Observations of interactions between Hector's dolphins (*Cephalorhynchus hectori*), boats and people at Akaroa Harbour, New Zealand

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A B S T R A C T

Theodolite tracking observations of Hector's dolphins (*Cephalorhynchus hectori*) and boat activity were conducted from cliff-side 30 m above sea level within a defined study site in Akaroa Harbour, South Island, New Zealand from 5 January 1999 to 12 February 1999 and from 6 January 2000 to 14 February 2000. Data were compiled and analysed to assess whether there were changes in dolphin distribution, or behaviour, due to boat activity. A total of 232 hours and 48 minutes of observations were made that covered 1369 boats and 2620 dolphin groups. Recreational boats were the most common boat type observed, comprising 64.1% in 1999 and 58.5% in 2000 of the total boat activity observed; however, recreational boats comprised only 1% and 2% respectively of total boat observations that were associated with dolphins. Dolphins were most commonly associated with kayak groups during both observation periods. The dolphin behaviour 'swimming' was significantly correlated with increasing boat density. Overall, dolphin density in the study area was independent of boat density and dolphin group size did not change with boat presence. Fourteen multi-boat events were observed where two or more boats in close proximity to each other were associated with the same group of dolphins. Included are observations of dolphin/boat/people interactions in Akaroa Harbour, a note on two calf mortalities in 1999 (possibly caused by boat strikes) a note on four beach-cast dolphins in 2000, and management and research recommendations.

Keywords: *Cephalorhynchus hectori,* Hector's dolphin, dolphin behaviour, boats, people, interactions, ecotourism, wildlife.

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1. Introduction

Hector's dolphins (*Cephalorhynchus hectori*) are very small dolphins (maximum length 1.6 m, Baker 1999) endemic to New Zealand and considered one of the rarest species of marine dolphin. They inhabit inshore waters, including harbours, and are particularly vulnerable to being caught in commercial and recreational set nets. The most recent population estimate of 3000–4000 was derived in 1988 (Dawson & Slooten 1988)[1]. The New Zealand Department of Conservation (DOC) classified Hector's dolphins as threatened in 1999. The World Conservation Union (IUCN) has recently declared the overall population of Hector's dolphins 'endangered', and the North Island sub-population 'critically endangered' (Hilton-Taylor 2000). Recent DNA analysis indicates that there are separate, genetically distinct populations of Hector's dolphins on the east, west and northwest coasts of New Zealand (Pichler et al. 1998), and that these populations have lost genetic variability in the last 20 years (Pichler & Baker 2000) as a result of fisheries-related mortality. The low population growth rate (Slooten & Dawson 1994) and the impact of factors such as mortalities associated with fisheries (bycatch) threaten the viability of the small discrete populations identified.

In 1988 the Banks Peninsula Marine Mammal Sanctuary was established by DOC to safeguard the dolphins from entanglement in set nets during the summer. The 1140 km^2 seasonal (summer) sanctuary in the South Island of New Zealand extends 4 nautical miles from the coast and from the Rakaia River mouth in the south to Sumner Head in the north (Fig. 1). The mortality rate due to gillnet entanglement was 26–90 animals per year during the four-year period 1984–88 (DOC 1988). This decreased to approximately 50 mortalities of which DOC is aware for the 6 years from 1988 to 1994. Efforts to monitor the effectiveness of the marine mammal sanctuary in mitigating mortalities have continued with an independent observer program in 1997/98 and 1999/2000. The effectiveness of acoustic pingers in deterring dolphins from gillnets has been tested by fishermen in the Canterbury district (Stone et al. 1999).

Our study focuses on the population of Hector's dolphins within Akaroa Harbour located at the centre of the Bank's Peninsula Marine Mammal Sanctuary (Fig. 1). Hector's dolphins use Akaroa Harbour during the summer, migrating in and out of it diurnally (Stone et al. 1995). The number of dolphins observed in the harbour decreases during the winter. This apparent seasonal migration is not clearly understood at this time. The dolphins' presence within the harbour during the summer months, and the fact that they are attracted to boats (Cawthorn 1988; Slooten & Dawson 1994), make them accessible to a tourism industry based on swimming with and viewing the dolphins.

A survey conducted in 1999 by this research team showed a significant estimated direct annual income to the Akaroa-based Hector's dolphin tour companies of 1.46 million New Zealand dollars. This estimate does not include the benefits to the general Akaroa economy from incidental income related to dolphin swim/tour tourists visiting other Akaroa businesses.

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[1] A population estimate based on a more recent count is soon to be released.

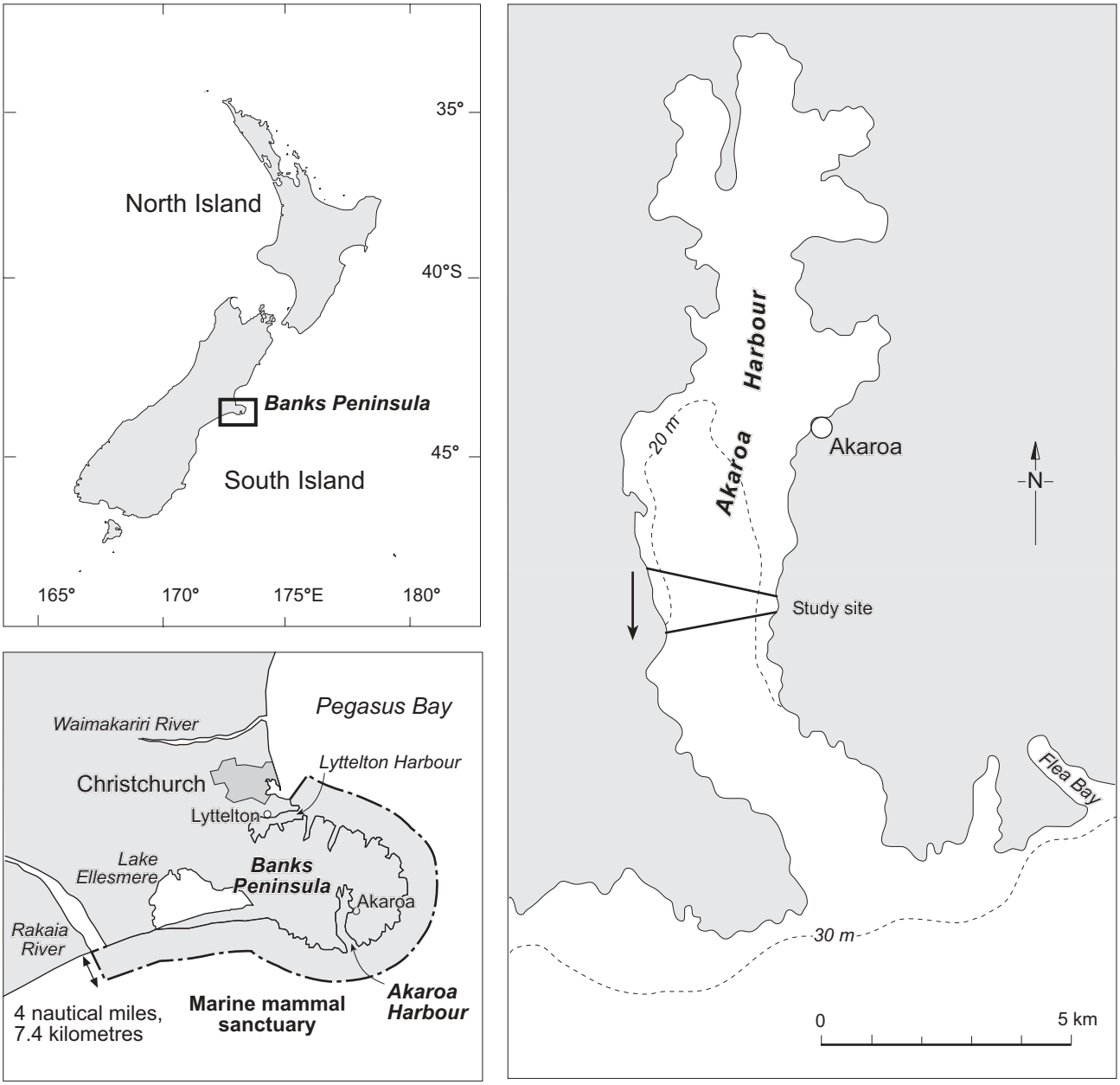

Figure 1. Map showing location of Banks Peninsula Marine Mammal Sanctuary and Akaroa Harbour study site.

The swim/tour industry started in Akaroa in 1990 with one natural history tour. At the time of our study there were four permitted swim/tour operators in Akaroa: Akaroa Harbour Cruises (AHC), Dolphin Experience (DE), Onuku Farm Hostel (OFH), and Bluefin Charters (Table 1). AHC and DE each were permitted to operate four swim/tour trips per day on each boat. Ten to twelve swimmers were allowed per trip, with ten swimmers allowed in the water at a time, and each trip lasting a maximum of 2 hours. AHC were also operating a 90-person-capacity natural history trip that ran up to two trips per day and a small natural history tour boat used during periods of high demand. OFH were operating one swim/tour boat, a viewing vessel that holds four to six people, and kayak trips with up to 12 kayaks. The swim trip schedule at OFH was dependent on demand, but kayak trips were usually run once per day during peak season. Bluefin Charters were

TABLE 1. SUMMARY OF PERMITTED SWIM/TOUR BOAT OPERATOR ACTIVITIES IN AKAROA 1999–2000.

OPERATOR	NUMBER OF BOATS	PERMITTED TRIPS PER DAY IN TOTAL
Akaroa Harbour Cruises	3	12
Dolphin Experience	2	8
Onuku Farm Hostel*	2	3
Bluefin Charters	1	3
Total	8	26

* Kayak trips not included

operating one boat, offering sport-fishing and nature tours on a charter basis: they advertised the presence of Hector's dolphins in the harbour as an added feature rather than as the focus of the trip. Akaroa Harbour was generally busy with other boat traffic including recreational boats, fishing boats, sail boats, and jet skis.

Our study set out to determine whether the tourist and recreational boats affect the dolphins and to describe the overall level of boat activity in Akaroa Harbour. DOC is the agency responsible for both issuing swim/tour programme permits and managing the marine mammal sanctuary. The results of this study will directly assist management of Hector's dolphins in Akaroa; they should also have implications for other regions in New Zealand where Hector's dolphins encounter boats and people.

2. Materials and methods

2.1 AKAROA HARBOUR

The period from early January to mid-February was chosen for the study because it is part of the busiest season in Akaroa Harbour when the heaviest boat and tour traffic can be observed. Theodolite tracking observations of dolphins and boats were conducted from 30 m above sea level at the same cliff-side position used for a 1998 study (Stone et al. 1998a). This site was chosen because the harbour is relatively narrow here. Most harbour activity passes through the area and can be easily observed (Fig. 1). An observation study site was designated using landmarks confirmed by all observers. The approximate dimensions of the observation study site are 1600 m from shore to shore on the south end and 2250 m on the north end. The theodolite was placed in the same position each day. Three to four researchers collected data on all fair-weather days from approximately 6 a.m. to noon as conditions permitted. Observations could not be made if winds rose above ten knots or if it was raining.

To collect data on a dolphin or boat, the target was observed through the theodolite. The horizontal and vertical angles determined by the theodolite were recorded on a palmtop computer connected to the theodolite. Observers

worked as a team of three: one making theodolite observations, one recording data on a palmtop computer, and the third making written records. To prevent observer fatigue, each observer worked in one of these stations for approximately one hour, then moved to the next station. All observers were designated a specific part of the study site to scan for dolphins and boats. The observer at the theodolite would scan the total study site without binoculars, the palmtop observer typically scanned the close study site with binoculars, and the note-taker scanned the far study site with binoculars. As each dolphin, dolphin group or boat was sighted, the observer who spotted it then directed the theodolite observer to it. To maintain surveillance over the entire study site during the recording process, the other observers continued to scan the full study site. Once the dolphin group or boat was seen within the theodolite lens, the palmtop computer was activated to record the coordinate markings and time of sighting relayed from the theodolite computer. Additional information was entered with each record into the palmtop by the observer as follows:

If a dolphin or dolphin group was recorded:

- dolphin group number for the day,
- number of members in the dolphin group,
- overall group behaviour.

For each boat, the following was recorded:

- boat number for the day,
- type of boat,
- whether dolphins were within 10 m of the boat.

