Cetacean sightings off the Fiordland coastline

Analysis of commercial marine mammal viewing data 1996–99

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ABSTRACT

From 1996 to 1999, 1422 sightings of cetaceans were recorded by observers on tour boats in the fiords and off the coast of Fiordland. These were compiled by the New Zealand Department of Conservation. Only 2.9% of the sightings were collected outside of Milford and Doubtful Sounds since most of the sampling effort was concentrated in these two fiords. In addition to species identification, group size and location were also recorded. Nine species were identified: bottlenose dolphin (*Tursiops* sp.), dusky dolphin (*Lagenorhynchus obscurus*), common dolphin (*Delphinus* sp.), long-finned pilot whale (*Globicephala malaena edwardi*), orca (*Orcinus orca*), humpback whale (*Megaptera novaeangliae*), southern right whale (*Eubalaena australis*), minke whale (*Balaenoptera acutorostrata*) and sperm whale (*Physeter catodon*). These are the first official records of long-finned pilot whale and minke whale in the region. Bottlenose dolphins were the most commonly observed species in all areas (87.8% of all sightings), followed by dusky dolphins (10.3%). Along the coastline outside the fiords, bottlenose dolphins were also the predominant species (48.1% of sightings, n = 27), followed again by dusky dolphin (33.3%). Observations from this sighting network were compared with studies, which used standard sampling techniques, undertaken in the area. Spatial and temporal variations in tour operator sightings were accurate and reliable. Estimates of dolphin group size were accurate up to 25 individuals. If the group was larger than 25 animals, its size was overestimated by tour operators. Species distribution at a large scale (Fiordland coastline) and small scale (within Doubtful and Milford Sounds) is discussed. Temporal variations in distribution and group size were also assessed; observer bias was taken into consideration.

Keywords: cetaceans, bottlenose dolphin, dusky dolphin, common dolphin, long-finned pilot whale, orca, humpback whale, southern right whale, minke whale, sperm whale, sightings, abundance estimates, Fiordland, New Zealand.

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1. Introduction

To better manage the natural resources of Fiordland, it is important to understand the distribution of cetaceans (dolphins and whales) in space and time. There are two reasons for this. First, cetaceans have a key position in marine and coastal ecosystems. Secondly, they play a key role in tourism in this area. The trophic level of most cetacean species ranges from meso- to top predator (Pauly et al. 1998). The role of large mammals, especially top predators, in the regulation of entire ecosystems has been thoroughly discussed in the literature (see Terborgh et al. 1999 for a review). This role has led many researchers to consider the potential use of large mammals in the design of regional reserve networks (Terborgh et al. 1999). The role of top predator in ecosystem stability has often been described as a 'top-down regulation' (Terborgh et al. 1999; Brett & Goldman 1997). Under this concept, species occupying the highest trophic level (top predators) exert a controlling influence on species at the next level (prey) and so on throughout the food web. As a consequence it has been concluded that the removal of a top predator can result in ecosystem instability (Paine 1966; Estes et al. 1989). Therefore it is important to determine whether human developments, including tourism activities, interfere with the population ecology and resource utilisation of predators such as dolphins and whales, because such interference has implications for the stability and health of the ecosystem. Basic parameters, such as species distribution and group size, are useful indicators of species ecology and can easily be recorded by keen observers with minimum training.

Little information is available on the biology and ecology of marine mammals utilising Fiordland waters. Most of the present knowledge has been gathered recently (in the 1990s) and is concentrated on one species (the bottlenose dolphin) in one fiord (Doubtful Sound) (Williams et al. 1993, Schneider 1999). People utilising the fiord system (fishers, tour operators, and other boaters) are a potentially valuable source of information on the past and present status of marine mammals in this area and their expertise can be a source of basic information on the ecology of these species in this location.

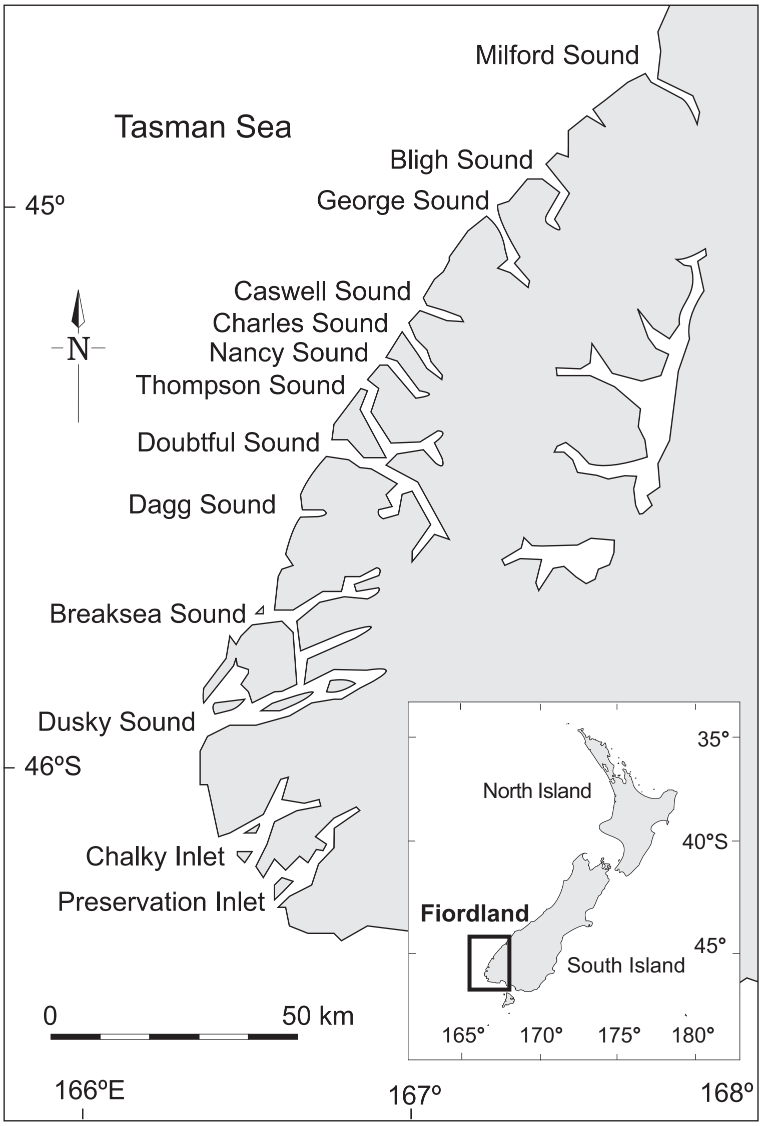
Webb (1973) described the species he encountered during an observation cruise aboard the Japanese longliner, *Lloret Lopez II*, in autumn 1970. From his account and other anecdotal data the following species are known to utilise Fiordland waters:

- bottlenose dolphin (*Tursiops truncatus*)
- dusky dolphin (*Lagenorhynchus obscurus*)
- common dolphin (*Delphinus* sp.)
- orca (*Orcinus orca*)
- sperm whale (*Physeter catodon*)
- humpback whale (*Megaptera novaeangliae*)
- southern right whale (*Eubalaena australis*)

Even though we have some understanding of the species that can be encountered in this area, we still lack information on their use of this unique habitat.

Fiordland extends from Milford Sound in the North to Preservation Inlet in the South (Fig. 1). The terrestrial portion of the area comprises Fiordland National Park, covering a land area of 12 524 km^2. The fiord complex is composed of 14 fiords. The main oceanographic feature of fiords is the presence of a low-salinity layer topping the marine stratum. The presence of this layer depends on several variables, particularly reduced water exchange with the ocean due to bathymetric conditions, and abundant rainfall. Fiordland is one of the wettest places on Earth. Annual rainfall on Wilmot Pass (Doubtful Sound) is more than 6700 mm (Stanton & Pickard 1981). The extremely steep topography of the glacier-formed valleys funnels most of this rain directly into the fiords. Being less dense than oceanic water, this accumulating freshwater floats on top of the oceanic water layer because of the reduced mixing effect inside the fiords (Gibbs et al. 2000). While flowing through the forested landscape, it dissolves a large amount of tannins, and the resulting tannin-stained low-salinity layer substantially reduces the amount of light penetrating the marine stratum. Because of the lack of light, species commonly found beyond the continental shelf are found at shallow depths in Fiordland waters. The low-salinity layer may also cause physiological stress on marine species such as cetaceans (Wilson et al. 1999).

Figure 1. Map of Fiordland, New Zealand.



From 1996 to 1999, companies operating tours in Fiordland recorded sightings of cetaceans for the New Zealand Department of Conservation. Most of the effort was concentrated in Milford and Doubtful Sounds (Figs 2 and 3), where cruises were undertaken on a daily basis. This report compiles these sighting records and assesses the efficiency of the sighting network by comparing these results with the long-term monitoring of bottlenose dolphins in Doubtful Sound carried out by the New Zealand Whale and Dolphin Trust. These three first years of the sighting network in Fiordland represent a preliminary test of what data can be reliably collected by casual observers.

Volunteer sighting networks have been recognised as useful to collect data on the distribution of various species at a large scale. One of the most famous networks (North American Breeding Bird Survey) established by the US Fish and Wildlife Services has permitted the monitoring of bird populations nationwide in the United States of America since 1966 (Boulinier et al. 2001, Link & Sauer 1998). Another network established in England allows the nationwide monitoring of badger populations (Moore et al. 1999, Ostler & Roper 1998). In both of these cases the networks allow for the collection of accurate data to a scale (spatial and temporal) that is not practical for most scientific studies because of their cost/benefit efficiency.

The goal of this report is to assess spatial and temporal variations in the utilisation of Fiordland by cetaceans. In addition to quantifying these biological parameters, the accuracy and precision of the tour operator's sighting network will be assessed. This assessment will show whether the data gathered are reliable and how sighting recording can be improved in the future.

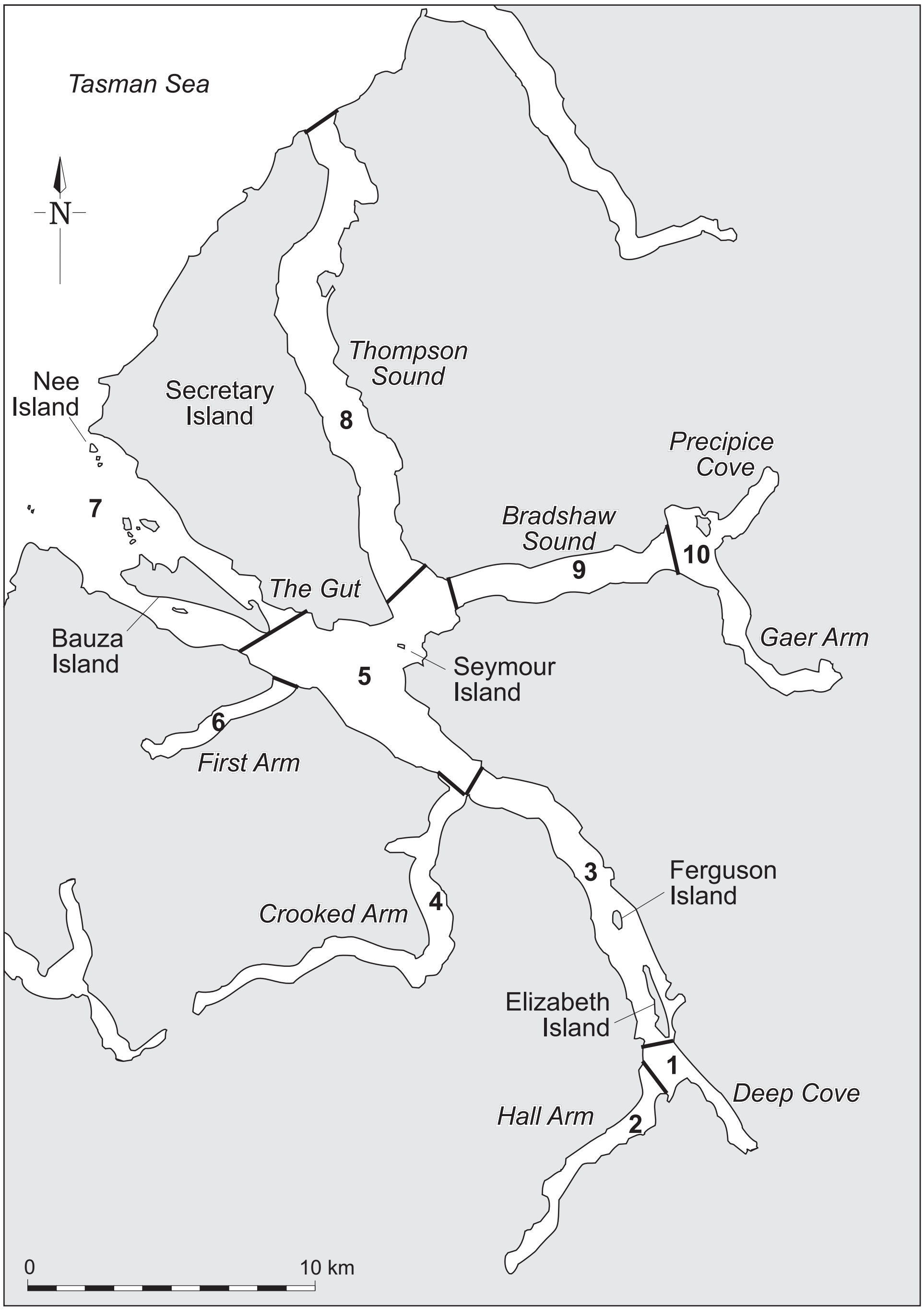


Figure 2. Map of Doubtful Sound, and location of quadrats used for spacial analysis.

