Visual Observations of Sea Birds in the Southern Ocean in the 1979–1980 Summer

Yoshikuni OHYAMA*, Yasuhiko NAITO* and Kazue NAKAMURA**

1979-1980 シーズンにおける南極海海鳥の目視観察

大山佳邦*・内藤靖彦*・中村一恵**

要旨：1979～1980年の夏期，南極海でオキアミの漁業調査を行った2隻の船および国際捕鯨委員会によるミンククジラの個体数調査船に海鳥の調査を依頼した．調査海域は主として63°S以南，パックアイス帯までの間で，東西には0°E～115°Eに及ぶ広い海域にわたった．

調査は1日1回，10分間（時刻は不定）に出現する海鳥の種類と個体数を，南極研究科学委員会鳥類小委員会の勧告したデータシートを若干改変したものに記入することであった．

今回の調査で東西に広い範囲にわたって出現した鳥は主としてこの時期に南極大陸あるいはその付近の島々で繁殖している種類であった．ナンキョクフルマカモメ，ユキドリ，マダラフルマカモメ，アシナガコシジロウミツバメなどがそれである．また亜南極の島々で繁殖しているハイイロアホウドリ，ハイイロミズナギドリもよく現れた．これらは外洋性の習性が強く，夏にはパックアイス近辺まで南下する種類である．

Abstract: Visual observations of sea birds in the Southern Ocean were carried out on board three ships during the austral summer of 1979-1980; two ships for exploratory fishing of krill, a factory ship SHINANO MARU and a trawler ORIENTO MARU, and one ship for the population census of minke whale, KYO MARU (a catcher). The surveyed area was south of 63°S between 0° E and 115° E in longitude.

Ten minutes within a day were allocated for bird observations. The species and the number of sea birds observed in ten minutes were recorded on a data sheet which was a slightly modified standard recording card of SCAR prepared for this survey.

The bird species that occurred in a wide longitudinal range were

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

** 神奈川県立博物館. Kanagawa Prefectural Museum, 60, Minami-Nakadori 5-chome, Naka-ku, Yokohama 231.

the breeders on the Antarctic Continent or on the adjacent island in austral summer, *i. e.* antarctic petrel, snow petrel, cape pigeon, and Wilson's storm petrel. Light-mantled sooty albatross and sooty shearwater that are breeding on the sub-Antarctic islands also occurred in a wide range; these two birds are highly pelagic in habit and often disperse south to the edge of the pack ice in summer.

1. Introduction

Studies of marine living resources in the Southern Ocean became important in recent years. The international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) programme which was commenced in 1977 aims to obtain "a deeper understanding of the structure and dynamic functioning of the Antarctic marine ecosystem as a basis for the future management of potential living resources" (BIOMASS, vol. 1). Sea birds form a part of the Antarctic marine ecosystem as consumers of crustaceans, molluscs, and fishes. The Subcommittee on Bird Biology of Scientific Committee on Antarctic Research (SCAR) pointed out the need for the collection of information on the distribution, abundance, and feeding ecology of sea birds in the Antarctic and sub-Antarctic regions, which is fundamental to implement the BIOMASS programme. The SCAR recommended to the national committees the use of a standardized recording form for bird observations.

Some bird observations in the Southern Ocean were carried out by Japanese (OZAWA *et al.*, 1964, 1968; AOYANAGI, 1973; NAITO *et al.*, 1979). No bird specialist participated in the past cruises to the Southern Ocean by the Japanese Antarctic Research Expedition and other organizations, and participation of bird specialists in future is unlikely. It was, therefore, attempted to collect the information of the Antarctic sea birds by layman observers on board various ships. NAKAMURA and NAITO (1979) compiled booklet of bird observations for non-specialist to identify the sea birds which occur in the area south of the Antarctic Convergence. Observations of sea birds were requested to the various ships to be operating in the Southern Ocean with the booklet and the sea bird observation sheet.

This paper reports the results obtained during the austral summer of 1979–1980.

2. Observations

This report includes the results of the observation by three ships, a factory ship SHINANO MARU (8852 gross tons), a krill fishery research ship ORIENTO MARU (349 gross tons), and KYO MARU (730 gross tons) which is a chartered ship for population census of minke whale planned by the International Whaling Commission. Since no specialist was on board these ships, all observations were made by officers or biologist of the Whale Research Institute in Tokyo: Toshio ARAI, Akira HASHIMOTO and Toshio HATA of SHINANO

南極海海鳥類目視観察データ・シート

船名	Shinano 丸	総トン数	8852 トン
航海コース	Fremantle 港発	Fremantle	港着
観察場所の高さ	1．ブリッジ	17 m	
	2．船尾デッキ	15 m	
	3．その他（ ）	m	