During data compilation, a boat that was out of the study site for 10 minutes or more was counted as another boat pass the next time it came through the study area (Tables A2a, b in Appendix 1). A boat was considered to have a dolphin associated with it if a dolphin/dolphin group was within 10 m of the boat. Codes were used to describe dolphin behaviours and boat types (Table 2). All boats and dolphins/dolphin groups present during the observation period were recorded at all times.

The first three lines in Table 3 show the data generated for a sample group 1, consisting of four dolphins which were originally swimming, then milling. The last three lines represent marks for the fourth boat of the day, a recreational power boat; on the first sighting it was not associated with a dolphin, while it was on the last two.

The note-taker recorded date, time, observers, weather and sea state and each mark recorded on the palmtop. In addition, dolphin group formation and break up, and boat associations were recorded.

All boats within the study site, and all dolphins visible in the study site were marked. Boats were marked entering and exiting the study site. Boat positions were also marked within the study site if the boat slowed, stopped, or if the boat was associated with a dolphin. Dolphin groups were marked at each respiration for as long as they were visible, or until another group was sighted. A dolphin group was defined as made up of one or more individuals exhibiting the same general behaviour, traveling the same general direction unless milling, and within approximately 10 body lengths of each other. An individual dolphin without any other dolphins within 10 body lengths was observed carefully to determine whether it was associated with any nearby groups and, if not, would

TABLE 2. DATA RECORDING CODES.

BEHAVIOUR	CODE	DEFINITION
Surfacing/swimming	0	Swimming at surface, no dives, jumps or splashes
Porpoising	1	Jumping slightly out of the water on each surfacing, usually associated with rapid movement
Logging	2	Lying motionless at the surface for five seconds or longer
Breaching/jumping	3	Jumping completely out of the water into the air
Milling	4	Slow swimming in circles or in the relatively same spot
Bow riding	5	Porpoising or surface swimming in the bow wave of a boat
Other	6	Lobtails, spyhopping, tailslaps

BOAT TYPE	CODE	DESCRIPTION
Canterbury Cat	1	Commercial ferry-type tour vessel with 90-passenger capacity
Swim with dolphin	2	One of five small commercial vessels with 12- to15-person capacities
Recreational power	3	Non-commercial motor boats including recreational rod and reel fishing
Dinghy	4	2-passenger outboard motor boats
Kayak	5	1- to 2-passenger paddled boats
Research	6	DOC motor vessels, project motor vessels, a catamaran research vessel (1999 and 2000), and an aluminium motor vessel (2000 only)
Fishing	7	Professional fishing vessels
Yacht—under sail	8	Masted vessels
Yacht—under motor	9	Masted vessels
Jet skis	0	1- to 2-passenger water-jet-powered vehicles

be marked as one group of one dolphin. If a second dolphin group was sighted, observers followed the first group while the second group was marked, and if the first group was still visible, it would be marked again. Groups were followed as long as possible. It was not possible to identify individual dolphins or to identify groups. Once a group was lost from sight, the next group seen would be recorded as a new group. All tour boats were marked when within sight of the observers, regardless of location within or out of the study site.

TABLE 3. SAMPLE DATA. (For explanation of codes, see text.)

TIME	CODES	VERTICAL	HORIZONTAL
06:30:15	140	924350	1544720
06:30:30	140	970920	1074150
06:31:15	144	914140	964930
06:32:00	43n	921414	966030
06:32:30	43y	932020	986030
06:32:50	43y	923030	1052030

2.2 FLEA BAY

Observations were also conducted in Flea Bay from 27 January 2000 to 12 February 2000. Flea Bay is part of the newly established Pohatu Marine Reserve and is the harbour closest to Akaroa with consistent dolphin sightings (Fig. 1). The bay faces southeast and is approximately 2.52 km northeast of the entrance to Akaroa Head and is 1.6 km long. Most of the harbour could be seen from the observation point. Observations were conducted with the same methodology as in Akaroa Harbour. The objective was to observe dolphin behaviour without boats present, as there is very little boat traffic in Flea Bay compared with Akaroa Harbour.

3. Results

Observations were made over two seasons from 5 January to 12 February 1999 and 6 January to 14 February 2000. A total of 232 hours and 48 minutes of observations was recorded. Over that time 1369 boats and 2620 dolphin groups were observed in the Akaroa Harbour study site. Individual identification of dolphins or of dolphin groups was not attempted. Numbers of dolphin groups and individual dolphins reflect dolphin presence only and not absolute numbers of dolphins. The days on which observers were trained at the beginning of each field season were omitted from analysis. Data shown represent the observations within the defined study sites.

3.1 AKAROA HARBOUR STUDY SITE

Tables A1a, b and A2a, b (Appendix 1) illustrate the boat traffic observed in the Akaroa study site. Each boat type is listed separately. Tables A3a, b illustrate the number of dolphin groups marked each day as well as the number of dolphins within the groups.

Tables A1a, b show the absolute number of boats marked in the study site. Total harbour boat activity is calculated from the absolute number of boats marked.

A total of 694 boats were observed over 25 days within the study site in 1999 and 675 boats over 21 days in 2000. The three most prevalent types were recreational, swim/tour and fishing boats. The 445 recreational boats in 1999 and 395 recreational boats in 2000 accounted for 64.1% and 58.5% of all boats respectively. This volume of recreational boats was consistent over each day, making up 55.5% of the boats observed on average each day in 1999 and 51.2% in 2000. In contrast, 61 swim/tour boats were observed in 1999, and 79 in 2000, making up 8.8% of the total observed boat activity in 1999 and 11.7% in 2000, for a daily average of 10.7% and 12.1% respectively (Table 4).

3.2 DOLPHIN PRESENCE AND BOAT DENSITY

Direct comparison of the number of dolphins and boats present was needed to determine whether there was any correlation between observed boat density and dolphin density. Since each dolphin group and boat was marked using different strategies, comparing the number of dolphin group and boat marks was not an accurate way of assessing densities. To enable direct comparison of the number of dolphins and boats present, the data were compressed into five-minute intervals so that each dolphin group and boat present in each five-minute interval was counted only once. Tables A4a, b (Appendix 1) illustrate an example of the compressed data.

Natural patterns of boat and dolphin presence were also considered. Boat presence tends to increase over the day, and dolphins were usually present in the early morning, at a time when boat traffic was lighter. To eliminate this confounding factor, the numbers of boats and dolphins present were graphed over time of day (see Figs A1a, b; A2a, b in Appendix 1). It can be seen that during the time period from 8.30 a.m. to 12.00 noon there was little change in the number of boats and dolphins present. This time period was used to compare boat density with dolphin group density in each five-minute interval for each day. Figures A3a, b (Appendix 1) show the number of boats compared with the number of dolphin groups for all observation dates. Although there

TABLE 4. SUMMARY OF BOAT ACTIVITY IN AKAROA HARBOUR OBSERVED DURING STUDY PERIODS IN 1999 AND 2000.

BOAT TYPE / YEAR	NUMBER OF BOATS		% OF TOTAL BOATS		DAILY AVERAGE %	
	1999	2000	1999	2000	1999	2000
Jet ski	10	2	1.4	0.3	1.3	0.3
Canterbury Cat	16	8	2.3	1.2	2.3	1.3
Swim/tour	61	79	8.8	11.7	10.7	12.1
Recreational	445	395	64.1	58.5	55.5	51.2
Dinghy	24	22	3.5	3.3	3.2	3.5
Kayaks	35	35	5.0	5.2	6.6	7.6
Research	19	45	2.7	6.7	3.2	9.8
Fishing	55	68	7.9	10.1	12.8	11.6
Yacht under sail	13	4	1.9	0.6	0.9	0.7
Yacht motoring	16	17	2.3	2.5	3.5	2.0
Total	694	675				

appears to be an inverse relationship—that as the number of boats increases, the number of dolphins decreases—not all the data points support this trend. There was no statistical evidence of a linear relationship between the number of boats and the number of dolphin groups.

3.3 DOLPHIN BEHAVIOUR

Dolphin behaviour and boat associations were assessed in an effort to determine whether the dolphins are affected by boat presence.

Tables A5a, b (Appendix 1) show the number of marks for each type of behaviour—swimming, porpoising, logging, breaching, milling and bow riding—in 1999 and 2000. The 'other' category was used for tailslaps, spyhopping and lobtailing, which were observed far less frequently.

The predominant behaviours noted were swimming and milling at 80.6% and 15% in 1999 and 90.1% and 6.9% in 2000 respectively (Table 5). Statistical analysis of the 1999 data indicates that as the number of boats increases, the number of times a group displays swimming behaviour increases ($P = 0.02$ for recreational boats and $P = 0.017$ for total boats).

Tables A6a, b (Appendix 1) show the boat density and average group size for each day in 1999 and 2000. Regression analysis of 1999 and 2000 data indicates no evidence of a change in average dolphin group size with changes in the number of total boats, recreational boats or swim/tour boats. In the regression analysis the daily rates and totals were used. There may be trends in group size and boat numbers within a day and further analysis using hourly data could be undertaken.

Dolphin associations with boats are summarised in Tables A7a, b (Appendix 1). Because the amount of time that each boat was observed and the number of times that it was marked varied, a relative value was needed to compare the dolphin associations among boat types. This value is shown as the percentage of total marks for which each boat type was associated with dolphins. Using this

TABLE 5. SUMMARY OF DOLPHIN BEHAVIOURS OBSERVED DURING STUDY PERIODS IN 1999 AND 2000.

YEAR	1999	1999	2000	2000
BEHAVIOUR	MARKS	% OF TOTAL	MARKS	% OF TOTAL
Swimming	1245	80.6	2155	90.1
Porpoising	11	0.7	15	0.6
Logging	2	0.1	5	0.2
Breaching	27	1.8	12	0.5
Milling	232	15.0	166	6.9
Bow riding	17	1.1	32	1.3
Other	10	0.6	7	0.3
Total marks	1544		2392	

analysis, dolphins were most often associated with kayaks in both 1999 and 2000 at 35% and 38% of the total marks, respectively. Associations with swim/tour boats increased slightly from 26% in 1999 to 31% in 2000. The Canterbury Cat tour boat was associated with dolphins 23% in 1999, but not at all in 2000 (see section 4.1). The dolphins are least often associated with recreational boats at 1% and 2% (Table 6).

3.4 MULTI-BOAT EVENTS

The multi-boat events observed during the study periods in 1999 and 2000 are shown in Table A8 (Appendix 1). Fourteen multi-boat events are documented. The total number of boats was 38. Tour boats, kayaks and recreational boats were involved most frequently at 37%, 29% and 21% respectively (Table 7). During our observations, it was noted that although the swim/tour boats usually operated according to regulations, recreational boats would often remain in the vicinity of the tour boats and swimmers, sometimes putting people in the water from their own vessels. In addition, groups of 10–12 kayaks often joined these multi-boat clusters, or boats would join the kayak groups. In these multi-boat encounters up to 12 kayaks were involved. Tour operators adhere to the mandatory limit of 2-hour interactions, but there was a common practice of 'handing off' the dolphins. As one tour boat operator would move away from an interactive group, another would move into the vicinity of the same group. This often came about through radio communication between tour boats about dolphin location and responsiveness (pers. obs. C. Nichols 1999, 2000).

TABLE 6. BOAT AND DOLPHIN ASSOCIATIONS BY BOAT TYPE OBSERVED DURING STUDY PERIODS IN 1999 AND 2000.

BOAT TYPE	NUMBER OF BOATS		TOTAL MARKS		MARKS WITH DOLPHINS		PERCENTAGE OF MARKS WITH DOLPHINS	
	1999	2000	1999	2000	1999	2000	1999	2000
Jet ski	10	4	34	8	9	0	26	0
Canterbury Cat	19	8	39	12	9	0	23	0
Swim/Tour	83	96	333	343	87	107	26	31
Recreation	448	455	799	826	9	19	1	2
Dinghy	34	24	82	50	13	1	16	2
Kayak	42	40	119	143	42	54	35	38
Research	26	53	80	122	18	14	23	11
Fishing	55	78	109	134	13	3	12	2
Yacht under sail	13	4	29	10	5	2	17	20
Yacht under motor	16	18	33	30	4	3	12	10
Totals	746	780	1657	1678	209	203		

TABLE 7. PERCENTAGE OF BOAT TYPES IN MULTI-BOAT EVENTS OBSERVED DURING STUDY PERIODS IN 1999 AND 2000.

