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一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

OSTEOLOGY OF PYGMY BLUE WHALE WITH ADDITIONAL INFORMATION ON EXTERNAL AND OTHER CHARACTERISTICS

HIDEO OMURA, TADAYOSHI ICHIHARA*
AND TOSHIO KASUYA**

INTRODUCTION

The name " Pygmy blue whale " was first given by Ichihara (1961) to blue whales inhabiting the waters around Kerguelen Island, recognizing differences in the external characteristics from the blue whales elsewhere in the Antarctic. Since then researches on this population have been carried out by various authors (Ichihara, 1963, 1966; Gambell, 1964; Ichihara and Doi, 1964; Zemsky and Boronin, 1964).

The subspecies *Balaenoptera musculus brevicauda* was proposed by Ichihara in a paper read in 1963 at the First International Symposium on Cetacean Research. His paper was not published until 1966 (Ichihara, 1966). Meanwhile, Zemsky and Boronin (1964) published the name *brevicauda* without calling it a new subspecies and without crediting Ichihara (Rice and Scheffer, 1968). The identification of the subspecies is mainly based upon the external characteristics.

In 1966 the Whales Research Institute was granted a special permission to take three pygmy blue whales for scientific researches, and a complete skeleton of this subspecies has been secured. The present paper deals with mainly the osteological study of the skeleton.

OSTEOLOGY

A complete skeleton of the pygmy blue whale was secured in 1966. This whale (66 Pl), a male of 18.6 m in length, was taken on 25 December 1966 at a position of 42°–08′S and 44°–09′E. The skeleton was transported on board factory ship to Japan. It had been burried in sand, at a corner of campus of the College of Marine Science and Technology, Tokai University, in Shimizu city during a period of about one and a half year from April 1967 to September 1968, for extraction of oils contained in bones. In September 1968 the bones were dug out and we made investigation of the bones, after cleaning. The photographs contained in this paper were also taken at this occasion. This skeleton is now mounted and being kept in the exhibition hall of the Marine Science Museum of the University. The body length of this whale is only 18.6 m (61 feet), but it had already attained physical maturity, because all of the vertebral epiphyses are fused completely to their centra, though

* Far Seas Fisheries Research Laboratory, Fisheries Agency.
** Ocean Research Institute, University of Tokyo.

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linea epiphysialis is still visible on some vertebrae, especially on those of thoracic region. This is rather surprising, judged from the knowledge of the usual blue whale in the Antarctic, in which the physical maturity is attained at a body length of 24.0 m (79 feet) in male (Nishiwaki and Hayashi, 1950).

Skull (Pls. I and II) The length of the skull is 26.1 % of the body length. Tomilin (1957) gives 21.2–23.9 % for female and 23–27 % for male as the proportional length of the skull of blue whale. The figure of 26.1 % of the pygmy blue

