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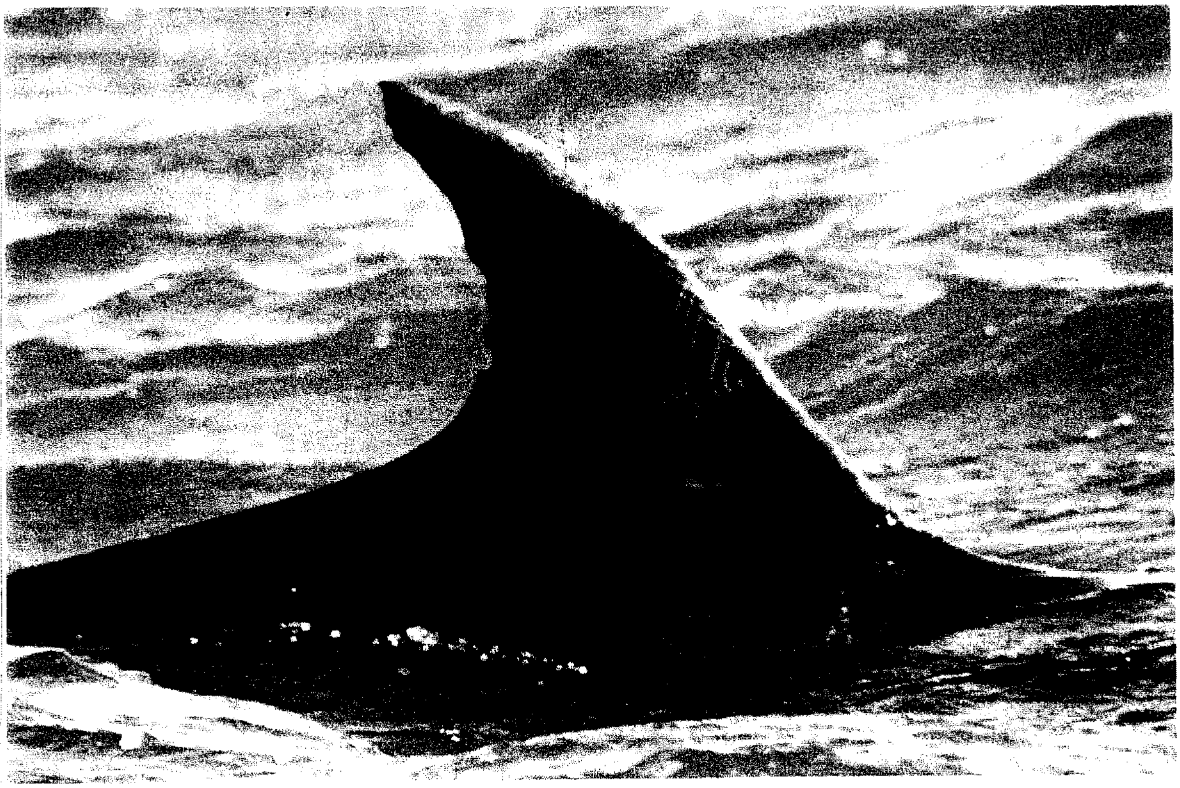

A.

B.

FIGURE 9. AN EXAMPLE OF THE RELIABILITY OF NICKS AND SCARS OVER TIME. DOLPHIN NO. 19.

A: PHOTOGRAH TAKEN 6 JUNE 1994.
B: PHOTOGRAPH TAKEN 11 JANUARY 1995.

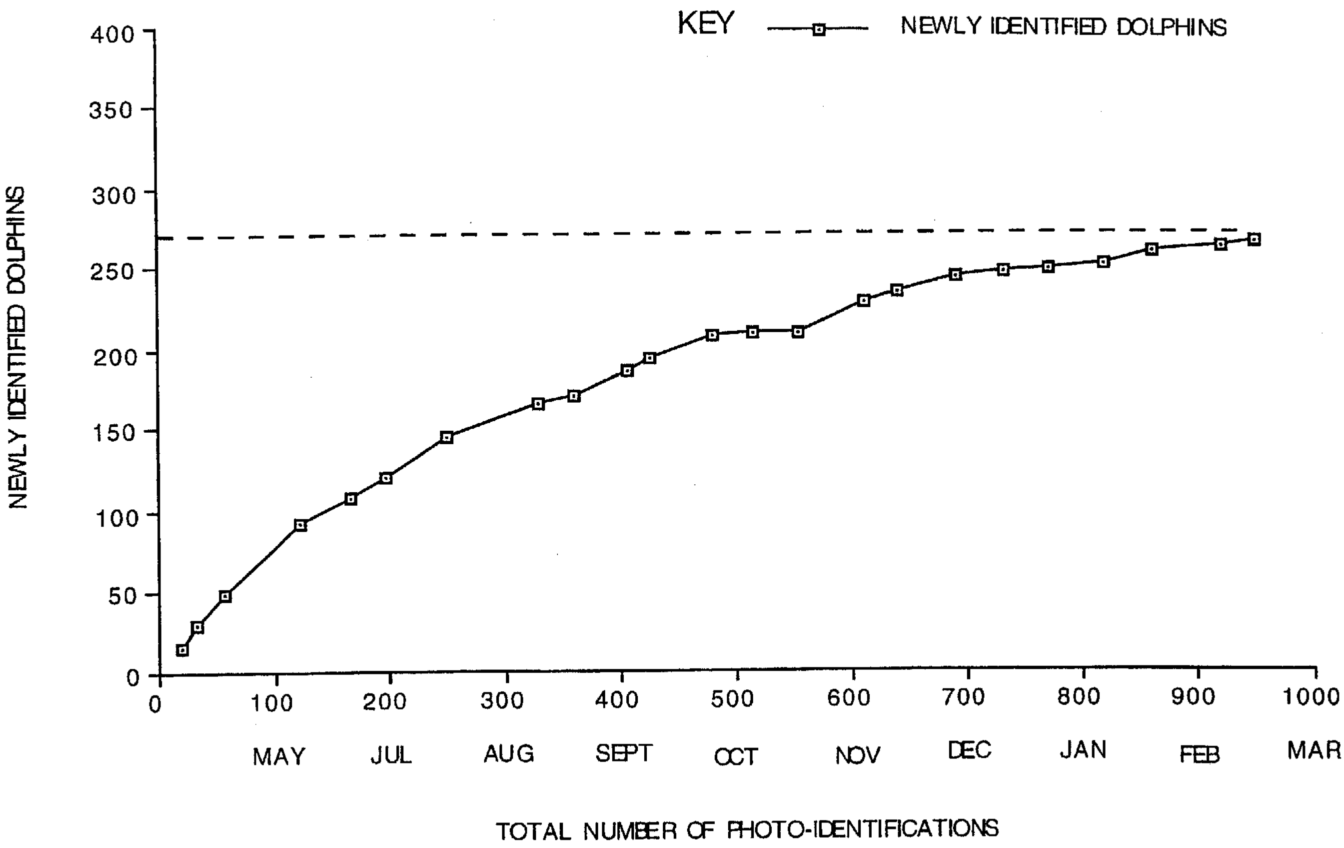

FIGURE 10. RATE OF DISCOVERY OF NEW DOLPHINS.

the 15 selected, three (20%) were found elsewhere in the catalogue (a missed match). In addition, 11 resighted animals (i.e., photographed on two or more separate encounters) were randomly chosen and compared to the catalogue. One (10%) of these was a mismatch and was matched to another photograph in the catalogue. The catalogue then underwent a final review by randomly selecting 30 photographs considered to be unique. Two (7%) were found to be missed matches and five were withdrawn from the catalogue as they were of poor quality. After checking the catalogue three times, the data was then analysed.

