

Distribution of the Antarctic Sea-birds in the Outer Margin of the Summer Pack Ice Area

Yasuhiko NAITO*, Keiji NASU** and Hiroshi SUZUKI***

南極海の夏季バックアイス帯外周域における海鳥類の分布

内藤 靖彦*・奈須 敬二**・鈴木 広志***

要旨: 海洋水産資源開発センターは毎年オキアミ調査を南極海で実施している。このオキアミ調査の一環として鳥類、海獣類の目視観察を実施している。本報告は1976-1977年、1977-1978年調査の結果である。

調査区域は東経 50° E~165° E, 南緯 62° S~68° S 以内であった。出現種は12種であり、卓越種群（アシナガコシジロウミツバメ等7種）は平均的に高い頻度でどの海域にも出現し、周極状分布が明瞭であった。非卓越種群（ハイイロアホウドリ等5種）は不均一分布を示し、周極状分布を示さなかった。

卓越種群はススイロミズナギドリを除き、オキアミ捕食者として知られている種であったが、非卓越種群はいずれもオキアミ捕食者でなく、オキアミと海鳥分布の相関関係が推察された。

Abstract: The distribution of the Antarctic sea-birds was investigated in 1976-1977 and 1977-1978 summer seasons. The observations were performed along the outer margin of the pack ice area between longitude 50° E and 165° E. The investigated area was centered latitudinally between 62° S and 68° S. Twelve species observed in this area are divided into two groups, namely, rare species group and dominant species group. The species which rarely appeared, such as light-mantled sooty albatross, Antarctic petrel, sooty albatross, wandering albatross and Antarctic skua, are not krill-feeders. The latter group is composed of sooty shearwater, Wilson's storm petrel, snow petrel, Antarctic prion, giant petrel, cape pigeon and Antarctic petrel. These species showed the circum-polar distribution, and they are known to feed on the krill, except sooty shearwater. The relation between the sea-bird distribution and the krill was suggested.

* 国立極地研究所. National Institute of Polar Research, 9-10, Kaga 1-chome, Itabashi-ku, Tokyo 173.

** 遠洋海区水産研究所. Far Seas Fisheries Research Laboratory, 1000 Orido, Shimizu 424.

*** 東京水産大学. Tokyo University of Fisheries, 5-7, Konan 4-chome, Minato-ku, Tokyo 108

1. Introduction

The Japan Marine Fisheries Resources Research Center annually operates the krill research vessel in the Antarctic Sea. In 1976–1977 and 1977–1978, the Antarctic sea-birds observations were performed on the krill research vessel BANSHU-MARU during the krill research operation. The birds observation was not a main subject of these cruises, but it has been carried out routinely in order to get long-term basic data of the Antarctic Sea. However, as it was a preliminary trial, many methodological problems remain to be solved and improved in the future. The present study is the first report of these observations. The result of this study may neither satisfy the bird biologists in their both general and special interest nor supply particularly new information beyond the result of the previous studies made by many other vessels in the Antarctic Sea.

2. Method of Observation

The krill research vessel BANSHU-MARU (3200 gross tons) started the observation from the 17th of November 1976 ($63^{\circ}50'S$, $146^{\circ}59'E$) ending on the 10th of February 1977 ($65^{\circ}31'S$, $53^{\circ}42'E$), and resumed it from the 1st of November 1977 ($62^{\circ}49'S$, $156^{\circ}08'E$) to the 23rd of February 1978 ($67^{\circ}33'S$, $160^{\circ}21'E$). As shown in Fig. 1, the ship tracks covered one-third of the antarctic circuit from about $50^{\circ}E$ to $165^{\circ}E$, and centered around the area between latitude $62^{\circ}S$ and $68^{\circ}S$. For the krill study which was the main program of these voyages, the ship decided to take the course along the margin of the pack ice zone. Therefore,

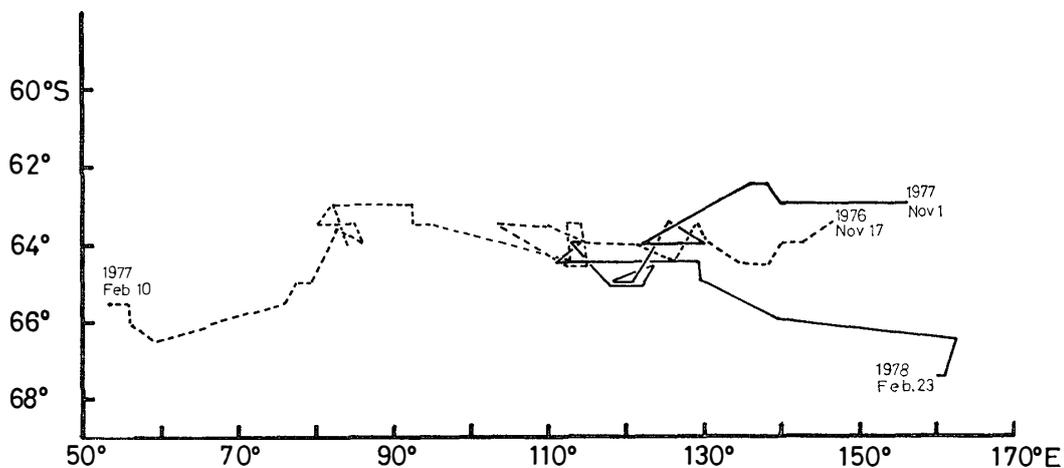


Fig. 1. Cruise tracks of R/V BANSHU-MARU. The dotted and solid lines show the 1976–1977 and 1977–1978 cruises respectively.

the sea-bird observations were also performed in the margin of the pack ice zone and the ship moved southwards as the season advanced (Fig. 1).

The observations were made from the ship's bridge 7.5 m above the water surface. The observers in charge were not bird specialists but the officers on bridge duty. However, they were sometimes technically advised by one of the authors of this report, a specialist in whales of the Antarctic Ocean, who is also interested and well experienced in sea-birds observation. The observations were made for a few minutes identifying the species and counting the number at almost every time of the krill net operation which was performed several times a day. Although the identification of species was sometimes very difficult owing to the short experience of the observers as bird watchers, many of species were successfully identified. The birds which were not definitely identified were not recorded. In order to cover the shortage of experience and to increase the accuracy of records, the sighting distance was limited within about 1 mile from the ship.

In this study a standardized observation effort was not made. So, the present study employed the following method to make the observation efforts even, in order to compare the data regionally. 1) To increase the observation number, the larger observation area unit was sectioned in 5 longitudinal degrees so that the observation frequency was averaged in each section. 2) To extract the result based on the reliable efforts, the maximum number observed, in each section was applied to represent the distribution amount of each species in that section. The maximum number was further classified into 4 ranks, *i.e.*, 1–10, 11–50, 51–100 and over 100. This method would not facilitate the comparison of small areas, but such a comparison was not intended in the present study which was just a tentative trial.

3. Result and Discussion

3.1. Observed species

During the two cruises of 1976–1977 and 1977–1978, 12 species in total were observed, 10 species in the first cruise and 11 in the second (Table 1). Out of the total 12 species observed, 9 were common to both cruises. In the 1976–1977 cruise, only light-mantled sooty albatross (*Phoebetria palpebrata*) was specifically identified. Identified in the 1977–1978 cruise were sooty albatross (*Phoebetria fusca*) and Antarctic petrel (*Thalassoica antarctica*). According to CARRICK and INGHAM (1967), 29 species (7 families) except penguins generally occur in the Antarctic region including north of the antarctic convergences. Also OZAWA (1967) mentioned 23 principal species of sea-birds except penguins with which the cruises

Table 1. Check list of species observed both in 1976–1977 and 1977–1978 cruises.

Scientific name	Common name
1976–1977 (10 species)	
Family <i>Diomedeidae</i>	
1. <i>Diomedea exulans</i>	Wandering albatross
2. <i>Phoebetria palpebrata</i>	Light-mantled sooty albatross
Family <i>Procellariidae</i>	
3. <i>Macronectes giganteus</i>	Giant petrel
4. <i>Daption capense</i>	Cape pigeon
5. <i>Fulmarus glacialoides</i>	Antarctic fulmer
6. <i>Pagodroma nivea</i>	Snow petrel
7. <i>Pachyptila desolata</i>	Antarctic prion
8. <i>Puffinus griseus</i>	Sooty shearwater
Family <i>Hydrobatidae</i>	
9. <i>Oceanites oceanicus</i>	Wilson's storm petrel
Family <i>Stercorariidae</i>	
10. <i>Catharacta maccormicki</i>	Antarctic skua
1977–1978 (11 species)	
Family <i>Diomedeidae</i>	
11. <i>Diomedea exulans</i>	Wandering albatross
12. <i>Phoebetria fusca</i>	Sooty albatross
Family <i>Procellariidae</i>	
13. <i>Macronectes giganteus</i>	Giant petrel
14. <i>Daption capense</i>	Cape pigeon
15. <i>Fulmarus glacialoides</i>	Antarctic fulmer
16. <i>Thalassoica antarctica</i>	Antarctic petrel
17. <i>Pagodroma nivea</i>	Snow petrel
18. <i>Pachyptila desolata</i>	Antarctic prion
19. <i>Puffinus griseus</i>	Sooty shearwater
Family <i>Hydrobatidae</i>	
20. <i>Oceanites oceanicus</i>	Wilson's storm petrel
Family <i>Stercorariidae</i>	
21. <i>Chatharacta maccormiki</i>	Antarctic skua

encountered from November to March in the Indian and Atlantic sectors as far south to the pack ice area. The number of the species mentioned by the above authors exceeds double the number of species observed in this study. However, the area covered by this study was a narrow outer margin of the pack ice zone, so that the number of species to be observed was possibly reduced. OZAWA (1967) illustrated the distribution maps of the sea-birds. According to the maps the number of species that possibly appear in the area of this study is apparently 16. In this study, 12 of 16 species, were recorded by the 4–6 daily observations that were performed at the time of krill net operations. Another reason for the small number

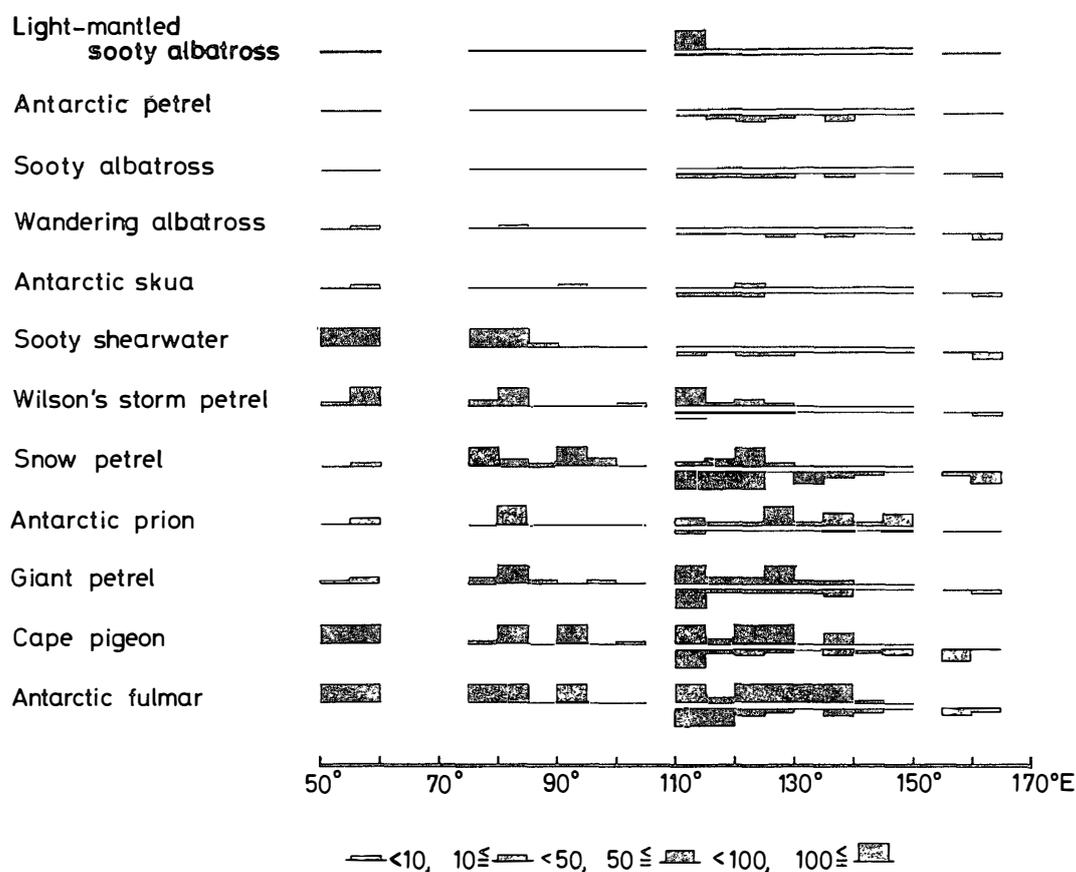


Fig. 2. The longitudinal distribution of sea-birds between 50° E—165° E. The results of both 1976–1977 and 1977–1978 cruises were shown in upper and lower side respectively.

of species recorded in this study may lie in the difficulties of specific identification for the observers who are not bird specialists.

3.2. Distribution of the species

As already mentioned, the observation was performed from November to February in both 1976–1977 and 1977–1978 cruises along the pack ice margin, so that the distribution described in this chapter only refers seasonally to the austral summer and regionally to the high latitude area.

The longitudinal distribution of each species is shown in Fig. 2 which seems to reveal two groups, *i.e.*, the dominant species group and the rare species group. Light-mantled sooty albatross, Antarctic petrel, sooty albatross, wandering albatross (*Diomedea exulans*) and Antarctic skua (*Catharacta maccormicki*) belong to the former group, and sooty shearwater (*Puffinus griseus*), Wilson's storm petrel (*Oceanites oceanicus*), snow petrel (*Pagodroma nivea*), Antarctic prion (*Pachyptila desolata*), giant petrel (*Macronectes giganteus*), cape pigeon (*Daption capense*)

and Antarctic fulmer (*Fulmarus glacialoides*) seem to belong to the latter group. In the former group, the light-mantled sooty albatross and the Antarctic petrel were expected to appear much more frequently.

In the latter group, the sooty shearwater was observed much more than expected in the pack ice edge region.

The light-mantled sooty albatross is considered to show circumpolar distribution as it is frequently found along the edge of the pack ice zone (OZAWA, 1967) and is a wraith-like companion of the ships (WATSON *et al.*, 1971). The result of the present study was different from the above reports. We could observe this bird only twice, one time as a large flock in longitude 110°/115°E section and another time as a small number in longitude 50°/55°E section in the 1976-1977 cruise, whereas not an individual was observed in the 1977-1978 cruise. The reason for the scarcity of this bird is not clear, but it may be ascribed to the fact that the observation was made 4-5 times a day only for a few minutes.

The Antarctic petrel is considered to be the representative species in the Antarctic and its northern limit of distribution range is about 100 miles seaward from the pack ice edge (OZAWA, 1967). It was also reported that the Antarctic petrel appeared at 80-100 miles seawards from the pack ice (FALLA, 1937) and disappeared in the pack ice region (OZAWA *et al.*, 1964). However, according to AOYANAGI (1973) a large number of the Antarctic petrel was observed only in the pack ice region but was not found in the open sea area off the pack ice zone. We could observe no individuals of this species in the 1976-1977 cruise and only a small number in the 1977-1978 cruise, which may support the result by AOYANAGI (1973). But the reason of the scarce occurrence of the light-mantled sooty albatross and the Antarctic petrel is not explained or guessed in this study.

The sooty albatross, the wandering albatross and the Antarctic skua appeared quite rarely in this study, particularly the sooty albatross was observed only in the 1977-1978 cruise.

The sooty albatross is known to have its distribution range in the temporal zone of the Atlantic and Indian Oceans extending to western Australia (OZAWA, 1967). Therefore, it is noticeable that this species, though small in number, was observed in a farther eastern latitudinal zone of 110°E-140°E in the 1977-1978 cruise.

The wandering albatross appeared in a small number over a wide area as it was reported as a circumnavigator (WATSON *et al.*, 1971) but a rare species in the pack ice region (OZAWA, 1967). The southern skuas present vexing systematic problems (WATSON *et al.*, 1971). However, in this study as the specific identification

was difficult, all skuas observed were recorded as the Antarctic skua (*i.e.*, South Polar skua *Catharacta maccormicki*) for convenience. The Antarctic skua was not observed very frequently but it was found in a small number like stepping-stones along the cruise course.

The sooty shearwater is known as a distant navigator, and according to OZAWA (1967) its movements extend northward as far as the Bearing Sea in the summer of the Northern Hemisphere, and in the austral summer they appear in the Antarctic pack ice edge area in large flocks. This species was observed in large flocks in a latitudinal zone between 50°/60°E and 75°/85°E sections in the 1976–1977 cruise. According to WATSON *et al.* (1971), none of this bird was observed in these areas. Therefore, the bird observed in this study may be the southernmost record of this species. However, the bird was not observed farther east from 90°E, and in the 1977–1978 cruise it was sometimes observed only in a small number. The Wilson's storm petrel was observed sporadically along the course of the both 1976–1977 and 1977–1978 cruises. This result may coincide well with the known distribution of this most common and widespread storm-petrel in the Southern Ocean (OZAWA, 1967).

The snow petrel which breeds in Antarctica and is a representative species of Antarctica (OZAWA, 1967) was observed very frequently all along the course of the both 1976–1977 and 1977–1978 cruises.

The Antarctic prion was quite difficult to be identified in the sea. For convenience, the name Antarctic prion was applied to all prions observed in this study. In the 1976–1977 cruise this bird was frequently observed, but in the 1977–1978 cruise a small number was found only in 110°/115°E section. The reason for this difference is not clear, but AOYANAGI (1973) reported that numerous prions were observed to be dominant in latitude between 50°S and 60°S on the cruise to Antarctica and no prions were observed on the cruise from Antarctica. This may indicate that the prions are irregularly distributed locally in large flocks and in the 1977–1978 cruise these large flocks might have been missed owing to the brief observations.

The giant petrel was observed frequently all along the course of the both 1976–1977 and 1977–1978 cruises. The apparent longitudinal maldistribution was not noticed and the distribution was almost the same in both cruises. The frequent appearance of this bird may be due to its behavior. The giant petrel is known as a scavenger and ocean wanderer and it flocks together around whaling factory ships (OZAWA, 1967). In this study also, the bird was found to flock together around the ship.

The cape pigeon has circumpolar distribution and is common in the Antarctic waters off the pack ice edge (OZAWA, 1967). This species was observed very commonly and similarly in both cruises, without showing any particular distribution pattern.

The Antarctic fulmer is also one of the representative species in the Antarctic sea and is very common even on the ice floating seas (OZAWA, 1967). This bird was observed very commonly and similarly in both cruises, and showed almost the same distribution as the cape pigeon and the light-mantled sooty albatross.

The survey was performed along the outer margin of the Antarctic pack ice zone. The environment of this marginal area seems to be ecologically changing, which may affect not only the primary production in the sea but also the total ecosystem of the area. Regarding the above consideration, it is interesting that the krill feeding species such as the Wilson's storm petrel, snow petrel, Antarctic prion, giant petrel, cape pigeon and Antarctic fulmer (CARRICK and INGHAM, 1967) are dominant in this area (Fig. 2), and the rare species such as the light-mantled sooty albatross, Antarctic petrel, sooty albatross, wandering albatross and Antarctic skua are not krill feeder. These facts may suggest that there exist some local relationships between the krill and the sea-birds distribution. To analyze these relationships we need much more observational study, especially on the feeding behavior in future.

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Appendix 1.

Date Latitude Longitude	Nov. 1976											
	17 63° 146°E	18 64° 143°	19 64° 140°	20 64°30' 139°	21 64°30' 136°	22 64°20' 135°	23 64°20' 134°20'	24 64°10' 134°	25 64° 130°	26 64° 129°30'	27 64° 129°20'	28 64° 129°10'
Species												
Antarctic prion	50	+	80	+	50			2	152	95	64	+
Antarctic fulmar		+			200	6	518	30	235	numerous	665	420
Cape pigeon			80	+					56	numerous	15	
Giant petrel			5	+	2	1	1		19	33	18	4
Snow petrel												
Wilson's storm petrel												
Antarctic skua												
Light-mantled sooty albatross												
Sooty shearwater												
Wandering albatross												

Date Latitude Longitude	Nov. 1976		Dec. 1976							
	29 63°45' 129°30'	30 63°50' 129°50'	3 64° 128°	4 64°30' 126°	5 64°15' 122°	6 64°18' 122°	7 64°15' 121°30'	8 64° 121°30'	9 64° 121°30'	10 64° 121°40'
Species										
Antarctic prion	+	+	+	4					+	
Antarctic fulmar	465	36	530	30	125	numerous	numerous	numerous	numerous	+
Cape pigeon	30	+	33	27	35	numerous	numerous	numerous	numerous	+
Giant petrel	100	20	58	5	2		12	20	30	+
Snow petrel	3			5	27	numerous	38	+		
Wilson's storm petrel				5	10					
Antarctic skua						1		+		
Light-mantled sooty albatross										
Sooty shearwater										
Wandering albatross										

Appendix 1 (continued).

Date Latitude Longitude	Dec. 1976										
	11 64°10' 119°30'	12 64° 117°	13 64° 116°50'	14 64° 116°	15 64° 114°	16 64° 116°30'	17 65°55' 116°30'	18 64°14' 115°30'	24 63°30' 103°50'	26 64°20' 112°	27 64°25' 113°20'
Species											
Antarctic prion							+				30
Antarctic fulmar	15	2	2			+	+	3		1	+
Cape pigeon	20	2	>20	+		+	+	1	1	3	50
Giant petrel	20	3	+	+		+	+	2		2	10
Snow petrel		16	<10	+	+						+
Wilson's storm petrel		2	+					1	2	1	+
Antarctic skua											
Light-mantled sooty albatross											
Sooty shearwater											
Wandering albatross											

Date Latitude Longitude	Dec. 1976			Jan. 1977								
	28 64°30' 114°	30 63°40' 113°	31 63°50' 112°50'	1 63°50' 112°50'	2 63°50' 112°30'	3 64° 113°	4 64° 112°50'	5 64° 113°	6 64° 112°50'	7 64°15' 112°	9 63°30' 95°98'	10 63°30' 92°50'
Species												
Antarctic prion												
Antarctic fulmar	+	40	10	130	numerous	+	numerous	6	1			numerous
Cape pigeon	2	15	5	50	numerous	+	numerous	14	50			numerous
Giant petrel	1	1		1	+	+	numerous	12	41		1	
Snow petrel	5										11	numerous
Wilson's storm petrel		1		+		+	numerous	3	5	2		
Antarctic skua												
Light-mantled sooty albatross						+	numerous					
Sooty shearwater												
Wandering albatross												

Appendix 1 (continued).

Date Latitude Longitude	Jan. 1977											
	12 63° 92°50'	14 63°15' 82°30'	15 63°10' 82°30'	17 64° 84°	20 63° 82°20'	21 60°30' 80°	22 63°55' 85°40'	23 64° 86°50'	24 63°20' 83°30'	29 64°54' 79°30'	30 65° 77°30'	
Species												
Antarctic prion	numerous											
Antarctic fulmar	+	numerous	2								numerous	numerous
Cape pigeon			numerous	3	numerous				numerous	2		
Giant petrel			numerous	4	2	2	1	1		10	7	
Snow petrel	numerous	10			2				1	numerous	numerous	
Wilson's storm petrel					1	numerous				+	10	
Antarctic skua	1											
Light-mantled sooty albatross												
Sooty shearwater			numerous	13	numerous	numerous	8	5	numerous	numerous	22	
Wandering albatross					1					1		