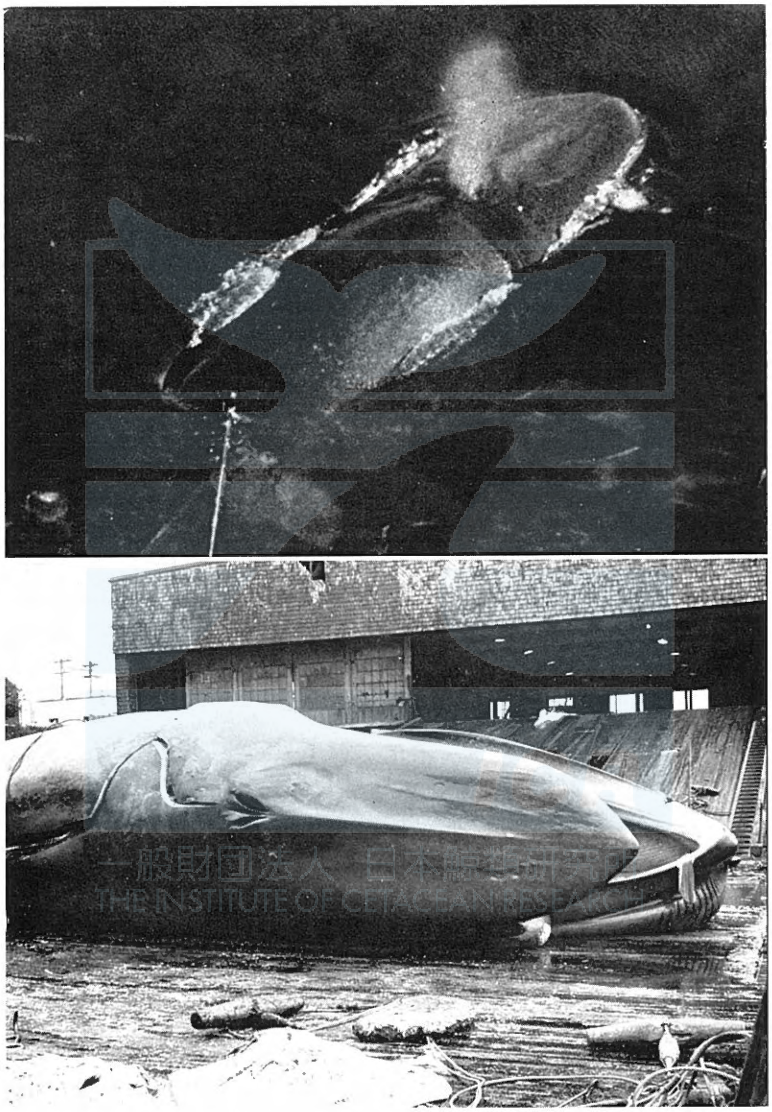


Fig. 1. Dorsal view of rostrum of blue whale.
Above: Blue whale in the Antarctic (photo by M. Yamada, 1947–48 season).
Below: Blue whale in the North Pacific (photo by M. Nishiwaki, Aug. 1963. Coal Harbour, Canada).

TABLE 1. SKULL MEASUREMENTS OF BLUE AND PYGMY BLUE WHALES

	Measurements	Tomilin 1957 ZMAN Ad. F. Ostend Skeleton 25 m		Tomilin 1957 ZMMGU Ad. F (?) Arctic Body 25.62 m		Miller 1924 U.S. Nat. Mus. Subad. M Newfoundland Body 22.87 m		True 1904 Philadelphia Mus. Juv. F. Ocean City Body 20.18 m		Present specimen Tokai Univ. Ad. M Antarctic Body 18.6 m	
		cm	%	cm	%	cm	%	cm	%	cm	%
1.	Condylo-premaxillary length	590.0	100.0	580.0	100.0	579	100.0	445.8	100.0	486.0	100.0
2.	Zygomatic width	310.0	52.5	287.0	49.5	274	47.4	221.0	49.6	236.0	48.6
3.	Orbital width	270.0	45.8	260.0	44.8	—	—	—	—	224.0	46.1
4.	Rostrum length	455.0	77.1	419.0	72.2	399	68.9	315.0	70.7	330.5	68.0
5.	Distance between orbital processes of maxillaries	270.0	45.8	259.0	44.6	—	—	—	—	216.5	44.6
6.	Rostrum width at base	180.0	30.5	168.0	28.9	206*	35.6*	—	—	143.5	29.5
7.	Rostrum width at middle	—	—	169.0	29.1	163*	28.2*	—	28.8**	123.5	25.4
8.	Length of maxillary	510.0	86.1	470.0	81.0	457	78.9	—	—	384.0	79.0
9.	Length of premaxillary	525.0	89.0	—	—	478	82.6	—	—	393.0	80.9
10.	Condyle width	44.0	7.3	43.0	7.4	43	7.4	—	—	36.5	7.5
11.	Occipital condyle height	34.0	5.7	32.0	5.5	—	—	—	—	27.5	5.7
12.	Occipital foramen width	13.5	2.3	12.3	2.1	11	1.9	—	—	9.1	1.9
13.	Occipital foramen height	13.0	2.2	16.0	2.7	—	—	—	—	11.0	2.3
21.	Length of nasal bones	32.0	5.4	—	—	28	5.0	—	—	22.0	4.5
22.	Total anterior width of both nasals	20.0	3.4	—	—	25	4.3	—	—	21.0	4.3
24.	Occipital bone width	186.0	31.5	182.0	31.3	—	—	—	—	141.0	29.0
25.	Occipital length, foramen to vertex	114.0	19.3	119.0	20.9	116	20.0	—	—	90.5	18.6
26.	Lower jaw length (straight)	—	—	600.0	103.4	568	98.0	462.3	103.7	468.0	96.3
27.	Lower jaw length (on curve)	—	—	636.0	109.6	612	105.7	520.7	116.8	487.0	100.2
28.	Lower jaw height at middle	—	—	47.0	8.1	39	6.8	33.0	7.4	37.0	7.6
29.	Lower jaw height, incl. coronoid	74.0	12.5	83.0	14.3	85	14.7	—	—	61.5	12.7

* Curved length.