Rate of discovery To estimate the size of the local population and to help determine if it was open or closed to immigration, the rate at which new dolphins were identified was plotted against time (Fig. 10). This `discovery curve' showed the rate of newly discovered dolphins started to decline early in the study and appears to approach an asymptote near the end of the study. During the last three months (or 37 surveys) of the study, for example, only 14% (n = 37) of identified dolphins were newly sighted individuals.

Frequency of resigbtings Of the 265 individually identified dolphins 24% (n = 63) were seen only once. The remaining 76% (n = 202) were seen 2-21 times (Fig. 11). Over half the dolphins were resighted on three or more occasions (n = 135). Three individuals (# 1, 16 and 17) were sighted 21 times, from 1 January 1993 to 6 March 1995 (fin #1); 2 February 1994 to 28 February 1995 (fin #16) and 2 February 1994 to 6 March 1995 (fin #17).

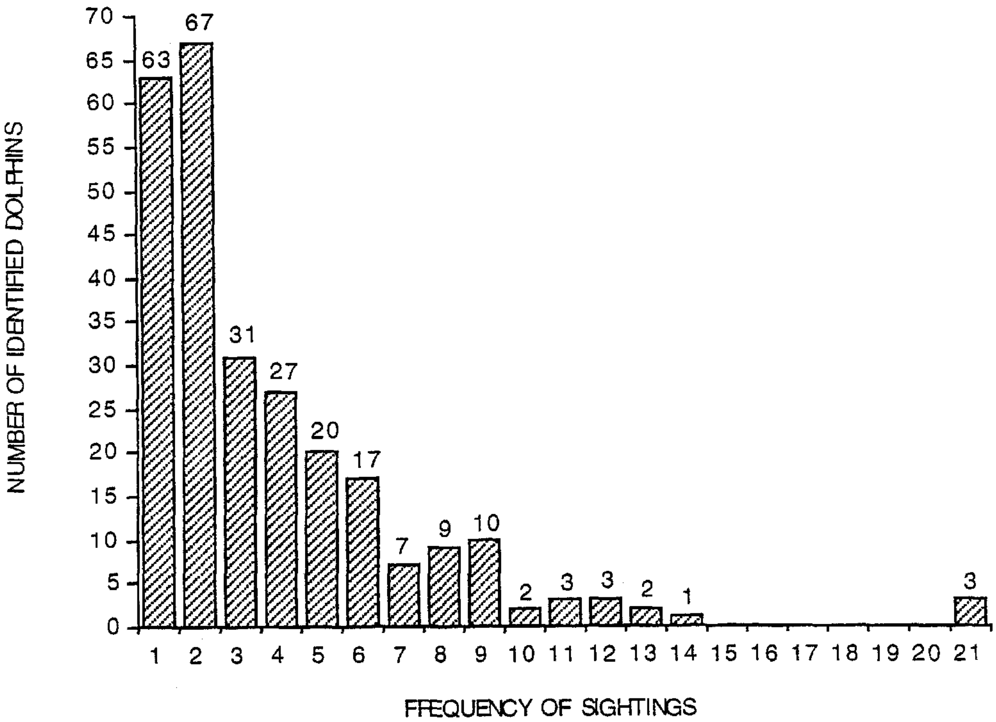

FIGURE 11. FREQUENCY OF SIGHTINGS OF IDENTIFIED DOLPHINS; n = 265.

Local Movement A small number of individual identification photographs were available to evaluate local movement of dolphins in the Northland region. Photographs of bottlenose dolphins taken by I. Visser near Tutukaka approximately 45 km south of the Bay of Islands matched photographs taken in the Bay of Islands. Five matching individuals seen together in Tutukaka were seen in the Bay of Islands at different times, i.e., not all in the same group. One had been photo-identified in the Bay of Islands on 5 August, one on 17 August, one on 21 August and two individuals on 22 August. Photographs of seven bottlenose dolphins taken by I. Visser on 5 October 1994, near Whangarei, match those found in the Bay of Islands, 75 km north. One of these, dolphin #1, was one of the most frequently encountered dolphins in the bay. Of these seven dolphins, one was photographed in the Bay of Islands on 3 October and another was in the bay on 8 October. This shows that at least some of the bottlenose dolphins encountered in the Bay of Islands travel south to Whangarei and probably further around the Northland coast.

3.3.3 Pod size and composition

Bottlenose dolphins. Pod sizes for bottlenose dolphins ranged from 3-40 individuals (X = 13.8:t S.D. 8.19). The most common group size (37%, n = 46) contained between 6 and 10 dolphins (Fig. 12). Pods containing 11-15 dolphins accounted for 30% (n = 37) and there were 9% (n = 11) of pods with 1-5 dolphins and an equal number with 16-20 dolphins. Mean pod size showed significant variation across the four seasons (F = 3.04 [3]; p = 0.03). Average pod size was largest and most variable in spring (X = 16.16 t S.D. 9.7) and summer (X = 15.3 t S. D. 8.3). Pod sizes were smaller in autumn (X = 10.8 t S.D. 4.8), differing significantly from both spring and summer. Pods during winter were intermediate in average size and did not differ significantly from the other seasons.

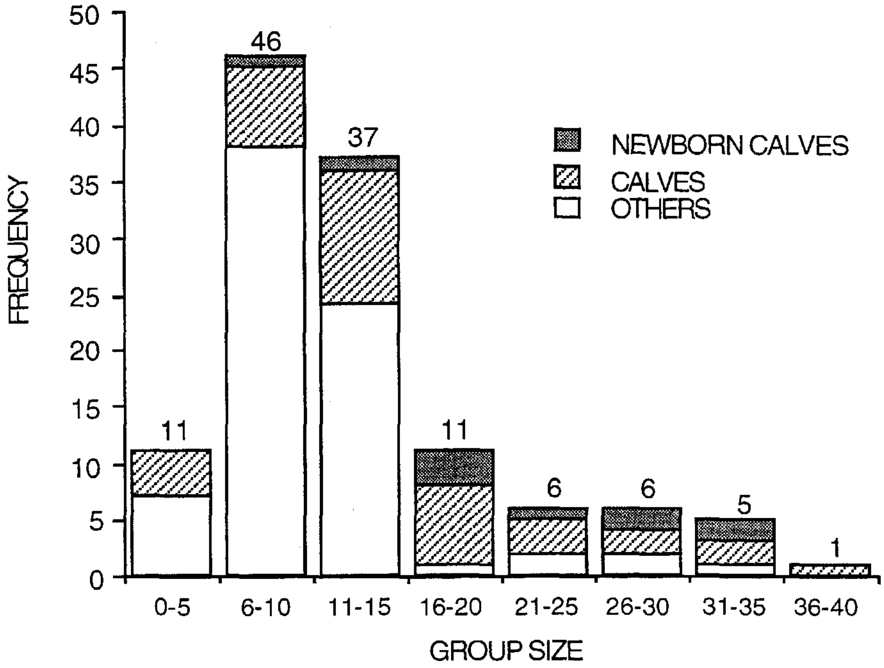

FIGURE 12. BOTTLENOSE DOLPHIN POD SIZES AND PROPORTION OF NEWBORN CALVES, CALVES AND OTHERS; n = 123.

