

## Sighting Records of Small Cetaceans in the Southern Hemisphere

By

**Nobuyuki MIYAZAKI**

Department of Zoology, National Science Museum, Tokyo

and

**Hidehiro KATO**

Whales Research Institute, Tokyo

**Abstract** Eight species of Delphinidae (*Orcinus orca*, *Lagenorhynchus cruciger*, *Lagenorhynchus obscurus*, *Globicephala melaena*, *Delphinus delphis*, *Stenella coeruleoalba*, *Lissodelphis peronii*, and *Grampus griseus*) and two species of Ziphiidae (*Berardius arnuxii* and *Hyperoodon planifrons*) were sighted during the minke whale assessment cruises in the Southern Hemisphere for three seasons, 1978/79, 1979/80 and 1980/81. Geographical distribution, relative density, school size, surface water temperature at sightings and characteristic behavior of the above ten species were examined in the present study. Killer whales and beaked whales were concentratedly sighted along the ice edge of 60-70°S and in the Ross Sea. Apparent segregation between killer whales and beaked whales were observed in their overlapped areas, and the former whales showed higher density in the Ross Sea than the latter. Both long-finned pilot whales and hourglass dolphins were sighted in the north and south of the Antarctic Convergence like killer whales and beaked whales. On the other hand, other five delphinid species were found only in the north of the Antarctic Convergence. Most of beaked whales (71.5%) were sighted in solitary or pair, although delphinid species were composed of relatively larger school of several animals to about one thousand animals. Seven types of multi-species combination were observed as follows: 1) killer whales and minke whales, 2) long-finned pilot whales and minke whales, 3) long-finned pilot whales and southern right whale dolphins, 4) beaked whales and minke whales, 5) hourglass dolphins and fin whales, 6) killer whales and humpback whales, 7) long-finned pilot whales, southern right whale dolphins and hourglass dolphins.

### Introduction

In the Antarctic Ocean, there has been reported sporadic catch and sighting records of small cetaceans (GASKIN, 1968; BROWNELL, 1974; BEST, 1980; LEATHERWOOD, TODD, THOMAS & AWBREY, 1982; ROSS, 1984). BROWNELL (1974) reviewed the distribution of ten species of small cetaceans (*Lagenorhynchus cruciger*, *Lagenorhynchus obscurus*, *Lagenorhynchus australis*, *Cephalorhynchus commersonii*, *Lissodelphis peronii*, *Globicephala melaena*, *Orcinus orca*, *Phocoena dioptrica*, *Hyperoodon plani-*

*frons*, and *Berardius arnuxii*) in the Antarctic Ocean and discussed their geographic speciation. He concluded that the following six genera, *Globicephala*, *Berardius*, *Lissodelphis*, *Hyperoodon*, *Phocoena*, and *Lagenorhynchus* are considered to be antitropical with allopatric species or population. BEST (1980) reported the sightings of killer whales, hourglass dolphins, long-finned pilot whales and beaked whales in Area IV (120°E to 180°) of the Antarctic during the Southern Hemisphere minke whale assessment cruise, 1978/79. LEATHERWOOD *et al.* (1982) reported sighting records including small cetaceans in southern sea and analyzed group size and indices of abundance of cetaceans.

Distribution of small cetaceans is one of the most important factors for understanding their ecological aspect in the Antarctic Ocean. However, little systematic study on their distribution has been made in the Southern Hemisphere compared with those of large cetaceans.

In the present study, distribution of small cetaceans in the Southern Hemisphere is undertaken to be analyzed based on the sighting informations of the three Southern Hemisphere minke whale assessment cruises under the International Decade of Cetacean Research (IDCR), from 1978/79 to 1980/81 season.

### Materials and Methods

The present sighting cruises for small cetaceans in the Southern Hemisphere were made in the summer season (middle of December to middle of February) in three international Southern Hemisphere minke whale assessment cruises in 1978/79, 1979/80 and 1980/81 season. In these three seasons, two Japanese scouting vessels were conducted for the sighting of minke whales and other cetaceans. In the last season, 1980/81, another Russian scouting vessel was also conducted for both the sighting of cetaceans and the marking on minke whales. The cruise tracks of scouting vessels are shown in Figs. 1, 2 and 3.

The analyses on sighting records of small cetaceans were made from all sighting data collected by the Japanese and Russian scouting vessels, while for the analysis of density of small cetaceans the informations collected from only Japanese scouting vessels were used because the effort data of the Russian vessel were not equivalent to those of the Japanese vessel. In the Japanese vessels (12 knots in speed), searchings of cetaceans were usually made by one observer in the top barrel of the foremast, several scientists and crews in the upper bridge. When the weather permitted, sighting was usually made from 0400 to 2000 hours every day. Using the binoculars (7×50), the observer searched the cetaceans in 90° of either side from the course of the vessel. When the cetaceans were sighted, scientists recorded species, sighting time, sighting position, school size, angle from the ship course, estimated distance between vessel and animal, surface water temperature, weather and sea conditions, characteristic behavior, associated cetaceans and so on. The female with calf was identified as the adult size animal swimming together with smaller size animal at

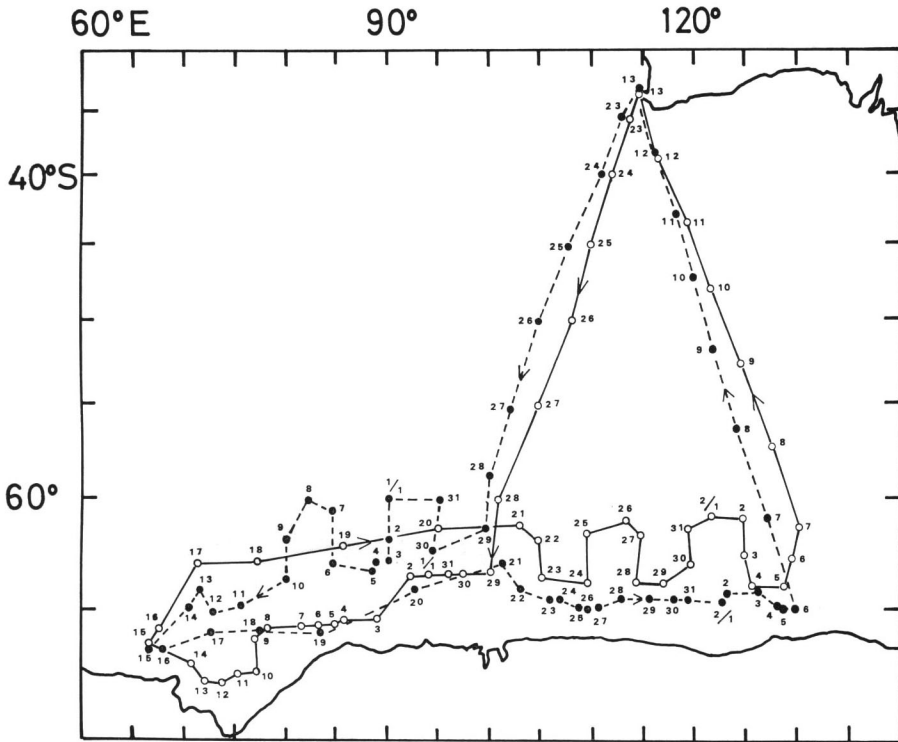


Fig. 1. Track chart of scouting vessels from 23 December 1978 to 13 February 1979. Open and closed circles are noon positions of the scouting vessel *Toshimaru 16* and *Toshimaru 18*, respectively. Solid and broken lines are track lines of the vessel *T16* and *T18*, respectively. Figures indicate date.

close distance.

