STOCK OF THE ANTARCTIC MINKE WHALE

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INTRODUCTION

Although the minke whale belongs to genus *Balaenoptera* which is a main object of modern whaling, it has not been interested as an object for large-sized whaling especially for the pelagic whaling, because it is the smallest species of the genus. Minke whale has been caught as one of the objects of small-sized whaling in the coast of Japan, and in the coast of Norway many minke whales have been caught since 1930's (Jonsgård, 1962). However, they had been seldom caught as a food of crew during sperm whaling season in the pelagic whaling.

Now, the main object species of whaling have changed from larger species to smaller ones in the history of whaling. For example, the sei whale (*Balaenoptera borealis*) which had been seldom caught in the Antarctic whaling during 1950's has become to the main object recently. So, it will be possible that the minke whale becomes one of the objects of pelagic whaling in the Antarctic in future. There remain many technical and economical problems for the catch of minke whales by means of an expedition for large-sized whaling, but if they are solved, the minke whales must be noticed as the next whale stock, since other baleen whale stocks have decreased. In actuality, Norway is planning to catch minke whales in the Antarctic by means of a small factory catcher boat.

Not for the sake of repeating the same failure as the past whaling history, it is need to prepare for the future operation studying proper policy for management of stock of minke whale in the present time when a regular whaling does not start. On this stand point, the present report aims to seize the initial condition of minke whale stock in the Antarctic, and we will get several biological parameters for the assessment of the stock. Although our materials are not enough for this purpose, we will be happy if they are used as a preliminary data for the future investigation of this stock. At the same time, we examine on the identification of so-called minke whales which distribute in the Antarctic, and try to unify some considerations on this problem.

There are not so many reports on the southern minke whales, and most of these reports are on classification or morphology (Burmeister, 1867; Gray, 1874; Williamson, 1959, 1961; Utrecht and Spoel, 1962; Zemsky and Tormosov, 1964; Kasuya and Ichihara, 1965), although there are few ecological reports (Taylor, 1957; Arsenyev, 1960; Kasuya and Ichihara, 1965; Gaskin, 1968). On the other hand, we have more developed reports on the ecology of the northern minke whales (Matsuura, 1936; Jonsgård, 1951, 1962; Stephenson, 1951; Omura and Sakiura, 1956; Tomilin, 1957; Sergeant, 1963). We will discuss on our results, comparing with these reports.

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MATERIALS AND METHODS

Japanese whaling expeditions have been carried out whale sighting in the Antarctic with scouting boats belonged to the expeditions. We estimated the distribution and abundance of minke whales using the sighting reports of whales during the seasons from 1965/66 to 1968/69. As the sighting materials, navigation miles, noon position and number of whales sighted per day for each scouting boats are used in the present report.

A Japanese expedition caught many minke whales at the first time in 1963/64 Antarctic season as shown in Table 10. Kasuya and Ichihara (1965) reported already on these data, so we did not use them as our materials. In 1967/68 season, 597 minke whales were caught by Japanese expeditions. Before the season we planed to investigate this whale species. The items of investigation were; species, sex, body length (0.1 m unit), stomach contents, foetus, date, time, and position caught, thickness of blubber (0.5 cm unit), weight of testis (0.1 kg unit), color on flipper and collection of earplug, ovaries, food, external parasites and foetus for each whales flensed. Body proportions were measured on 12 individuals, and body weights were also measured on 6 whales. One of us (A. Kawamura) who was on board of a factory ship made several detailed investigations and collections on 6 whales. Almost the same investigations were made on 42 minke whales caught in 1968/69 season.

Collected ovaries were counted their number of corpora lutea and albicantia. Earplugs were prepared with the same method as other whale species, and read their laminations in the laboratory. Food and parasites were identified their species.

We used catch statistics from the International Whaling Statistics.

MORPHOLOGY

Body color

The general appearance of Antarctic minke whales shows much resemblance with that of the northern minke whales, *Balaenoptera acutorostrata* Lacépède, as having been described in previous reports (Jonsgård, 1951; Omura and Sakiura, 1956): the body is covered with dark grey or bluish dark grey which separates the coloration of body into upper dark dorsal part and light ventral part along the dorso-lateral line. The dark grey on the dorsal surface expands widely to a whole body covering the dorsal surface of head, flippers, dorsal fin and tail flukes. The transitional line which lies between dark grey of black and white ventral side of the body runs approximately along the dorso-lateral line from the tip of upper mandible to the tip of tail flukes through just below the eyes and the base of flipper.

Both right and left margins of upper mandible are colored with dark grey in upper half, turning to white toward the lower margin. The coloration of lower mandible follows almost the same way as that of upper mandible though white part spreads out more widely so as to reach to the tip of upper or lower mandible. There are distinct creamy white patch on the tip of right upper mandible being ac-

companied by creamy white baleen plates as it is found in fin whales. The extent of dark coloration on the upper surface of flippers varies with each individuals: some of them show a light slate grey as one may see in the Williamson's description (Williamson, 1959), and the others show a grey as dark as dorsal surface (Pl. I, Fig.I). The dark grey on the back turns gradually to light silvery grey towards the ventral side to form a broad transitional zone at the mid-dorso-lateral line. The transitional zone runs from the angle of gape to the base of tail flukes with slight waves along lateral side of the body as has been figured by Williamson (1959, 1961), and Kasuya and Ichihara (1965), though the general appearance varies considerably with each individuals. On the flippers and tail flukes as shown in Pl. I, Fig. 2, the dark grey parts expand to the under surface to form a narrow dark emargination which grows thicker at the tips. The ventral side of the body including the ventral grooves shows complete white such as fin whales, and dark grey patches which are often seen in sei whales are not observed.

One of the distinct characters of Antarctic minke whales in comparison with northern species, *B. acutorostrata*, is the complete absence of white band on the upper surface of flippers as having been pointed out by Williamson (1959) on the four specimens of " Balaena " expedition. Our observations on this matter agree well with the previous records (Williamson, 1959, 1961; Utrecht and Spoel, 1962; Kasuya and Ichihara, 1965); *i.e.*, the surface of the flippers lacks white band, being colored with monotonous dark grey (Plate I, Fig. 1). It can be said in general that the body color of Antarctic minke whales does not differ from those descriptions of previous workers, and some differences observed in the present study could be considered as individual variations.

The Japanese whalers catch sight of many minke whales every year while they operate in the Antarctic. However, they report no evidence on the presence of minke whales with white banded flippers. According to personal communication with Williamson, Arsenyev (1960) convinces that no white band in the Antarctic minke whales is considered as their own peculiar character. However, Taylor (1957) and Kasuya and Ichihara (1965) suggested the presence of both kinds of individuals in the southern seas. As there are no clear evidences to discard " the presence of minke whales with white banded flippers ", we cannot but recognize the presence of both forms in the Antarctic at the present.

Baleen plates

The difference in the coloration of baleen plates comes next as a distinct character of Antarctic minke whales (Williamson, 1959), and we made observations on the number and the length of a row of baleen plates in the five individuals (Table 1). The baleen plates gradually change to bristle-like hair near at the tip of snout to give some confusions for counting the number of baleen plates. This makes to allow some differences in the results obtained by other workers. In practical measurement, we took the length along the outer margin of gum as the length of a row of baleen plates. The number of baleen plates was also counted along the same line as a way mentioned above.

TABLE 1. BALEEN PLATES OF MINKE

Measurements			This study				
Body length (m)			8.5	8.1	8.4	8.4	8.0
Sex			M	M	M	M	F
Number of baleen plates[1]	White	R	126(56)		110(61)	107(57)	
		L	114			59(27)	
	Dark	R	(121)		162(119)	152	
		L	188			218(174)	
	Total	R	(177)		(180)	259	
		L	302(167)	(160)	359(176)	277(201)	261(182)
Length (cm)		R	26.1	25.3	22.3	25.4	24.0
		L	26.1	24.1	22.0	23.7	24.8
Breadth (cm)		R	10.9	10.8	13.7	13.4	12.7
		L	11.6	10.6	14.1	12.8	13.3
Breadth of dark band on plates		R	4.6	3.9	3.9	5.3	4.8
		L	4.8	5.0	4.1	6.2	4.9
Breadth/Length[2]		R	0.42	0.53	0.61	0.53	0.53
		L	0.44	0.44	0.64	0.54	0.54

1) Length of a row of baleen plates is given in parenthesis (cm).
2) Both right and left were averaged on 5 measurements of the plates.
3) Approximate value taken from the figure in the text.

The presence of small creamy white baleen plates as often being observed in fin and sei whales is quite usual in Antarctic minke whales, though the latter carries them on both right and left of upper jaw. However, the number of creamy white baleen plates varies with each individuals, and sometimes it was observed to lack them completely (Williamson, 1959; Utrecht and Spoel, 1962). In our observations, two individuals carried more plenty cream white baleen plates on the right than the left as fin and sei whales (Pl. II, Fig. 2).

In the four individuals examined, a row of baleen plates on the left were consisted of 261–359 plates, and 299 plates spread out 177 cm long on an average. The upper extreme in the number of baleen plates was 359 plates in 176 cm. long. So each baleen plates grow thick keeping about 0.5 cm intervals while the others were about 0.6 cm intervals on an average. The number of baleen plates observed in our observations does not differ so much when compared with the result of 247 or 264 plates (Williamson, 1961) and 270 plates (Utrecht and Spoel, 1962), by allowing some counting error by the observers. According to the monograph by Tomilin (1957), North Pacific minke whale carries 231–270 baleen plates while North Atlantic's does 300–325 plates. It goes still more, 270–348 plates and 304 on an average in Norwegian minke whales (Jonsgård, 1951), while it reduces down to 266–295 plates, 275 on an average in the minke whales of Japanese waters (Omura and Sakiura, 1961).

To figure out an external character of baleen plates the indices from the breadth/length ratio on the largest baleen plates was calculated after the same manner as described by Kasuya and Ichihara (1965, p. 40). The largest baleen

WHALE CAUGHT IN THE ANTARCTIC

Williamson (1959)		Williamson (1961)		Utrecht & Spoel (1962)	Kasuya & Ichihara (1965)
27 (ft)	27.6 (ft)	8.4	8.4	8.41	
F	M	M	F	M	
70	110		134		
30	75	75	103		
			264	270 (128)	
		(156)	247	270 (128)	
		28.0	29.0	30.0	23.5
		12.0			14.0
		4.0		3.7	4.4[3)]
	0.43	0.5			0.6

plate was 26.1 cm long along the outer edge of the plate which was taken from 8.5 m male. As shown in Pl. III, Fig. 1, three types of baleen plates were noticed, *i.e.*, " sei whale type " with index number of 0.4, " fin whale type " with 0.6, and " intermediate type " with 0.5. The form of baleen plates described in previous papers agrees well with our results within the range of individual variations (Table 1).

The breadth of the dark brownish band on the outer edge of baleen plates lies 3.9–6.7 cm on the whole, and 4.5 cm on the right and 5.0 cm on the left on an average. However, as the breadth of the dark band varies even in the plates next to each other within a few centimeters, this character is considered to be quite variable in each individuals.

Ventral grooves

The number of ventral grooves at the line to discern both the right and left anterior end of the flippers was counted on three individuals. The number of ventral grooves was 26 to 30 grooves with 28 as an average, though the number was given as a half of actual numbers. This agrees well with the result of 30 grooves counted by Williamson (1961). However, the number of ventral grooves varies with each individuals and does also by the part of body where counting was made due to obscure feature at the end of ventral grooves. Since Tomilin (1957) gives 50–70 grooves as a whole number of ventral grooves of minke whales, 56 grooves for the Antarctic minke whales are considered as same as with those for northern species.

Body proportions

One of the aims of our minke whale investigation was firstly to know the evidence which makes us assure some taxonomical criterions on several points which Williamson (1959, 1961) and Utrecht and Spoel (1962) pointed out as a peculiar charactor of Antarctic minke whales, and secondly, to figure out the details of character being left unsolved by Kasuya and Ichihara (1965). One of them was a proportional relationship between the umbilicus and the posterior end of the ventral grooves, and the other was the length of flipper. For this purpose we made a series of the measurement of body proportions on 10 males and 2 females after the manner of Discovery Investigation (Mackintosh and Wheeler, 1929) (see Table 2, *Appendix I*).

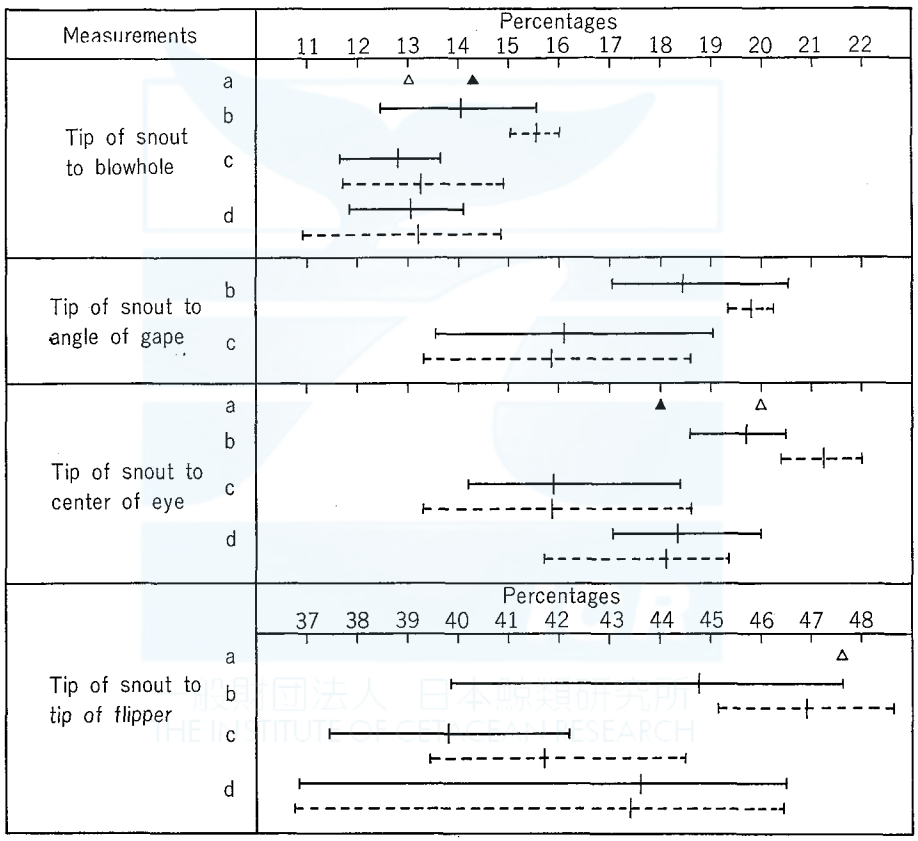

Fig. 1. Proportions related to head length on minke whales from the Antarctic, North Pacific and Atlantic Oceans.
———— Males. ····· Females. *Antarctic* a: Williamson (1959) ▲, and Utrecht and Spoel (1962) △, b: Present study. *North Pacific* c: Omura and Sakiura (1956). *North Atlantic* d: Jonsgård (1951)

In Table 2 it is noticed that the result agrees well on the whole within 1–2% of

fluctuation notwithstanding the fact that measurements comprised from three different sources. This makes us acertain that the measurement error by each observers is negligible. The body length of the males was between 710 and 850 cm. Judging from their body length, it is considered that they had almost attained at the physical maturity. However, there were no individuals whose epiphysis of the fifth dorsal vertebrae had fused completely.

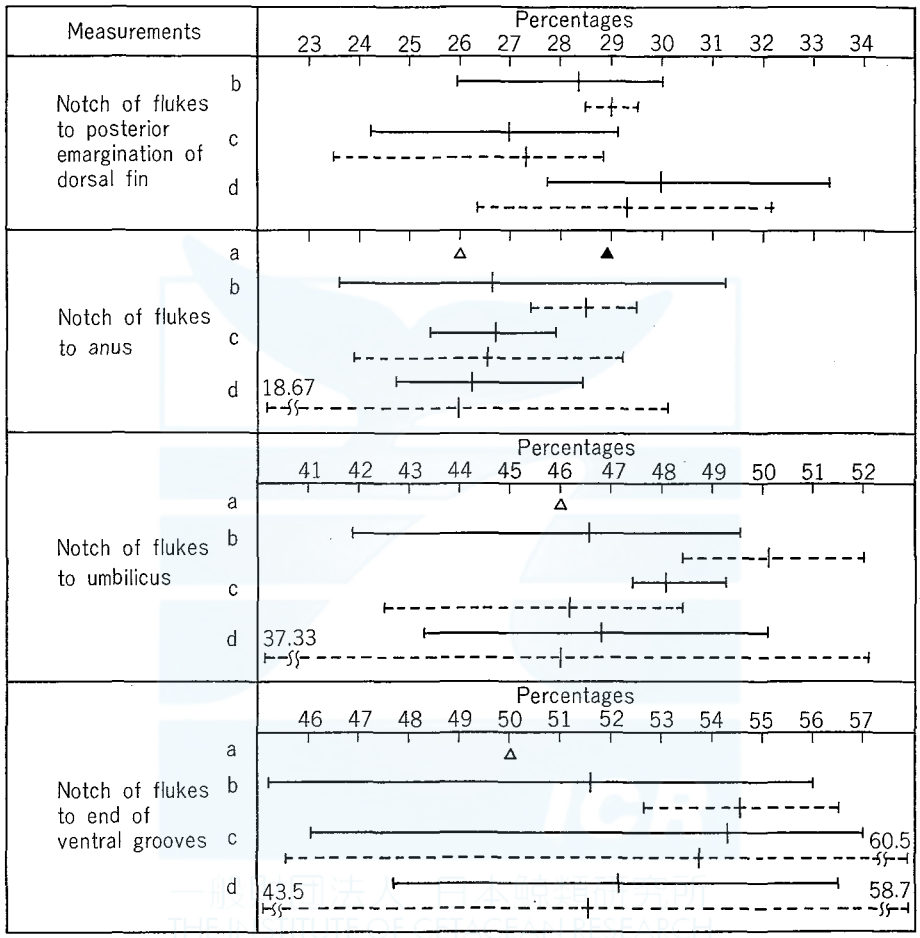

Fig. 2. Abdominal proportions on minke whales from the Antarctic, North Pacific and Atlantic Oceans. Legend as in Figure 1.