	NUMBER OF BOATS	PERCENTAGE OF BOATS
Jet ski	0	0
Canterbury Cat	0	0
Swim/Tour	14	37
Recreational	8	21
Dinghy	3	8
Kayaks	11	29
Research	1	3
Fishing	0	0
Yacht under sail	1	3
Yacht under motor	0	0
Total	38	

3.5 OBSERVATIONAL INFORMATION

Descriptions of typical of interactions observed among boats, people and dolphins follow. Although these observations cannot be treated statistically, they provide important information about what occurs between boats and dolphins inside Akaroa Harbour and may aid managers in overseeing these activities.

3.5.1 Summary of interactions observed among Hector's dolphins, boats and people

Appendix 2 provides detailed descriptions of some interactions observed among Hector's dolphins, boats and people. The range of interactions included:

- swimmers from non-permitted boats put into water near dolphins,
- swimmers appearing to touch dolphins,
- swimmer and dolphins touching or very close,
- lobtail, tailslap by dolphins, followed by close approach to swimmers,
- people on boats putting their hands or other objects into the water close to dolphins,
- boats pursuing and circling dolphins swimming away from them,
- boats passing directly over clearly visible groups of dolphins,
- dolphin groups forming, splitting and milling in association with kayaks and associated with kayaks for long periods of time,
- individual dolphins and groups approaching and travelling with boats and riding the bow waves.

Appendix 3 provides detailed descriptions of some interactions observed between Hector's dolphin calves, boats and people. These included:

- calf births in close proximity to a tour boat,
- mother and calf bow-riding,
- mother and calf pair playing with seaweed after jet ski interaction.

3.5.2 Observations of dolphin behaviour in Flea Bay

Table A9 (Appendix 1) records the behaviour of dolphins in Flea Bay. Dolphins were present on five of the eight observation days. A swim/tour boat came into the bay on only one of the days, 29 January 2000. Data collected 10 minutes before boat arrival and after boat departure are excluded from data presented in Table A8.

3.6 DOLPHIN MORTALITIES

Two dead neonate calves were recovered from Akaroa Harbour on two consecutive days during February 1999 (Stone & Yoshinaga 2000). Post-mortem examinations indicate that both calves may have been killed by collisions with boats.

DOC employees retrieved four beach-cast male dolphins in March 2000. Two were calves with fetal folds still visible (DOC stranding numbers H32/00 and H33/00). Two were sub-adults (DOC stranding numbers H30/00 and H31/00), being 75% and 82% the size of the largest adult male reported (Slooten & Dawson 1994). One calf and the two sub-adults had net marks indicating that entanglement in gill nets was a possible cause of death. The other calf, which was approximately 1 month old, showed no external evidence which might indicate cause of death.

4. Discussion

4.1 AKAROA HARBOUR STUDY SITE

We are confident that we observed most boating activity in Akaroa Harbour during our study periods. Although it is possible that some boats travelled within the northern inner harbour unobserved, most boats present in the harbour could be seen from the study observation site. Overall, we observed a high incidence of interactions between dolphins and boats, particularly kayaks and swim/tour boats. This high association rate with the relatively slow-moving kayaks and swim/tour boats supports and quantifies earlier observations that Hector's dolphins are often associated with slower moving vessels (Baker 1978; Cawthorn 1988; Dawson & Slooten 1988; Slooten & Dawson 1988).

Kayaks

Dolphins were associated most often with kayaks, at 35% in 1999 and 38% in 2000 (Table 6), although kayaks made up only 5.0% and 5.2% respectively of the total boats recorded over the two field seasons (Table 4). Part of the reason for this association may be that kayaks are slow, making it easy for dolphins to follow and stay near them.

Swim/tour boats

Dolphin association with the swim/tour boats increased from 26% in 1999 to 31% in 2000 (Table 6). As swim/tour boats only accounted for 8.8% and 11.7% respectively of boats recorded (Table 4), this is the second-highest association rate (after kayaks). These data indicate that the goal of the person operating the vessel is important. If operators search for them, dolphins will often be found. The decrease in association rate with the Canterbury Cat recorded in 2000 (Table 4) is most likely an artifact of decreased observations of this vessel. Our observations often stopped earlier in the day in 2000 because of poor weather, before the late-morning passage of the Canterbury Cat.

Recreational boats

In terms of boat numbers, recreational powerboats were the most common boat type recorded (at 64.1% in 1999 and 58.5% in 2000, Table 4). However, they had the lowest rate of interaction with dolphins (1% in 1999 and 2% in 2000, Table 6). One reason for this may be that recreational boats were often travelling at speed. Slooten & Dawson (1994) noted that Hector's dolphins are attracted to slower-moving boats. This is confirmed by the high association rate with kayaks (as noted before), and yachts under sail which were associated with dolphins at 17% in 1999 and 20% in 2000 (Table 6). The issue of boat speed needs further examination, especially in light of the two Hector's dolphin calves found dead, possibly of boat-strike, in the 1999 field season.

Dinghies

The proportion of dinghies recorded remained fairly constant at 3.5% in 1999 and 3.3% in 2000 (Table 4). In 1999 dolphins were moderately associated with dinghies, at 16%. This rate decreased to 2% in 2000 (Table 6). In 1999 most sightings were of one particular dinghy, which consistently went out in the harbour with the purpose of viewing dolphins. In 2000, the operator of that dinghy had a different type of vessel. This reinforces the point made above—that the goal of the vessel operator may be as important as the type of vessel.

4.2 DOLPHIN PRESENCE AND BOAT DENSITY

Sighting boats is very accurate because they are large and easy to place within the theodolite sights to mark their positions. Sighting and marking dolphins is considerably more difficult since they are smaller, move faster, and spend most of their time underwater. As some dolphins may not have been observed, our recorded dolphin densities are likely to be lower than actual dolphin densities.

Our observations indicate that at this time boats did not displace Hector's dolphins. This would correspond to behaviour reported by Slooten & Dawson (1994), and responses of Hector's dolphins in Porpoise Bay on the southeast coast of the South Island (Bejder et al. 1999). Although there appears to be an inverse relationship between boat density and dolphin presence, as described in Section 3.2, this is not statistically significant with our sample size. Larger sample sizes and more research are needed to more fully explore this possible relationship. However, this trend is worth noting, as it is suggested for both 1999 and 2000, and may indicate a level of boat activity that affects the dolphins' presence in the harbour.

Spinner dolphins (*Stenella longirostris*) in Hawaii exhibit a diurnal migratory pattern and return to particular bays throughout the year to rest near-shore during the day. They do so even when repeatedly disturbed by boats and swimmers. However, recent studies have found instances where disturbance has caused dolphins to leave the bay for the remainder of the day (Driscoll-Lind & Ostman-Lind 1999). Hector's dolphins migrate into and out of Akaroa Harbour diurnally (Stone et al. 1995) in a pattern similar to Spinner dolphins in Hawaii. However, it appears that present boat traffic levels are not displacing Hector's dolphins in Akaroa harbour.

4.3 DOLPHIN BEHAVIOUR

Dolphin swimming behaviour is exhibited more frequently with increasing boat presence. This behaviour is energetically more taxing than milling behaviour, the second most prevalent behaviour. Jumping, breaching, lobtailing and aggression are all more common when two or more groups have just come together (Slooten & Dawson 1988) and may be regarded as social interactions (Slooten & Dawson 1994). These behaviours were often observed around boats, but were also observed in Flea Bay when no boats were present. It would be of concern if the extra time dolphins spent swimming in Akaroa Harbour when boats were present was at the expense of other behaviours, such as feeding and interacting with other dolphins.

4.4 MULTI-BOAT EVENTS

Multi-boat events are addressed in the Marine Mammals Protection Regulations 1992 (MMPR) and DOC's Code of Conduct for Marine Mammal Operations 2000 (COC). The COC states that 'no vessel shall approach within 300 m of any pod of Hector's dolphins for the purpose of enabling passengers to watch the dolphins, if the number of vessels already positioned to watch that pod is 2 or more' (point 16). The MMPR states that 'where 2 or more vessels or aircraft approach an unaccompanied dolphin or seal, the masters concerned shall co-ordinate their approach and manoeuvres and the pilots concerned shall coordinate their approach and manoeuvres' (Reg. 20f). With respect to swimmers, the COC states that 'There shall be no greater than ten swimmers in the water at any one time with any one pod of mammals. This applies to all vessels in the vicinity of the group or pod of marine mammals' (point 29).

There are two parameters to multi-boat/dolphin encounters that need to be addressed: one of intensity of interaction, and the other of duration of interactions over the day. While these issues should be a consideration for managers, we are not at present able to quantify or predict what the long-term effect of repeated dolphin-multi-boat interactions will be. Recommendations for further research to quantify dolphin response to these situations are presented in Section 5.

The biggest concern regarding boat clusters, and placement of tour boats and kayaks in general, is that the ability of a dolphin to depart the vicinity of a boat or boats should never be impaired. The MMPR and COC state that 'no person or

vessel shall cut off the path of a marine mammal or prevent a marine mammal from leaving the vicinity of a person or vessel' (Reg.18(k) in the MMPR; point 7 in the COC). Clearly, the number of vessels in some observed boat groupings is greater than that allowed for in the MMPR, and these vessels create a dense area of surface activity that the dolphins must navigate through.

In an effort to provide a successful trip for their clients, boat operators are likely to go to areas where dolphins are known to be present and interacting. Those dolphins would experience longer periods of boat and swimmer presence—possibly up to 8 hours if all the boats went to the same area during one day.

4.5 SUMMARY OF OBSERVATIONAL INFORMATION

The interactions described in Appendix 3 show that the general public is interested in Hector's dolphins, yet often is uneducated about appropriate behaviour around wild dolphins. These interactions are unregulated and cannot be controlled, yet they are now part of the environment for the dolphins, and add to the cumulative impact of human activities on them.

Of particular concern were three dolphin/swimmer events described in Appendix 2 when dolphins made close approaches to the swimmers after either a tail-slap (twice) or a lob-tail (once). While this may be exciting for the swimmer, these behaviours are not clearly understood and should be cause for some concern. Aggression is considered rare among Hector's dolphins. Slooten & Dawson (1994) stated that usually 'direct approaches, displacements and open-mouth displays avert more obvious aggression' when dolphins are interacting with each other. However, in the case of a dolphin interacting with a swimmer, approaches and displacement behaviours might be interpreted simply as an interaction. The swimmer would not respond as the dolphin expected, and the dolphin may escalate its signals. This kind of interpretation needs more study. Whatever the motivation, tail slaps involve a strong movement of the fluke that is very powerful and could be harmful if a person were struck.

These behaviours, along with breaches and porpoising, were also evident in Flea Bay, when no boats or swimmers were present and are likely social interactions among the dolphins. If this is the case, then it could be interpreted that when Hector's dolphins exhibit these behaviours around boats and swimmers, they are using energy which would be better conserved or expended in activities more directly related to their survival. Development of social behaviours and foraging skills are important to the overall biological fitness of the dolphins. For example, in Monkey Mia, Australia there was an increase in calf mortality among female dolphins that were being fed, spending more time with people and less time feeding and tending to their calves (Ford 1997). Analysis of the 1999 Hector's dolphin data indicates that dolphins spend more time swimming, rather than exhibiting other behaviours, when boats are present. More research is needed to provide better understanding of the context of different behaviours exhibited by Hector's dolphins.

4.6 THE QUESTION OF HABITUATION

Akaroa Harbour has been used for dolphin swim/tour programs since 1987 and the relatively long-term exposure the dolphins have had to boats and people needs to be considered in evaluating whether boats affect dolphin activity at present. Hector's dolphins were shown to migrate in and out of the harbour diurnally (Stone et al. 1995). The constant and increased presence of boats and dolphin tour operations has not noticeably excluded Hector's dolphin from the Akaroa Harbour habitat. Dolphin group size was also not affected by increased boat density. In a study of Hector's dolphins in Porpoise Bay (Bejder 1998), Hector's dolphins formed tighter pods in response to boat presence. It may be that the Hector's dolphins in Akaroa Harbour are habituated to a certain amount of boat activity because of the long period that boats have been present in the harbour. An individual photo-identification study showed a relatively high degree of site fidelity exhibited by Hector's dolphins during summer months around Banks Peninsula (Stone 1992). This further creates the opportunity for habituation to occur. Habituation is the progressive waning of response to stimuli that were once key to the animal's survival (Thorpe 1963). We have observed dolphins in Akaroa Harbour each summer since 1990 (Stone & Yoshinaga 1990; Stone 1991; Stone 1992; Stone et al.1995; Stone et al. 1998a, b) and have noted a decrease in avoidance response to boat and swimmer presence over this time (Stone & Yoshinaga 2000).