In the calculation of density by  $5^{\circ}$ -square, total sighting efforts of a day were represented at noon position of the scouting vessel of the day. Thus, in the present analysis on the density of cetaceans, there were some cases that several sightings were recorded in the  $5^{\circ}$ -square area without sighting effort. In these cases, the fraction (number of individuals/number of schools) was specially shown in the square.

### Results and Discussion

Eight species of Delphinidae (*Orcinus orca*, *Lagenorhynchus cruciger*, *Lagenorhynchus obscurus*, *Globicephala melaena*, *Delphinus delphis*, *Stenella coeruleoalba*, *Lissodelphis peronii*, and *Grampus griseus*) and two species of Ziphiidae (*Berardius aunuxii* and *Hyperoodon planifrons*) were sighted in the present survey. Number of schools, number of animals, mean school size and density of small cetaceans are shown in each species (Table 1). Among the total 576 schools sighted during the

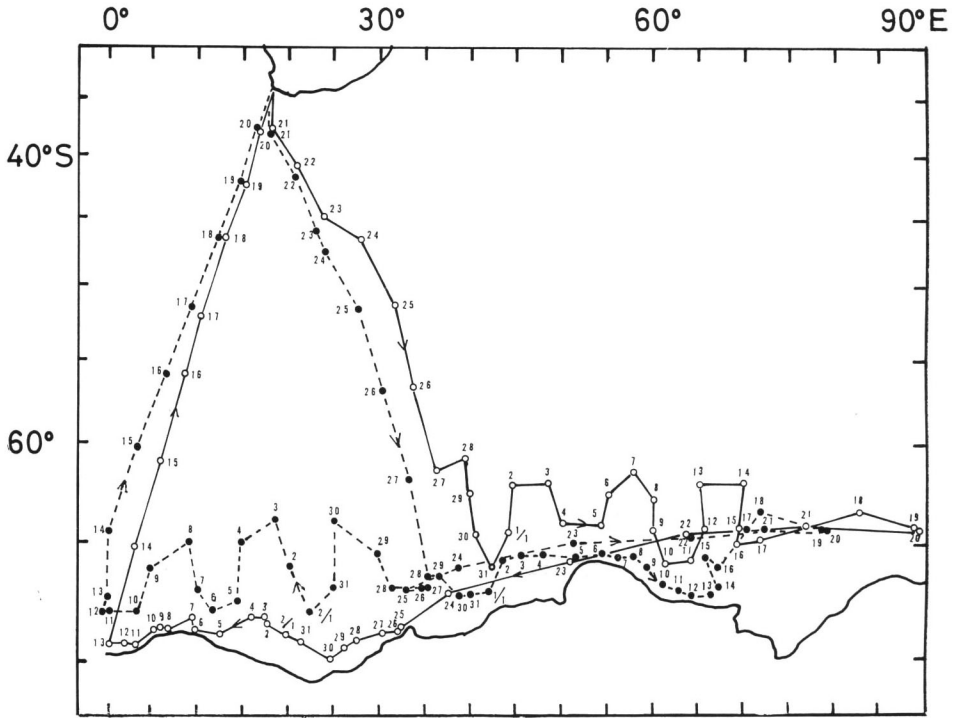


Fig. 2. Track chart of scouting vessels from 21 December 1979 to 20 February 1980. Open and closed circles are noon positions of the scouting vessel *Toshimaru 11* and *Kyomaru 27*, respectively. Solid and broken lines are track lines of the vessel *T11* and *K27*, respectively. Figures indicate date.

survey, beaked whales comprised 56.8% of the total and were followed by *O. orca* (30.2%), *L. cruciger* (3.6%), *G. melaena* (3.5%), *D. delphis* (0.9%), *S. coeruleoalba* (0.5%), *L. peronii* (0.5%), *L. obscurus* (0.5%) and *G. griseus* (0.1%). The remaining 19 schools (3.3%) were composed of unidentified dolphins.

Percentage of number of animals in each species to the total was slightly different in the order from that of number of schools. *Orcinus orca* occurred in 36.2% of the total and was followed by *S. coeruleoalba* (20.9%), *G. melaena* (15.9%), beaked whales (8.7%), *L. cruciger* (4.7%), *D. delphis* (3.4%), *L. peronii* (1.1%), *L. obscurus* (0.2%) and *G. griseus* (0.1%). Among them, three species (*O. orca*, *G. melaena*, and *L. cruciger*) and beaked whales were mainly found in the south of 50°S.

### Sightings

*Beaked whales*: Two species of Ziphiidae, *Berardius arnuxii* and *Hyperoodon planifrons*, are distributed in the Antarctic waters (BROWNELL, 1974). Because it was

