DUSKY DOLPHIN (*LAGENORHYNCHUS OBSCURUS*) BEHAVIOR AND HUMAN INTERACTIONS: IMPLICATIONS FOR TOURISM AND AQUACULTURE

A Thesis

by

NICHOLAS MATTHEW THOMSON DUPREY

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2007

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Bernd Würsig
Committee Members,	Frances Gelwick
	Robert Ditton
Head of Department,	Delbert M. Gatlin, III

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ABSTRACT

Dusky Dolphin (*Lagenorhynchus obscurus*) Behavior and Human Interactions: Implications for Tourism and Aquaculture. (May 2007)

Nicholas Matthew Thomson Duprey, B.Sc., University of Manitoba

Chair of Advisory Committee: Dr. Bernd Würsig

Interactions between humans and dusky dolphins in the coastal waters of New Zealand are increasing. My research focused on tourism interactions, with Kaikoura as the study site; and, on habitat use in an active aquaculture area, with Admiralty Bay as the study site. In Kaikoura, companies engaged in commercial cetacean tourism (For Hire Company) have permits issued by the New Zealand's Department of Conservation, allowing them to take paying customers out to view and swim with wild dusky dolphins.

During summer and fall of 2005, I assessed the effectiveness of a voluntary 'rest period' established to give time free of humans to the dolphins. I used a theodolite to track the movements of large groups of dusky dolphins and recorded the arrival, departure and behaviors of all vessels approaching within 400 m of the group. The 'rest period' resulted in a reduction of vessel visits compared to non-rest periods, yet one For Hire Company and private recreational vessels continued to visit dusky dolphin groups during this time. To increase compliance with the voluntary regulation, more education is needed targeting private recreational vessels.

Weekend traffic was higher compared to weekday traffic, during both rest and non-rest periods; a large increase occurred in weekend non-commercial vessel traffic. Swimming with calves is prohibited by New Zealand's Marine Mammal Protection Regulations of 1992, yet 71.4 percent of the swim attempts I observed on-board For Hire Company tours were conducted with groups containing calves. More should be done to reduce the number of swims conducted with groups of dusky dolphins containing calves.

In winter of 2005, I used hourly theodolite scans to record the number of dusky dolphin groups using Admiralty Bay, a different near-shore environment with less tourism than off Kaikoura, and with near-shore mussel farms. Groups of dusky dolphins were observed in Admiralty Bay using the full extent of the bay. This re-enforces previous findings that Admiralty Bay is an important winter foraging ground for dusky dolphins, and further aquaculture development in the bay would remove available foraging habitat.

ACKNOWLEDGMENTS

I thank Jody Weir for her constant never ending support both in and out of the field; I could not have completed this adventure without her and I look forward to the beginning of our next adventure. I thank committee chair Bernd Würsig for his friendship, support of my research ideas, and giving me the opportunity to study dusky dolphins in New Zealand. Thanks to Thomas Egli, Keltie Dienes, Marie Fournier, Robin Vaughn and Heidi Pearson for helping to collect field data and making the project run smoothly, and to the Earthwatch Institute and over 140 Earthwatch volunteers who helped both financially and physically with the completion of this research. I also thank Jack Van Berkel (Edward E. Percival Field Station, University of Canterbury) and Danny and Lyn Boulton for their logistical help and orientation to Kaikoura and Admiralty Bay, respectively. I thank the University of Canterbury for lending theodolite equipment and NIWA for supplying GIS bathymetry maps of the study areas; and the Whale and Dolphin Adoption Project, the New Zealand Department of Conservation and Marlborough District Council, who all provided funding for this project. I also thank the local cetacean tourism company for their help in making this research possible.

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CHAPTER I

HUMAN INTERACTIONS WITH NEW ZEALAND'S DUSKY DOLPHINS (*Lagenorhynchus obscurus*): IMPLICATIONS FOR TOURISM AND AQUACULTURE

As the human population increases, so is our use of natural resources increasing. In terrestrial ecosystems, impacts caused by humans are especially noticeable. Urban sprawl affects biodiversity (Huston 2005), forestry practices change wildlife abundance (Thompson et al. 2003), and farming practices manipulate animal diversity (Green et al. 2005). Marine ecosystems are less understood and human impacts there are usually less noticeable. Commercial fishing impacts to marine ecosystems (Coleman & Williams 2002), invasive species introduced with ballast water (Firestone & Corbett 2005), and recreational diving effects on marine animals (Saphier & Hoffmann 2005) are examples of areas where knowledge about human impacts is being gathered.

Dusky dolphins (*Lagenorhynchus obscurus*) are a small southern hemisphere delphinid found in the near shore waters of Chile, Argentina, Peru, Namibia, South Africa, and the South Island of New Zealand. In Golfo San José, Argentina, group sizes fluctuate depending on time of year. Between May-September, small groups (<20) are most common, large (>20) and small groups are more equally sighted at other times of the year (Würsig & Würsig 1980). Non surface-feeding small groups were observed most in the morning, with larger groups more often associated with feeding bouts in the afternoon. These Argentine groups were also found to use different parts of the bay depending on the time of year, and it was speculated that this was due to temperatures affecting prey availability (Würsig & Würsig 1980).

Near Kaikoura, New Zealand, the Kaikoura Canyon comes close to the coast, resulting in water depths of up to 1000 m only 4 kilometers off shore. Large groups of

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This thesis follows the style of Conservation Biology.

dusky dolphins, up to 2000 individuals, are regularly seen resting and socializing near shore during the day (Cipriano 1992, Barr 1997, and Yin 1999). These groups are found closer to shore during summer and further off shore during winter, with group sizes typically larger in winter (Cipriano 1992). In the evening, groups begin moving offshore to feed off the deep scattering layer (DSL), taking advantage of this abundant food source when it is closest to the surface. The dolphins return towards shore in early morning, when the DSL has migrated back below their comfortable diving capabilities (Benoit-Bird et al. 2004). Although little is known about the movements of dusky dolphins around the South Island of New Zealand, some individuals move between Kaikoura and Admiralty Bay in the Marlborough Sounds (Markowitz 2004). These individuals change their foraging behavior from night-time dive-feeding on the DSL to daytime group-coordinated schooling of small fish (McFadden 2003).

Human impacts on dusky dolphins in New Zealand include commercial fishing, tourism, recreational fishing, and habitat loss from aquaculture. The focus of this thesis is on tourism interactions, with Kaikoura, New Zealand as the study site; and habitat use in an active aquaculture area, with Admiralty Bay, New Zealand as the study site.

Tourism

Viewing and in some cases interacting with wild cetaceans has been gaining popularity as a recreational activity, so that now whale watching tourism is a 1 billion USD industry (Hoyt 2001). The effect of these interactions on cetaceans is important, not only for their survival but also for the sustainability of the industry.

Interactions between delphinids and boats have been studied extensively to understand the impact boat traffic has on dolphin behavior and dolphin populations (for a review, see Bejder & Samuels 2004). One effective manner of study is by theodolite tracking. Theodolite tracking involves use of a surveyor’s transit from a high land-based station to follow cetacean groups. The technique has been adapted to follow fast moving delphinids, allowing movement patterns to be studied without influencing behavior

(Würsig et al. 1991). Bejder et al. (1999) used theodolite tracking in Porpoise Bay, New Zealand, to monitor the behavioral reactions of Hector's dolphins (*Cephalorhynchus hectori*) to tour boats and swimmers. Bejder et al. (1999) found that groups of Hector's dolphins formed tighter, less dispersed groups when boats were present in the bay, and suggested that this could be an indication of higher stress when boats are present.

Another useful technique to collect data on the effects vessels have on dolphin groups is to be on the potentially disturbing vessel. Such research has led to descriptions of behavioural changes during tour boats interactions [bottlenose dolphins (*Tursiops truncatus*), Constantine 2001; dusky dolphins and Commerson's dolphins, Coscarella et al. 2003]. Constantine (2001) found that tour vessels changed dolphin behaviours depending on where swimmers were placed, and that juvenile dolphins interacted with swimmers more than did other age classes.

In New Zealand, the Marine Mammal Protection Regulations (1992) impose restrictions to boats near cetaceans, including a limit of 3 boats within 300 m, a no wake speed within 300 m, and explain slow and careful methods of approaching cetaceans. Companies that take paying customers to view or swim with cetaceans (For Hire companies) are required to have permits and an educational component to their tours.

In Kaikoura, cetacean tourism began in the late 1980's, with two boat-based For Hire companies. Cetacean tourism in Kaikoura has rapidly increased since then, with more tourists, larger boats, and more employment opportunities every year. Aerial For Hire companies are now offering trips for those wanting to see whales and dolphins from above. Currently, For Hire Company #1 holds and utilizes three permits for commercial swim-with-dolphins operations in the Kaikoura area. For Hire Company #2 holds 4 such permits as well, but only uses theirs to view dolphins, not swim-with-them.

The most recent study to monitor Kaikoura's dusky dolphins in relation to tourism was conducted in the 1998–1999 summer season. Since then, tour operators have had numerous changes to vessel types and sizes. The high season (busiest time of year) for watching whales and swimming with dolphins has been extended in recent years, with more trips and more tourists. The Department of Conservation together with For Hire

Company #1 and #2 have developed a voluntary two-hour "rest period". During this "rest period" they agreed on not visiting dusky dolphins groups between 1130–1330 daily, from 1 December to 31 March (DOC 1999). Private recreational vessels are also encouraged to participate (DOC 1999). As part of my thesis, I have evaluated the effectiveness of this voluntary two-hour period in eliminating or reducing vessel traffic.

Theodolite tracking has been used in Kaikoura to document overall dusky distribution (Cipriano 1992, Brown 2000) and to study small groups of dolphins (Yin 1999). During Yin's (1999) study, she found that small groups were often ignored by boats or viewed only for short periods; the larger groups attracted most of the boat traffic. Barr (1997) tracked dusky dolphin groups in the Kaikoura area from 1993–1995, observing a significant increase in For Hire company and private recreational boat traffic between study years. She suggested that a precautionary approach should be taken and that the amount of boat traffic in the area should be kept at or below the 1995 levels.

The study of dusky dolphin interactions with vessels in the Kaikoura area has been prioritized as urgent by DOC (Suisted & Neale 2004). Globally, New Zealand offers an opportunity to study how mandatory regulations, set in place to help minimize disturbances of cetaceans, are working and if extra voluntary regulations are effective in further reducing traffic around dolphin groups. In Chapter II, I investigate the effectiveness of current regulations in reducing traffic around dolphin groups. I hope that Chapters II and III will increase our knowledge crucial to decisions on granting new swim-with-dolphin permits.

Aquaculture

Aquaculture has been increasing world-wide to aid in the production of large quantities of fish and shellfish consumed globally. Shrimp, salmon, oysters, and mussels are a few examples of the species groups currently farmed in ocean waters. Concerns about the effects of marine farms have led to numerous studies to investigate farm-related water quality, invasive species, changes in the natural food web, nutrient extraction from the environment, and resulting habitat loss for other species (Crawford et al. 2003, Inglis & Gust 2003, Watson-Capps & Mann 2005, Markowitz et al. 2004).

Green-lipped mussels (*Perna canaliculus*) are an endemic species of New Zealand mussel reaching about 90-120 mm for optimum harvest. Farming first began in New Zealand in the 1970s, after the naturally occurring mussel beds collapsed, owing probably to excessive dredging. The market price for New Zealand green-lipped mussels increased by about 700% from 1988 to 2000, by which time there were 605 farms in New Zealand, covering 2850 Ha. The farms consist of several rows, between 15-20 m apart, of large buoys floating at the surface; in each row, the buoys are connected via two long ropes. Hanging down from these rows are mussel-laden ropes around 1 m apart, where the mussels fasten and grow, until harvested after approximately 12-24 months (Lloyd 2003).

Markowitz (2004) studied dusky dolphins in the Marlborough Sounds region and found daytime foraging to be the dominant behavior in the area. However, green-lipped mussel farms were not used for dolphin foraging, and dolphins rarely entered the farms (Markowitz et al. 2004). At the time this research was conducted, there were several outstanding permit applications for new mussel farms, including extensions of existing farms in the Admiralty Bay region.

Chapter IV focuses on shore-based surveys of dusky dolphin habitat use in the Admiralty Bay region, to enhance our knowledge of dusky dolphin spatial use of the area. Through this increased knowledge, I hope to address whether new mussel farming sites or extensions to existing farms in the bay would conflict with dolphin use.

Objectives

This thesis concentrates on human impacts on dusky dolphins in New Zealand, via addressing the effectiveness of current regulations as well as providing managers with necessary biological data to address future tourism and aquaculture permits.

