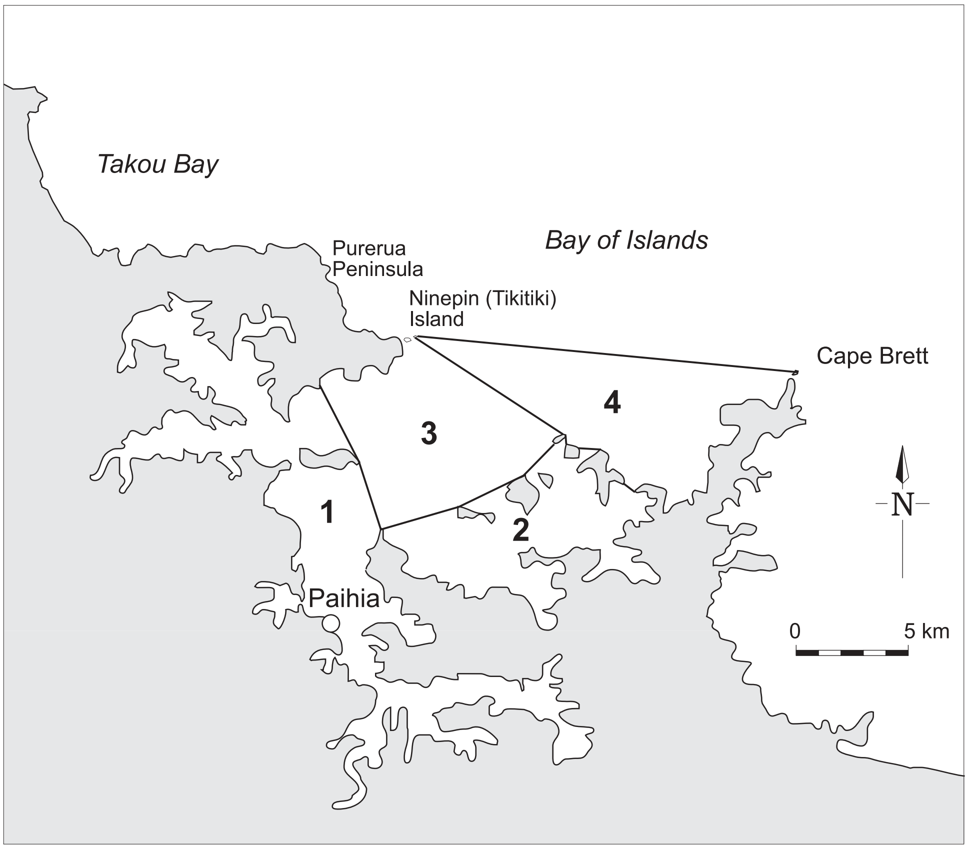


Figure 1. The four zones within the Bay of Islands: 1—inner bay, 2—inner islands, 3—middle ground, 4—outer bay.

2001). Some of the questions relating to the effects of vessel traffic are currently in press (Constantine et al. in press) The following questions are addressed in this report:

1. Should 4 permitted vessels be allowed within 300 m of a pod of bottlenose dolphins?
2. Has the increase in the number of permitted vessels since this research started had an effect on the bottlenose dolphin population?
3. Has the staggered departure times of permitted vessels adversely affected the bottlenose dolphins?
4. Are the dolphins being disturbed by permitted vessels re-encountering the same pod of dolphins during the same trip?
5. Does the current number of swim attempts have any adverse effect(s) on bottlenose dolphins?
6. Does the current number of swimmers have any adverse effect(s) on bottlenose dolphins?
7. Does the habitat use of the Bay of Islands by bottlenose dolphins indicate that some areas should be excluded from the permitted marine mammal operators' area of operation?
8. Should there be a decrease in the number of permitted vessels operating in the Bay of Islands / Northland Conservancy area?

Some of the questions (2 & 3, 5 & 6) are closely related and addressed together in this report.

2. Background

These questions needed to be addressed because of changes in the number of dolphin tour boats and their methods of operating during the period of the research.

At the initiation of the research in December 1996, there were four operators taking passengers to swim with dolphins. Three of these—Dolphin Discoveries, Fullers Northland, and Heritage Tours—operated a maximum of two trips per day which departed from Paihia at approximately 0800 and 1230 h each day. The fourth operator—Carino New Zealand—operated one trip per day and an encounter with the dolphins was part of a larger day-sailing tour throughout the bay. They infrequently encountered dolphins and contributed only minimally to the data set on dolphin behaviour in the presence of the permitted operators.

In December 1998, a permit was issued to King's Tours to operate one swim-with-dolphin tour per day from the vessel 'Explorer II'. In January 1999, Dolphin Discoveries began operating two dolphin viewing tours per day from 'Discovery IV'. The initiation of these tours, as well as a change in operating time for Heritage Tours, resulted in the operators changing from discrete departure times to staggered departure times. This resulted in a change from three boats leaving at 0800 and 1230 h and one boat leaving at 1000 h, to two boats leaving at 0800 h, two at 0900 h, two at 1000 h, two at 1230 h, one at 1300 h, and one at 1330 h.

This frequently resulted in the permitted boats overlapping their encounters with the same group of dolphins and thereby increasing the length of time a group was exposed to at least one permitted operator. These two departure procedures are referred to in the rest of this report as 'discrete' and 'staggered'.

3. Methods

3.1 FOCAL FOLLOWS TO DETERMINE THE EFFECT OF VESSELS—QUESTION 1

Between 5 December 1996 and 27 February 2000, a total of 55 days and 260.5 hours were spent conducting 'follows' on dolphin focal groups from an independent research boat. Focal groups ranged in size from 2 to 50 individuals and were divided into four group size categories: 2–10 (n = 17), 11–20 (n = 20); 21–30 (n = 8), and 31–50 (n = 10). The data were analysed separately by season.

A total of 7595 two-minute focal group scan samples (Altmann 1974; Mann 1999) were collected during the 55 independent observation periods (see Table 1 for definitions of behavioural states). Definitions of behavioural states were modelled on Shane et al. (1986) and modified from those used in Constantine (1995). Summer (n = 3086) and autumn (n = 2530) had the greatest number of recorded observations, and winter (n = 1393) and spring (n = 586) had the least. The majority of observations for any one category of boat number were made during the absence of vessels other than the research boat (42%, $n = 3192$). There were a decreasing number of observations for subsequent numbers of boats (up to the category 4+ boats).

Focal groups were always encountered by the permitted operators at some point during each sampling period. Therefore, data collected on minimum disturbance was limited to varying periods of time when the research boat was the only boat present. Despite these limitations, *a priori* comparisons of dolphin behaviour in the presence of the research boat v. all other boats showed a significant difference for all seasons. This suggests that the research boat, when handled carefully, could be considered as a suitable observation platform to contrast behaviour in the presence of boats other than a carefully driven research boat. This does not suggest the research boat itself had no impact, but that measured changes occurred over and above the effect of the research boat.

3.2 DEFINITION OF BOAT ENCOUNTER—QUESTIONS 1–4

A boat encounter was considered to be initiated whenever a boat of any type came within 300 m of the focal group with the intention of viewing or swimming with the dolphins. Under the New Zealand Marine Mammals Protection Regulations (1992), 300 m is the distance whereby all boats (i.e. permitted and non-permitted) must slow to idle or no wake speed when the intention is to view marine mammals (Regulation 18(l)). For the purpose of consistency, 300 m was also chosen for this study.