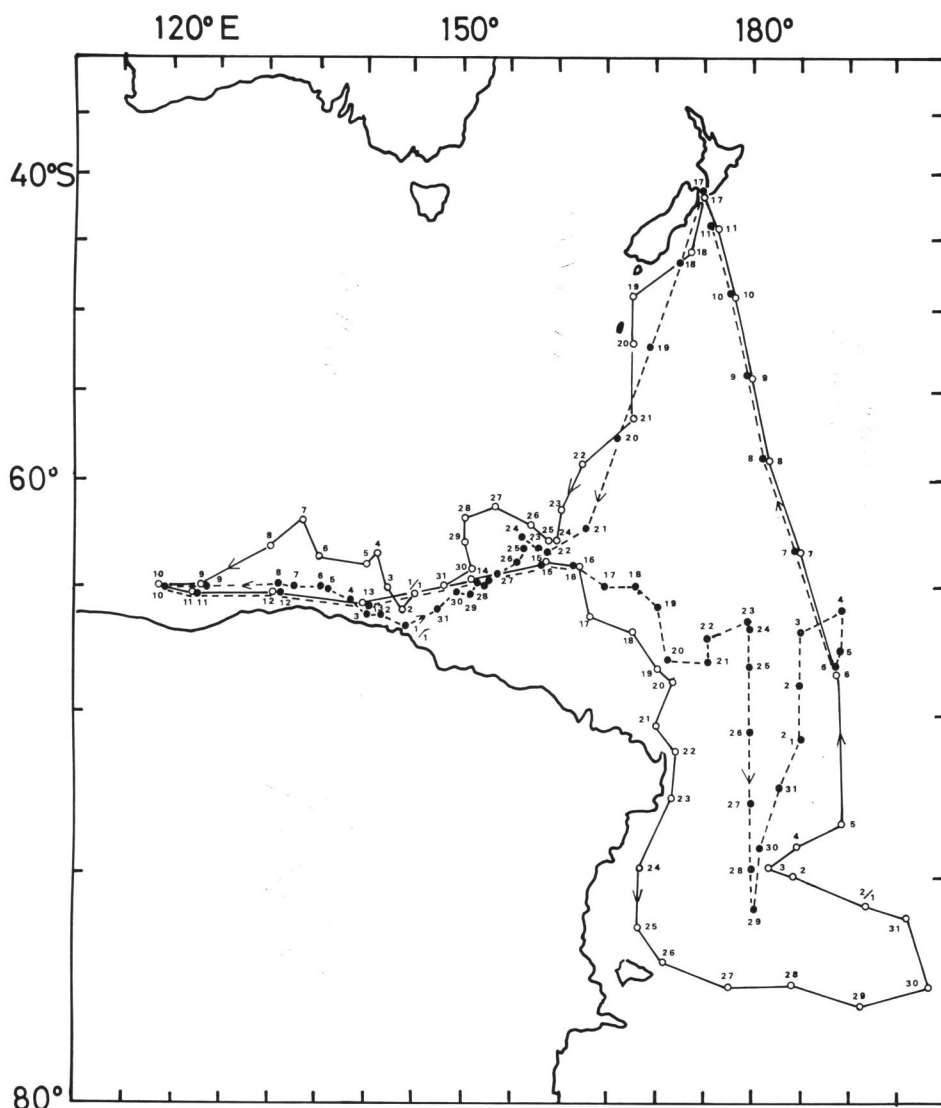


Fig. 3. Track chart of scouting vessel from 17 December 1980 to 11 February 1981. Open and closed circles are noon positions of the scouting vessel *Toshimaru 11* and *Kyomaru 27*, respectively. Solid and broken lines are tracklines of the vessel *T 11* and *K 27*, respectively. Figures indicate date.

not easy to distinguish *B. arnuxii* from *H. planifrons* at sea without closing to the animals, most of beaked whales (96.3%) were not identified to the species level in the present study. However, on some occasions when the vessel approached close enough to the animals for identification, eleven schools of *H. planifrons* and one school of

Table 1. Number of schools, number of individuals, mean school size and density of small cetaceans sighted from two Japanese scouting vessels in the Southern Hemisphere under IDCR for three seasons, 1978/79, 1979/80 and 1980/81.

Species	Latitude											Total	
	35°S-	40°S-	45°S-	50°S-	55°S-	60°S-	65°S-	70°S-	75°S-				
<i>Stenella coeruleoalba</i>	No. of schools	3	0	0	0	0	0	0	0	0	0	0	3
	No. of individuals	1750	0	0	0	0	0	0	0	0	0	0	1750
	Mean school size	583.3	—	—	—	—	—	—	—	—	—	—	583.3
	Density*	1379.0	0	0	0	0	0	0	0	0	0	0	58.6
<i>Stenella</i> spp.	No. of schools	2	0	0	0	0	0	0	0	0	0	0	2
	No. of individuals	320	0	0	0	0	0	0	0	0	0	0	320
	Mean school size	160.0	—	—	—	—	—	—	—	—	—	—	160.0
	Density*	252.2	0	0	0	0	0	0	0	0	0	0	1.0
<i>Grampus griseus</i>	No. of schools	1	0	0	0	0	0	0	0	0	0	0	1
	No. of individuals	7	0	0	0	0	0	0	0	0	0	0	7
	Mean school size	7.0	—	—	—	—	—	—	—	—	—	—	7.0
	Density*	5.5	0	0	0	0	0	0	0	0	0	0	0.2
<i>Delphinus delphis</i>	No. of schools	1	3	1	0	0	0	0	0	0	0	0	5
	No. of individuals	250	27	4	0	0	0	0	0	0	0	0	281
	Mean school size	250.0	9.0	4.0	—	—	—	—	—	—	—	—	56.3
	Density*	19.7	23.2	3.6	0	0	0	0	0	0	0	0	9.4
<i>Lagenorhynchus obscurus</i>	No. of schools	0	1	2	0	0	0	0	0	0	0	0	3
	No. of individuals	0	11	7	0	0	0	0	0	0	0	0	18
	Mean school size	—	11.0	3.5	—	—	—	—	—	—	—	—	6.0
	Density*	0	9.5	6.3	0	0	0	0	0	0	0	0	0.6
<i>Lagenorhynchus cruciger</i>	No. of schools	0	0	2	4	4	6	5	0	0	0	0	21
	No. of individuals	0	0	5	27	55	79	230	0	0	0	0	396
	Mean school size	—	—	2.5	6.8	13.8	13.2	46.0	—	—	—	—	18.9
	Density*	0	0	4.5	23.7	36.9	6.0	28.6	0	0	0	0	13.3

<i>Lagenorhynchus</i> spp.	No. of schools	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	No. of individuals	0	0	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	Mean school size	—	—	5.0	2.5	—	—	—	—	—	—	—	—	—	—	—	—	—	3.8
<i>Lissodelphis peronii</i>	Density*	0	0	9.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	No. of schools	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	3
	No. of individuals	0	0	6	59	30	30	0	0	0	0	0	0	0	0	0	0	0	95
<i>Globicephala melana</i>	Mean school size	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	31.7
	Density*	0	0	5.4	51.7	20.1	20.1	0	0	0	0	0	0	0	0	0	0	0	3.2
	No. of schools	1	0	0	3	7	7	9	0	0	0	0	0	0	0	0	0	0	20
<i>Orcinus orca</i>	No. of individuals	5	0	0	105	343	343	878	0	0	0	0	0	0	0	0	0	0	1331
	Mean school size	5.0	—	—	35.0	49.0	49.0	97.6	—	—	—	—	—	—	—	—	—	—	66.6
	Density*	3.9	0	0	92.0	230.2	230.2	66.6	0	0	0	0	0	0	0	0	0	0	44.5
Beaked whales	No. of schools	2	0	0	0	3	3	75	38	12	16	16	16	16	16	16	16	16	146
	No. of individuals	11	0	0	0	16	16	770	892	1019	322	322	322	322	322	322	322	322	3030
	Mean school size	5.5	—	—	—	5.3	10.3	23.5	84.9	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.8
Unidentified dolphins	Density*	8.7	0	0	0	10.7	58.4	110.8	785.1	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	101.4
	No. of schools	4	6	7	4	13	13	176	108	1	1	1	1	1	1	1	1	1	320
	No. of individuals	12	10	12	9	29	29	395	252	5	5	5	5	5	5	5	5	5	729
Unidentified dolphins	Mean school size	3.0	1.7	1.7	2.3	2.2	2.2	2.2	2.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	2.3
	Density*	9.5	8.6	10.8	7.9	19.5	19.5	30.0	31.4	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	24.4
	No. of schools	3	0	4	4	1	1	1	0	0	0	0	0	0	0	0	0	0	13
Unidentified dolphins	No. of individuals	662	0	16	9	2	2	2	0	0	0	0	0	0	0	0	0	0	691
	Mean school size	220.7	—	4.0	2.3	2.0	2.0	2.0	—	—	—	—	—	—	—	—	—	—	53.2
	Density*	521.7	0	14.4	7.9	1.3	0.2	0	0	0	0	0	0	0	0	0	0	0	23.1

\* Density is indicated as number of individuals/10<sup>4</sup> nautical miles.