CHAPTER II

THE EFFECTIVENESS OF A TOURISM 'REST PERIOD' FOR REDUCING VESSEL TRAFFIC AROUND DOLPHINS: SUPPLEMENTING MANDATORY REGULATIONS WITH VOLUNTARY REGULATIONS

Introduction

Indications exist that non-consumptive human disturbances are having effects on wildlife populations (brown bears, *Ursus arctos*, Olson et al. 1997; raptors Bautista et al. 2004; sea turtles Lutcavage et al. 1997), especially tourism activity (Asian rhinos, *Rhinoceros unicornis*, Lott & McCoy 1995; Northern Royal Albatross, *Diomedea epomophora sanfordi*, Highman 1998; Royal penguins, *Eudyptes schlegeli*, Holmes et al. 2005; Magellanic penguins, *Spheniscus magellanicus*, Walker at al. 2006). Research on marine mammal populations indicates that human activities cause behavioral changes in populations (harbour porpoises, *Phocoena phocoena*, and harbour seals, *Phoca vitulina*, Koschinski et al. 2003; Florida manatee, *Trichechus manatus latirostris*, Nowacek et al. 2004, Sorice et al. 2006; polar bears, *Ursus maritimus*, Dyck & Baydack 2004). With the recent increase in cetacean watching tourism, several studies have focused on the behavioral effects of tourism activity on populations (bottlenose dolphins, *Tursiops truncatus*, Constantine et al. 2004, Lusseau 2003a, 2003b, Lusseau & Highman 2004, Samuels & Bejder 2004; Hector's dolphins, *Cephalorhynchus hectori*, Bejder et al. 1999; sperm whales, *Physeter macrocephalus*, Richter et al. 2006; orca, *Orcinus orca*, Williams et al. 2002a, 2002b; Chilean dolphins, *Cephalorhynchus eutropia*, Ribeiro et al. 2005; and dusky dolphins, *Lagenorhynchus obscurus*, Würsig et al. 1997, Barr & Slooten 1999, Yin 1999, Coscarella et al. 2003). Regardless of the species in question, effective management is necessary to control the level of human disturbance and mitigate any potentially harmful effects on the population.

Two regulatory methods exist for managing wildlife populations, mandatory regulations and voluntary regulations, and both have advantages and disadvantages. One problem with mandatory regulations is that they can become very complex and confusing for the user being regulated (Gjerdalen & Williams 2000). The vernacular of mandatory regulations can also be a problem; words such as "harassment" are difficult to define and do not fully explain what behaviors are acceptable and unacceptable (Sorice et al. 2003). While mandatory regulations are enforceable in theory, they are often poorly enforced or simply impossible to enforce due to budgetary constraints. However, mandatory regulations do have consequences that can be enforced when individuals or companies are not following them.

Voluntary regulations are good at filling voids in mandatory regulations while the latter are developed and finely tuned -- a process that can take much longer than implementing voluntary regulations (Garrod & Fennel 2004). Voluntary regulations also provide great building blocks for mandatory regulations, resulting in better final regulations that work and are more common sense (Garrod & Fennel 2004). However, voluntary regulations are not legally enforceable and require individuals to comply due to wanting to do the right thing, or due to peer-pressure.

Using these two methods together allows for a greater degree of adaptability to large or diverse geographic areas; for example, basic mandatory regulations can cover activities on a national level, with local voluntary regulations used to adapt management to local circumstances (Garrod & Fennel 2004).

In New Zealand, the Marine Mammal Protection Act (1974) and the more recent Marine Mammal Protection Regulations (1992) restrict the number of boats within 300m of a dolphin group to 3, impose a no-wake speed limit while around dolphin pods, and advise on proper methods of approaching pods. All For Hire companies (cetacean tourism operators) in New Zealand are required to have permits to take paying customers to view or swim with dolphins; they are also required to have an educational component to their tours.

In 1999, the New Zealand Department of Conservation (DOC) established a voluntary 'rest period' that was adopted by the local For Hire companies. Both companies agreed to avoid dusky dolphin groups between the hours of 1130-1330 from 1 December to 31 March. This voluntary regulation did not include aerial For Hire companies as their traffic was much lower, but private recreational vessels have been encouraged to comply.

Kaikoura is coming to a cross roads in marine mammal tourist activities. In 2009, the Department of Conservation must decide whether to grant permits to current applicants or continue the moratorium on permits for the area. Research in other areas of New Zealand has shown that some marine mammal populations are being affected by human disturbances (Hector's dolphins, Bejder et al. 1999; bottlenose dolphins, Constantine et al. 2004, Lusseau 2003a, 2003b). Past research in Kaikoura has also indicated concern with increasing vessel activities around the Kaikoura coast (Würsig et al. 1997, Barr & Slooten 1999, Yin 1999, Brown 2000).

Our objectives were to: 1) evaluate the effectiveness of the voluntary 'rest period', 2) determine the contribution that private recreational vessels make to the traffic around dolphins, and 3) make recommendations for future strategies in managing For Hire eco-tourism enterprises via voluntary or mandatory measures.

Methods

Theodolite tracking

Between 25 January and 18 April 2005, all large groups, over 150 individuals, of dusky dolphins were tracked by theodolite between the Kaikoura Peninsula and Haumuri Bluffs. Theodolite tracking is a non-invasive method of collecting cetacean movement and behavior data from an elevated shore-based station (Würsig et al. 1991). Tracking was performed using a Sokkia DT5 theodolite slaved to a field notebook computer (Dell Inspiron 1150) allowing the use of Pythagoras, a computer program developed for tracking cetaceans (Gailey & Ortega-Ortiz 2002). Positions were taken at five minute intervals with the middle of the group used to calculate its location, called a fix. Tide data were obtained at 5 minute intervals from the Old Wharf in Kaikoura, via the NIWA and University of Canterbury tide measure.

Ota-Matu observation site was used as the theodolite station for the study (this has been used in past theodolite studies; Cipriano 1992, Barr 1997, Yin 1999, and Brown 2000). The station height was 72.6 meters above mean low tide. The theodolite tripod was set up in the same location each day (S42° 29' 01.8" E173° 31' 41.0"), roughly balanced and then the theodolite was placed on top. Once completely balanced in each plane, the theodolite was turned on. The horizontal was zeroed by aligning the cross-hairs in the monocular to an electrical pole on the highway in Goose Bay, this was the zero reference point for our study (S42 28' 41.4" E173 31' 45.7"). Using the known locations of both the theodolite station and the zero reference point, the reference azimuth, was calculated to be 9.6 relative to true north.

Vessel interactions data

Boat activity around the dolphin groups was collected by recording the arrival and departure times of vessels. Any plane, helicopter, boat, kayak, or surfer (from now on termed "vessel") was recorded as "visiting" when it approached within 400m of the outside edge of a focal dolphin group (distance at potential disturbance; Kruse 1991). The time the boat arrived and departed was recorded (hours, minutes and seconds) and its behavior around the dolphins was also categorized (see below for description of vessel behaviors). The name of the vessel was recorded if known; for example, the large For Hire Company vessels had visible names on them and could be identified; however, smaller private recreational vessels were less likely to have visible names on the hull.

For Hire Company vessels were designated as For Hire Company #1 (FHC#1) and For Hire Company #2 (FHC#2); the aerial For Hire companies, using helicopters and fixed-wing planes, were combined and designated as For Hire Company #3 (FHC#3). For Hire Company vessels were given one of the following behaviors; traveling, viewing, or swimming and viewing. Planes and helicopters flying over focal dolphin groups were recorded if any attempts at circling the group were made; aircraft flying at high altitude (>1,500 ft.) were not recorded. Commercial Fishing Vessels were labeled as such while private recreational anglers were designated as Private Recreational Vessels (with their behavior designated as fishing). Commercial fishing vessels were described as traveling, fishing, or viewing. Private Recreational Vessels were given one of the following behaviors; traveling, viewing, swimming and viewing, fishing, fishing and viewing or S.C.U.B.A. diving. Boat-based research was also conducted on dusky dolphins in the Kaikoura area, aboard "Punua Aihe", a 5.5m rigid hulled inflatable boat. Whenever Punua Aihe was present within 400m of a focal group, she was recorded.

Traveling was described as moving past a group of dolphins without stopping to view them. Vessels could have slowed down when close to a group but did not come to a stop and approach the group to view dolphins. Viewing was when a vessel stopped traveling to view dolphins and came along side the group so that dolphins were very close to the vessel. Viewing vessels (except aircraft) generally had dolphins within 1 m of their vessel at some time during an observation session. Aircraft were described as viewing when they circled groups, or "buzzed" groups by flying low directly over the group. Swimming and viewing was when at least one swimmer from the vessel entered the water to swim with the dolphins; most of the time vessels remained in the area for an extended amount of time either before or after a swimmer was in the water. Fishing was designated for any vessel in which crew were setting fishing nets, placing crayfish pots, or fishing with a rod and reel. Occasionally, a Private Recreational Vessel would be seen fishing, and after some time approach the dolphins for viewing. These vessels were designated a behavior of fishing and viewing; for analysis they were included as a vessel viewing and/or swimming.

Results

A total of 36 days and 8032 minutes were spent searching for and observing dusky dolphin groups along the Kaikoura coast. During this time, 38 groups were tracked via theodolite (mean follow time 204.4 minutes SD = 15.57) resulting in 1,742 group locations recorded. In total, 402 vessel approaches were recorded; commercial tourism operations made 236 (58.7%) of the vessel approaches (Table 2-1).

Table 2-1. Total recorded visits to large focal groups of dusky dolphins by vessel category between 25 January and 14 April 2005.

	For Hire companies							
	FHC#1	FHC#2	FHC#3	CFV	PRV	Research	Other	Total
Total Visits	118	88	30	14	113	23	16	402

a. FHC = For Hire Company Vessels
b. PRV = Private Recreational Vessels
c. CFV = Commercial Fishing Vessels

Vessel traffic during non-rest and rest periods

During the summer season (1 December to 31 March), the voluntary rest period is in effect. Over 28 days (between 25 January and 30 March 2005), 35 dolphin groups were tracked and observed for vessel traffic (mean follow time 201.9 minutes SD = 16.35). Of the 372 vessels observed visiting dolphin groups between 25 January and 30 March, 324 visits occurred during non-rest periods and 48 during rest periods. Observations of vessel traffic were divided into 2 blocks, the rest period, 26.55 hours, and non-rest periods, 88.98 hours. An observation session had to last a minimum of 30 minutes in a block to qualify for analysis of rest vs. non-rest. Mean visits per hour indicate a significant decrease in traffic between the voluntary rest period (1130-1330) and other times of day (Mann-Whitney U=107.5, $P<0.05$, Table 2-2). This decrease is mostly made up of the lack of FHC#1 vessels visiting groups during this period, as they were seen visiting dolphin groups more than any other vessel category (Table 2-1), but were never seen approaching dolphins during the rest period (Table 2-3).

Table 2-2. Visits per hour of all vessel types during non-rest and rest periods.

	Visits per hour by all vessels		
	n[a]	Mean	Standard Error
Non-rest Period	34	3.28	0.349
Rest Period	17	1.78	0.384

a. Represents the number of group follows used to calculate mean.

Private Recreational Vessel traffic was high during the rest period and other times of the day. During the non-rest period, Private Recreational Vessel traffic had the second highest mean visits per hour of all vessel categories; FHC#1 vessel traffic was highest. During the rest period, Private Recreational Vessels had the highest mean visits per hour of all vessel categories (Table 2-3). PRV traffic was variable during both rest and non-rest periods; ranging from 0 visits for an entire field day to as many as 22 visits seen over a 3.5 hour group follow (6.81 visits/hr.). No FHC#1 vessels were seen approaching within 400m of a focal dolphin group during the rest period, 1130-1330, resulting in their visits per hour being significantly lower between rest and non-rest periods. FHC#2 vessels were seen interacting with focal dolphin groups during the rest period, and there was no significant change in their mean visits per hour between rest and non-rest periods.

Table 2-3. Mean visits per hour during the rest period (1130-1330) and non-rest periods by vessel type. SE = Standard error of mean.

	Mean visits per hour (± SE)	
Vessel type	Non-rest period	Rest period
FHC#1[a]	1.18 ± 0.130	0.00 ± 0.00
FHC#2[a]	0.70 ± 0.117	0.62 ± 0.204
FHC#3[a]	0.17 ± 0.054	0.35 ± 0.121
Total	2.05 ± 0.166	0.97 ± 0.232
CFV[b]	0.10 ± 0.041	0.03 ± 0.035
PRV[c]	0.91 ± 0.243	0.64 ± 0.205
Research	0.20 ± 0.050	0.07 ± 0.046
Other[d]	0.02 ± 0.014	0.06 ± 0.064
Total	1.23 ± 0.270	0.81 ± 0.213

a. FHC = For Hire Company Vessels
b. CFV = Commercial Fishing Vessels
c. PRV = Private Recreational Vessels
d. Other = Kayaks, jet-skis, surfers, etc.

During 115.53 hours of observing dolphin groups for vessel traffic, 54.37 hours (47.1%) had no vessels within 400m of the groups. During the remainder of the time, anywhere from 1 to 7 vessels were seen around the dolphin groups (Figure 2-1). The number of vessels exceeded 3 for 4.31 hours (3.7%) during the entire observation time. There was more ‘vessel free time’ during rest periods than during non-rest periods; during only 24.4% of the observation time were any vessels seen with a focal dolphin group (Figure 2-2). At no time were more than 3 vessels around a focal dolphin group during the rest period (Figure 2-2).