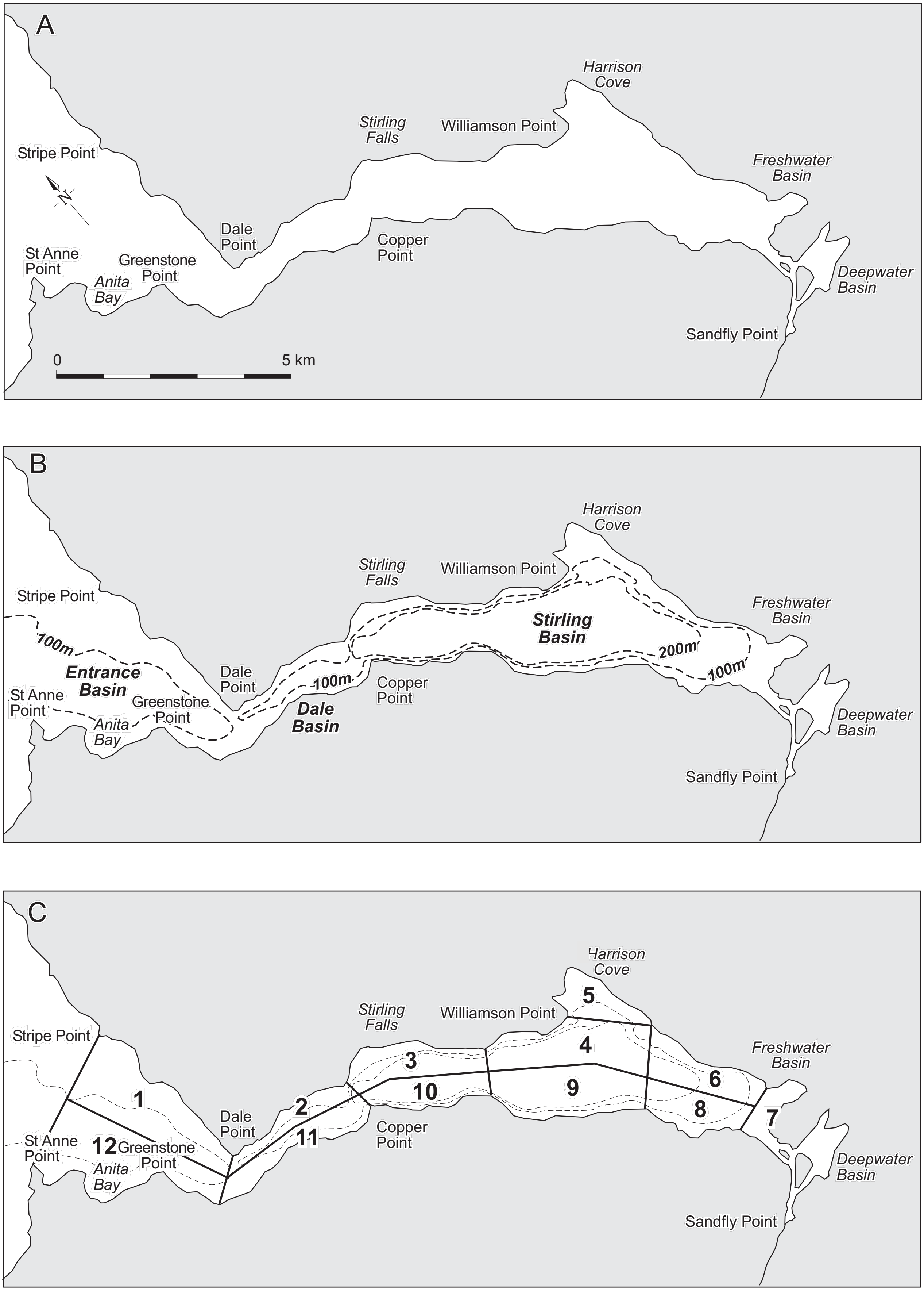


Figure 3. A Map of Milford Sound. B Major basins in Milford Sound. C Location of quadrats utilised for the spatial analysis.

1.1 CETACEAN SPECIES PRESENT IN FIORDLAND

Prior to this survey seven species of cetacean (listed below) had been recorded from the Fiordland coastline. These records were from short-term observation cruises (Webb 1973), museum specimens (Gaskin 1968) and anecdotal information from local residents.

Bottlenose dolphin (*Tursiops* sp.)

Bottlenose dolphins are regularly observed in all fiords, and a resident population has been described in Doubtful Sound (Williams et al. 1993). The species is also known to be present year-round in Milford Sound. It is a cosmopolitan species with a distribution ranging from 60° N to 47° S. Fiordland represents the southern extremity of their range.

Dusky dolphin (*Lagenorhynchus obscurus*)

Dusky dolphins are infrequently seen in Doubtful Sound and tend to be present in Milford Sound for some part of the year. They are often encountered in large schools (> 100 individuals) but also in smaller groups (e.g. sightings in Milford Sound). The species can be found in coastal waters of New Zealand, South Africa, and Argentina.

Common dolphin (*Delphinus* sp.)

Common dolphins are infrequently encountered in the fiords and have never been observed in their upper reaches. Webb (1973) described a sighting in the Gut, Doubtful Sound (Fig. 2). Common dolphins are meso-pelagic and tend to be restricted to warm waters (above 14°C, Gaskin 1982). Two species have been described in the Pacific Ocean based on cranial morphometry and coloration pattern (Heyning & Perrin 1994): the short-beaked common dolphin (*Delphinus delphis*) and the long-beaked common dolphin (*Delphinus capensis*). A population of short-beaked common dolphin is known to occur seasonally along the eastern coast of New Zealand's North Island (D. Neumann, pers. comm. 1999).

Orca (*Orcinus orca*)

Gaskin (1968) described a stranding of six male orcas in Milford Sound that occurred in 1964. Little information is available about orca present in New Zealand waters. The species is cosmopolitan, and several social organisations have been described based on the foraging habits of individual populations (Baird & Dill 1995).

Humpback whale (*Megaptera novaeangliae*)

There have been infrequent sightings of humpback whales along the coastline and offshore (Webb 1973) of Fiordland. Humpback whales sighted in New Zealand waters belong to the Antarctic area V stock; they pass the New Zealand coastline on the way to their breeding (or winter) and feeding (or summer) grounds (Figs 4 and 5). Population declines due to over-exploitation (whaling) most likely led to a change in migration route (Gaskin 1968), but the species

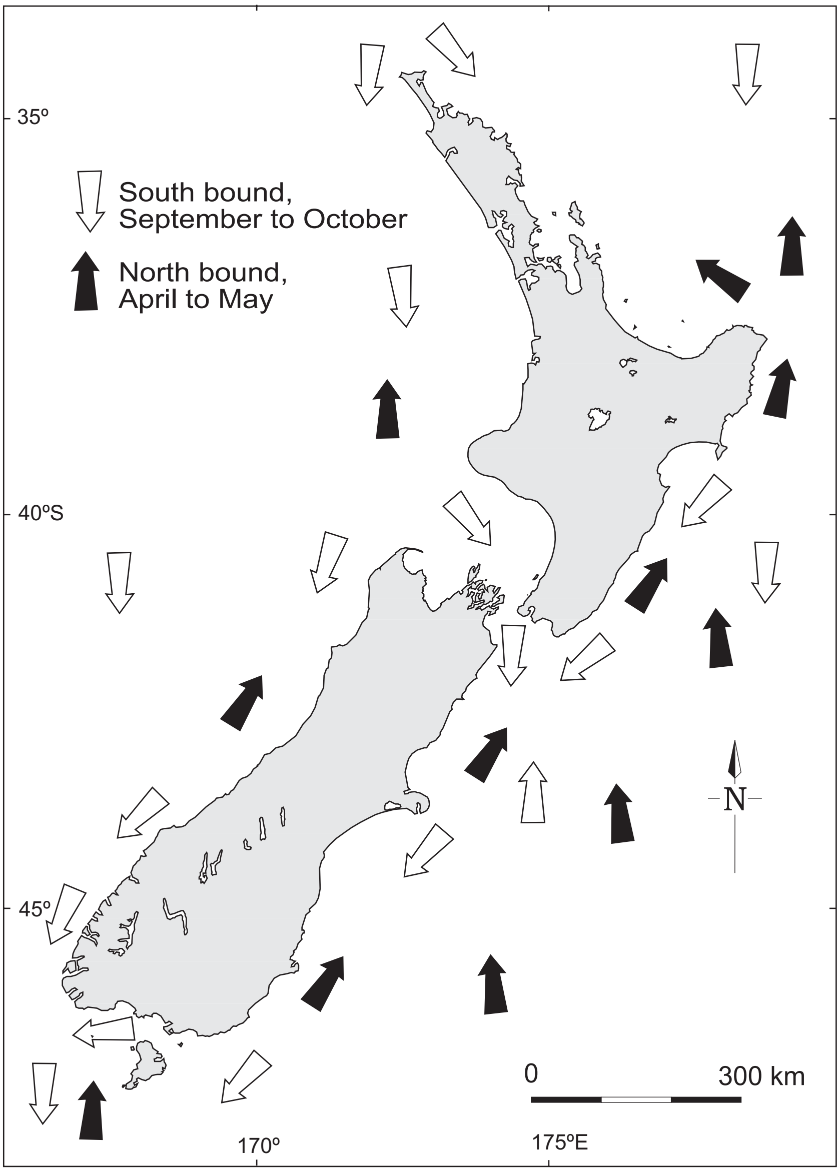


Figure 4. Movement pattern of humpback whales around New Zealand in summer and winter. (Adapted from Gaskin 1968.)

can still infrequently be observed along New Zealand's eastern and western coasts (Gibbs & Childerhouse 2000).

Sperm whale (*Physeter catodon*)

Sperm whales have occasionally been observed along the coastline between Doubtful and Breaksea Sounds (Webb 1973) but not inside the fiords. In most cases only solitary individuals were observed. Fiordland borders one of the former American whaling grounds (Fig. 6, Solander Ground) indicating that the species was once more common off the Fiordland coastline.

Southern right whale (*Eubalaena australis*)

Southern right whales used to be common throughout New Zealand waters but the species faced extinction at the beginning of the 20th Century due to over-

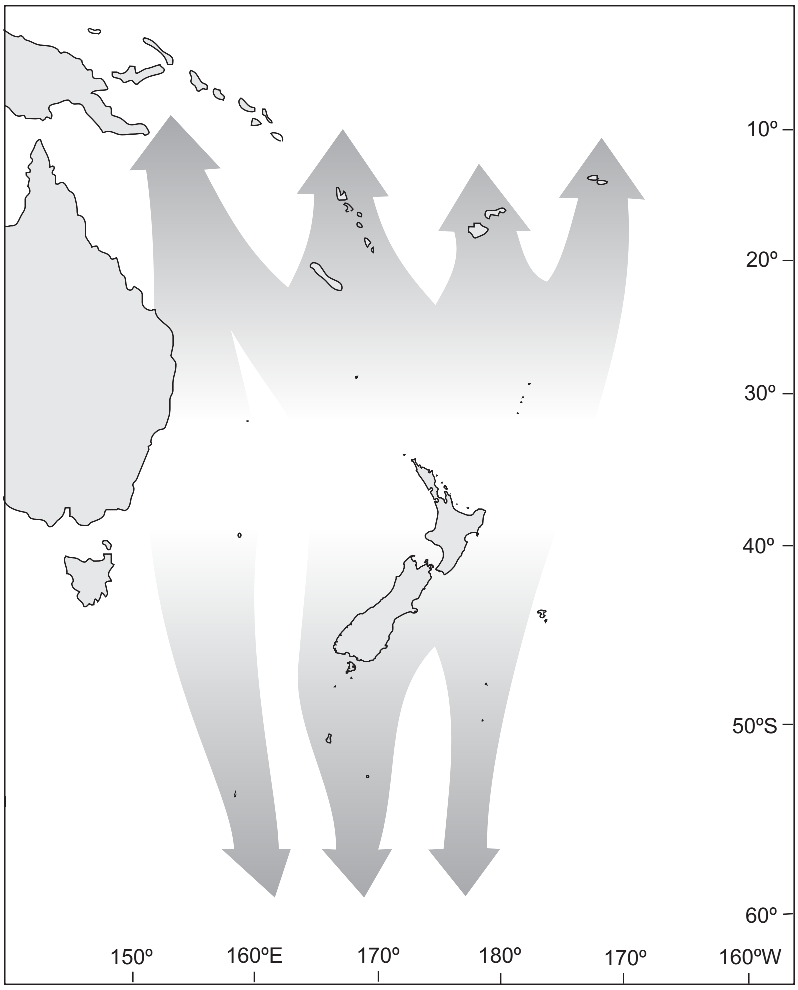


Figure 5. Migration movements of humpback whales from the Antarctic area V. (Adapted from Gaskin 1968.)

exploitation (whaling). There are reports of a specimen stranding in Freshwater Basin in Milford Sound (Fig. 3) during the mid-1980s.

1.2 OBJECTIVES

There were several objectives for this study:

1. Determine the efficiency of the volunteer sighting network.
2. Determine what cetacean species are present along the Fiordland coastline.
3. Describe the distribution of each species both at a large scale (coastal) and fine scale (within Doubtful and Milford Sounds).
4. Determine temporal variations in distribution for each species.
5. Assess inter-specific interactions (i.e. is there any relationship among species distributions?).
6. Determine mean group size for each species, along with temporal and spatial variations in this parameter.