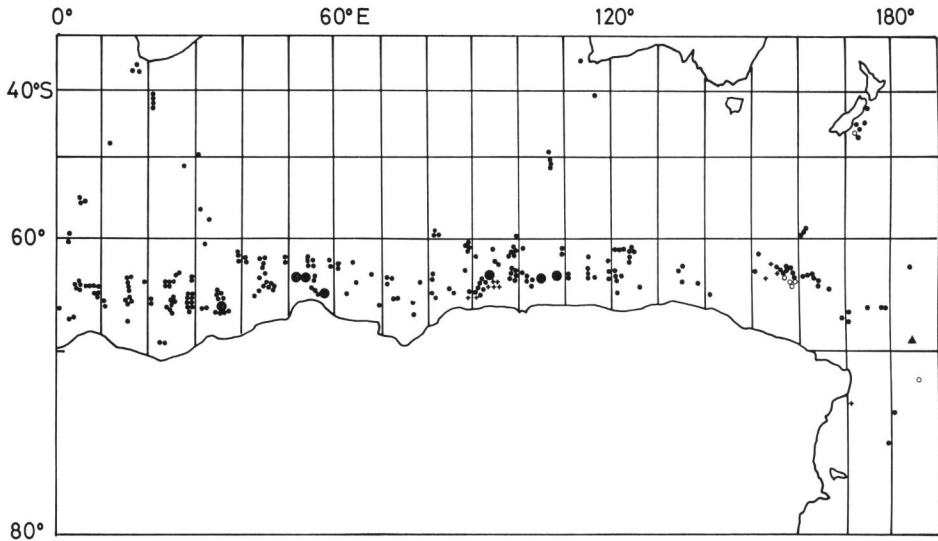


Fig. 4. Sighting positions of beaked whales recorded by the scouting vessels for three seasons, 1978/79, 1979/80 and 1980/81. Small closed circles indicate one school and large closed circles 10 schools. Double crosses indicate *Hyperoodon planifrons*, closed triangle *Berardius arnuxii*, and open circles beaked whales sighted by *Vdumchiviyi* 34.

*B. arnuxii* could be identified certainly by morphological characteristics such as the beak length, shape of head and both the shape and size of dorsal fin. The beaked whales were widely observed in the waters from 35°00'S to 75°50'S on latitude in the Southern Hemisphere (Fig. 4). Especially, many beaked whales (88.7% of the total) were concentratedly sighted in the south areas (60–70°S) of the Antarctic Convergence (Fig. 5). In the waters of 60–70°S in latitude, there were three longitudinal sectors, having larger number of schools, 0–60°E, 90–110°E and 150–170°E (Fig. 4).

Comparing the density (number of whales sighted per 10<sup>4</sup> nautical mile) by the area of each 5° in latitude (Table 1), the density of the beaked whales in the area of 60–70°N was higher than that of the other areas. The density was calculated by 5°-square area and were classified into the following 5 classes: 1) 0 individual / 10<sup>3</sup> nautical mile, 2) less than 1 individual / 10<sup>3</sup> n.m., 3) 1–9 individuals / 10<sup>3</sup> n.m., 4) 10–99 individuals / 10<sup>3</sup> n.m., and 5) 100 individuals or more / 10<sup>3</sup> n.m. (Figs. 6 and 10). Higher density area of beaked whales appears to be closely related with the ice pack zone along the Antarctica. Especially, the density was higher along the ice pack zone in the area of 60–70°S and 10–60°E, while in the innermost waters of the Ross Sea the density was lower.

The beaked whales formed smaller school ranged from one to ten animals (Fig. 7). Most of the beaked whales (71.5%) were found in solitary or pair. Among 327 schools observed, at least three pairs of female and calf were identified. Com-



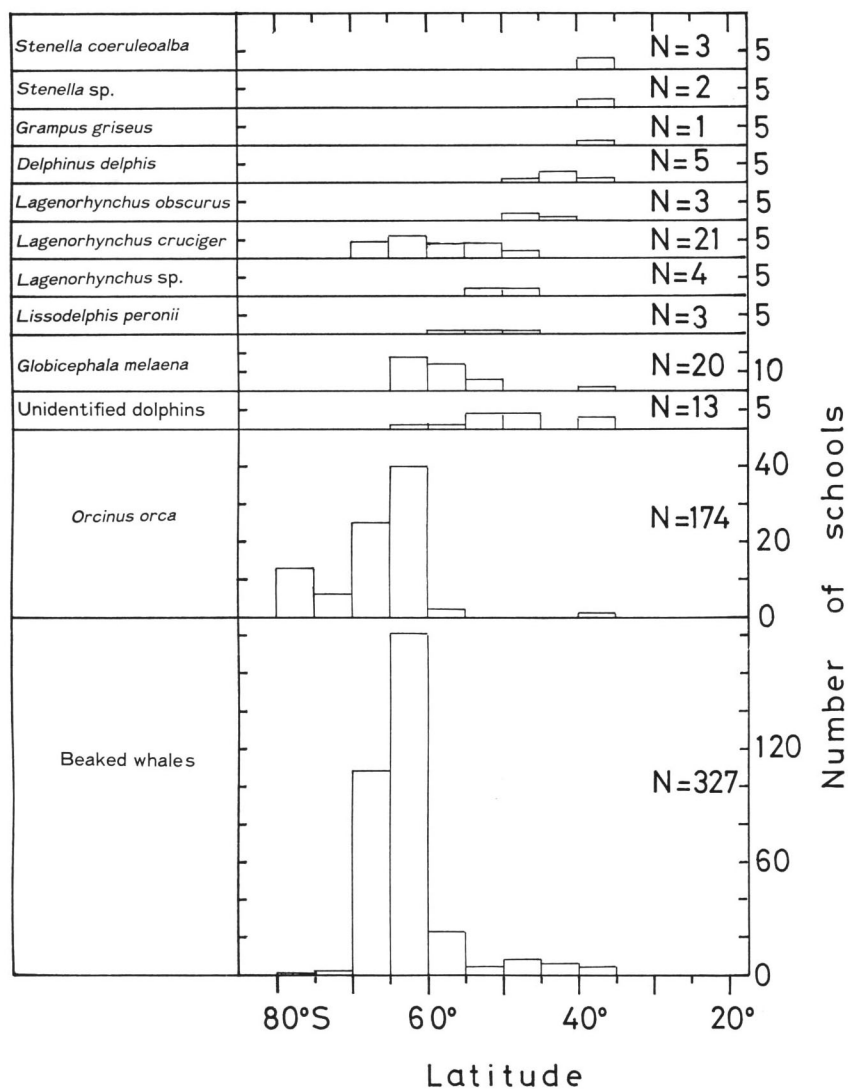


Fig. 5. Number of schools of small cetaceans by 5° latitude.

paring school size of the beaked whales in each 5°-square area, there was no significant trend between school size and locality.

The beaked whales were widely observed in the Southern Hemisphere, subsequently the surface water temperature of their sighting positions varied from -1.2 to 22.8°C (Fig. 8). About 90% of the beaked whales was sighted in the areas colder than 3°C in the surface water temperature.