Of the 405 visits observed during the study, 323 had their arrival and departure times as well as their behavior around the dolphin group recorded. The mean time spent around a dolphin group for all vessel types and behaviors was 20.9 minutes (SE=1.41). This mean was brought down by vessels simply traveling by the group, unlike those that spent more time viewing or swimming with the dolphins. For vessels with persons viewing and/or swimming, FHC#1 vessels had mean visit lengths significantly longer than the other vessel types (ANOVA, df = 5,257, F=112.32, p<0.05, Bonferroni p<0.05 for all vessel type comparisons, Table 2-4). Mean lengths of FHC#3 vessel visits were significantly shorter than FHC#1, FHC#2 and Private Recreational Vessels (ANOVA, df = 5,257, F=112.32, p<0.05 Bonferroni p<0.05). No commercial fishing vessels were seen viewing or swimming with dolphin groups; the only behavior observed from these vessels was fishing or traveling, unlike the behavior of For Hire companies which was almost always swimming and/or viewing.

Table 2-4. Mean visit lengths in minutes of vessels engaged in all behaviors and viewing and swimming only. SE = standard error of the mean.

	All visits			*Viewing and/or swimming visits only*		
Vessel type	N	Mean	SE	n	Mean	SE
FHC#1[a]	62	60.5	3.77	62	60.5	3.77
FHC#2[a]	80	13.3	0.52	79	13.5	0.50
FHC#3[a]	30	1.6	0.18	30	1.6	0.18
PRV[b]	105	10.6	1.17	58	13.3	1.76
Research	20	15.9	3.22	20	15.9	3.22
CFV[c]	11	20.7	6.04	0	0	0
Other[d]	15	13.8	3.24	14	14.8	3.33

a. FHC = For Hire Company Vessels
b. PRV = Private Recreational Vessels
c. CFV = Commercial Fishing Vessels
d. Other = Kayaks, jet-skis, surfers, etc.

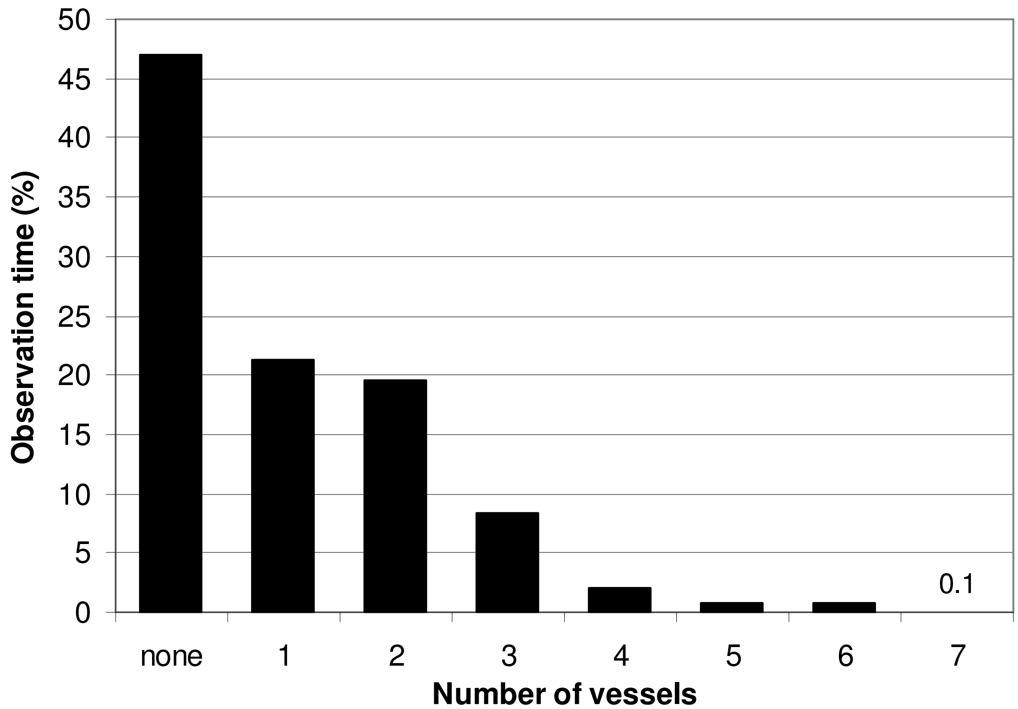

Figure 2-1. Percentage of observation time vessels were within 400m of the focal dusky dolphin group.

Vessel traffic during weekends and weekdays

Results of our 7 weekend (Saturday and Sunday) and 21 weekday (Monday to Friday) samples indicate unevenness in vessel traffic between weekends and weekdays. Weekends provided less vessel free time during the rest period compared to weekdays, while non-rest periods remained relatively stable in vessel free time between weekdays and weekends (Figure 2-3). Weekday non-rest periods had significantly lower mean visits per hour than weekend non-rest periods (Mann-Whitney U=37.0 p=0.014). And while the mean visits per hour during rest and non-rest periods remained significantly different for weekday samples (Mann-Whitney U=88.5, p=0.025), Saturday and Sunday samples failed to show a significant difference between the two periods (Mann-Whitney U=10.0, p=0.223). The presence of FHC and non-FHC vessels increases on weekends resulting in more traffic overall around dolphin groups (Figure 2-4).

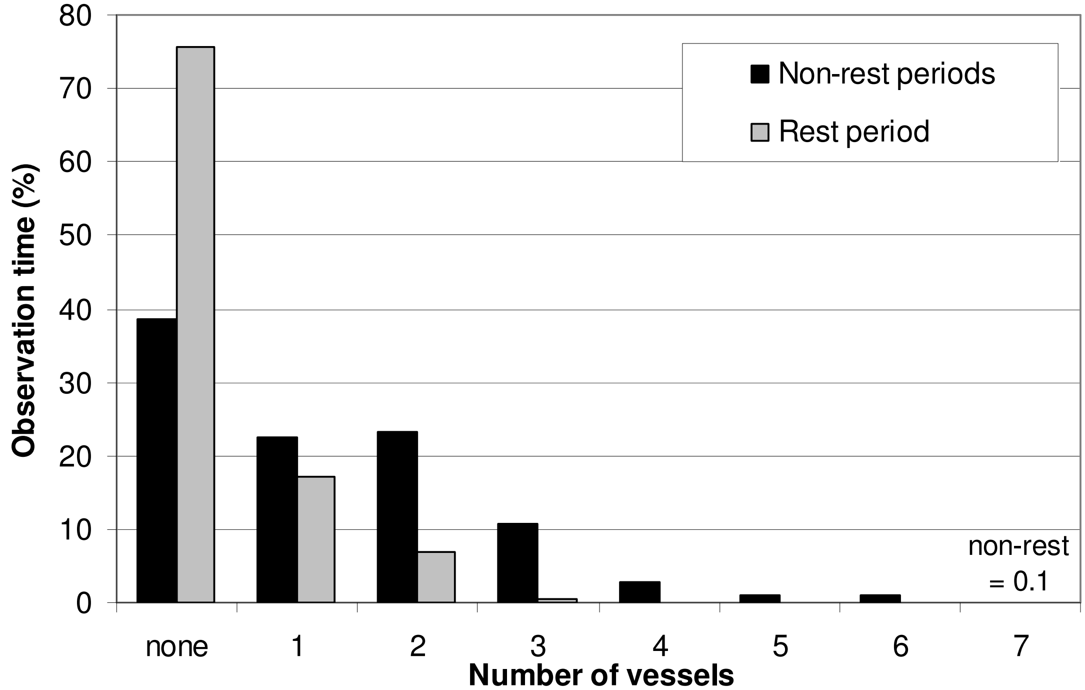

Figure 2-2. Percentage of observation time vessels were within 400m of the focal dusky dolphin group during rest and non-rest periods.

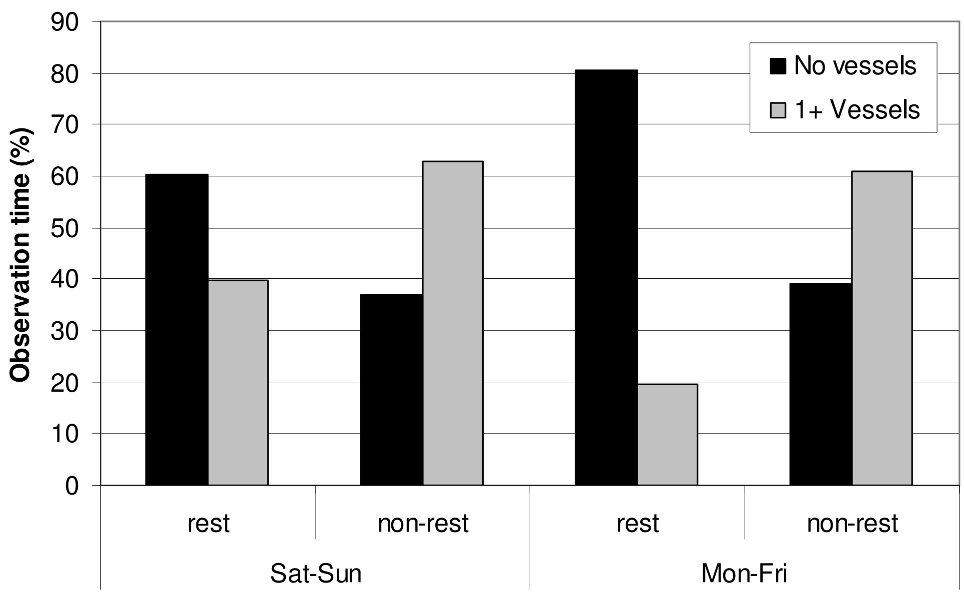

Figure 2-3. Comparisons of weekend and weekday observation time when vessels were and were not present during rest and non-rest periods.

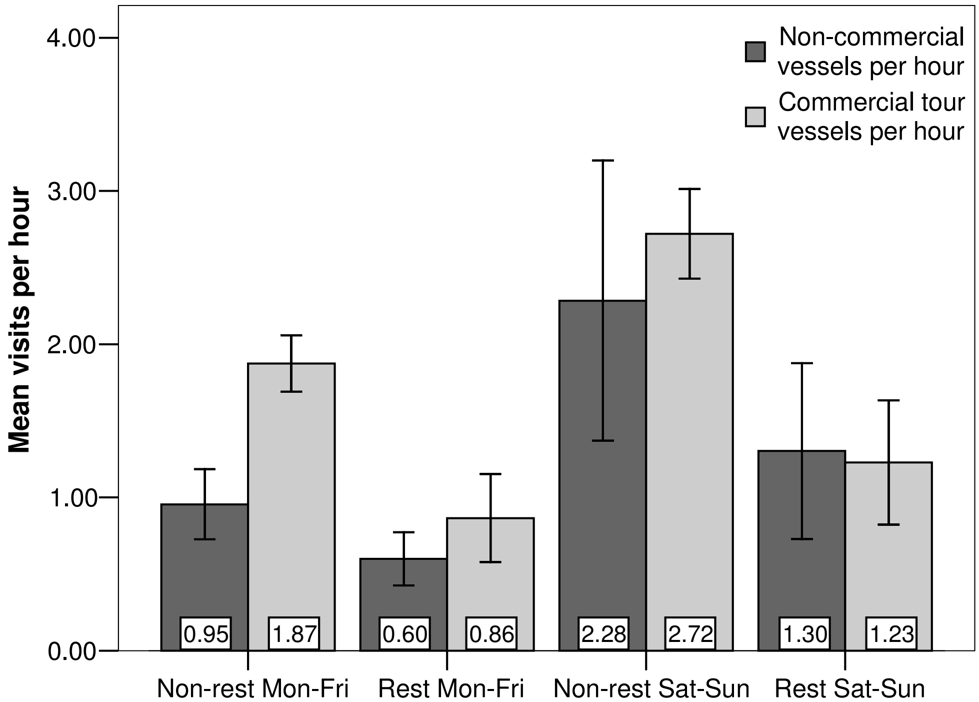

Figure 2-4. For Hire Company (FHC) and non-FHC mean visits per hour during weekdays and weekends by rest and non-rest periods. Error bars represent ± 1.00 standard error of mean.

Discussion

Effectiveness of the voluntary rest period

The voluntary regulations developed to eliminate or reduce vessel traffic around dusky dolphin groups in the Kaikoura area have been successful in some respects, but not in others. The overall number of visits to dolphin groups during the 'rest period' was lower than other times of the day; however, visits still occurred and For Hire Company vessel traffic still made up more than half of the traffic around groups. For Hire Company #1 (FHC#1), whose business was directed solely at dusky dolphin groups in the area, followed the voluntary regulations 100% of the time, never visiting dolphin groups during the "rest period". For Hire Company #2 (FHC#2), whose main target was the sperm whale population along the Kaikoura coast, did not follow the voluntary regulations as their visitation rates were not significantly different between rest and non-rest periods. It could be that these two companies had different incentives for following the voluntary 'rest period' due to their different levels of attachment to the dolphin population as a part of their respective businesses. The reduction of commercial traffic between rest and non-rest periods was almost completely a result of FHC#1 avoiding dolphin groups during this time.