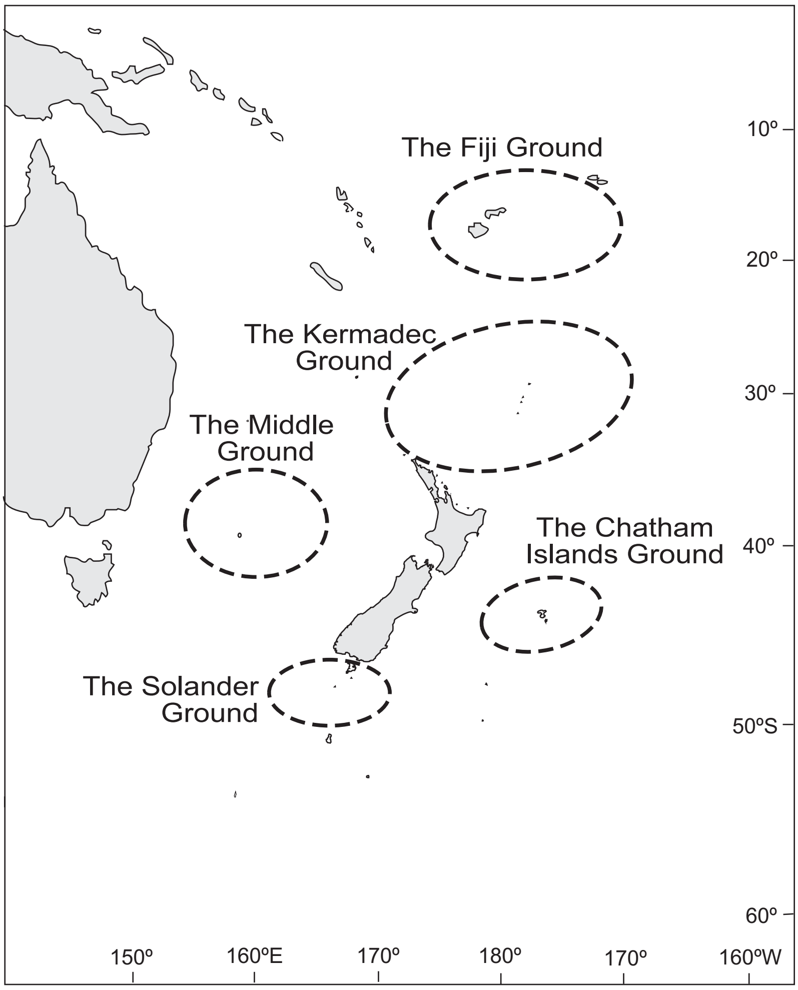


Figure 6. Concentrations of sperm whales around New Zealand waters. Data from American whaling industry 1790–1900. (Adapted from Gaskin 1968.)

2. Material and methods

From February 1996 to April 1999 tour operators in Fiordland recorded sightings of cetacean species (dolphins and whales) in this area on sighting record sheets (see Fig. 7). Sighting records were then transcribed to a digital map of the area (using Adobe™ Illustrator). The sampling effort was estimated by monitoring vessel routes, during the census period, and the time each vessel was at sea sampling. Tour operators participating in the data collection provided this information during a meeting held in Milford Sound in May 1999. Spatial and temporal distributions of each encountered species were then determined taking into account any sampling bias.

2.1 OBSERVER BIAS AND RELIABILITY

A meeting with skippers involved in the collection of data permitted an assessment of the following types of observer bias:

1. Not recording a sighting when it occurred.
2. Recording a sighting when it did not occur.

VESSEL: ………………………… **OBSERVER**: ………………………..

DATE: …………………………

DOLPHIN SIGHTINGS: Note whether they are bottlenose or dusky dolphins.

Time/ Species Approx. group size	………………………………. 2 5 10 15 20 25 30 35 40-100 >100
Time/ Species Approx. group size	………………………………. 2 5 10 15 20 25 30 35 40-100 >100
Time/ Species Approx. group size	………………………………. 2 5 10 15 20 25 30 35 40-100 >100
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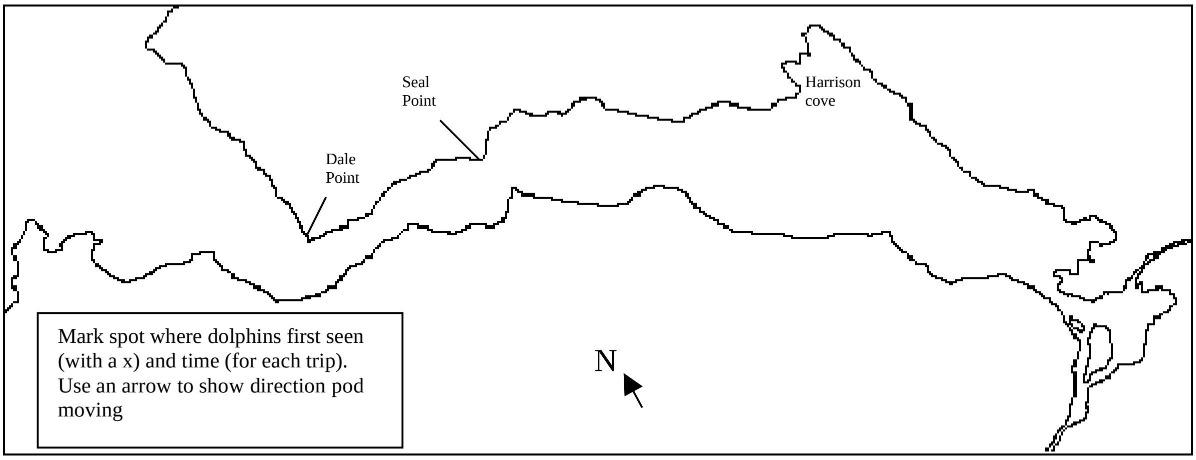

Figure 7. Example of a datasheet distributed in Milford Sound. Datasheets were the same at other locations except that the map was changed. A section for comments was added at the bottom of each sheet.

3. Misidentifying species.
4. Inaccurate estimation of group size.

Spatial and temporal analyses could only be conducted for the more common species in the more intensively sampled locations. For infrequently observed species, only location and date of sightings were reported.

The reliability of spatial and temporal sighting rates was tested against standardised methods. For the past 6 years the New Zealand Whale and Dolphin Trust has been conducting a long-term study of the behavioural ecology of bottlenose dolphins in Doubtful Sound. Spatial and temporal patterns have been described in that fiord using a standardised systematic survey route and photo-identification (Schneider 1999). The pattern observed from the sighting network data was compared to the one described by Schneider (1999). In addition, Schneider (1999) and Haase (2000) obtained bottlenose dolphin group size frequencies in Doubtful Sound using visual scan sampling (Altman 1974) and photo-identification from 1994 to 1997 and in 1999. Again, the sampling technique of the sighting network was tested against these techniques to assess their reliability in dolphin group size estimation.

2.2 TEMPORAL ANALYSES

Temporal variations in species sightings, standardised to the sampling effort, were assessed at a seasonal level using a presence/absence coding of sightings. The existence of cycles was also assessed. Once these temporal variations were ascertained for each species, inter-specific interactions were easily determined.

The year was divided into seasons to assess differences in frequency of occurrence of each species in each location. Seasons were defined as follow:

- Summer: December, January, and February.
- Autumn: March, April, and May.
- Winter: June, July, and August.
- Spring: September, October, and November.

2.3 SPATIAL ANALYSES

Spatial analyses could only be conducted for sightings in Milford and Doubtful Sounds. Variations in spatial distribution were estimated by dividing these two fiords into quadrats (Figs 2 and 3C). In the case of Milford Sound three geographic scales were utilised to assess spatial patterns, with quadrats of approximately equal size (Fig. 3C and Table 1). For Doubtful Sound, quadrats were determined on a geographic basis (arms v. main fiord body); consequently quadrats had unequal surface area. This discrepancy was taken into consideration when calculating expected frequencies of occurrence of dolphins

TABLE 1. THREE GEOGRAPHIC SCALES UTILISED TO ASSESS SPATIAL PATTERN IN MILFORD SOUND.

SCALE	DESCRIPTION (FIGURE 3C)
Fine scale	12 quadrats
Entrance, middle, and upper fiord	Entrance: quadrats 1 + 12 Middle: quadrats 2 + 3 + 10 + 11 Upper fiord: quadrats 4 + 5 + 6 + 7 + 8 + 9
North and South coasts	North: quadrats 1 + 2 + 3 + 4 + 5 + 6 South: quadrats 7 + 8 + 9 + 10 + 11 + 12

in each quadrat. In other words the expected probability of finding dolphins in a quadrat was related to the size of that quadrat.

Subsequently a goodness of fit test, using a chi-square distribution, was performed to investigate the deviation of observed frequency of sightings in each quadrat from the expected frequency. If the distribution of cetaceans was homogeneous then the chances of observing them in any quadrat would be equal (or related to the size of the quadrat). Differences between observed and expected frequencies for each quadrat were then added up and this sum was compared to a χ^2 (chi-square) distribution. This goodness of fit test was chosen because all quadrats had more than five sightings. It was used to determine if the overall pattern of dolphin distribution was significantly different from random.

2.4 GROUP SIZE FREQUENCY DISTRIBUTION

To assess variations of group size among species and location observed group sizes were classified using 10 group size categories (see Fig. 7). Because of the difference in class sizes provided in the datasheet, the data were pooled into 9 equal group size classes (classes of size 5 individuals). Medians for grouped data and 25% and 75% quartiles were calculated following the technique described by Sokal & Rohlf (1981). These statistics provide an estimation of the central tendency and the degree of variability of the frequency distribution. In other words they provide the same information as average and standard deviation would for a continuous dataset. Most group sizes were estimated as ranges and therefore could be included in group size classes but point data could not be estimated without increasing the estimation error of each sighting. Group sizes were then compared for different locations using a χ^2 test of independence. This analysis tested the independence of group size frequency distribution from the area in which the group was encountered.

3. Results

3.1 OBSERVER BIAS

Tour operators seem to have a good understanding of the cetacean species that occur regularly in Fiordland. However, there seems to be some discrepancies in the ability to identify infrequently seen species. Therefore, sightings of these species were only recorded when they were correctly and independently identified by several observers.

There is a chance that dolphins were present but not sighted. Some skippers felt that dolphins had eluded them during long dives. There were no quantitative data for dolphins being present but unrecorded but if it did occur it was likely to be infrequent because of the number of observers involved in the data collection. Moreover the cruises undertaken were not stopped after one group of dolphin was encountered. Since tours operating in Fiordland are scenic cruises, the trajectory of the cruise is constant over time and always completed. Therefore the probability that a group of dolphin was not recorded because another group was already present in the fiord is low. It is equivalent to the probability a group of dolphins was not sighted yet was present. No data were available to assess the probability that a sighting was recorded when none occurred, but we judged that the likelihood was low. Observers seemed to have recorded sightings only when confirmed by other operators. Moreover, because of the geography of fiords the distance between boats and animals was never excessive.

On six occasions different vessels recorded the same sighting (same location at the same time). By comparing the group size estimated by each observer for these sightings it was determined that the estimation of group size was reasonably consistent among observers and never deviated by more than one group size class.

Tours started at different times of the day and more tours occurred during afternoon than morning hours. It was therefore not possible to assess difference in dolphin distribution depending on time of the day.

3.2 SAMPLING EFFORT

Seasons were unequally sampled in all locations. The Fiordland coastline was only sampled by one boat during winter months (May to September) and by occasional cruises during the other months. By contrast, Milford and Doubtful Sounds were sampled less during winter (Tables 2 and 3). Most sampling occurred temporally during 1997 and 1998 and, as expected, spatially in Milford and Doubtful Sounds (Tables 2, 3 and 4).

Milford Sound was evenly sampled by tour operators (see Fig. 8) except for quadrat 7 which was not always entirely visited. Deepwater basin was regularly visited by only one vessel. This lack of regular observation was taken into consideration when calculated the area sampled in quadrat 7. In Doubtful Sound quadrats 1 to 5 were habitually sampled (see Fig. 9) throughout the year.

TABLE 2. TOTAL NUMBER OF DAYS SPENT OBSERVING IN DOUBTFUL SOUND EVERY SEASON, 1997–99.

SEASON	1997	1998	1999	TOTAL
Summer	90	90	75	255
Autumn	50	59	3	112
Winter	41	38	N/A	79
Spring	50	57	N/A	107

TABLE 3. TOTAL NUMBER OF DAYS SPENT OBSERVING IN MILFORD SOUND EVERY SEASON, 1996–99.

SEASON	1996	1997	1998	1999	TOTAL
Summer	28	89	90	90	297
Autumn	92	71	92	61	316
Winter	57	30	0	N/A	87
Spring	0	70	59	N/A	129

TABLE 4. RELATIVE FREQUENCY OF SIGHTINGS (n = 1422) IN EACH SAMPLED REGION OF FIORDLAND, 1996–99.

LOCATION	FREQUENCY OF SIGHTINGS (%)
Milford Sound	**52.60**
George Sound	0.14
Doubtful Sound	**42.83**
Between Doubtful and Dusky Sounds	0.42
Dusky Sound	3.66
South of Preservation Inlet	0.35

Figure 8. Typical cruise pattern followed (clockwise) by tour operators in Milford Sound.