Date Latitude Longitude	Jan. 1977 Feb. 1977										
	31 65°30' 76°	2 66°20' 58°30'	3 66°20' 58°20'	4 66°20' 58°10'	5 66° 56°30'	6 65°40' 56°20'	7 65°30' 55°20'	8 65°30' 54°20'	9 65°30' 54°30'	10 65°30' 53°50'	
Species											
Antarctic prion	10										
Antarctic fulmar	numerous	30	numerous	numerous	numerous	numerous	numerous	numerous	numerous	numerous	
Cape pigeon	1	+	numerous	numerous	numerous	numerous	numerous	5	numerous	numerous	
Giant petrel	3	10		2	6			6	8	+	
Snow petrel	2	+	1	+							
Wilson's storm petrel	+	2	numerous	+	2			1	1	4	
Antarctic skua					1						
Light-mantled sooty albatross							2				
Sooty shearwater	23	numerous		+	numerous	numerous	8	4	numerous	numerous	
Wandering albatross					2						

Appendix 2.

Date Latitude Longitude	Nov. 1977					Dec. 1977						
	1 63° 156°E	5 63° 148°30'	9 63° 140°30'	10 62°30' 138°	11 62°30' 136°	13 64° 122°	14 64° 122°	15 64° 122°	16 64° 122°	17 64° 122°	21 64° 124°	22 64° 125°30'
Species												
Antarctic prion												
Antarctic fulmar	10		5				11		+			
Cape pigeon	60	14	5	+	13	10	+	1		1	1	1
Giant petrel									1	1		1
Snow petrel	5		3	+	13	5-6	+	5	1	2		
Wilson's storm petrel							+					
Antarctic skua										1		
Sooty albatross							+	+				
Sooty shearwater												
Wandering albatross												
Antarctic petrel					13	15	+	1	11	8	4	2

Date Latitude Longitude	Dec. 1977					Jan. 1978						
	23 64° 126°	25 64° 129°30'	26 64° 130°	28 63°30' 125°	29 63°30' 125°	30 63°30' 125°	31 63°30' 126°	1 63°30' 126°	2 65° 121°30'	3 65° 118°30'	4 65° 118°	5 64°30' 124°
Species												
Antarctic prion												
Antarctic fulmar		+		2					1	1		
Cape pigeon		1	3		1	6				1		
Giant petrel		4	6	3	1	2	2	2		1		
Snow petrel										5	1	
Wilson's storm petrel												
Antarctic skua												
Sooty albatross					1	2	1					
Sooty shearwater	1	1			1	4	1					
Wandering albatross												
Antarctic petrel		7	3						3	2		1

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Appendix 2 (continued).

Date Latitude Longitude	Feb. 1978										
	2 64° 112°30'	3 64° 113°	5 64°30' 118°30'	7 64°30' 129°	8 65° 129°30'	9 65° 134°	10 65° 135°30'	11 66° 139°30'	19 66°30' 162°30'	20 67°30' 161°30'	21 67°30' 161°
Species											
Antarctic prion											
Antarctic fulmar	numerous		1				>10	2		1	
Cape pigeon	numerous						1	6	>15		
Giant petrel	numerous	>40		1		1		14			
Snow petrel						50				>80	<14
Wilson's storm petrel	+									1	
Antarctic skua										5	1
Sooty albatross			1	5	1		1				
Sooty shearwater									>15	1	2
Wandering albatross				2				2	>15	6	
Antarctic petrel											

Date Latitude Longitude	Feb. 1978	
	22 67°30' 160°30'	23 67°30' 160°30'
Species		
Antarctic prion		
Antarctic fulmar		
Cape pigeon		
Giant petrel	1	4
Snow petrel	1	>22
Wilson's storm petrel		
Antarctic skua	1	5
Sooty albatross	2	
Sooty shearwater		
Wandering albatross		
Antarctic petrel		