** Estimated by True. See text.

The same measurements number in Table 13 of Tomilin (1957) is used here.

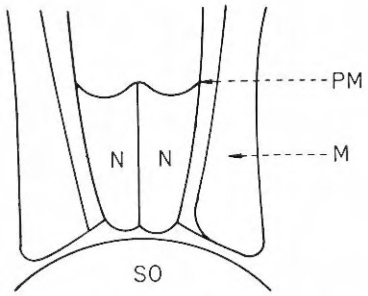
whale is in the range of male blue whale, and this coincides with the conclusion by Ichihara (1966) that no difference is noted in the head region between pygmy and ordinary blue whales, from a study of external body proportions.

In the lateral aspect the skull has a very flat appearance (Pl. I, Fig. 1). The profile resembles very closely to that of the Newfoundland specimen (No. 49757, US National Museum) as reported by Miller (1924).

The most striking point in general view of the skull of pygmy blue whale is in the dorsal aspect. The principal characteristic feature of the ordinary blue whale's cranium is its wide rostrum with convex margins. The width of the rostrum at the middle of its length is as wide, or almost as wide as the width of its base (Tomilin, 1957). This is not applied to the rostrum of the pygmy blue whale. As seen in Pl. I the rostrum is less curved at its outer margin, but tapering from its base. In Table 1 the skull measurements of blue and pygmy blue whales are compared. The width of the rostrum at base does not differ between blue and pygmy blue whales, showing 29–31 % of the skull length. On the contrary, in the width at its middle there is a good difference between the blue and pygmy blue whales. In the former this value is about 29 % whereas in the latter about 25 %. To our regret, however, only few papers on the osteology of blue whale are available. The only reliable measurement of the width at middle of the rostrum is that given by Tomilin (1957, specimen ZMMGU) which shows 29.1 % of the skull length (Table 1).

Miller (1924) presents measurements of the skeleton of the Newfoundland specimen, found among the MS. notes left by Doctor True. But in the Table breadths of rostrum at middle as well as at base were measured on curve. The Ocean City specimen lacks premaxillae, and maxillae were separated from the cranium (True, 1904), but True states " With a suitable allowance for the premaxillae and interspace, the breadth of the rostrum (at middle) is 28.8 % (of the skull length). He states nothing whether this is straight or curved, but probably the latter, judged from the measurements reported by Miller (1924). If so, this value agrees well to that of the Newfoundland specimen. In any case no great difference between measurements in straight and on curve is expected at this position of the rostrum. Accordingly we can safely conclude that the rostrum width of the pygmy blue whale is about 25 % whereas in blue whale 28–29 % at its middle.

The fact that the width of the rostrum at the middle of its length is as wide, or almost as wide as the width of its base in blue whale is well supported by a drawing by van Beneden and Gervais (1880) and also by two photographs (dorsal and ventral aspects of the same skull) presented by Miller (1924). To our knowledge no paper is available on the osteology of blue whale in the Antarctic and in the North Pacific. But from Fig. 1, which shows the rostrum of the blue whale in these oceans, no difference is suggested in this respect among blue whales from different oceans. Tomilin (1957) states that in the blue whale the age-determined variations of the cranium are quite markedly expressed, and they are associated with the relative elongation of the facial region (rostrum, maxillaries, and premaxillaries) and the lateral expansion of the posterior region of the cranium and rostrum. For the



N . . . Nasal
PM . . . Premaxillary
M . . . Maxillary
SO . . . Supraoccipital

Fig. 2. Schematic drawing of nasals in ordinary blue whale, based upon van Beneden and Gervais (1880), and Miller (1924).

Fig. 3. Nasals of pygmy blue whale.

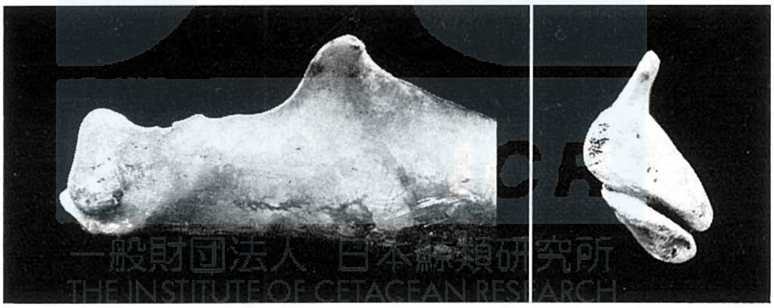


Fig. 4. Mandible of pygmy blue whale (posterior portion).
Left: Lateral view. Right: Posterior view.

pygmy blue whale only one skull is available and no conclusion is drawn at the moment.

Nasal bones are different from those of blue whale. In blue whale they are concave anteriorly, and the inner and outer borders end at nearly the same level (Fig. 2). But as shown in Fig. 3, in nasals of pygmy blue whale their inner borders are extending more anteriorly than outer borders, and they are rather convex anteriorly in general and only their outer margins concave. The length of nasals is shorter than that of blue whale in proportion to its width (Table 1).

In the dorsal aspect of the skull no other remarkable difference is noted. In the ventral aspect of the skull we find no significant difference from that of the Newfoundland specimen, comparing to the photograph presented by Miller (1924). He also reports the length of inferior margin of palatine which measures 1.22 m (21.1 % of skull length). In our specimen it is 1.06 m (21.8 % of skull length) and the proportional length is quite similar.

From Table 1 it will be noted that mandible of the pygmy blue whale is shorter than in the blue whale in general, and especially in the length on curve. The posterior portion of the mandible is shown in Fig. 4. The groove between angular and articular parts is deep, and the former projects behind the latter. Such relation between the two parts is a characteristic which separates the sei and Bryde's whales and may be of some significance in the taxonomy of baleen whales. But as regards to blue whale we have no material to compare at present.

A detailed measurements of the skull of the pygmy blue whale are shown in Table 2.

Fig. 5. Lacrymal and malar of pygmy blue whale.
Left: Lacrymal. Right: Malar.

Lachrymals are of no special feature, but malars (jugals) are seemed to be congenital bipartite. As seen in Fig. 5 the right malar is a single bone, but towards its posterior portion it is constricted and suggesting that originally it is composed of two ossicles, an anterior major and posterior minor elements. In the left malar this posterior minor element is lacking. Fraser and Cave (1969) report relatively high incidence of congenital jugal bipartism in mysticetes and among four blue whale specimens they investigated three had bipartite jugal. Omura *et al.* (1969) also report a case of bipartite malar in the black right whale in the North Pacific.

Vertebrae (Pls. III and IV) Total number of vertebrae is 63 and the vertebral formula is C 7, D 15, L 14, Ca 27. Tomilin (1957) gives a formula of the blue whale C 7, D 15 (16), L 14 (16), Ca 26 (27); total 64 (65). The same vertebral count has been reported by True (1904) for three female embryos. In comparing above figures we note the only difference of the pygmy blue whale is in the total number. Ichihara (1966) reports the vertebral formula for four fetuses

TABLE 2. SKULL MEASUREMENTS OF PYGMY BLUE WHALE

Measurement		Actual length (mm)	% of skull length	% of skull breadth
Length of skull, straight		4860	100.00	205.93
„ „ beak		3305	68.00	140.04
„ „ premaxillary, straight	R.	3930	80.86	166.53
„ „ „ „	L.	3840	79.01	162.71
„ „ maxillary along upper surface	R.	3920	80.66	166.10
„ „ „ „ „ „	L.	3830	78.81	162.29
Tip of premaxillary to posterior end of maxillary	R.	3970	81.69	168.22
„ „ „ „ „ „ „ „	L.	3900	80.25	165.25
Tip of premaxillary to vertex		3950	81.28	167.37
„ „ „ „ tip of nasals (mesial)		3700	76.13	156.78
Tip of premaxillary to anterior end of palatines (mesial)		3360	68.93	142.37
Tip of premaxillary to posterior end of palatines (mesial)		4420	90.95	187.29
Tip of premaxillary to posterior end of pterygoid		4515	92.90	191.31
„ „ „ „ anterior end of maxillary		205	4.22	8.69
„ „ „ „ „ „ „ vomer		505	10.39	21.40
Length of supraoccipital from foramen magnum		905	18.62	38.35
Greatest breadth of skull, squamosal		2360	48.56	100.00
Breadth of skull, frontal		2240	46.09	94.92
„ „ „ , maxillary		2165	44.55	91.74
„ „ beak at base		1435	29.53	60.81
„ „ „ „ middle		1235	25.41	52.33
„ across premaxillaries, greatest		525	10.80	22.25
„ „ „ at base of beak		505	10.39	21.40
„ „ „ „ middle of beak		455	9.36	19.28
„ „ „ „ posterior ends		260	5.35	11.02
„ „ maxillaries at posterior ends		485	9.98	20.55
Breadth of pterygoids		580	11.93	24.58
„ „ palatines		630	12.96	26.69
„ between tympanic bullae, outer		750	15.43	31.78
Length of nasals mesially		220	4.53	9.32
Breadth of nasals at anterior ends		210	4.32	8.90
„ „ „ posterior ends		180	3.70	7.63
„ „ frontal plane posterior to premaxillary	R.	445	9.16	18.86
„ „ „ „ „ „ „	L.	435	8.95	18.43
Breadth of orbit (frontal wing)	R.	290	5.97	12.29
„ „ „ „ „	L.	290	5.97	12.29
„ „ occiput between squamosal sutures		1410	29.01	59.75
„ across occipital condyle		365	7.51	15.47
Height of occipital condyle	R.	275	5.66	11.65
„ „ „ „	L.	270	5.56	11.44
Breadth of foramen magnum		91	1.87	3.86
Height of foramen magnum		110	2.26	4.66
Breadth across mastoid process, tip to tip		1860	38.27	78.81
„ „ „ „ , greatest				
Length of mandible, straight	R.	4680	96.30	198.31

Continued . . .

TABLE 2. Continued.

Measurement	Actual length (mm)	% of skull length	% of skull breadth
Length of mandible, straight	L. 4660	95.88	197.46
„ „ „ , along outer curve	R. 4870	100.21	206.36
„ „ „ „ „ „	L. 4840	99.59	205.08
Height of mandible at coronoid	R. 615	12.65	26.06
„ „ „ „ „	L. 610	12.55	25.85
„ „ „ „ processus articularis	R. 405	8.33	17.16
„ „ „ „ „ „	L. 400	8.23	16.95
„ „ „ „ middle	R. 370	7.61	15.68
„ „ „ „ „	L. 380	7.82	16.10

of the pygmy blue whale, and in these the total number is 64–66. He also gives vertebral number of three blue whale fetuses in the North Pacific, and in these the number is 63–65. From the above figures the amount of variation in the vertebral number of the pygmy blue whale is considerable, as True (1904) states for blue whale, and no difference between pygmy and ordinary blue whales is noted.

Detailed measurements of each vertebra are shown in Table 3, as well as in Fig. 6. In this Table the most interesting feature is the fact that in the length of the centrum the 12th lumbar shows the largest value. As shown in Fig. 6 (the bottom figure) in the caudal region the length of the centra decrease gradually from the 1st caudal to the 14th, thence very steeply until 17th, and from there again less steep. A similar figure is also presented for the Bryde's whale, comparing with that of the sei whale (Omura 1959, Fig. 3). The curve for the pygmy blue whale is quite similar to that for the Bryde's whale, but it differs from that for the sei whale. In the sei whale the caudal vertebrae are more developed, showing a curve slightly rises from the 1st caudal towards about 5th and then decreases gradually, and then steeply, and lastly again less steep towards the end. In the black right whale this curve is somewhat different from the above (Omura *et al.* 1969, Fig. 23), and the length of the centra decreases gradually from the 1st caudal towards the last, showing no remarkable steep portion, but in this species too the longest centrum is in the lumbar region.

These facts may possibly connected with the manner of swimming. In the species which swim fast or follow long distant migration the caudal vertebrae may develop well and hence longer than those of the slow swimmer. In this connection it is interesting to compare the pygmy blue whale and the ordinary blue whale, but to our regret no material is available for the latter.

Tomilin (1957) states "In adult animals, the cervical region forms 5%, the thoracic 23%, the lumbar 34%, and the caudal 38% of the total length of the vertebral column (E. J. Slijper, 1936)." In our specimen of the pygmy blue whale the total length of the vertebral column is 12,054 mm, and the percentages of the respective regions are: cervical 5.13%, thoracic 24.46%, lumbar 31.11%, and caudal 39.40%. This specimen has attained already of its physical maturity, as

TABLE 3. MEASUREMENTS OF VERTEBRAE OF PYGMY BLUE WHALE
(in mm)