Encounters could involve people either viewing or swimming with dolphins and there was no minimum or maximum time period defining an encounter. The number of boats encountering the dolphins were recorded as 1, 2, 3, and 4+ where '1' was the research boat. Even though there was a maximum number of 21 vessels observed with the focal group, the sample sizes for all numbers greater than four boats were small, therefore pooling the data resulted in a sample size comparable to the other categories.

Boats were divided into three categories: permitted operators, non-permitted operators, and recreational boats. Permitted operators spent longer periods of time with the dolphins than any other boat type (Berghan 1998). There were seasonal differences in the number of boats on the water with summer being the busiest time of year (Constantine & Baker 1997).

Changes in the behaviour (see Table 1 for definitions) of dolphins due to the number of boats, boat type, season, and group size were tested using the CATMOD procedure (SAS 1996). This categorical data-modeling method uses a maximum-likelihood estimator to obtain a chi-squared approximation of the probability for each factor in the model. The data were also tested to determine whether there was an interaction effect between the independent variables 'group size' and 'number of boats'. The level of autocorrelation which would normally be associated with continuous sampling was minimal in this study as the number of boats present varied over short periods of time. Any autocorrelation that remained after allocating the 2-minute samples was examined using the autoregressive (AR(1)) option in the model, and was found to be non-significant (SAS 1996).

3.3 EFFECT OF DISCRETE V. STAGGERED BOAT DEPARTURE TIMES—QUESTION 3

The effect of the discrete v. staggered departures on dolphin behaviour was tested using CATMOD (SAS 1996). To avoid an interaction of seasons, this test was conducted separately for summer and autumn. Winter and spring did not have sufficient sample sizes to run the analysis. The data were tested to determine whether there was an interaction effect between the independent variables 'group size' and 'number of boats'. A significant interaction effect was found so a full factorial model was used for the analysis. The autumn data set had sufficient sample sizes only for analysis of group sizes 2–10 and 11–20 dolphins.

3.4 FREQUENCY OF SWIM ENCOUNTERS—QUESTIONS 5 & 6

During the two boat-based research periods used for the analysis, 1994–95 and 1997–98, the dolphins were exposed to three vessels running tours up to twice daily for a maximum of 42 trips per week. Data were collected primarily from the three commercial swim-with-dolphin tour boats (96%, n = 260 of recorded swims) but when conditions were comparable, data were collected from a smaller, independent research vessel. This accounted for 4% (n = 11) of recorded swim attempts (Constantine 2001).

Swims were usually attempted with dolphin groups without calves. A group was defined as any number of dolphins moving in a similar direction, engaged in similar behaviors and within five body lengths of any other dolphin (Shane 1990; Fertl 1994). Groups could contain various combinations and numbers of neonates, calves, juveniles and adults.

3.5 SWIMMER PLACEMENT AND DOLPHIN RESPONSE—QUESTIONS 5 & 6

Quantitative data to examine the effects of swimmer placement on dolphin response, and the change in response over time were collected using focal group scan sampling methods (Altmann 1974; Mann 1999).

Initial observation of the swim-with-dolphin operations indicated that they consistently used one of three strategies to place swimmers in the water:

1. 'line abreast', i.e. the swimmers were placed to the side and slightly ahead of the dolphins' path of travel,
2. 'in path', i.e. the swimmers were placed in the dolphins' path of travel, and
3. 'around boat', i.e. the boat was stationary and dolphins were milling around the boat when swimmers entered the water.

The dolphins' response to swimmers was defined as one of the following:

1. interaction, i.e. at least one of the dolphins repeatedly swam (milling) within 5 m of at least one swimmer (the minimum interaction time was 15 s),
2. neutral, i.e. no apparent change in dolphin behavior, and

3. avoidance, i.e. the dolphins either changed their path of travel away from the swimmers, or dived and surfaced away from the swimmers.

Immediately prior to swimmers entering the water, a focal group scan sample (Altmann 1974) was conducted to determine the behavioral state of the dolphins. The chance of re-sampling the same individual was minimal as the average group size was small (11.8 ± 10.05, range 2–50 individuals), and the scan was conducted rapidly (Mann 1999).

At the initiation of a swim attempt a scan sample of the focal group was conducted and the dolphins' response was recorded within five seconds of the first swimmer entry (Altmann 1974; Mann 1999). This was used to determine the dolphins' response to swimmer placement.

To test whether the differences in dolphin response were caused by swimmer placement alone or if changes in response were also affected by time, a categorical maximum likelihood ANOVA (SAS 1996) was used. When more than one swim was attempted per group, independence of the first and subsequent swim attempts were tested for (Constantine 2001).

TABLE 1. DEFINITIONS OF DOLPHIN BEHAVIOURAL STATES.

BEHAVIOURAL STATE	DEFINITION
Social	Dolphins observed leaping, chasing and engaged in body contact with each other. Involved aspects of play and mating with other dolphins. Serves a social and sexual role.
Forage	Dolphins involved in any effort to capture and consume prey as evidenced by chasing fish on the surface, co-ordinated deep diving with loud exhalations (but not chuffing) and no contact between individuals (as often observed when socialising), and rapid circle swimming (but not chasing another dolphin). Prey is sometimes observed in the dolphin's mouth and frequently observed during the foraging bout.
Rest	Dolphins engaged in very slow movements as a tight group (i.e.< one body length between individuals). Movements are slower than those seen in slow travelling behaviour. Resting lacks the active components of the other behaviours described.
Slow travel	Dolphins involved in persistent directional movement at speeds less than three knots.
Slow travel—other	Dolphins involved in persistent directional movement at speeds less than three knots but were also engaged in equal amounts of another behaviour (forage, social and mill).
Travel	Dolphins involved in persistent directional movement at speeds of greater than three knots.
Mill	Dolphins showing frequent changes in heading that sometimes appear as a transition behaviour between other behavioural states. Milling may be associated with foraging, socialising or play.

3.6 HABITAT USE OF THE BAY OF ISLANDS—QUESTION 7

Surveys for bottlenose dolphins were conducted in the Bay of Islands between December 1996 and February 2000. During these surveys, focal groups of dolphins were followed, and data on their behaviour and position (using a Garmin 45XL GPS) were collected. The groups' behavioural states were recorded every 10 min. using a focal group scan sampling method (Altmann 1974; Mann 1999).

The surveys of the Bay of Islands were not designed to equally weight search time in the various areas, but all areas were covered on a frequent basis. Because of the complex geography of the Bay of Islands, including many islands, and weather that would allow some areas to be surveyed at a particular time, but not others, transects were not used. Instead, a focal group follow methodology (Altmann 1974; Mann 1999) was used. With an average of 1.2 groups of bottlenose dolphins in the Bay (calculated from the number of groups encountered per survey on the tour operators' boats), the focal group was likely to be the only group encountered. Subsequently, the assumption was made that the focal group followed was representative of the dolphins' use of the Bay.

When a focal group was encountered, the initial position was recorded, and after this, the time and position of the group was automatically stored in the GPS unit every 10 min. At the end of the day, the GPS data were downloaded into the computer using MACGPS. The way-points were then saved onto Excel spreadsheets, and the behavioural states recorded were matched to the time and GPS position. These data were plotted using the ARCMAP extension of ArcView (Environmental Systems Research Institute 1996) on a digitised nautical chart (N.Z.5122) (Land Information New Zealand, Wellington, New Zealand). In addition, the initial position of encounter was recorded for groups encountered that were not the subject of a focal follow.

A total of 138 groups of dolphins were encountered on 123 days. Focal group follow data were collected from 31 independent groups of dolphins, over 28 days, between 5 December 1996 and 27 February 2000. A total of 276 h 36 min of focal follows were conducted, with an average duration of 4 h 43 min (s.e. = 18 min, range = 60 min – 7 h 42 min). During these follows, 847 GPS positions and their associated behavioural state were recorded.