Recreational vessel traffic

Private Recreational Vessel (PRV) traffic in the Kaikoura area was shown to be increasing by Barr and Slooten (1999), yet PRVs are not the focus of current management plans. This is mostly due to the difficulty in enforcing regulations on private recreational non-licensed vessels. Private Recreational Vessels are even less economically invested in dolphins than For Hire companies as they do not require a license to approach marine mammals, are allowed unlimited time and visits to whales and dolphins as long as they follow the Marine Mammal Protection Regulations (1992).

Private Recreational Vessels spent less time around groups; their mean visit lengths were much shorter than FHC#1 visits and when viewing or swimming with groups, they remained with groups for similar lengths of time that FHC#2 remained with groups. Weekends produced much more traffic than weekdays and this was heavily influenced by Private Recreational Vessel traffic. Although our sample sizes were low, the significantly higher rate of visits on Saturday and Sunday during the non-rest periods compared to Monday to Friday non-rest periods shows heavy increases in traffic during weekends. The large decrease on weekends in the amount of vessel free time that dolphin groups have during the rest period was attributable in part to the higher visitation rates of Private Recreational Vessels during that time.

The trend for Private Recreational Vessel traffic to be lower during the 'rest period' was less likely compliance to the voluntary regulations and more likely a result of these smaller vessels not having the larger FHC vessels to use as guides to locate dolphin pods. Local residents and returning visitors to the Kaikoura coast are familiar with the FHC vessels and know that if these vessels are grouped together in one spot, a large group of dolphins is likely in the area. When the FHC vessels are not on the water, while respecting the voluntary ‘rest period’, they are no longer markers for recreational vessels as to the position of the dolphin groups. This could be influencing the visitation rates of Private Recreational Vessels; further study of Private Recreational Vessel traffic would allow an assessment of boater knowledge of the voluntary regulations and marine mammal populations in the area. Currently, there is no on-site education regarding the voluntary ‘rest period’ for the Kaikoura area, and therefore it is unlikely that Private Recreational Vessels have an opportunity to learn about the voluntary ‘rest period’.

Management recommendations

The use of voluntary regulations to supplement mandatory regulations in the Kaikoura area seems to be working effectively to reduce traffic, but not eliminate it, during the ‘rest period’. The For Hire Company with the strongest ties to the dolphin population along the coast had a greater amount of compliance than other groups of visitors.

We recommend that management focus resources first on weekend and holiday traffic, when both For Hire Company and Private Recreational Vessel traffic is highest. Dolphins were targeted more during weekends especially by Private Recreational Vessel traffic, who may not have been familiar with either the mandatory or voluntary regulations. Although one For Hire Company is fully endorsing and following the voluntary regulations, another For Hire Company and Private Recreational Vessels are not. If the management goal is to have no vessel interactions during the mid-day ‘rest period’, to allow the dolphin groups to truly have a rest, then more education is needed targeting the Private Recreational Vessels and more of an effort needs to be focused at getting all For Hire companies to participate in the vessel free time period. This would allow the dolphins time to truly rest, the activity seen most during this time of the day (Barr & Slooten 1999, Yin 1999).

This study indicates that overall voluntary measures can be a successful supplementary tool to mandatory regulations, and partially mitigate the potential for human disturbances. However, these voluntary measures require constant observations and encouragement so that they continue to be effective year after year.

CHAPTER III

ON-BOARD A FOR HIRE COMPANY'S CETACEAN TOURISM OPERATION IN KAIKOURA, NEW ZEALAND

Introduction

New Zealand's commercial cetacean tourism began in Kaikoura when it's first For Hire Company opened in 1987. A second For Hire Company was established shortly after in 1989. Since these early days, cetacean tourism in Kaikoura has rapidly increased, with more tourists, larger boats, and more employment opportunities every year (Barr & Slooten 1999, Hoyt 2001). Currently, helicopter and plane tours are also available for those wanting to see whales and dolphins from above. A third For Hire Company, which had begun business in the early 1990s, sold its cetacean tourism permit to one of the other For Hire companies in the late 1990s, resulting in the Kaikoura area having two For Hire companies conducting commercial cetacean tourism operations.

When swimming with dolphins first began, vessels were small and trips occurred relatively sporadically throughout the week, depending on demand. As For Hire Company operations have evolved in Kaikoura, the number of trips, length of trips and the overall experience for participants has also changed. Currently, both For Hire companies have agreed to a daily voluntary 'rest period', between 1130-1330 from 1 December to 31 March (DOC 1999). This voluntary 'rest period' was established as a result of research conducted by Barr and Slooten (1999) and Yin (1999) who found that dusky dolphins (*Lagenorhynchus obscurus*) spent most of their time resting during midday. Large numbers of vessels were found to be interacting with dusky dolphin groups in the Kaikoura area and this number appeared to be increasing annually (Barr & Slooten 1999).

In 1999, the Department of Conservation (DOC) put a 10-year moratorium on issuing more permits to swim-with or view dusky dolphins in the Kaikoura area. The moratorium was established to allow research into the human impacts on dusky dolphins and to determine if any harmful effects of these activities were evident in the dolphin population. In 2009, DOC must decide whether to grant new permits to waiting applicants or continue their moratorium on new permits for dolphin related tourism operations.

Through research conducted in 2005, the ‘rest period’ was found to reduce vessel traffic between Monday and Friday. One For Hire Company voluntarily structured their tours so they would not interact with dusky dolphin groups between 1130-1330; however, another For Hire Company was still seen visiting dusky dolphin groups during the ‘rest period’ (Duprey 2007, chapter 2). On weekends, overall higher levels of vessel traffic were observed compared to Monday-Friday observations (Duprey 2007, chapter 2).

During this study, a Kaikoura For Hire Company allowed researchers to accompany their swim-with-dolphins tours. Being on-board the vessels allowed for easy and accurate measurements of different segments of the tour. The number of swims, amount of time spent swimming, location of swims, and size of the group targeted for swims. Displacement between individual swims, dolphin group size and the number of boats in the area were also recorded. Our primary questions were trip lengths, number of times swimmers entered the water, total time spent swimming, and distance traveled between swims.

Methods

Research teams were on-board tour vessels during morning trips between 8-19 January and 12-30 April 2006; data were collected on a total of 34 tours. While on-board tour vessels, three different types of data were collected: swim data, GPS data, and dusky dolphin data.

Swim data

Swim data were collected on all tours. The number of swimmers on a tour was recorded, as was the start and end time of each tour (these were when the vessel passed the green buoy at the South Bay slipway). Swim attempts were defined as any time one or more swimmers entered the water to attempt to view and/or interact with dolphins. The start and end times for swim attempts were recorded including the maximum number of swimmers in the water at one time. Swim start times were when the first swimmer entered the water, swim end times were recorded when the last swimmer exited the water. The "swim period" for a tour was defined as the total time of a tour dedicated to swimming or attempting to swim with dolphins. It was measured from when the first swimmer entered the water on the first swim attempt to when the last swimmer exited the water on the last swim attempt. The "educational period" was measured from when the last swimmer exited the water on the last swim attempt to when the vessel left the dolphins and began traveling back towards the South Bay slipway.

GPS data

Latitude and longitude were recorded at the beginning of each swim attempt. The swimming segment of the tour ended when the skipper indicated for all participants to remove their snorkeling gear and wet-suits. Once swimming was complete, the location of the vessel was recorded at 5 minute intervals.

Dusky dolphin data

At the beginning of each swim attempt, the target dolphin group was categorized into one of 3 group sizes of <150, 150-500 or >500. Observations were made throughout the swim attempt to see if any calves were present. Calves were defined as small (less than one-half size of adult) dolphins continuously swimming close to an adult dolphin, and having "cork-like" abrupt surfacings (see Weir 2007).

Results

We accompanied 34 For Hire Company tours over 19 days. The tours were divided between January 2006, 21 tours over 11 days, and April 2006, 13 tours over 8 days. A total of 114 swim attempts were observed, 65 during January and 46 during April. During our research, the fewest number of swim attempts conducted on a single trip was 1 and the most was 7. The mean length of tours was 127.3 minutes (SE = 2.95), with January mean tour lengths not significantly different to those in April (Mann-Whitney U=115, df=34, p=0.445, Table 3-1). During 34 tours, swim attempts were made; however, on 2 tours (5.9%) there was no educational period due to poor weather conditions. The swim period was significantly longer than the educational period (Mann-Whitney U=384.0, df=66, p=0.04, Table 3-2).

Table 3-1. Mean length of all tours accompanied in 2006 and mean lengths of tours accompanied in January and April 2006. "n" is the number of tours used to calculate means.

Time of year	n	Mean tour length ± SE (in minutes)
All tours	34	127.3 ± 2.95
January	21	124.1 ± 4.18
April	13	132.5 ± 3.44

Time of year

Statistical analysis revealed no significant difference in Swim Period length in January compared to April 2006 (Mann-Whitney U=112.5, df=33, p=0.613, Table 3-2). The Educational Period was also found to have no significant statistical difference in length between January and April 2006 (Mann-Whitney U=121.0, df=33, p=0.852, Table 3-2). Although the mean number of swims conducted per tour was slightly lower in January compared to April (Table 3-3), this difference was not found to be significant (t-test, t=-0.799, df=32, p=0.465). The mean length of individual swims was not significantly different between January and April (t-test, t=0.781, df=109, p=0.433, Table 3-3).

Table 3-2. Mean Swim Period and Educational Period lengths (in minutes) for all tours, January tours and April tours.

	Swim Period length	Educational Period length
All tours	35.6 ± 1.49	29.3 ± 2.15
January	35.3 ± 1.84	28.6 ± 3.01
April	36.3 ± 2.64	30.5 ± 2.82

Table 3-3. Mean swim attempts (in min.) per tour and mean length of individual swim attempts for all tours, January tours and April tours in 2006.

Month	Mean swim attempts per tour (± SE)	Mean length of individual swim attempts (± SE)
All tours	3.26 ± 0.268	8.15 ± 0.581
January	3.10 ± 0.300	8.51 ± 0.797
April	3.54 ± 0.514	7.64 ± 0.841

During 17 tours, observations for calves were conducted, 15 (88.2%) tours had calves present during at least one swim attempt. Observations for calves were made during 58 swim attempts, 34 in January and 24 in April. During these 58 observations, 42 (72.4%) of them had calves around the vessel or swimmers. The presence of calves during swim attempts was slightly higher in January, 26 (76.47%) as compared to April, 16 (66.67%).

Of the 34 tours we accompanied, 5 (14.7%) conducted 1 swim attempt; the other 29 (85.3%) had 2 or more swim attempts. Using GPS data collected on 22 tours with more than 1 swim attempt, the distance between swim attempts was calculated. The mean total distance traveled during the Swim Period was higher in January; however, this difference is not statistically significant (t-test, t=1.019, df=20, p=0.320, Table 3-4). The mean distance traveled during the Swim Period indicates a large amount of travel required to remain with the group to make repeated swim attempts. This is reinforced by the median distance traveled between swim attempts for both January and April (Figure 3-1). The longest distance traveled between 2 swim attempts was 3.4 Km, indicating a high level of pursuit, and the shortest distance traveled between swim attempts was 43 m, indicating little pursuit or movement required between swim attempts.

Table 3-4. Mean total distance traveled during a tour's Swim Period for all tours, January tours and April tours 2006. n = number of tours, SE = standard error.

	n	Mean distance traveled during swim period (m) (± SE)
All samples	22	2178 ± 336.5
January	13	2463 ± 413.6
April	9	1766 ± 565.8

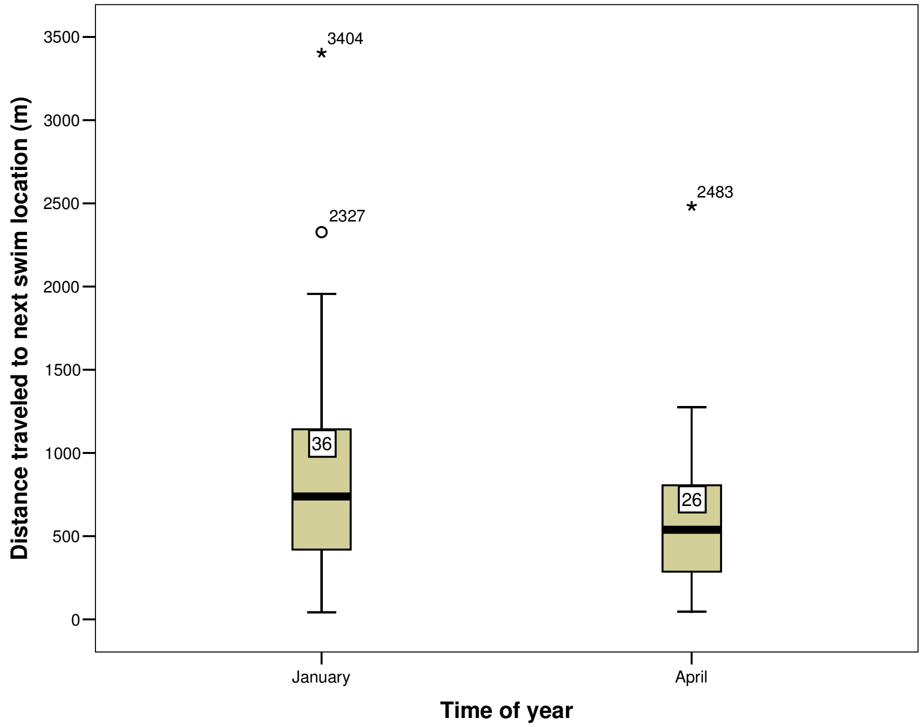

Figure 3-1. Distance traveled between swim attempts for January and April 2006. The * symbol indicates an extreme outlier and ○ symbol indicates an outlier. Medians are represented by a black line inside of the box, sample sizes inside the box indicate the number of inter-swim distances measured.