Serial No.	Vertebral No.	Greatest breadth	Greatest height	Centrum			Neural canal	
				Breadth	Height	Length	Breadth	Height
1	C 1	755	414	389	291	112	123	
2	,, 2	1,065	467	373	209	106	139	131
3	,, 3	990	353	345	204	73	152	105
4	,, 4	950	345	342	221	71	175	95
5	,, 5		410	321	240	85	133	85
6	,, 6	914	395	325	230	75	135	83
7	,, 7	958	390	318	245	96	187	83
8	D 1	985	542	318	243	107	134	93
9	,, 2	980	546	328	238	120	177	92
10	,, 3	960	585	312	243	141	190	92
11	,, 4	970	635	313	242	164	179	96
12	,, 5	945	680	327	244	183	155	130
13	,, 6	970	700	317	248	192	141	100
14	,, 7	1,030	725	316	246	199	132	97
15	,, 8	1,120	770	309	251	212	112	107
16	,, 9	1,115	775	317	250	223	102	107
17	,, 10	1,125	780	319	252	227	98	103
18	,, 11	1,130	780	323	251	231	96	105
19	,, 12	1,155	775	327	249	232	92	105
20	,, 13	1,180	790	335	250	237	89	99
21	,, 14	1,205	805	337	251	240	89	111
22	,, 15	1,210	815	342	252	241	85	112
23	L 1	1,205	835	340	260	251	86	117
24	,, 2	1,205	845	336	268	257	85	114
25	,, 3	1,200	860	338	284	260	85	94
26	,, 4	1,215	860	337	274	257	86	107
27	,, 5	1,195	880	339	289	262	85	96
28	,, 6	1,180	900	337	301	266	82	76
29	,, 7	1,155	900	342	305	270	80	80
30	,, 8	1,100	900	346	293	270	81	79
31	,, 9	1,130	905	340	302	370	83	76
32	,, 10	1,070	895	349	297	272	82	77
33	,, 11	1,030	905	355	300	276	74	80
34	,, 12	985	890	355	305	281	71	81
35	,, 13	940	885	359	312	279	80	88
36	,, 14	890	900	356	318	279	78	88
37	Ca 1	825	880	359	321	275	75	77
38	,, 2	770	860	363	325	275	70	78
39	,, 3	730	825	358	324	272	54	77
40	,, 4	680	800	361	327	270	50	76
41	,, 5	655	740	359	327	269	51	67
42	,, 6	625	680	365	333	272	47	55
43	,, 7	550	610	367	341	268	43	43
44	,, 8	515	560	365	333	267	41	41
45	,, 9	463	490	358	328	264	34	22
46	,, 10	416	470	353	322	260	24	13

Continued . . .

TABLE 3. Continued.

Serial No.	Vertebral No.	Greatest breadth	Greatest height	Centrum Breadth	Centrum Height	Centrum Length	Neural canal Breadth	Neural canal Height
47	Ca 11	380	435	338	321	253	18	5
48	„ 12	350	410	327	317	248	17	—
49	„ 13	326	380	306	311	240	16	—
50	„ 14	310	360	291	301	228	15	—
51	„ 15	289	338	276	285	202	12	—
52	„ 16	—	306	261	262	153	11	—
53	„ 17	—	258	228	216	113	4	—
54	„ 18	—	225	226	196	98	3	—
55	„ 19	—	189	189	173	85	—	—
56	„ 20	—	178	172	—	77	—	—
57	„ 21	—	155	147	—	72	—	—
58	„ 22	—	137	125	—	67	—	—
59	„ 23	—	106	102	—	56	—	—
60	„ 24	—	80	92	—	51	—	—
61	„ 25	—	63	71	—	45	—	—
62	„ 26	—	47	49	—	32	—	—
63	„ 27	—	27	43	—	25	—	—

TABLE 4. COMPARISON OF VERTEBRAE. OCEAN CITY AND PRESENT SPECIMENS ARE COMPARED

Measurements	Actual length in mm OCS	Actual length in mm PB	% of skull length OCS	% of skull length PB	% of skull breadth OCS	% of skull breadth PB
Greatest breadth of axis	914	1,065	20.50	21.91	41.36	45.13
Height of centrum of axis	254	209	5.70	4.30	—	—
Greatest breadth of 1st dorsal	880	985	19.94	20.27	40.23	41.74
Height of centrum of 1st dorsal	267	243	5.99	5.00	—	—
Greatest breadth of 1st lumbar	1,194	1,210	26.78	24.79	54.03	51.27
Height of centrum of 1st lumbar	318	252	7.13	5.19	—	—
Greatest breadth of 1st caudal	914	825	20.50	16.98	41.36	34.96
Height of centrum of 1st caudal	368	321	8.25	6.60	—	—

OCS: Ocean City specimen (True, 1904). Skull length 4,450 mm. Skull breadth 2,210 mm.
PB: Present specimen of pygmy blue whale. Skull length 4,860 mm. Skull breadth 2,360 mm.

stated already. In comparing these figures it is suggested that the pygmy blue whale has a somewhat shorter dorsal and lumbar region, both combined, and a longer caudal region than the blue whale, contrary to our expectation. This is probably due to the different methods of measurements. In our specimen each vertebra is measured and then they are added. Since from studies of the external body proportions the pygmy blue whale is concluded to have a shorter tail region than ordinary blue whale, this problem should be left to future study.

True (1904) presents some vertebral measurements of the Ocean City specimen. In Table 4 these are compared with our specimen. As seen in this Table the proportional height of the centrum is smaller in the pygmy blue whale than in the Ocean City specimen. Further the greatest breadth of axis and 1st dorsal vertebrae of the pygmy blue whale are greater, but that of 1st lumbar and 1st caudal is smaller than in the Ocean City specimen. It is suggested, therefore, that in the pygmy blue whale the centrum of the vertebral bone is smaller in general than in the ordinary blue whale and it decreases more steeply its breadth in lumbar and caudal regions. This is clearly shown in the percentage figures of greatest breadth against the skull breadth. One problem which is needed for consideration in this matter is the size variation of vertebrae according to growth, as the Ocean City specimen is a juvenile one, but to our regret no material is available for further discussion.

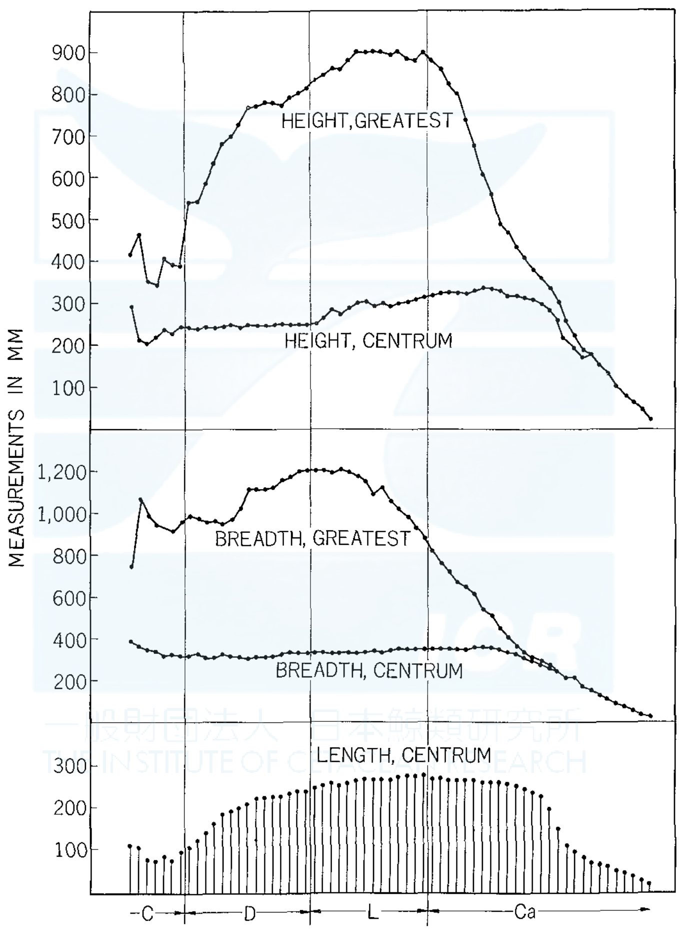


Fig. 6. Vertebral measurements of pygmy blue whale.

In our specimen of pygmy blue whale the first vertebra in which the transverse process is perforated is the 47th (11th caudal) and the neural arch is obsolete on

TABLE 5. MEASUREMENTS OF RIBS (in mm) NEWFOUNDLAND AND PRESENT SPECIMENS ARE COMPARED

Rib No.	PB (right)		PB (left)		NFS	% of skull length	
	Str. l.	Curved l.	Str. l.	Curved l.	Str. l.	PB, right	NFS
1	1,345	1,605	1,315	1,575	1,750	27.67	30.22
2	1,850	2,080	1,825	2,060	1,780	38.07	30.74
3	2,170	2,460	2,145	2,405	2,130	44.65	36.79
4	2,245	2,605	2,245	2,595	2,240	46.19	38.69
5	2,250	2,675	2,220	2,670	2,410	46.30	41.62
6	2,260	2,725	2,310	2,705	2,390	46.50	41.28
7	2,215	2,655	broken	—	2,390	45.58	41.29
8	2,160	2,575	2,200	2,600	2,290	44.44	39.55
9	2,040	2,485	2,030	2,495	2,240	41.98	38.69
10	1,975	2,360	2,010	2,355	2,220	40.64	38.34
11	1,895	2,220	1,895	2,210	2,150	38.99	37.13
12	1,785	2,040	1,795	2,065	2,070	36.73	35.75
13	1,690	1,850	1,580	1,875	1,990	34.77	34.37
14	2,625	1,705	1,630	1,725	1,890	33.44	32.64
15	1,635	1,685	1,645	1,685	1,800	33.64	31.09
16	515	515	—	—	—	—	—