A total of 752 data points were plotted into one of the four zones in the Bay of Islands; i.e. inner bay, inner islands, middle ground, and outer bay (Fig. 1). Ninety-five of the total number of data points were not included in the analysis because they were collected in areas outside the limits of the chart used, e.g. Waikare Inlet and Te Puna Inlet. To examine spatial distribution and habitat use of the rest of the Bay of Islands, the Bay was divided into four areas delineated by the similarity in oceanographic features. These four areas were: 1—inner bay, 2—inner islands, 3—middle ground, and 4—outer bay (Fig. 1). Variations in behavioural states recorded in each of the zones were examined.

4. Results and Discussion

4.1 SHOULD 4 PERMITTED VESSELS BE ALLOWED WITHIN 300 m OF A POD OF BOTTLENOSE DOLPHINS?

The research showed no difference in dolphin behaviour in the presence of non-permitted tour boats and recreational boats, and subsequently they were combined for comparison with dolphin behaviour in the presence of the permitted boats. There was a difference in dolphin resting and milling behaviour in the presence of permitted v. non-permitted boats in autumn (for group size 2–10 dolphins), summer, and spring (Table 2). Overall, significantly more resting and less milling behaviour was observed in the presence of the non-permitted boats (Fig. 2).

Bouts of resting behaviour were rarely observed in the presence of the permitted boats. Of 74 observations of permitted boats, resting behaviour was observed on only 8.1% (n = 6) of occasions, although it often occurred when other non-permitted boats were present. Examination of dolphin resting behaviour after the operators' departure showed 78.9% (n = 45) of the time the last permitted operator departed from the morning or afternoon tours, the dolphins entered a bout of resting behaviour (usually within 20 mins of departure) (Fig. 3).

These results show that the permitted boats do have an effect on dolphin behaviour, in particular resting and milling behaviour, and that the presence of one permitted boat is sufficient to cause these changes in behaviour. The New

TABLE 2. GLS ANALYSIS OF CONTRASTS BETWEEN PERMITTED BOATS v. NON-PERMITTED BOATS BY SEASON. SUMMER AND AUTUMN WERE TESTED USING A FULL FACTORIAL MODEL, AND WINTER AND SPRING WERE TESTED USING A MAIN EFFECTS MODEL.

SEASON	GROUP SIZE	χ^2	D.F.	P
Summer		64.24	7	< 0.000
(n = 1603)	2–10 dolphins	22.70	7	0.0019
	11–20 dolphins	52.39	7	< 0.000
	21–30 dolphins	14.59	7	0.036
	31–50 dolphins	28.88	7	< 0.000
Autumn		1.33	7	0.988 NS*
(n = 976)	2–10 dolphins	22.35	7	0.002
	11–20 dolphins	2.14	7	0.952 NS
	21–30 dolphins	9.63	7	0.210 NS
	31–50 dolphins	7.92	7	0.340 NS
Winter (n = 1116)		11.89	7	0.104 NS
Spring (n = 208)		15.93	7	0.026

* NS denotes a non-significant result.

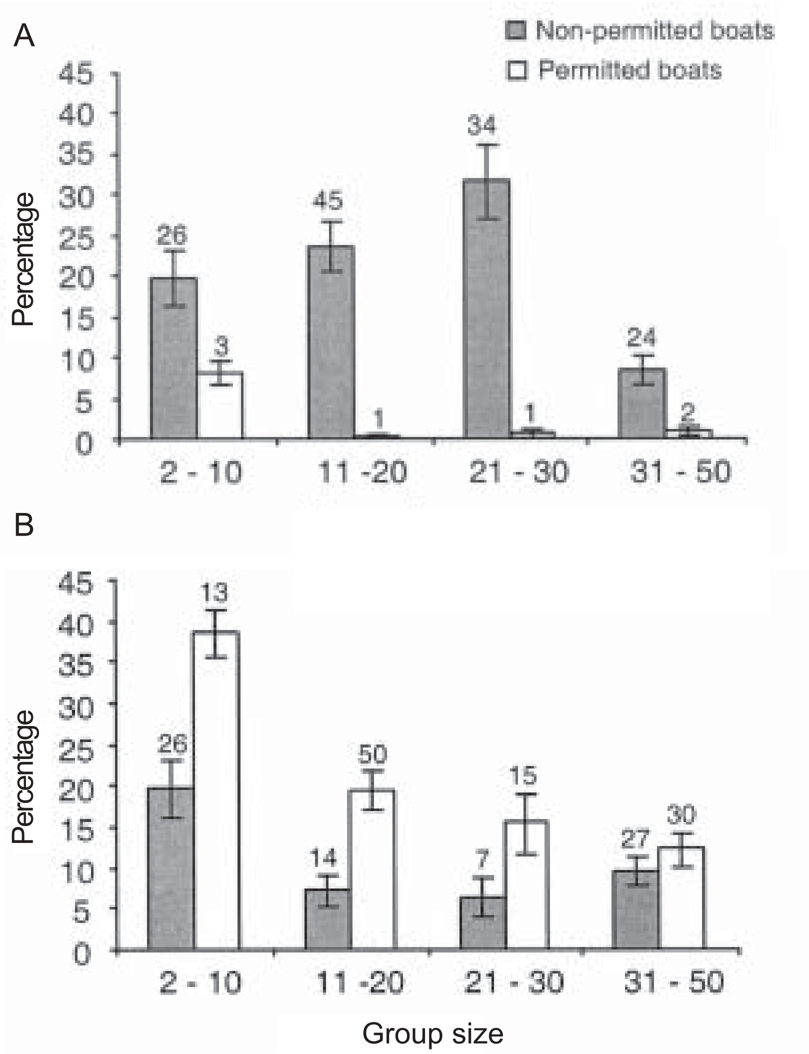


Figure 2. A = Resting behaviour with non-permitted boats by dolphin group size in summer. B = Milling behaviour with non-permitted boats by group size in summer. The values on the y axis represent the percentage of behaviour observed in the boat category that was resting behaviour (A) and milling behaviour (B). N values above 95% CI error bars (Constantine et al. in press).

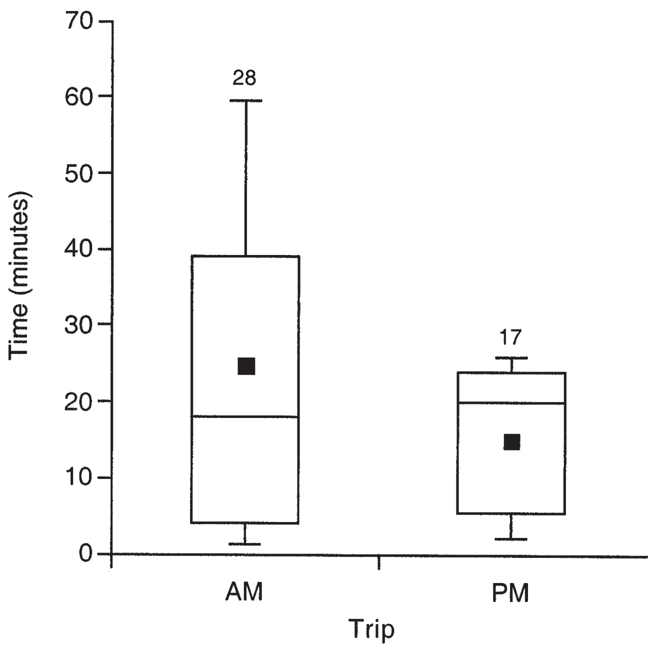


Figure 3. Time until rest after the permitted boats' departure (morning and afternoon trips) from the dolphins. The horizontal bars show the 10th, 25th, median, 75th and 90th percentiles. The square represents the mean. N values are above the bars.