Of the 123 pods of bottlenose dolphins encountered, 61% (n = 75) were of mixed ages (Table 6). The remaining 39% (n = 48) of pods were all adults. Mother/calf pairs were observed in 40% (n = 49) of the pods. The size of pods with mother/calf pairs (x = 18.2) was significantly larger than pods without calves (X = 10.8). Of all dolphins observed, 4.9% were calves.

Common dolphins Common dolphin pods ranged in size from two to an estimated 300 individuals. Only 14% (n = 8) of common dolphin pods were judged to be all adults and 43% (n = 24) of groups were judged to have at least one calf (Table 6 & Fig. 13b). Pods containing 30-100 dolphins were most frequently observed.

TABLE 6. NUMBER OF ALL ADULT v. MIXED-AGE GROUPS AND GROUPS WITH MOTHER/CALF PAIRS v. OTHERS (EITHER ALL ADULT GROUPS OR GROUPS CONTAINING JUVENILES).

	BOTTLENOSE DOLPHINS			COMMON DOLPHINS		
MIXED AGE (calves and juveniles)	61%	(n =	75)	86%	(n =	48)
ALL ADULTS	39%	(n =	48)	14%	(n =	8)
MOTHER/CALF	40%	(n =	49)	43%	(n =	24)
OTHERS (adults and juveniles)	60%	(n =	51)	57%	(n =	32)

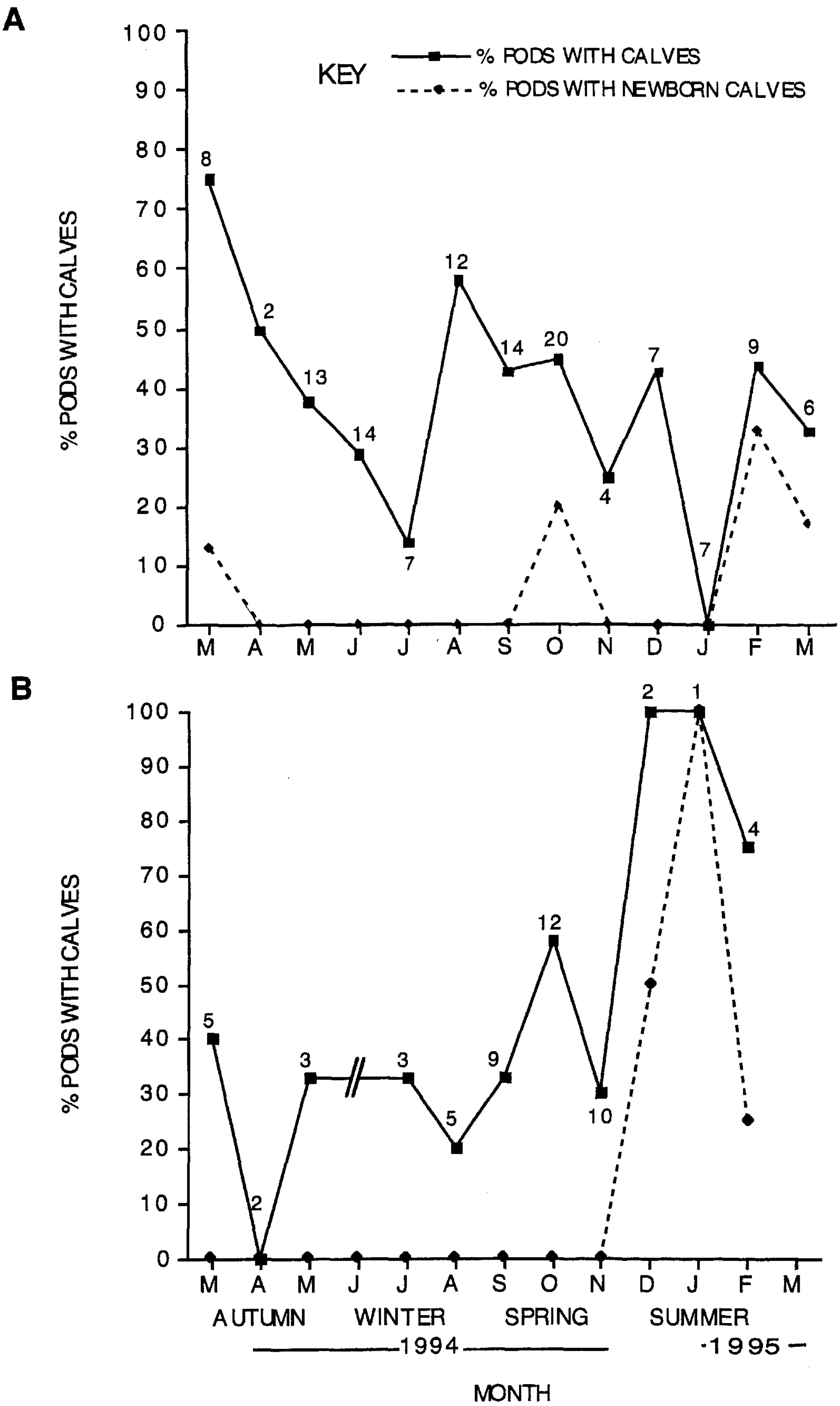

FIGURE 13. PERCENTAGE OF PODS CONTAINING CALVES AND NEWBORN CALVES. NUMBER OF GROUPS OBSERVED PER MONTH (n VALUE) APPEAR BY THE DATA POINTS.

A: BOTTLENOSE DOLPHINS; N = 123.

B: COMMON DOLPHINS; N = 56.

3.3.4 Water depth and temperature

Bottlenose dolphins The mean water depth at which bottlenose dolphins were found was 22.9 metres as judged by water depth at the location of the initial encounter. Water-depth preference varied significantly across the four seasons (F = 7.26 [3]; p = 0.0002). Average water depth was greatest in summer (x = 30.63 t S.D. 21.51) and least in winter (x = 15.2 t S.D. 14.19). There was a significant difference in water depths between all seasons except autumn v. summer and winter v. spring (Fisher LSD test). There was a strong correlation between water depth and temperature throughout the year (R^2 = 0.80 [1]; p = 0.0001). A plot of sighting depth and sea surface temperature shows a trend for the dolphins to move into shallower waters during the colder winter months and then into deeper waters over summer (Fig. 14a). July, August and September had the lowest mean temperature of 13.6 °C and February, 1995 provided the highest mean temperature of 20.9°C, a difference of 7.3°C.