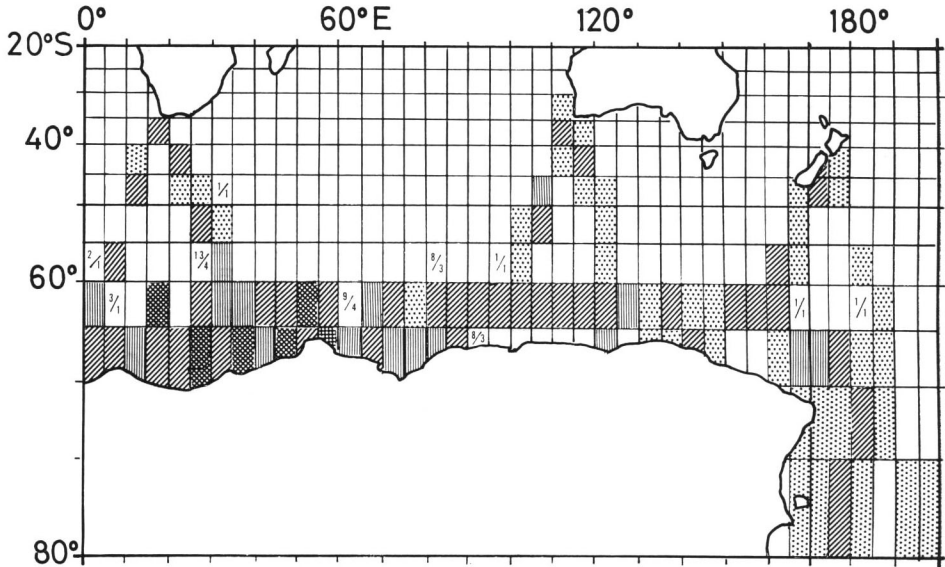


Fig. 6. Density of beaked whales by 5°-square is classified into four classes: 1) □: 0 individual / 10<sup>3</sup> nautical miles; 2) ▤: less than 1 individual / 10<sup>3</sup> n. m.; 3) ▥: 1-9 individuals/10<sup>3</sup> n. m.; 4) ▦: 10-99 individuals / 10<sup>3</sup> n. m. Fractions indicate number of individuals / number of schools in the area where sighting effort was not recorded.

*Orcinus orca*: Sightings of *Orcinus orca* are plotted in Fig. 9. The species was found in the waters of 37°03'S to 78°23'S in latitude and mainly found in the waters of south of 60°S, which was along the ice edge zone and in the innermost of the Ross Sea (Figs. 5 and 9). In the middle latitudes of the Southern Hemisphere, relatively few killer whales were sighted compared with those in the high latitudes (Figs. 9 and 10). This trend suggests that the killer whales in the higher sea areas are separate population from those of temperate and / or tropical waters in the Southern Hemisphere. Although both killer whales and beaked whales were concentratedly sighted along the ice edge zone, the former species appears to be found further close to the ice edge of the Antarctica compared with the latter. In the Antarctic waters of 60-80°S, there are three longitudinal sectors with larger number of schools, 50-80°E, 110-130°E and the innermost of the Ross Sea (Fig. 9). From above, killer whales apparently segregate from the beaked whales in the high latitudes of the Southern Hemisphere.

School size of killer whales were ranged from 1 to 345 individuals with a peak in 10-20 individuals (Fig. 7). The proportion of schools comprising 20 animals or less was 76.6% of the total schools. Single large adult male (2.9% of the total) was widely found in the high sea areas of the Southern Hemisphere and its occurrence showed no specific trend in distribution (Fig. 9). Comparing the ratio of number of

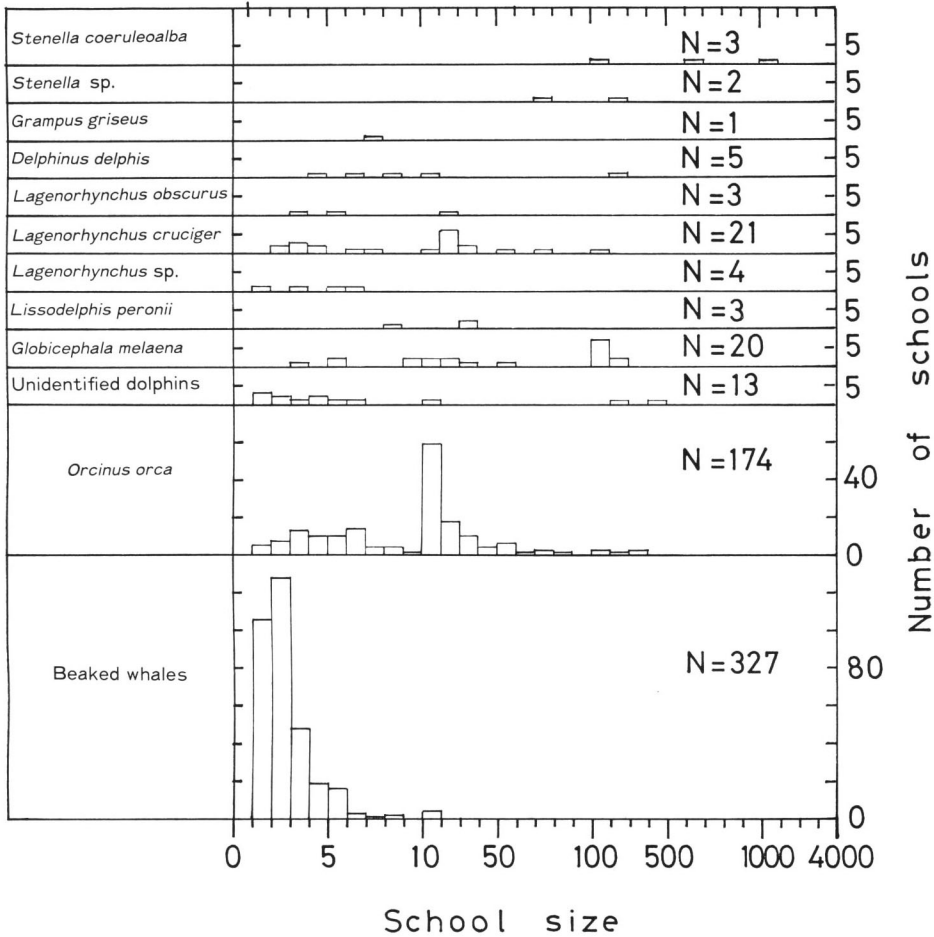


Fig. 7. School size frequency of small cetaceans.

schools more than 20 animals to the total schools among three sectors, 60–65°S, 65–70°S and 70–80°S in the Southern Hemisphere, the ratio becomes higher from 6.3% (N=80) in 60–65°S to 28.0% (N=50) in 65–70°S, and then to 44.7% (N=38) in 70–80°S with increase of latitude. This tendency is supported by the increase of mean school size with latitude (Table 1). Killer whales were widely sighted in the waters of -1.7 to 21.5°C in the surface water temperature (Fig. 8). Most of schools (97.8%) were sighted in the waters colder than 3°C in surface water temperature. From these informations, it is concluded that relatively large school of killer whales are concentratedly observed in the cold waters along the ice edge zone or ice shelf of the Antarctica where density of the species is higher.