Zealand Marine Mammals Protection Regulations (1992), allows no more than three vessels within 300 m of a pod of dolphins (Regulation 20(e)). The results reported here suggest that the presence of three permitted boats is unlikely to cause further disruption to dolphin resting or milling behaviour, as the dolphins were rarely observed resting in the presence of any permitted boat. The current results suggest that allowing the permitted operators to interact with the dolphins within a discrete time period is preferable to interactions distributed over an extended period of time. It would be useful to have more detailed examination of the potential cumulative effects of the permitted boats' presence on the focal groups' behaviour to determine whether the simultaneous presence of several permitted boats affects other behaviours which may be sensitive to boat number, e.g. foraging, socialising or travelling.

4.2 HAVE THE INCREASE IN THE NUMBER OF PERMITTED VESSELS AND STAGGERED DEPARTURE TIMES ADVERSELY AFFECTED THE BOTTLENOSE DOLPHINS?

Comparison of the 'discrete' and 'staggered' departure periods showed a significant increase in the amount of time the dolphins were accompanied by at least one permitted boat once staggered departures started. With discrete departure times the dolphins had an average of 98 min (s.e. = 10.4 min) interaction time with the operators per survey. With staggered departures the dolphins had a significantly longer average total interaction of 152 min per survey (s.e. = 11.3 min) (two-tailed $t = 3.529$, d.f. = 49, $P = 0.0009$). The number of scan samples during which there was at least one permitted boat present increased from 36.8% ($n = 1417$) for discrete departures to 45.0% ($n = 1734$) for staggered departures (Constantine et al. in press).

The increased number of permitted boats resulted in a 54-min increase, on average, in the duration of time that the dolphins were accompanied by permitted boats on each independent survey. The data showed that not only did dolphin behaviour differ significantly in the presence of the permitted boats, compared to other types of boat (see Question 1), but also that their behaviour was affected by the increased number of permitted tours.

Only summer and autumn had sufficient sample sizes for analysis and there was a significant difference in resting, milling, travelling, and foraging behaviours between discrete and staggered departures in summer (Figs 4–7).

The dolphins may be using milling to conserve energy in times when they are unwilling to rest because there are too many boats present. Alternatively, milling could be a transitional behaviour, or reflect uncertainty in group cohesion. The energetic costs of this change on behaviour are unknown. Also, with increasing numbers of boats, there may be more dolphins interacting with the boats thereby causing the remainder of the group to mill in order to maintain contact. The increased number of permitted operators and the change in their departure times is of concern as it may affect energy budgets or group cohesion, as reflected in the change in dolphin milling behaviour. Changes in travelling and foraging behaviour were observed between the discrete and

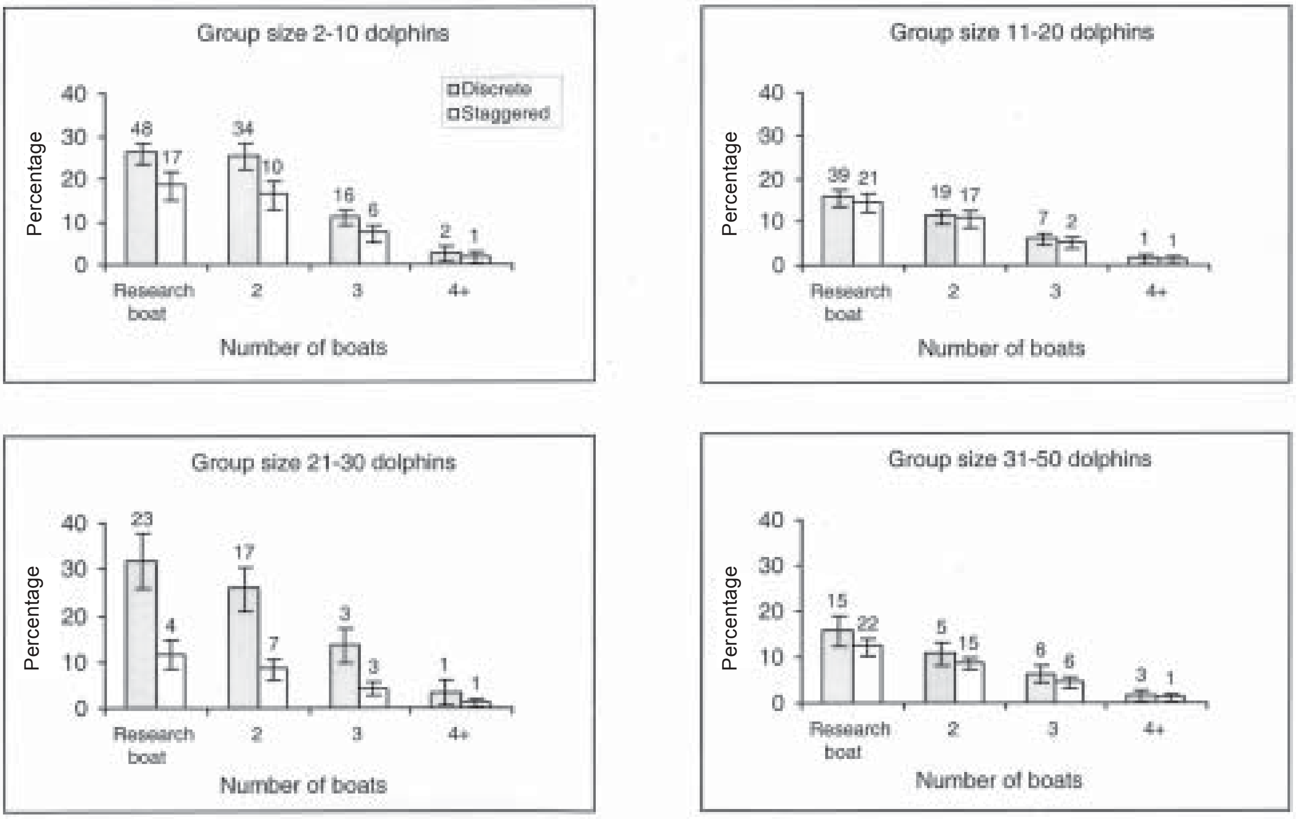


Figure 4. Resting behaviour by boat number with discrete v. staggered operator departures for summer. The values on the y-axis represent the percentage of behaviour observed in the boat category and group size that was resting behaviour. N values above 95% CI error bars.