Common dolphins The mean water depth at which common dolphins were found across the 12 month study was 80 metres. The range of depths at which they were found was 6-141 metres. Water-depth preference varied significantly (F = 22.65 [3]; p = 0.0001). Trends in seasonal water-depth preference were similar to bottlenose dolphins. Average water depth was greatest in summer (R = 108.9 t S.D. 22.0) and least in spring (X = 52.9 t S.D. 17.9). As with the bottlenose dolphins, a Fisher LSD test showed a significant difference in water depth between all seasons except autumn v. summer and winter v. spring. Common dolphins showed a tendency to frequent shallower waters from late autumn until late spring (Fig. 14b). As with bottlenose dolphins, there was a strong correlation between water depth and water temperature for common dolphins (R^2 = 0.95 [1]; p = 0.0001) (Table 7). The dolphins were found in shallower waters when the water temperatures were at their lowest and moved into deeper waters outside the bay as the temperature increased. There are no data for common dolphins in June 1994 and March 1995, as no common dolphins were observed by the commercial operators during these months.

TABLE 7. SEASONAL MEANS OF WATER DEPTHS WHERE BOTTLENOSE AND COMMON DOLPHINS WERE ENCOUNTERED.

	BOTTLENOSE DOLPHINS				COMMON DOLPHINS			
	X	S.D.	S.E.	n	X	S.D.	S.E.	n
AUTUMN (March, April, May)	26m	14.8	2.8	9	98m	23.7	7.5	10
WINTER (June, July, August)	15m	14.2	2.5	33	55m	24.9	8.8	8
SPRING (Sept., Oct,, Nov.)	16m	11.4	1.8	38	53m	17.9	3.2	31
SUMMER (Dec., Jan., Feb.)	31m	21.5	4.5	23	109m	22.0	8.3	7

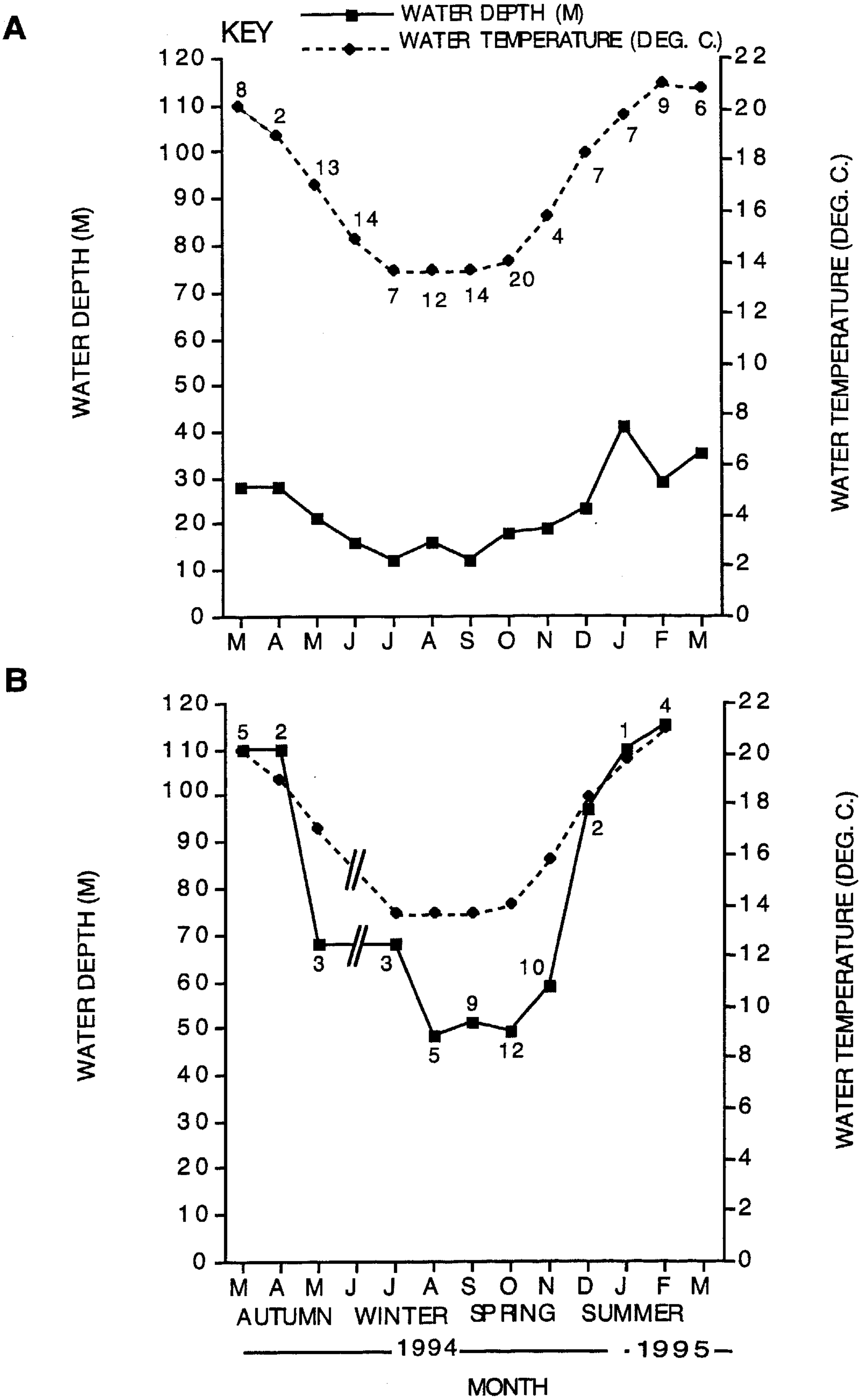

FIGURE 14. MEAN MONTHLY WATER DEPTH AND SEA SURFACE TEMPERATURE AT INITIAL ENCOUNTER WITH THE DOLPHIN PODS. NUMBER OF GROUPS OBSERVED PER MONTH (n VALUE) APPEAR BY THE DATA POINTS.

A: BOTTLENOSE DOLPHINS. TOTAL n = 123.

B: COMMON DOLPHINS. TOTAL n = 56.

3.3.5 Feeding

Bottlenose dolphins Bottlenose dolphins were observed feeding on a number of smaller fish species. They were frequently observed flicking a fish out of the water and then swimming to retrieve it. Individual dolphins were seen catching a fish then swimming with it in their mouth for up to ten minutes, only occasionally dropping it and turning back to retrieve it. The species of fish identified as prey items for bottlenose dolphins were: flounder *(Rhombosolea* spp.), yellow-eyed mullet *(Aldrichetta forsteri),* kahawai *(Arripis trutta),* parore *(Girella tricuspidata),* piper *(Hyporhampbus ihi),* blue maomao *(Scorpis violaceus)* and leatherjacket *(Parika scaber).*

Common dolphins. Common dolphins were observed feeding mainly on schooling fish such as pilchards *(Sardinops neopilchardus)* but on two occasions individual common dolphins chased and caught a flying fish *(Cypselurus lineatus).*

Fisheries interactions

on two occasions, bottlenose dolphins were observed milling and feeding in the vicinity of small gillnets fishing for yellow-eyed mullet *(Aldrichetta forsteri).* These are reported below as case histories.