10分間観察記録記入表

観察者名（1名）	ARAI Toshio				船速			0 ノット	
観察場所（○で囲む）	1．ブリッジ ②．船尾デッキ 3．その他（ ）								
日付：	'80 年 1 月 16 日				観察時間（10分間）			15 時 56分 ～ 16時 06分	
船位：	緯度 63° 度 08' 分 S 秒，	経度 90° 度 24' 分 E 秒							
天候	o				風向： WSW			風力： 4	
気温	- 1.0 ℃				水温			0.8 ℃	
船の行動状況（○で囲む）	1．航走中 2．ゴミ投棄中 3．曳網中 4．海洋観測中 5．延縄操業中 6．魚獲物処理中 ⑦．停船中 8．ヘリコプター飛行中 9．捕鯨中								
種名	観察数(1－100)	観察数(100～)	鳥の状態（○で囲む）						
1．Cape pigeon	羽	約 100 羽	⑪飛翔中	採餌中	⑪面上	船につく	水上	その他	
2．Southern fulmar	8 羽	約 羽	⑪飛翔中	採餌中	⑪面上	船につく	水上		
3．Light-mantled sooty al.	2 羽	約 羽	⑪飛翔中	採餌中	海面上	船につく	水上		
4．Southern giant ful.	3 羽	約 羽	飛翔中	採餌中	⑪面上	船につく	水上		
5．White-chinned pet.	8 羽	約 羽	⑪飛翔中	採餌中	⑪面上	船につく	水上		
6．Wilson's storm-pet.	3 羽	約 羽	⑪飛翔中	採餌中	海面上	船につく	水上		
7．Chinsrtap penguin	3 羽	約 羽	飛翔中	採餌中	⑪面上	船につく	水上		
8．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
9．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
10．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
11．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
12．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
13．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
14．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
15．	羽	約 羽	飛翔中	採餌中	海面上	船につく	水上		
備考									

Fig. 1. An example of the sea bird observation sheet filled out during the present survey.

MARU; Atsushi OWADA of ORIENTO MARU; Shigehisa USUDA and Hidehiro KATO of KYO MARU. The observations were carried out mostly from the bridge 17 m above the water in SHINANO MARU and 6 m in ORIENTO MARU. The observations by KYO MARU were made from the upper-bridge 10.5 m above the water.

Observation was carried out for ten minutes each day; the species and the number of birds that occurred during the ten minutes were recorded in a sea bird observation sheet. An example of the sheet completed is shown in Fig. 1. Other items to be filled were ship's position, air and water temperatures, weather, ship's activity, bird's state, and so on. In KYO MARU, most of the ten-minute observations were performed from 15 : 50 to 16 : 00 at local time, while in other two ships they were made at various time in a day from early morning to late evening, because the observers had their duties on board.

3. Locations of Observations

Fig. 2 show the locations where the observations of birds were made. Most of them are in the south of 63°S and extend over the area from 0°E to 115°E. SHINANO MARU made observations from January 10, 1980 (63°22′S, 90°34′E) to February 12, 1980 (63°53′S, 93°54′E), and the locations are included in the shaded area in Fig. 2. Observations by ORIENTO MARU shown with solid circles were from January 8, 1980 (63°28′S, 90°44′E) to February 13, 1980 (63°54′S, 93°57′E), and part of the observed locations are included in the shaded area. KYO MARU made observations from Decem-

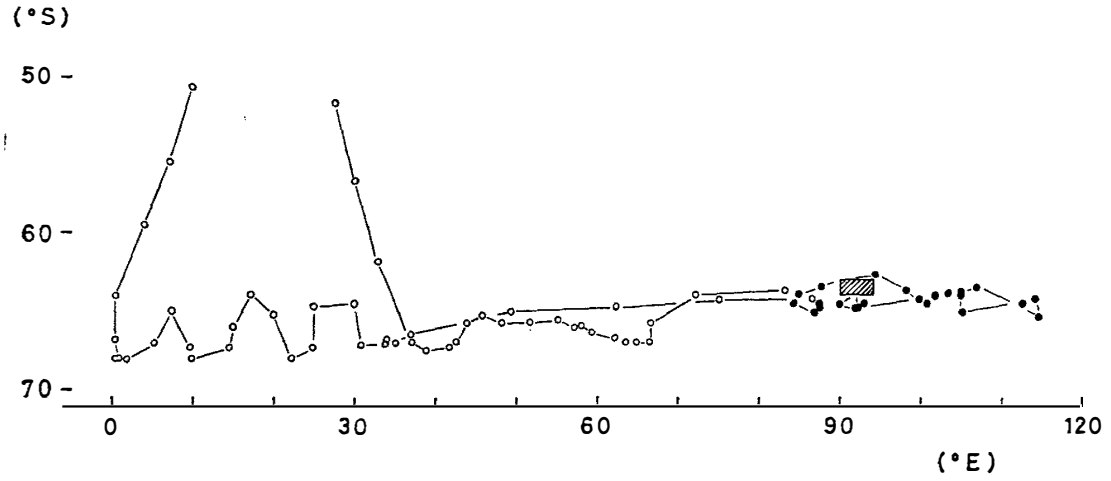

Fig. 2. Locations where sea bird observations were made. Open circles indicate those of KYO MARU; solid circles ORIENTO MARU; shaded area SHINANO MARU.

ber 22, 1979 (42°15′S, 20°49′E) to February 21, 1980 (34°12′S, 18°06′E), and the locations are shown by the open circles.

4. Results and Discussion

4.1. Bird species observed

Both of Latin and common bird names used in the present paper are adopted from WATSON (1975).