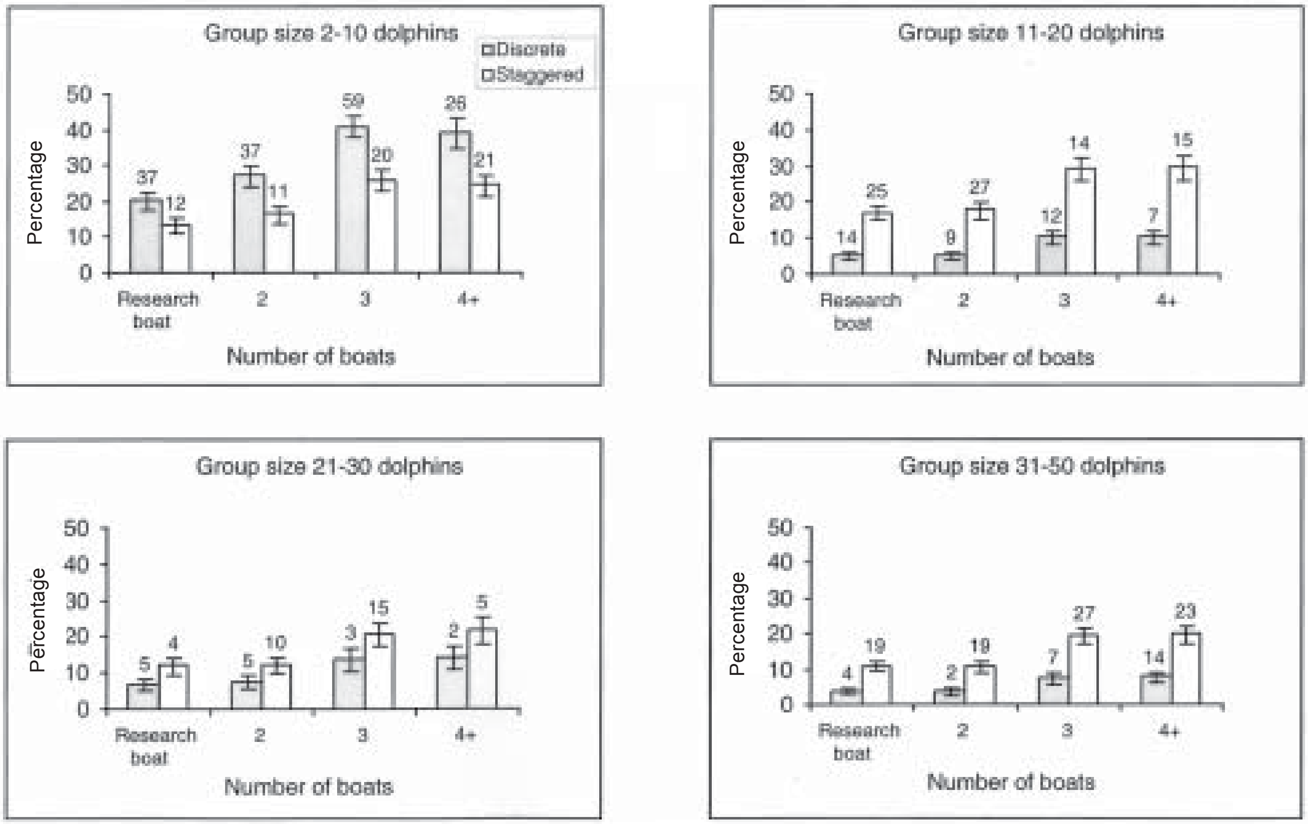


Figure 5. Milling behaviour by boat number with discrete v. staggered operator departures for summer. The values on the y-axis represent the percentage of behaviour observed in the boat category that was milling behaviour. N values above 95% CI error bars.

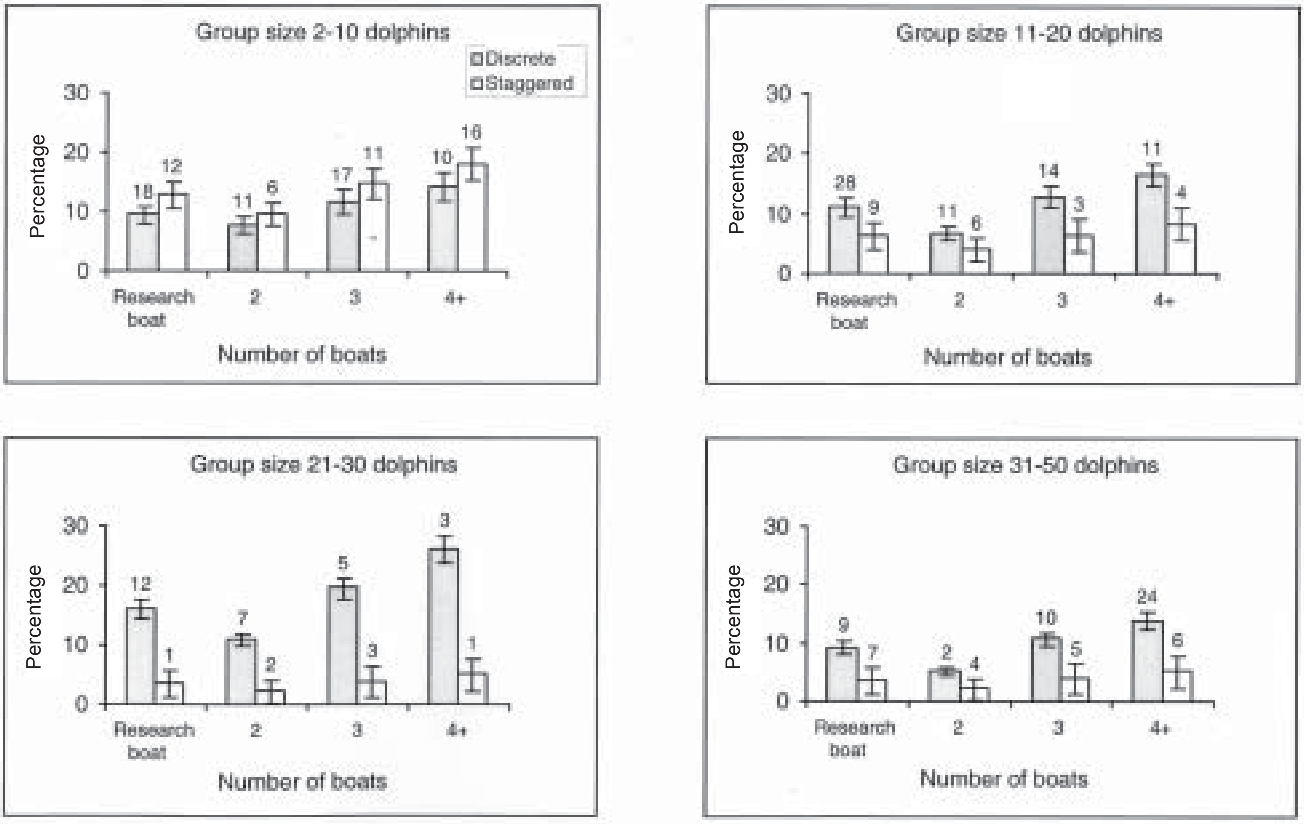


Figure 6. Foraging behaviour by boat number with discrete v. staggered operator departures for summer. The values on the y-axis represent the percentage of behaviour observed in the boat category that was foraging behaviour. N values above 95% CI error bars.