Group size influences

Group size data were collected on 18 tours and 67 swims. Of the three group size categories (<150, 150-500, and >500) the 150-500 dolphin category had the most swim attempts (table 10). During only 1 tour (5.6%), were swims attempted on a group of over 500 dolphins.

Table 3-5. Number of swim attempts targeting different group sizes and percentage of swims with calves present.

Group size	Number of swim attempts	Percentage of swims with calves present
<150	25	52.6 (n=19)
150-500	40	81.1 (n=37)
>500	2	100 (n=2)

When comparing tours targeting groups of <150 and 150-500, the number of swim attempts, total time spent in-water swimming, length of the Swim Period, and length of the Educational Period were not found to be statistically different (number of swim attempts, t-test t=-0.762, df=16, p=0.457; total time spent in-water t-test t=-0.337, df=16, p=0.740, Swim Period length, Mann-Whitney U=28.0, df=18, p=0.270; Educational Period, Mann-Whitney U=31.0, df=18, p=0.402). Calves were seen significantly less often during swims with groups of less than 150 dolphins (t-test t=-2.114, df=29.39, p=0.043, Table 3-5).

The mean total distance traveled over the course of a Swim Period was not statistically different between the <150 and 150-500 group sizes (Mann-Whitney U=18.0, df=14, p=0.439). This is a result of either small sample size or that group size may not affect the amount of travel required to stay with the dolphin group.

The GPS positions at the first swim attempt for each field day were plotted to investigate possible trends in locations of groups along the Kaikoura coast (Figure 3-2). Although a very small sample size, most dolphin groups were first swum with near the Goose Bay region.

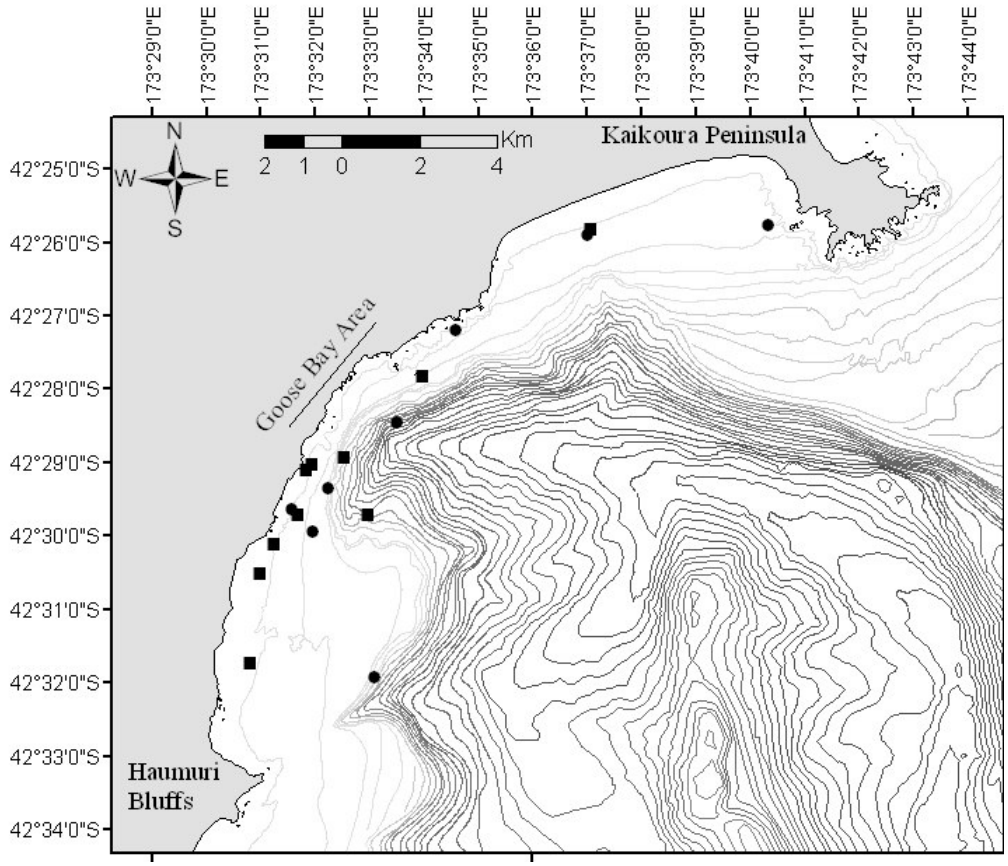

Figure 3-2. Locations of the first swim attempt during 18 tours. The 10 January tours are represented by a solid black square symbol and the 8 April tours are represented by a solid black circle symbol.

Discussion

A comparison between the data presented here and data collected by Markowitz (2004) between 1997-2003 shows close similarities. Markowitz (2004) accompanied 31 tours during this time, calculating a mean tour length of 127 minutes, virtually identical to our reported mean of 127.3 minutes. His reported mean 3.4 swim attempts per tour, and mean 8.3 minutes per individual swim attempt is again close to our mean 3.26 swims per tour and 8.15 minutes per swim attempt. Markowitz published his data in 2004, both to the For Hire Company and the Department of Conservation, indicating that a high percentage, 71.4%, of swim attempts taking place had calves present. It seems little has changed since these reported findings as our percentages are similar with 72.4% of all swim attempts having calves present. Overall, the structure of the tours (how long they swim for, tour length, etc.) has not changed much in the past 3 years.

Although the length of the Educational Period was shorter than the Swim Period, the Educational Period still made up an average of 22.8% of the tour. This also does not take into account any brief informative talks given while trying to locate the pods of dolphins. Having an educational component to the tour is required by the Department of Conservation and the For Hire Company in Kaikoura is fulfilling this obligation. When the weather is poor, the educational component is the first part of the tour to be shortened or eliminated. Of course, whether the tourists on-board these tours are actually retaining any of the information relayed to them is another question and deserves more attention considering the fantastic opportunity these tours give to disseminate information about whales, dolphins and the ocean (Orams 1997).

The large number of tours and individual swim attempts conducted with calves present in the target pod is of concern. The marine mammal protection regulations (1992) clearly state that swimming with non-adult dolphins is prohibited.

R20 special conditions applying to dolphins or seals --
(b) Persons may swim with dolphins and seals but not with juvenile dolphins or a pod of dolphins that includes juvenile dolphins.

Although it is generally accepted that the regulations should read calves, not juveniles, operations in Kaikoura are still regularly found breaking this part of the regulations both from our research and Markowitz's (2004) research. These regulations are no doubt in place to protect calves and mothers who are not as maneuverable or quick to avoid potential danger such as vessels, predators or swimmers. The addition of engine noise has the added drawback of potentially reducing predator detection by the calf and mother and increasing the calves' already heightened risk of predation. Dusky dolphins that are attracted to bow riding are usually described as playful and fulfilling a voluntary interaction. However, there is evidence from other locations of the negative effects human interactions can have on calves when their mothers leave natural behaviors to partake in other behaviors such as food partitioning and human interactions (Mann & Barnett 1999). This reduction in parental care has been suspected to increase calf mortality (Mann & Kemps 2003). Male and female dusky dolphins may avoid vessel interactions in different ways similar to bottlenose dolphins (Lusseau 2003) and killer whales (Williams et al. 2002). The potential for a negative effect on the reproductive success from the high number of vessel interactions with the dusky dolphin calf population should not be ignored. Constantine (2001) conducted research on the anthropogenic effects on bottlenose dolphins in the Bay of Islands; she found that dolphins accompanied by calves were not targeted for swim attempts. Why operations in Kaikoura are not pressured to avoid conducting swim attempts when calves are present is unknown.

There was no seasonal effect between our January and April tour data, and group size also had little effect on swim attempts, swim lengths, and overall Swim Period and Educational Period lengths. This study was small in sample size, so some of these differences could have been masked. A more dedicated study conducted over one or two years may be able to reveal some of the more subtle differences between seasons, and would greatly increase our understanding of seasonal interaction levels.

The proportion of swims with calves present in small groups was lower than the larger group sizes, and this may be indicative of smaller groups breaking off to interact with swimmers, while mothers with young calves continue on with the main part of the large group.

The distance traveled over a swim period was extensive; dolphin groups were followed for repeated swims over large distances. This may indicate dolphins attempting to avoid the vessels yet being pursued for more swims (Bejder et al. 1999). The distance covered between swims (median for both seasons were over 500 m) also strengthens the idea that groups are being followed over long distances for repeated swims.

Markowitz (2004) opined that little to no negative effects were evident from the dolphin watching industry in Kaikoura (citing Würsig et al. 1997 and Barr and Slooten 1999 as supporting this as well). I stay closer to what Würsig et al. (1997) and Barr and

Slooten (1999) actually report: a concern over increased commercial cetacean tourism activity and the need for continued study and monitoring of this successful industry. Cetacean tourism has become a successful and important industry for this small town. The health of the dusky dolphin population is not only important from a wildlife conservation context but also for Kaikoura's economy. Dolphin tours not only support a business that employs approximately 50 people, the economic benefits ripple through the community with restaurants, hotels and other tourist activities benefiting from the large number of people who come to town to swim with wild dolphins.

CHAPTER IV

DOLPHIN MOVEMENT PATTERNS AND HABITAT USE IN ADMIRALTY BAY, NEW ZEALAND

Introduction

Dusky dolphins have been studied for over 20 years off the coast of Kaikoura and we are beginning to understand more about their genetic make-up (Harlin 1999, Harlin et al. 2003), social behaviors (Cipriano 1992, Markowitz 2004), human-interactions (Barr 1997, Barr and Slooten 1999, Yin 1999, Duprey et al. 2005, chapter 2 and 3), mother-calf behaviors and distribution (Weir et al. 2005, Weir 2007), foraging strategies (Benoit-Bird et al. 2004) and acoustic communication (Au and Würsig 2004). One recent finding was that dusky dolphins photographed in Kaikoura were later re-photographed in the Marlborough Sounds. Currently, at least 41 individuals have been recognized as moving from Kaikoura to the Marlborough Sounds, more specifically to Admiralty Bay (Markowitz 2004, Weir 2007). It appears that dusky dolphins use Admiralty Bay differently than the Kaikoura region; they forage during the day and are found in smaller groups than off Kaikoura (McFadden 2003).

The Admiralty Bay region is used extensively for green-lipped mussel (*Perna canaliculus*) farming. Inner Admiralty Bay, defined as the area south of a line drawn from Clayface Point to Whangapoto Point (Fig 4-1), farms currently take up 0.85 km^2 (2.9%) of the 29.35 km^2 Bay. Several applications are outstanding for new farms in the Inner Admiralty Bay region and several new farms have been granted permits for other parts of Admiralty Bay. In fact the New Zealand Department of Conservation and Marlborough District Council have gone to court twice in the past three years to ascertain whether new farms may be legally constructed in Inner Admiralty Bay. The strongest evidence currently available for denying new permits for the Admiralty Bay region, especially Inner Admiralty Bay, is that dusky dolphins avoid foraging in the areas farms occupy

(Markowitz et al. 2004). Foraging was observed in 72% of the dusky dolphin groups using the Admiralty Bay region (Markowitz et al. 2003), working together in small groups to corral fish into tight bait balls so they can pick off individuals on the outside edges of the bait ball (McFadden 2003). Other delphinids are sporadically seen in the Admiralty Bay region, common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*), and orca (*Orcinus orca*); it is also possible that these dolphins could displace dusky dolphin groups, especially orca as they are known to attack dusky dolphins (Constantine et al. 1998).

We do not know of previous land-based studies of dolphins in the Admiralty Bay region. This study was designed to better understand how many dusky dolphin groups are seen in the bay at one time as well as throughout the day; previous boat-based research does not give accurate information on how many groups are in the area at any one time. Analysis focuses on the number of groups seen in the bay, where groups were found, and if different times of day or tidal phase affected how many groups and group size while in the bay.

Methods

Study area

Admiralty Bay is part of the Marlborough Sounds on the northern tip of the South Island, New Zealand. The bay is bordered by D'Urville Island on the north-west side, and the west-end of the Marlborough Sounds region on the south and east sides. Clayface Point was used as the observation station throughout the study; this site was ideal for a good view of Inner and Outer Admiralty Bay (Figure 4-1), but with best resolution within about 5 km of the Clayface Point station.