Case I On 16 June 1994, the `Dolphin Discoveries' boat followed a pod of 12 dolphins from 11:45 to 12:54. They were feeding as a scattered pod and travelling slowly towards the net which was attached to a four metre boat. The dolphins swam parallel to the net approximately ten metres away from it. They then turned and approached the net to less than two metres and swam past in single file then continued travelling up the Waikare Inlet.

Case 2 On 5 October 1994, a pod of 20 bottlenose dolphins were milling and feeding near the Brampton Reef. At 08:49 ten adult dolphins grouped together in a tight formation and approached a 100 metre long gillnet. It was attached to a small boat and the fishermen were present. As the dolphins approached within five metres of the net they lined up one to two dolphins wide and swam the entire length of the net remaining at a distance of one to two metres from the net. When they got to the end they passed around the other side and spread out into a milling and feeding pod whilst slowly swimming away from the net.

On both occasions the dolphins were not seen feeding from or within ten metres of the net, but there may have been fish near the net which were easy to catch, with little obvious effort by the dolphins. Such feeding may not have been seen by observers.

3.3.6 Interspecies associations

Bottlenose dolphins Of 123 encounters with bottlenose dolphins, 98% (n = 120) were without the obvious presence of another species of bird or cetacean. There were gannets with the dolphins on two occasions and white fronted terns *(Sterna striata)* on one occasion (Table 8). During an encounter with dolphins on 4 November 1994, four bottlenose dolphins were observed swimming around a large leatherback turtle *(Dermochelys coriacea)* in water 11 metres deep. The dolphins then proceeded to bowride the operator's boat and we lost sight of the turtle. The turtle's carapace was estimated to be approximately 80 cm long.

TABLE 8. INTERSPECIES ASSOCIATIONS. OBSERVED DURING ENCOUNTERS WITH COMMON (n = 56) AND BOTTLENOSE DOLPHINS (n = 123).

SPECIES	SCIENTIFIC NAME	BOTTLENOSE	COMMON
No association		120	17
Gannets only	*Sula serrator*	2	22
Sooty shearwaters only	*Puffinus griseus*	0	1
Buller's shearwaters	*Puffinus hulteri*	0	4
Fluttering shearwaters	*Puffinus gavia*	0	3
Skuas	*Stercorarius spp.*	0	2
Flesh footed shearwaters	*Puffinus carneipes*	0	1
Sooty shearwaters	*Puffinus griseus*	0	1
Mollymawks	*Diomedea metanophrys*	0	1
White fronted terns	*Sterna striata*	1	0
Baleen whales		0	4

Common dolphins Unlike bottlenose dolphins, common dolphins in the Bay of Islands were frequently found associated with birds. On 63% (n = 35) of encounters they were associated with birds and on 7% (n = 4) of encounters they were associated with one or more whales (Table 8). The remaining 30% of encounters had no apparent interspecies association. Of all associations with birds, 97% (n = 34) involved gannets *(Sula serrator)* and on 63% (n = 22) of occasions there were only gannets present. During one encounter there were only sooty shearwaters *(Puffinus griseus)* present. On all four occasions that common dolphins were with whales, there were also gannets present.

3.3.7 Other cetacean sightings

Species of cetaceans other than bottlenose and common dolphins were encountered on 17 occasions. Baleen whales were observed ten times between 5 October, 1994 and 17 December, 1994. A total of 17 whales were observed but exact identification of the species was not possible on all occasions. During two encounters a positive identification was made of three Bryde's whales *(Balaenoptera edeni)* by direct observation of the three ridges on their rostrum. Size and behaviour suggested that the others were Bryde's or sei whales.

Common dolphins were observed feeding with the whales on three of the ten occasions, twice in November and once in December. During two encounters, common dolphins were observed bowriding a whale as it travelled rapidly on the surface. During five encounters with whales lunge feeding was observed, two of these occasions involved feeding on pilchards *(Sardinops neopilchardus)*.

Killer whales *(Orcinus orca)* were encountered seven times between 17 August, 1994 and 25 October 1994. Group size ranged from five to ten individuals and all groups observed had at least one calf and one adult male, identified by his tall dorsal fin. There was no association between the killer whales and other cetacean species, but on 11 September 1994 a group of 30 bottlenose dolphins came within 400 metres of a group of nine killer whales. The dolphins then turned away abruptly and swam at a high speed, porpoising away from them. There was no apparent change in behaviour by the killer whales. Similar behaviour by bottlenose dolphins upon encountering killer whales was observed in Golfo San Jose, Argentina by Wursig & Wursig (1979).

3.4 DISCUSSION

3.4.1 Abundance and residency

The asymptote of the discovery curve suggests that after 12 months of research effort the majority of bottlenose dolphins using the Bay of Islands area had been identified. Thus, the total of 265 individual dolphins identified during the study can be considered a minimum estimate of population size for the Bay of Islands region. A capture-recapture analysis of these data was not conducted because a number of the assumptions of the models outlined in Seber (1973) could not be evaluated during the one year of study.

It seems unlikely that the Bay of Islands has a closed population such as those described for bottlenose dolphins in Sarasota Bay, Florida by Irvine *et al.* (1981) and in Doubtful Sound, New Zealand by Williams (1992). The Bay of Islands is open to the ocean, unlike the enclosed waters of Sarasota Bay, Florida and Aransas Pass, Texas (Shane 1990b). This may result in more dispersed food resources requiring dolphins to travel further than in narrow, channel areas. Shane, (1990b) noted that the dolphins in Aransas Pass concentrated their feeding around narrow channel areas and suggested that a concentration of prey allowed the dolphins to gain a large quantity of their dietary needs in this way. Such concentrations could reduce the need to travel greater distances in order to find food. Bottlenose dolphins in open habitats may be exposed to more patchy resources and may travel greater distances to feed (Shane *et al.* 1986). This would appear to hold true for dolphins using the Bay of Islands region which would often travel from one side of the bay to the other to feed at areas thought by local fishers to have concentrations of bait fish.

Direct evidence that bottlenose dolphins photo-identified in the Bay of Islands do travel further along the coast was provided by photographs taken near Tutukaka and Whangarei. We were able to match five of the dolphins from Tutukaka to the catalogued dorsal fin photos from the bay. These five individuals were seen in the bay at different times, i.e., not all in the same group. Seven of the dolphins photographed in Whangarei matched those found in the Bay of Islands catalogue, including dolphin #1, one of the most frequently encountered dolphins in the bay. This shows that some of the dolphins using the Bay of Islands have home ranges of at least 100 km along the Northland coast.

3.4.2 Pod size and composition

Bottlenose dolphins Pod sizes of bottlenose dolphins in the Bay of Islands were comparable to those found in other open-bay habitats around the world. Pods ranged in size from 3 to 40 individuals (X = 13.8). This is comparable to Wursig and Wfirsig's (1978) findings in Golfo San Jose of a mean pod size of 14.9 dolphins; dos Santos and Lacerda's (1987) 13.7 dolphins per pod in Sado estuary, Portugal and Ballance's (1990) Gulf of California mean pod size of 15 dolphins. Extreme values were found by Saayman *et al.* (1972) who reported a mean pod size of 140.3 at the southeastern Cape coast of South Africa and Brager *et al.* (1994) who reported a considerably smaller mean pod size of 4.4 dolphins in Galveston Bay, Texas.