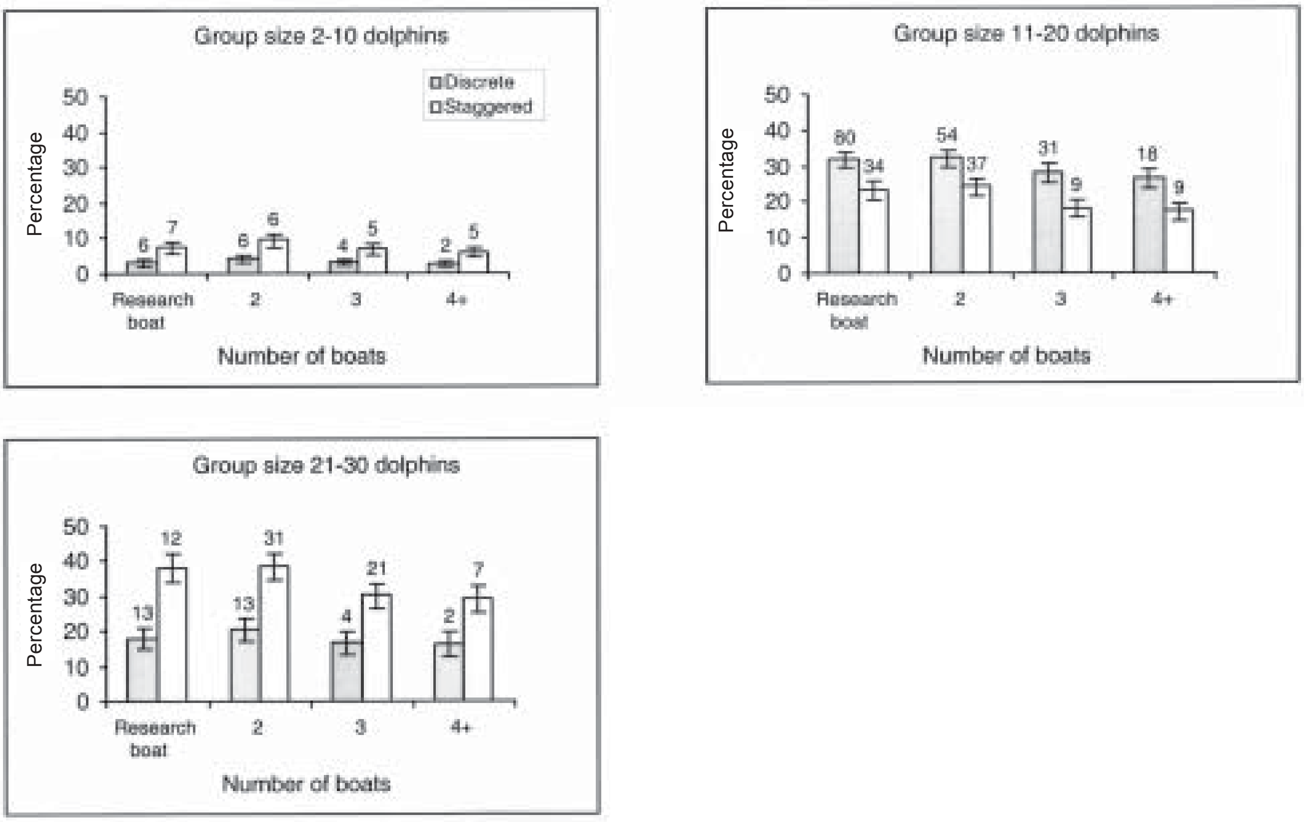


Figure 7. Travelling behaviour by boat number with discrete v. staggered operator departures for summer. The values on the y-axis represent the percentage of behaviour observed in the boat category that was travelling behaviour. N values above 95% CI error bars.

staggered periods, and could be of interest in future research, but these trends weren't as consistent as those observed for resting and milling behaviour.

The decrease in resting behaviour between the discrete and staggered departure times is of concern, especially with the already low level of resting behaviour observed in the presence of the permitted boats (see Question 1). As with the behavioural changes observed between permitted and non-permitted boats, the decrease in resting behaviour was accompanied by an increase in milling behaviour.

No pre-tourism data exist for this population so it is unknown whether the dolphins have preferred times for particular behaviours. Because of this, creating specific times of the day when dolphin interactions would be restricted is not advised. Instead, the establishment of operating times that accomodate the needs of commercial operators with the dolphins' need for extended periods of time when no permitted operators were on the water would be advised. Dolphins were often observed emerging from a resting bout long before the permitted operators actually observed the group (R. Constantine unpubl. data) and, although acoustic data were not collected, it was assumed that the dolphins were responding to the sound of the boats approaching. If this is the case, then periods of time when the permitted operators are not on the water are important to minimise potential disturbance.

4.3 ARE DOLPHINS BEING DISTURBED BY PERMITTED VESSELS RE-ENCOUNTERING THE SAME GROUP OF DOLPHINS DURING THE SAME TRIP?

The effect of the same boat re-encountering the same group of dolphins during a trip was not specifically examined during the research. However, aside from any as yet undetermined effects, the research findings on the effects of the permitted operators' boats (Question 1) and the discrete v. staggered departures (Questions 2 & 3) would suggest that boats re-encountering dolphins would cause some disturbance to the dolphins' behaviour, by increasing the total time the dolphins are accompanied by a permitted boat.

It is likely to be difficult for an operator to determine whether a group of dolphins encountered is the same group from earlier in the trip because bottlenose dolphins can travel considerable distances in a short time throughout the Bay of Islands, and may have moved considerably since the earlier sighting.

4.4 ARE THE CURRENT NUMBER OF SWIM ATTEMPTS AND SWIMMERS AND SWIMMER PLACEMENT HAVING ANY ADVERSE EFFECT ON BOTTLENOSE DOLPHINS?

Field effort and the rate of sightings and swim attempts were similar for both sampling periods (Table 3) (Constantine 2001). A total of 316 surveys resulted in encounters with 255 groups of bottlenose dolphins. Of these, 36% (n = 93 groups) were exposed to at least one swim attempt. These 93 groups were often exposed to multiple swim attempts, resulting in observations of 271 swims.

The research found that dolphin response to multiple swim attempts was not significantly different (χ^2 = 8.59, d.f. = 4, P = 0.072). It should be noted that the number of swim attempts allowed was not limited when research on the effects of swims was initiated in 1994–95 (Constantine 1995; Constantine & Baker 1997). The restriction to three attempts per trip occurred before the initiation of the Ph.D. research in late 1996. Nonetheless, the number of swims attempted during these two research periods were comparable (2.7 ± 1.35, range = 1–7, n = 49 in 1994–95, and 3.1 ± 1.20, range = 1–5, n = 44 in 1997–98) (Constantine 2001).

Dolphins appeared to make their decision on whether or not to interact with swimmers within five seconds of the first swimmer entry. Therefore the number of swimmers per attempt may not have an impact on the dolphins' response. As with swim attempts, the number of swimmers allowed in the water per attempt changed during the research period. In 1994–95 a maximum of 12 swimmers per boat were allowed in the water per swim attempt (Constantine 1995). When the PhD research began in late 1996, a maximum of 36 swimmers were allowed in the water per boat but this changed part way through the research to 18 swimmers per boat. The permitted operators adopted the change in swimmer number at different times and subsequently the specific effects of this were not examined.

Swimmer placement is the key issue affecting dolphin behaviour. Comparison of the data collected in 1994–95 (Constantine 1995; Constantine & Baker 1997) with the present study showed that dolphin response to swim attempts varied with swimmer placement and that avoidance has increased over time. This is discussed in detail in Constantine (2001). A significant difference in response was detected due to both swimmer placement (χ^2 = 58.51, d.f. = 4, P < 0.001), and year (1994–95 v. 1997–98; χ^2 = 9.08, d.f. = 2, P = 0.011). There was a decrease in interaction responses from 48% to 38% for all types of swimmer placement between the two research periods. Avoidance responses increased

TABLE 3. SUMMARY OF SAMPLING EFFORT.