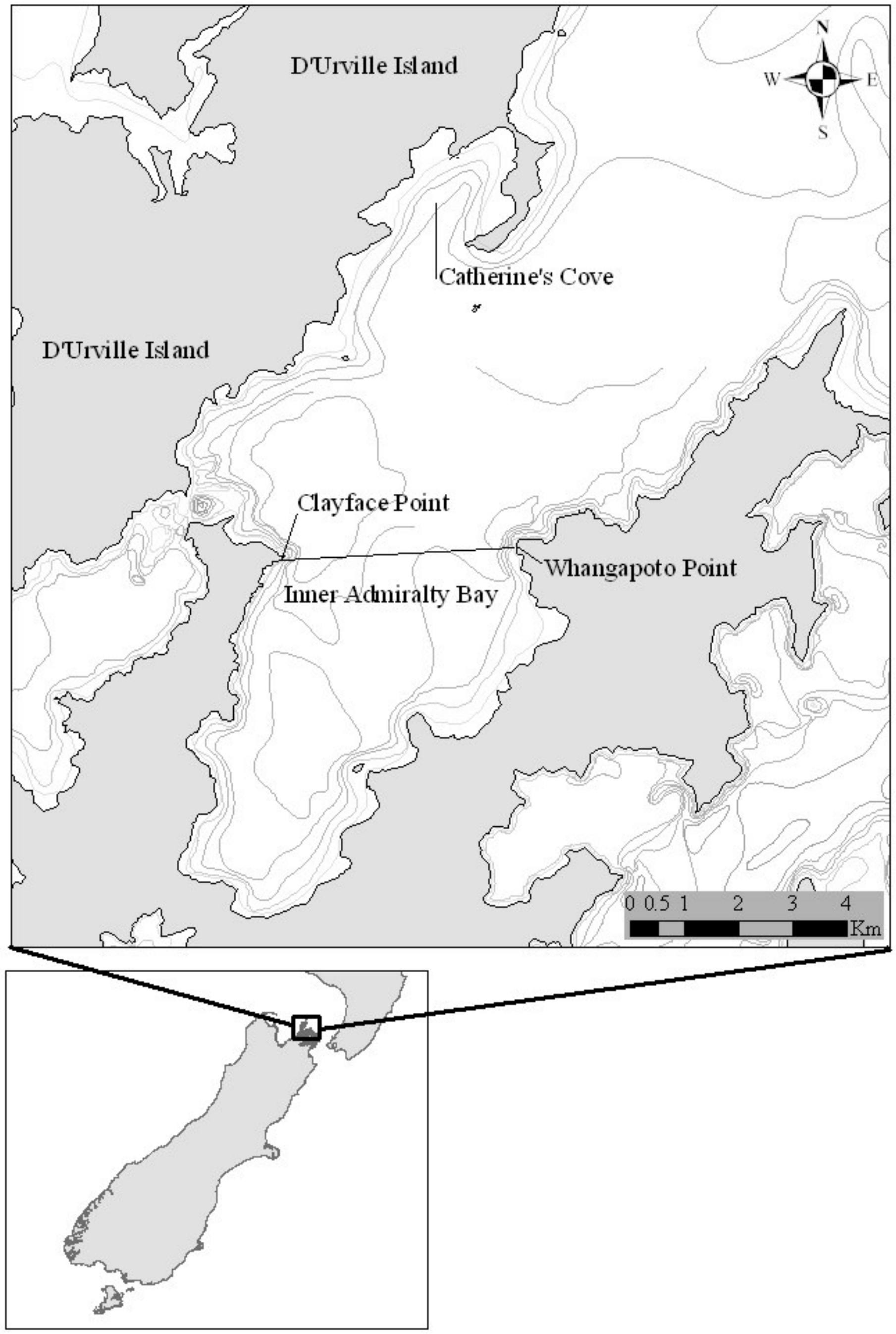

Figure 4-1. Map of Admiralty Bay, Marlborough Sounds. The line from Clayface point to Whangapoto Point is the boundary of Inner Admiralty Bay. Clayface Point was used as the observation point for all surveys.

Hourly scans

Three species of dolphin were seen in Admiralty Bay during the winter 2005 study--dusky dolphins (*Lagenorhynchus obscurus*), common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*). Data collection focused on dusky dolphins, with bottlenose dolphins recorded whenever they were seen in the area. As dolphins are constantly moving and are using a large area of the bay, we obtained positional information only when our protocol required it; therefore, dolphins also may be using other areas than those reported here.

Between 9 June and 22 July, 2005, surveyor's transit or theodolite surveys (*sensu* Würsig et al. 1991) were conducted from an observation station at Clayface Point (S 40.93°, E 173.85°). After leveling, the theodolite was zeroed horizontally by aligning the cross-hairs in the monocular to an electrical pole on the French Pass road, our horizontal reference point for the study (S 40.94°, E 173.84°).

Tides were calculated from NIWA's predicted tide charts for Elmslie Bay (town of French Pass). These tides were then corrected for error based on visual observations of a tide stake mounted on the Elmslie Bay jetty. Over 5 days and 31 hours of tidal observations were used to calibrate the predicted tides, with observed high tides between 1.3m and 1.6m lower than the predicted levels. The corrected tides were used in the calculations of positions.

The height of Clayface Point Station was calculated using a total station similar to methods described in Würsig et al. (1991) and Bailey and Lusseau (2004). On July 22, 2005, measurements were taken from the Clayface Point Station to a position at the base of the cliff at the water's edge, concurrent with a "total station" with accurate laser rangefinder. Using the recorded time, very accurate tides were obtained from observation of the tide stake on the Elmslie Bay jetty. Average station height was calibrated as 59.15 m for mean low water.

Hourly scans of Admiralty Bay were conducted to obtain a positional location of all groups seen in the Admiralty Bay region. Scans were started on the hour (beginning at the southwest corner of Inner Admiralty Bay); binoculars were used to sweep from west to east. Scans continued from west to east, then east to west, in a northward direction until the inner part of Admiralty Bay was completely scanned. Scans continued into the outer Admiralty Bay from east to west, and west to east again, moving in a northward direction. Whenever a group of dolphins was spotted, a theodolite position (or "fix") was taken of the center of the group, and group size and the group's instantaneous behavior were recorded. Each group was given a number along with its scan number (e.g. for the first scan of the day group 1 was Scan 1-1, groups 2 was Scan 1-2, etc.). Scans were only conducted in Beaufort sea-states of less than 3 and when visibility allowed for sighting in our study area. Rain, strong winds, and intense glare resulted in the termination of data collection.

The behavior of each group of dolphins was designated at the time a positional fix was recorded. Six different behaviors were defined for dolphins: travel, fast travel, foraging I, foraging II, rest, and social (Table 4-1).

Table 4-1. General group ethogram of dolphin behaviors seen from theodolite station in the Admiralty Bay region.

Behavior	Definition
Travel	Group moving at a slow to moderate pace, all together as a group
Fast travel	Group moving at a fast pace, together as a group, with slicing or porpoising
Foraging I	Group with long surfacing intervals and when head first re-entry leaps or half leaps observed in concert with long surfacing intervals
Foraging II	Group has short surfacing intervals and more surface foraging behaviors, including half-dives, quick directional changes at the surface, and chasing (assumed from slicing water, quick directional changes, and short surface intervals)
Rest	Group moving slowly close together with slow surfacing (dorsal fin is seen at the surface longer than other behaviors)
Social	Group performing noisy displays, spy-hopping, rolling over each other, or belly-to-belly swimming

Results

During 14 field days collecting scan data, a total of 68 scans were conducted with a mean number of scans per day of 4.86 (SE = 0.51, high= 8, low=1). A total of 341 groups were spotted during the scans, with a mean of 5.01 groups/scan (SE = 0.46, high= 17, low=0).

Errors for positional fixes were estimated from land markings fixed at different times during the study. The estimated error was ± 108.4m to the east side of Stewart Island (approximately 5,900-6,000m from Clayface Point Station), ± 60.1m to the east side of Anatakapu Island (approximately 3,900m from Clayface Point Station), and ± 71.1m to the south end of Hamilton Island (Karaka Island) (4,200m from Clayface Point Station).

Dusky dolphins (DD)

During the scans, a total of 332 groups of dusky dolphins were seen in Inner and Outer Admiralty Bay (Table 4-2 for mean groups/scan). Figure 4-2 shows all groups of dusky dolphins seen during the 68 scans. Only 2 of the 332 groups of dusky dolphins were seen inside a mussel farm during the scans; these were on 7 July, Scan 4-01 and 7 July, Scan 4-03. During 11 of the 68 scans (16.2%), no dusky dolphin groups were seen in the bay, six of these scans occurred when bottlenose dolphins had been spotted in the bay during that day. Group sizes ranged from 2 to 40 in the 332 groups of dusky dolphins seen during scans (Table 4-3), but 279 of the groups observed during scans (84.0%) were equal to or fewer than 10 individuals.

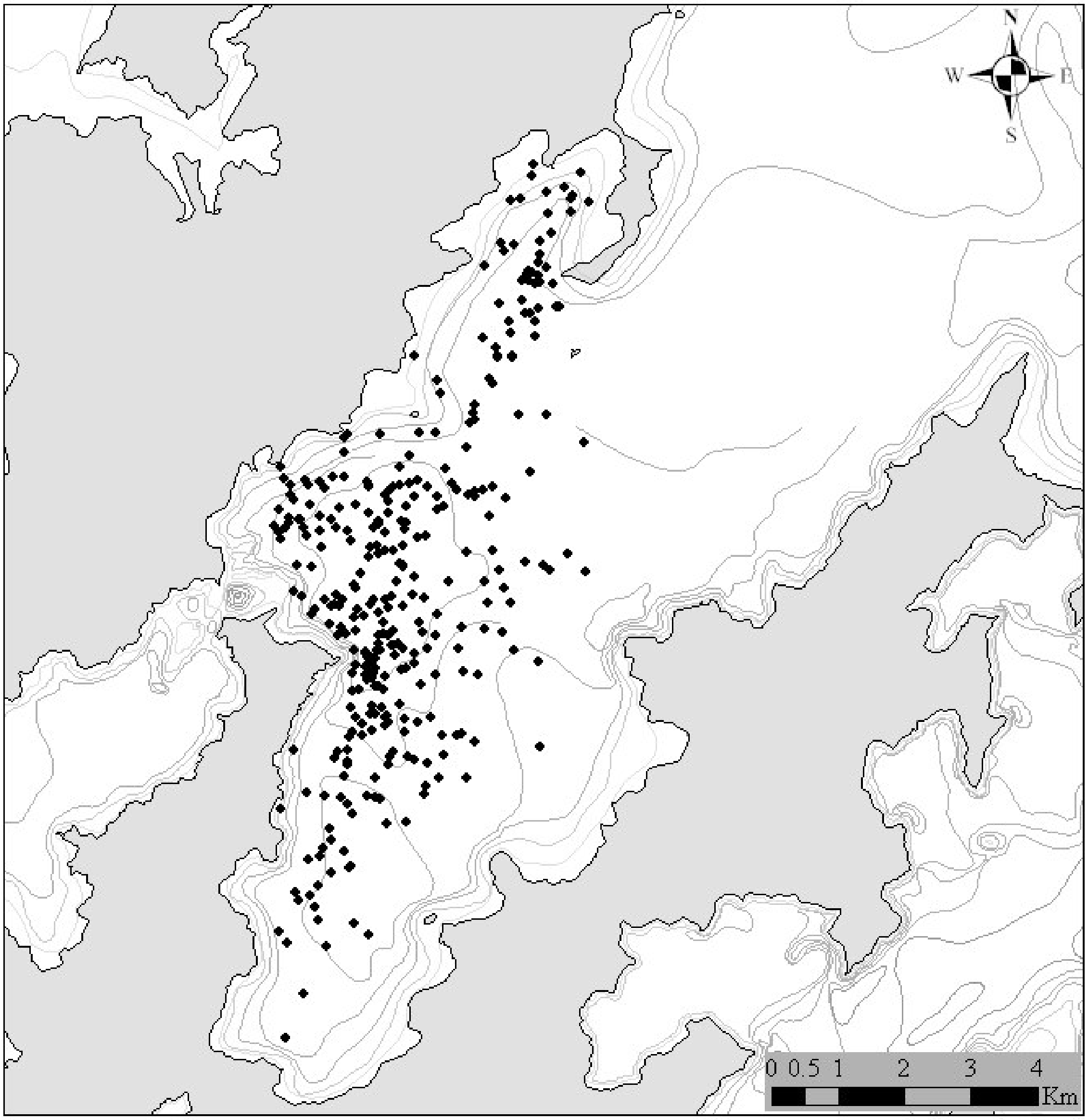

Figure 4-2. Locations of the 332 groups of dusky dolphins seen during the 68 hourly scans.

Table 4-2. Mean number of groups observed during scans for dusky and bottlenose dolphins.

Species	Mean groups/scan	SE	High	Low
Dusky dolphin	4.88	0.470	17	0
Bottlenose dolphin	0.13	0.046	2	0
All species	5.03	0.460	17	0

Table 4-3. Mean group size observed in dusky and bottlenose dolphin groups.