In general, Hector's dolphins have been described as attracted to boats (Baker 1978; Cawthorn 1988; Slooten & Dawson 1988, 1994). Baker in 1978 and Cawthorn in 1988 described the dolphins' associations with boats as brief. However, Hector's dolphins in Akaroa Harbour currently exhibit high boat association rates over extended time periods. Mothers and newborn calves were reported to be shy and to seldom approach stationary or moving boats (Slooten & Dawson 1994). The two reports of birth occuring next to tour boats may just have been coincidence, but the fact that the females were in such close proximity to boats initially is noteworthy. The observations describing mother/calf pair behaviour are limited (Appendix 3), but appear to indicate a change, i.e. the dolphins seem now to be less wary of boats. Mother and calf pairs have a slower pace and response time. A dolphin that is habituated to boats may not change its response to boats when it has a calf, even though the dolphin's ability to manoeuvre around boat activity when accompanied by a calf is impaired. Researchers have observed increasing tolerance of diver presence in Akaroa over the past ten years (Stone & Yoshinaga 2000). As pointed out by Bejder (1994), it is repeated and prolonged encounters over time that lead to problems.

A potential problem for Hector's dolphins is that habituation to boats during the annual ban on set-net use, November 1 to the last day in February, could lead to increased incidental catch during the set-net season. The dolphins may not see the set-net boats as a hazard if they are increasingly habituated to other boats, particularly during the time they spend in Akaroa Harbour during summer.

In general, habituation of wild animals to humans is not beneficial for the animals or people. The following is summarised from Stone & Yoshinaga (2000). Interactions between humans and animals in the wild on a regular basis are not a natural condition. Animals can either become dependent on interactions with

people, or may become emboldened and thus exposed to risks they might not otherwise face, as evidenced by the dolphins that will approach and investigate hands and objects held at the water's surface. Conner & Smolker (1985) documented habituation to people and changes in wild bottlenose dolphin behaviour in Monkey Mia, Australia, in a situation where people on the beach can pat, feed and swim with the dolphins. There is one report of a female dolphin who allowed her calf to be handled by people, and there are reports of dolphins becoming aggressive and sexually interested in human swimmers (Ford 1997). Dolphins sometimes try to keep swimmers in the water for extended play and contact. An extreme dolphin/human interaction occurred in Brazil when a habituated dolphin caused the death of a swimmer (Bryant et al. 1995). Ford (1997) reports that human association 'soured' the nature of this bottlenose dolphin named Tiao, who killed a tourist on December 8, 1994. Dolphins are also known to bite humans during encounters in the wild (Angilella 1993, 1995; Brooks, 1996). Biting can be a normal part of inter-dolphin behaviour, but when it is used during encounters with people, the panic and injury caused by the bite can be dangerous for all involved. These documented accounts show that habituation can jeopardise the health of dolphins and pose a potential danger to people as well (Flanagan 1996; Seideman 1997).

It is important to consider that it is the cumulative change that must be considered when assessing environmental risks. 'Cumulative environmental change or cumulative effects may result from the additive effect of individual actions of the same nature or the interactive effect of multiple actions of a different nature' (Spaling & Smit 1993). The impact of any one factor may not be harmful, but the combined effect can advance in slow and unexpected ways. The repeated and combined effects of various changes over time can add up to a measurable impact (Parry 1990).

5. Recommendations

Recent analysis has shown that Hector's dolphins exhibit a marked segregation of maternal lineages across a small geographic range, with a low rate of female dispersal (Pichler et al. 1998). In the same paper it was stated that this could increase the vulnerability of local populations to extinction resulting from fisheries-related mortalities. The genetic diversity of the East Coast South Island population has declined and it is predicted that all mtDNA diversity will be lost within the next 20 years (Pichler & Baker 2000). To prevent this from happening, managers need to implement measures that allow the population to remain stable or increase.

Management regimes such as the Banks Peninsula Marine Mammal Sanctuary act directly to reduce dolphin mortality from incidental bycatch and by regulating dolphin, boat and human interactions.

Studying the dolphins will identify any direct threats not presently addressed in the management regime and, in the longer term, any impacts of dolphin/human interactions that could decrease the dolphins' biological fitness by interfering with their natural behaviours.

5.1 RESEARCH

Long-term studies are the only way to determine whether changes in dolphin behaviour are occurring over time. 'Long-term behavioural studies are key to understanding the nature of cetacean sociality and the selective forces that shaped patterns of cetacean communications, cognition, life history, behaviour and ecology' (Mann 2000).

The considerable amount of boat activity, the possible calf strikes by boats, and the number of controlled and uncontrolled interactions that occur between dolphins and boats emphasise the need to maintain observations of dolphin/boat interactions within Akaroa Harbour. In future seasons, it is recommended that observations continue at the same Akaroa site using the same survey methodology described in this report. This will allow comparison of year-to-year data to show changes in dolphin behaviour, distribution and density over time. A study of the Hawaiian spinner dolphin (*Stenella longirostris*) described an apparent trend of dolphin displacement by human activities (Forest 1999). The researchers were able to observe this because they conducted their observations with comparable methodology at the same site used by researchers 12 years previously.

Complementary studies assessing dolphin behaviour by observing dolphin focal group behaviour with and without boats should also be implemented. Such studies may help to better elucidate the behavioural repertoire of Hector's dolphins, such as the frequency of approaches, breaches, tailslaps, lobtailing, spyhopping and bubble blowing within the contexts of boat/swimmer presence and absence. With more knowledge of dolphin behaviour, better education can be provided to tour boat operators and the public about how to behave around the dolphins. The Flea Bay observation site used in this study, where there is minimal boat traffic, could be used as a comparison site for Akaroa Harbour.

One aspect of Hector's dolphin behaviour that requires investigation is whether or not they exhibit a daily resting period. Other coastal dolphins that exhibit diurnal migratory patterns, for example, Kaikoura dusky dolphins, *Lagenorhynchus obscurus* (Cipriano 1992) and spinner dolphins, *Stenella longirostris* (Norris 1994), have been shown to have a period of decreased activity during the day. If a resting period is identified, it should be taken into consideration in management decisions. In particular, tour operators could be asked to conduct their activities outside the resting period.

5.2 MANAGEMENT

The following recommendations are made to assist DOC in ensuring that operators of marine mammal commercial ventures satisfy the following criterion: 'That it should be in the interests of the conservation, management, or protection of the marine mammals that a permit be issued' (MMPR, Reg. 6(d)).

The high number of unregulated interactions between recreational boats and Hector's dolphins, and reports from tour operators that recreational boats often interfere with or participate in tours, are of concern.

The death of two calves, possibly from boat strike, provides a clear signal that speeding boats in Akaroa Harbour may be a serious hazard to Hector's dolphins. As is clear from the descriptions of various encounters between dolphins and recreational boats, the public is unaware of the protections afforded to Hector's dolphins through the Marine Mammals Protection Act 1978 and the MMPR.

Kayaks were the boat type most often associated with dolphins. Kayaks are also the least intrusive boat-based way to observe dolphins. However, there is the potential for problems when kayakers are not considerate of dolphins, or cluster around them. Once tour participants set off in their separate kayaks, tour guides are not able to monitor all of them all of the time. This highlights how important it is for kayak tour participants to be instructed on appropriate behaviour when they encounter dolphins.

5.2.1 Public education

Criteria for the issuance of permits to commercial marine mammal operations include the requirement that each operation should have sufficient educational value to participants or to the public. When the participants leave the swim/tour boat experience, they should be more knowledgeable about Hector's dolphins, about conservation efforts and about the Banks Peninsula Marine Mammal Sanctuary. It is recommended that all operators be required to give an educational speech to each tour group, and that DOC provides minimum requirements for the information to be included in that presentation.

Public campaigns using newspaper articles, pamphlets, and boat-ramp signs to educate recreational boat users about Hector's dolphins are recommended. Buoys should be placed in the harbour with clear messages requesting boat operators to proceed slowly through the harbour and around dolphins. Special emphasis should be placed on the fact that Hector's dolphins are often present in the harbour with calves, that mother and calf pairs move slowly, and that the threat of boat strike by fast-moving vessels is real.

5.2.2 Operator education

It is recommended that DOC conduct a workshop at the beginning of each summer season to maintain communication between DOC and tour operators, provide all operators with the same information on rules and regulations of operation around marine mammals, and answer operator questions. This periodic contact would let the operators know that DOC is interested and involved in ensuring the best outcome for dolphins and tour operators.

5.2.3 Boat/dolphin interactions

Prolonged exposure of one group of dolphins to boat/swimmer activity over the day can be avoided by operator coordination. Each operator could report on his return where he had swimmers in the water for longer than a specified period of time, and that area can be avoided on the next trip.

It is recommended that a pilot program be initiated to provide tour operators with a mechanism to record and report recreational boat activity that interferes with tour boat operation or endangers dolphins. This would provide DOC with more surveillance of the harbour than could otherwise be managed, and create positive relationships between operators and DOC. It has been shown that stakeholders

participate more readily in management programmes of their resources when they know that other stakehoders are held to the same standards (Pinkerton 1994). A good first step would be to gather information, and then determine whether an enforcement policy needs to be implemented, such as sending warnings or information to offending recreational boat operators.

5.2.4 Swim/tour business density

Whether or not the current level of dolphin tour boat activity in Akaroa Harbour is having a detrimental impact on Hector's dolphins is not known. The current level does not appear to have affected the dolphins' use of the harbour. In other parts of the world, tour boat activity has led to displacement of dolphins. It is recommended that dolphin tour boat activity in Akaroa Harbour not be increased to avoid potential displacement of Hector's dolphins from their Akaroa Harbour habitat.

Additionally, Hector's dolphins do show a high degree of interaction with boats. It can be surmised that increasing the amount of tour boat activity might increase the amount of dolphin/boat interaction time, which may decrease the overall biological fitness of this vulnerable population. The fact that the dolphins do not change their group structure in the presence of boats, as compared with the dolphins in Porpoise Bay, may indicate that these dolphins are already habituated. It is prudent at this time not to allow any further activities that may result in increased habituation of Hector's dolphins to boats and people.

5.2.5 Summary of recommendations

- A long-term observation study of Hector's dolphin/boat interactions should be implemented at the same Akaroa site used in this study using the same survey methodology.
- Complementary studies assessing dolphin behaviour by observing dolphin focal group behaviour with and without boats should be implemented in order to understand the full behavioural repertoire and corresponding energy budgets of the dolphins.
- All operators should be required to give an educational speech to each tour group, with DOC specifying minimum requirements for the information to be included.
- Public campaigns using newspaper articles, pamphlets, and boat-ramp signs to educate recreational boat users should be implemented. Buoys should be placed in the harbour with clear messages requesting boat operators to proceed slowly through the harbour when dolphins are present.
- DOC should conduct yearly tour operators' workshops.
- Each operator should report on his return where he had swimmers in the water for longer than a specified period of time; that area can then be avoided on the next trip so that individual groups of dolphins are not subject to prolonged and repeated exposure to boats and swimmers.
- A pilot project to provide tour operators with a mechanism to record and report any activity that endangers dolphins or interferes with safe and appropriate tour boat operation should be investigated.

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Appendix 1

SUPPORTING DATA

TABLE A1a. ABSOLUTE NUMBER OF BOATS (WITHOUT RETURN PASSES)—1999.

DAY OF THE WEEK	DATE	JET SKI	CANTERBURY CAT	SWIM/TOUR BOATS	RECREATIONAL BOATS	DINGHY	KAYAKS	RESEARCH BOAT	FISHING VESSELS	YACHT UNDER SAIL	YACHT MOTORING	TOTAL BOATS
Wednesday	06-Jan-99	0	0	0	8	0	0	0	0	0	2	10
Thursday	07-Jan-99	0	2	0	59	2	4	0	5	1	0	73
Saturday	09-Jan-99	0	1	4	33	1	1	1	1	2	2	46
Sunday	10-Jan-99	3	1	1	56	1	4	0	1	6	1	74
Monday	11-Jan-99	1	0	0	13	1	0	1	3	0	0	19
Saturday	16-Jan-99	1	0	5	25	0	1	2	0	0	0	34
Sunday	17-Jan-99	0	1	4	35	4	1	1	1	2	3	52
Tuesday	19-Jan-99	0	1	6	21	4	2	2	3	0	1	40
Wednesday	20-Jan-99	0	1	1	17	1	2	2	5	0	0	29
Friday	22-Jan-99	0	2	2	19	1	1	0	2	1	1	29
Saturday	23-Jan-99	0	0	4	16	0	1	1	3	0	1	26
Sunday	24-Jan-99	0	0	1	6	0	0	1	1	0	0	9
Monday	25-Jan-99	0	0	1	3	0	0	0	3	0	0	7
Tuesday	26-Jan-99	2	1	5	10	3	2	3	1	0	0	27
Wednesday	27-Jan-99	0	0	3	2	1	4	1	3	0	0	14
Thursday	28-Jan-99	0	1	3	12	0	0	1	1	0	0	18
Friday	29-Jan-99	0	0	1	2	0	3	0	1	0	1	8
Saturday	30-Jan-99	0	1	5	24	0	0	0	3	0	0	33
Tuesday	02-Feb-99	0	1	1	11	1	2	1	2	0	0	19
Wednesday	03-Feb-99	1	0	2	7	0	0	0	1	0	0	11
Friday	05-Feb-99	0	1	3	7	1	0	0	3	0	1	16
Sunday	07-Feb-99	2	0	3	49	1	3	1	3	1	1	64
Tuesday	09-Feb-99	0	0	0	0	0	1	0	3	0	1	5
Thursday	11-Feb-99	0	1	2	4	1	1	1	4	0	1	15
Friday	12-Feb-99	0	1	4	6	1	2	0	2	0	0	16
	Total Boats	10	16	61	445	24	35	19	55	13	16	694

TABLE A1b. ABSOLUTE NUMBER OF BOATS (WITHOUT RETURN PASSES)—2000.

DAY OF THE WEEK	DATE	JET SKI	CANTERBURY CAT	SWIM/TOUR BOATS	RECREATIONAL BOATS	DINGHY	KAYAKS	RESEARCH BOAT	FISHING VESSELS	YACHT UNDER SAIL	YACHT MOTORING	TOTAL BOATS
Sunday	09-Jan-00	1	0	3	33	0	1	1	3	0	3	45
Tuesday	11-Jan-00	0	1	4	31	1	0	5	7	0	2	51
Wednesday	12-Jan-00	0	1	8	36	2	1	3	4	0	2	57
Thursday	13-Jan-00	0	1	11	35	1	1	4	6	0	1	60
Friday	14-Jan-00	0	0	6	21	2	1	4	2	0	0	36
Saturday	15-Jan-00	0	0	2	38	2	4	1	4	0	2	53
Sunday	16-Jan-00	0	0	2	16	1	2	0	1	1	0	23
Monday	17-Jan-00	1	0	5	11	2	3	2	6	0	2	32
Tuesday	18-Jan-00	0	1	4	15	2	2	2	3	1	1	31
Wednesday	19-Jan-00	0	1	4	12	2	2	2	3	1	1	28
Thursday	20-Jan-00	0	0	6	11	2	1	4	2	1	1	28
Friday	21-Jan-00	0	1	6	22	1	1	1	5	0	2	39
Saturday	22-Jan-00	0	0	5	22	0	1	0	2	0	0	30
Sunday	23-Jan-00	0	0	1	38	1	4	1	5	0	0	50
Monday	24-Jan-00	0	1	4	4	1	1	2	4	0	0	17
Monday	07-Feb-00	0	0	0	3	2	4	3	2	0	0	14
Tuesday	08-Feb-00	0	0	0	1	0	1	2	1	0	0	5
Wednesday	09-Feb-00	0	1	3	10	0	1	1	2	0	0	18
Thursday	10-Feb-00	0	0	1	1	0	1	1	1	0	0	5
Friday	11-Feb-00	0	0	3	4	0	2	5	3	0	0	17
Saturday	12-Feb-00	0	0	1	31	0	1	1	2	0	0	36
	Totals	2	8	79	395	22	35	45	68	4	17	675

TABLE A2a. NUMBER OF BOAT PASSES BY DATE—1999.

DAY OF THE WEEK	DATE	JET SKI	CANTERBURY CAT	SWIM/TOUR BOATS	RECREATIONAL BOATS	DINGHY	KAYAKS	RESEARCH BOAT	FISHING VESSELS	YACHT UNDER SAIL	YACHT MOTORING	TOTAL BOATS
Wednesday	06-Jan-99	0	0	0	8	0	0	0	0	0	2	10
Thursday	07-Jan-99	0	3	0	59	4	4	0	5	1	0	76
Saturday	09-Jan-99	0	1	5	33	1	1	1	1	2	2	47
Sunday	10-Jan-99	3	1	1	56	2	6	0	1	6	1	77
Monday	11-Jan-99	1	0	0	13	1	0	1	3	0	0	19
Saturday	16-Jan-99	1	0	5	25	0	1	6	0	0	0	38
Sunday	17-Jan-99	0	1	4	35	5	1	1	1	2	3	53
Tuesday	19-Jan-99	0	1	6	21	4	2	4	3	0	1	42
Wednesday	20-Jan-99	0	1	2	17	1	2	3	5	0	0	31
Friday	22-Jan-99	0	3	2	19	1	1	0	2	1	1	30
Saturday	23-Jan-99	0	0	5	16	0	1	1	3	0	1	27
Sunday	24-Jan-99	0	0	2	6	0	0	1	1	0	0	10
Monday	25-Jan-99	0	0	1	3	0	0	0	3	0	0	7
Tuesday	26-Jan-99	2	2	7	10	4	2	3	1	0	0	31
Wednesday	27-Jan-99	0	0	4	2	2	4	1	3	0	0	16
Thursday	28-Jan-99	0	1	4	12	0	0	1	1	0	0	19
Friday	29-Jan-99	0	0	1	2	0	4	0	1	0	1	9
Saturday	30-Jan-99	0	1	11	24	0	0	0	3	0	0	39
Tuesday	02-Feb-99	0	1	2	14	3	4	1	2	0	0	27
Wednesday	03-Feb-99	1	0	2	7	0	0	0	1	0	0	11
Friday	05-Feb-99	0	1	5	7	1	0	0	3	0	1	18
Sunday	07-Feb-99	2	0	5	49	2	5	1	3	1	1	69
Tuesday	09-Feb-99	0	0	0	0	0	1	0	3	0	1	5
Thursday	11-Feb-99	0	1	3	4	2	1	1	4	0	1	17
Friday	12-Feb-99	0	1	6	6	1	2	0	2	0	0	18
	Total Boats	10	19	83	448	34	42	26	55	13	16	746

TABLE A2b. NUMBER OF BOAT PASSES BY DATE—2000.

DAY OF THE WEEK	DATE	JET SKI	CANTERBURY CAT	SWIM/TOUR BOATS	RECREATIONAL BOATS	DINGHY	KAYAKS	RESEARCH BOAT	FISHING VESSELS	YACHT UNDER SAIL	YACHT MOTORING	TOTAL BOATS
Sunday	09-Jan-00	2	0	3	36	0	1	2	3	0	3	50
Tuesday	11-Jan-00	0	1	4	34	1	0	6	7	0	3	56
Wednesday	12-Jan-00	0	1	9	39	2	1	3	4	0	2	61
Thursday	13-Jan-00	0	1	11	40	1	2	5	8	0	1	69
Friday	14-Jan-00	0	0	7	32	3	2	5	2	0	0	51
Saturday	15-Jan-00	0	0	4	43	2	5	2	6	0	2	64
Sunday	16-Jan-00	0	0	2	17	1	2	0	1	1	0	24
Monday	17-Jan-00	2	0	5	13	2	3	3	7	0	2	37
Tuesday	18-Jan-00	0	1	6	16	2	3	2	4	1	1	36
Wednesday	19-Jan-00	0	1	4	15	3	2	3	3	1	1	33
Thursday	20-Jan-00	0	0	10	15	2	1	4	4	1	1	38
Friday	21-Jan-00	0	1	7	24	1	1	1	6	0	2	43
Saturday	22-Jan-00	0	0	5	24	0	1	0	2	0	0	32
Sunday	23-Jan-00	0	0	2	41	1	4	1	5	0	0	54
Monday	24-Jan-00	0	1	4	4	1	1	2	4	0	0	17
Monday	07-Feb-00	0	0	0	5	2	4	3	2	0	0	16
Tuesday	08-Feb-00	0	0	0	1	0	1	3	2	0	0	7
Wednesday	09-Feb-00	0	1	6	13	0	2	1	2	0	0	25
Thursday	10-Feb-00	0	0	1	1	0	1	1	1	0	0	5
Friday	11-Feb-00	0	0	5	5	0	2	5	3	0	0	20
Saturday	12-Feb-00	0	0	1	37	0	1	1	2	0	0	42
	Totals	4	8	96	455	24	40	53	78	4	18	780

TABLE A3. TOTAL NUMBER OF DOLPHINS MARKED IN THE STUDY SITE.
a = 1999, b = 2000.

a

DATE	GROUPS	NUMBER OF DOLPHINS
06-Jan-99	0	0
07-Jan-99	25	68
09-Jan-99	145	304
10-Jan-99	30	59
11-Jan-99	82	214
16-Jan-99	9	25
17-Jan-99	28	72
19-Jan-99	45	100
20-Jan-99	20	74
22-Jan-99	41	103
23-Jan-99	32	58
24-Jan-99	4	15
25-Jan-99	9	32
26-Jan-99	74	177
27-Jan-99	65	151
28-Jan-99	35	96
29-Jan-99	67	157
30-Jan-99	25	64
02-Feb-99	2	2
03-Feb-99	2	3
05-Feb-99	56	148
07-Feb-99	54	135
09-Feb-99	55	114
11-Feb-99	39	82
12-Feb-99	12	28
Totals	956	2281

b

DATE	GROUPS	NUMBER OF DOLPHINS
09-Jan-00	111	175
11-Jan-00	33	62
12-Jan-00	81	149
13-Jan-00	128	232
14-Jan-00	57	114
15-Jan-00	59	108
16-Jan-00	59	116
17-Jan-00	139	268
18-Jan-00	73	195
19-Jan-00	47	80
20-Jan-00	118	238
21-Jan-00	123	238
22-Jan-00	36	81
23-Jan-00	93	205
24-Jan-00	24	38
07-Feb-00	28	88
08-Feb-00	19	50
09-Feb-00	106	226
10-Feb-00	58	116
11-Feb-00	52	109
12-Feb-00	220	571
	1664	3459

TABLE A4. SAMPLE OF DATA COMPRESSED INTO 5-MINUTE INTERVALS.
a = ORIGINAL DATA, b = COMPRESSED DATA.

a

TIME	BOAT NUMBER	GROUP NUMBER	NUMBER OF DOLPHINS
08:30:10	1		
08:35:34	2		
08:35:58	2		
08:37:30	1		
08:41:12	3		
08:47:37	3		
08:52:50		1	4
09:06:59		2	3
09:07:07		2	3
09:07:16		2	3
09:17:36	4		
09:17:58	4		
09:30:29		3	3
09:30:44		3	3
09:30:59		3	3
09:31:25		3	3
09:32:41		4	3
09:33:18		4	3
09:34:04		4	3
09:35:40		4	3
09:35:52		4	3
09:39:14	5		
09:42:45	5		
09:44:28	5		
09:47:03	5		
09:47:32		5	2
09:47:47	5		
09:47:53		5	2
09:47:53		5	2
09:48:00	5		
09:48:09		6	2
09:48:17	5		

b

TIME	NUMBER OF BOATS	NUMBER OF DOLPHIN GROUPS	NUMBER OF DOLPHINS
08:30	1	0	0
08:35	2	0	0
08:40	1	0	0
08:45	1	0	0
08:50	0	1	4
08:55	0	0	0
09:00	0	0	0
09:05	0	1	3
09:10	0	0	0
09:15	1	0	0
09:20	0	0	0
09:25	0	0	0
09:30	0	2	6
09:35	1	1	3
09:40	1	0	0
09:45	1	2	4

TABLE A5a. DOLPHIN BEHAVIOURS—1999.