A total of 17 species were observed by three ships (Table 1): nine species observed by SHINANO MARU; 14 species by ORIENTO MARU; 16 species by KYO MARU. Only eight species out of total 17 species are common. The number of bird species in the present surveys is smaller than that of CARRICK and INGHAM (1967) who listed 29 species except the penguins that breed in the Antarctic and sub-Antarctic regions. OZAWA (1967) also listed 23 species, except the penguins, based on the surveys on board the UMITAKA MARU in

Table 1. List of bird species observed during the present survey.

Spheniscidae
Pygoscelis entarctica (Chinstrap penguin)
Diomedeidae
Diomedea exulans (Wandering albatross)
Diomedea melanophris (Black-browed albatross)
Diomedea chrysostoma (Gray-headed albatross)
Phoebetria palpebrata (Light-mantled sooty albatross)
Procellariidae
Macronectes giganteus (Southern giant fulmar)
Fulmarus glacialoides (Southern fulmar)
Thalassoica antarctica (Antarctic petrel)
Daption capense (Cape pigeon)
Pagodroma nivea (Snow petrel)
Pterodroma lessoni (White-headed petrel)
Procellaria aequinoctialis (White-chinned petrel)
Puffinus griseus (Sooty shearwater)
Prions
Oceanitidae
Oceanites oceanicus (Wilson's storm petrel)
Stercorariidae
Catharacta maccormicki (South polar skua)
Laridae
Terns

several summers between 1961 and 1967 in Indian and Atlantic sectors of the Southern Oceans. The smaller number of species in this survey than that of CARRICK and INGHAM (1967) and OZAWA (1967) might be due to the limited area of observations having been made mostly in a narrow region just north of the ice edge. NAITO *et al.* (1979) listed 12 species in the surveys on board krill research vessels which operated in 1976-1977 and 1977-1978. Since their surveys were performed in a narrow area along the outer margin of the Antarctic pack ice, they also attributed the small number of species to the narrowness of the area surveyed. Another reason for the poverty in species found may be related to a matter of specific identification of birds.

The most important problem in the present study is the identification of bird species observed, because of the absence of bird specialist on board. As for the identification of bird species in Spheniscidae and Diomedeidae, there may be no problem for their characteristic plumage. There may also be no confusion between the light-mantled sooty albatross and the sooty albatross in view of the area where the present surveys were made. In Procellariidae, the observers would not fail to identify the birds with characteristic plumage like the cape pigeon, the snow petrel, the antarctic petrel, and the southern fulmar, whereas it is hard to identify the birds with dark plumage. There were some cases when the observers were unable to distinguish between the sooty shearwater and the Kerguelen petrel in the present surveys on board. Since the sooty shearwater is found in the area more southerly than the Kerguelen petrel (WATSON, 1975), the birds assigned to the sooty shearwater in the present paper might contain a small part of the Kerguelen petrel. The prions are also hard to identify; some of them are impossible to distinguish their species by the on-board observation. The prions are, therefore, shown as the total number of the blue petrel and other prions together. As for the species of Oceanitidae and Stercorariidae, there is no problem to identify the Wilson's storm petrel and the south polar skua in view of the area surveyed. Terns are also hard to distinguish between the arctic tern and the antarctic tern. There were cases recording both the arctic and the antarctic tern in the present surveys. They are more likely the arctic tern because of the area of sea surveyed, but in this paper they are dealt as the terns.

Of three ships which took part in the present survey KYO MARU cruised about the Southern Ocean widely, while SHINANO MARU moved only in a narrow region (Fig. 2). The observations of sea birds by SHINANO MARU

were made always at the time when the ship was stationary. KYO MARU observed 16 species as compared with nine species of SHINANO MARU. Another interesting thing in SHINANO MARU is that bird species observed decreased to two or three in the latter half of the survey period; only the cape pigeon and the southern giant fulmar were observed (Appendix). In the case of ORIENTO MARU, when the survey was drawing to close and the ship was not far from a stoppage or a krill net operation point, the bird species also decreased and only the cape pigeon and the sooty shearwater were observed.

4.2. Distribution of the birds observed

As already mentioned, most of the surveys were performed from 0°E to 115°E in the Southern Ocean just north of the ice edge in the austral summer of late December to middle February.

The longitudinal distribution of the main birds that occurred frequently in the area south of 63°S is given in Fig. 3. The thickness of black band

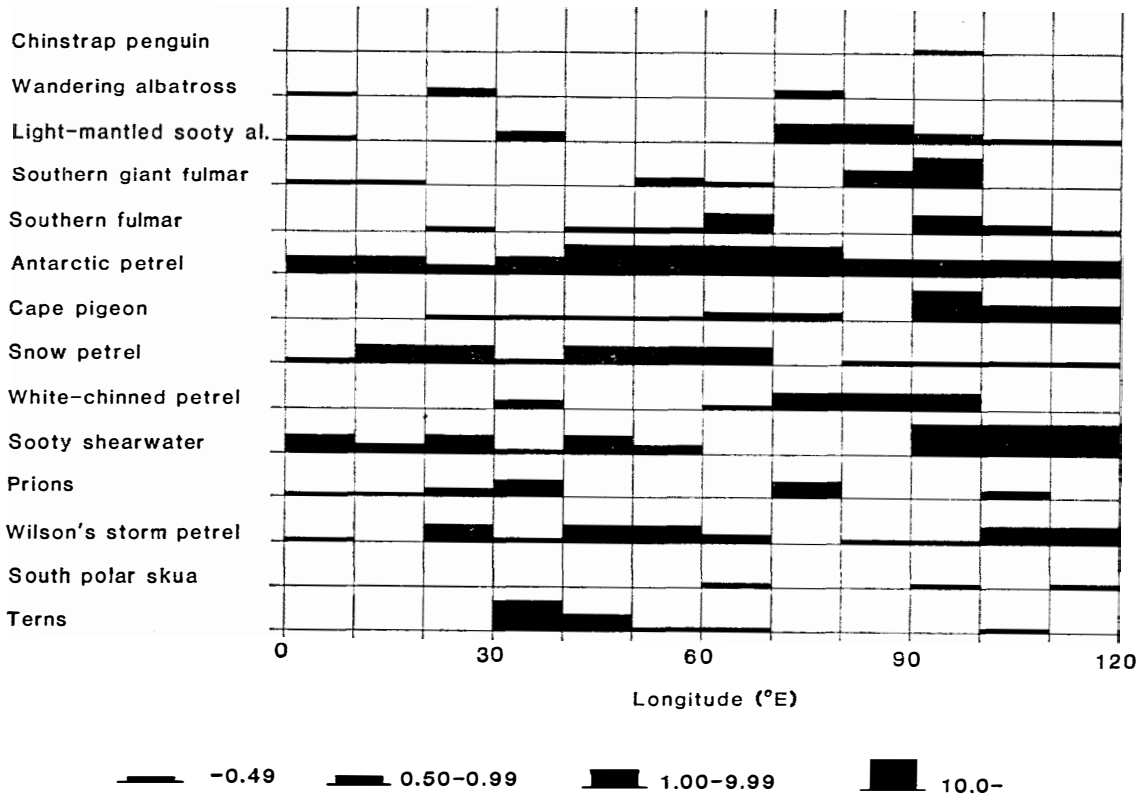

Fig. 3. Longitudinal distribution of main sea birds that occurred in the present survey. Average number of birds in a ten-minute observation is indicated in four steps.

shows an average individual number of the sea birds that occurred in ten-minute observations in a section of ten-degree interval. The averaged numbers are classified into four steps of 0.01 to 0.49, 0.50 to 0.99, 1.00 to 9.99, and more than 10.0 individuals for a ten-minute observation. The frequencies of observations in each section were as follows: 8 times in the section of 0°E to 10°E; 5 in 10°E to 20°E; 4 in 20°E to 30°E; 7 in 30°E to 40°E; 6 in 40°E to 50°E; 5 in 50°E to 60°E; 8 in 60°E to 70°E; 2 in 70°E to 80°E; 8 in 80°E to 90°E; 45 in 90°E to 100°E; 8 in 100°E to 110°E; 3 in 110°E to 120°E.

As shown in Fig. 3, the antarctic petrel occurs in all the sections and is dominant in number. The snow petrel and the Wilson's storm petrel are the next. The light-mantled sooty albatross, the cape pigeon, the southern fulmar, and the sooty shearwater occur in more than half of the total sections.

The distribution of the antarctic petrel is closely related to that of sea ice and icebergs. OZAWA *et al.* (1964) observed the occurrence of this species in relation to the sea ice. They pointed out that the northern limit of the species is usually about 100 miles from the edge of the pack ice. Some of the species range far south in the winter to find open water. MAWSON recorded a few of them at Cape Denison during every winter month except August (FALLA, 1937).

The snow petrel occurs also near the pack ice or icebergs, and is almost entirely restricted to the colder Antarctic waters (WATSON, 1975). This species is usually found within an area of 40 miles from the pack ice (OZAWA, 1967).

The Wilson's storm petrel is distributed in cold Antarctic and sub-Antarctic waters during the breeding season of austral summer. It migrates, however, mainly to the north Atlantic waters of similar climate through tropics in the off season (WATSON, 1975). The antarctic petrel, the snow petrel, and the Wilson's storm petrel breed in the Antarctic Continent or the adjacent islands, and show the circumpolar distribution with the preference of cold Antarctic waters.

The light-mantled sooty albatross breeds in the sub-Antarctic islands, and disperses south into the ice edge in summer season. OZAWA *et al.* (1964) investigated the relationship between the abundance of the bird and the temperatures of surface sea water, and mentioned that the bird occurred in the

temperature range of 4° to −0.9°C and was particularly abundant in the waters below 0°C. OZAWA *et al.* (1968) also reported the birds crowded on the water with the patches of krill.

According to Fig. 3, the cape pigeon occurred in large number in the sections of 90°E to 120°E, whereas in small number in the sections of 20°E to 80°E. These results may be due to the ship's activity at the time of observation rather than the regional difference. In the former sections, the bird was recorded by SHINANO MARU and ORIENTO MARU which made short moves, especially they moved in the limited area in the latter half of this survey. As already mentioned, the cape pigeon seemed to follow the ships when they were cruising in a limited area.

The southern fulmar is a dweller of cold Antarctic water just like the antarctic petrel and the snow petrel (OZAWA, 1967). The southern fulmar showed the similar occurrence as the cape pigeon in Fig. 3, though the number was a few.

The sooty shearwater was frequently observed in large flocks in the sections of 90°E to 120°E. During the late summer (February-March) large feeding flocks move into the Southern Ocean mainly between 70°E and 150°E, and there was no record further west of 70°E (PHILLIPS, 1963). However, NAITO *et al.* (1979) recorded the species in large flocks between 50°E and 60°E in February of 1977. Their records provide evidence of a more extensive migratory movement in a westerly direction along the pack ice. These birds must be non-breeder, since most breeding adults leave their colony from about the last week in April onwards, and the fledgelings leave the nest burrows between the last week in April and the third week in May (RICHDALE, 1944). However, all these identification were made in the field and no birds were collected. Only collecting will establish which muttonbirds, *Puffinus griseus* or *Puffinus tenuirostris,* occur at these high southern latitudes. NAKAMURA (private communication) discussed the detailed distribution and migration in relation to the food supply in the Southern Ocean.

The prions were observed in large flocks in the sections of 30°E to 40°E, and of 70°E to 80°E in Fig. 3. AOYANAGI (1973) reported that the prions were most abundant latitudinally around 55°S. In the present survey, KYO MARU recorded abundant prions around 55°S (Appendix).

The wandering albatross and the white-chinned petrel are widely distributed in the Southern Ocean, but they were not so abundant in the present

survey. Since they are dwellers of a little to the north in the area where this survey was made, the birds observed seem to be their southernmost groups. The south polar skua was also not so abundant.

As already mentioned, most of the birds assigned to the terns appear to be the arctic terns. According to WATSON (1975), the arctic terns which migrated to the Antarctic were mostly recorded from about 150°E to the Weddell Sea. They may take advantage of the east wind near the continent to move west into the Weddell Sea, where they completed molting of wings and tail before returning to north in March *via* Africa. The flocks of tern recorded in the sections of 30°E to 50°E might be the arctic terns moving to the Weddell Sea.

CARRICK and INGHAM (1967) reviewed the ecological research on Antarctic sea birds, and stated that the most important organisms as food for sea birds are euphausiids, squids and, to a lesser degree, fishes. There are abundant euphausiids and squids in the area where the present surveys were performed. Most of the sea birds dealt with here take euphausiids and squids as the main food: the Wilson's storm petrel feeds on euphausiids; the cape pigeon and the southern fulmar not only on euphausiids but also squids; the light-mantled sooty albatross on squids. The antarctic petrel takes them thoroughly. The snow petrel feeds on fish mainly, and besides euphausiids and squids.

The sea birds that occurred in a wide range in Fig. 3 are breeding on the Antarctic Continent or the adjacent islands in austral summer annually, namely the antarctic petrel, the snow petrel, the cape pigeon, the Wilson's storm petrel, and the southern fulmar. The light-mantled sooty albatross and the sooty shearwater, however, are not breeders on the continent but on sub-Antarctic islands. Both are highly pelagic in habit and disperse far south into the ice edge in summer. Although the south polar skua is breeding on the continent in summer season, very few were observed only in three sections of the present survey (Fig. 3). The skua may occur frequently near penguin rookeries in the summer in the continent or the adjacent islands, and seldom disperse to the area of sea off the pack ice. It is reasonable to conclude that the sea birds that occurred widely in this survey are breeding on the continent or the adjacent islands in austral summer, and take food in the sea off the pack ice.

References

AOYANAGI, M. (1973): Dai-13-ji kokai-chû ni kansatsu shita shuyô kaichô no shutsugen kiroku (Occurrence records of principal sea birds during the cruise of the 13th Japanese Antarctic Research Expedition). Nankyoku Shiryô (Antarct. Rec.), **46**, 119–124.

CARRICK, R. and INGHAM, S. E. (1967): Antarctic sea-birds as subjects for ecological research. JARE Sci. Rep., Spec. Issue, **1**, 151–184.

FALLA, R. A. (1937): Birds. Rep. BANZARE 1929-31, Ser. B, 1–288.

GROUP OF SPECIALISTS ON LIVING RESOURCES OF THE SOUTHERN OCEAN, SCAR AND SCOR ed. (1977): Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS). Vol. 1 (Research Proposals). 1–79.

NAITO, Y., NASU, K. and SUZUKI, H. (1979): Distribution of the Antarctic sea-bird in the outer margin of the summer pack ice area. Nankyoku Shiryô (Antarct. Rec.), **66**, 50–63.

NAKAMURA, K. and NAITO, Y. (1979): Nankyoku kai mokushi manyuaru, umidori hen (A field guide of sea birds in the Antarctic Ocean). Tokyo, Natl Inst. Polar Res., 1–63.

OZAWA, K. (1967): Distribution of sea birds in austral summer season in the Southern Ocean. Nankyoku Shiryô (Antarct. Rec.), **29**, 1–36.

OZAWA, K., MIMURA, K., EGOSHI, H. and NAGOSHI, K. (1964): Observations of sea birds of the Southern Ocean (II). J. Tokyo Univ. Fish. (Spec. ed.), **7**, 1–41.

OZAWA, K., YAMADA, T., KIRA, M. and SHIMIZU, T. (1968): Observations of sea-birds in the Southern Ocean (III). J. Tokyo Univ. Fish. (Spec. ed.), **9**, 51–100.

PHILLIPS, J. H. (1963): The pelagic distribution of the sooty shearwater *Procellaria grisea*. Ibis, **105**, 340–353.

RICHDALE, L. E. (1944): The sooty shearwater in New Zealand. Condor, **46**, 93–107.

WATSON, G. E. (1975): Birds of the Antarctic and Sub-Antarctic. Washington, Am. Geophys. Union, 350 p.

(Received September 4, 1980; Revised manuscript received December 15, 1980)

Appendix 1. KYO MARU.

Date	Dec. 1979 24	25	26	27	29	30	31	Jan. 1980 1	2	3	4
Time	09:00～	11:30～	11:30～	11:25～	14:00～	11:30～	11:00～	15:50～	15:50～	15:50～	?
Latitude (S)	47°08′	51°38′	56°42′	61°49′	66°53′	67°32′	67°14′	66°49′	65°42′	65°14′	65°41′
Longitude (E)	23°23′	27°46′	30°16′	32°56′	37°18′	39°00′	40°02′	42°39′	43°57′	46°05′	48°31′
Water temperature (°C)	5.3	4.2	1.5	0.7	0.8	0.3	−0.8	2.4	−1.3	2.0	−0.7
Ship's activity	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising
Species											
Chinstrap penguin*											
Wandering albatross		1									
Black-browed albatross	3										
Gray-headed albatross		1	1								
Light-mantled sooty albatross				1							
Southern giant fulmar											
Southern fulmar							1	1			
Antarctic petrel							16	7	2	2	
Cape pigeon				2		1		1			
Snow petrel				1		1	1		3	13	
White-headed petrel											
White-chinned petrel	1										
Sooty shearwater	1	1		1							7
Prions	3	50	50	30							
Wilson's storm petrel		4				1	1		1	4	2
South polar skua	1										
Terns					70			7	20		

* Species which was not observed at KYO MARU.

Appendix 1. KYO MARU (continued).

Date	Jan. 1980 5	6	7	8	9	10	11	12	13	14	15
Time	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	08:00～	17:00～
Latitude (S)	65°39′	65°29′	66°05′	65°48′	66°21′	66°46′	66°56′	67°01′	67°07′	66°50′	65°40′
Longitude (E)	52°04′	55°19′	57°02′	58°15′	59°29′	62°18′	63°45′	64′57′	66°51′	66°44′	66°48′
Water temperature (°C)	−0.8	−0.2	0.4	2.0	2.4	2.0	1.2	2.8	0.8	0.2	1.4
Ship's activity	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising	cruising
Species											
Chinstrap penguin*											
Wandering albatross											
Black-browed albatross											
Gray-headed albatross											
Light-mantled sooty albatross											
Southern giant fulmar		1	1		2						1
Southern fulmar		1				1		2	2	4	
Antarctic petrel	26	16		29	5		2	7	ca100	30	1
Cape pigeon		2				5	1				
Snow petrel		3	24	2	1	2	4		2		
White-headed petrel											
White-chinned petrel											
Sooty shearwater		3									
Prions											
Wilson's storm petrel	1	2			2	4		1			
South polar skua						2					
Terns	1										

* Species which was not observed at KYO MARU.

Appendix 1. KYO MARU (continued).

Date	Jan. 1980 16	17	18	20	21	22	23	24	25	26	27
Time	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～
Latitude (S)	65°40′	64°03′	63°38′	64°12′	64°18′	64°46′	65°01′	66°34′	67°03′	66°57′	66°50′
Longitude (E)	66°44′	72°20′	83°31′	86°56′	75°20′	62°24′	49°27′	37°07′	34°03′	35°15′	34°26′
Water temperature (°C)	1.4	1.2	0.6	1.0	1.6	2.0	1.4	1.4	0.2	0.4	0.0
Ship's activity	?	?	stationary	cruising	cruising	cruising	cruising	cruising	cruising	cruising	stationary
Species											
Chinstrap penguin*											
Wandering albatross		1									
Black-browed albatross											
Gray-headed albatross											
Light-mantled sooty albatross		4	3		1				1	1	3
Southern giant fulmar											
Southern fulmar											
Antarctic petrel	5	40	2	2	3	2	45	1	35	1	3
Cape pigeon		1									
Snow petrel											
White-headed petrel											
White-chinned petrel		8	23		8	3		1	2		
Sooty shearwater								1			
Prions		1			2			1	2	7	25
Wilson's storm petrel	1					1		1			
South polar skua											
Terns	1										

* Species which was not observed at KYO MARU.

Appendix 1. KYO MARU (continued).

Date	Jan. 1980 28	29	30	31	Feb. 1980 1	2	3	4	5	6	7
Time	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～
Latitude (S)	67°10′	64°26′	64°44′	67°22′	68°00′	65°15′	64°00′	65°59′	67°15′	67°57′	67°13′
Longitude (E)	31°00′	29°52′	25°02′	25°03′	22°23′	19°53′	17°16′	15°00′	14°44′	10°00′	09°46′
Water temperature (°C)	0.2	0.7	0.6	0.0	0.3	0.7	1.2	0.9	0.0	−0.2	0.3
Ship's activity	cruising	cruising	?	cruising	cruising	cruising	cruising	cruising	stationary	cruising	cruising
Species											
Chinstrap penguin*											
Wandering albatross		1		1							
Black-browed albatross											
Gray-headed albatross											
Light-mantled sooty albatross											
Southern giant fulmar										1	1
Southern fulmar		1									
Antarctic petrel		2	1			2		3	2	4	11
Cape pigeon		1									
Snow petrel	9		1	4	5			2	1	2	
White-headed petrel											
White-chinned petrel	1										
Sooty shearwater	1	9	3			1	2				
Prions	10	3					1				
Wilson's storm petrel	1	1	1	2							
South polar skua											
Terns											

* Species which was not observed at KYO MARU.

Appendix 1. KYO MARU (continued).

Date	Feb.1980 8	9	10	11	12	13	14	15	16	17	18
Time	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～	15:50～
Latitude (S)	64°59′	66°55′	67°52′	68°01′	67°56′	66°46′	64°01′	59°32′	55°21′	50°40′	45°56′
Longitude (E)	07°16′	05°20′	02°06′	00°30′	01°02′	00°30′	00°33′	04°11′	07°17′	10°11′	12°50′
Water temperature (°C)	1.4	0.4	0.0	0.2	0.0	0.4	1.4	0.6	0.9	4.0	7.9
Ship's activity	cruising	?	cruising	cruising	?	cruising	cruising	cruising	cruising	cruising	cruising
Species											
Chinstrap penguin*											
Wandering albatross						1		2			
Black-browed albatross										1	1
Gray-headed albatross										2	
Light-mantled sooty albatross						1					
Southern giant fulmar						1					
Southern fulmar											
Antarctic petrel	1	2	7	3	1	4	5				
Cape pigeon								1			
Snow petrel	1	1	1								
White-headed petrel									1	2	
White-chinned petrel											2
Sooty shearwater	2			2	3	4	8	12	10	2	
Prions							1	6	36	5	
Wilson's storm petrel			2		1						
South polar skua											
Terns											

* Species which was not observed at KYO MARU.

Appendix 2. ORIENTO MARU.

Date	Jan. 1980 8	9	10	11	12	13	14	15	16	17	18	19	20
Time	14:10～	18:00～	16:00～	15:45～	17:30～	16:05～	09:15～	11:30～	12:15～	16:00～	09:40～	20:40～	19:25～
Latitude (S)	63°28′	63°56′	64°32′	64°40′	65°08′	64°14′	64°37′	64°02′	63°35′	63°00′	62°39′	63°40′	64°33′
Longitude (E)	90°44′	91°48′	90°16′	87°41′	86°59′	84°29′	87°41′	85°00′	87°48′	90°23′	94°30′	98°24′	100°59′
Water temperature (°C)	0.3	0.1	−0.2	0.0	0.0	0.3	0.2	0.2	0.4	−0.7	0.7	0.4	0.1
Ship's activity	cruising	cruising	cruising	cruising	cruising	cruising	trawling	cruising	?	cruising	cruising	cruising	?
Species													
Chinstrap penguin*													
Wandering albatross*													
Black-browed albatross*													
Gray-headed albatross										1			
Light-mantled sooty albatross	2							2	4	3	3		
Southern giant fulmar				1	4	ca20	2	3					
Southern fulmar													
Antarctic petrel		1	2	1		15	2	10			ca50	3	
Cape pigeon	4									5	ca20		
Snow petrel				1									
White-headed petrel													
White-chinned petrel		3	3						ca15	ca10			
Sooty shearwater													ca5,000
Prions													
Wilson's storm petrel								1	1			1	
South polar skua													
Terns													

* Species which was not observed at ORIENTO MARU.

Appedix 2. ORIENTO MARU (continued).

Date	Jan. 1980 21	22	23	24	25	26	27	28	29	30	31	Feb. 1980 1
Time	19:40～	20:00～	17:45～	?	19:20～	14:00～	06:30～	?	10:00～	08:00～	20:00～	06:50～
Latitude (S)	64°00′	63°49′	63°56′	64°57′	64°25′	64°14′	65°18′	63°31′	63°40′	64°14′	64°42′	64°38′
Longitude (E)	101°47′	103°40′	105°03′	105°18′	112°43′	114°18′	114°46′	107°00′	105°05′	100°01′	92°04′	92°23′
Water temperature (°C)	0.4	1.1	1.2	0.7	0.7	0.3	−0.8	0.8	1.1	0.2	0.3	0.3
Ship's activity	?	cruising	cruising	?	cruising	?	cruising	cruising	?	cruising	?	?
Species												
Chinstrap penguin*												
Wandering albatross*												
Black-browed albatross*												
Gray-headed albatross												
Light-mantled sooty albatross							1	2		1	2	1
Southern giant fulmar												
Southern fulmar			1				1	1		2		
Antarctic petrel	3						4			5		3
Cape pigeon			1	15	5	5	6	13	7		5	
Snow petrel	3						1					
White-headed petrel												
White-chinned petrel												
Sooty shearwater		ca200		ca500	ca100	ca200		ca50	ca300	ca1,000		20
Prions				5								
Wilson's storm petrel		3	4	1	1	2		3	2			
South polar skua					1							
Terns								2		1		

* Species which was not observed at ORIENT MARU.

Appendix 2. ORIENTO MARU (continued).

Date	Feb. 1980 2	3	4	5	6	7	8	9	10	11	12	13
Time	20:00~	10:10~	12:10~	11:00~	11:00~	13:30~	10:45~	12:00~	?	07:30~	12:00~	11:30~
Latitude (S)	63°29′	63°33′	63°33′	63°03′	64°22′	63°37′	63°35′	63°38′	63°34′	63°50′	63°55′	63°54′
Longitude (E)	92°03′	92°13′	92°38′	92°59′	93°00′	93°14′	93°20′	93°27′	93°28′	93°42′	93°56′	93°57′
Water temperature (°C)	0.9	1.0	1.1	1.1	0.8	0.9	0.9	1.0	1.1	1.0	0.6	0.6
Ship's activity	trawling	trawling	stationary	oceano-graphy	oceano-graphy	trawl-ing	station-ary	station-ary	station-ary	trawl-ing	trawl-ing	trawl-ing
Species												
Chinstrap penguin*												
Wandering albatross*												
Black-browed albatross*												
Gray-headed albatross												
Light-mantled sooty albatross		2			1			2			2	
Southern giant fulmar												
Southern fulmar	2		2				2		1	2	5	3
Antarctic petrel				5								
Cape pigeon	ca50	ca30	ca50		10	ca100	ca50	20	20	ca30	20	ca50
Snow petrel												
White-headed petrel											1	
White-chinned petrel												
Sooty shearwater						ca50		ca200	ca100	ca100		
Prions												
Wilson's storm petrel				1		2	1	2	3			
South polar skua												
Terns												

* Species which was not observed at ORIENTO MARU.

Appendix 3. SHINANO MARU.

Date	Jan. 1980 10	11	12	13	14	14	15	16	18	20	21	22	23
Time	12:00～	20:00～	20:00～	14:00～	08:00～	16:20～	15:10～	16:00～	17:00～	22:00～	17:10～	17:00～	22:30～
Latitude (S)	63°22′	63°11′	63°09′	63°13′	63°14′	63°12′	63°08′	63°08′	63°19′	63°25′	63°42′	63°46′	63°52′
Longitude (E)	90°34′	90°31′	90°29′	90°11′	90°20′	90°13′	90°17′	90°24′	90°36′	90°35′	90°52′	90°38′	90°50′
Water temperature (°C)	0.3	1.2	0.8	0.6	0.1	0.9	0.8	1.0	1.0	1.5	1.3	1.5	1.3
Ship's activity	cruising	stationary	stationary	stationary	stationary	stationary	stationary	stationary	stationary	?	stationary	stationary	stationary
Species													
Chinstrap penguin				3	2		3						
Wandering albatross*													
Black-browed albatross*													
Gray-headed albatross*													
Light-mantled sooty albatross				2			2				8		3
Southern giant fulmar						1	3					12	ca100
Southern fulmar							8		12		3	50	20
Antarctic petrel*													
Cape pigeon			2	1	3	48	ca100	6	ca100	6	6	ca300	ca200
Snow petrel	1												
White-headed petrel*													
White-chinned petrel	8	6	3	8		8	8	4	1	4	ca100	20	
Sooty shearwater*													
Prions*													
Wilson's storm petrel						1	3						
South polar skua					1								
Terns*													

* Species which was not observed at SHINANO MARU.

Appendix 3. SHINANO MARU (continued).

Date	Jan. 1980 26	27	28	31	Feb. 1980 2	5	6	7	9	10	11	12
Time	11:40～	06:30～	18:20～	16:00～	07:10～	09:00～	08:10～	09:10～	08:10～	16:10～	11:20～	11:10～
Latitude (S)	64°00′	63°55′	63°50′	63°26′	63°26′	63°32′	63°38′	63°40′	63°37′	63°41′	63°46′	63°53′
Longitude (E)	91°11′	91°09′	91•35′	92°04′	92°24′	92°32′	92°51′	93°05′	93°26′	93•36′	93°36′	93°54′
Water temperature (°C)	1.4	1.4	1.1	1.0	0.8	1.1	1.5	1.0	0.9	1.1	0.7	0.7
Ship's activity	station-ary	station-ary	station-ary	?	station-ary	station-ary	station-ary	station-ary	station-ary	station-ary	station-ary	?
Species												
Chinstrap penguin												
Wandering albatross*												
Black-browed albatross*												
Gray-headed albatross*												
Light-mantled sooty albatross			1					1		2		1
Southern giant fulmar	10	31	55	3	ca100	18	ca100	63	82	42	43	ca100
Southern fulmar					20		ca100		9			
Antarctic petrel*												
Cape pigeon	ca200	ca300	ca250	6	ca300	ca300	ca900	ca400	ca200	ca100	ca100	ca200
Snow petrel												
White-headed petrel*												
White-chinned petrel												
Sooty shearwater*												
Prions*												
Wilson's storm petrel												
South polar skua												
Terns*												

* Species which was not observed at SHINANO MARU.