*Stenella coeruleoalba*: All three sightings of *Stenella coeruleoalba* were made

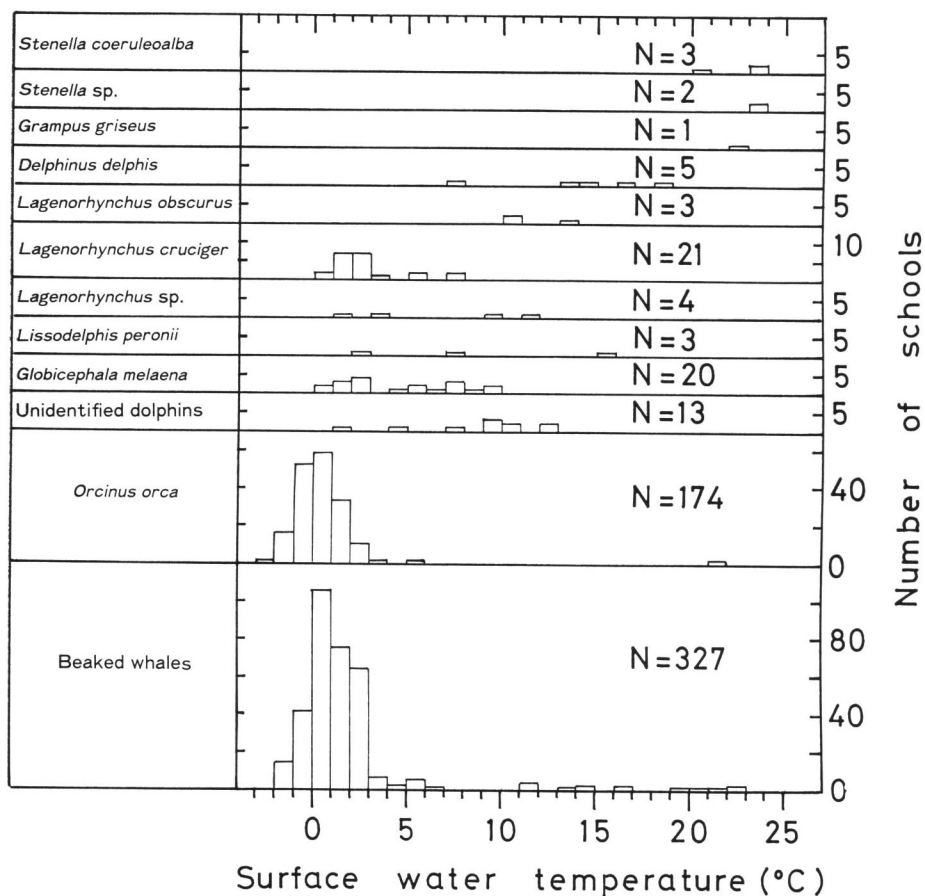


Fig. 8. Number of schools of small cetaceans in each surface water temperature ( $^{\circ}\text{C}$ ).

off Cape Town in the 1979/80 season. The striped dolphins were sighted in the waters from  $37^{\circ}31'$  to  $38^{\circ}13'S$ , while no sighting was recorded in the waters of the south of the Antarctic Convergence (Fig. 11). All sightings were made in the waters warmer than  $20^{\circ}\text{C}$  (Fig. 8). School size of the species was ranged from 100 to 1000 animals (Fig. 7).

*Grampus griseus*: One school of *Grampus griseus* composed of 7 individuals was sighted in the warm water of  $22.4^{\circ}\text{C}$  ( $37^{\circ}14'S$ ,  $18^{\circ}27'E$ ) off Cape Town on 21 December 1979 and it was not found in the waters of south of the Antarctic Convergence as well as *S. coeruleoalba* (Fig. 11).

*Delphinus delphis*: Five sightings of *Delphinus delphis* were made during three seasons, 1978/79, 1979/90 and 1980/81. The species was found in the waters north of  $50^{\circ}\text{S}$  ( $40^{\circ}50'$  to  $48^{\circ}51'S$ ), ranging from 7 to  $19^{\circ}\text{C}$  in surface water tempera-

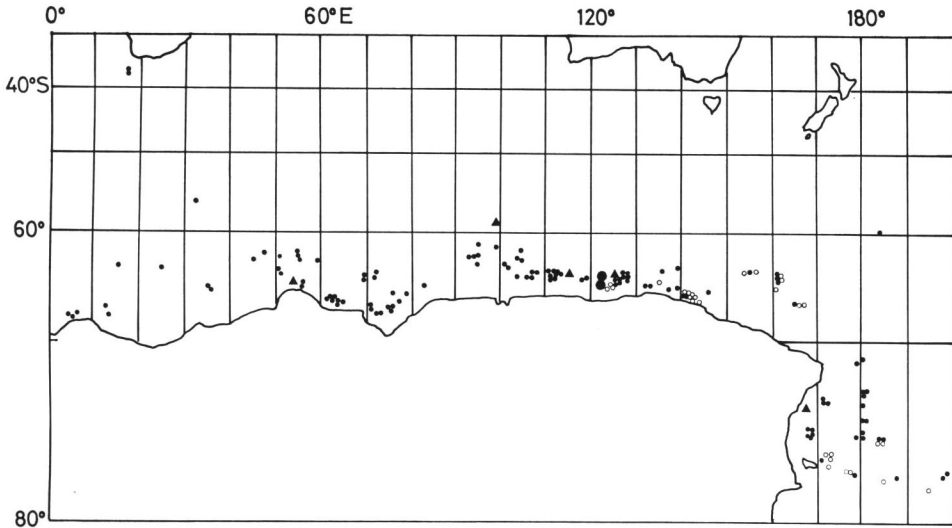


Fig. 9. Sighting positions of killer whales recorded by the scouting vessels for three seasons, 1978/79, 1979/80 and 1980/80. Small closed circles indicate one school and large closed circles 10 schools. Open circles indicate killer whales sighted by *Vdumchivyi 34*. Closed triangles indicate single adult male.

ture, but not in the waters south of the Antarctic Convergence (Fig. 11). As most of sightings (80%) were made in the waters warmer than 13°C in the surface water temperature (Fig. 8), the species is considered to be distributed in the temperate waters. However, the common dolphins were found in the comparatively colder waters as compared with previous two species, *S. coeruleoalba* and *G. griseus*. One school of 200 animals was sighted close to the coast, while other four schools (4 to 12 animals) were sighted offshore.

*Globicephala melaena*: In the present study, all of pilot whales sighted in the Antarctic Ocean were dealt here as *Globicephala melaena* although it was too difficult to accurately identify whether the pilot whales sighted off Cape Town were *G. melaena* or *G. macrorhynchus*. The species sighted in the Antarctic showed the characteristic color pattern, a prominent white post-ocular blaze and a white saddle behind the dorsal fin. The sightings of the species ranged from 38°24' to 64°24'S (Fig. 11). Most of long-finned pilot whales (95% of the total) were sighted in the colder waters of 50–65°S (Fig. 5), where surface water temperature ranged from 0.6 to 9.0°C (Fig. 8). However, the species was not found in the innermost of the Ross Sea. In the 50–65°S areas, many schools of long-finned pilot whales were found in the two areas, 90–130°E and 160°E–170°W, while in the areas of 0–90°E only one school was found (Fig. 11). The species was found in the waters both north and south of the Antarctic Convergence, and its density was obviously higher in the southern waters than the

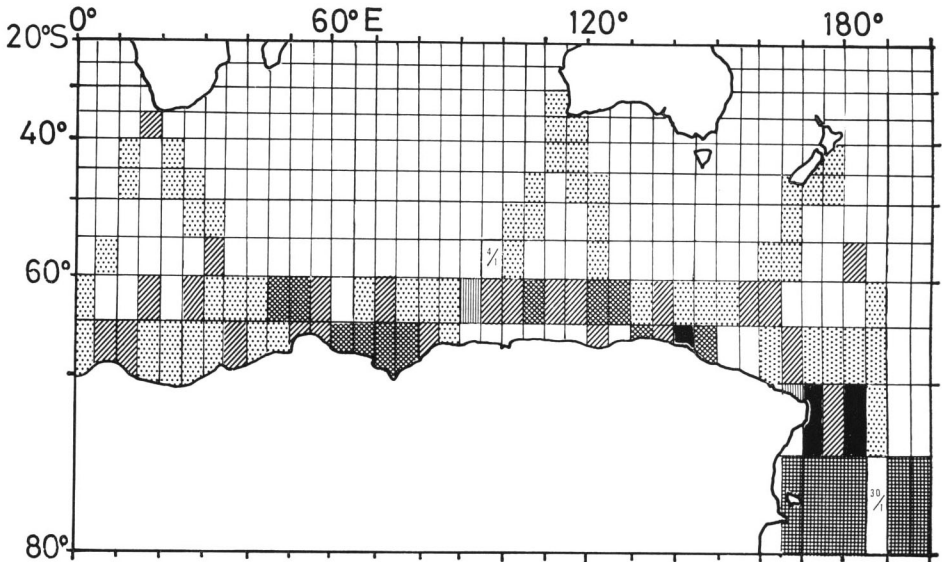


Fig. 10. Density of killer whales by 5°-square. ■: more than 100 individuals/ $10^3$  nm.; for other marks see Fig. 6.

northern (Table 1). School size of the species ranges from 3 to about 200 animals. The school of 100 animals or more comprised 45.0% of the total (Fig. 7). Among 13 schools examined in detail it is observed that about 70% of nine schools contained the adult female with calf.

*Lissodelphis peronii*: Three sightings of *Lissodelphis peronii* were made in two seasons of 1979/80 and 1980/81 seasons. All of them were sighted together with other cetaceans, both long-finned pilot whales and hourglass dolphins, fin whales, and long-finned pilot whales (Table 2). Southern right whale dolphins were sighted in both temperate and colder waters of 45°06'–57°47'S ranging from 7 to 15°C in the surface water temperature (Figs. 8 and 11). All of the school sighted were composed of less than 40 animals (Fig. 7).

*Lagenorhynchus obscurus*: All three sightings of *Lagenorhynchus obscurus* were made off New Zealand in the 1980/81 season. Sighting positions ranged from 43°48' to 49°20'S (Fig. 11). One male dusky dolphin of 173 cm in body length was collected at 49°06'S, 166°29'E on 19 December 1980. The skeleton of this specimen was deposited in the National Science Museum of Japan (Museum no. M23652). Surface water temperature of these sightings ranged from 10.4 to 13.9°C (Fig. 8) and it is almost similar to that of *D. delphis*. School size of dusky dolphins was from 2 to 20 animals (Fig. 7).

*Lagenorhynchus cruciger*: *Lagenorhynchus cruciger* was sighted in the colder waters (0.6 to 7.9°C at the surface water temperature), ranging from 46°29' to 67°38'S (Figs. 8 and 11). Most of the hourglass dolphins (90.5%) were sighted in the waters

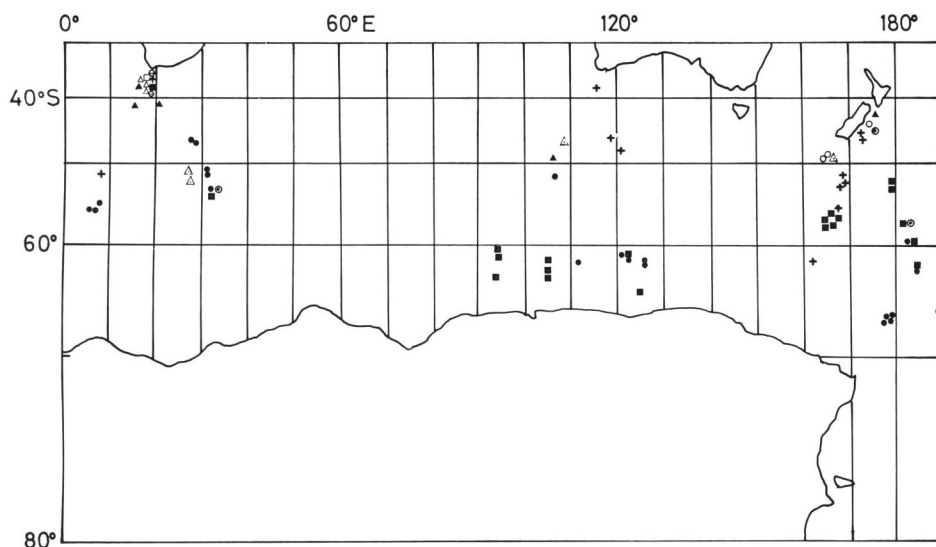


Fig. 11. Sighting positions of small cetaceans found by the scouting vessels for three seasons, 1978/79, 1979/80, and 1980/81. Open squares indicate *Grampus griseus*, closed squares *Globicephala melaena*, open circles *Lagenorhynchus obscurus*, closed circles *Lagenorhynchus cruciger*, open triangles *Stenella coeruleoalba*, closed triangles *Delphinus delphis*, open circles including spot *Lissodelphis peronii*, open circles including bar *Stenella* spp., open triangle including spot *Lagenorhynchus* spp., and double crosses unidentified delphinid species.

of 50–70°S (Fig. 5). The dolphins were sighted in the both north and south waters of the Antarctic Convergence as well as *G. melaena*. As the species was found along the floating ice but not inside it, it is considered that one of the limited factors of southern area for distribution of *L. cruciger* might be the floating ice. The behavior of the species which did not enter inside the floating ice was also observed in *G. melaena*, while *O. orca* was sometime entered into it. The hourglass dolphins formed a various school size ranging from 2 to about 100 individuals (Fig. 7). In the 21 schools sighted in the present survey, about one half of schools were from 10 individuals or less. The species seems to form relatively smaller school than *G. melaena*. In the 16 schools observed in detail, only one school (6.3% of the total) of 6 hourglass dolphins contained a pair of adult female and calf. These school compositions of the species were greatly different from those of *G. melaena*.

Although BROWNELL (1974) reported that the sightings of hourglass dolphins have been made north and south of the Antarctic Convergence in the Southern Hemisphere except for the Indian Ocean, in the present study considerable number of hourglass dolphins were observed in the colder waters south and north of the Antarctic Convergence in the Southern Hemisphere including the Indian Ocean. From these informations, it can be concluded that the hourglass dolphins are

Table 2. Multi-species combinations sighted in the Antarctic Ocean under IDCR for three seasons, 1978–79, 1979–80 and 1980–81.

Date	Position	Surface water temperature (°C)	School size	Remarks
13 Jan. '79	67°50'S, 72°48'E	1.4	5	Killer whales (20%) and minke whales (80%)
22 Jan. '79	62°38'S, 105°04'E	2.2	104	Long-finned pilot whales (96%) and minke whales (4%)
1 Feb. '79	64°39'S, 123°10'E	-0.4	75	Killer whales (25%) and minke whales (75%)
2 Feb. '79	64°24'S, 123°24'E	1.6	9	Killer whales (67%) and minke whales (33%)
4 Feb. '79	64°01'S, 127°59'E	1.6	12	Killer whales (83%) and minke whales (17%)
25 Dec. '79	53°06'S, 31°58'E	2.9	143	Long-finned pilot whales (56%), right whale dolphins (41%) and hourglass dolphins (3%)
29 Jan. '80	65°36'S, 29°51'E	0.6	3	Beaked whales (67%) and minke whales (33%)
16 Feb. '80	56°00'S, 7°43'E	1.1	31	Hourglass dolphins (81%) and fin whales (19%)
4 Jan. '81	66°18'S, 140°57'E	0.5	46	Killer whales (13%) and minke whales (87%)
4 Jan. '81	66°18'S, 140°57'E	0.5	75	Killer whales (33%) and minke whales (67%)
6 Jan. '81	65°04'S, 133°32'E	-0.4	50	Killer whales (96%) and humpback whales (4%)
30 Jan. '81	73°58'S, 179°20'W	-0.3	22	Killer whales (91%) and minke whales (9%)
30 Jan. '81	73°50'S, 179°19'W	-0.3	80	Killer whales (97%) and minke whales (3%)
8 Feb. '81	57°47'S, 178°48'W	7.0	150	Long-finned pilot whales (80%) and right whale dolphins (20%)

distributed in the colder waters in the Southern Hemisphere and are circumpolar species.

### Multi-species Combinations

Of 576 sightings of cetaceans, the 14 combinations of the multi-species were recorded during this survey (Table 2). There were seven types of the multi-species combination as follows: 1) killer whales and minke whales, 2) long-finned pilot whales



and minke whales, 3) long-finned pilot whales and southern right whale dolphins, 4) beaked whales and minke whales, 5) hourglass dolphins and fin whales, 6) killer whales and humpback whales, and 7) long-finned pilot whales, southern right whale dolphin and hourglass dolphins. Among these 14 combinations, that of killer whales and minke whales showed the highest percentage of 57.1%. Most of the multi-species combinations (90.5% of the total) were composed of both mysteceti and odontoceti, and the remainings were the combination of plural species of odontoceti.

According to CRUICKSHANK and BROWN (1981), four of eight sightings of southern right whale dolphins were observed with other dolphin species (two occasions with duskydolphins; another two with pilot whales). FRASER (1964) reported an observation of one group of 40 hourglass dolphins with a pod of 6 fin whales. Thus, it can be said that it is not rare to form multi-species combination between cetaceans in the Southern Hemisphere.

### Segregation by Species

Comparison of sighting positions between cetaceans examined in the present cruises (Figs. 4, 9 and 11) showed that four delphinid species (*S. coeruleoalba*, *G. griseus*, *L. obscurus* and *D. delphis*) were observed in the warmer-temperate waters but not found in the southern areas of the Antarctic Convergence where *O. orca* and the beaked whales were mainly sighted. Both *L. cruciger* and *G. melaena* were much concentratedly found in the southern areas rather than the north of the Antarctic Convergence. *Lissodelphis peronii* was sighted not only at warm-temperate waters but also at the colder waters close to the Antarctic Convergence. Among above four species sighted in the warm-temperate waters, both *D. delphis* and *L. obscurus* were sighted in the relatively colder or southern waters than the other two species (*S. coeruleoalba* and *G. griseus*), and were found in the relatively warmer or northern waters than *L. peronii* (Figs. 5 and 8). Killer whales were the southernmost delphinid species in the Southern Hemisphere. Both killer whales and beaked whales were sighted in the waters of much wider latitude in the Southern Hemisphere as compared with other small cetaceans observed in the present cruises (Fig. 5).

Comparison of sightings and density between killer whales and the beaked whales indicated that both species were concentratedly distributed along the ice edge of the Antarctica but killer whales seemed to be segregated into the further near ice edge and the innermost of the Ross Sea, and some apparent segregations were observed in the east-west areas of 50–70°N between them (Figs. 4, 6, 9 and 10).

Both *G. melaena* and *L. cruciger* were mainly sighted in the middle and high sea areas in the Southern Hemisphere but not found in the floating ice areas. The floating ice seems to be an obstacle of the southern limit for above two species but not to be always an obstacle for killer whales which were often found in the floating ice areas. It is considered that this kind of characteristic behavior of killer whales might lead to the geographical segregation between the killer whales and the beaked whales.

Frequency of school size for each species indicated that the beaked whales formed relatively smaller school than the other eight species (Fig. 7). Both *O. orca* and *L. cruciger* having almost the same tendency in the school size frequency seemed to form relatively small school than *G. melaena*. Although sample size was smaller, both *S. coeruleoalba* and *D. delphis* showed a tendency of forming relatively large school in the Southern Hemisphere.

Four species (*G. griseus*, *L. obscurus*, *D. delphis* and *S. coeruleoalba*) were often sighted in the coastal waters (less than 3,000 m in water depth) off Cape Town and / or around New Zealand, while other species (*G. melaena*, *L. peronii*, *L. cruciger*, *O. orca* and the beaked whales) were mainly found in the pelagic waters (3,000–5,000 m). Thus, the latter animals were considered to be pelagic species.

Among *L. cruciger*, *G. melaena*, *O. orca* and the beaked whales, which were sighted more than 20 times in the present study, *O. orca* showed the highest density and was followed by *G. melaena*, the beaked whales and *L. cruciger*. On the other hand, *G. melaena* showed the largest mean school size and was followed by *O. orca*, *L. cruciger* and the beaked whales (Table 1). Considering both smaller school size and difficulty of sighting for the beaked whales, there seems to be possibility that the density of the beaked whales might be underestimated. This tendency also appeared to be observed in *L. cruciger* as compared with *O. orca* and *G. melaena* because the hourglass dolphins were often sighted in the storm zone of the Southern Hemisphere.

*Lagenorhynchus cruciger* is probably allopatric with *L. obscurus* although these two species were not able to be compared in distribution with *L. australis* which was not sighted here. Summing up the sighting records of cetaceans in the present study, it can be safely said that in the Southern Hemisphere there are at least five antitropical genera with allopatric species (*Globicephala*, *Lissodelphis*, *Lagenorhynchus*, *Hyperoodon* and *Berardius*). Although BROWNELL (1974) considered that *Phocens* is also the antitropical genus as well as above five genera in the Antarctic Ocean, this genus has not been recognized in the Southern Hemisphere during the present survey. Concerning the detailed distribution of the small cetaceans in the Southern Hemisphere, further sighting survey should be needed.

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