3.3 SPECIES INFREQUENTLY OBSERVED

Seven species were infrequently observed by the sighting network in Fiordland waters (Table 5 and Figs 10 and 11). Common dolphins were observed only during summer months (3 sightings, Table 6) and at the entrance of fiords (Figs 10 and 11). Both sightings in Doubtful Sound were in the gut area (Fig. 10). No description allowed to distinguishing which species of common dolphin is present in Fiordland. Southern long-finned pilot whales (*Globicephala melaena edwardi*) were sighted at the entrance of Dusky Sound and in Doubtful Sound, in the vicinity of Elizabeth Island (Figs 10 and 11). Only two sighting records were available for that species. In both cases the group size was small (1 and 5 individuals) which is uncommon for the species. These sightings are the first official record of this species in Fiordland. A group of 10 orcas was observed travelling south at the entrance of Milford Sound (Fig. 11).

Sperm whales were observed on two occasions in the vicinity of Dagg Sound during winter 1996 and 1998 (Fig. 11). Surprisingly, humpback whales were

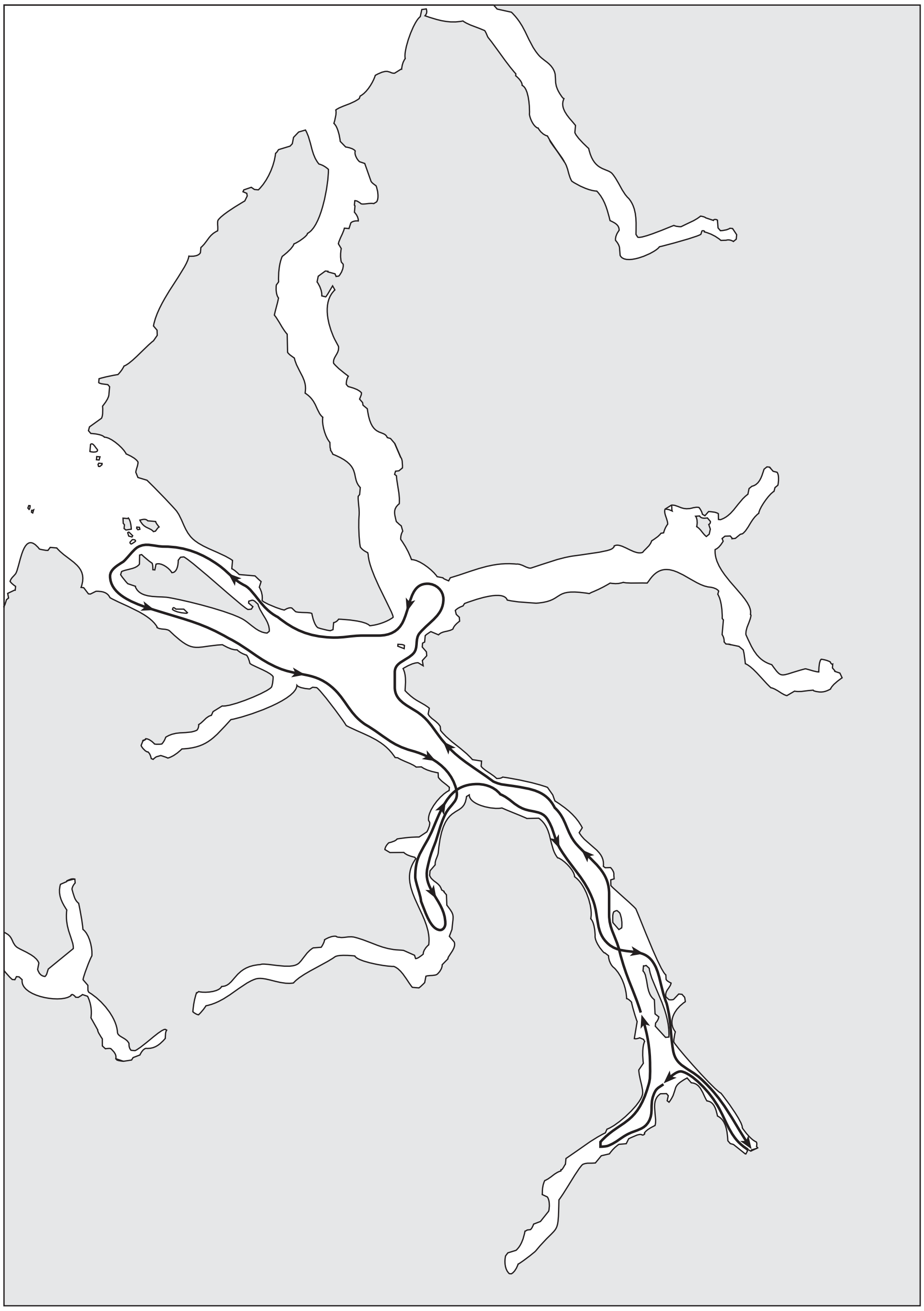

Figure 9. Typical cruise pattern followed by tour operators in Doubtful Sound.

observed during summer and winter, seasons when they are supposed to be at, respectively, their feeding and breeding grounds (Table 6). A group of six whales was encountered inside Doubtful Sound as far as the entrance of Crooked Arm in January 1998 (Fig. 10). A solitary minke whale (*Balenoptera acutorostrata*) was sighted off Ferguson Island, Doubtful Sound in October 1997, constituting the first official record of this species in Fiordland. Finally, only a solitary southern right whale was seen during this 3-year observation period in Milford Sound in June 1997.

TABLE 5. RELATIVE FREQUENCY OF OCCURRENCE (n = 1422) OF EACH CETACEAN SPECIES OBSERVED FROM TOUR BOATS IN FIORDLAND, 1996–99.

SPECIES	FREQUENCY OF SIGHTINGS (%)
Bottlenose dolphin	**87.75**
Dusky dolphin	**10.35**
Mixed schools of bottlenose and dusky dolphins	0.28
Common dolphin	0.28
Pilot whale	0.14
Orca	0.07
Sperm whale	0.14
Humpback whale	0.35
Minke whale	0.07
Southern right whale	0.07

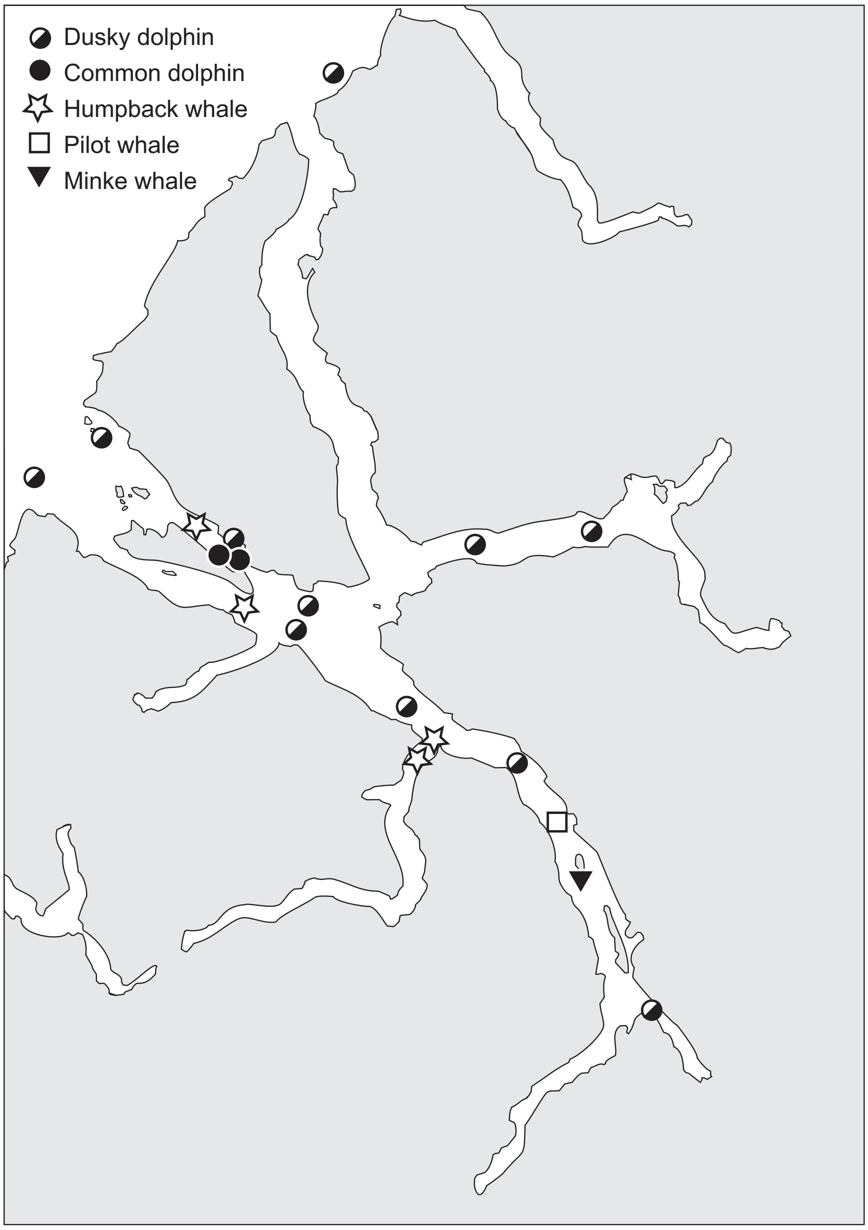

Figure 10. Sighting records of infrequently observed species in Doubtful Sound.

Figure 11. Sighting records along the Fiordland coast, 1996–99. Numbers next to symbols give the number of sightings at that locality. Sightings of bottlenose dolphins in Milford and Doubtful Sounds are not included. For sightings of infrequently seen species in Doubtful Sound see Fig. 10.

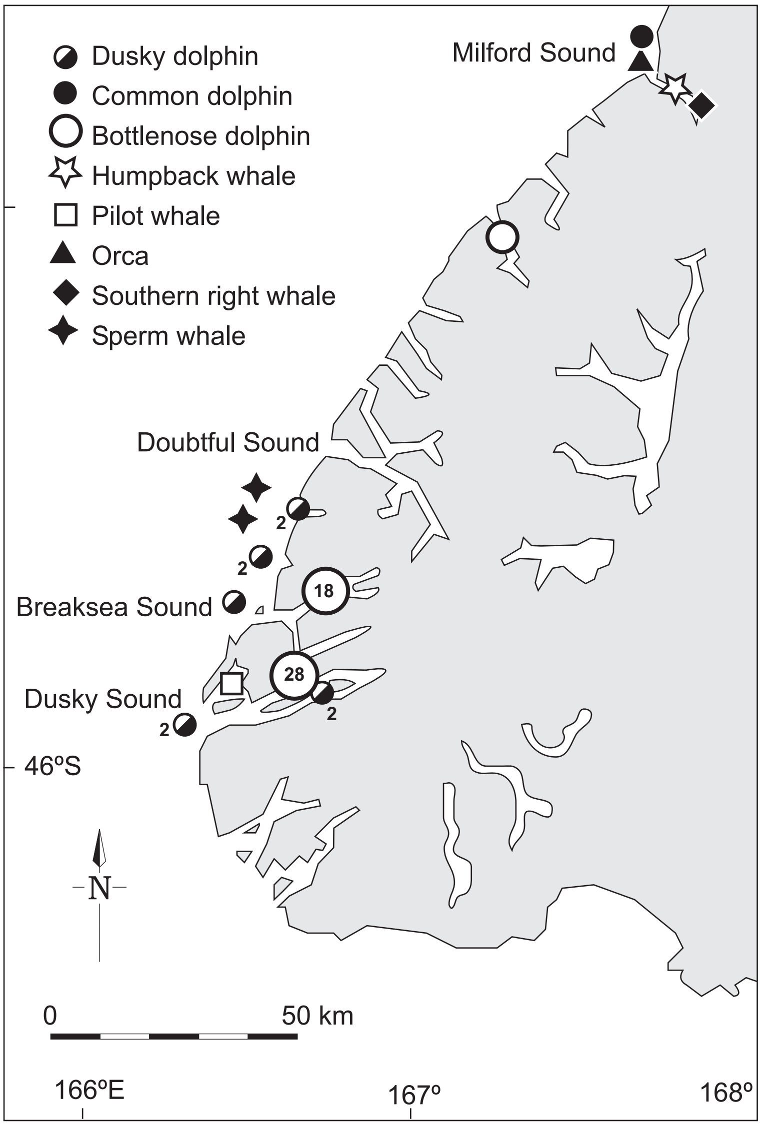

TABLE 6. SEASONAL OCCURRENCE (NUMBER OF DAYS WITH SIGHTINGS) OF INFREQUENTLY OBSERVED SPECIES ALONG FIORDLAND COASTLINE, 1996–99.

	SUMMER	AUTUMN	WINTER	SPRING
Common dolphin	3	-	-	-
Pilot whale	1	-	-	1
Orca	1	-	-	-
Sperm whale	-	-	2	-
Humpback whale	2 (Jan)	-	1 (Jul)	1 (Nov)
Minke whale				1
Southern right whale	-	-	1	-

3.4 MILFORD SOUND

3.4.1 Spatial variation

Bottlenose dolphin

Sightings of bottlenose dolphins were not homogeneous throughout Milford Sound. In the finer scale analysis most of the χ^2 value was contributed by differences from expected sighting frequency in quadrats 2, 3, and 4 (Table 7). Bottlenose dolphins tended to spend more time in these quadrats than would be expected if sightings were evenly distributed among quadrats. They also tended to spend more time along the northern shore, especially in the vicinity of Dale Point (Table 8, Fig. 12) and in the middle of the fiord (Table 9).