DAY OF THE WEEK	DATE	BEHAVIOUR								
		SWIMMING	PORPOISING	LOG	BREACH	MILL	BOW RIDING	OTHER	GROUPS	NUMBER OF DOLPHINS
Wednesday	06-Jan-99	0	0	0	0	0	0	0	0	0
Thursday	07-Jan-99	60	1	0	0	1	1	0	25	68
Saturday	09-Jan-99	167	2	0	5	38	0	0	145	304
Sunday	10-Jan-99	36	3	0	0	0	1	0	30	59
Monday	11-Jan-99	95	0	0	1	20	1	1	82	214
Saturday	16-Jan-99	17	0	0	0	0	0	0	9	25
Sunday	17-Jan-99	45	0	0	2	5	0	0	28	72
Tuesday	19-Jan-99	46	0	0	2	3	4	0	45	100
Wednesday	20-Jan-99	24	0	1	0	14	0	0	21	74
Friday	22-Jan-99	45	0	0	1	14	0	0	41	103
Saturday	23-Jan-99	38	0	0	1	2	0	0	32	58
Sunday	24-Jan-99	3	0	0	0	0	0	0	4	15
Monday	25-Jan-99	6	0	1	6	4	1	9	9	32
Tuesday	26-Jan-99	157	0	0	0	3	0	0	74	177
Wednesday	27-Jan-99	91	0	0	1	19	1	0	65	151
Thursday	28-Jan-99	44	0	0	0	7	0	0	35	96
Friday	29-Jan-99	77	3	0	0	19	0	0	67	157
Saturday	30-Jan-99	50	1	0	0	6	0	0	25	64
Tuesday	02-Feb-99	2	0	0	0	0	0	0	2	2
Wednesday	03-Feb-99	3	0	0	0	0	0	0	2	3
Friday	05-Feb-99	62	0	0	0	17	0	0	56	148
Sunday	07-Feb-99	66	1	0	0	23	5	0	54	135
Tuesday	09-Feb-99	56	0	0	1	18	0	0	55	114
Thursday	11-Feb-99	45	0	0	1	19	3	0	39	82
Friday	12-Feb-99	10	0	0	6	0	0	0	12	28
	Totals	1245	11	2	27	232	17	10	957	2281

TABLE A5b. DOLPHIN BEHAVIOURS—2000.

DAY OF THE WEEK	DATE	BEHAVIOUR								
		SWIMMING	PORPOISING	LOG	BREACH	MILL	BOW RIDING	OTHER	GROUPS	NUMBER OF DOLPHINS
Sunday	09-Jan-00	118	2	1	0	10	4	0	111	175
Tuesday	11-Jan-00	31	0	0	0	2	0	0	33	62
Wednesday	12-Jan-00	97	0	0	1	2	0	0	81	149
Thursday	13-Jan-00	142	4	0	1	2	0	1	128	232
Friday	14-Jan-00	66	0	0	0	1	5	0	57	114
Saturday	15-Jan-00	71	0	0	0	6	0	2	59	108
Sunday	16-Jan-00	78	0	0	1	4	10	0	59	116
Monday	17-Jan-00	193	1	2	0	22	0	1	139	268
Tuesday	18-Jan-00	93	1	0	1	8	0	0	73	195
Wednesday	19-Jan-00	38	1	0	0	1	11	0	47	80
Thursday	20-Jan-00	177	0	1	1	9	0	0	118	238
Friday	21-Jan-00	170	1	0	1	12	0	0	123	238
Saturday	22-Jan-00	46	0	0	0	3	1	0	36	81
Sunday	23-Jan-00	128	0	0	0	17	0	1	93	205
Monday	24-Jan-00	27	2	0	1	1	1	0	24	38
Monday	07-Feb-00	38	0	0	0	7	0	0	28	88
Tuesday	08-Feb-00	23	0	0	0	5	0	0	19	50
Wednesday	09-Feb-00	134	3	0	0	11	0	0	106	226
Thursday	10-Feb-00	86	0	0	0	5	0	0	58	116
Friday	11-Feb-00	68	0	0	2	9	0	1	52	109
Saturday	12-Feb-00	331	0	1	3	29	0	1	220	571
	Totals	2155	15	5	12	166	32	7	1664	3459

TABLE A6. GROUP SIZE AND BOAT DENSITY. a = 1999, b = 2000.

a

DAY OF THE WEEK	DATE	GROUPS	TOTAL NUMBER OF DOLPHINS	AVERAGE GROUP SIZE	TOTAL BOATS	SWIM/TOUR BOATS	RECREATIONAL BOATS
Wednesday	06-Jan-99	0	0	n/a	10	0	8
Thursday	07-Jan-99	25	68	2.72	76	0	59
Saturday	09-Jan-99	145	304	2.10	47	5	33
Sunday	10-Jan-99	30	59	1.97	77	1	56
Monday	11-Jan-99	82	214	2.61	19	0	13
Saturday	16-Jan-99	9	25	2.78	38	5	25
Sunday	17-Jan-99	28	72	2.57	53	4	35
Tuesday	19-Jan-99	45	100	2.22	42	6	21
Wednesday	20-Jan-99	20	74	3.70	31	2	17
Friday	22-Jan-99	41	103	2.51	30	2	19
Saturday	23-Jan-99	32	58	1.81	27	5	16
Sunday	24-Jan-99	4	15	3.75	10	2	6
Monday	25-Jan-99	9	32	3.56	7	1	3
Tuesday	26-Jan-99	74	177	2.39	31	7	10
Wednesday	27-Jan-99	65	151	2.32	16	4	2
Thursday	28-Jan-99	35	96	2.74	19	4	12
Friday	29-Jan-99	67	157	2.34	9	1	2
Saturday	30-Jan-99	25	64	2.56	39	11	24
Tuesday	02-Feb-99	2	2	1.00	27	2	14
Wednesday	03-Feb-99	2	3	1.50	11	2	7
Friday	05-Feb-99	56	148	2.64	18	5	7
Sunday	07-Feb-99	54	135	2.50	69	5	49
Tuesday	09-Feb-99	55	114	2.07	5	0	0
Thursday	11-Feb-99	39	82	2.10	17	3	4
Friday	12-Feb-99	12	28	2.33	18	6	6

b

DAY OF THE WEEK	DATE	GROUPS	TOTAL NUMBER OF DOLPHINS	AVERAGE GROUP SIZE	TOTAL BOATS	SWIM/TOUR BOATS	RECREATIONAL BOATS
Sunday	09-Jan-00	111	175	1.58	50	3	36
Tuesday	11-Jan-00	33	62	1.88	56	4	34
Wednesday	12-Jan-00	81	149	1.84	61	9	39
Thursday	13-Jan-00	128	232	1.81	69	11	40
Friday	14-Jan-00	57	114	2.00	51	7	32
Saturday	15-Jan-00	59	108	1.83	64	4	43
Sunday	16-Jan-00	59	116	1.97	24	2	17
Monday	17-Jan-00	139	268	1.93	37	5	13
Tuesday	18-Jan-00	73	195	2.67	36	6	16
Wednesday	19-Jan-00	47	80	1.70	33	4	15
Thursday	20-Jan-00	118	238	2.02	38	10	15
Friday	21-Jan-00	123	238	1.93	43	7	24
Saturday	22-Jan-00	36	81	2.25	32	5	24
Sunday	23-Jan-00	93	205	2.20	54	2	41
Monday	24-Jan-00	24	38	1.58	17	4	4
Monday	07-Feb-00	28	88	3.14	16	0	5
Tuesday	08-Feb-00	19	50	2.63	7	0	1
Wednesday	09-Feb-00	106	226	2.13	25	6	13
Thursday	10-Feb-00	58	116	2.00	5	1	1
Friday	11-Feb-00	52	109	2.10	20	5	5
Saturday	12-Feb-00	220	571	2.60	42	1	37

TABLE A7a. BOAT AND DOLPHIN ASSOCIATION BY DATE AND BOAT—1999.

DATE	**0**	M	M/D	**1**	M	M/D	**2**	M	M/D	**3**	M	M/D	**4**	M	M/D	**5**	M	M/D	**6**	M	M/D	**7**	M	M/D	**8**	M	M/D	**9**	M	M/D
06-Jan-99	0	0	0	0	0	0	0	0	0	8	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	0
07-Jan-99	0	0	0	3	7	1	0	0	0	59	100	1	4	13	1	4	10	3	0	0	0	5	10	1	1	1	0	0	0	0
09-Jan-99	0	0	0	1	1	0	5	23	14	33	53	3	1	3	1	1	9	8	1	3	0	1	1	0	2	6	2	2	2	0
10-Jan-99	3	7	0	1	1	0	1	10	3	56	98	0	2	3	1	6	13	3	0	0	0	1	2	0	6	12	2	1	2	0
11-Jan-99	1	2	0	0	0	0	0	0	0	13	23	0	1	3	0	0	0	0	1	3	0	3	4	1	0	0	0	0	0	0
16-Jan-99	1	1	0	0	0	0	5	13	0	25	46	0	0	0	0	1	3	0	6	13	0	0	4	0	0	0	0	0	0	0
17-Jan-99	0	0	0	1	2	0	4	9	0	35	60	0	5	9	1	1	1	0	1	6	0	1	2	0	2	4	0	3	5	3
19-Jan-99	0	0	0	1	1	0	6	37	12	21	37	0	4	7	2	2	4	0	4	6	2	3	4	0	0	0	0	1	1	0
20-Jan-99	0	0	0	1	1	0	2	4	0	17	29	0	1	2	0	2	3	0	3	9	5	5	8	0	0	0	0	0	0	0
22-Jan-99	0	0	0	3	8	0	2	8	0	19	22	0	1	2	0	1	1	0	0	0	0	2	4	0	1	4	1	1	2	0
23-Jan-99	0	0	0	0	0	0	5	19	3	16	30	0	0	0	0	1	5	0	1	2	0	3	7	1	0	0	0	1	2	0
24-Jan-99	0	0	0	0	0	0	2	4	0	6	9	0	0	0	0	0	0	0	1	3	0	1	1	0	0	0	0	0	0	0
25-Jan-99	0	0	0	0	0	0	1	9	4	3	4	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0
26-Jan-99	2	11	9	2	9	6	7	48	16	10	33	3	4	10	1	2	17	9	3	8	0	1	2	0	0	0	0	0	0	0
27-Jan-99	0	0	0	0	0	0	4	22	9	2	6	2	2	14	4	4	16	8	1	17	11	3	4	0	0	0	0	0	0	0
28-Jan-99	0	0	0	1	2	0	4	12	4	12	21	0	0	0	0	0	0	0	1	2	0	1	2	0	0	0	0	0	0	0
29-Jan-99	0	0	0	0	0	0	1	9	6	2	3	0	0	0	0	4	19	11	0	0	0	1	1	0	0	0	0	1	2	0
30-Jan-99	0	0	0	1	1	1	11	22	0	24	44	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0
02-Feb-99	0	0	0	1	1	0	1	3	0	14	27	0	3	4	0	4	5	0	1	6	0	2	8	0	0	0	0	0	0	0
03-Feb-99	1	3	0	0	0	0	2	6	0	7	15	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0
05-Feb-99	0	0	0	1	3	1	5	15	2	7	14	0	1	1	0	0	0	0	0	0	0	3	6	0	0	0	0	1	1	0
07-Feb-99	2	10	0	0	0	0	5	27	9	49	90	0	2	8	2	5	6	0	1	2	0	3	8	4	1	2	0	1	3	0
09-Feb-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	3	8	3	0	0	0	1	2	1
11-Feb-99	0	0	0	1	1	0	2	23	5	4	9	0	2	2	0	1	3	0	1	0	0	4	8	3	0	0	0	1	2	0
12-Feb-99	0	0	0	1	1	0	6	10	0	6	14	0	1	1	0	2	2	0	0	0	0	2	3	0	0	0	0	0	0	0
Totals	10	34	9	19	39	9	83	333	87	448	799	9	34	82	13	42	119	42	26	80	18	55	109	13	13	29	5	16	33	4

Legend: 1 = Canterbury Cat, 2 = Swim/Tour Boat, 3 = Recreational, 4 = Dinghy, 5 = Kayak, 6 = Research, 7 = Fishing, 8 = Yacht under sail, 9 = Yacht under motor; M = Marks, M/D = Marks with dolphins.