Species	Mean group size	SE	High	Low
Dusky dolphin	7.27	0.316	40	2
Bottlenose dolphin	29.11	7.635	60	6

Four daylight periods were used to compare time of day to the number and size of dolphin groups using Admiralty Bay. The four daylight periods were 8:00-10:00, 10:00-12:00, 12:00-14:00 and 14:00-16:00. The 12:00-14:00 daylight period had the highest mean number of groups seen per scan while the early daylight period 8:00-10:00 had the lowest mean number of groups seen per scan (Table 4-4). Positions of dusky dolphin groups were also separated into daylight periods (Figure 4-3). The 8:00-10:00 and 10:00-12:00 daylight periods had higher percentages of groups seen inside Inner Admiralty Bay. The mean number of groups seen per scan was not significantly different between different daylight periods (Kruskal-Wallis X^2=1.808, df=3, 66, p=0.613). Mean group size between different daylight periods (Table 4-5) was also not significantly different (Kruskal-Wallis X^2= 5.947, df=3, 332, p=0.114).

Table 4-4. Mean number of dusky dolphin groups observed per scan for different daylight periods.

Daylight period	Mean (groups/scan)	SE	Scans conducted	Number of groups seen
08:00-10:00	3.88	1.481	8	31
10:00-12:00	4.96	0.965	23	114
12:00-14:00	5.79	0.775	19	110
14:00-16:00	4.56	0.821	16	73

Table 4-5. Dusky dolphin mean group size observed during scans conducted during the four daylight periods.

Daylight period	Mean group size	SE	Scans conducted	Number of groups seen
08:00-10:00	6.52	1.421	8	31
10:00-12:00	6.80	0.422	23	114
12:00-14:00	7.67	0.536	19	110
14:00-16:00	7.79	0.786	16	73

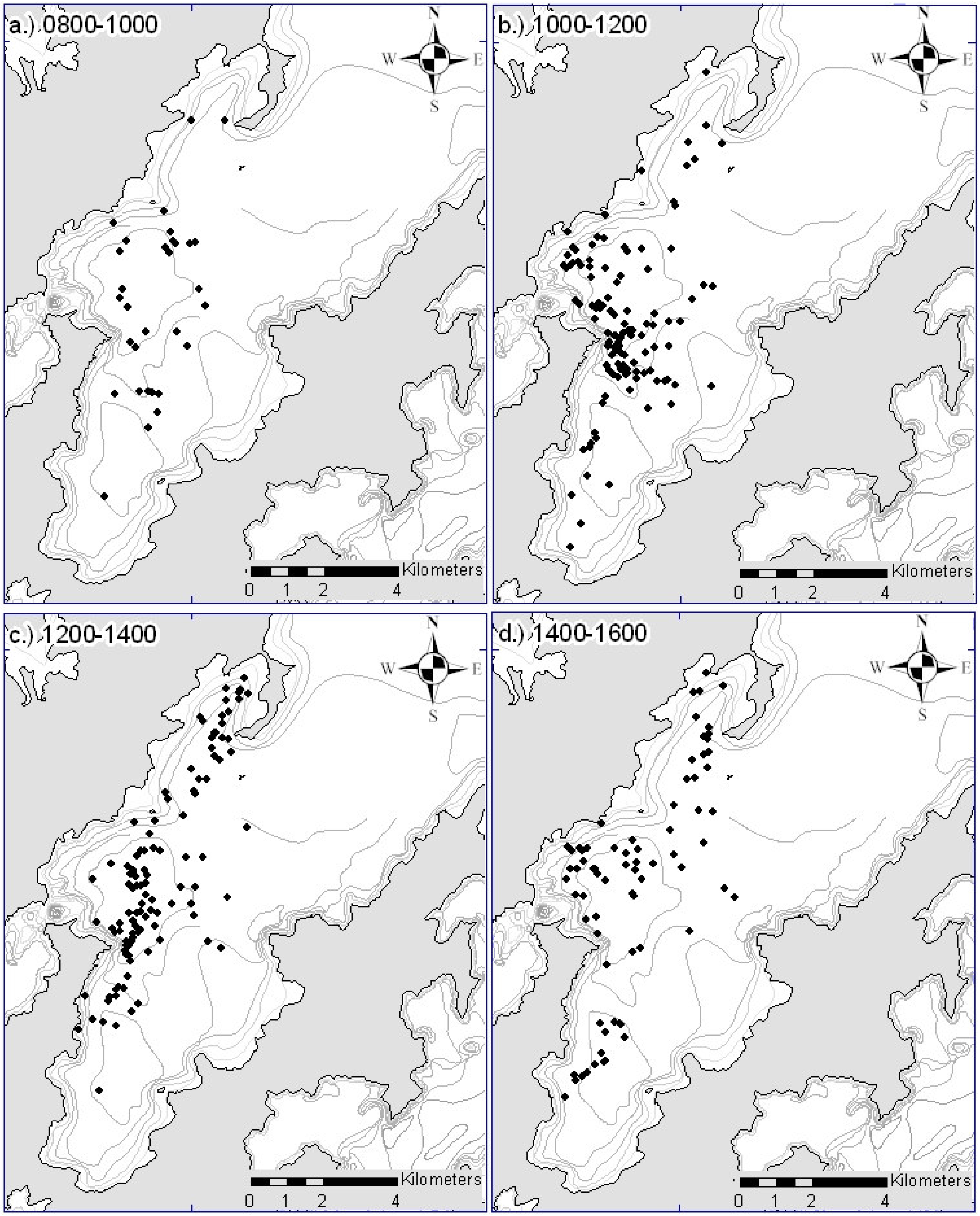

Figure 4-3. Dusky dolphin group presence in Admiralty Bay by daylight period.

Dusky dolphin presence was also divided into one of four tidal states; the tidal cycling of low tide to high tide and back to low tide was divided into 4 states. Low tide rising to mid tide (LMR), mid tide rising to high tide (MHR), high tide lowering to mid tide (HML) and mid tide lowering to low tide (MLL) were the four tidal states used for analysis (Figure 4-4). As scans were started at the beginning of every hour and the times of each tidal state changed everyday, there was a potential for some groups seen during a scan to be in one tidal state and other groups seen later that scan to be in another tidal state. This occurred only once, on 7 July, during the 1300 scan. The scan began in the LMR tidal state; however, the last two groups were seen 2 minutes into MHR. For analysis, these last two groups were included in LMR. During the LMR tidal state, groups were spread from Inner Admiralty Bay northeastwards into Catherine's Cove, and with a high concentration in front of French Pass. The MHR tidal state also had dolphin groups spread between Inner Admiralty Bay and Catherine's Cove. During both the HML and MLL tidal states, when currents are flowing out of Admiralty Bay through French Pass, high concentrations of groups were seen near French Pass and the western entrance into Inner Admiralty Bay.

The mean number of groups observed per scan was lowest during the MHR tidal state; however, the mean number of dusky dolphin groups seen per scan by tidal state was not significantly different (Kruskal-Wallis X^2=2.684, df=3,68, p=0.433, Table 4-6). Mean group sizes were also not significantly different between tidal states (Kuskal-Wallis, X^2= 7.182, df=3, 332, p=0.066); however, there is an indication that mean group sizes may be getting smaller during the MHR tidal state.

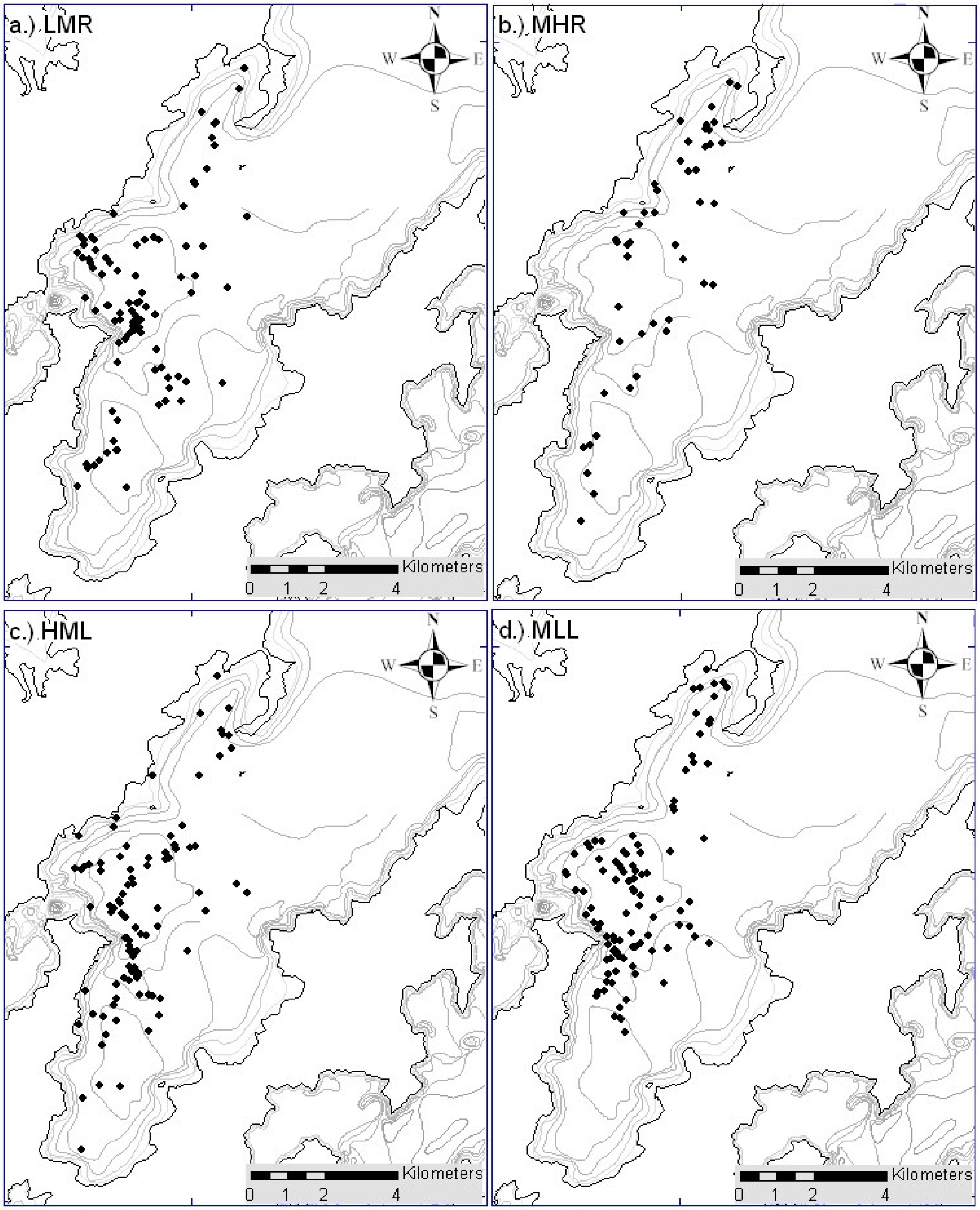

Figure 4-4. Dusky dolphin groups presence in Admiralty Bay by tidal state. LMR = rising tide from low tide to mid tide, MHR = rising tide from mid tide to high tide, HML = lowering tide from high tide to mid tide, and MLL = lowering tide from mid tide to low tide.

Table 4-6. Mean number of dusky dolphin groups seen during scans for four different tidal states.

Tidal State	Scans conducted	Number of groups seen	Mean groups per scan	Mean group size
LMR	20	92	4.60 ± 0.816	7.58 ± 0.526
MHR	13	45	3.46 ± 0.998	6.02 ± 0.802
HML	16	92	5.75 ± 0.951	7.39 ± 0.839
MLL	19	103	5.42 ± 0.989	7.44 ± 0.608

Fast travel was merged with travel for analysis as there were few sightings during scans of groups fast traveling. The behaviors of groups seen during scans were dominated by foraging (194 observations or 58.4%), divided into foraging I and foraging II (Table 4-7).

Table 4-7. Instantaneous behaviors of dolphin groups seen during scans. Sample sizes are 332 groups of dusky dolphins and 9 groups of bottlenose dolphins.

Species	Travel and fast travel	Foraging I	Foraging II	Rest	Socialize
Dusky dolphin	101	127	67	32	5
Bottlenose dolphin	5	0	0	2	2

On 7 July 2005, a large group of bottlenose dolphins entered the eastern side of Inner Admiralty Bay close to Whangapoto Point. During this time, a group of dusky dolphins was seen fast traveling close to shore on the western side of Hamilton Bay. This group of dusky dolphins moved in a westward direction towards Elsie Bay until out of sight. As the bottlenose dolphin group moved southwards deeper into Inner Admiralty Bay approaching Hamilton Bay, we saw two groups of dusky dolphins traveling very close to

the western shore of Inner Admiralty Bay. We observed these two groups, seen during scans as 7 July, Scan 4-01 and 7 July, Scan 4-03, traveling through several mussel farms as they made their way out of Inner Admiralty Bay. Very little time was spent inside the mussel farms as the groups were tight together and quickly moving out of the inner portion of the bay.

Bottlenose dolphins (BD)

During the 68 scans, a total of 9 groups of bottlenose dolphins were recorded in Inner and Outer Admiralty Bay (see Table 4-2 for mean groups/scan). Figure 4-5 shows the position of all 9 sightings of bottlenose dolphins during scanning. Overall, bottlenose dolphins were seen from Clayface Point Station on 3 days; 19 June, 23 June, and 7 July. Bottlenose dolphins were not seen entering mussel farms at any time we were tracking them.