Dusky dolphin

Similarly, the chance of finding dusky dolphins in Milford Sound was not equally distributed over the fiord (n = 89, χ^2 = 60.26, p < 0.0001). Most sightings occurred in quadrat 1 (25.8%, n = 89). Tables 10 and 11 and Fig. 13 also show

TABLE 7. RELATIVE FREQUENCY OF OCCURRENCE (%) OF BOTTLENOSE DOLPHINS IN EACH QUADRAT IN MILFORD SOUND FROM FEBRUARY 1996 TO MAY 1998.

QUADRAT	OVERALL (n = 513)	SUMMER (n = 208)	AUTUMN (n = 198)
1	7.4	7.7	6.1
2	**14.2**	**19.2**	11.1
3	**14.0**	12.0	**16.7**
4	**13.6**	11.1	14.6
5	4.7	6.7	4.5
6	7.8	5.8	10.1
7	4.9	4.8	6.6
8	4.1	5.8	2.0
9	7.8	6.2	8.1
10	10.1	7.2	11.6
11	7.4	8.6	5.0
12	3.9	4.8	3.5
Homogeneity test	χ^2 = **100.96** p < 0.0001	χ^2 = **46.54** p < 0.0001	χ^2 = **54.00** p < 0.0001

TABLE 8. RELATIVE FREQUENCY OF OCCURRENCE (%) OF BOTTLENOSE DOLPHINS ALONG EACH SHORE OF MILFORD SOUND FROM FEBRUARY 1996 TO MAY 1998.

SHORELINE	OVERALL (n = 513)	SUMMER (n = 208)	AUTUMN (n = 198)
North shore	61.8	62.5	63.1
South shore	38.2	37.5	36.9
Homogeneity test	χ^2 = **28.45** p < 0.0001	χ^2 = **13.00** p = 0.0003	χ^2 = **13.66** p = 0.0002

Figure 12. Sighting records of bottlenose dolphins in Milford Sound, 1996–98.

TABLE 9. RELATIVE FREQUENCY OF OCCURRENCE (%) OF BOTTLENOSE DOLPHINS IN EACH SECTION OF MILFORD SOUND FROM FEBRUARY 1996 TO MAY 1998.

SECTION	OVERALL (n = 513)	SUMMER (n = 208)	AUTUMN (n = 198)
Entrance	11.3	12.5	9.6
Middle	**45.8**	**47.1**	**44.4**
Upper fiord	42.9	40.4	46.0
Homogeneity test	χ^2 = **37.99** $p < 0.0001$	χ^2 = **17.87** $p = 0.0001$	χ^2 = **13.92** $p < 0.001$

that dusky dolphins tended to be found at the entrance and in the outer fiord, with few sightings in the inner middle portion of the fiord.

3.4.2 Temporal variation

Bottlenose dolphin

Bottlenose dolphins appeared to be present year-round in Milford Sound (Fig. 14). The number of sightings was generally lower during winter and spring but the sighting effort during these months is too low to draw any firm conclusions from this result (Table 12).

Dusky dolphin

Observations of dusky dolphins indicate that the dolphins are mainly present in Milford Sound during summer months (Fig. 15 and Table 13). However the low sampling effort outside the summer season made it impossible to test this hypothesis.

TABLE 10. RELATIVE FREQUENCY OF OCCURRENCE (%, n = 89) OF DUSKY DOLPHINS ALONG EACH SHORE OF MILFORD SOUND FROM FEBRUARY 1996 TO MAY 1998.

SECTION	FREQUENCY (%)
North shore	**61.8**
South shore	38.2
Homogeneity test	χ^2 = **4.96** p = 0.026

TABLE 11. RELATIVE FREQUENCY OF OCCURRENCE (%, n = 89) OF DUSKY DOLPHINS IN EACH SECTION OF MILFORD SOUND FROM FEBRUARY 1996 TO MAY 1998.

SECTION	FREQUENCY (%)
Entrance	**39.3**
Middle	12.4
Upper fiord	48.3
Homogeneity test	χ^2 = **39.21** p < 0.0001

Figure 13. Sighting records of dusky dolphins in Milford Sound, 1996–98.

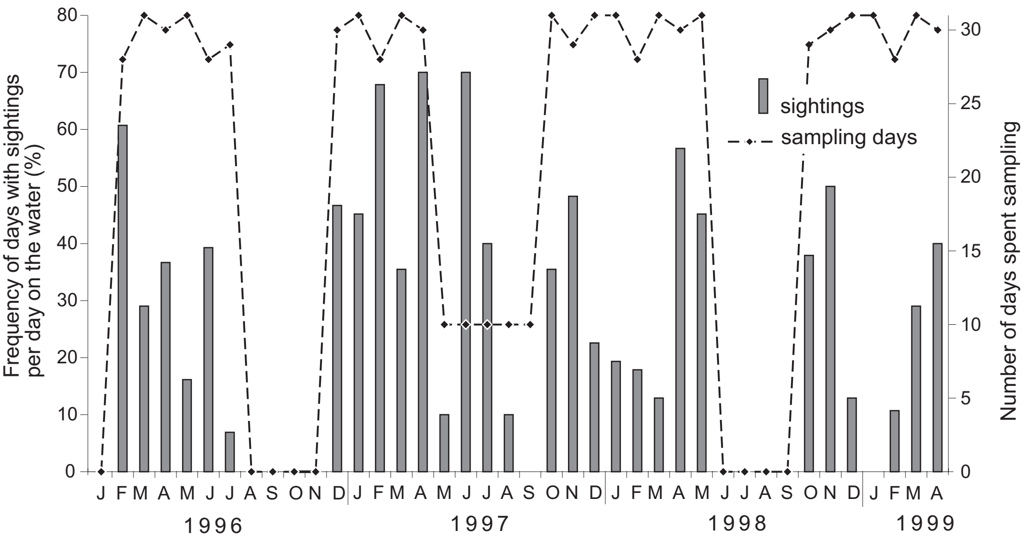

Figure 14. Monthly frequency of occurrence (%) of bottlenose dolphins in Milford Sound from January 1996 to April 1999. Frequencies are standardised to the time spent observing each month, shown on the right-hand axis.

TABLE 12. FREQUENCY OF OCCURRENCE (%) OF DAYS WITH SIGHTINGS OF BOTTLENOSE DOLPHINS IN MILFORD SOUND (1996-99) STANDARDISED TO THE NUMBER OF DAYS SPENT COLLECTING DATA.

SEASON	1996	1997	1998	1999	TOTAL
Summer	**60.7**	**52.8**	20.0	**7.8**	35.3
Autumn	27.2	46.5	38.0	34.4	36.5
Winter	22.8	40.0	N/A	N/A	31.4
Spring	N/A	35.7	**45.8**	N/A	40.7

TABLE 13. FREQUENCY OF OCCURRENCE (%) OF DAYS WITH SIGHTINGS OF DUSKY DOLPHINS IN MILFORD SOUND (1996-99) STANDARDISED TO THE NUMBER OF DAYS SPENT COLLECTING DATA.

SEASON	1996	1997	1998	1999	TOTAL
Summer	7.1	28.1	8.9	15.6	14.9
Autumn	0.0	1.4	1.1	1.6	1.0
Winter	0.0	0.0	N/A	N/A	0.0
Spring	N/A	0.0	5.1	N/A	2.5

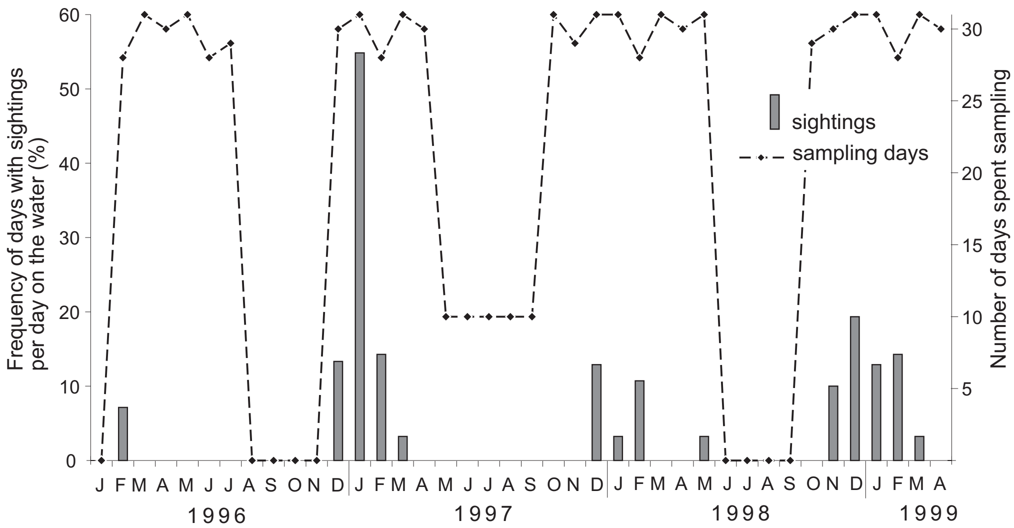

Figure 15. Monthly frequency of occurrence (%) of dusky dolphins in Milford Sound from February 1996 to April 1999. Frequencies are standardised to the time spent observing each month, shown on the right-hand axis.

3.4.3 Interaction between bottlenose and dusky dolphins

Sufficient data to examine the interaction between these two species was only available for Milford Sound. A larger sample size is required to detect any significant trend in the interaction between the two species. However, it was noticeable that both species are rarely present at the same time in Milford Sound.

Dusky dolphins were sighted on 55 days (6.6% of the sampling period) and bottlenose dolphins on 289 days (34.9% of the sampling period). Out of those days both species were encountered at the same time in the fiord on only 15 days (1.8% of the sampling period). In other words on most of the days dusky dolphins were sighted (72.7%), bottlenose dolphins were not encountered within the fiord. Conversely, on 94.8% of the days bottlenose dolphins were sighted, dusky dolphins were absent from Milford Sound. In both cases the probability of finding one species when another is present is significantly less than random (Fisher's exact test: encountering bottlenose dolphins when dusky dolphins are present, $p = 0.0013$; encountering dusky dolphins when bottlenose dolphins are present, $p < 0.0001$).

3.4.4 Seasonal variations in habitat use

Sufficient data were available to analyse the interaction of space and time in only bottlenose dolphin distribution for summer and autumn months. The preference for the northern shore of the middle portion of the fiord seemed to be consistent during summer and autumn (Tables 7, 8 and 9; Figs 16 and 17). The middle of the fiord seemed to be also preferred during winter and spring, but more data are needed for a thorough statistical analysis (Figs 18 and 19).

3.4.5 Group size

Bottlenose dolphin

The median group size was 16 individuals (Fig. 20). Bottlenose dolphin group size was not related to the shoreline along which they were observed (north vs. south shore: n = 508, $\chi^2 = 9.62$, df = 8, $p = 0.29$). Large groups were observed more often in the fiord entrance, while smaller groups were sighted more often inside the fiord ($\chi^2 = 33.71$, df = 12, $p < 0.001$, Table 14).

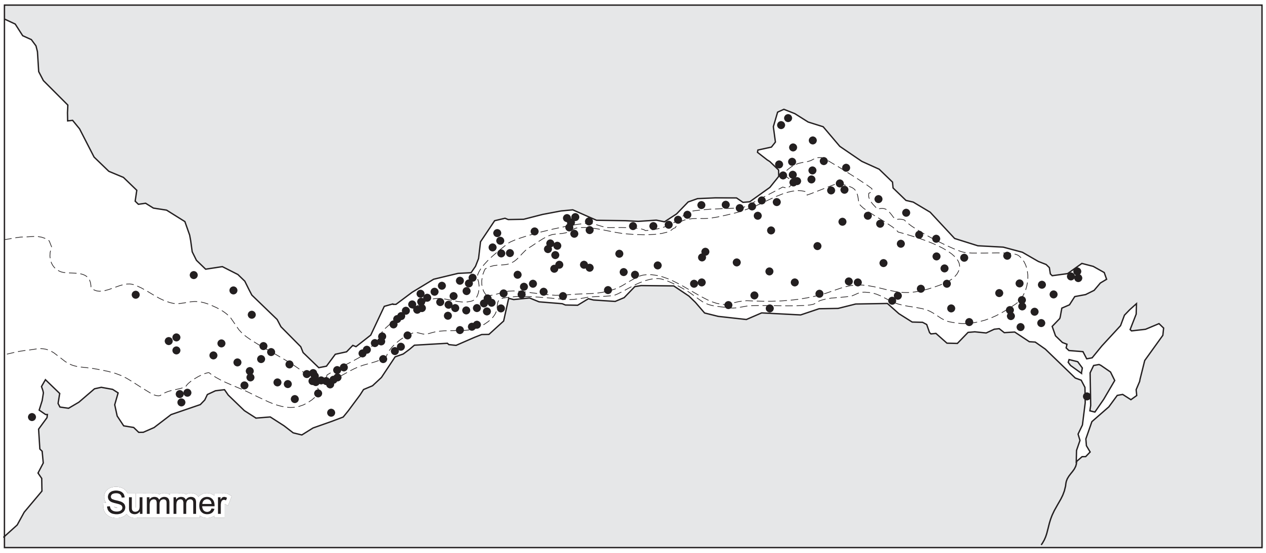

Figure 16. Sighting records of bottlenose dolphins in Milford Sound, summer 1996–98.

Figure 17. Sighting records of bottlenose dolphins in Milford Sound, autumn 1996–98.