TABLE A7b. BOAT AND DOLPHIN ASSOCIATION BY DATE AND BOAT—2000.

DATE	**0**	M	M/D	**1**	M	M/D	**2**	M	M/D	**3**	M	M/D	**4**	M	M/D	**5**	M	M/D	**6**	M	M/D	**7**	M	M/D	**8**	M	M/D	**9**	M	M/D
09-Jan-00	2	2	0	0	0	0	3	15	3	36	66	5	0	0	0	1	3	0	2	3	1	3	5	0	0	0	0	3	5	1
11-Jan-00	0	0	0	1	3	0	4	16	14	34	55	0	1	3	0	0	0	0	6	20	4	7	14	0	0	0	0	3	3	0
12-Jan-00	0	0	0	1	1	0	9	32	10	39	79	0	2	4	0	1	5	0	3	7	0	4	7	0	0	0	0	2	3	0
13-Jan-00	0	0	0	1	1	0	11	47	14	40	66	0	1	3	0	2	11	6	5	12	5	8	12	0	0	0	0	1	2	0
14-Jan-00	0	0	0	0	0	0	7	21	6	32	56	0	3	7	0	2	3	1	5	9	0	2	3	2	0	0	0	0	0	0
15-Jan-00	0	0	0	0	0	0	4	17	7	43	83	0	2	4	0	5	16	7	2	3	0	6	10	1	0	0	0	2	4	0
16-Jan-00	0	0	0	0	0	0	2	12	8	17	28	0	1	5	0	2	4	0	0	0	0	1	1	0	1	4	0	0	0	0
17-Jan-00	2	6	0	0	0	0	5	17	4	13	30	5	2	4	0	3	13	8	3	5	0	7	14	0	0	0	0	2	5	2
18-Jan-00	0	0	0	1	1	0	6	19	8	16	27	0	2	4	0	3	10	3	2	3	0	4	7	0	1	2	1	1	1	0
19-Jan-00	0	0	0	1	1	0	4	24	5	15	31	1	3	5	1	2	5	1	3	5	0	3	4	0	1	1	1	1	2	0
20-Jan-00	0	0	0	0	0	0	10	25	7	15	24	1	2	2	0	1	6	5	4	10	0	4	8	0	1	3	0	1	2	0
21-Jan-00	0	0	0	1	1	0	7	19	6	24	52	6	1	2	0	1	1	0	1	1	0	6	9	0	0	0	0	2	3	0
22-Jan-00	0	0	0	0	0	0	5	17	6	24	40	0	0	0	0	1	0	1	0	0	0	2	3	0	0	0	0	0	0	0
23-Jan-00	0	0	0	0	0	0	2	5	0	41	68	0	1	2	0	4	8	1	1	2	0	5	8	0	0	0	0	0	0	0
24-Jan-00	0	0	0	1	2	0	4	11	0	4	13	1	1	1	0	1	2	0	2	8	3	4	8	0	0	0	0	0	0	0
07-Feb-00	0	0	0	0	0	0	0	0	0	5	9	0	2	4	0	4	14	4	3	7	1	2	4	0	0	0	0	0	0	0
08-Feb-00	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	1	0	3	6	0	2	4	0	0	0	0	0	0	0
09-Feb-00	0	0	0	1	2	0	6	23	6	13	24	0	0	0	0	2	14	5	1	2	0	2	4	0	0	0	0	0	0	0
10-Feb-00	0	0	0	0	0	0	1	6	1	1	2	0	0	0	0	1	13	8	1	1	0	1	2	0	0	0	0	0	0	0
11-Feb-00	0	0	0	0	0	0	5	13	2	5	10	0	0	0	0	2	5	0	5	17	0	3	5	0	0	0	0	0	0	0
12-Feb-00	0	0	0	0	0	0	1	4	0	37	61	0	0	0	0	1	9	4	1	1	0	2	2	0	0	0	0	0	0	0
Totals	4	8	0	8	12	0	96	343	107	455	826	19	24	50	1	40	143	54	53	122	14	78	134	3	4	10	2	18	30	3

Legend: 1 = Canterbury Cat, 2 = Swim/tour Boat, 3 = Recreational, 4 = Dinghy, 5 = Kayak, 6 = Research, 7 = Fishing, 8 = Yacht under sail, 9 = Yacht under motor; M = Marks, M/D = Marks with dolphins.

TABLE A8. MULTI-BOAT EVENTS 1999, 2000.

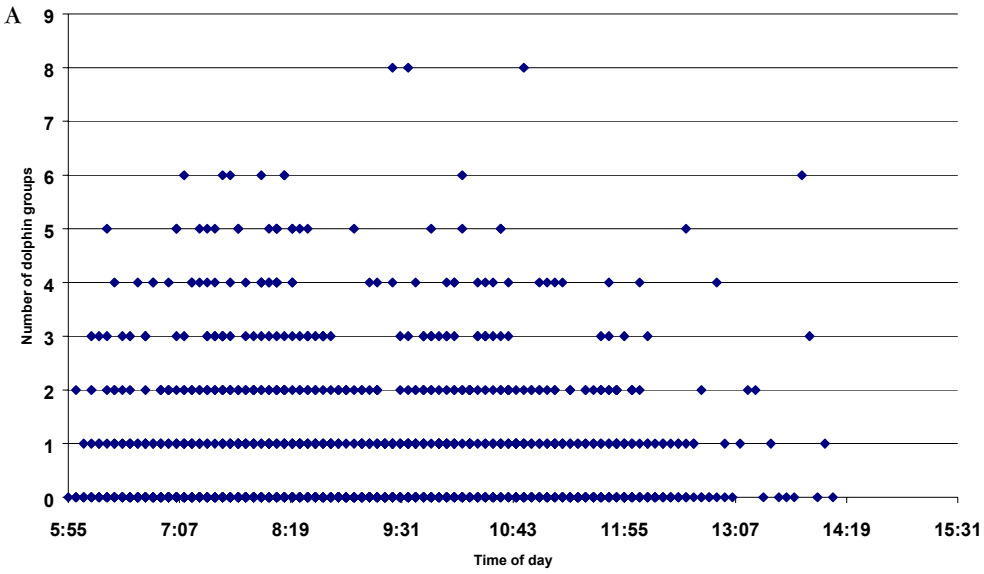
DATE	NOTES	NUMBER OF BOATS	TYPE OF BOATS	NUMBER OF DOLPHIN GROUPS	NUMBER OF DOLPHINS	DURATION (MINUTES)
10/01/1999	*Joined	2	Tour boat 2 kayaks	4	2	7
10/01/1999		3	Tour dinghy 2 kayaks 1 sailboat	2	2	5
26/01/1999	Joined Joined	3	Dinghy Research Tour boat	4	8	4
26/01/1999		3	Tour boat Recreational **1 set kayaks	2	3	6
29/01/1999		2	Tour boat 1 set kayaks	9	20	18
09/02/1999		3	Tour dinghy 1 set kayaks Recreational	4	7	11
11/01/2000		4	2 tour boats 1 set of kayaks 1 recreational	3	8	12
14/01/2000	Joined	2	Tour boats	6	15	13
		3	Recreational Tour boats 1 set of kayaks	2	3	1
15/01/2000	Joined	2	Tour boat Recreational	2	3	5
20/01/2000	Joined	3	Tour boat 2 recreational 1 set of kayaks	13	20	13
21/01/2000		2	1 recreational Tour boat	15	24	13
07/02/2000	Joined	2	Tour boat 1 set of kayaks	4	4	24
09/02/2000	Joined	2	Tour boat 1 set of kayaks	14	36	20
10/02/2000	Joined	2	1 set of kayaks Tour boat	11	20	13

Shaded areas indicate that the event occurred outside the study area; time of event could have been longer than noted.
*Joined: Indicates that the boat type entered the area after the first boat was already associated with dolphins.
**1 set of kayaks indicates > two kayaks

TABLE A9. DOLPHIN BEHAVIOUR IN FLEA BAY.

	SWIMMING	PORPOISING	LOG	BREACH	MILL	BOW RIDING	OTHER	GROUPS	NUMBER OF DOLPHINS
27-Jan-00	9	0	0	0	0	0	0	9	9
29-Jan-00	71	5	0	3	18	0	1	170	65
30-Jan-00	124	3	0	2	12	0	8	80	214
04-Feb-00	3	0	0	0	20	0	0	7	11
05-Feb-00	1	0	0	0	3	0	0	2	5
Totals	208	8	0	5	53	0	9	268	304
During boat presence	25	1	0	0	13	0	1	28	80
10 Min. buffer	9	0	0	0	1	0	0	7	19
Total behaviors without boat present	174	7	0	5	39	0	8	233	205

Figure A1. Dolphin group density over time of day; A = 1999, B = 2000.



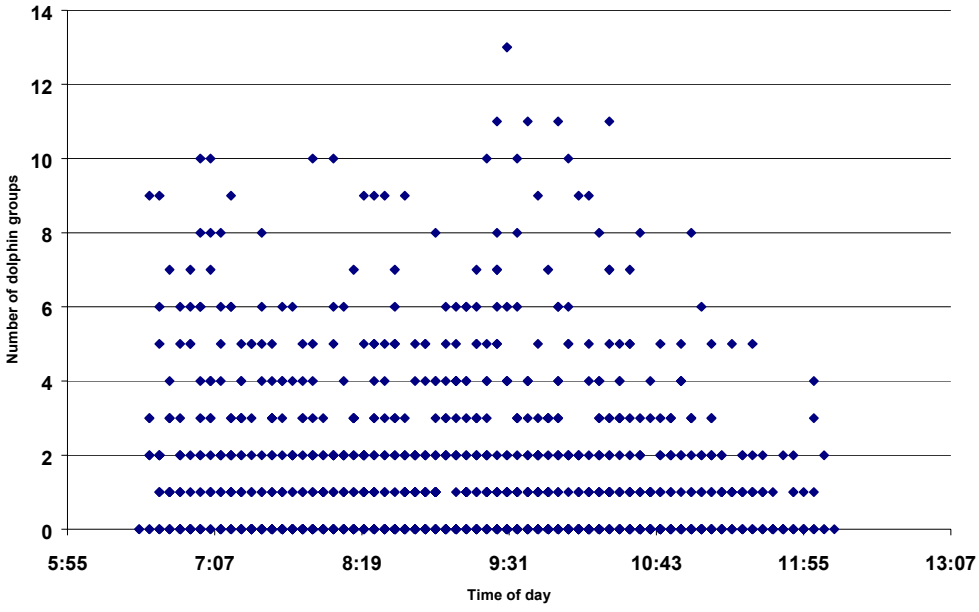


Figure A2. Boat density over time of day; A = 1999, B = 2000.