There were no sightings of solitary dolphins as reported in Sarasota Bay, Florida (Irvine *et al.* 1981) and no sightings of solitary mother/calf pairs as reported in Galveston Bay, Texas (Fertl 1994b). These solitary sightings may be a feature of the shallow protected waters unavailable in the Bay of Islands.

The bottlenose dolphin pod sizes in the Bay of Islands were smaller when there were no mother/calf pairs present. Even if the mother/calf pairs were counted as a single unit, the mean pod size of 16.5 was still higher than those without mothers and calves (X = 10.8). This could be explained by the fact that juveniles remain with their mothers for a period of time even after a new calf is born and thereby increase the number of dolphins in close association with one another. Also it is possible that the group size is larger to help reduce the risk of predation (Shane *et al.* 1986) or to give assistance to the mother with her new calf, e.g., `babysitting' (Fertl 1994b). Of all dolphins observed, 4.9% were calves. This compares to 10% in Golfo San Jose (Wursig & Wursig 1978), 7.1 % in California (Hansen 1990) and 9.7% in Lower Tampa Bay, Florida (Weigle 1990).

Common dolphins Pods containing an estimated 30 to 100 common dolphins were most frequently seen in the Bay of Islands. The group sizes observed may have been biased by the operators' strategies when searching for common dolphins. The operators often located common dolphins by searching for gannets or other birds that were feeding with the dolphins. This may have resulted in smaller, non-feeding groups going undetected. As common dolphins are essentially a coastal shelf species (Gaskin 1992), they often feed cooperatively by herding pelagic fishes as a group. The type of feeding described here for common dolphins is also reported for dusky dolphins (Hui 1979, Wursig & Wursig 1980) and Pacific white-sided dolphins (Black 1994). It has been noted that often where there is a high quality resource with patchy spatial distribution such as pelagic schooling fishes, large groups may form (Pulliam & Caraco 1984). The large pods of up to 1000 dolphins reported in Leatherwood & Reeves (1983) were not observed in the Bay of Islands, but may occur further offshore.

3.4.3 Seasonal habitat use

Bottlenose dolphins showed significant seasonal variations in habitat use. They were observed in different areas of the Bay of Islands during late spring and summer and late autumn and winter. This movement was correlated with seasonal changes in the sea surface water temperature. As the water temperature increased during spring and summer, bottlenose dolphins were found in deeper waters, generally outside the inner islands area. In other regions of the world, the distribution of prey is an important factor in the seasonal movement of bottlenose dolphins. Wells *et al.* (1990) suggested that warm waters passing the Californian coast changed the distribution of bottlenose dolphin prey and was therefore a primary factor leading to the shift in dolphin distribution along the coast. Saayman and Tayler (1979) found correlations between fish distributions and humpback dolphin movements in southeastern South Africa. Similar findings were made for bottlenose dolphins in Golfo San Jose, Argentina by Wursig and Wursig (1979).

Little is known about seasonal changes in the movements and abundance of fish in the Bay of Islands, but it is known that the East Auckland Current brings warm water to Northland over the summer months (National Institute of Water and Atmospheric Research (NIWA) sea surface temperature isotherm analysis). This warm current brings fish such as yellowfin tuna *(Thunnus albacares)* and striped marlin *(Makaira audax)* which are the basis of a large game-fishing industry in the Bay of Islands. It is possible that there were other species of fish travelling with this warm water current which provided an alternate and seasonally limited food source for the dolphins. If these fish were travelling with the current through deeper offshore waters, this may have resulted in the dolphins moving out' in order to gain access to the new food source.

The possibility that individual dolphins have variable seasonal use of their home range within the Bay of Islands or Northland requires further investigation. Shane (1980) noted that some bottlenose dolphins in Aransas Pass, Texas used different portions of their home range on a seasonal basis. Bottlenose dolphins in Sarasota Bay were found to use different areas of their home range depending on the season (Irvine *et al.* 1981) and the age composition of the pod (Wells *et al.* 1980). It was suggested that the dolphins' movements reflected changes in food distribution or predation pressure (Scott *et al.* 1990). Most researchers believe that dolphin movements are influenced to varying degrees by food supply, predator avoidance and time of day (Saayman & Tayler 1973, Shane *et al.* 1986) and it is possible that each of these factors influence the Bay of Islands bottlenose dolphins.

Common dolphin depth preferences were strongly correlated to water temperature. During late spring and summer they were found in deeper waters outside the limits of the Bay of Islands and during the late autumn and winter months they were frequently found inside the bay. It is likely that the common dolphins were also outside the bay during winter, but the operators would generally try to find dolphins closer to shore and not search further out to sea for other pods. Common dolphins were found by Selzer and Payne (1988) to move relative to water temperature and salinity levels off the coast of Maine, U.S.A. These findings were consistent with those of Gaskin (1968) for common dolphins off the coast of New Zealand. It is thought that the factors influencing the dolphins' movements may be initially affecting prey movements. This explanation seems most likely for the seasonal movement of common dolphins in the Bay of Islands area who would be influenced by the warm East Auckland Current.

The seasons bring different species of cetaceans into the Bay of Islands. Killer whales were seen in the bay only from August to October. These are the months during which the bottlenose and common dolphins were found in shallower waters and this trend may also hold for the killer whales.

3.4.4 Inter-species associations

Bottlenose and common dolphins were never observed together in the Bay of Islands, although they were sometimes separated by only a few kilometres. This is consistent with observations of habitat partitioning by sympatric species of dolphins elsewhere. In Golfo san Jose, Argentina, bottlenose dolphins were most frequently found in water <10 metres deep whereas dusky dolphins *(Lagenorhynchus obscurus)* were found in deeper offshore waters and the two species were rarely observed interacting (Wursig & Wursig 1979). Bottlenose and humpback dolphins (Sousa *cbinensis)* were almost never observed interacting in the Persian Gulf and this was attributed to preferences for different water depths (Henningsen & Constantine 1992). The humpback dolphins were found in waters <10 metres deep and bottlenose dolphins in water deeper than 10 metres. Saayman and Tayler (1979) described different feeding methods by bottlenose and humpback dolphins in southeast South Africa which only occasionally saw the two species interact. The same two species in Moreton Bay, Australia were frequently found together, but this may be attributed to the human influence on their environment, as the two species were observed feeding around fishing trawlers (Corkeron 1990). In New Zealand, dusky dolphins and Hector's dolphins are generally not known to associate with each other. The dusky dolphin is a more pelagic species, although it is occasionally seen close to shore and the dusky dolphin is a more coastal, shallow water species.

Bottlenose dolphins in the Bay of Islands were very rarely associated with birds. This is in contrast to the findings of Ballance (1992), who frequently saw bottlenose dolphins and birds feeding together in water <10 metres deep in the Gulf of California and noted that diving seabirds became one of the most reliable methods of locating a pod of dolphins. The association between sea birds and bottlenose dolphins has also been observed in pelagic waters off Isla del Coco, Costa Rica (Acevedo & Wursig 1991).

Associations between common dolphins and birds, particularly gannets, occurred frequently in the Bay of Islands. The presence of birds was often used by the operators to find common dolphins and if a scan of the horizon failed to detect any birds, the operators would frequently travel in closer to the coastline to search for bottlenose dolphins. In the Bay of Islands, common dolphins and gannets were observed feeding on pilchards in the same feeding aggregation.