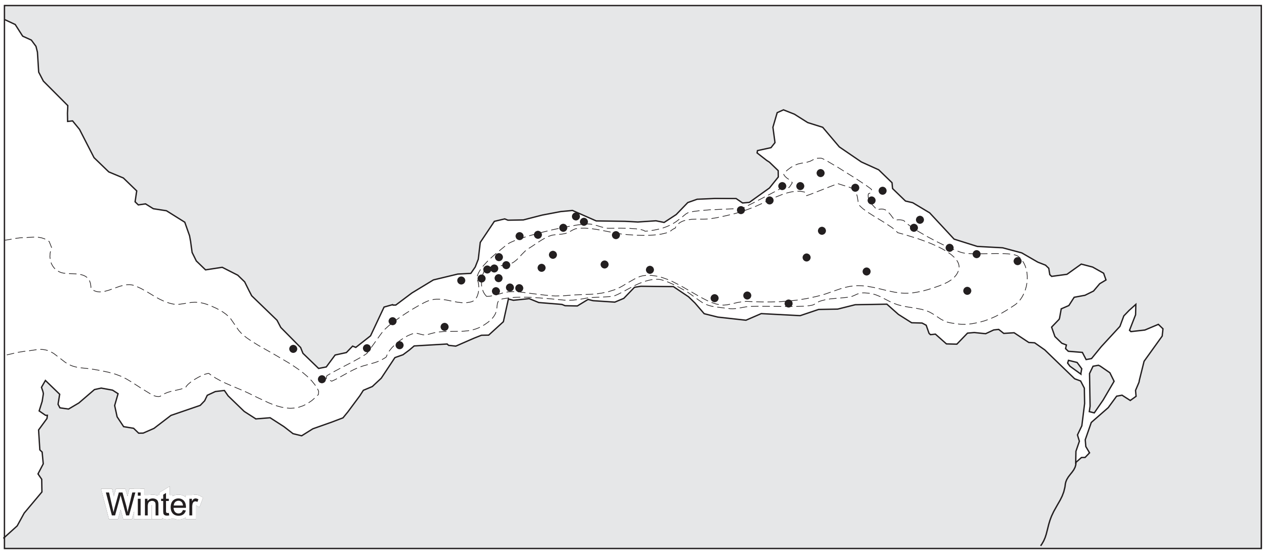

Figure 18. Sighting records of bottlenose dolphins in Milford Sound, winter 1996–98.

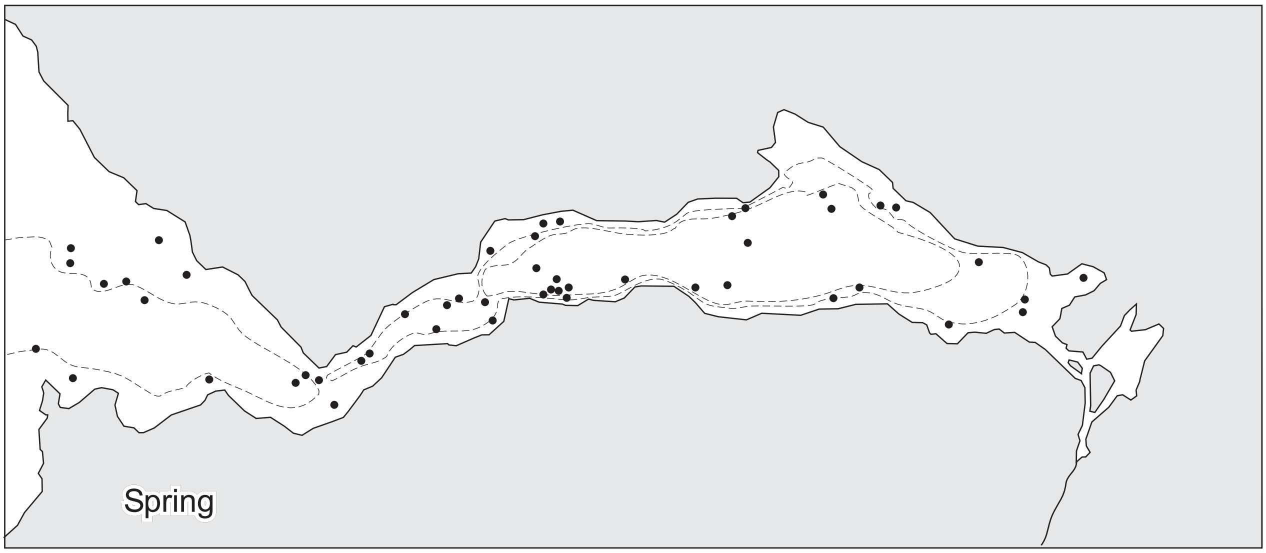

Figure 19. Sighting records of bottlenose dolphins in Milford Sound, spring 1996–98.

Dusky dolphin

The median group size was 32 individuals (Fig. 21). No spatial analysis of group size frequency distribution could be performed because the sample size was too low (n = 98).

3.5 DOUBTFUL SOUND

Bottlenose dolphins were the only species seen frequently in Doubtful Sound. Consequently, spatial and temporal analyses of sighting records could only be carried out for this species.

3.5.1 Spatial variation

Quadrats were unequally sampled in Doubtful Sound. Most observers spent most of their time in quadrats 1 to 5. As they were the only ones equally

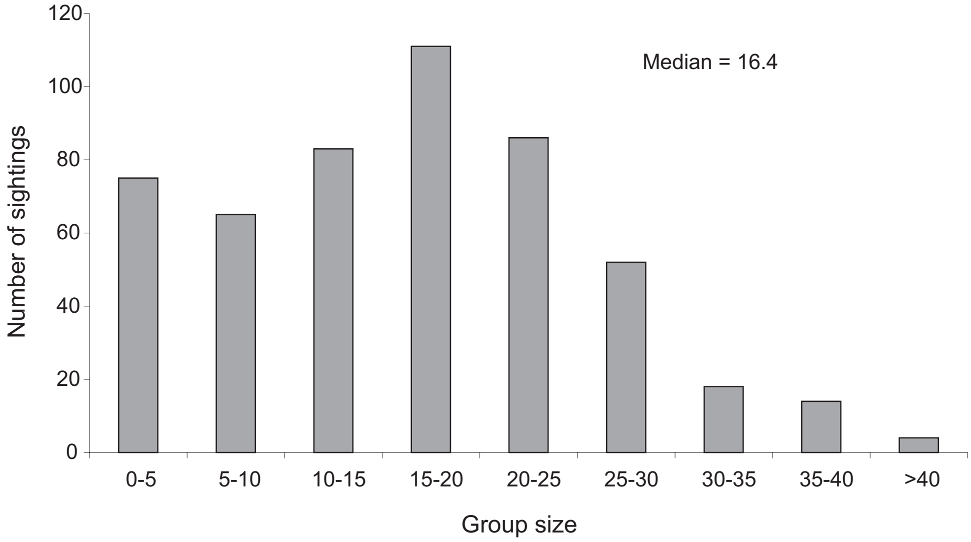

Figure 20. Bottlenose dolphin group size frequency distribution (n = 508) in Milford Sound.

TABLE 14. GROUP SIZE FREQUENCY DISTRIBUTION IN EACH SECTION OF MILFORD SOUND (1996–99).

GROUP SIZE CLASS (No. of individuals)	OBSERVED FREQUENCY (%) Entrance (n = 58)	Middle (n = 230)	Upper fiord (n = 220)
0–5	12.1	13.5	16.8
5–10	5.2	11.7	15.9
10–15	8.6	15.7	19.1
15–20	22.4	**28.3**	**15.0**
20–25	19.0	16.1	17.3
25–30	13.8	8.3	11.4
> 30	**19.0**	6.5	4.5
Independence test		χ^2 **= 33.71**	$p < 0.001$

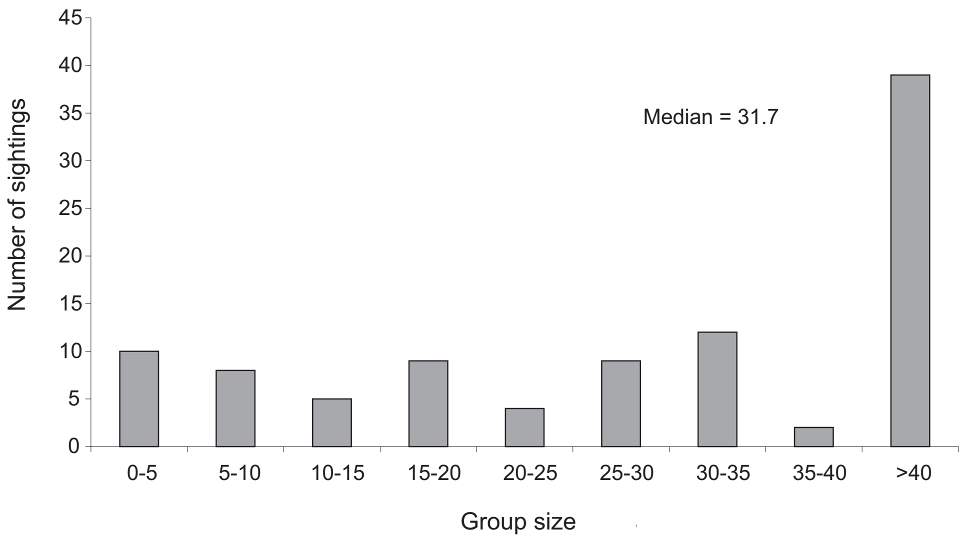

Figure 21. Dusky dolphin group size frequency distribution (n = 98) in Milford Sound.

Figure 22. Sighting records of bottlenose dolphins in Doubtful Sound from December 1996 to February 1999.

sampled, quadrats 1 to 5 were only considered in this analysis.Bottlenose dolphins tended to be observed more than expected in Crooked Arm and less than expected in Deep Cove (Table 15 and Fig. 22). This finding is in agreement with results from the long-term monitoring program of bottlenose dolphins in Doubtful Sound (Schneider 1999).

A similar spatial distribution seemed to occur during summer and autumn (Table 15 and Fig. 23), but bottle-nose dolphins tended to spend more time in the main body of the fiord (quadrat 5) during the colder seasons (Table 15 and Fig. 23). Once again this distribution matches the one described by Schneider (1999); dolphins spent more time in the arms during warmer seasons and in the main fiord body during colder seasons.

TABLE 15. RELATIVE FREQUENCY OF OCCURRENCE (%) OF BOTTLENOSE DOLPHINS IN EACH QUADRAT IN DOUBTFUL SOUND FROM DECEMBER 1996 TO FEBRUARY 1999.

QUADRAT	OVERALL (n = 518)	SUMMER (n = 275)	AUTUMN (n = 117)	WINTER/SPRING (n = 123)
1	1.7	1.1	2.6	2.4
2	8.6	10.2	6.8	7.3
3	21.0	21.1	17.1	25.2
4	**41.7**	**49.8**	**52.1**	12.2
5	26.8	17.8	21.4	**52.8**
Homogeneity test	χ^2 = **202.20** $p < 0.0001$	χ^2 = **190.76** $p < 0.0001$	χ^2 = **86.58** $p < 0.0001$	χ^2 = **23.17** $p = 0.0001$

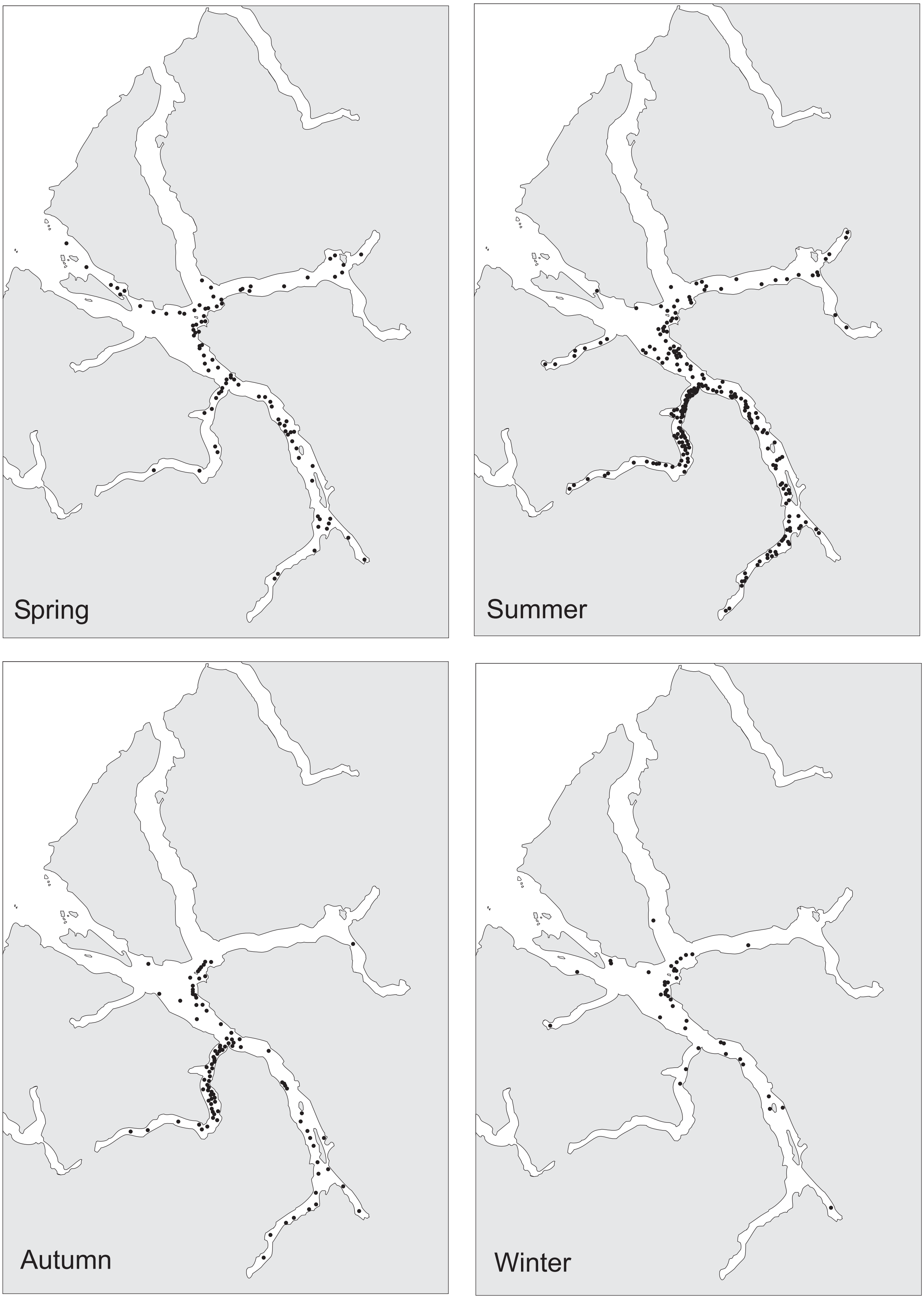

Figure 23. Sighting records of bottlenose dolphins in Doubtful Sound during different seasons, December 1996 to February 1999.