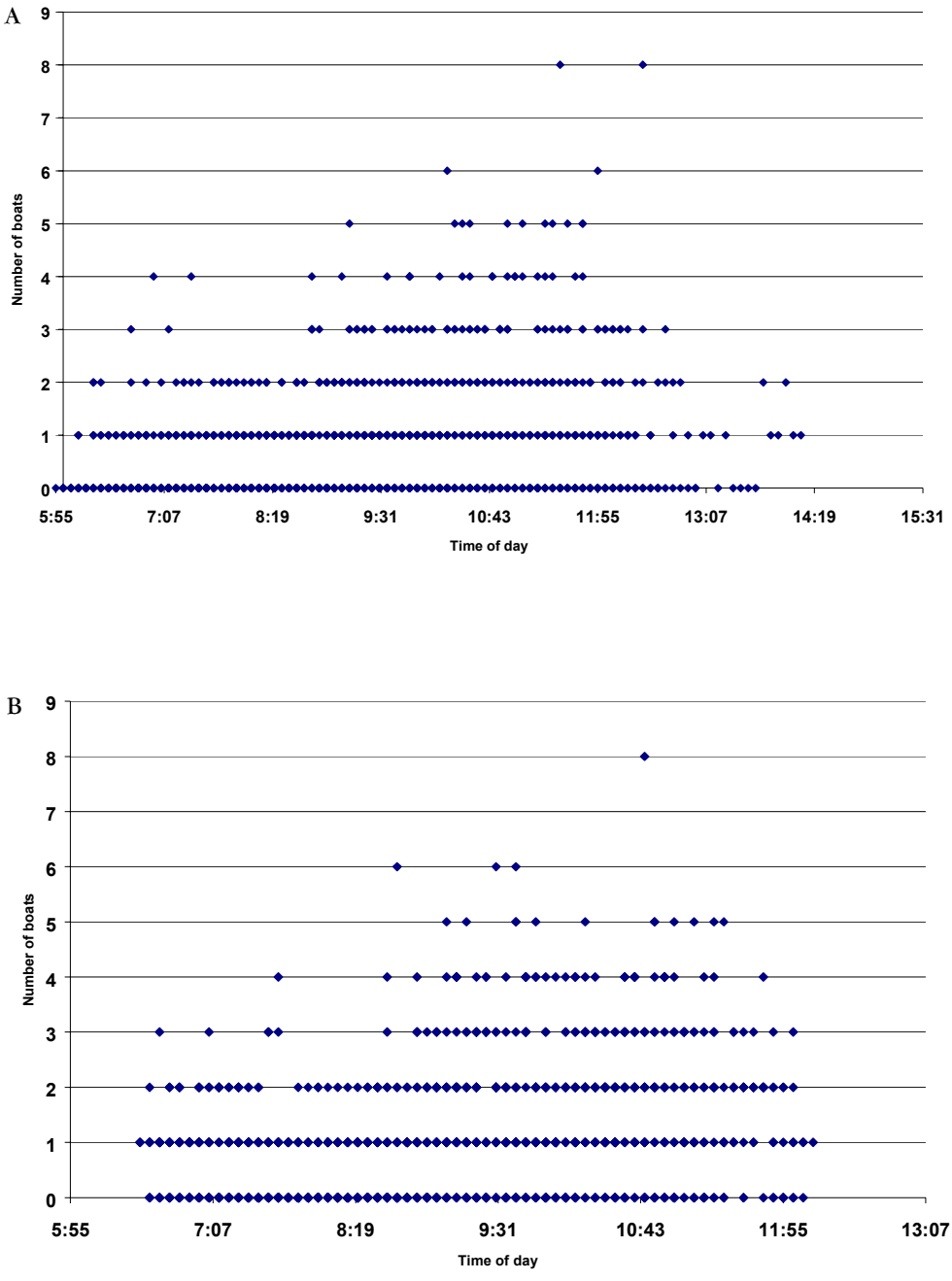
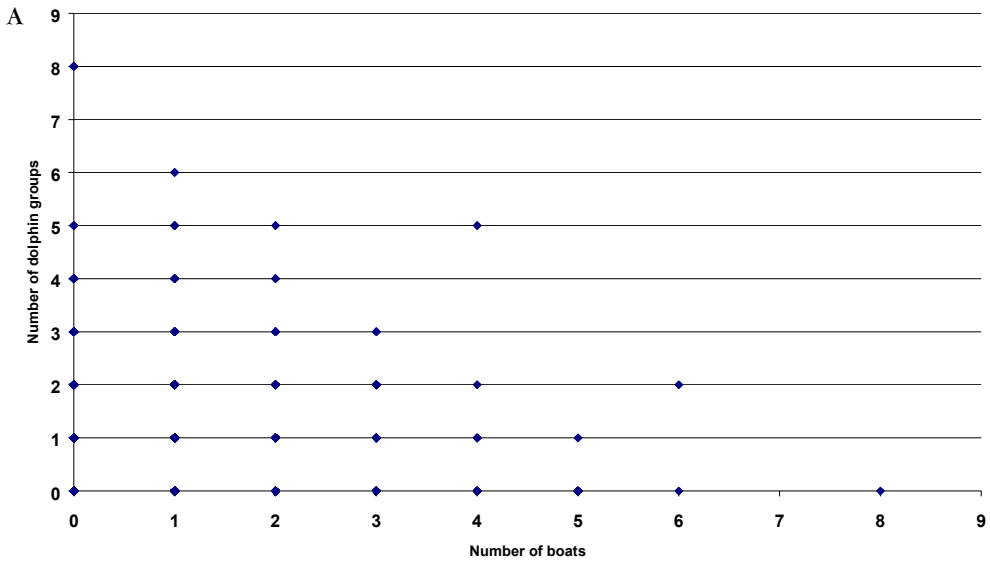
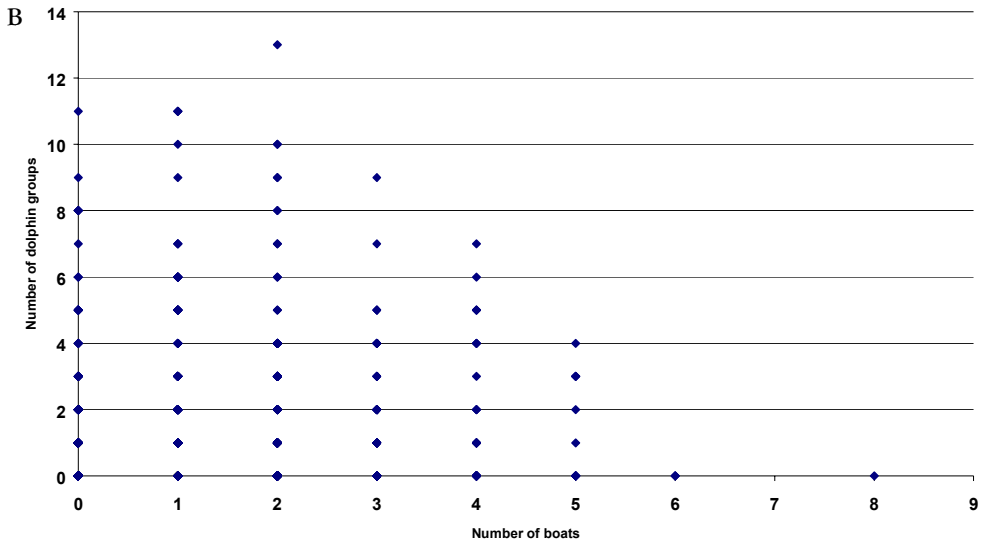


Figure A3. Number of boats compared with number of dolphin groups; A = 1999, B = 2000.





Appendix 2

RECORDED OBSERVATIONS OF INTERACTIONS BETWEEN HECTOR'S DOLPHINS, BOATS AND PEOPLE

9 January 1999

A group of 5 kayaks observed from 10.16 a.m. to 12.15 a.m. were marked as associated with dolphins nine of 12 times. There were nine dolphin groups involved in the interactions ranging in size from one to five individuals.

A yacht under sail was observed to put swimmers in the water. At 11.34 a.m. swimmers from the yacht entered the water for approximately 2 minutes. There were four dolphin groups associated with the boat during that time.

10 January 1999

At 11.51 a.m. a yacht was observed. At the same time a group of two dolphins 200 m from the boat swam directly toward the bow of the boat. The boat was observed for 5 minutes; during that time the dolphins approached, breached and rode the bow wave.

19 January 1999

At 6.46 a.m. a swim/tour boat entered the study site. At 6.47 a.m. it became associated with one dolphin, and at 7.05 a.m. another dolphin was marked as breaching twice while swimming toward the boat. At 7.07 a.m. and 7.08 a.m. two potentially different groups of two and three were seen bow riding with the boat. During this interval, from 6.46 a.m. to 7.13 a.m., the boat had six groups of dolphins associated with it. The boat was marked seven times, five times with dolphins. Over the whole observation period, this boat was observed from 6.24 a.m.to 7.39 a.m., marked 16 times and was associated with dolphins on eight of the 16 marks.

At 9.21 a.m., a kayak was marked with dolphins, and the kayaker had his hands in the water. Seventeen seconds later a dolphin was marked as associated with the same kayak.

26 January 1999

A group of kayaks was observed in the study site from 8.53 a.m. to 10.04 a.m. During that time they were associated with dolphins on nine of 16 marks. One interaction was characteristic of dolphin group formation and split around boats. At 8.57 a.m., a single dolphin was associated with a group of 12 kayaks. It was joined by another dolphin close to the kayaks. These two dolphins were marked together from 8.59.09–9.00.04 a.m. At 9.03 a.m., another pair of dolphins was in the vicinity of the kayaks. They split up, and the two groups formed a group of four still within the range of the kayaks. The interaction ended with the group of four milling. The total interaction lasted from 8.57 to 9.08 a.m.

A jet-ski entered the study site at 10.57 a.m. The jet-ski operator spotted a group of four dolphins, two adults and two calves. The jet-ski slowed, circled the group and continued to follow the dolphins trying to take a picture as the dolphins swam in a direction away from the jet ski. The interaction lasted for 8 minutes.

7 February 1999

At 8.30 a.m. a recreational boat passed directly over the location of a clearly visible group of three dolphins which had been marked twice. The dolphins did not reappear in the same location.

9 February 1999

A recreational boat was observed from 9.00 a.m. until 9.30 a.m. During that time a swimmer from the boat was put in the water three times. During two of those events, the boat was marked as associated with dolphins. In total, the boat was marked nine times in 30 minutes, and was associated with dolphins for three of those marks.

9 January 2000

1. A swim/tour boat was observed from 6.29 a.m. to 8.20 a.m. There were swimmers in the water from approximately 7.43 a.m. to 8.14 a.m. During that time, three dolphin/swimmer interactions were observed in which it appeared that a dolphin was touching or very close to a swimmer. On one of these occasions, a dolphin displayed a lobtail behaviour, and then proceeded to swim next to a swimmer. The boat was marked 11 of 20 times with dolphins, while 22 groups of dolphins were marked as associated with the boat.

2. From 10.20 a.m. to 10.25 a.m., a recreational boat was observed and marked three times. Dolphins were associated with the boat on all marks. Children from the boat were put in the water soon after four groups of dolphins were marked as associated with the boat.

16 January 2000

At 7.06 a.m. a dolphin was observed to tailslap and then closely approach a swimmer.

17 January 2000

1. A group of kayakers was observed from 8.34 a.m. to 10.04 a.m., and marked 12 times. Eight of those marks were associated with dolphins while a total of 15 dolphin groups were noted as associated with the kayaks. During this time, there were two notable interactions:

- 9.15 a.m.: One kayaker in the group placed his hand flatly on the surface of the water, and a dolphin surfaced under his hand. It appeared that the kayaker had touched the dolphin.
- 9.35 a.m.: With the same group of kayakers, a kayaker held a water bottle at the surface of the water, a dolphin surfaced under the water bottle and appeared to touch it.

2. At 10.21 a.m. a person on a recreational boat put his hand in the water. A dolphin surfaced directly under the hand.

19 January 2000

1. A recreational boat was observed from 10.28 a.m. to 10.30 a.m. and had up to four dolphin groups associated with it. It was marked three times, associated with dolphins on one mark. A child leaned out of the boat and put his hand in the water when dolphins were present.

2. A recreational boat was observed at 11.04 a.m. passing through the study site. It passed directly over a spot where dolphins had surfaced a moment before.

24 January 2000

A recreational boat entered the study site at 10.05 a.m. pulling an inner tube. Three swimmers were put into the water just after the boat was marked with a dolphin. The swimmers were in the water from 10.18 a.m. to 10.22 a.m. The boat was marked nine times, and was associated with dolphins on one mark.

Appendix 3

RECORDED OBSERVATIONS OF INTERACTIONS BETWEEN HECTOR'S DOLPHIN CALVES, BOATS AND PEOPLE

1. One of the swim/tour operators was in the process of putting people in the water when he noticed a group of dolphins close to the side of the boat. The operator reported that while he was observing the dolphins, a calf was born. An adult dolphin in the group pushed the baby to the surface alongside and up against the side of the boat. On another occasion, a dolphin within a group breached, and after the breach, a calf was present within the group. Both of these occurences were described by Nigel Irvine, owner of Dolphin Experience.
2. A swim/tour naturalist on the Akaroa Harbour Cruises reported to the author observing a female and calf bow-riding. The female would bow-ride, then move aside and the calf would move in and attempt to bow-ride.
3. 26 January 1999. A mother and calf pair were followed and circled by a jet ski. Nine minutes later they were seen playing with seaweed for 1 minute, 5 seconds.