Baleen whales were found feeding in close association with common dolphins and gannets during spring. The dolphins were observed riding on the pressure wave created as the whale swam rapidly on the surface during feeding bouts. These multispecies aggregations are assemblages of various species, both predators and prey and are frequently sighted, particularly during feeding. Norris *et* al. (1994) suggest that these aggregations of fishes and dolphins provide protection from predation, availability of food and removal of ectoparasites for the species involved. Saayman *et al.* (1972) observed feeding between seals, birds, dolphins and whales off the South African coast. Common dolphins were observed feeding with pelicans, terns, gulls, boobies and sealions in the Sea of Cortez (Wursig 1986). Black (1994) found sea lions, humpback whales and birds associated with Pacific white-sided dolphins in southern California when anchovies were abundant. Au (1991) suggested that these multi-species aggregations help increase the feeding success by all individuals involved. This may be ascribed to increased access to resource information or advantageous feeding technique, e.g., dolphins herding prey to the water surface allowing the birds greater access to the fish. On two occasions whales, dolphins and gannets were observed feeding on pilchards *(Sardinops neopilchardus)* that were trapped in a tight ball on the surface of the water. On these occasions gannets were seen taking whole fish, unlike the shearwaters near the Azores Islands that were observed taking only scraps of fish flesh (Martin 1986).

4. Summary and recommendations

4.1 OBJECTIVES

The results of the four primary objectives of this research are summarised below.

1. Document exposure Over a 12 month period a total of 179 pods of dolphins were encountered during 156 trips aboard the commercial swim-with-dolphin boats in the Bay of Islands. There were 123 encounters with bottlenose dolphins and 56 encounters with common dolphins. The operators had an 86% success rate in finding dolphins from the 156 trips on which they were accompanied by the researcher. There was an average of 1.15 pods of dolphins encountered per trip. From the average trip length of 3 hours 6 minutes, the operators spent an average of 54 minutes with each pod of bottlenose dolphins and an average of 44 minutes with each pod of common dolphins. Less time was spent searching for dolphins in winter and spring than in summer and autumn. There was at least one swim attempted with the dolphins on 37% (n = 66) of encounters. The likelihood of swimming with bottlenose dolphins per encounter (41%) was greater than swimming with common dolphins (27%). Bottlenose dolphins were exposed to an average of 2.9 swim attempts per encounter and common dolphins were exposed to 1.9 swim attempts per encounter.

2. Behavioural response The behaviour of dolphins was observed during the vessel approach on 112 encounters. As the swim-with-dolphin boats approached from a distance of 400 metres to 100 metres, bottlenose dolphins changed their behaviour on 32% of approaches and common dolphins changed their behaviour on 52% of approaches. Bottlenose dolphins approached to bowride the operator's boat on 23% of these interactions and dived to avoid the boat (avoidance response) on 4% of approaches. Common dolphins approached the boat to bowride on 43% of approaches and were not observed avoiding the boat. Observations of avoidance are likely to be an underestimate due to the limitations of assessing behaviour from the potential source of disturbance.

Bottlenose dolphins had a sustained interaction i.e., remained swimming within five metres of the swimmers, on 48% of swims and actively avoided swimmers on 22% of swims. Common dolphins had a sustained interaction with swimmers on 24% of swims and actively avoided swimmers on 38% of swims. Bottlenose dolphins spent an average of 4.2 minutes (range: 14 seconds - 20 minutes) in sustained interactions with swimmers and common dolphins spent an average of 5.3 minutes (range: 22 seconds - 14 minutes 45 seconds).

Commercial boats used three strategies for placing swimmers in the water: 1) `line abreast', 2) `in path of travel', 3) `around boat'. The 'line abreast' strategy gave the dolphins three options to respond: to approach, avoid or remain unchanged in their orientation to the swimmers. The `in path' and `around boat' strategies gave the dolphins only two options: to avoid the swimmers by changing course or to remain unchanged in their original orientation and thus resulting in the dolphins interacting with the swimmers. The `in path' strategy caused the highest rate of avoidance behaviour, with bottlenose dolphins avoiding swimmers placed in their path of travel on 50% of the entries and common dolphins avoiding the swimmers placed in their path of travel on 86% of the entries. The `line abreast' strategy had the lowest rate of avoidance with bottlenose dolphins avoiding swimmers on 10% of swimmer entries and common dolphins avoiding swimmers on 21% of entries. The `around boat' strategy had the highest rate of sustained approaches with bottlenose dolphins approaching swimmers on 63% of swims and common dolphins approaching swimmers on 75% of swims.

3. Photo-identification During the 12 month study, a total of 265 bottlenose dolphins were individually identified from photographs of nicks and scars on their dorsal fins. The majority (76%) were resighted on more than two encounters, with the most frequently sighted dolphins photo-identified 21 times. The rate of `discovery' of newly identified individuals declined steadily throughout the study, suggesting that the majority of the local or regional population was identified. The Bay of Islands does not seem to be the exclusive home range of any subset of the local or regional population, but it may be an important preferred range for some individuals. The geographic boundaries of the bottlenose dolphin population using the Bay of Islands is unknown. Common dolphins were considered too numerous and indistinct to photo-identify.

4. Demographic information The average pod size of bottlenose dolphins in the Bay of Islands was 13.8 animals. Pod sizes were significantly larger in spring (X = 16.2) and summer (X = 15.3) than autumn (X = 10.8). There were calves in 40% of bottlenose dolphin pods. The average pod size for groups containing mother/calf pairs was larger than those without mother/calf pairs. Pods containing 30-100 common dolphins were most frequently observed and 43% of pods were seen containing at least one calf. A calf was defined as an individual that was distinctly smaller (usually half the size) than a closely associated accompanying adult. The calf was usually found swimming beside an adult but slightly behind it.

Bottlenose and common dolphins were never observed together. Bottlenose dolphins were found in waters with a mean depth of 22.9 metres and common dolphins were found in waters with a mean depth of 80 metres. Both species were found in shallower waters during winter and spring than during summer and autumn. There was a strong seasonal correlation between water depth and sea surface temperature for both species. With higher water temperature, the dolphins were found in deeper waters.

Bottlenose dolphins were associated with birds or other cetacean species on only 2% of encounters. Common dolphins were associated with birds on 63% of encounters and with baleen whales on 7% of encounters. Of all associations with birds, 97% were with gannets.

4.2 RECOMMENDATIONS

1. Operator strategies for placing swimmers in the water affected the response of dolphins. The `line abreast' strategy resulted in the lowest rate of avoidance behaviour by dolphins and the 'in path' resulted in the highest. It is recommended that the 'in path' strategy be avoided by all operators.
2. Bottlenose dolphins observed to be feeding were the least likely to approach the commercial boats. Common dolphins observed to be resting were least likely to approach the commercial boats. Socialising was the behavioural state most likely to change for both species. These observations supports current regulations and permit conditions that prohibit approaching these should be maintained.
3. In the current regulation of permits, the definition of a 'juvenile dolphin' is ambiguous. The generally accepted scientific definition of juveniles are individuals which are about two-thirds the length of an adult and often often swim independently of other members of the pod. This definition would exclude the majority of dolphin pods from swim attempts. Calves are likely to be the most vulnerable age group, but definitions need to be clarified by the Department of Conservation and regulations enforced.