3.5.2 Temporal variation

Bottlenose dolphins were observed year-round (Table 16, Fig. 24). Unequal sampling prevented any temporal analysis (Fig. 24), but there were no obvious seasonal cycles. Bottlenose dolphins are known to be resident in Doubtful Sound (Schneider 1999) and Schneider sighted them 98.3% of the days he was on effort. The lower sighting rate yielded by the tour operator sighting network in Doubtful Sound may be related to the complex geography of the area making it difficult for observers to find dolphins on short cruises.

3.6 COMPARISON OF GROUP SIZE FREQUENCY DISTRIBUTION

There were enough data to compare the group size frequency distribution of bottlenose dolphins present in Milford, Doubtful and Dusky Sounds (Fig. 28). No other comparison could be made due to low sample size. Doubtful Sound had the higher median group size (21.4; quartiles: 25% = 12.2, 75% = 33.8; n = 568), followed by Milford Sound (16.4; quartiles: 25% = 9.0, 75% = 22.7; n =

TABLE 16. FREQUENCY OF OCCURRENCE (%) OF DAYS WITH SIGHTINGS OF BOTTLENOSE DOLPHINS IN DOUBTFUL SOUND (1997-99) STANDARDISED TO THE NUMBER OF DAYS SPENT COLLECTING DATA.

SEASON	1997	1998	1999	TOTAL
Summer	46.7	90.0	53.3	63.3
Autumn	66.0	79.7	N/A	72.8
Winter	41.5	68.4	N/A	54.9
Spring	70.0	63.2	N/A	66.6

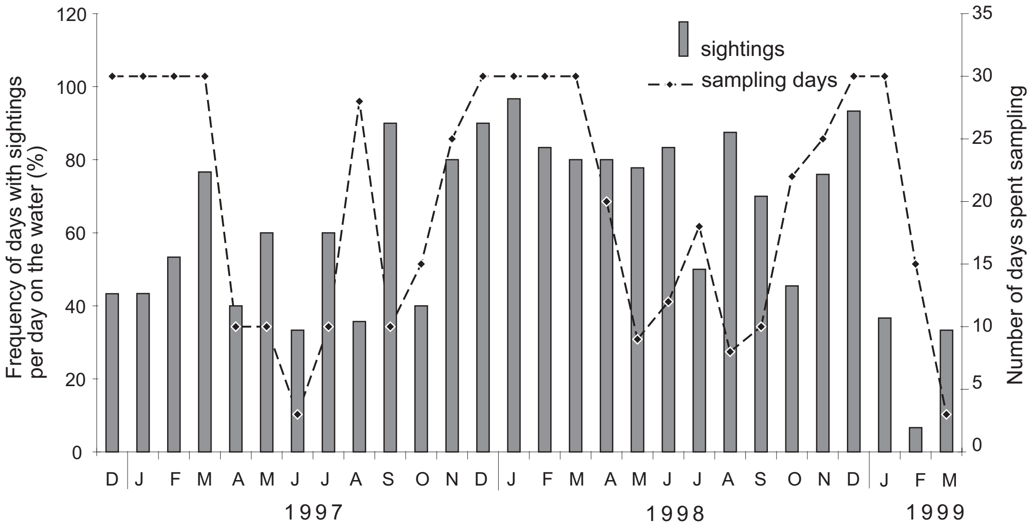

Figure 24. Monthly frequency of occurrence (%) of bottlenose dolphins in Doubtful Sound from December 1996 to March 1999. Frequencies are standardised to the time spent observing each month, shown on the right-hand axis.

508) and Dusky Sound (11.3; quartiles: 25% = 6.0, 75% = 19.2; n = 46). The sampling effort was spatially inconsistent in Dusky Sound. Because of the relationship between spatial location and group size described above, the sample size for Dusky Sound may be too low to obtain a reliable estimation of the group size frequency distribution in that fiord. It was therefore not compared with those from the two other fiords.

Group size frequency distributions in Milford and Doubtful Sounds were independent (χ^2 = 112.5, df = 8, p < 0.0001). The distribution for groups in Doubtful seemed to peak at '10–15' and '> 40' size classes (Fig. 25), while the one for groups in Milford seemed to peak only at the '15-20' size class.

Frequency distribution of group size was compared to the one from the New Zealand Whale and Dolphin Trust (NZWDT) obtained from 1994 to 1999, inclusive (Schneider 1999; Haase 2000). Both Schneider's (1999) and Haase's (2000) studies were pooled together in order to cover a similar time range as the sighting network did (1994 to 1997 and 1999 vs. 1996 to 1999). The median group size in Doubtful Sound is slightly higher than NZWDT's estimate (median group size = 20.3; quartiles: 25% = 11.84, 75% = 34.06; n = 1487) but falls within the same range. The frequency distributions of group size described by Schneider (1999) and Haase (2000) and the volunteer network were significantly independent (χ^2 = 24.76, df = 8, p = 0.002). Group size estimations from Schneider and Haase studies are bound to be more accurate since they are derived from photo-identification of every individual present in the group. Figure 26 shows that operators tended to underestimate the number of groups within the '25-30' and '30-35' classes and overestimate the number of groups within the '35–40' and '> 40' classes. This bias in estimation is easily demonstrated by pooling all classes above 25 individuals in size together. In that case the frequency distributions described by Schneider and Haase and by the sighting network are similar (χ^2 = 3.8, df = 5, p = 0.578). This result demon-

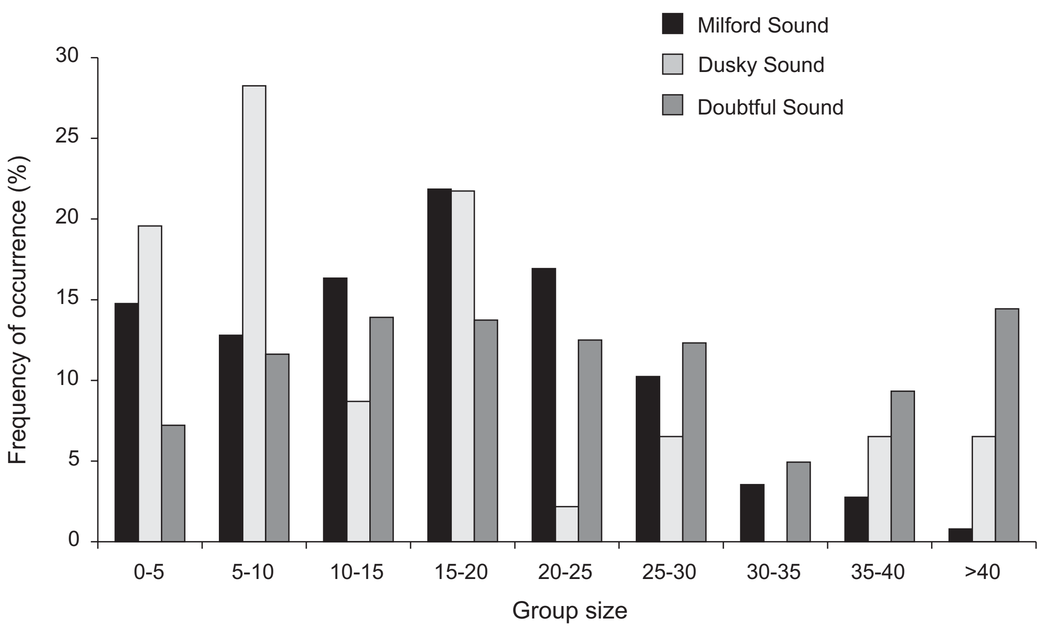

Figure 25. Group size frequency distribution for bottlenose dolphin groups in Milford, Doubtful, and Dusky/Breaksea Sounds.

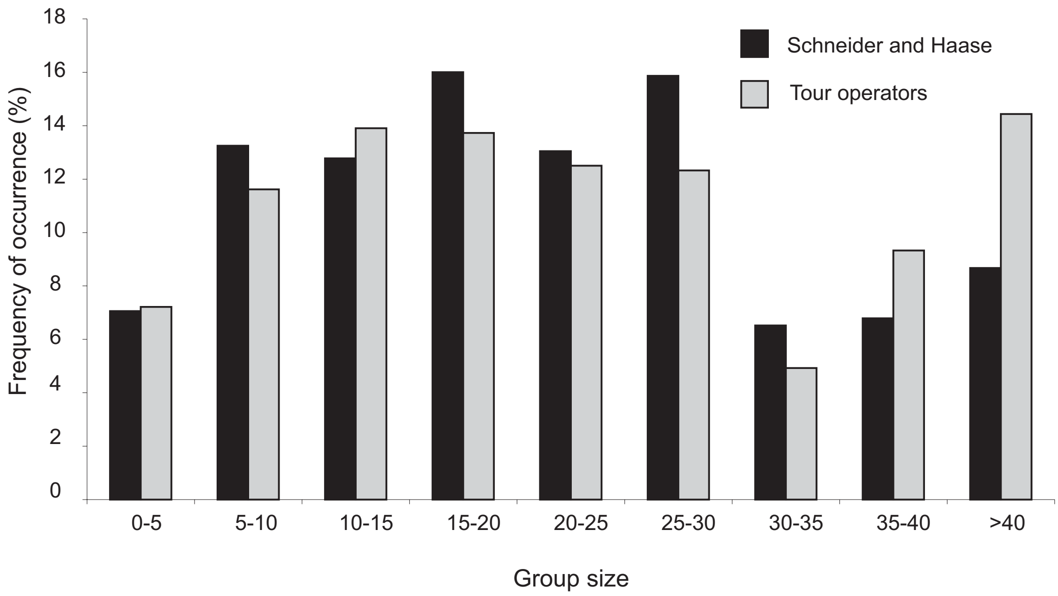

Figure 26. Comparison of group size frequency distributions between estimates of Schneider and Haase (1994–97 and 1999) and of tour operators (1996–99).

strates that tour operators were not able to estimate accurately the size of groups containing more than 25 individuals.

4. Discussion

4.1 OBSERVER BIAS AND SAMPLING EFFORT

The sighting network was an efficient way to gather data both at both large and small scales over an extended period of time. Moreover the data collected were in general agreement with results from standard sampling techniques applied in another study in Doubtful Sound (Schneider 1999). It can therefore be concluded that the spatial information gathered by that the sighting network is reliable. However this study shows that group size could not be reliably estimated if there was more than 25 individuals in the group. This bias in the estimation of the size of large group did not affect the estimation of the median group size. The median estimated from the sighting network data was in agreement with Schneider (1999) and Haase (2000) findings. The inequality in temporal sampling effort was the most notable disadvantage of this sampling technique. This could be remedied by involving more diverse observers, particularly those active when tourism activities are low.

Inconsistency in data collection was also a problem with the sighting network. Calving seasons could not be estimated because the occurrence of calves in a group was not consistently recorded (within and among observers). The movement of the animals was another piece of information that, even though it did not require much experience from observers, was not consistently reported. Despite these problems, it would still be very useful to continue to collect these data. Quality can be increased to a reliable level with a minimum of training of observers. Two studies relying on observers to collect data should that the precision of data collection was increased by training of the observers, as well as by increasing their experience (Miller & Death 1996; Kendall et al. 1996). Moreover, short-term double-blind tests would allow an assessment of the efficiency of the training by monitoring the consistency in data collection.

4.2 INFREQUENTLY OBSERVED SPECIES

The presence of humpback whales along the Fiordland coastline is not surprising, as they were once abundant in New Zealand waters. Conversely, the timing of some of the sightings made by the sighting network seemed to contradict the accepted species migration pattern. One sighting occurred in July when whales were supposedly at their feeding ground in Antarctic waters. Another sighting, which included a calf, was made in January when whales tend to be at their breeding ground. Gibbs & Childerhouse (2000) reported fewer than 5 sightings of humpback whales in New Zealand waters in January over a 30-year period. That represented 3.2% of all the sightings reported, while most observations were recorded between May and September (Gibbs & Childerhouse 2000). Misidentification cannot be disregarded as an explanation for these sightings, but the inter-observer consistency in identification and the ease of identification of this species render it highly improbable. These ‘stray’ sightings support Gaskin’s hypothesis (1968) that the migration pattern of the population of humpback whales New Zealand waters was disrupted by over-exploitation. It is also likely that the generalised migration pattern is an oversimplification. Identifying individual humpback whales encountered in Fiordland would be very helpful in determining whether they have any site fidelity in this area. If the same whales were seen coming back to this coast every year it would be important to understand the purpose of their presence in Fiordland waters.

The two records of long-finned pilot whales were the first in Fiordland, even though numerous strandings of this species have occurred both north and south of the Fiordland coastline (Gaskin 1968). Pilot whales tend to be pelagic and are often observed in large groups; they are especially known for their mass strandings. The observation of small groups or solitary animals is uncommon and most likely can be classified as stray sightings. More observations are required to see if these sightings are repeated over time. Similarly the sighting of a minke whale in Doubtful Sound was most likely a lost individual coming from offshore. The species identification was confirmed by a whale expert that happened to be onboard the tour boat at the time and therefore misidentification is not probable. This is the first recorded sighting of minke whale in Fiordland.

Meso-pelagic species (common and dusky dolphins) tended to spend more time in an area West of the Gut when present in Doubtful Sound. The particular oceanographic and topographic features at this location may result in a greater abundance of resources or an increase in foraging efficiency. The restriction between Bauza and Secretary islands (Fig. 2) may make it easier for marine predators to trap prey against the tidal flow.

4.3 MILFORD SOUND

Little was known about cetaceans present in Milford Sound before the sighting network was established. Many questions still await answers, but important conclusions can be made from the first three years of survey.

4.3.1 Bottlenose dolphin

Bottlenose dolphins were present year-round in Milford Sound. The home range of these dolphins clearly extends beyond Milford Sound, as their sighting frequency within the Sound varies over time. The temporal pattern of their presence is still unresolved, but they tend to be more common during warmer months. The home range of other studied bottlenose dolphin populations is in the vicinity of 100 km^2 (Wells et al. 1988; Wilson et al. 1997; Schneider 1999). It is therefore likely that Milford Sound alone cannot support a resident population of bottlenose dolphins and that several fiords would be required to meet their energetic and spatial requirements.

Tour operators reported seeing bottlenose dolphins repeatedly feeding on yellow-eyed mullet by herding schools in small bays and trapping them against the rock wall of the fiord. This may explain the apparent preference for the middle northern shore of Milford Sound. This shoreline contains many cusps and bays, which may facilitate predation, while the southern shore is more even. Dolphins also seem to prefer narrowing areas such as Dale and Copper Points (Figs 3 and 12). These places may also facilitate the capture of pelagic, schooling prey.

There were also reports from tour operators of bottlenose dolphins feeding on flounder, eels and trout. Most of these prey items (including yellow-eyed mullet) have life cycles with pelagic and freshwater phases (McDowall 1990). Their presence in Milford Sound is therefore dictated by these cycles and may be highly seasonal. More observations are required to detect any differences in habitat use that could be related to a seasonal shift in prey preference and availability.

Group size relates to behavioural state in bottlenose dolphin groups in other areas (Shane 1990; Lusseau et al. 1998). In Florida, bottlenose dolphins tend to travel in larger groups and feed in smaller groups. The fact that larger groups were observed at the entrance to Milford Sound suggests that bottlenose dolphins may use the middle portion of the fiord mainly for feeding, while they are likely to be in the process of travelling (in or out) when seen at the entrance of the fiord.

4.3.2 Dusky dolphin

The presence of dusky dolphins in Milford Sound was highly seasonal, with most of sightings during summer. The sighting pattern of dusky dolphins off Kaikoura is similar; dolphins come to within 1–3 km of shore during daytime in summer and tend to be sighted further offshore and in larger groups during winter (Barr & Slooten 1999). This pattern may be related to a need to protect newly born calves from offshore predation or to increase social interactions during the reproduction period, but more information is required to test these hypotheses.

Interestingly, dusky dolphins tended to avoid the deeper basin of Milford Sound and spent more time at the entrance (Fig. 4). Dusky dolphins off Kaikoura tend to feed at night, when their prey are present within 50–100 m of the surface (Würsig et al. 1997). These dolphins may not be deep-divers preferring to wait for their prey to come within reachable depths. A similar scenario may occur in Milford Sound, which could explain dusky dolphins' avoidance of the deeper area (Fig. 4) and the preference for the shallower entrance basin. Once again more data are required before habitat use of dusky dolphins in Milford Sound can be fully understood.

Dusky dolphins tended to be observed in large groups, which is normal for this species. More observations are necessary to determine whether group size varies with their location in the fiord.

4.3.3 Interaction between dusky and bottlenose dolphins

There were reports from tour operators of dusky dolphins actively avoiding bottlenose dolphins when both species were simultaneously present in Milford Sound. However, mixed schools of these two species were also encountered. The interaction between these two dolphins remains unclear, even though there seems to be a tendency for them not to be seen at the same time in Milford Sound. Dusky and bottlenose dolphins may feed on different prey species, and the spatial abundance of these may determine which species of dolphin is present. It can also be hypothesised that the presence of one species of dolphin may impair the foraging ability of the other and therefore displace that species. This is the case with sympatric populations of orcas where transient and resident orcas are rarely observed in the same area at the same time (Baird & Dill 1995). Resident orcas mainly feed on fish and have developed highly specialised vocalisation patterns to co-operate during foraging bouts. Transient orcas mainly feed on other marine mammals that are able to detect orca vocalisations. Transient orcas are silent during hunting to avoid being detected by their prey. The presence of resident orcas therefore makes it difficult for transient orcas to feed, as their prey are alerted by the vocalisations of the residents. Similar differences may exist between dusky and bottlenose dolphins; for example, some fish species may be more sensitive to bottlenose dolphin vocalisations, these same fish being the preferred prey of dusky dolphins.

4.4 DOUBTFUL SOUND

Observations in Doubtful Sound agreed with results from previous research (Schneider 1999). Bottlenose dolphins can be observed year-round and tend to spend more time in the arms of the fiord during warmer months and in the main body of the fiord during colder months. Dusky dolphins are seen infrequently throughout the fiord.

4.5 BOTTLENOSE DOLPHIN GROUP SIZE IN MILFORD, DOUBTFUL, AND DUSKY SOUNDS

Bottlenose dolphins are often encountered in Dusky and Breaksea Sounds (Fig. 11) and this fiord system may support a resident population. When comparing group size of bottlenose dolphins in this fiord with those in Doubtful and Milford Sounds, it is found that the largest fiord (Dusky/Breaksea Sound) seems to have the smallest median group size. This could be due to a biased sampling effort and a limited sample size (i.e. number of trips) in Dusky Sound compared with the two other fiords. Group size is related to spatial location (see above) so, without an equal sampling of most parts of the fiord (e.g. arms and main body, inner and outer fiord) it is not possible to draw conclusions about differences in group size. A better understanding of the spatial use of Dusky Sound by tour operators is needed.

In Milford and Doubtful Sounds, observed group size fits the theory that the size of the group depends on the occupied habitat: the greater the depth and/or the openness of the area, the larger the school (Norris & Dohl 1980).

5. Conclusions and recommendations

There is still much information that needs to be gathered on cetaceans utilising Fiordland. Cetaceans are one of the most important natural resources of Fiordland. They affect, and are affected by, all user groups present in this unique region. Their link to non-consumptive users is evident since they are one of the main reason tourists cruise the fiords. As key species in the local ecosystem cetaceans are also indirectly related to consumptive user groups. Much information on cetaceans can be gathered by the established sighting network, and it appears to be relatively efficient and reliable. However, there is also a need to answer specific questions that will require more standard methodology. For example, managing the potential effects of tourism requires a better understanding of the detailed ecology of bottlenose dolphins in Milford Sound, including population size, their residency pattern and their foraging ecology. It is also important to understand why dusky dolphins visit Milford Sound. Do they visit during summer months because of prey availability or to provide a protective area for their calves? Where do they spend the rest of the year? Finally a better understanding of how humpback whales use Fiordland waters would be useful. Do the same individuals come back every year? How do they utilise Fiordland? Are humpback whales seen just stray individuals taking a rest on their migrations? Do the same individuals spend a long period in the same area? Can they be related to humpback whales seen on nursery grounds? Increased collaboration between the scientific community carrying formal studies in Fiordland and the tour boat sighting network will improve the amount and quality of data available on cetaceans in Fiordland.

This study raised several issues concerning the tour operator-sighting network, which can be remedied to improve the quality of the data gathered. Here are recommendations to help improve the sighting record quality.

Diversification of the observers involved in the network

Diversification will help to increase the sampling effort during the winter season and increase the sampling effort of Fiordland coastline outside Milford and Doubtful Sounds. Fishing charter operators, professional fishermen, and helicopter and plane pilots would be good candidates to join the sighting network.

Photo-identification

Observers of the sighting network are more prone to encounter infrequently seen cetacean species. They should therefore be encouraged and trained to contribute photo-identifications of individual whales and dolphins encountered.

New sighting sheet

A new sighting sheet (similar to the one proposed in Fig. 27) needs to be established to eliminate the confusion of what should be recorded. It is also necessary to clarify group size classes. The new sighting sheet needs to enable observers to systematically record:

- The size of the group (group size estimation should not go beyond 25 individuals)
- The presence of calves in the group
- Effort (whether cetaceans were sighted or not)
- Movement of the group

Training

An information seminar would benefit observers willing to join the sighting network. The seminar could be designed as a one-day forum and the following issues could be raised:

- How to recognise calves and juveniles from adults
- How to record effort
- How to photo-identify cetaceans
- Estimation of the size of large groups of cetaceans
- Familiarisation with the sighting sheet
- How to identify whales and dolphins

Feedback

Every year a meeting could be held or a report could be sent to every observer taking part to the sighting network. Such a document would explain the progress made in the year by the network and how the data gathered has been utilised. This feedback is necessary to maintain the interest, and therefore the reliability, of the observers.

Double-blind test for quality control

Once a year a double-blind test could be run in a random location within the sampled area (i.e. Fiordland). The goal of the test would be to determine the

This sheet needs to be filled in every day. One sheet per day.

VESSEL: ………………………… **OBSERVER**: ………………………..

DATE: …………………………

Did you observe any dolphin/whale today? Yes No (circle one)

CETACEAN SIGHTINGS: Note the species

1	Time/ Species	……………………………….
	group size (circle one range)	0-5 5-10 10-15 15-20 20-25 >25
	calf present?	Yes No (circle one) How many?:…………..
2	Time/ Species	……………………………….
	group size (circle one range)	0-5 5-10 10-15 15-20 20-25 >25
	calf present?	Yes No (circle one) How many?:…………..
3	Time/ Species	……………………………….
	group size (circle one range)	0-5 5-10 10-15 15-20 20-25 >25
	calf present?	Yes No (circle one) How many?:…………..
4	Time/ Species	……………………………….
	group size (circle one range)	0-5 5-10 10-15 15-20 20-25 >25
	calf present?	Yes No (circle one) How many?:…………..
5	Time/ Species	……………………………….
	group size (circle one range)	0-5 5-10 10-15 15-20 20-25 >25
	calf present?	Yes No (circle one) How many?:…………..

Mark location where cetaceans were first seen (**with a x**). Place the **sighting number** (from the table) next to the cross. Indicate with an **arrow** the direction the animals are moving.

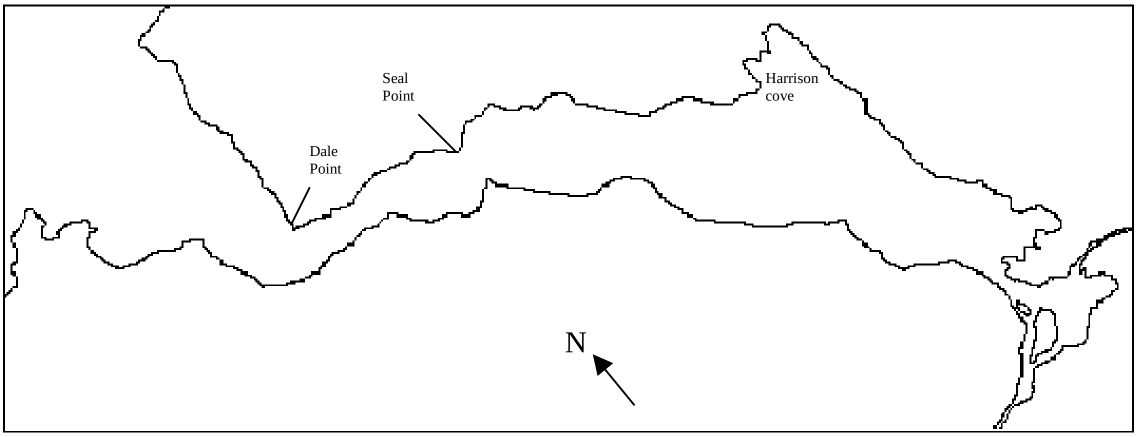

Figure 27. Suggested improvements for datasheet distributed in Milford Sound. A 'comments' section will also be present at the bottom of the sheet.

precision and accuracy of the sighting network by using standard sampling methods. In a location where sampling is known to occur, an independent vessel would run a series of strip transects looking for cetaceans. Every time a cetacean group was encountered, similar information that gathered by the network would be recorded. Both sets would later be compared.

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