The proportions to the total body length in terms of the percentages on the anterior part of the body are shown in Fig. 1 with the results obtained previously. It is clear in the figure that the result agrees well in general with those got by Williamson (1954) and Utrecht and Spoel (1962). One of the distinct features of Antarctic minke whales is more larger porportional length about 1.5–4.5 % at each measurements than those of northern minke whales *B. acutorostrata*, though some of

them overlap each other. The great variation between the tip of snout to the tip of flipper must be the result due to the difference in resting position of the flipper when they were measured. In addition to larger head in Antarctic minke whales, it is noticed that the female shows much greater distances about 1.5–2.0 % than the male. Although the results lack complete reliability due to the variation of age and sex, the difference between both sexes could be considered to be probable with confidence from the same evidence found in physically mature sei whales (Omura, 1957) and also in those foetuses (Kawamura, 1969). The only curiosity is the result of *B. acutorostrata* which shows the same or rather longer proportional length in the male. One of the causative facts is that those variation might derived from the different feeding habits in both northern (*B. acutorostrata*) and Antarctic forms, *i.e.*, the northern forms chiefly feed on fishes (Omura and Sakiura, 1956; Jonsgård, 1951), while the Antarctic minke whales chiefly feed on euphausiids and copepods.

In the Antarctic minke whales the distance from the notch of flukes to the posterior end of dorsal fin lies at middle of two measurements on *B. acutorostrata*. However, the difference is included within 3 % on an average, and we have no other evidence to separate those two types in this measurement. In the following distances it is noticed that the individual variations are quite distinct between northern and Antarctic minke whales; the distances from anus, umbilicus and posterior end of ventral grooves to the notch of flukes, though the female of Antarctic forms always keeps about 1 % larger distances than the male, while the male is similarly larger in northern forms. However, it is difficult to get the conclusive evidence to separate these two forms at the present state. We need still more data especially on females.

Williamson (1959) reported that there were about 30 cm distance between the posterior end of ventral grooves and umbilicus, and later he (Williamson, 1961) denied his former description, *i.e.*, the ventral grooves end just at the umbilicus. Kasuya and Ichihara (1965) also followed the same description. In our observation, however, the end of ventral grooves and the umbilicus was separated clearly (Plate I, Fig. 1 and Plate II, Fig. 1) keeping the distance about 39.4 cm, 4–5 % (Table 2, Fig. 2). Utrecht and Spoel (1962) reports that this distance is 1 ft., and this agrees with Williamson's former description. In northern minke whales, on the other hand, the distance is slightly greater (5.4–7.6 %) than the Antarctic forms. Accordingly, we cannot but conclude that those are not fundamental difference in both forms of minke whales.

The proportion of appendages are shown in Fig. 3. As we see in this figure, the flipper of Antarctic forms is longer with the range of 1.5–2.0 % than that of northern forms. Judging from our result got by averaging the measurements of 12 specimens, the length (7 %) given by Utrecht and Spoel (1962) for Antarctic forms seems to be a quite unusual case. Our result agrees well with those given by Williamson (1959). It is noticed on the whole in the figure that the flipper is longer in both northern and Antarctic forms of the male than the female, and the female of Antarctic forms overcome the other among them. There are no differences in the breadth of flipper and the height of dorsal fin. Relatively small length at the base of dorsal fin in the Antarctic minke whales suggests that they carry more slender shaped dorsal fin.

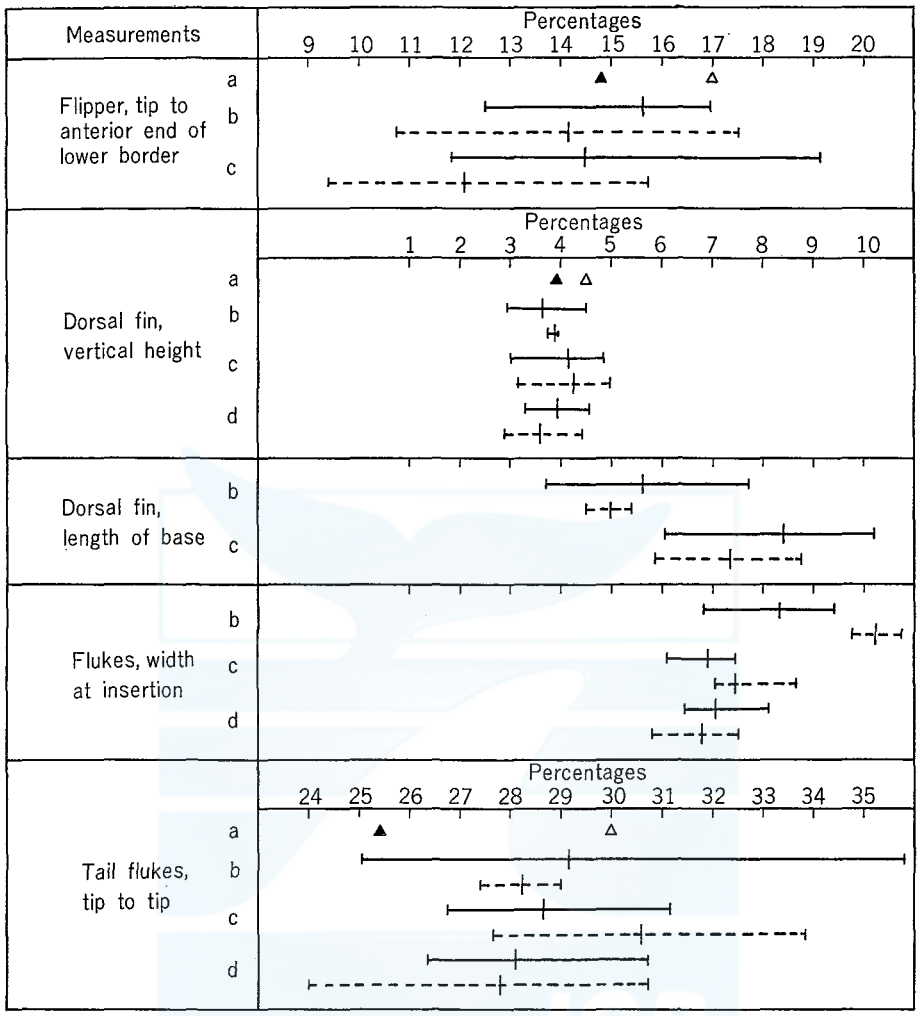

Fig. 3. Proportions of appendages on minke whales from the Antarctic, North Pacific and Atlantic Oceans. Legend as in Figure 1.

On the total spread of tail flukes, Utrecht and Spoel (1962) pointed out that the Antarctic minke whales show wider spread than the northern forms. However, the spread in the present materials showed that there is considerable individual variation (Fig. 3). By taking the result by Williamson (1959) into consideration, it cannot be concluded easily on this matter at the present state. The shape of the notch of flukes showed quite usual one as we see in fin or sei whales (Pl. I, Fig. 2). According to Williamson (1959, 1961), the tail flukes shows a triangular shape on the whole. It is, however, indicated that the tail flukes vary with each individual, and some of them carry a round curve in the anterior margin to form a quite round tail flukes in the whole shape (Pl. III, Fig. 2).

TABLE 2. MEASUREMENTS OF BODY PROPORTIONS ON

Measurements	Workers / Sex / Present authors / Males: Range of length (cm)	Mean length (cm)	Range of proportions as percentages of total length	Mean percentages
1. Total length	710–850	803.8	—	100.00
2. Tip of snout to blowhole	104–120	112.7	12.24–15.52	14.07
3. Tip of snout to angle of gape	133–170	148.3	17.07–20.54	18.45
4. Tip of snout to center of eye	143–172	158.5	18.29–20.48	19.73
5. Tip of snout to tip of flipper	315–400	359.4	39.86–47.62	44.73
6. Eye to ear (center)	39– 44	40.7	4.71– 5.70	5.07
7. Notch of flukes to posterior emargination of dorsal fin	190–254	228.3	25.98–30.00	28.35
8. Flukes, width at insertion	53– 80	67.0	6.79– 9.41	8.31
9. Notch of flukes to anus	193–244	213.9	23.57–31.28	26.65
10. Notch of flukes to umbilicus	330–410	372.9	41.88–49.52	46.54
11. Notch of flukes to end of ventral grooves	375–470	414.1	45.18–55.95	51.58
12. Anus to reproductive aperture, center	26– 70	54.3	3.33– 8.89	6.78
13. Dorsal fin, vertical height	25– 35	29.0	2.98– 4.23	3·62
14. Dorsal fin, length of base	31– 60	44.9	3.69– 7.69	5.63
15. Flipper, tip to anterior end of lower border	105–139	125.3	12.50–16.98	15.61
16. Flipper, greatest width	24– 32	28.9	2.82– 3.98	3.61
17. Tail flukes, tip to tip	210–290	234.3	25.06–35.80	29.16

TABLE 3. NUMBER OF VERTEBRAL COLUMN OF THE MINKE WHALE FOETUSES FOUND IN THE ANTARCTIC IN 1967/68 SEASON

Sex	Body length (cm)	Body weight (Kg)	Number of vertebral column: Cervical	Dorsal	Lumbar	Caudal	Total
Female	48.6	2.35	7	11	12	18	48
Male	46.5	1.80	7	12*	12	18	49
Male	50.5	2.29	7	11	12	18	48

* Included one separated small lib.

Number of vertebrae

To know the number of vertebrae of the Antarctic minke whale, three foetuses collected in the Antarctic during 1967/68 season were dissected along their vertebral column (Table 3), and the following vertebral formula was obtained: C7, D11–12, L12, Ca 18=48–49. One of the foetuses which carried D12 proved to carry a small free rib as the last one of a set. According to Tomilin's monograph on the 13 specimens of *B. acutorostrata* (Tomilin, 1957), 8 specimens among them had the vertebral formula; C7, D11, L12, Ca 18=48, 3 specimens were 49 in all and 2 specimens were 50. Later, he reported again on the number of vertebrae of the whales examined that his specimen should be C7, D11, L12, Ca18=48. Omura (1957) gives

MINKE WHALES CAUGHT IN THE ANTARCTIC OCEAN

Present authors Females				Williamson (1959) Males				Utrecht & Spoel (1962) Males	
Range of length (cm)	Mean length (cm)	Range of proportions as percentages of total length	Mean percentages	Length (cm)	Percentages	Length (cm)	Percentages	Length (cm)	Percentages
800–930	865.0	—	100.00	840	100.00	820	100.00	841	100.00
128–140	134.0	15.05–16.00	15.52	—	—	117	14.3	107	13.0
162–180	171.0	19.35–20.25	19.80	—	—	—	—	—	—
176–190	183.0	20.43–22.00	21.23	—	—	148	18.0	168	20.0
389–420	404.5	45.16–48.63	46.89	—	—	—	—	(400.5)	47.6
40– 50	45.0	5.00– 5.38	5.19	—	—	—	—	43	5.0
236–265	250.5	28.49–29.50	28.99	—	—	—	—	—	—
86– 90	88.0	9.68–10.75	10.21	—	—	—	—	—	—
236–255	245.5	27.42–29.50	28.46	—	—	237	28.9	221	26.0
420–450	435.0	48.38–52.50	50.44	—	—	—	—	(388)	46.0
452–490	471.0	52.69–56.50	54.59	—	—	—	—	(421)	(50.1)
25– 35	30.0	3.13– 3.76	3.45	—	—	—	—	58	7.0
32– 35	33.5	3.76– 4.00	3.88	33	3.9	33	3.9	38	4.5
36– 50	43.0	4.50– 5.38	4.94	—	—	—	—	141.5	17.0
(100)–140	(120>140.0)	10.75–17.50	14.13	—	—	122	14.8	—	—
33– 35	34.0	3.70– 4.13	3.95	—	—	—	—	—	—
232–255	243.5	27.42–29.00	28.21	229	27.4	209	25.4	254	30.0

a following formula as a result obtained from 2 minke whales caught in Japanese waters; C7, D11, L12, Ca 17–18, Total 47–48. The number of vertebrae of Antarctic minke whales has been the last key point left behind to offer a decisive conclusion in the classification of both northern and Antarctic minke whales. The agreement in the number of vertebrae obtained in this study with those *B. acutorostrata* is considered to give somewhat conclusive evidence which supports the Antarctic minke whales as only a subspecies of *B. acutorostrata*. However, it is still hoped to get and examined on the skeletal specimens of physically mature individuals for a further consideration on this matter.

Thickness of blubber

The thickness of blubber at the dorso-lateral line just below the dorsal fin was measured with an accuracy of 0.5 cm. The mean thickness in December was shown in Fig. 4 by the sex and the body length. The blubber grows thicker as the body length increases. It is slightly thicker in the male than in the female within the same class of body length. It is known that blubber of blue whale is variable in accordance with their sexual conditions; pregnant female has the thickest blubber and it was most slender in lactating female (Mackintosh and Wheeler, 1929). A quite high percentages of pregnancy in the Antarctic minke whales supports the case mentioned above by those evidence of other whales.

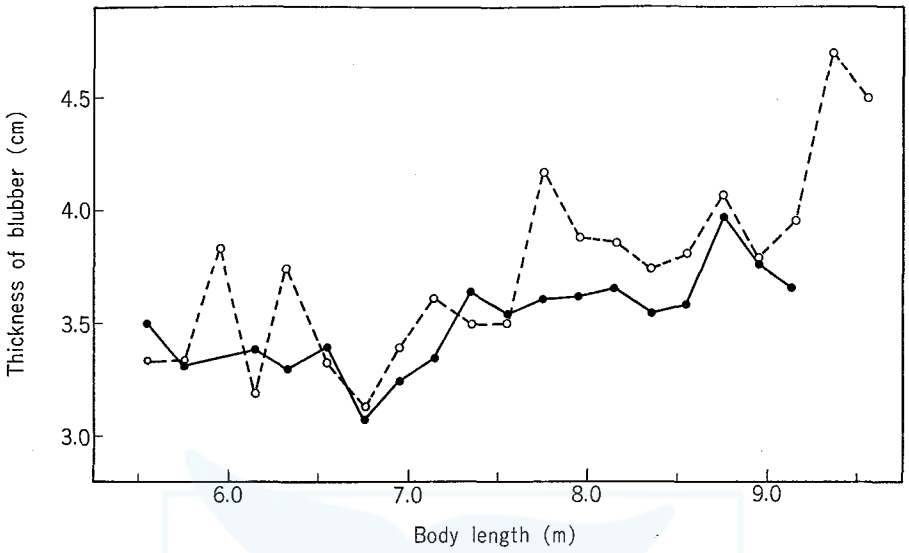

Fig. 4. Mean thickness of blubber at each body length in the Antarctic in December, 1967/68. Open circle and broken line : females, Closed circle and solid line : males.

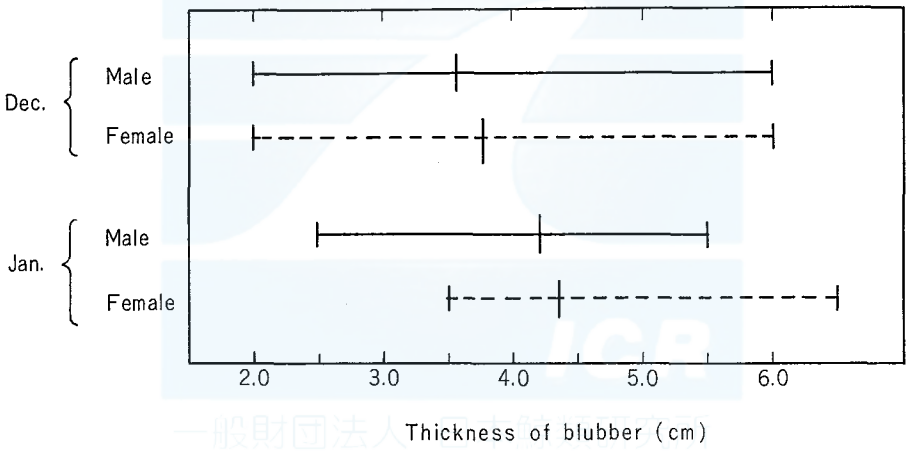

Fig. 5. Range and mean of blubber thickness in minke whales in the Antarctic.

There were no enough data to show the seasonal variation in the thickness of blubber of the minke whale except Omura's unpublished data (Omura, personal communication) which were obtained from the minke whale caught in Japanese waters. As shown in Fig. 5, the mean thickness of blubber in December of 1967/68 season was 3.6 cm in the male and 3.8 cm in the female. In January of 1968/69 season they were 4.2 cm in the male and 4.4 cm in the female. Since the mean body length in both seasons can be assumed as the same, it is supposed that the blubber grows thick during January-February as it is observed in the other baleen whales.

This fact leads to the following consideration that the Antarctic during the austral summer is a main feeding ground for the Antarctic minke whales.

TABLE 4. BODY WEIGHTS OF MINKE WHALES IN THE ANTARCTIC

Items	Measurements (Kg)					
Whale number	22N 1	22N 2	22N 3	22N 4	22T 2	22T 1
Body length (m)	8.0	7.8	7.1	7.54	8.2	9.3
Sex	Male	Male	Male	Male	Male	Female
Meat	3,216	2,970	2,564	3,285	4,310	5,078
Dorsal	1,409	1,358	1,104	1,476	1,844	2,007
Ventral	756	696	581	646	874	960
Ventral grooves	320	292	257	327	472	525
*Munaita**	280	298	165	311	453	567
Others	451	326	457	525	667	1,019
Bone	837	734	629	924	796	941
Skull	234	207	168	285	248	262
Mandibles	84	62	52	82	85	115
Ribs	82	74	66	98	75	104
Vertebrae	348	299	274	362	305	435
Flipper, Scapulae	74	82	60	85	82	100
Others	15	10	9	12	1	—
Blubber	776	1,725	(667)	(796)	922	1,270
Body	604	462	437	564	732	717
Head	89	66	67	91	97	100
Mandibles	34	52	33	39	26	82
Tail flukes	49	43	48	39	54	105
Others ("*Aba*")	—	102	82	63	12	266
Viscera	397	550	284	343	494	551
Heart	17	20	22	23	30	38
Lung	39	44	26	44	40	58
Liver	49	65	50	54	76	105
Kidney	16	16	17	17	20	24
Stomach and pancreas	28	21	25	28	31	34
Intestine	63	142	75	73	81	109
Tongue	39	89	8	—	16	75
Others	146	153	61	104	200	108
Baleen plates	29	34	25	37	36	45
Total	5,255	5,013	4,169	5,385	6,558	7,961

* Bosom

Body weight

The body weight was obtained from six carcasses caught in 1967/68 season by weighing each part of the body, separately (Table 4). The average body length and the weight were 8.0 m and 5.7 tons, respectively. To compare with the result obtained from other balaenopterids, the percentage weights of several parts of the body were given in Table 5. It is noticed from the table that the ratio of the meat has a tendency to increase against the size of species decrease, on the contrary,

whale oil materials (bones, blubber and internal organs) decrease, except the sei whale. From the view point of relative weights of the whale parts, the Antarctic minke whales should be utilized effectively as a resources for meat products rather than those for the whale oil same as the sei whale.

TABLE 5. COMPARISON OF PARTIAL BODY WEIGHTS AMONG SEVERAL SPECIES OF *BALENOPTERA*

Species	Body length (m)	Body weight (ton)	Per cent of partial weight to total				
			Meat	Bones	Blubber	Internal organs	Others
Blue whale[a)]	24.3	87.29	39.4	17.7	27.1	11.6	4.2
Fin whale[a)]	21.1	51.67	45.5	16.9	23.9	10.4	3.3
Sei whale[b)]	15.2	18.15	59.2	11.1	17.1	10.4	2.2
Bryde's whale[c)]	13.1	14.00	46.1	15.4	22.1	10.6	5.8
Minke whale[d)]	8.0	5.72	62.4	14.2	15.0	7.6	0.8

a) Nishiwaki (1950), from the Antarctic; b) Omura (1950), from coast of Japan; c) Fujino (1955), from Bonin Islands; d) Present report from the Antarctic.

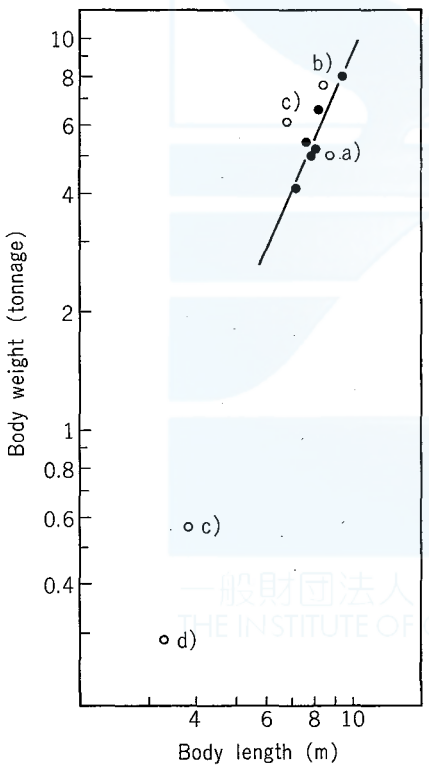

Fig. 6. Plot of body weight against body length for minke whales.
Closed circle: Antarctic Open circle: a) Tomilin (1957), b) Zenkovich (1955), c) Scheffer and Slipp (1948), d) Fry (1935).

The following formula as a length-weight relationship was obtained from the the data shown in Fig. 6: that is,

$$W = 0.0466L^{2.31}$$

where, W: body weight (ton)
L: body length (m)

It is noticed in Fig. 6 that the length-weight relationship agrees well with that obtained from northern minke whales within the body length of 6–9 m, and the formula would be needed some modifications for smaller individual less than 4.0 m in body length. It is strongly hoped to be accumulated the data of body weight of small individuals of the Antarctic minke whale.

GROWTH

Age determination

Earplug is the most useful age character of the baleen whales (Ohsumi, 1967). Ichihara (1959) and Sergeant (1968) described on the earplug of minke whale. Ichihara (*loc. cit.*) notes that the glove-finger of the minke whale belongs to the similar type as that of sei and Bryde's whale (*Balaenoptera edeni*), of which glove-finger has no papilla. And he showed a photograph of a earplug which had 9 laminae. Sergeant (*loc. cit.*) read lamination clearly on only one out of 11 minke whales' earplugs which were collected in good condition.

The earplug of the Antarctic minke whale is small, and the shape is similar to that of Bryde's whale. Its longitudinal section is not black as those of the blue and sei whales, and is not so difficult to be read as Sergeant described. But, earplugs of young individuals are so small and soft that it is very difficult to read them, and we think it is need to develop new technics for collection and preparation of them.

It has not been confirmed yet on the accumulation rate of lamination of earplug for the minke whale, and Sergeant (1963) adopted the theory that two laminae accumulated a year. However, it will be reasonable to adopt another theory that one lamina accumulates per one year, as it is clearified for the fin whale (Ohsumi, 1964; Roe, 1967).

Jonsgård (1951), Stephenson (1951) and Omura and Sakiura (1956) tried to determine the age of minke whale by means of mode of size distribution, but this method is not suitable for age determination of whales (Ohsumi, 1967). The age determinaion by means of baleen plate was tried by Stephenson (1951) for minke whale, but the baleen plate can be used as an age character for only young stage, and Jonsgård (1951) and Sergeant (1963) noted the ridge of baleen plate in the minke whale was difficult to be read. Ovaries of minke whale are small, and so corpora albicantia are small, but it is possible to count them by naked eyes. Although the corpus albicans has some weak points as an age character, it is used for some problems on reproduction in the present report.

Growth curve

Figs. 7 a and b show the relation between age and body length on the individuals of which age was determined with earplug. Number of materials is not enough for drawing good growth curve. Stephenson (1951) drew growth curves in North Atlantic minke whales, but they will be not true caused on wrong age determination.

Since we have no materials on the whales which are five years and younger,

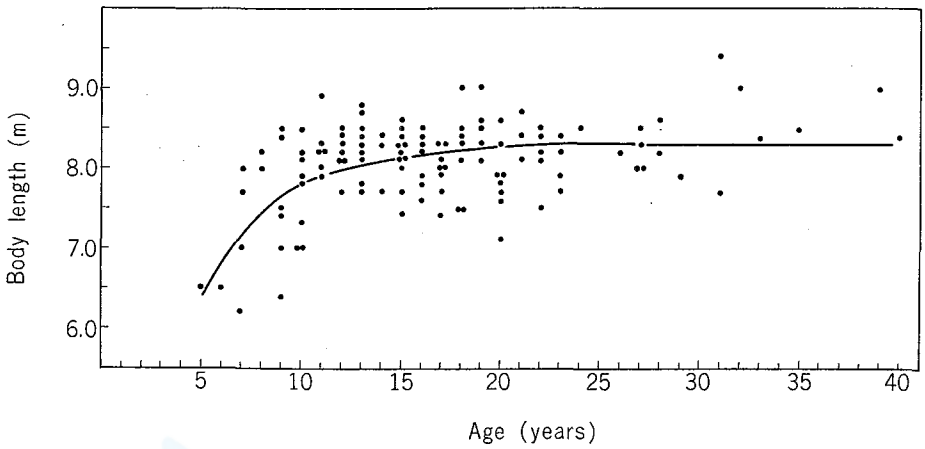

Fig. 7a. Growth curve of the male minke whales in the Antarctic.

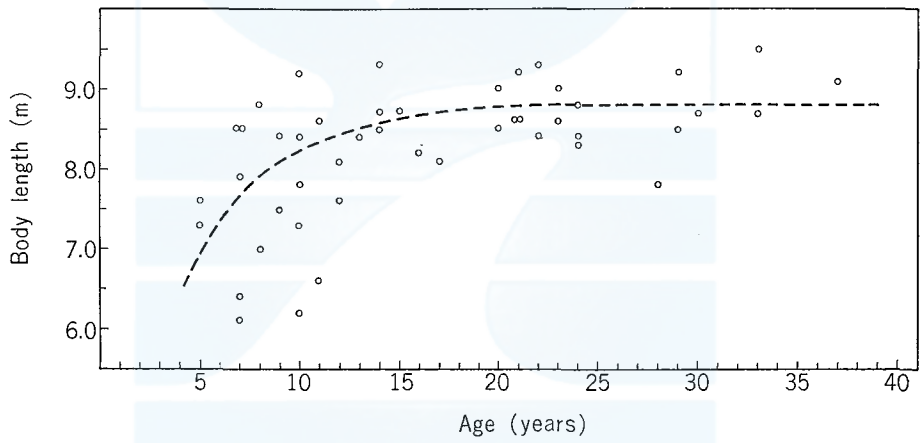

Fig. 7b. Growth curve of the female minke whales in the Antarctic.

we can not know the growth of younger age. In addition, we have no knowledges on the body length at the time of birth for the Antarctic minke whale. On the northern minke whales, Jonsgård (1951) and Stephenson (1951) estimated that the neonatal body length was 9 feet (270 cm), and Omura and Sakiura (1956) described it as 280 cm. Then, we may estimate the birth length of the Antarctic minke whale will be 270–290 cm.

MATURITY

Weight of testis

Both right and left testes were weighed on the males which were caught in 1967/68 and 1968/69 Antarctic seasons. Fig. 8 shows the relation between body length and weight of larger side of testes for these whales. Although mature and imma-

ture testes as shown by Omura and Sakiura (1956), are not separated clearly in this figure the average testis weight increases suddenly at the body length of 7.1 m.

Frequency distribution of testis weight (larger testis for each individual) has one valley at 0.3 kg, as shown in Fig. 9. The left mountain means immature testis, and the right one will show the mature group. Separating these two mountains in the valley, the two mountains cross each other at 0.35 kg. Although it will be need to examine testis tissues histologically, this 0.35 kg will be the mean testis weight at maturity for the Antarctic minke whale.

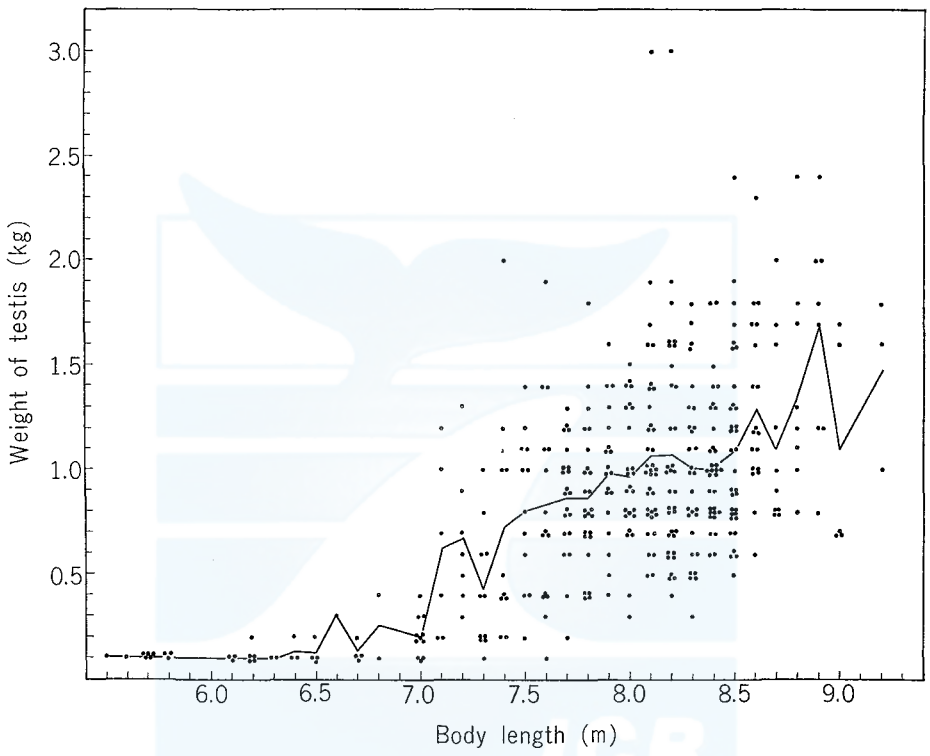

Fig. 8. Relation between body length and weight of larger testis in the males.

Jonsgård (1951) determined the mature testes as 0.225 kg (both testes conbined) for the North Atlantic minke whale, and Omura and Sakiura (1956) reported it was 200–300 gr (one side of testes) for the North Pacific minke whale. Our result is larger than these two reports.

Body length at sexual maturity

Assuming that the male of which larger testis is 0.4 kg and over and the female which has one or more corpus luteum or albicans are recognized as sexually mature, we obtain size distributions of minke whales caught in 1967/68 and 1968/69 seasons by sexual maturity as shown in Table 12.

The maximum lengths of immature whales are 8.3 and 8.8 m for male and

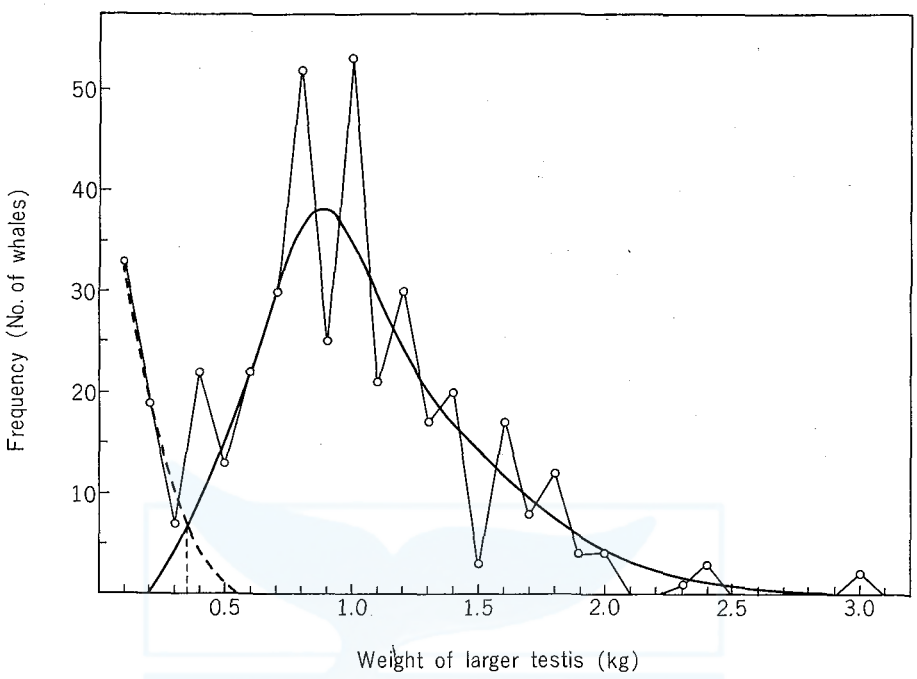

Fig. 9. Frequency of weight of larger testis in the southern minke whales and the estimation of testis weight at maturity. Broken curve: Immature, Solid curve: Mature

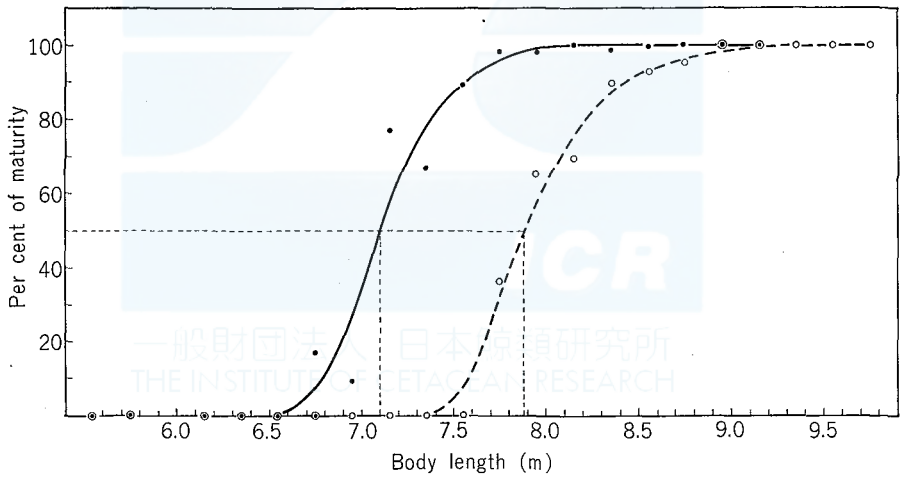

Fig. 10. Proportion of sexually mature minke whales at each length in the Antarctic Area IV. Closed circle and solid curve: males, Open circle and broken curve: female.

female, respectively, and the minimum lengths of mature males and females are 6.8 and 7.7 m, respectively. Change of sexual maturity rate by body length class is shown in Fig. 10, and the length at 50% of maturity is 7.1 and 7.9 m for the male and female, respectively. These values will be considered as the average

lengths at sexual maturity for the Antarctic minke whale.

There are some reports on the sexual maturity length in the northern hemisphere minke whales (Jonsgård, 1951; Omura and Sakiura, 1956; Sergeant, 1963). According to the report by Jonsgård, the body length at sexual maturity of the Norwegian minke whale is 24 feet (7.3 m) and 22 feet (6.7 m) for the female and male, respectively. Omura and Sakiura estimates that it is 24 feet in the female and 22–23 feet (6.7–7.9 m) in the males from the coast of Japan. The present values are 0.1–0.4 m larger in the males and 0.6 m larger in the females than those of northern minke whales. According to Mackintosh (1965, Table 4), the southern stock is larger than northern stock in the body length at sexual maturity, and the deviation of the lengths is the same for males as for the females in at least *Balaenoptera* species. The average body length of mature Antarctic minke whales are 8.12 and 8.88 m in the males and females, respectively, and the deviation between both sexes is 0.76 m. This value is almost the same as the deviation of the average length of sexual maturity between both sexes (0.8 m) in the present report. Therefore, our value of the length at sexual maturity will be true. Comparing the size distributions of North Pacific minke whales with those of Antarctic minke whales, the deviation of modes is 2 feet (0.6 m) for both the males and females, equally. Then, it will be reasonable to consider that the average body length at sexual maturity in the males of the northern minke whales is 0.6 m smaller than that of the Antarctic minke whales as same as in the females.

TABLE 6. AGE DISTRIBUTION OF SEXUALLY IMMATURE AND MATURE MINKE WHALES IN THE ANTARCTIC

Age	Males		Females	
	Immature	Mature	Immature	Mature
5	1	1	2	—
6	2	—	—	—
7	2	2	2	2
8	—	2	2	—
9	2	3	1	1
10	3	5	2	2
11	—	6	1	1
12	1	6	1	—
13	—	9	—	—
14	—	3	—	3
15	—	10	—	1
16	—	6	—	1
17	—	8	—	1
18	—	7	—	—

Age at sexual maturity

We have not yet enough data to determine the age at sexual maturity of the Antarctic minke whale. Table 6 shows the age distribution by sexual maturity, based on the reading of earplug lamination. From this table, we estimate that the average age at sexual maturity is 7–8 years, and the female attains at sexual

maturity little later than the male. Estimating from the growth curves which are shown in Fig. 10, the ages corresponded to the body lengths at sexual maturity (7.1 m in males and 7.9 m in the females) is considered to be 7–8 years. Furthermore, in the relation between age and number of ovulation in Fig. 11, the age at one ovulation is about 8 years.

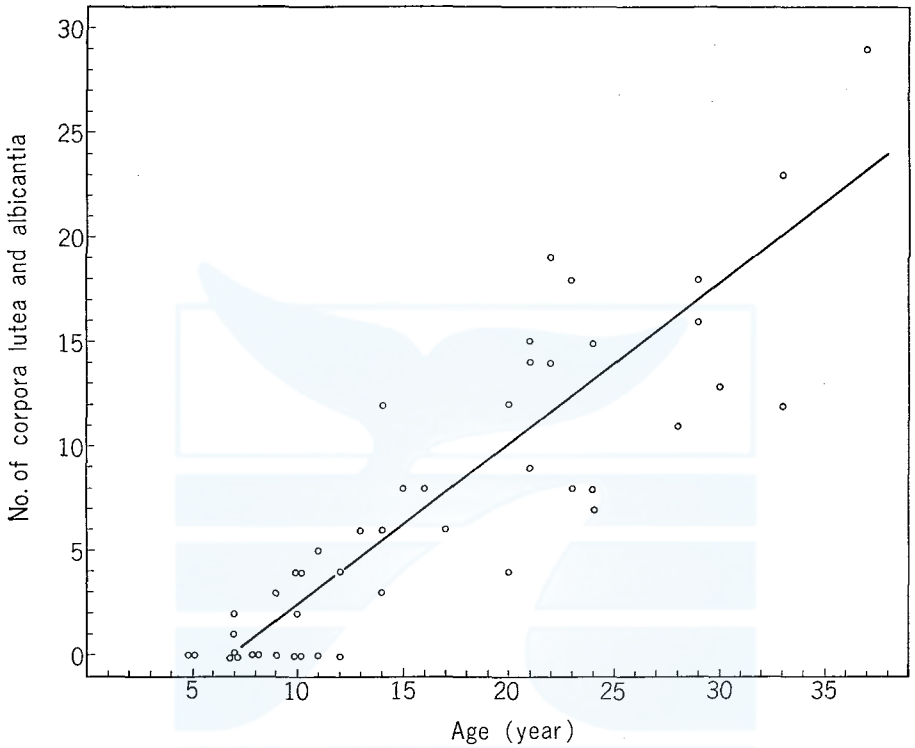

Fig. 11. Relation between age and number of ovulations in the Antarctic minke whales.

Jonsgård (1951) and Omura and Sakiura (1956) determined age by means of size distribution, and they estimated that age at sexual maturity was two years for the northern hemisphere minke whales. However, their result will not be correct, for it is difficult to determine the age from size distribution in whales.

Physical maturity

Although the physical maturity should be determined with vertebral column in the whales (Wheeler, 1930), we have only six materials. So, we estimated the body lengths in which growth stoped from growth curves, adopting the method by Ohsumi *et al.* (1958).

Estimating from Fig. 7, growth of females stops in 20–22 years, and the average length after this age is 8.8 m. And the males stop their growth in 18–20 years old, and the average length after then is 8.3 m. Fig. 12 also shows the average body length in each number of ovulations. From this figure we estimate that the

growth of females stop at 11 ovulations in average, and the average length after then is 8.8 m. Then, we may conclude that the Antarctic minke whale attains at physical maturity at about 20 years of age, and the average body length at physical maturity is 8.3 m in the males and 8.8 m in the females. The range of body length of the physically mature whales is estimated from growth curves to be 7.6–9.2 m for the males and 7.8–8.8 m for the females, respectively.

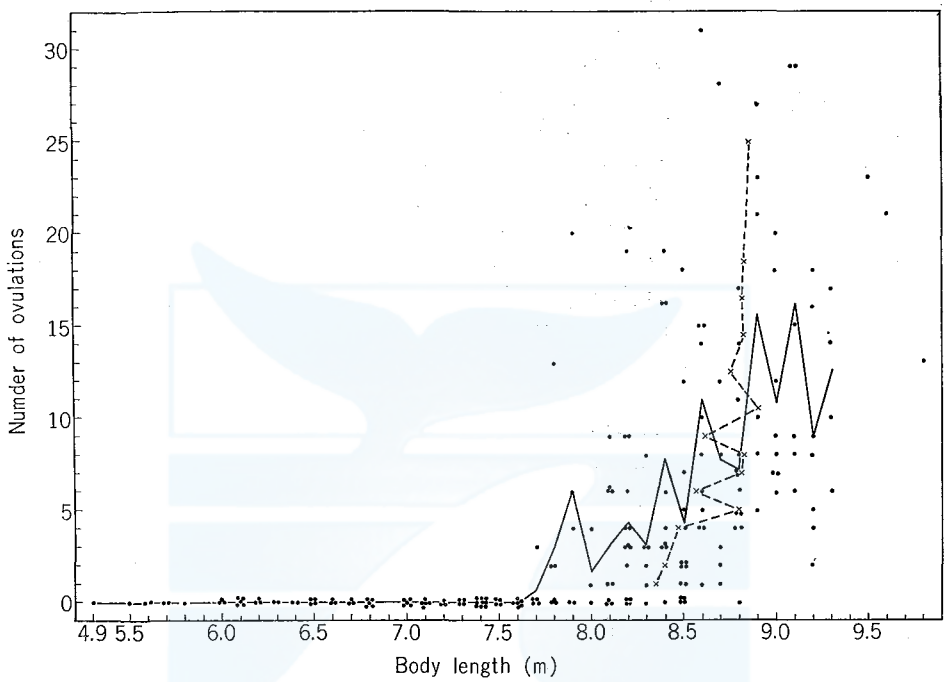

Fig. 12. Relation between body length and number of ovulations in the females.
Solid line : Average number of ovulation, Broken line : Average body length

Jonsgård (1951) estimated the body length at physical maturity on the minke whale from the Norwegian waters as 27 feet (8.2 m) in the males and 29 feet (8.8 m) in the females. However, these values will be too large, comparing with the deviations in the size distributions and age at sexual maturity between southern and northern hemisphere minke whales. Laws (1956) discusses on the relation between body lengths at sexual maturity and those at physical maturity among marine mammals, showing that the ratios of length at sexual maturity to that at physical maturity are almost constant, and 87–89% for the case of female *Balaenoptera* species excepting minke whale. The ratio in minke whales is calculated as 82.7% from the result by Jonsgård, and it is too smaller than above ratios. On the contrary, the present ratio of the Antarctic minke whale is 89.8%, and it is near the values obtained for other *Balaenoptera* species. This discussion will confirm that the physically mature length shown by Jonsgård is higher than real one, and it may be 27.3 feet for the female minke whales in the northern hemisphere.

REPRODUCTION

Pregnancy rate

Out of 114 sexually mature females which were caught in 1967/68 season (mainly in December), pregnant whales were 90, and so pregnancy rate was 78.9 %. There were additionally 12 individuals which had a corpus luteum in ovaries but were not found foetus in uterus. Adding these individuals into the former whales, 89.5 % of mature females were estimated to be pregnant or ovulating. In 1968/69 season 5 whales (83 %) were pregnant in the sexually mature females.

According to Jonsgård (1951), 85 minke whales from Norwegian waters (95.5 %) were pregnant out of 89 mature females, and among these pregnant whales 13 were simultaniously lactating. Sergeant (1963) reported that in 14 sexually mature females one was ovulating and others were all pregnant. Above results indicate that the pregnancy rate of both the northern and southern minke whales is nearly 90 %, and as Jonsgård (1951) and Omura and Sakiura (1956) estimated, most minke whales give birth every year, and then the pregnancy rate in the minke whale is the highest among *Balaenoptera* whales.

However, in general, the pregnancy rate of baleen whales in the feeding area has a tendency to change seasonally, and that in earlier season is higher than that in later season. Then, the obtained result does not always show the true pregnancy rate. It is need to investigate pregnancy rate through the year for the sake of solution on this problem.

Foetus

All foetuses (102) were single, and multiplets were not yet found from the Antarctic minke whales. However, two individuals had two corpora lutea in ovaries out of 107 whales which had corpora lutea in ovaries.

Concerning with the sex ratio of the foetus, we found that 43 were males, 51 were females and 8 were sex unknown. Although we have not enough materials, it will be considered that sex ratio of the Antarctic minke whale is ♂: ♀=1: 1.

Fig. 13 shows size of foetuses by decades in the Antarctic minke whales. We do not obtain the result to indicate that there are two breeding seasons in a year as shown by Matsuura (1936) and Omura and Sakiura (1956) for the minke whales from the Japanese coastal waters. Therefore, it will be estimated that the Antarctic minke whale has one breeding season in a year as the same as the minke whales from the North Atlantic (Jonsgård, 1951; Stephenson, 1951).

The size range of foetuses which were found in December is 1–73 cm, and the average length is 27.3 cm. This value is similar to that of the North Atlantic minke whale in May (Jonsgård, 1951), and it also coincides to the value in June in the growth curve of foetus which were reported by Stephenson (1951). This will estimate that there is half year's slip of breeding season between northern and southern minke whales as same as the fin whales (Ohsumi *et al.*, 1958) and the sperm whales (Ohsumi, 1965).

We do not obtain full foetal growth curve and gestation period for the Antarctic minke whale, but they may be almost the same as those from the northern hemisphere.

Ovulation rate

Fig. 11 shows the relation between the age and number of corpora lutea and albicatia in ovaries. A corelation formula is calculated as follows:

$$Y=0.767\ X-4.59$$

where, Y: Number of ovulations,
X: Age in years

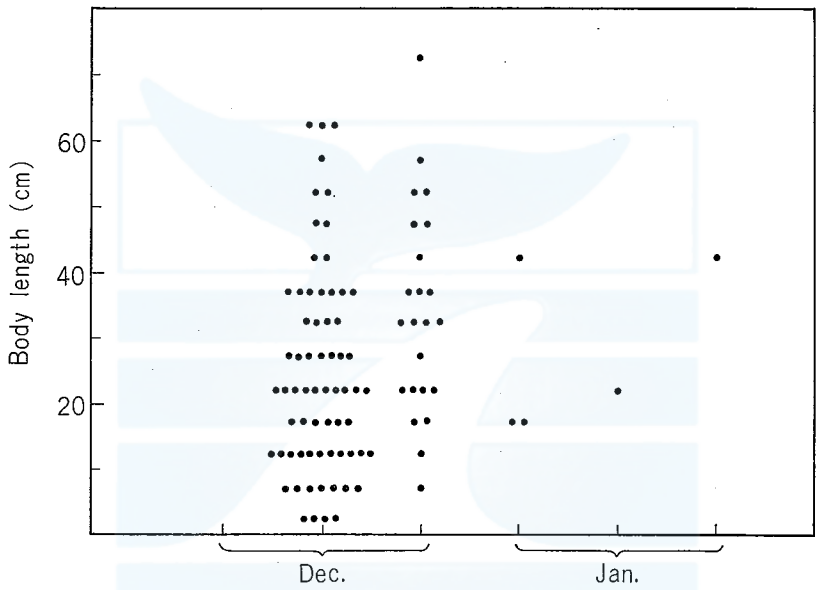

Fig. 13. Length of foetuses and decade of occurrence in the Antarctic

It means that the average ovulation rate a year is 0.77. This value is higher than that for the Antarctic fin whale (0.49: Ohsumi, 1964), and it is also related with higher pregancy rate in this species than other *Balaenoptera* species. Omura and Sakiura (1956) describes on the possibility that the pregnancy of minke whales from coastal waters of Japan occures every one or one and half a year, and our result means that the Antarctic minke whale ovulates once per 1.3 years in average.

FOOD

Species of food

In 1967/68 season 591 stomachs of minke whales were examined and 25 food samples were collected. In the following season (1968/69) 42 stomachs were again examined. Japanese whaling expeditions which usually record the kind of stomach

contents by a rough classification such as euphausiids, amphipods, Calanus*, squid, fish, etc., and the euphausiids are recorded in three kinds by their body sizes as follows: large (50 mm–), medium (40–50 mm), and small (–40 mm).

Although " empty ", the stomach with no food, was the most cases among the examined whales, it is shown in Table 7 that the small sized *Euphausia superba* is a chief diet of minke whales in terms of the feeding percentages, *i.e.*, stomach with food/stomach examined. There were several cases of mixed euphausian food with large-medium, large-small or medium-small, and the sizes given in Table 7 are represented by the quantitatively dominant forms among them.

TABLE 7. NUMBER OF MINKE WHALES BY THE KIND OF FOOD ORGANISMS IN THE ANTARCTIC SEASONS 1967/68 AND 1968/69

Food	Number of whales	
	Male	Female
Euphausiids		
" Large "	24	10
" Medium "	93	34
" Small "	104	69
Calanus tonsus	5	1
Empty	179	101

TABLE 8. FOOD OF MINKE WHALES IN THE ANTARCTIC

Species of food organisms	Size	Body length (mm)	Condition of food
Euphausia superba	L	40<	Single
	M	20–40	Mixture of " Large " or " Small "
	S	10–20	Mixture of " Large "
Euphausia spinifera	S	16–21	Single
*Calanus tonsus**)		2.8–3.5	Single

*) Copepodite IV and V. *Parathemisto gaudichaudii* and furcillia larvae of euphausiids were contaminated in the samples at times though they were very few in numbers.

The food organisms identified were: *Euphausia superba*, *E. spinifera* and *Calanus tonsus* (Table 8). Although the kind of food species is relatively poor when it is compared with that listed by Nemoto (1959, 1961) for the Antarctic baleen whales, it is interesting that *Calanus tonsus* of adult female and copepodite V, and *E. spinifera* were found firstly as a food of minke whales notwithstanding the fact that the most of minke whales as shown in Fig. 21 were sighted or hunted at relatively higher latitudes, far south from the usual distributional area of *C. tonsus* (Vervoot, 1957; Tanaka, 1960, 1964; Brodskii, 1964; Kawamura and Hoshiai, 1969). *C. tonsus* had not yet been reported from the Antarctic waters as a food of baleen whales but only records from South African waters off Cape Province as a diet of sei whales (Best, 1967). *Calanus tonsus* of copepodite V and adult female having the body length 2.8–3.5 mm were fed by 5 whales which were caught at 59°33′S; 85°52′E and 61°27′S; 89°09′E. As the minke whales carry a considerably fine

* " Calanus " means copepods

and dense baleen fringes (Nemoto, 1959), it may be possible to feed on small sized copepods. Since the diameter of baleen fringes of the Antarctic minke whales lies between those of sei whales and Bryde's whales (0.2–0.3 mm) (Kasuya and Ichihara, 1965), it is quite possible for Antarctic minke whales to feed on such a small sized copepods as *C. tonsus* in the Antarctic, and their patchy distribution would make the whales more easy to feed on them.

According to Vervoot (1957) and Tanaka (1960), *C. tonsus* is an important epiplankton in the sub-antarctic region. They chiefly occur in 30–60°S which lies between Antarctic Convergence and Subtropical Convergence (Brodskii, 1964). The juveniles of copepodites IV and V are not only found in the sub-antarctic region but also found off the south end of South Island of New Zealand during the austral summer (Jillett, 1968). Occurring sometimes in great population densities (Jillett, 1968), they seem to keep an important position as a foregoing food staff for the baleen whales which enter into the Antarctic region in the early summer. As one of us (A. K.) described in the following report, a considerable number of sei whales fed on *C. tonsus* in the Indian sector of the Antarctic Ocean, where the latitudinal position of occurrence was found between 40° and 50°S. Therefore, *C. tonsus* is considered to be one of the important food staff of baleen whales in relatively lower latitudes of the Antarctic as well as those in South African waters (Best, 1967). From this fact the occurrence of *C. tonsus* at 59°33′S and 61°27′S suggests quite unusual southward shift from their usual distribution area. As the summer season proceeds, the copepodite V of *C. tonsus* gradually moves down to the deeper water for wintering (Jillett, 1968), the whaling grounds formed by this kind of food organisms would be limited within early summer, and not last for long throughout the season.

As the size of *E. spinifera* is similar to that of young *E. superba*, they were not separated as a different species in Table 8, since it was hardly possible to identify them for the whalers. *E. spinifera* which was consisted of adult males and females with body length 15.5–20.3 mm was fed by only one whale caught at 61°20′S; 101°08′E. It should be noted that *E. spinifera* did not occur as a mixture as observed in young *E. superba*.

No fishes were found as a food of the Antarctic minke whales while those are the chief diet for the northern minke whales (Jonsgård, 1951; Omura and Sakiura, 1956). Sometimes, however, a few small fishes were found among the bulk of *E. superba* though they might have been mixed and fed by a chance. Most of those small sized fishes were Myctophid fishes about 10 cm in body length, and *Myctophum subasperum* was the most dominant species among them. As it is considered from Tables 7 and 8, the chief diet of minke whales in the Antarctic is considered as *E. superba* of 1-year group with body length less than 40 mm. It is also noticed that *E. superba* of " medium " and " small " never occurs in a pure population as a state of food but few cases.

Quantity of food and feeding habits

The quantity of food in the first stomach was recorded on each whales after

the following five classes:

Classes	0	r	rr	rrr	R
Quantity of food	Empty	Few	Moderate	Rich	Full
Approx. per cent	0	–25	25–50	50–75	75–100

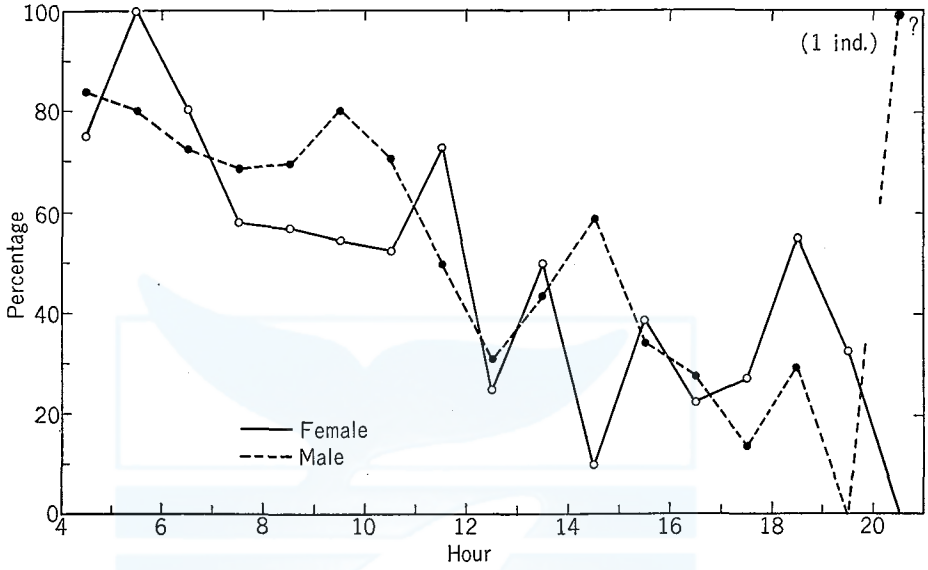

Fig. 14. Feeding percentages of minke whales caught in the Antarctic (1967/68 ; 1968/69). Open circle : female, Closed circle : male.

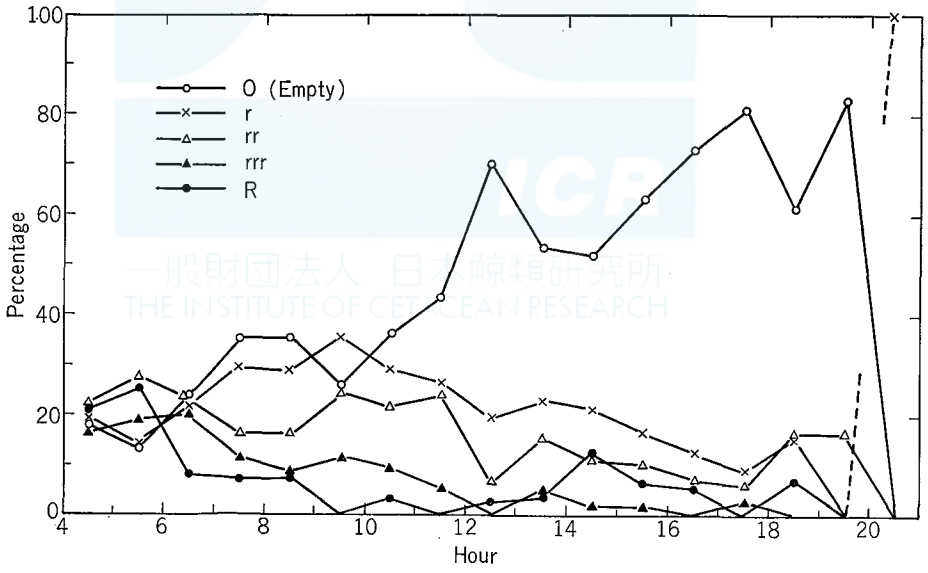

Fig. 15. Feeding percentages of minke whales caught in the Antarctic in terms of the degree of repletion in the first stomach.

In order to know the daily variations of feeding activity, the ratio of the number of stomach with food repleted more than " r " against the total number of stomachs examined was shown in Fig. 14. Fig. 14 shows that the most whales feed on actively before dawn and the feeding activity is on decrease toward midday though it recovers again gradually in the afternoon toward the evening. It is in the highest at just before and after sunrise; 04–06 hours. It is also suggested that the females feed on more actively than the males. Mentioning on the daily variation of feeding activity of baleen whales, Nemoto (1957, 1959) convinced that the most causeful factors on those variations lie chiefly on the vertical movement of food organisms rather than control by the whale themselves. The minke whales in the Antarctic seem to follow the similar way, because there are the fact that the feeding activity of sei whales which feed on *C. simillimus* are considered to be completely controlled by the diurnal movement of *C. simillimus* (Kawamura, 1970), though it varies also with another reasons such as the species of food, their developmental stages, and sometimes with the bottom topography of the sea (Nemoto, 1959). Fig. 15 shows that the considerable number of whales (3–10%) seem to feed still on food during the daytime, since the whales with the first stomach repleted more than 50% are considered having been caught at least within several hours after their feeding, judging from the freshness of their stomach contents. It leads to the consideration that the bulk of food organisms still remain within the upper layer to make the whales enable to feed on them, since there are the fact that relatively larger *E. superba* are found in the surface throughout the daytime (Marr, 1956; Hardy and Gunther, 1935). Although most whales seem to feed early in the morning in the present study, it is supposedly considered that the minke whales in the Antarctic feed on food whenever the food organisms are available.

ECTOPARASITES

The general features of ectoparasites infected on the minke whales were poor both in the number of individuals and species. The diatom films formed with *Cocconeis ceticola* were found on six whales which were examined on F. S. Nisshin Maru. The yellowish brown diatom films were usually found on the white skin of ventral side especially around the anus and genital apertures. They formed not such a patchy colony as usually observed on the skin of fin whales but only homogeneous brownish thin films.

The whale-lice, *Cyamus balaenopterae* were found in seven whales (Table 9). The part of the body where they infected were only the ventral grooves. As Leung (1967) reported only *C. balaenopterae* being found on the Antanctic minke whales, it seems that no other whale-lice occur in them. The whole individuals of *C. balaenopterae* were collected from two whales. It is noticed that the number of whale-lice is quite few in minke whales. The juveniles of both sexes were judged from their process on the base of gills and the developmental conditions of marsupium in females. The body length of juveniles which could not separate by the sex by this way was less than 3.0 mm though the most of them were between

1.2–2.8 mm. The female overcame in the sex ratio though it was about 1: 1 by assuming the juveniles unidentified the sex were the male. The infection rate of *C. balaenopterae* and other ectoparasites were too low to utilize them as an indicator for detecting the presence of any subpopulations as has been discussed on some possibilities in the south ern sei whales by thoracic cirripede, *Xenobalanus sp.* (Kawamura, 1969b).

TABLE 9. WHALE-LICE, *CYAMUS BALAENOPTERAE* FOUND ON THE SKIN OF MINKE WHALES IN THE ANTARCTIC SEASON 1967/68

Whale number		68	71	72	97	192	183	430
Part of body from which specimens were collected		Ventral grooves	Ventral grooves	Ventral grooves	—	—	—	—
Male	Adult	1	1	2	3	5	4	9
	Body length (mm)	7.3	6.2	5.7	4.2–5.7	4.6–5.3	3.8–4.3	4.3–5.4
	Juvenile	18	—	—	—	—	1	2
	Body length (mm)	—	—	—	—	—	3.6	4.3–4.4
Female	Adult	1[1]	1[1]	2[2]	2[2]	6[2]	3[3]	—
	Body length (mm)	4.9	6.9	5.0	4.4–4.9	5.4	4.6–5.4	—
	Juvenile	25	20	—	—	1	19	7
	Body length (mm)	3.0–4.8	2.8–3.5	—	—	5.4	2.8–4.3	2.2–4.8
Juveniles of unknown sex		2	12	3	—	—	4	32
	Body length (mm)	2.8–3.5	2.2	1.2–2.0	—	—	—	1.9–2.6

1) Carrying eggs in marsupium.
2) Marsupium developped well but no eggs were observed.
3) Included one deformed individual whose gills were considerably stunted.

CATCH AND CATCH COMPOSITIONS

Catch

Based on the International Whaling Statistics, minke whales were caught firstly by Soviet expedition in the Antarctic in 1951/52 season. Soviet expeditions caught minke whales one handred and more every season during 1957/58 to 1960/61, but after then the catch has not increased so many by Soviet expeditions (Table 10). Japanese expeditions caught 96 minke whales in the Antarctic in 1963/64 season (Kasuya and Ichihara, 1965), and then they caught 597 and 42 minke whales in 1967/68 and 1968/69 seasons respectively. Norwegian and U. K. expeditions have caught 6 minke whales each, and a Netherlands expedition caught one in 1959/60 Antarctic season (Utrecht and Spoel, 1962).

Then, 1,827 minke whales were caught in the Antarctic during 1951/52 to 1967/68 seasons. Additionally, it is estimated that there are some unreported minke whales which were caught as a food by some catcher boats in some sperm whaling seasons. Nevertheless, the total minke whales caught in the Antarctic whaling ground will be under 2,000 by 1968/69. Although minke whales have been increasing to be caught in Brazilian coast recently (488 whales in 1967, according to the International Whaling Statistics), they have not been caught many in other coastal whaling in the southern hemisphere. Therefore, it is considered that the

catch has not so influenced to the stock of southern minke whale, and it remains still in an initial stock level.

TABLE 10. NUMBER OF MINKE WHALES CAUGHT IN THE ANTARCTIC
(From International Whaling Statistics)

	Japan	USSR	Norway	U.K.	Netherlands	Total
1945/46	—	—	—	—	—	—
1946/47	—	—	—	—	—	—
1947/48	—	—	—	—	—	—
1948/49	—	—	—	—	—	—
1949/50	—	—	—	—	—	—
1950/51	—	—	—	—	—	—
1951/52	—	9	—	—	—	9
1952/53	—	—	—	—	—	—
1953/54	—	—	—	3	—	3
1954/55	—	—	—	—	—	—
1955/56	—	41	—	1	—	42
1956/57	—	46	—	—	—	46
1957/58	—	493	—	—	—	493
1958/59	—	102	—	1	—	103
1959/60	—	203	—	1	1*	205
1960/61	—	162	—	—	—	162
1961/62	—	2	—	—	—	2
1962/63	—	21	—	—	—	21
1963/64	96	5	—	—	—	101
1964/65	2	4	1	—	—	7
1965/66	—	8	2	—	—	10
1966/67	1	14	3	—	—	18
1967/68	597	8	—	—	—	605
1968/69	42	17	—	—	—	59
Total	738	1,135	6	6	1	1,886

* after Utrecht and Spoel (1962).

TABLE 11. CATCH DATA ON THE MINKE WHALES SEPARATED FROM MAIN GROUND AS SHOWN IN FIG. 16

Date Caught	Position caught	Sex	Body length (m)	Testis (kg)
31/XII/64	49°27′S, 25°05′W	M	8.3	
1/ I/65	50°12′S, 46°22′W	M	8.3	
12/XII/66	40°37′S, 04°33′E	M	8.8	1.8, 1.4
15/ III/69	45°51′S, 174°14′E	F	6.0	

There is no record on catch areas of minke whales in the Antarctic in the International Whaling Statistics. Fig. 16 shows the catch positions of minke whales which were caught by Japanese whaling expeditions in 1963/64, 1967/68 and 1968/69 seasons. Most whales were caught in Area IV (60°E–130°E), especially in the waters along the Kerguelen-Gausberg Ridge. Other minke whales were caught by Japanese expeditions as shown in Table 11. Therefore, several biological results which will be reported in the present paper are obtained from a stock in Area IV.

Concerning with catch days, Japanese expeditions caught minke whales during

January 6 to 8 in 1963/64 (Kasuya and Ichihara, 1965), and in 1967/68 season they were mostly caught during December 11 to 21. They were also caught mainly during January 18 to 25 in 1968/69. As minke whales are not a main object in the Antarctic whaling, we have not yet obtained materials through all months. According to the International Whaling Statistics, the catch months of minke whales by Soviet expeditions which caught many minke whales from 1955/56 to 1960/61 seasons were November, December and March, and the catch in January and February were relatively few.

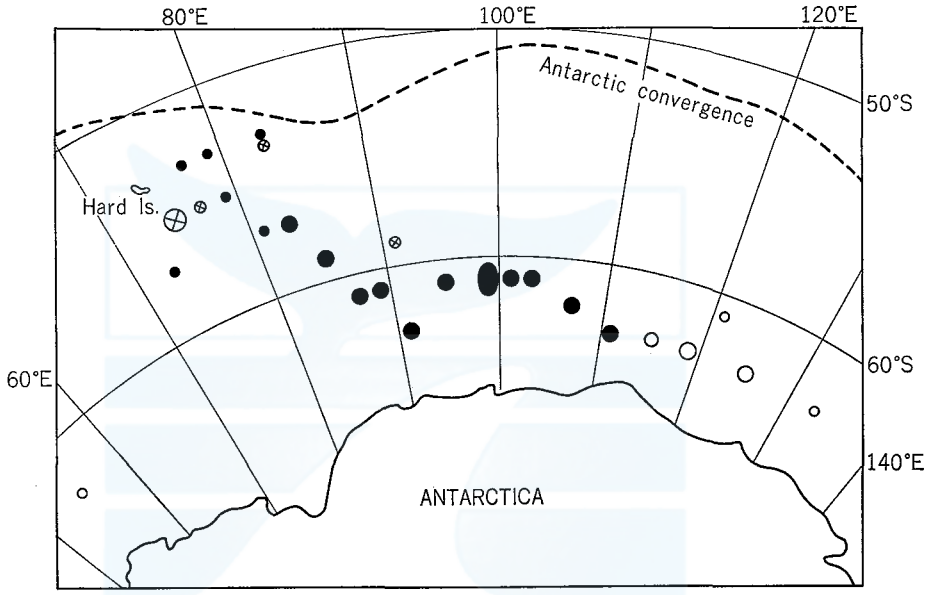

Fig. 16. Positions of minke whales caught by Japanese expeditions.
Open circle: 1963/64, Closed circle: 1967/68, Circle and cross: 1968/69.

Because this whale has been caught concentrately in short days or seldomly caught, it is difficult to get good values of catch per catcher day (CPUE) of this species in the present stage. Nisshin-Maru No. 3 Expedition caught 579 minke whales in the Antarctic concentrately with 9 catcher boats during 11 days from December 11 to 21 in 1967/68 season. From these data CPUE is calculated as 5.85. But it is dangerous to regard this value as the true CPUE of the minke whale stock in the Antarctic in the initial population level.

Composition of minke whales caught

The number of minke whales caught in 1967/68 and 1968/69 seasons by Japanese expeditions is 597 (including one whale lost) and 42, respectively, and all whales were caught in the waters southward the Antarctic Convergence in Area IV excluding only one whale. We would like to obtain some biological parameters of the Antarctic minke whale in the initial stock level by means of these catch data.

As any catch regulational limits do not assign on catch of minke whales in the Antarctic under the International Whaling Convention now, the present result will be regarded to reflect well the stock which distributes in a part of the Antarctic.

Sex ratio

The sex ratios of males caught are 65.1 and 78.5 % in 1967/68 and 1968/69 seasons, respectively. And according to Kasuya and Ichihara (1965), it was 82.3 % in 1963/64. In any seasons males are dominant in catch. This phenomenon means that there is a sexual segregation in this species, and males migrate dominantly in high latitudinal waters in the Antarctic, at least in Area IV.

Jonsgård (1951) found that female minke whales entered into Norwegian fjords, males stayed in far seas, and females were dominant in the Arctic. And he described that there is a tendency to separate into male and female groups, when they migrate into the feeding areas. Omura and Sakiura (1956) and Matsuura (1936) also reported the similar phenomena on the minke whales in the waters around Japan.

It may be considered that there is a sexual segregation in migration of minke whale in the southern hemisphere, reviewing these report on the northern hemisphere minke whales. But it is still unknown where the females distribute dominantly in summer season, although we find that males are dominant in high latitudinal waters in Area IV. It is estimated that the female is dominant in high latitudinal waters in the northern hemisphere, but this phenomenon is contrary to that in southern hemisphere. It will be hoped to investigate the minke whales in Ross Sea or Weddel Sea in future, and it will be needed to investigate also them in the waters north of the Antarctic Convergence in summer or in lower latitudinal waters in winter season for solution of this problem.

Size distribution

Although whalers want to take larger individuals and it will be relatively difficult to take a small minke whale, it may be regarded that the size distribution represents the whale stock which distributes there.

Table 12 shows the size distribution of the Antarctic minke whales caught by sex. The smallest was 4.9 m (16 feet), and the largest one was 9.8 m (32 feet) in the females. The smallest was 5.5 m (18 feet), and the largest one was 9.8 m (32 feet) in the males. The maximum size will not exceed 10 m in both sexes.

The maximum body length of the minke whales in the northern hemisphere are 30 feet female and 28 feet male, according to Jonsgård (1951), and they are 30 and 29 feet for the female and male, respectively, according to Omura and Sakiura (1956). Beneden (1889) and Stephenson (1951) reported that the maximum length of the minke whales from European waters was 36 feet, but it is considered to be too high.

Size distribution of males is different from that of females, that is to say, there are many large whales in the males, on the contrary, females have relatively many small whales. Modes of size distributions are 27 and 28 feet for males and females, respectively. And the average body lengths are 7.92 and 8.13 m for males and

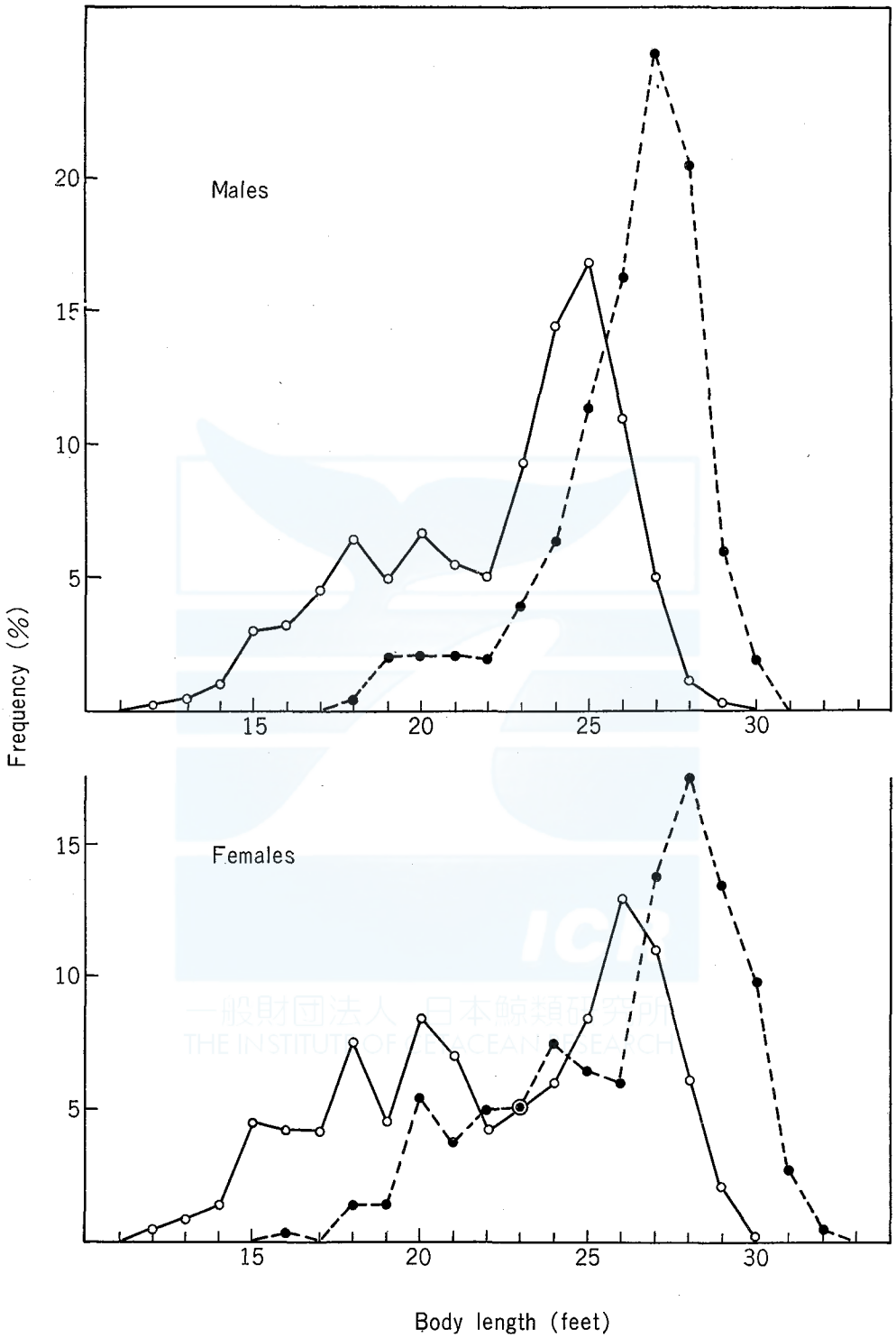

Fig. 17. Comparison of size distributions between the minke whales from the Antarctic and the coast of Japan.
Open circle and solid line : from the coast of Japan, Closed circle and broken line : from the Antarctic

females, respectively.

According to Omura and Sakiura (1956), the modes of size distribution of the minke whales from the North Pacific are 25 feet and 26 feet for males and females, respectively, and those from Scotland waters are almost the same as former ones (Stephenson, 1951). Sliding them 2 feet, they fit with the size distributions of the Antarctic minke whales. This shows that the Antarctic minke whales are 2 feet larger than the northern hemisphere minke whales.

TABLE 12. SIZE DISTRIBUTIONS BY SEXUAL CONDITIONS OF MINKE WHALES IN THE ANTACTIC (1967/68 and 1968/69)

Body length (m)	Males				Females		
	Immature	Mature	Unknown	Total	Immature	Mature	Total
4.9–5.0	—	—	—	—	1	—	1
5.5–5.6	2	—	—	2	3	—	3
5.7–5.8	8	—	—	8	3	—	3
5.9–6.0	—	—	—	—	4	—	4
6.1–6.2	8	—	1	9	8	—	8
6.3–6.4	5	—	—	5	4	—	4
6.5–6.6	5	—	—	5	7	—	7
6.7–6.8	5	1	1	7	8	—	8
6.9–7.0	10	1	—	11	5	—	5
7.1–7.2	3	10	—	13	9	—	9
7.3–7.4	7	14	—	21	13	—	13
7.5–7.6	3	24	—	27	10	—	10
7.7–7.8	1	45	—	46	7	4	11
7.9–8.0	1	43	—	44	3	5	8
8.1–82.	—	71	—	71	7	16	23
8.3–8.4	1	63	—	64	2	13	15
8.5–8.6	—	53	—	53	3	27	30
8.7–8.8	—	19	—	19	1	21	22
8.9–9.0	—	13	—	13	—	14	14
9.1–9.2	—	3	—	3	—	13	13
9.3–9.4	—	—	—	—	—	4	4
9.5–9.6	—	—	—	—	—	2	2
9.7–9.8	—	—	—	—	—	1	1
Total	59	360	2	421	97	120	217
Mean body length	6.67	8.12	6.45	7.92	7.19	8.88	8.13
Sexual rate (%)	14.1	85.9			55.3	44.7	

Rate of sexual maturity

Rates of sexual maturity of minke whales caught are 85.9 and 55.3 % for males and females, respectively, determining with reproductive organs, and that of males is very high, notwithstanding there is no legal size limit on this species. This suggests that there is geographical segregation with not only sex but also with age in the males. Segregation with age is not so remarkable in females.

The average lengths of mature males and females are 8.12 and 8.88 m, respectively, and those of immature males and females are 6.67 and 7.19 m, respectively.

Age composition and mortality rate

The age composition of minke whales caught in 1967/68 Antarctic season is shown in Fig. 19. We have not enough materials for drawing age composition by sexes. The youngest whale which were able to be determined its age with earplug lamination is 5 years old, and the oldest one is 40 years old. Mode of distribution is found at 15 years.

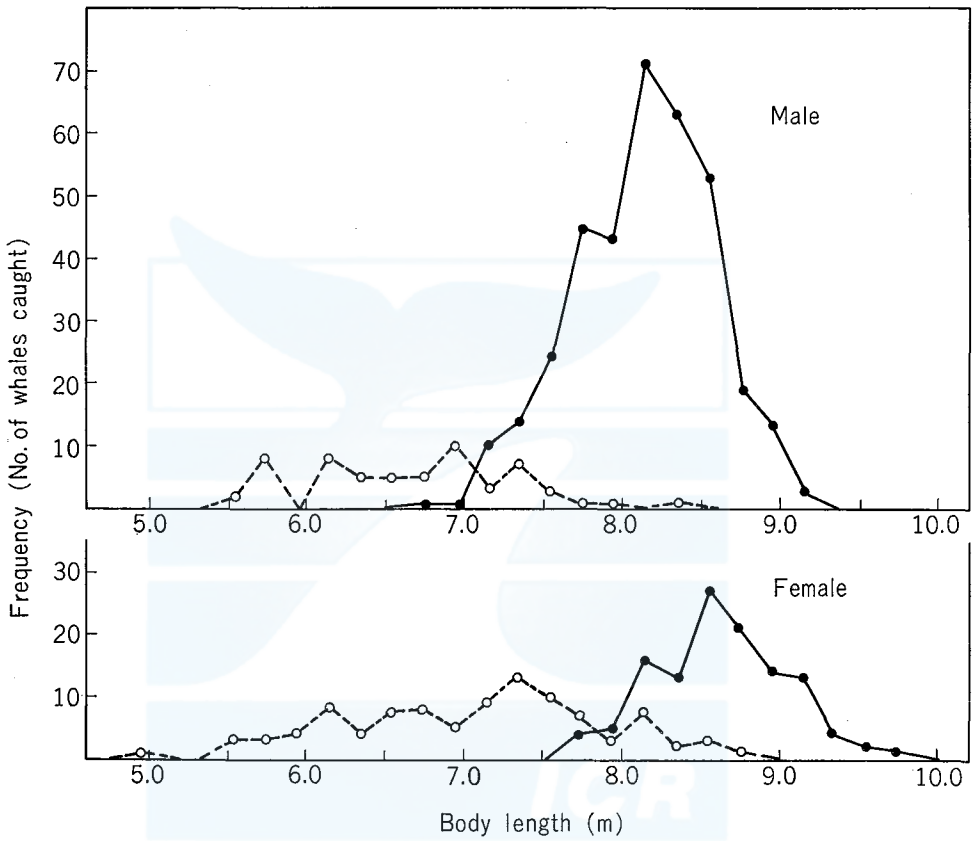

Fig. 18. Size distributions of minke whales caught in the Antarctic in 1967/68 and 1968/69 seasons. Open circle and broken line : Immature, Closed circle and solid line : Mature.

Calculating a total mortality coefficient from the frequencies of 15 years and over, it is 0.102. In the present stage when the catch has not begun in large scale, this value will mean the natural mortality coefficient.

The most number of ovulations is 31, and if this whale has an average age at sexual maturity and an average rate of ovulations, its age is estimated to be 47–48 years. Therefore, the longest life span of the minke whale will be under 50 years, and it is the youngest among *Balaenoptera* species.

Frequency distribution of ovulations is shown in Fig. 20. A total mortality coefficient calculated from this distribution and the average number of annual ovula-

tions is 0.104. It is the almost the same value as that obtained from age distribution.

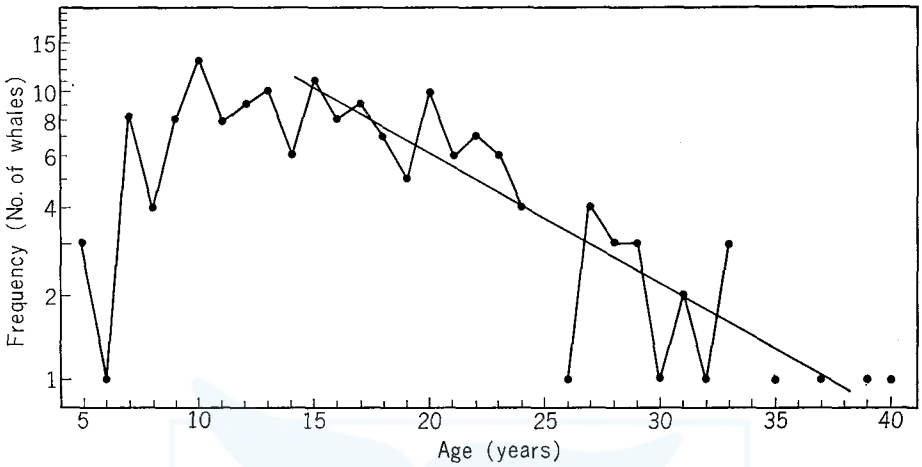

Fig. 19. Age distribution of male and female minke whales caught in the Antarctic in 1967/68 season.

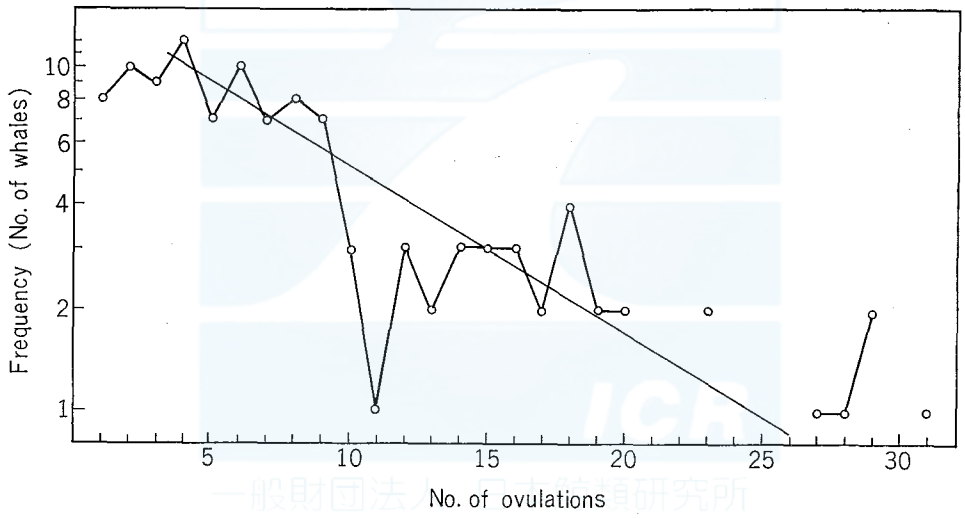

Fig. 20. Frequency distribution of number of ovulations in the Antarctic minke whales.

Natural mortality coefficient of the Antarctic minke whales is higher than those of the Antarctic fin whale (0.042: Doi *et al.*, 1969) or of the Antarctic sei whale (0.06–0.08: Doi *et al.*, 1967). As it is considered that the natural mortality coefficient has a tendency to decrease with the decrease of population size, we must pursue the change of natural mortality on this species after the begining of ordinal whaling.

There is a mode in ovulation distribution at 4 ovulations. This may be estimated that there is segregation by age in females as well as in males.

DISTRIBUTION AND ABUNDANCE

Distribution

Whale sighting has been continued with scouting boats belonged to Japanese whaling expeditions in the Antarctic. Fig. 21 shows number of minke whales sighted per day in each 2° squares during the seasons from 1965/66 to 1968/69. Although we have few data in Area I and higher latitudinal waters in Areas II and III, it is estimated that the minke whales distribute in all waters in the Antarctic in summer and the distribution density is generally low in north of the Antarctic Convergence, on the contrary, it is high in south of the Convergence. Especially, minke whales distribute in high density in the waters from eastern margin of Area III to Area V.

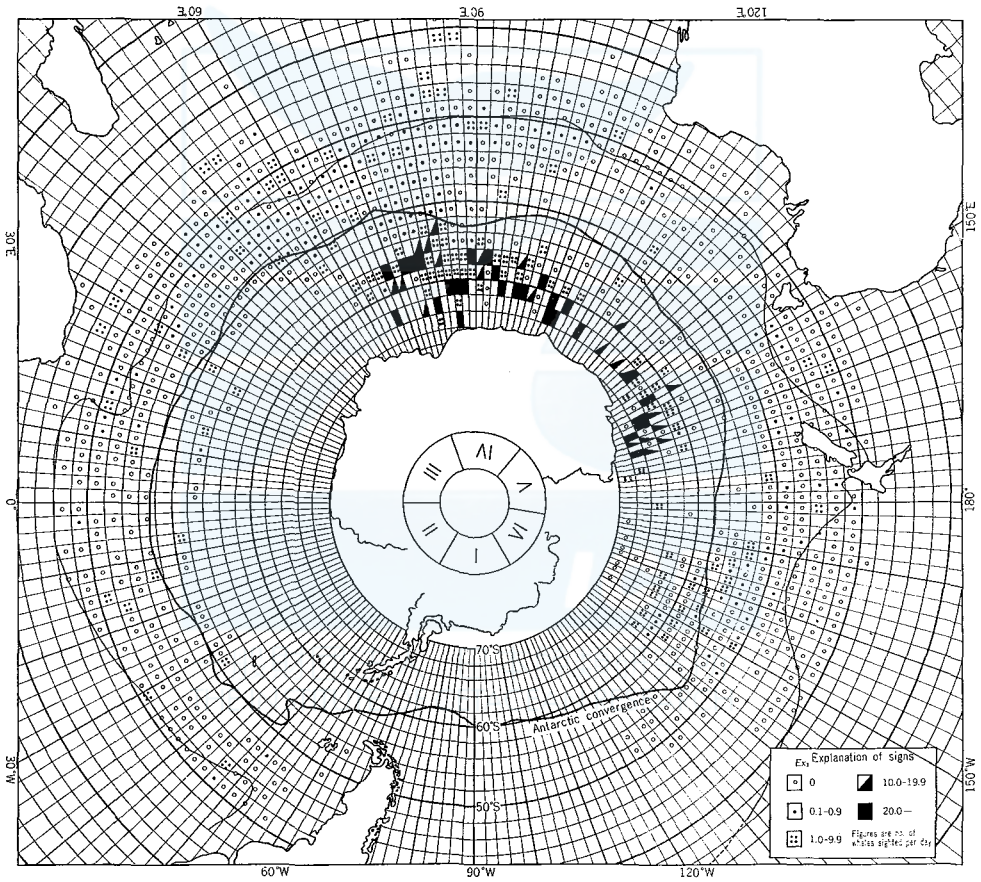

Fig. 21. Distribution of minke whales sighted by Japanese scouting boats in the Antarctic seasons 1965/66–1968/69.

Table 13 shows the density distributions of baleen whales in each Sectors during

the seasons 1966/67–1968/69. Density is represented as the number of whales sighted per 100 miles navigations. The density of minke whales is the highest in Area IV, and the higher the Sector is in each Areas, the higher the density becomes. Among all Sectors Sector IVB is the highest density for the minke whales.

TABLE 13. WHALE SIGHTING WITH SCOUTING BOATS BELONGED WHALING EXPEDITIONS IN THE ANTARCTIC SEASONS 1966/67–1968/69

Sector	Navigation (miles)	Number of whales sighted						Number of whales sighted per 100 miles navigation					
		Blue	Fin	Hump.	Sei	Right	Minke	Blue	Fin	Hump.	Sei	Right	Minke
I D	208	—	—	—	—	—	—	0.00	0.00	0.00	0.00	0.00	0.00
I A	209	—	—	—	18	—	—	0.00	0.00	0.00	0.09	0.00	0.00
II E	1,075	—	—	—	54	2	1	0.00	0.00	0.00	5.02	0.19	0.09
II D	2,929	—	—	3	9	5	2	0.00	0.00	0.10	0.31	0.17	0.07
III E	11,922	4	11	—	750	—	10	0.03	0.09	0.00	6.29	0.00	0.08
III D	143,446	565	1,611	6	6,279	15	287	0.39	1.12	0.00	4.38	0.01	0.20
III A	5,222	4	34	—	26	—	74	0.08	0.65	0.00	0.50	0.00	1.42
IV E	18,745	—	9	2	603	—	32	0.00	0.05	0.01	3.22	0.00	0.17
IV D	90,484	75	502	16	2,251	20	183	0.08	0.56	0.02	2.49	0.02	0.20
IV A	76,637	28	3,864	20	1,789	2	2,695	0.04	5.04	0.03	2.33	0.00	3.52
IV B	4,139	2	4	1	6	—	291	0.05	0.10	0.02	0.15	0.00	7.03
V E	3,704	4	2	—	145	—	—	0.11	0.05	0.00	3.92	0.00	0.00
V D	71,920	7	162	5	3,343	8	45	0.01	0.03	0.01	4.65	0.01	0.06
V A	18,051	4	538	2	336	2	189	0.02	2.98	0.01	1.86	0.01	1.05
V B	4,191	6	—	1	19	—	133	0.14	0.00	0.02	0.45	0.00	3.17
VI D	24,298	—	6	2	730	1	3	0.00	0.03	0.01	3.00	0.00	0.01
VI A	30,704	1	78	2	1,448	8	67	0.00	0.25	0.01	4.72	0.03	0.22
VI B	7,722	5	45	6	113	—	29	0.07	0.58	0.08	1.46	0.00	0.38
Total	515,606	705	6,866	66	17,919	63	4,041	0.14	1.33	0.01	3.48	0.01	0.78

Remarks: E: 30°S–40°S, D: 40°S–50°S, A: 50°S–60°S, B: 60°S–70°S, I: 60°W–120°W, II: 60°W–0°, III: 0°–70°E, IV: 70°E–130°E, V: 130°E–170°W, VI: 170°W–120°W.

Arsenyev (1960) showed a longitudinal distribution of the minke whales sighted by USSR expeditions in the Antarctic whaling grounds between 60°W and 170°W eastward. According to his paper, minke whales do not distribute equally in the Antarctic, and there are three peaks of distribution in 10°–20°W, 60°–70°E and 160°–170°E. He also estimated that the stock in the Indian Ocean had larger populations than that in the Atlantic. There is no record of the latitudinal distribution in his report, and we did not investigate in higher latitudinal waters in Area II. So, it is difficult to compare the present result with the record by Arsenyev, but it will be certain that relatively many minke whales distribute in the Indian Ocean waters of the Antarctic in summer. And the catches of minke whales by Japanese expeditions concentrate mainly in this area.

It is difficult to separate stock units only by means of distribution in the present report as Arsenyev also described. Stock identification will be need to be done with other methods in future.

According to Taylor (1957), many minke whales swim in opening ice waters in

distal ice of the Antarctica (63°S, 57°W), and they can live in cold water temperature. We have no data on the distribution of the minke whales in the waters southward 70°S in the present paper.

Minke whales have been caught in the waters near Spitsbergen, and they distribute in Davis Straight (Jonsgård, 1951). According to Sleptzov (1955), they are also found in north of the Bering Strait. Then, minke whales distribute in the highest latitude in both hemisphere among *Balaenoptera* species.

The distribution of southern minke whales in lower latitude is not so certain, but the catch in Resife of Brazil (8°S) have increased recently. Whaling season in this waters is during June to November, and the optimum season is October (International Whaling Statistics, No. 61). According to an information by a whaler who opearated in these waters and a sample of baleen plates, the minke whales in Brazilian waters have the same morphological characters as so called "*Balaenoptera bonaerensis*". Clarke (1962) reported that some minke whales were found in the position of 33°S, 73°W, but they were not found during a cruise of 3°S–1°N, 81°W–94°W. Minke whales were sighted off the west coast of Australia (Chittleborrough, 1953), and a new born calf or near term foetus of the minke whale was stranded on the coast of New Zealand (Gaskin, 1968).

TABLE 14. SCHOOL COMPOSITION OF MINKE WHALES SIGHTED IN THE ANTARCTIC

Latitude	Average number of whales in a school					
	1	2	3	4	5	6
40°S–50°S	106	31	15	3	2	2
50°S–60°S	106	144	88	52	9	2

We have no knowledge on migration of the minke whale in the southern hemisphere. However, as Lillie (1915) noted that minke whales were common in the Antarctic in January-Feburary, it is clear that they distribute concentratley in high latitudal waters of the Antarctic in summer season, and some of them stay in these waters in winter season (Taylor, 1967). Some minke whales of the northern hemisphere are considered to stay in higher latitude in winter season, for they strand through all months on the coast of North Scotland (Stephenson, 1951). There are some records on the stranding of minke whales in New Zealand in February, May, June, September and October. Whaling season in Brazil is during winter to spring.

It has been clearly shown that the northern minke whales migrate seasonally (Matsuura, 1936; Jonsgård, 1951; Stephenson, 1951; Omura and Sakiura, 1956; Sergeant, 1962). And it has been also known that migration season and area are different with sex, age and sexual condition for the northern minke whales.

School composition

Table 14 shows frequency distributions of average number of whales composed a school, using records of number of total minke whales and total schools. In the waters north of 50°S lone whales are dominant, on the other hand, number of whales

in a school increases in south of 50°S. There is a tendency that school composition is many in the day when many minke whales were sighted. These phenomena will mean that minke whales gather each other in high latitudinal waters of the feeding ground. We have no data on the maximum number in a school.

Arsenyev (1960) describes that school composition is 10, 20, 50 and more than 50 in the Indian areas of the Antarctic. Jonsgård (1951) reported that lone minke whales were many in the western coast of Norway, but school composition became large in the Arctic waters, and he estimated that this was a result that lone whale gathers each other in the end of migration in summer. Nemoto (1964) says that fin whale changes school composition in feeding ground, and there is no consort relationship. We consider that minke whales has almost the same tendency.

Comparison of distribution density with other whale species

As shown in Table 13, the density distribution of minke whales is the third of the whale species sighted (sei whale is the first, and fin whale the second). Considering that the minke whales are economically valueless, observers will pay little attention to find them, and they are more difficult to be find, because they are the smaller species, the real density will be higher than the values obtained in Table 13.

Density distribution of the sei whales is high in lower latitude (D-sector), and that of the fin whales is the highest in A-sector, on the other hand, that of the minke whales is the highest in B-sector, and it becomes lower in lower latitude. Then, this tendency seen in minke whales is almost the same as that in the ordinal blue whales (*Balaenoptera musculus*).

TABLE 15. ESTIMATED STOCK SIZE OF THE MINKE WHALES BY MEANS WHALE SIGHTING IN THE ANTARCTIC

	Area					
Sector	II	III	IV	V	VI	I
D	270	930	810	220	40	?
A	?	5,370	11,410	3,400	590	?
B	?	?	10,940	6,610	750	?
C	?	—	—	?	?	?

Estimation of population size

Mackintosh and Brown (1956) tried in the first time to estimate population size of whales by means of whale sighting, and Nasu and Shimadzu (in press) developed the former method. In the present paper, we used as the materials the Sector size (A), navigation miles (L) and number of whales sighted (n), and adopted needful coefficients as visible width=11.1 miles, rate of sighting=0.344 at finding efficiency=0.7 from Nasu and Shimadzu, the population size will be calculated as the following formula:

$$N = \frac{A \cdot n}{0.344 \times 11.1\ L}$$

Result of calculation of the population size in areas south of 40°S is shown in

Table 15. Excepting Area IV other Areas are not got total population sizes covering all sectors. Therefore, we have not got the total population size in the whole Antarctic. The population size in Area IV is calculated to be 23,200, and the total sizes in the waters investigated are also calculated as about 41,000. Perhaps 70,000 minke whales and over will distribute in the Antarctic in summer. Considering that density distribution of the minke whales is high in the high latitude, there are wide areas where are not investigated and the finding and records are possiblly more scarce than other larger whale species, the real population size will be remarkably larger than the figure estimated. Furthermore, whale sighting is only one of the methods to assess a population size, and some assessment of population will be introduced after the beginning of regular whaling on this species.

PRODUCTION

Amount of production

Nisshin-Maru No. 3 Expedition caught only minke whales exclusively in the Antarctic during 11 days from December 11 to 22 in 1967. The amount of production from these minke whales is shown in Table 16. The average body length of the whales disposed is 7.9 m, and the biomass is calculated from a formula of body length-body weight relationship.

TABLE 16. PRODUCTION FROM MINKE WHALES WHICH WERE CAUGHT BY NISSHINMARU NO. 3 IN 1967/68 ANTARCTIC SEASON

Items	Production (ton)	Production per whale (ton)
Number of whales carried	578	
Calculated biomass	3,190	
Frozen meat	933	1.61
Whale oil	332	0.57
Meal	90	0.16
Bone meal	63	0.11
Extract	13	0.02
Total	1,432	2.48

Oil production per a whale was 0.57 tons. According to Tomilin (1957), usually one ton of whale oil is produced from a large and fatty minke whale. However the present figure is smaller than this value. Whalers produced 1.61 tons of meat per a minke whale, and the total production from a minke whale are 2.48 tons in average.

Discussions on the Blue Whale Unit of the minke whale

There is no catch limit on the minke whale in the Antarctic under the present International Whaling Convention, and therefore, a value of Blue Whale Unit (BWU) has not put on this whale species. Of course, as population management should be set up for each whale species and each stock units, it is not reasonable to calculate the value of BWU on the minke whale for a purpose of population manage-

ment. However, we think it will be useful to calculate it as a standard for examination of production of this species.

Calculation of Blue Whale Unit from whale oil: BWU system began to be used for an agreement of production regulation among whalers since 1932, and it was determined based on oil production of each whale species.

Determining the oil production per one blue whale as 110 barrels, exchange rate of each species were calculated using oil production per each one whale. Oil production per one BWU in 1966/67 Antarctic season calculated by Omura (1969) is 109.5 barrels. This figure is almost the same as the original.

Average oil production per one Antarctic minke whale was 0.57 tons (3.42 barrels) from Table 16. Then, regarding oil production as the standard of BWU, 32 minke whales are considered to be regarded as one BWU. Average total production per one BWU (catch of sei whales were 96 % of total catch) by Japanese expeditions in 1966/67 Antarctic season was 85.40 tons. One BWU is 34.4 minke whales, if total production is regarded as a standard. This value is almost the same as that formaly obtained from oil production.

In the present time there is no legal size limit on the Antarctic minke whale, and so small individuals were also caught. If legal size would be set up at larger length than actually caught, number of minke whales per one BWU will become smaller than those obtained in the present report.

Calculation of Blue Whale Unit from biomass: Crisp (1962) examined BWU in view of biomass. According to his paper, the average body weight of the blue whale as the standard of calculation of exchange rate was 83.9 tons. As the average body length of the minke whales caught by Japanese expeditions in 1967/68 was 7.90 m, the average body weight was calculated to be 5.52 tons. from the formula of length-weight relationship. Then, based on biomass, 15.2 minke whales will be regarded as one BWU.

BWU exchange rate obtained from oil production is about twice of that from biomass. Table 5 shows comparison of proportional weights of meat, blubber and bones among several *Balaenoptera* species. Above phenomenon is caused from that the minke whale has small proportion of oil materials, and has large proportion of meat materials.

DISCUSSION

Problem on classification of the Antarctic minke whale

A minke whale with no white band on flippers which was found by Williamson (1959, 1961) in the Antarctic has been regarded as different species or different subspecies from so called minke whale, *Balaenoptera acutorostrata.* He also reported that the former whale was the same as *B. bonaerensis* from Argentina which had reported by Burmeister in 1867, and *B. huttoni* was also a synonym of this species.

Utrecht and Spoel (1962) and Kasuya and Ichihara (1965) reported the same type of species as that by Williamson from the Antarctic. Gaskin (1968) also describes that the minke whales which had stranded on the coast of New Zealand were mostly

same type. Nishiwaki (1965) adopted the Williamson's report, and he proposed to name " Kurominku kuzira " in Japanese and " New Zealand piked whale " in English as a common name for this species.

All individuals which were dealed in the present report have the same morphological characters as so called New Zealand piked whale, having no white band on flipper, large baleen with wide black band on the outer margin. There are some differences in measurements of body proportions, and the Antarctic minke whale is about two feet larger than the northern hemisphere one. However, we could not find any qualitative differences between them, that is to say, both the Antarctic minke whale and northern hemisphere minke whale (*Balaenoptera acutorostrata*) have the same number of baleen plates, same rate of breadth to length of baleen plate, same number of ventral grooves, same position relation between umbilicus and end of ventral grooves and same number of vertebrae. We think the minke whales which was observed by Williamson (1961) and of which both positions of end of ventral grooves and of umbilicus coincided each other was an exceptional. Kasuya and Ichihara (1965) estimated similar whales only with photograph. We can find a minke whale of which umbilicus and end of ventral grooves coincide from the coastal waters of Japan in a report by Omura and Sakiura (1956, Appendix-Table, No. 21 Specimen, p. 33). We heard that whalers sometimes found minke whales with no white band on flippers from the Okhotsk Sea. On the other hand, it is noted that there are some minke whales with white band on flippers in the Antarctic (Taylor, 1962; Kasuya and Ichihara, 1965). Individual variations of body colour are very large in the humpback whale (*Megaptera novaeangliae*). Although the Antarctic minke whale is about two feet larger than the northern hemisphere minke whale, in other *Balaenoptera* species southern hemisphere stocks are clearly larger than the northern stocks, but they are classified into the same species. Black band in outer margin of baleen plates is found in some northern hemisphere minke whales. We must notice that there is individual variation in qualitative characters.

As a conclution of above discussion, we support a report by Utercht and Spoel (1962) that *Balaenoptera bonaerensis* is a synonym of *B. acutorostrata* from the northern hemisphere, and it will be regarded as a variation or subspecies of the latter. Therefore, we used the name of minke whale for the whales which were treated in the present paper.

For the purpose of further study on the problems of classification of this stock, we should examine osteologically by a collection of skeletons of the Antarctic minke whale. It will be also need to study on the minke whales with white band on flipper in the Antarctic and to compare with the Antarctic minke whales with no white band.

Stock management of the minke whales in the Antarctic

It will be desirable that any animal stocks should not be left to chance to be utilized, but should be utilized under the carefull management so as not to let them decrease under the stock level which give the maximum sustainable yield. In this meaning, we hope to exploit the minke whales more in the Antarctic in

future. However, we think we should prepare some plans for the stock management firmly for maintenance of optimum stock level in future minke whaling. For, past history of whaling teaches us that it is very difficult to recover a stock which had been decreased under the level of maximum sustainable yield.

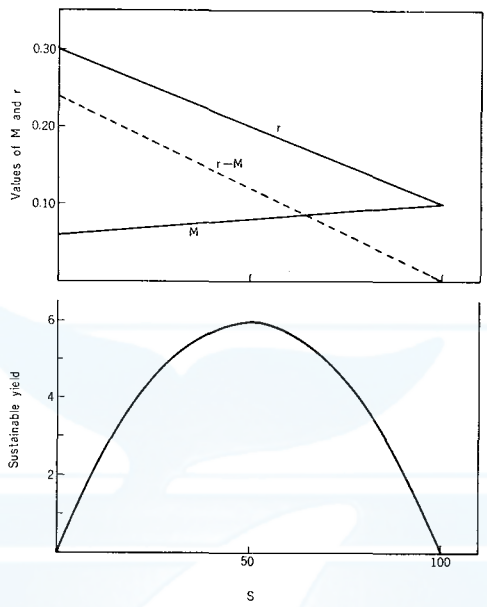

Fig. 22. Estimation of sustainable yield curve for the Antarctic minke whale.

Some characteristics of the Antarctic minke whale among the biological parameters concerned with population assessment are estimated that the sexual maturity attains at younger age, rate of reproduction is higher and natural mortality rate is higher than other species of genus *Balaenoptera*. As a mortality coefficient at initial stock level was calculated to be 0.102–0.104, it will be 0.10. Natural mortality rate will decrease as population decreases. The smallest mortality coefficient at the lowest population level is unknown, but we set it as 0.06. Recruitment rate (r) must be the same value as mortality coefficent at the initial population level (0.10). The recruitment rate at the lowest stock level is calculated from the following equation:

$$r = \frac{p}{2} e^{-TM}$$

Where, p is a pregnancy rate, and it is assumed to be 0.85 at the lowest stock level, for the present pregnancy rate is 0.75 and it will increase as population decreases. Notation of T is age at recruitment, and it is also assumed as 5 years at the lowest stock level. Then, r-value is calculated to be 0.315. This value is considered as the upper limit at the lowest stock level, so we estimate it is 0.30 at that level.

If r and M are assumed to change straightly with stock level, $r-M$ changes as

shown in Fig. 22. And then, sustainable yield curve is obtained which is also shown in the same figure. The stock level which gives maximum sustainable yield will be half of the initial stock level, and the maximum sustainable yield will be 0.13 times of the half of the initial stock size.

Although we have not yet obtained satisfactorily the whole population size of the minke whales in the Antarctic, it will be estimated to be about 70,000 by means of whale sighting. If it is true, the population size at maximum sustainable yield level will be about 35,000 and maximum sustainable yield will be about 4,200. That is to say, if 4,200 minke whales are caught in the Antarctic every year, we can continue a minke whaling safely for ever. Above result is only one of trial calculations, for there are too many assumptions in this calculation. But it will be need to antisipate catch size before a regular whaling start and to endeaver to maintain a population at proper level, correcting continuously by the investigation in every year.

According to the above calculation, annual catch amount of the minke whales is only about 130 BWU based on oil yield, and it is about 280 BWU based on biomass. So, it will be dangerous to continue large amount of catch of minke whales in the Antarctic, using such a large scaled expeditions which operate at present.

It is needless to set up size limit, if a quater is set up for the regulation of whaling, but if not, size limit is practical as one of the methods of regulation. In the third meeting of the International Whaling Commission, a proposal that size limit of minke whale should be 25 feet was offered as one of the agenda, but it was withdrawed at that time. Then, there have been no size limit on this whale species. It will be worth to consider how many length it will be, if size limit will be set up. Present legal size limit for the baleen whales are all set up under the body length at sexual maturity. Legal sizes for the Antarctic blue, fin and sei whales are about 90 % of the length at sexual maturity. If a legal size of the minke whale is set up in the same ratio, it will be 6.8 m, or 23 feet, based on the average body length at sexual maturity of both the males and females. Even in the present situation catch of males under 7 m is very scarce in the high latitude of the Antarctic. Therefore, size limit is needless on the males. Catch of 83 % of females is over 6.8 m in the present situation, and so catch of the females is also not influenced by setting of legal size limit for minke whaling in the Antarctic. However, there is a possibility to increase small individuals on the minke whales which distribute in lower latitude.

SUMMARY

Following results were obtained studying for the purpose of estimating some biological parameters in the initial stock level of the minke whale in the Antarctic, by means of materials which were got with Japanese expeditions.

1. Minke whales caught in 1967/68 and 1968/69 Antarctic seasons had all no white band on the flipper.

2. Number of baleen plates on the left side was 261–359, and 299 on an average. Although there is individual variation, the black band in the outer margin of baleen plates was wide, and the ratio of the breadth to length of the longest plate was 0.4–0.6.
3. Number of ventral grooves was 52–60 between both flippers, and the posterior end of the ventral grooves was in front of umbilicus, and clearly separate each other.
4. There were some difference in the external proportions between the Antarctic and the northern hemisphere minke whales, and between both sexes.
5. Vertebrae formula was C7, D11–12, L12, Ca18, Total 48–49.
6. From above morphological characters, so called New Zealand piked whale (*Balaenoptera bonaerensis*) should be a synonym of the minke whale (*B. acutorostrata*) in the northern hemisphere.
7. Ages were determined with earplug. Although materials were not so enough, growth curves were drawn after the age determination.
8. Testis weight at maturity was estimated to be 0.35 kg for each sides.
9. Average body length at sexual maturity was 7.1 m and 7.9 m for males and females, respectively. And the average age at sexual maturity will be 7–8 years.
10. Average length at physical maturity is 8.3 m for the males and 8.8 m for the females, respectively. Age at physical maturity was estimated as 18–22 years.
11. Pregnancy rate of mature females was considered to be 80–90 %, and annual ovulation rate was also estimated to be 0.767. Therefore, reproduction rate of this whale is considered to be higher than other species of genus *Balaenoptera*.
12. Sex ratio of the foetuses is 1 : 1, and the seasons of fertilization and parturition slip about half a year between the Antarctic and northern hemisphere minke whales each other. Breeding season will be once a year.
13. As the stomach contents, one year group of *Euphausia superba* were most frequently found. *E. spinifera* and *Calanus tonsus* were also identified from stomach contents. Daily fluctuation was observed in the feeding activity.
14. *Cocconeis ceticola* and *Cyamus balaenopterae* were found as ectoparasites.
15. Catch of minke whales in the Antarctic has not been many still, so that population is considered to maintain the initial level.
16. Most catch of minke whales with Japanese expeditions were from the waters southward the Antarctic Convergence of Area IV.
17. Sex ratio of whales caught was 70–80 % of males at least in the high latitudinal waters of Area IV.
18. Maximum body lengths were 9.2 m for males and 9.8 m for the females, respectively, and so the Antarctic minke whale is considered to do not exceed over 10 m. Average body length of whales caught were 7.92 m and 8.13 m for males and females, respectively.
19. There is a tendency of ageal segregation for the males which distribute in higher latitude of the Antarctic, and sexually mature males were 86 % of total males caught. On the contrary, females distribute fewer than the males in that waters, and ageal segregation was not so remarkable in the females.
20. Natural mortality coefficient was estimated to be 0.10, which is higher than

other species of genus *Balaenoptera*. The longest life span is considered not to exceed 50 years.

21. Based on whale sighting, minke whales distribute widely in the Antarctic in summer, but density distribution was higher southwards of the Antarctic Convergence, and it was considered to be the highest in Area IV.

22. Lone whales were many in lower latitude, and the number of whales in a school had a tendency to increase in higher latitude.

23. By means of whale sighting population size in Area IV was estimated to be about 23,000. It is still difficult to estimate the whole population size of the minke whales in the whole Antarctic, but it may perhaps exceed 70,000.

24. If the initial population size is 70,000, maximum sustainable yield is calculated to be 4,200, and catch of 4,200 minke whales will be permitted safely every season.

25. Thickness of blubber is more in the females than the males, and they were 2–7 cm at the position of side under the dorsal fin. Thickness of blubber had a tendency to increase from December to January.

26. Body length/body weight relationship was shown in the following formula:

$$W = 0.466\ L^{2.31}$$

27. Production per whale was 0.57 ton. of whale oil, 1.61 ton. of whale meat and 2.48 ton. of total production.

28. Number of minke whales per one Blue Whale Unit was calculated as 32 based on whale oil production, and 15 based on biomass.

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APPENDIX I. BODY PROPORTIONS OF THE MINKE WHALES CAUGHT IN THE ANTARCTIC OCEAN DURING 1967/68 SEASON. THE PERCENTAGES TO TOTAL BODY LENGTH (CM) ARE GIVEN IN PARENTHESIS

	Whale number	22 N1	22 N2	22 N3	22 N4	22 N5	22 N6	22 III N425	22 III N511	22 III N221	22 III N171	22 T2	22 T1
	Sex	M	M	M	M	M	F	M	M	M	M	M	F
1.	Total length	810	828	840	840	850	800	710	754	780	806	820	930
2.	Tip of snout to blowhole	108 (13.33)	116 (14.01)	112 (13.33)	113 (13.52)	104 (12.24)	128 (16.00)	105 (14.79)	117 (15.52)	120 (15.38)	112 (13.90)	120 (14.63)	140 (15.05)
3.	Tip of snout to angle of gape	153 (18.89)	170 (20.53)	160 (19.05)	162 (19.29)	147 (17.29)	162 (20.25)	133 (18.73)	136 (18.04)	144 (18.46)	138 (17.12)	140 (17.07)	180 (19.35)
4.	Tip of snout to center of eye	162 (20.00)	160 (19.32)	170 (20.24)	172 (20.48)	163 (19.18)	176 (22.00)	143 (20.14)	147 (19.50)	158 (20.26)	160 (19.85)	150 (18.29)	190 (20.43)
5.	Tip of snout to tip of flipper	366 (45.19)	330 (39.86)	400 (47.62)	374 (44.52)	374 (44.00)	389 (48.63)	315 (44.37)	350 (46.42)	350 (44.87)	365 (45.29)	370 (45.12)	420 (45.16)
6.	Eye to ear (center)	40 (4.94)	39 (4.71)	44 (5.24)	40 (4.76)	40 (4.71)	40 (5.00)	40 (5.63)	43 (5.70)	39 (5.00)	40 (4.96)	42 (5.12)	50 (5.38)
7.	Notch of flukes to posterior emargination of dorsal fin	232 (28.64)	239 (28.86)	250 (29.76)	252 (30.00)	254 (29.88)	236 (29.50)	190 (26.76)	202 (26.79)	211 (27.05)	240 (29.78)	213 (25.98)	265 (28.49)
8.	Flukes, width at insertion	76 (9.38)	59 (7.13)	78 (9.29)	79 (9.40)	80 (9.41)	86 (10.75)	60 (8.45)	55 (7.29)	53 (6.79)	65 (8.06)	65 (7.93)	90 (9.68)
9.	Notch of flukes to anus	220 (27.16)	225 (27.17)	220 (26.19)	198 (23.57)	217 (25.53)	236 (29.50)	193 (27.18)	200 (26.53)	244 (31.28)	222 (27.54)	200 (24.39)	255 (27.42)
10.	Notch of flukes to umbilicus	396 (48.89)	410 (49.52)	400 (47.62)	368 (43.81)	356 (41.88)	420 (52.50)	330 (46.48)	350 (46.42)	365 (46.79)	384 (47.64)	380 (46.34)	350 (37.63)
11.	Notch of flukes to end of ventral grooves	431 (53.21)	445 (53.74)	470 (55.95)	389 (46.31)	384 (45.18)	452 (56.50)	375 (52.82)	403 (53.45)	400 (51.28)	423 (52.48)	421 (51.34)	490* (52.69)
12.	Anus to reproductive aperture (center)	61 (7.53)	70 (8.45)	50 (5.95)	46 (5.48)	56 (6.59)	25 (3.13)	55 (7.95)	67 (8.89)	26* (3.33)	46 (5.71)	66 (8.05)	35 (3.76)
13.	Dorsal fin, vertical height	25 (3.09)	35 (4.23)	35 (4.17)	25 (2.98)	32 (3.76)	32 (4.00)	29 (4.08)	27 (3.58)	29 (3.72)	28 (3.47)	25 (3.05)	35 (3.76)
14.	Dorsal fin, length of base	40 (4.94)	52 (6.28)	31 (3.69)	37 (4.40)	48 (5.65)	36 (4.50)	53 (7.46)	46 (6.10)	60 (7.69)	40 (4.96)	42 (5.12)	50 (5.38)
15.	Flipper, tip to anterior end of lower border	120 (14.81)	131 (15.82)	139 (16.55)	105 (12.50)	130 (15.29)	140 (17.50)	110 (15.49)	128 (16.98)	128 (16.41)	130 (16.13)	132 (16.10)	100* (10.75)
16.	Flipper, greatest width	29 (3.58)	32 (3.86)	31 (3.69)	27 (3.21)	24 (2.82)	33 (4.13)	28 (3.94)	30 (3.98)	29 (3.72)	31 (3.85)	28 (3.48)	35 (3.76)
17.	Flukes, tip to tip	290 (35.80)	228 (27.54)	280 (33.33)	248 (29.52)	213 (25.06)	232 (29.00)	218 (30.70)	210 (27.85)	210 (26.92)	216 (26.80)	230 (28.05)	255 (27.42)

* Unreliable.

EXPLANATION OF PLATES

PLATE I

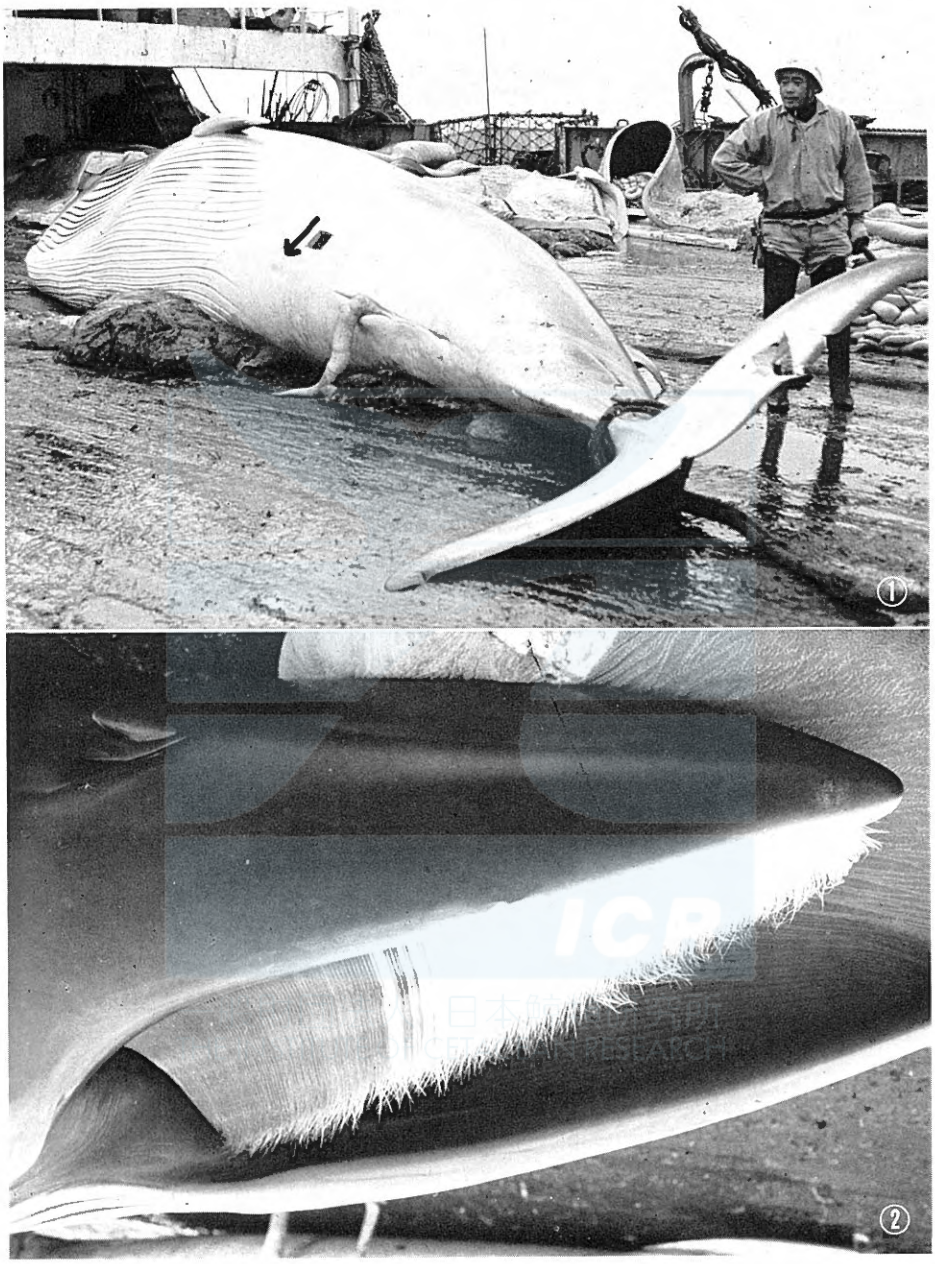
Fig. 1. Dorsal side of right flipper, the posterior margin of ventral grooves and umbilicus. Arrow shows umbilicus.
Fig. 2. Ventral side of tail flukes.

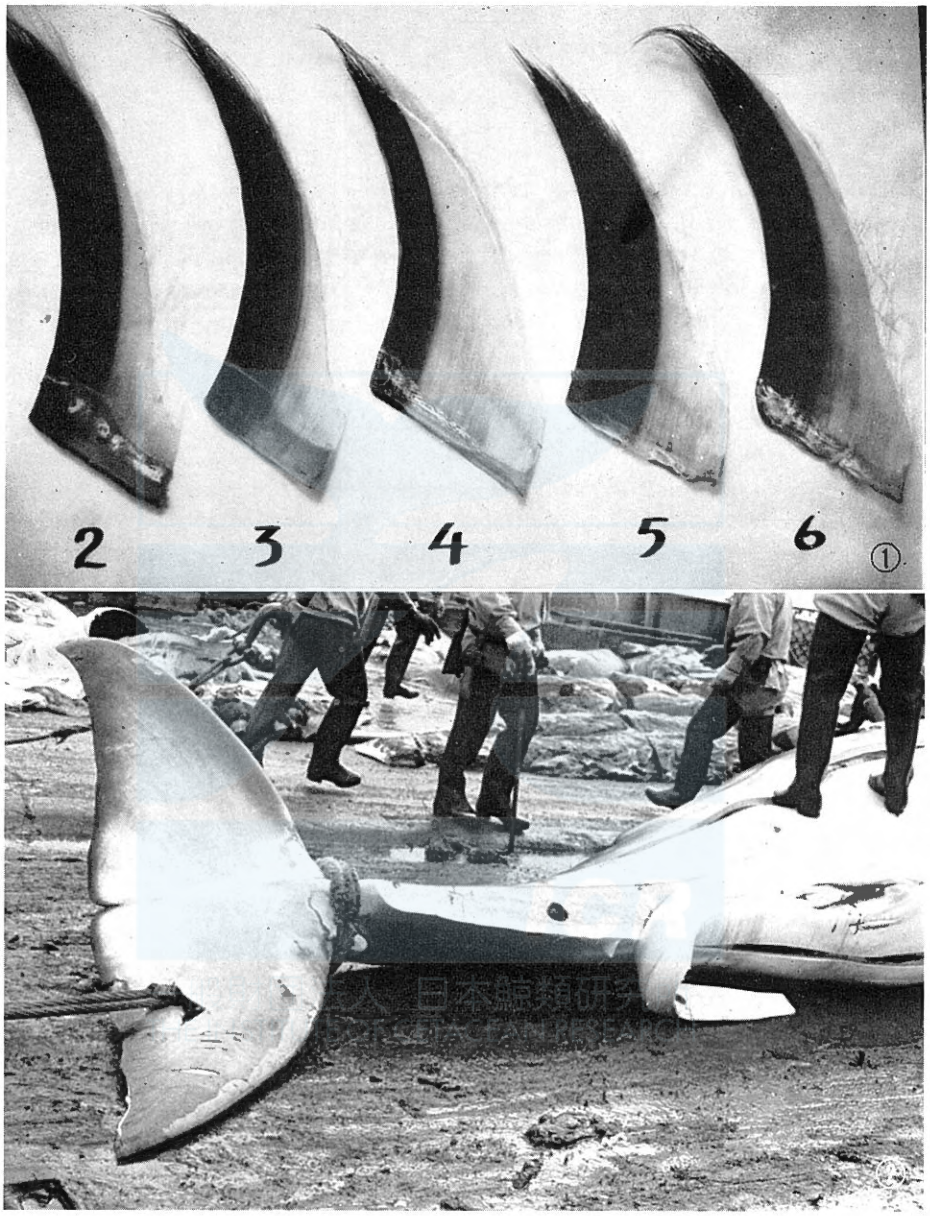
PLATE II

Fig. 1. Post-ventral view. Arrow shows umbilicus.
Fig. 2. Right side of rostrum showing the color of baleen plates.

PLATE III

Fig. 1. Baleen plates
Fig. 2. Ventral view of tail portion.

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