4.3 FUTURE RESEARCH

There are a number of questions raised by this initial research that could not be addressed in a one-year study. These include:

1. Where do the bottlenose dolphins go when they are not in the Bay of Islands? This research shows that some dolphins from the Bay of Islands were also identified in Whangarei and Tutukaka, but this is almost certainly not the full extent of the dolphins' range. Accurate knowledge of their home ranges is necessary to assess the cumulative impact of swim-with-dolphin operations around the Northland coast.
2. What are individual patterns of responses to boats and swimmers? Preliminary observations suggest that some individual dolphins or social groups are more `friendly' towards swimmers and boats than others. The

ability to recognise these individuals or groups would enhance the success of swim attempts and prevent disturbance to `shy' individuals.

3. How do changes in the bottlenose and common dolphins' environment affect their movement patterns? This single year study showed a correlation between sea surface temperature and the water depth in which the dolphins were found. Research on dolphin movements in other regions of the world shows a correlation between prey movements and dolphin distribution. Research on fish distribution and movements is needed in Northland to evaluate the impacts of changes in the local environment, e.g., what was the impact of the recent pilchard die-off in the Northland region and how does the East Auckland current affect fish distribution?

4. What impact do seasonal changes in boat traffic have on the dolphins' movement patterns and behavioural responses? There was a strong seasonal correlation between water temperature and water depths in which dolphins were found. This effect could either mask or be enhanced by the increase in summer boat traffic. There is insufficient data from just 12 months of research to make any conclusions about the impact of boat traffic and this should be addressed in future research projects.

5. How will the dolphins' ongoing experience with swim-with-dolphin operations influence their future behavioural responses? As the swim-with-dolphin operations are a relatively new activity, it is possible that individual dolphins will become familiar with the boats and choose to increase their approaches to or, conversely, develop a cumulative aversion towards them. Long-term research focussing on individual dolphins is needed to monitor these changes.

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APPENDIX 1.

DATA SHEET - BAY OF ISLANDS 1994/95

FORM #:
DATE: AM PM
DAY:
OPERATOR:
WEATHER CONDITIONS:
- CLOUD COVER:
- SEA STATE: CALM SLIGHT CHOP CHOPPY
- SWELL: meters
- WIND (Beaufort):
- WIND DIRECTION:
- TIDE: INCOMING OUTGOING
- MOON PHASE:

TOTAL DISTANCE COVERED-
DEPARTED PORT (TIME):
RETURNED (TIME):
DOLPHIN SIGHTING (TIME):
TOTAL SEARCH TIME TO 1ST SIGHTING:
POSITION OF SIGHTING:
WATER DEPTH & TEMP (AT SIGHTING POINT):
SIGHTING CUE:
- UNASSISTED:
- INFO. FROM OTHER VESSELS:
- ASSOCIATION
  - BIRDS:
  - CETACEANS:
  - OTHER BOATS:
- WHAT SPECIES?
  - GANNETS:
  - STORMY PETRELS:
  - BULLERS SHEARWATERS:
  - SKUAS:
  - OTHER:
    - specify:

DOLPHIN SPECIES SIGHTED:
GROUP SIZE (MIN. ESTIMATE):
CALVES:
#JUVENILES:
#FOETAL FOLDS:
ENCOUNTERED DOLPHINS (TIME) 400 - 100 M:
OTHER BOATS:
ACTIVITY ENGAGED IN WHEN ENCOUNTERED:
(ASSESSED 400 - 100 M AWAY FROM DOLPHINS)
- SOCIALISING
- TRAVELLING:
- FEEDING:
  - SURFACE RUSHES:
  - DEEP DIVING:
  - CIRCLING:
- RESTING:
- MILLING:
- BOWRIDING: RESEARCH BOAT/OTHER BOAT
- REALTIVE DISTANCE TO SWIMMERS:
- OTHER:
  - specify:

COMMENTS:

APPROACHED DOLPHINS (TIME) < 100 M:

DID THEIR ACTIVITY CHANGE WHEN APPROACHED (< 100 M)?

YES NO

WHAT DID THEY CHANGE TO?

- SOCIALISING
- TRAVELLING:
- FEEDING:
- RESTING:
- MILLING:
- BOWRIDING: RESEARCH BOAT/OTHER BOAT
- OTHER:
-specify:

SWIMMING

YES NO

TOTAL # OF SWIMS:
BOATS PRESENT (INCL. RESEARCH BOAT):
PEOPLE IN WATER (TIME 1ST IN):
PEOPLE ENTERED WATER:

- IN FRONT OF DOLPHINS
- TO SIDE OF DOLPHINS
- IN DOLPHINS PATH OF TRAVEL

PEOPLE IN WATER (TOTAL - ALL BOATS):
REACTION TO PEOPLE: YES NO
IF YES THEN:

TYPE OF REACTION:

- REMAINED WITH PEOPLE (WITHIN 5 M):
- SWIMMING THROUGH GROUP OF PEOPLE:
- OTHER:
-specify:

IF NO THEN:

TYPE OF REACTION:

- DIVED:
- SWAM PAST (STAYED ON COURSE):
- SWAM PAST (CHANGED COURSE):
- OTHER:
- specify:

LENGTH OF TIME DOLPHINS STAYED WITH PEOPLE:
PEOPLE OUT OF WATER (TIME LAST OUT):
LENGTH OF SWIM:
REASON FOR TERMINATION OF SWIM:

- DOLPHINS LEFT:
- PEOPLE TIRED:
- OPERATOR STOPPED SWIM:
- OTHER:
- specify:

COMMENTS:
TERMINATION OF DOLPHIN ENCOUNTER (TIME):
REASON FOR TERMINATION:

- DOLPHINS LEFT:
- OPERATOR LEFT:
- DOLPHINS ATTRACTED TO ANOTHER BOAT:
  - BOWRIDING BOAT:
- OTHER:
-specify:

ACTIVITY ENGAGED IN WHEN LEAVING:

- SOCIALISING:
- TRAVELLING:
- FEEDING:
- RESTING:
- MILLING:
- BOWRIDING RESEARCH BOAT OTHER BOAT

POSITION WHERE WE LEFT THEM:

RE-EVALUATE POD SIZE:

OBJECTIVE CRITERIA:

- LEAPS	YES	NO
- TAIL SLAPS	YES	NO
- HEAD SLAPS	YES	NO
- VOCALISATIONS	YES	NO
- BOWRIDING	YES	NO

COMMENTS:

BOATS PRESENT - (SCAN SAMPLE 5 MINS) RESEARCH BOAT INCL.

00 MINS:	35 MINS:	70 MINS:
05 MINS:	40 MINS:	75 MINS:
10 MINS:	45 MINS:	80 MINS:
15 MINS:	50 MINS:	85 MINS:
20 MINS:	55 MINS:	90 MINS:
25 MINS:	60 MINS:	95 MINS:
30 MINS:	65 MINS:	100 MINS:

COMMENTS: