A POPULATION STUDY OF THE WEDDELL SEAL IN LÜTZOW-HOLM BAY AND ITS ADJACENT WATERS, ANTARCTICA

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Abstract: A population study of the Weddell seal (*Leptonychotes weddelli* LESSON) was carried out in the fast ice area between 34°E and 44°30′E along the coastline of Lützow-Holm Bay and the Prince Olav Coast, East Antarctica. The observations were made in April and in the period from September to December 1980. The study comprises ground survey and aerial census. The ground survey was done to obtain detailed information on the age and sex structures of the Weddell seal. It was made in a limited part of the area studied. The aerial census was undertaken to estimate the total population of seals in the whole of the area investigated and to examine their seasonal movement there. The Weddell seal began to appear on the ice in early spring and its population number reached a peak between October and November. The total seal population in the study area was estimated to be about 10000. The population density was 0.27/km^2. The population density in the Prince Olav Coast area was high compared with that in Lützow-Holm Bay. It was higher in the coastal area than in the offshore area. A remarkable decrease of seal population in the coastal area and its increase in the offshore area occurred concurrently with the progress of the season.

1. Introduction

One of the effective approaches for the ecosystem analysis is estimation of the biomass of the components at the highest trophic level in a given system. The Weddell seal (*Leptonychotes weddelli* LESSON) predominates in the coastal antarctic ecosystem. However, information on the Weddell seal population in Lützow-Holm Bay and its adjacent waters is quite scarce, though the Japanese Antarctic Research Expedition has continued its scientific efforts. In 1975 a population census was made with a small aircraft in Lützow-Holm Bay (HOSHIAI, 1981). Since then no investigations of the Weddell seal population have been performed.

The senior author participated in the wintering party of the 21st Japanese Antarctic Research Expedition (JARE-21) in 1980. As JARE-21 brought two aircrafts for scientific researches, he attempted the estimation of seal population by the aviation census and by the watch with snow vehicles.

However, one of the two aircrafts was lost by the breakup of the sea ice in March 1980 and he was obliged to contract his proposed program. The ground survey with snow vehicle was also limited by the tightness in field operations due to the bad sea ice condition. Accordingly, the results obtained are not always satisfactory in accuracy. However, the present information may contribute to the progress in the marine ecosystem analysis in Lützow-Holm Bay and its adjacent waters.

2. Area Studied

The area in which the seal population study was undertaken consists of Lützow-Holm Bay and the Prince Olav Coast area except its southwestern end, the northern outside of the bay (Fig. 1). The area was divided into four subareas A, B, C and D. Subarea A is the eastern part of the bay. East Ongul Island on which Syowa Station (69°00′S, 39°35′E) is situated is in subarea A. There are small islands, grounded icebergs surrounded by tide and shear cracks and floating icebergs accompanied by shear cracks. These fissures of sea ice provide a favorable structure for the Weddell seal to haul out of the water. A dense population of seals was expected in this subarea. Both the ground survey and the aerial census were undertaken there.

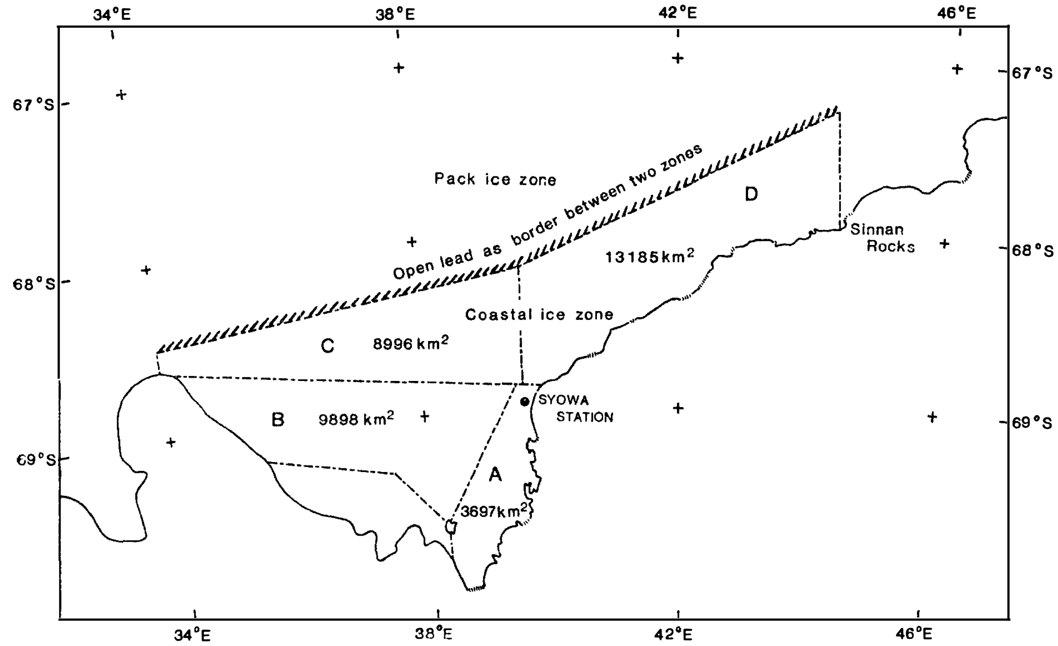

Fig. 1. Study area composed of subareas A, B, C and D.

The southwestern end of the bay was completely covered with the consolidated ice accompanied by the shelf ice of 2 to 4 m high above the sea level. It was considered that the Weddell seal could not haul out of the water there. Consequently, this part was excluded from the census area. Subarea B occupies the central and the western part of the bay. The fissures of the sea ice are well developed along the west coast of the bay and along the margin of the consolidated ice and shelf ice zone. The flat sea ice stretched over the rest part of this subarea.

Subarea C is the outside of Lützow-Holm Bay. The surface of sea ice was even and few cracks were there. Subarea D extends along the Prince Olav Coast. There were many tide cracks adjacent to the coastline. The icebergs are scattered in parallel to the coastline and are distributed densely in the north of Sinnan Rocks and the west end of the Prince Olav Coast. In the subareas other than subarea A, only the aerial census was carried out.

Although it is interesting to compare the populations of the fast ice zone and of the pack ice zone, the present observation was conducted only in the fast ice zone according to the flight regulation for the safety of JARE. Throughout the spring–summer observation period, the fast ice zone was separated from the pack ice zone by an open lead, which occurred at a definite position and was easily identified in the satellite NOAA-6 imagery (Fig. 2).

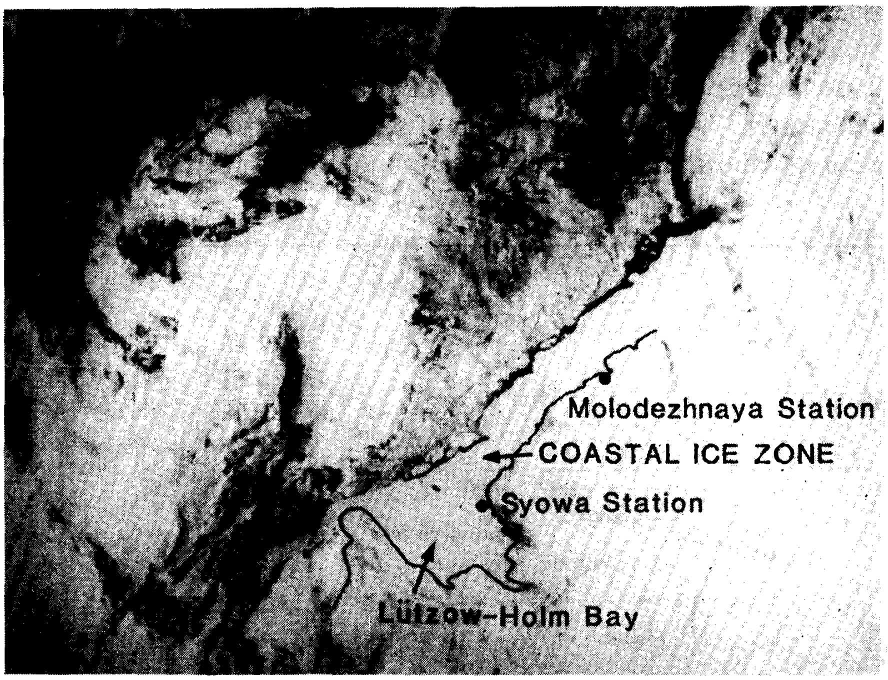

Fig. 2. Satellite NOAA-6 imagery (December 14, 1980).

3. Ground Survey

The ground survey was intended for knowing the species composition of seals and also for examining the age and sex structures of the Weddell seal. Since it was carried out only in a part of subarea A (Fig. 3), further examinations are necessary prior to the application of the present results to the other subareas. However, the data obtained seem to be suggestive for the understanding of the dynamics of the Weddell seal population in the whole area dealt with. Counting of Weddell seals along a definite route of 30 km by snow vehicle (Fig. 3) was made in April, September and October. Several day trips were repeated in each of three observation periods and the maximum seal population in the route was recorded (Table 1). Information on the species composition was added by other occasional trips.

Species composition of seals was quite simple throughout the year. Only the crabeater seal (*Lobodon carcinophagus* (HAMBRON and JACQUINOT)) was found other than the Weddell seal. Three immature seals were found on November 23. This figure is 1.5% of the total seals discovered at that time. Such low rate of the crabeater seal as 0.58% was known by the aerial census which was made in subarea A at the end of November. Therefore, the crabeater seal is not dealt with in the present paper.

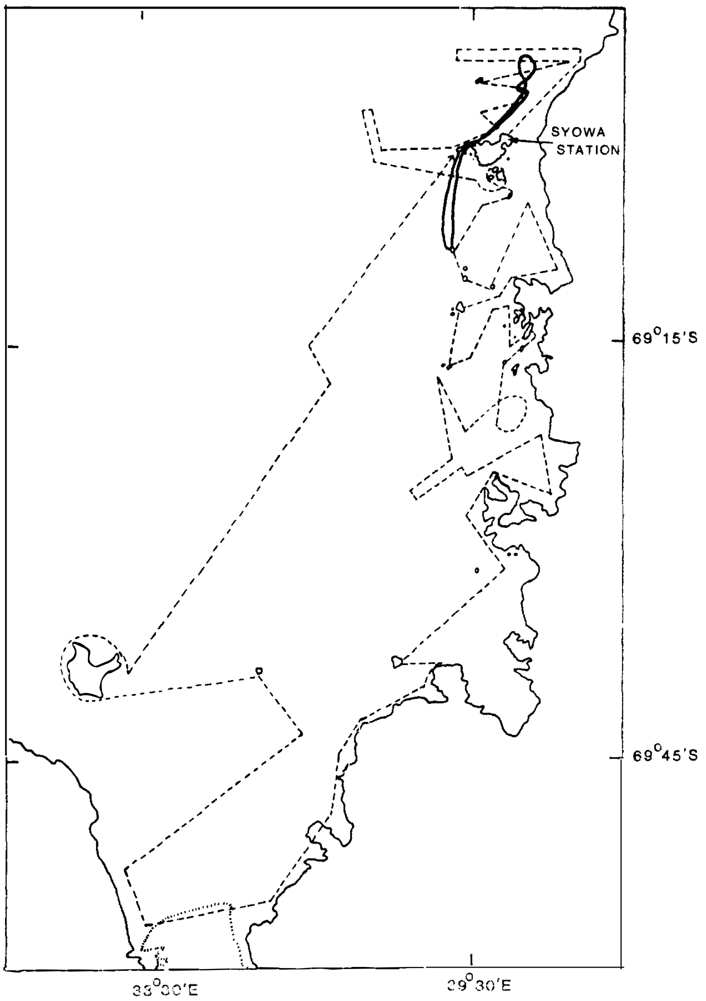

Fig. 3. Flight route (broken line) and route of snow vehicle trips (solid line) in subarea A.

Table 1. Seasonal change of the age and sex structures of the Weddell seal in a part of subarea A. Numerals are maximum individual number of the Weddell seal recognized during each observation period. Figures in parentheses show the sex ratio in percentage.

	April 4–30		September 5–15		October 25–30	
	f	m	f	m	f	m
Adult	7 (35.0)	13 (65.0)	1 (12.5)	7 (88.5)	90(77)* (82.6)	19 (17.4)
Subadult	3 (42.9)	4 (57.1)	0	0	3 (75.0)	1 (25.0)
Immature	6 (60.0)	4 (40.0)	0	0	6 (50.0)	1 (50.0)

* Number of adult females with pup.

The results of the ground survey are shown in Table 1. According to the age-body length key of STIRLING (1971) seals were classified as the immature (1–2 years old), the subadult (3–4 years old) and the adult (over 5 years old). Pups were also recorded.

The data of April show the numerical superiority of the adult, particularly the male adult in the Weddell seal population after the breeding season. The number of the subadult and the immature did not change before and after the breeding season. The Weddell seal stayed in the water and seldom appeared on the sea ice in the winter as stated by BERTRAM (1940). They began to appear from middle or late August in the study area. The male adult arrived on the sea ice prior to the appearance of the subadult and the immature. These findings seem to support the statement of SINIFF *et al.* (1975) that the male adult stays in a breeding area throughout the year to protect it. The number of the female adult reached a peak in late October and the population size of the Weddell seal was limited by the female adult.

4. Aerial Census

The aerial census was made by a Pilatus Porter-PC6 in the four subareas. In subarea A, seals were counted as completely as possible. In subareas B, C and D, the counting of seals for providing the basis of the population estimation was made in the belts along the flight courses. The flight course was selected to reflect the distribution pattern of the Weddell seal. The configuration of the coastline, the distribution of icebergs and the feature of the sea ice were considered. However, the proposed flight in subarea D was often restricted by the bad weather. Since the Weddell seal decreases during the winter and the darkness of the winter prevents the flight operation, a preliminary census was undertaken on April 14, before the dark winter, in order to set up flight courses for the spring–summer observation. The spring–summer observation was made once a month from September through December.

It was well known that the number of seals on the sea ice fluctuated depending on the weather condition and the time of a day (MATSUDA, 1963; SINIFF *et al.*, 1970, 1971; ERICKSON *et al.*, 1971; GILBERT and ERICKSON, 1977). Therefore, the weather and flight time for the observation were strictly limited. The flight was undertaken when the wind velocity was less than 10 m/s and the total amount of cloud at Syowa Station was less than 50%. The observation was done between 1000 and 1500 in local time. The counting of seals was made with the sighting by two scientists seated at each side of the aircraft. Recording by a camera or a movie camera was not made. A continuous sighting time was limited to less than about 3.5 hours to prevent the observers from getting tired. It was decided that the flight altitude of aircraft was to be kept at about 305 m (1000 feet) during observations. The ground speed was set at 167 km/hour (90 knots) but it varied slightly by influence of the wind. The width of observation belts was defined as the maximum distance in which the counting is possible without missing a seal. The maximum distance was calculated with the altitude of aircraft and the angle which was formed by the vertical line and the line connecting eyes and the margin of an observation belt (maximum sighting angle). As the maximum sighting angle, 81° was actually obtained by the field tests.

The whole seals in subarea A and in the coastal route of subarea B were counted. Part of the coastal route of subarea D was covered by the observation of October. Consequently, the coastal seal population in October was calculated from the data obtained in this route. The whole of the coastal route was investigated in November and December. The populations of seals in subarea C and in the offshore regions of subareas B and D were estimated by the calculation based on the individual numbers of seals discovered within the observation belts. As shown in Fig. 1, the coastal route was not included in subarea C. The estimation of population was done according to the following formula;

$$P=\frac{S-s}{d(2\,h\tan\theta-a)}\cdot\frac{N}{R}+n,$$

P: seal population in subareas B, C and D,
S: area of subareas B, C and D,
s: area of coastal observation belt,
d: distance of observation belt,
h: altitude of aircraft (0.305 km),
θ: maximum sighting angle (81°),
a: width of blind part below aircraft (0.388 km),
R: finding rate (assumed 1.0),
N: individual number of seals in offshore observation belts,
n: individual number of seals in a coastal observation belt.

The width of observation belts which was calculated based on the maximum sighting angle was 1.896 km. Accodingly, the distance covered from both sides of the aircraft was 3.788 km. However, a certain range just below the aircraft was completely blind. The width of this blind area was 0.388 km. Therefore, the width of the actually visual belt became 3.400 km. Within this observation field, the number of seals counted from aircraft differed little from the actual number of seals as mentioned above. Therefore, the finding rate of seals was assumed to be 1.0.

In subarea A, the irregular flight course was set up to count the whole seals of this subarea (Fig. 3). As shown in Table 2, the number of seals was 109 and the population density was 0.03/km^2 in September. In late October, just after the pupping season, the seals increased to 1054 including pups. The population density became 0.29/km^2. After the breeding season, the individual numbers and population densities gradually decreased to 687 and 0.19/km^2 by late November and to 343 and 0.09/km^2 by late December. The decrease of seal number is probably due to the increase of the underwater life and the dispersion of adult females from this subarea. However, there has been no information on the behavior of the Weddell seal in the water in Lützow-Holm Bay area.

The flight route for the observation of subareas B and C is illustrated in Fig. 4. The route between Okidashi A and Okidashi B was provided for the observation of

Table 2. Seasonal change of Weddell seal population in subarea A.

	Number of seals sighted	Census area (km^2)	Density (Individ. No./km^2)
September	109 (0)	3697	0.03
October	1054 (339 pups)	3697	0.29
November	687 (156 pups)	3697	0.19
December	343 (0)	3697	0.09

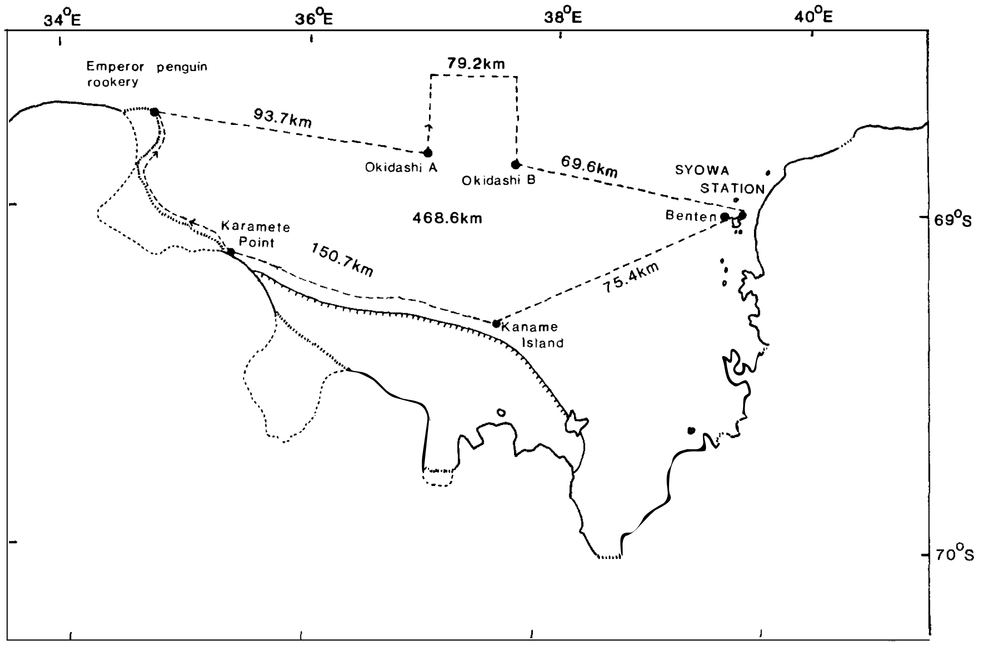

Fig. 4. Flight course in subareas B and C.

Table 3. Seasonal change of number and population density of seals in subareas B and C. Figures in parentheses show the number of pups.

		Flight distance (km)	Census area (km²)	October	November	December
Area B	Kaname Island–Emperor penguin rookery	150.7	512.7	458(172)	274(51)	263(—)
	Density (Individ. No./km²)			0.89	0.53	0.51
	Benten Island–Kaname Island	75.4	265.5	49(8)	52(6)	53(—)
	Density (Individ. No./km²)			0.18	0.20	0.20
	Emperor penguin rookery–Okidashi A	93.7	318.8	16(0)	84(21)	136(—)
	Density (Individ. No./km²)			0.05	0.26	0.43
	Okidashi B–Benten Island	69.6	236.8	47(11)	19(2)	28(—)
	Density (Individ. No./km²)			0.20	0.08	0.12
Area C	Okidashi A–Okidashi B	79.2	269.4	21(1)	10(0)	11(—)
	Density (Individ. No./km²)			0.08	0.04	0.04

seals in subarea C. Although this route was short, sufficient data for the seal population estimation seem to have been obtained because the surface of sea ice was flat and uniform in this subarea. The rest of the route of Fig. 4 was set up for the observation of subarea B. Individual number and population density of seals were larger in the coastal route between Kaname Island and emperor penguin rookery than in other parts of the flight course (Fig. 4 and Table 3). The number of seals decreased in the coastal route with the progress of the season. On the contrary, it increased between emperor penguin rookery and Okidashi A, which belongs to the offshore region or the central part of Lützow-Holm Bay. The increase of seal population in the central part of the bay may be a result of dispersion of adult females from the coastal area of subarea B as well as subarea A after pupping. However, further investigations are necessary to verify this assumption. The indivudual number and population density of seals in subarea C were very low in comparison with those of subareas A and B.

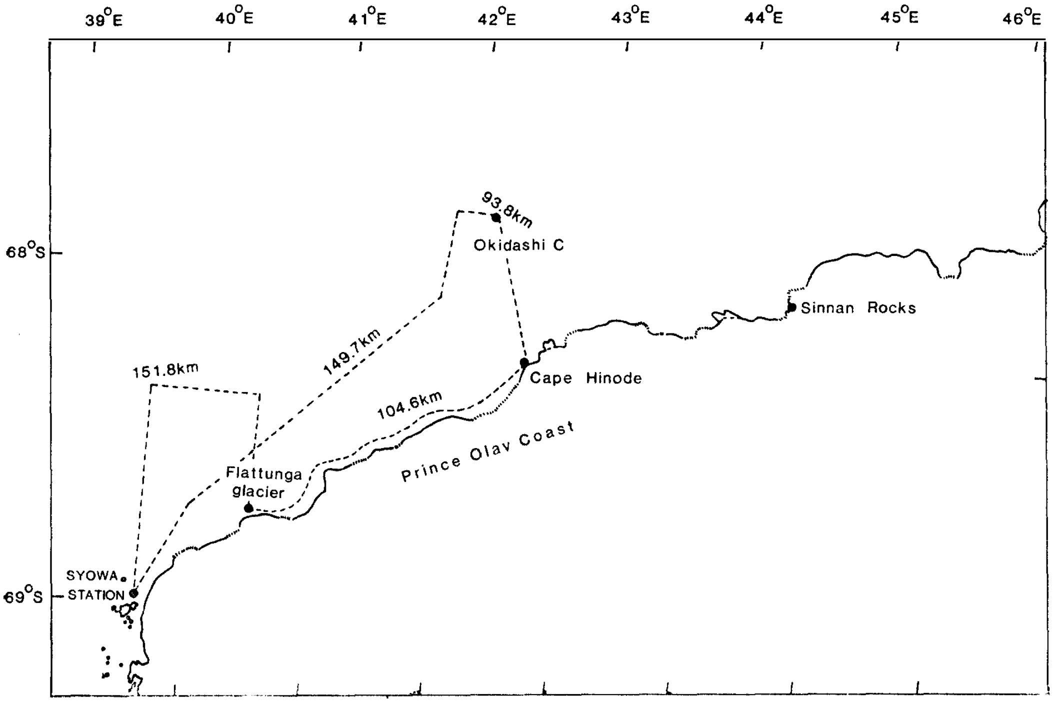

Fig. 5. Flight course in subarea D in October.

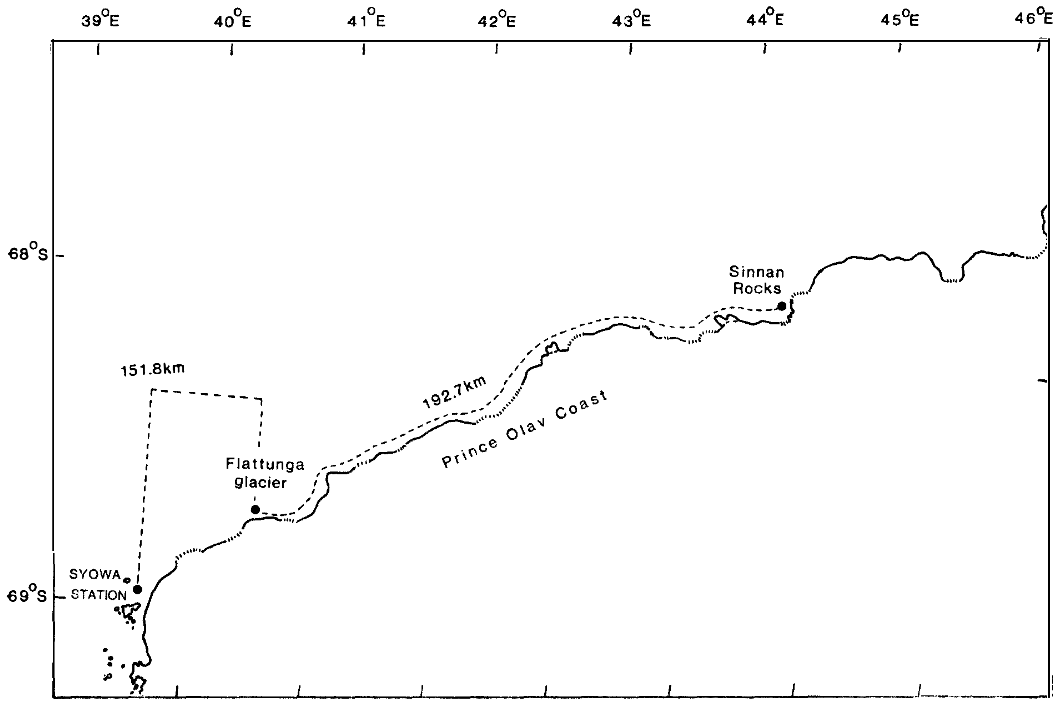

Fig. 6. Flight course in subarea D in November and December.

Subarea D consists of three parts, characterized by the coastline, the scattered icebergs and the flat sea ice respectively. The flight in October covered these three kinds of seal habitat. The courses from Syowa Station to the Flattunga glacier and from Cape Hinode to Okidashi C (Fig. 5) crossed over the areas with icebergs. The seals in the former course were counted in October through December. The course between the Flattunga glacier and Cape Hinode as the coastal route was studied in October. The course between the Flattunga glacier and Sinnan Rocks was investigated in November and December as the coastal route (Figs. 5 and 6). The population density of seals in the coastal route is higher than in the other routes (Table 4). The seal density in the coastal route of this subarea also decreased with the progress of the sea-

Table 4. Seasonal change of individual number and population density in subarea D.

	Distance (km)	Census area (km²)	October	November	December
Flattunga glacier–	104.6	355.8	748(249)	—	—
Cape Hinode			2.10		
Flattunga glacier–	192.7	655.6	—	654(195)	411(—)
Sinnan Rocks				1.00	0.62
Syowa Station–	151.8	516.4	168(56)	252(76)	124(—)
Flattunga glacier			0.33	0.49	0.24
Cape Hinode–	93.8	319.1	188(68)	—	—
Okidashi C			0.59		
Okidashi C–	149.7	509.3	176(35)	—	—
Flattunga glacier			0.35		

Table 5. The number and population density in Lützow-Holm Bay and its adjacent waters.

	Subarea A	Subarea B Coastal area	Subarea B Offshore area	Total in Lützow-Holm Bay	Subarea C	Subarea D Coastal area	Subarea D Offshore area	Total in area studied
September								
Individ. No.	109	—	—	—	—	—	—	—
Density	0.03	—	—	—	—	—	—	—
		—				—		
October								
Individ. No.	1054	458	1314	2826	720	1378	4869	9793
Density	0.29	0.89	0.14		0.08	2.10	0.40	0.27
		1772				6247		
November								
Individ. No.	687	274	1840	2801	360	650	—	—
Density	0.19	0.53	0.18		0.04	1.00	—	—
		2114				—		
December								
Individ. No.	343	263	2440	3048	360	411	—	—
Density	0.09	0.51	0.26		0.04	0.62		—
		2703				—		

son. There is little difference between the population density in the area with icebergs and that in the flat sea ice area in October. These two areas were considered the off-shore as a whole.

5. Estimated Seal Population

The seal number counted in subarea A and those estimated in subareas B, C and D are given in Table 5. The population densities were also included. Based on the data of October, the total Weddell seal population in the study area was about 10000 and the population density was 0.27/km^2 in 1980. The actual population seems to be larger than this figure because no individuals in the water were considered. The total seal population of Lützow-Holm Bay which comprises subareas A and B was estimated as less than 3000 and did not vary through the observation period. This figure is about three-times as large as the result of HOSHIAI (1981). At the present stage of knowledge in the vicinity of Lützow-Holm Bay, it is difficult to say whether this discrepancy was derived from the difference of the observation method adopted or from the acutal variation of seal population.

Acknowledgments

The authors thank Mr. H. OHMORI, Mr. T. MIZUSHIMA and Mr. T. YASHIRO for their cooperation in the aviation operation. They extend their tnanks to Prof. S. KAWAGUCHI, deputy leader of JARE-21 for his thoughtful administration for the present research. Thanks are also due to Dr. T. KASUYA for his valuable advice in preparing the manuscript.

References

BERTRAM, G. C. L. (1940): The biology of the Weddell and crabeater seals. Sci. Rep. Br. Graham Land Exped. 1934–37, **1**, 1–139.

ERICKSON, A. W., SINIFF, D. B., CLINE, D. R. and HOFMAN, R. J. (1971): Distributional ecology of antarctic seals. Symposium on Antarctic Ice and Water Masses, ed. by G. DEACON. Cambridge, Scott Polar Res. Inst., 55–76.

GILBERT, J. R. and ERICKSON, A. W. (1977): Distribution and abundance of seals in the pack ice of the Pacific sector of the Southern Ocean. Adaptations within Antarctic Ecosystems, ed. by G. A. LLANO. Washington D. C., Smithson. Inst., 703–740.

HOSHIAI, T. (1981): Aerial census of Weddell seal (*Leptonychotes weddelli* Lesson) in Lützow-Holm Bay, Antarctica. Nankyoku Shiryô (Antarct. Rec.), **71**, 109–112.

MATSUDA, T. (1963): Nankyoku ni sumu Uedderu azarashi ni tsuite no 2, 3 no seitai kansatsu (Some ecological observations on the Antarctic Weddell seal). Nippon Seitai Gakkaishi (Jap. J. Ecol.), **13**, 161–163.

SINIFF, D. B., CLINE, D. R. and ERICKSON, A. W. (1970): Population densities of seals in the Weddell Sea, Antarctica, in 1968. Antarctic Ecology, Vol. 1, ed. by M. W. HOLDGATE. London, Academic Press, 377–394.

SINIFF, D. B., TESTER, J. R. and KUECHLE, V. B. (1971): Some observations on the activity patterns of Weddell seal as recorded by telemetry. Antarctic Pinnipedia, ed. by W. H. BURT. Washington, Am. Geophys. Union, 173–180 (Antarct. Res. Ser., **18**).

SINIFF, D. B., STIRLING, I., HOFMAN, R. J., DEMASTER, D., REICHLE, R. and KIRBY, R. (1975): Population studies of Weddell seals in eastern McMurdo Sound. Antarct. J. U. S., **10**, 120.

STIRLING, I. (1971): Population dynamics of the Weddell seal (*Leptonychotes weddelli*) in McMurdo Sound, Antarctica 1966–68. Antarctic Pinnipedia, ed. by W. H. BURT. Washington, Am. Geophys. Union, 141–161 (Antarct. Res. Ser., **18**).

(*Received November 16, 1982; Revised manuscript received March 2, 1983*)