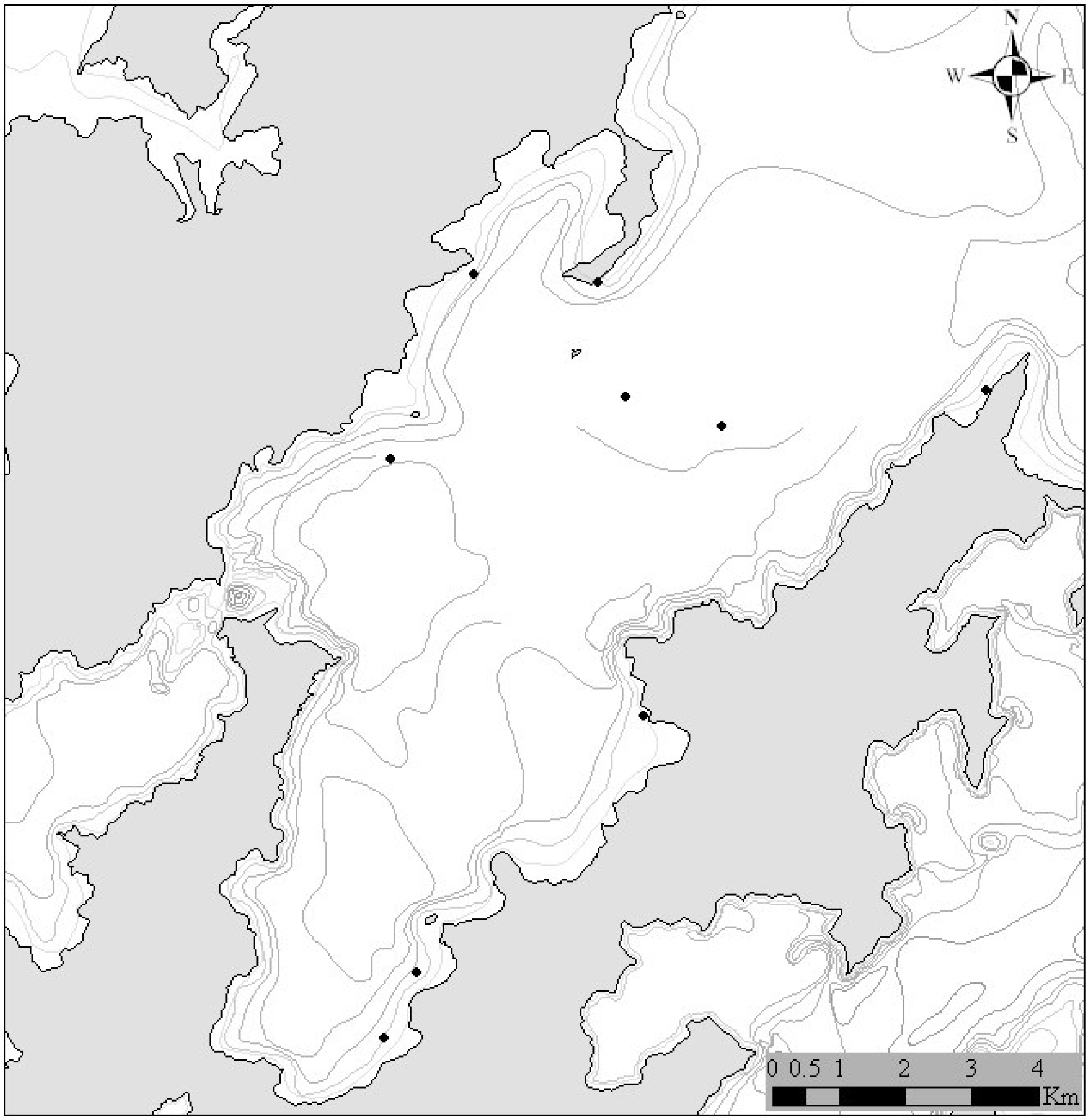

Figure 4-5. Location of the 9 groups of bottlenose dolphins seen during the 68 hourly scans.

Discussion

Our shore-based work agrees with boat-based findings of Markowitz et al. (2004) that the Admiralty Bay region supports a large number of dolphins in winter. Large numbers of dusky dolphin groups were seen throughout this study, and the number of groups seen per scan was fairly consistent throughout the day. This, along with few scans resulting in no dusky dolphins being sighted, is interesting as it may indicate that dusky dolphins are using Admiralty Bay somewhat regularly throughout the day in winter. Over half of the scans resulting in no dusky dolphins being sighted were when bottlenose dolphins were in the bay; this could be an indication that bottlenose dolphins are displacing dusky dolphins. Comparisons of how these two species use Admiralty Bay indicates bottlenose dolphins simply move through the area whereas dusky dolphins use the area mainly for foraging (Weir et al. 2006). The possibility of competitive exclusion of dusky dolphins by bottlenose dolphins remains to be investigated more fully.

Tidal fluctuations are assumed to be a potential factor in how dolphins choose their habitat or where they are found. Although tidal state does not seem to be having an effect on the number of groups or size of groups we are seeing in the Admiralty Bay region, it may be having some effect on the location of groups in the bay. Further analysis of this data combined with other positional data collected in Admiralty Bay may produce positional patterns relative to tidal state or daylight period. It is possible that dusky dolphins use tides relative to finding and securing fish prey, but this has not yet been investigated.

From the cliff top, we essentially produced “snap shots” of dolphin distribution and behavior in the area. From this perspective, we were able to produce a much more accurate estimate of the overall “big picture” of habitat use within about 5 km of Clayface Point. The large numbers of groups seen from the observation station, using all areas of Admiralty Bay, indicates the importance of the entire bay. As the distance from the station increased, our ability to see and reliably track groups is reduced. While previous research has highlighted the importance of Inner Admiralty Bay as foraging habitat for dusky dolphins (Markowitz et al. 2004), we argue that the nearby and intricately connected areas of Outer Admiralty Bay, Catherine's Cove and French Pass, are also important areas for dusky dolphins. Further study of how dolphins are herding prey could lend insight into how tidal flows or currents are helping or hindering foraging success.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

New Zealand's dusky dolphins are under pressure from tourism off Kaikoura and habitat loss due to increasing aquaculture in Admiralty Bay. In chapter II, I was able to identify the levels and types of boat traffic that interact with the large dusky dolphin groups on a daily basis off Kaikoura. Specifically, I was able to highlight some successes of the voluntary 'rest period'. There was a reduction in visits, yet not an elimination of visits, during this time. In the third chapter of my thesis I concentrated on the activities of a For Hire Company's tours and was able to determine that tours are very similar to those conducted between 1997–2004. The issue of greatest concern regarding the tours was the continuation of tourist swims when calves were present in the group. In the last chapter of my thesis, I showed that dusky dolphins are seen throughout the Admiralty Bay region with no significant differences in the number of groups or sizes of groups observed during different daylight or tidal periods.

In Kaikoura, levels of tourism are continuing to increase and the industry will most likely continue to grow into the future. Even with the 1999 moratorium on new cetacean tourism permits, the high number and consistency of human interactions with dusky dolphins is concerning. If private recreational vessel traffic increases, this would continue to elevate the number of vessel interactions occurring in the area. Kaikoura has been actively working to increase its tourism levels to increase the economic opportunities for local residents. Local New Zealanders also find Kaikoura an appealing summer home and vacation destination. This trend will likely increase the number of private recreational boaters in the area. Combining this with the knowledge that one of the local For Hire companies is not complying with the current voluntary 'rest period' raises concerns about whether new For Hire companies in the area would also fail to comply with these voluntary regulations. However, it is encouraging that the other For Hire Company has continued to participant in observing the 'rest period' and eliminated their interactions with dusky dolphins during this time. The reduced amount of traffic around the dolphin groups can only be viewed positively.

I believe that the current amount of vessel traffic in the Kaikoura area is high and that increasing traffic by including new commercial operators could be harmful to the dusky dolphin population. It is important to remember that dusky dolphins near Kaikoura are socializing and resting during the day because they spend their nights foraging on the deep scattering layer (DSL). A disturbance to the population during daylight hours may be considered equivalent to disturbing diurnal animals at night while they are resting. Parts of the marine mammal protection regulations are already being violated. Examples of such violations are the number of vessels within 300m (Barr and Slooten 1999) and swimming with calves (Markowitz 2004, Duprey chapter 2). Without an increased presence of Department of Conservation staff that could enforce the regulation, I see that increasing the number of permits in the Kaikoura area would only exacerbate these problems.

On the North Island, tour operators taking tourists to swim with bottlenose dolphins change their tours to “view only” when calves are noted in the group, and perhaps this is a strategy that needs to be further considered off Kaikoura.

My preliminary analysis of habitat use by dusky dolphins in Admiralty Bay indicated that neither group size nor the number of groups in the area were affected by time of day or tidal cycle. Working with colleagues and incorporating a larger data set, I hope to see how these daily as well as tidal cycles affect where in the bay groups are located. As for considering new green-lipped mussel farms for the area, I believe that Admiralty Bay is too active as a dolphin foraging ground to remove more habitat for use by the mussel farm industry. There are many other locations in the Marlborough Sounds that experience far less dolphin traffic than Admiralty Bay (Markowitz 2004), and I believe that these areas should be considered as mussel farm sites before potentially critical foraging habitat is taken away from dusky dolphins. As a relatively recent research site, we know very little about the dusky dolphins using Admiralty Bay, information about where they go at night, where they travel to after foraging in Admiralty Bay, and how much time they spend in the area. Research has shown that dolphins photographed in the

Kaikoura area have also been photographed in the Admiralty Bay area, so some individuals do travel between the two sites. What we still do not know is how long it takes them to travel between the two sites, if they travel directly to Admiralty Bay or perhaps Admiralty Bay is only one of many locations where they spend part of their year. Without understanding how important Admiralty Bay actually is to the fitness of the dusky dolphin population, it would be unwise to further alter their habitat.

The movement of at least some dusky dolphins between Kaikoura and Admiralty Bay (Markowitz 2004, Weir 2007) leads to a potential of having the effects of these human impacts and habitat manipulations building on one another. There is currently no way of knowing how stresses occurring in one environment might change an animal's reaction to stresses found in another environment. For example, we cannot currently predict how increasing tourism in Kaikoura might affect the number of individual dolphins traveling to Admiralty Bay or how removing more foraging habitat in Admiralty Bay may change the reaction and behaviors of dolphins in Kaikoura.

Dusky dolphins are an economically valuable resource to Kaikoura. Through continued monitoring, communication between stakeholders and adoption of the precautionary principle, dusky dolphins will continue to be a valuable resource for current and future generations.

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APPENDIX A

GLOSSARY OF TERMS

To avoid confusion and misinterpretation of terms the following list gives definitions of terms used throughout this thesis. Any reference to the following terms in the text uses these definitions as their meaning.

Aircraft. Includes both small fixed wing airplanes and helicopters.

DOC. New Zealand Department of Conservation. The government department charged with managing cetacean populations, granting commercial cetacean tourism permits (For Hire Company permits) and enforcing the marine mammal protection regulations.

Commercial Fishing Vessel. Vessels who have permits/quotas to use nets, pots and lines to catch fish to re-sell to fish vendors or the public.

Educational Period. The period of time after swimming is complete on For Hire Company tours until the vessel begins heading back to the South Bay Ramp.

For Hire Company. A company in possession of a permit from the New Zealand Department of Conservation allowing them to accept payment from customers to go out and see or swim with wild cetaceans.

Non-rest period. Any time outside of the voluntary rest period (1130-1330 daily).

Private Recreational Vessel. This is a privately owned recreational vessel, usually small, less than 8m. These vessels are using the marine area around Kaikoura for fishing, touring, cetacean watching, joyriding or some other recreational activity.

Research Vessel. We knew of only one vessel in the area conducting research at the time of this study, therefore any reference to a research vessel indicates *Punua Aihe* a small 5,5 m rigid hull inflatable.

Rest period. A voluntary regulation developed by the Department of Conservation and the local For Hire companies. The regulation was put in place to reduce vessel disturbance while dusky dolphins are resting. From 1 December to 31 March, two For Hire companies (#1 and #2) have agreed to avoid visiting dusky dolphins between 1130–1330. Private Recreational Vessels are also encouraged to comply,

Swim attempt. Used to describe swim activity on-board For Hire Company vessels. A swim attempt was defined as one or more swimmers entering the water. Swim attempts were timed from when the first swimmer entered the water to when the last swimmer exited the water.

Swim period. The period of time when swim attempts were being made. The swim period lasted from when the first swimmer entered the water on the first swim to when the last swimmer exited the water on the last swim attempt.

Tour. A For Hire Company excursion to view and/or swim with wild dusky dolphins. Tours were conducted on vessels carrying up to approximately 30 passengers, with no more than 13 swimmers permitted to be in the water at one time.

Vessel. Any man-made object used to carry people on or above water. Examples boats, planes, helicopters, kayaks, surfers or jetskis.

Visit. The approach of a vessel within 400 m of the outside edge of a group of dolphins. The vessel may be traveling, viewing, fishing, attempting to swim with the dolphins or any combination of these behaviors.

VITA

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