	1994–95	1997–98
Surveys	156	160
Groups encountered	123	132
Groups exposed to ≥ 1 swim attempt	49	44
Swims observed	134	137

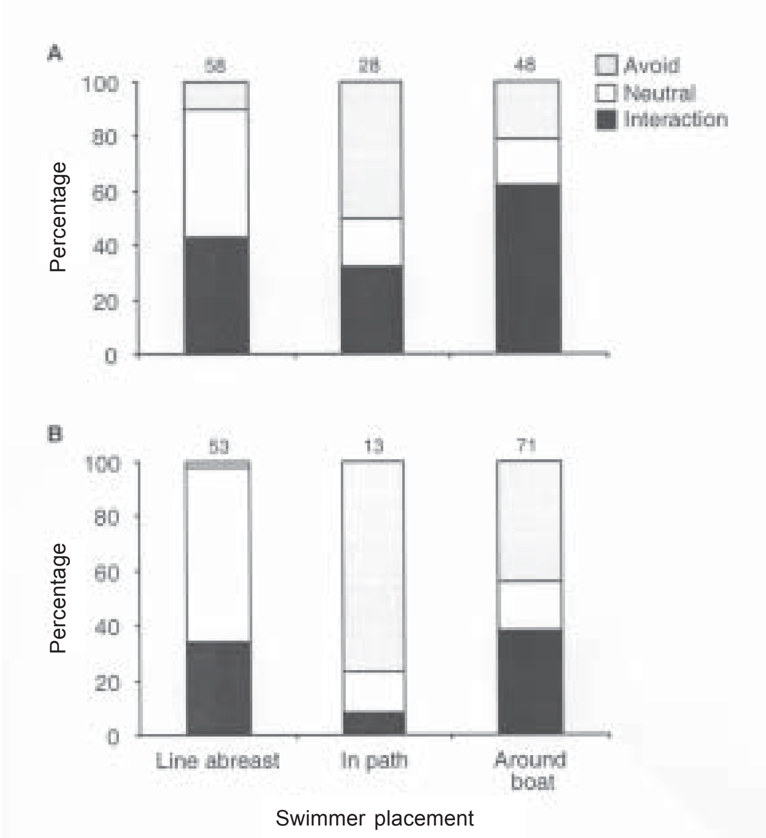


Figure 8. Dolphin response to swimmer as a function of swimmer placement, A = 1994–95 (n = 134); B = 1997–98 (n = 137).

for swimmer placement overall (from 22% to 31%) as a result of increased avoidance responses to the 'in path' (from 50%, n = 14 to 77%, n = 10) and 'around boat' (from 21%, n = 10 to 44%, n = 31) placements (Fig. 8). In contrast, 'line abreast' placement resulted in a decreased avoidance response by the dolphins (from 10%, n = 6 to 2%, n = 1). Neutral responses increased from 47% (n = 27) to 64% (n = 34) for the 'line abreast' placement and increased from 17% (n = 8) to 18% (n = 13) for the 'around boat' placement.

The change in responses to swim attempts affected the operators' swim success (defined as an interaction between at least one dolphin and one swimmer) between the two research periods. There was a significant reduction in successful swims between the two sampling periods (χ^2 = 5.65, d.f. = 1, P = 0.017) (Fig. 9). This may be explained by the increase in avoidance responses for the 'in path' and 'line abreast' placements, and the increase in neutral responses for the 'line abreast' placement.

The research shows that the dolphins have changed their responses to swimmers over time because of cumulative exposure to swim attempts. Over a year, an 'average' dolphin may be exposed to 31 swim attempts and core users of the Bay of Islands may be exposed to as many as 147 attempts.

The 'line abreast' placement is the only swimmer placement that gives the dolphins the choice to approach and therefore does not force uninterested dolphins to make a decision. It is recommended that swimmers only be placed in the water 'line abreast' of the dolphins' path of travel for all swim attempts, as it is the method that minimises swimmer impact on the dolphins. However, it is possible that the dolphins may further modify their responses with time. The effects of this should be studied and no further permits for swim-with-dolphin tours should be issued.

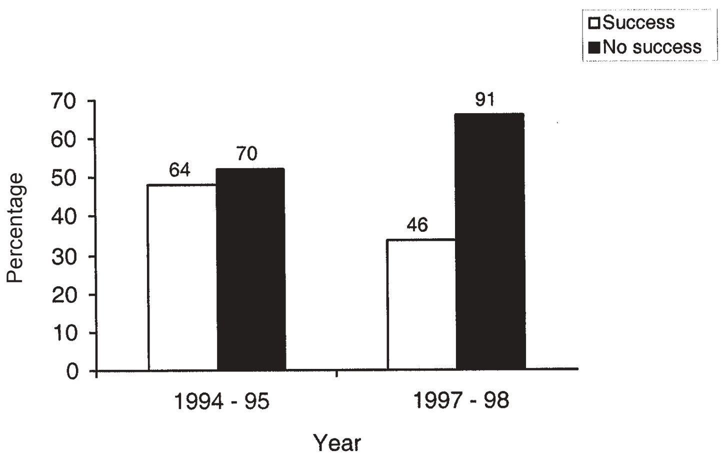


Figure 9. Comparison of the operators' swim success between 1994–95 (n = 134) and 1997–98 (n = 137). Sample size for each category shown above bars.

4.5 DOES HABITAT USE OF THE BAY OF ISLANDS BY BOTTLENOSE DOLPHINS INDICATE THAT SOME AREAS SHOULD BE EXCLUDED FROM THE PERMITTED MARINE MAMMAL OPERATORS' AREA OF OPERATION?

The research showed that all areas in the Bay of Islands were important for the bottlenose dolphins. Only the Waikare, Te Puna, and Kerikeri Inlets were not examined because the permitted operators were not allowed to interact with dolphins in these areas.

Over the course of the study there was a significant difference in the frequency of particular behavioural states observed in the four zones (1—inner bay, 2—inner islands, 3—middle ground, and 4—outer bay) (χ^2 = 28.98, d.f. = 12, P = 0.004) (Fig. 10, Table 2).

Resting behaviour occurred more in the exposed outer bay zone, particularly along the outer edges of the islands, and the Deep Water Cove section of the Cape Brett Peninsula. There was less resting in the shallow, calm waters of the inner islands zone. This may be because the typically calm inner islands area also has concentrated boat traffic. Unfortunately, there are no pre-tourism data on the Bay of Islands bottlenose dolphin population, so it is not known whether the inner islands was historically a more important resting area or not. The outer bay has considerably less boat traffic, so perhaps this is one of the features that makes it a preferred habitat for resting behaviour.

The current level of boat activity interacting with dolphins is likely to influence the behaviours observed. This is of concern, in particular for resting behaviour which has been shown to be affected by the presence of boats (Questions 1, 2, & 3). Unfortunately, we will never know how this population utilised the Bay of Islands before tourism began.

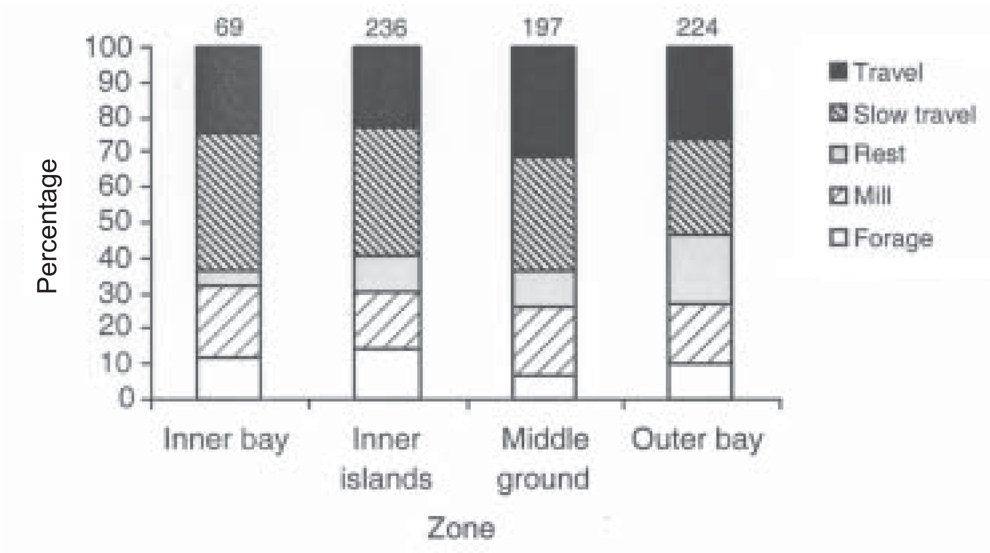


Figure 10. Percentage of behavioural states observed in the four different zones in the Bay of Islands. N values above bars.

4.6 SHOULD THERE SHOULD BE A DECREASE IN THE NUMBER OF PERMITTED VESSELS OPERATING WITHIN THE BAY OF ISLANDS AND / OR NORTHLAND CONSERVANCY AREA?

The current number of permitted dolphin swim / watch tours in the Bay of Islands has demonstrated an effect on dolphin behaviour. Dolphins are affected by both boats and swimmers. The presence of the permitted boats has an impact on resting and milling behaviour in particular, and the reduction in resting behaviour is of concern. Although these results show impact, no threshold on the number of permits can be recommended. Nonetheless, there are a number of possibilities to minimise the effects of the permitted boats on dolphin behaviour. No further permits should be issued. Ideally, there should be a reduction in the number of permitted tours from the present. This would alleviate the impact of tourism on this population of bottlenose dolphins. Alternatively, a change in the current operating times of the existing tours would reduce the amount of time that the dolphins were accompanied by a permitted boat. Setting a maximum interaction time allowed per group may also serve to minimise the total time a group was accompanied by a permitted boat and discourage lengthy encounters. During the research period the permitted swim-with-dolphin operators spent an average interaction time of 57.4 ± 24.66 min per group of bottlenose dolphins (range = 7 min – 2hrs 18 min). With an average of only 1.2 groups of dolphins in the Bay per day, it is, unfortunately, not possible for the permitted operators to distribute their tours amongst a number of bottlenose dolphin groups.

The dolphins are avoiding the swimmers more and interacting with them less and it appears that, with cumulative experience, they have become sensitised to swimmers placed in their path or when they're milling around the boat. If an interaction with swimmers did occur, on average only 19% of the group were involved (Constantine 2001). The long-term impact of the changes in dolphin behaviour identified in this research are unknown. Bottlenose dolphins are long-lived, slow-breeding animals and any effects on fecundity or population size are likely to remain undetected for up to 30 years (Thompson et al. 2000). The use of management strategies that minimise short-term impacts will, at least in part, contribute to a reduction in the potential long-term impacts on the population.

The research has shown that the bottlenose dolphins ranging along the northeastern coast of the North Island, New Zealand are an isolated population. The next nearest population of bottlenose dolphins is over 1000 km to the south in the Marlborough Sounds – West Coast, South Island, region (Bräger & Schneider 1998). Comparison of photographs of Bay of Islands dolphins with those of Marlborough Sounds region dolphins has, to date, found no matches.

In the Bay of Islands, the high mark rate of adults and the asymptote of the discovery curve suggest that the majority of the population have been photographed. A closed population estimate found 446 (95% C.I. = 418 – 487) adult dolphins use the Bay of Islands. With no new dolphins identified outside the Bay of Islands during the study, it is likely that the majority of the population along the northeastern coast of the North Island utilise the Bay at some stage. Individuals were photographed up to a minimum distance of 400 km south (Tauranga) and 80 km north (Doubtless Bay) of the Bay of Islands, suggesting a large home range for at least some members of this population.

5. Conclusions and recommendations

Question 1. Should 4 permitted vessels be allowed within 300 m of a pod of bottlenose dolphins?

Dolphins are affected by the presence of the permitted dolphin-watching boats beyond the effect of any other type of boat (i.e. recreational or non-permitted commercial boats). Resting behaviour decreased and milling behaviour increased in the presence of the permitted boats. Dolphins were rarely observed resting in the presence of any permitted dolphin-watching boat. The cumulative effect of increasing numbers of permitted vessels was not examined during the research period.

Questions 2 & 3. Have the increase in the number of permitted vessels and staggered departure times adversely affected the bottlenose dolphins?

The increase in the number of permitted operators and the change from 'discrete' to 'staggered' boat departures has resulted in an increase in interaction time between permitted dolphin tour boats and dolphins, which has led to a decrease in dolphin resting behaviour. The current operating times of existing tours need to be changed to provide the dolphins with large blocks of time where there are no dolphin-watching boats on the water; in effect, reverting back to more discrete departure times. This may help reduce the effects of the permitted tour boats on the dolphins.

Question 4. Are dolphins being disturbed by permitted vessels re-enountering the same group of dolphins during the same trip?

The effects of the same boats re-encountering the same group of dolphins during individual trips was not specifically examined during the research. However, re-encounters increase the length of time the dolphins are accompanied by permitted boats, and the behaviours that are observed when the boats are present (see Question 1 above). Re-encounters should be avoided within the same trip as the number of groups of dolphins encountered in the Bay of Islands per trip is only 1.2.

It is recommended that, where possible, the permitted tour boats avoid re-encountering a group of dolphins on each trip, especially if they have already had a successful encounter. Some of the tour boat staff are now becoming familiar with individual dolphins (recognised by nicks in their dorsal fin) and this may help the operators determine whether they encountered the group earlier. However, this will only be of use if there are people on board who recognise individual dolphins.

Questions 5 & 6. Are the current number of swim attempts and swimmers and swimmer placement having any adverse effect on bottlenose dolphins?

Dolphin avoidance of swimmers has increased over time. Swimmer placement appears to be the key issue affecting dolphin behaviour. The 'line abreast' placement results in the fewest avoidance responses, and it is recommended that swimmers only be placed in the water 'line abreast' of the dolphins' path of travel, and that no further permits for swim-with-dolphin tours be issued.

Question 7. Does habitat use of the Bay of Islands by bottlenose dolphins indicate that some areas should be excluded from the permitted marine mammal operators' area of operation?

Examination of the spatial distribution and habitat use of dolphins in the Bay of Islands showed that there was a difference in the frequency of behavioural states observed in four zones, but that all zones were used by and therefore important to the dolphins. Because all areas are utilised by the dolphins there is no basis to exclude any specific zone from the permitted tour boats' area of operation.

Question 8. Should there should be a decrease in the number of permitted vessels operating with the Bay of Islands and / or Northland Conservancy area?

Although the studies have demonstrated impact on the dolphins from permitted dolphin-watching tour boats, no threshold on the number of permits can be recommended. However, to minimise effects on the dolphins, it is recommended that no further permits be issued.

GENERAL COMMENT

This population of bottlenose dolphins is now exposed to dolphin tourism throughout its range (Doubtless Bay, the Bay of Islands, Whangarei, Auckland, Whitianga, Whangamata, and Tauranga) and further permits continue to be issued. At the initiation of the research in 1994 there were only two permits issued in the Bay of Islands. At the beginning of the Ph.D. research in 1996 there were permits issued in the Bay of Islands, Tutukaka, Whitianga, and Tauranga. With the rapid growth in dolphin-based tourism and with our understanding of the impacts on this population when in the Bay of Islands, the potential cumulative impact from these tours should not be ignored.

This industry has enormous potential to change the attitudes of people towards the marine environment by allowing them to interact with these fascinating creatures (Orams 1994, 1995). The most important aspect, though, is the welfare of the dolphins. It is to be hoped that management policies guided by sound research will minimise impact, enhance education and maintain a sustainable, economically viable industry.

6. Acknowledgements

Funding for the preparation of this report came from the Department of Conservation's Unprogrammed Science Advice fund.

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