PB: Pygmy blue whale. Skull length 4,860 mm.
NFS: Newfoundland specimen (Miller, 1924). Skull length 5,790 mm.
Str. l.: Straight length.
Curved l.: Curved length.

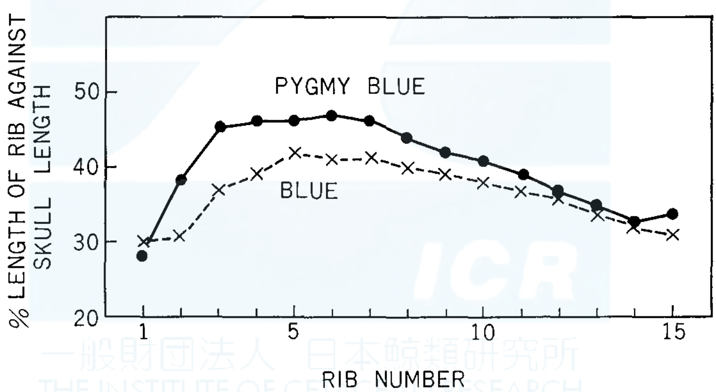


Fig. 7. Length of ribs. Pygmy blue whale and Newfoundland specimen are compared.

the 55th (19th caudal) vertebra. In the Ocean City specimen, as reported by True (1904), they are 46th and 55th respectively and show good agreement in these respects.

Ribs (Pl. IV) Fifteen pairs of ribs are present in our specimen, but in addition one very small rib has been secured. Only the 3rd and 4th ribs are double headed. On the transverse processes of the dorsal vertebrae the articulating facet for ribs are clearly present on the 11–21st vertebrae, and on the 22nd they are faintly recognizable. But in the 23rd vertebra there is no trace of such facet. The additional small rib is quite different from the foregoing ribs in size. It is less than one third of the 15th and only rudimental. We assigned, therefore, the number of dorsal vertebrae as 15 instead of 16.

Measurements of ribs are shown in Table 5. In this Table the data for the Newfoundland specimen, reported by Miller (1924), are included for comparison. The straight length of ribs are also converted into percentages against their skull lengths for both specimens, and these figures are also shown in Fig. 7. It is clearly shown in Fig. 7 that in the pygmy blue whale the length of ribs in the anterior portion of the thorax is much longer proportionally than in the blue whale. The Newfoundland specimen is an adult male of 75 feet in length and quite comparable to our specimen, because both specimens are thought to be nearly at the same stage of growth, notwithstanding of their sizes. In calculating the proportional lengths of ribs of both specimens against their body length we got similar curves as those shown in Fig. 7, but in this case the greatest difference between the corresponding ribs is 2.2% (3rd rib). The range of variation in the length of ribs is not known yet, but this trend in length of ribs in general is thought to be a difference between subspecies, pending upon future studies.

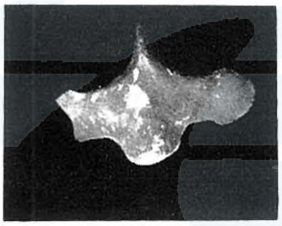


Fig. 8. Sternum of pygmy blue whale.

Sternum (Fig. 8) The sternum in our specimen is roughly crosslike. Its anterior and posterior processes are short, and the former process is broad and the latter pointing. The size and form of the sternum, however, is highly variable and has no taxonomic significance. In our specimen it is 41 cm long and about 60 cm wide (partly broken. Estimated).

Hyoid (Fig. 9) Measurements of hyoid bones are shown in Table 6, comparing with those of the other specimens of pygmy blue whale as reported by Omura (1964). Most of the measurements are within the ranges of the other specimens, but in the combined bone of basihyal and thyrohyals the height at center is slightly higher and the stylohyals are slightly longer and more flat than the other specimens. But in general no specific feature is observed in comparison to other specimens. No material is available for the ordinary blue whale and we are not able to make comparison between subspecies.

Chevron bones (Fig. 10) Eighteen pairs of chevron bones are present in our specimen of the pygmy blue whale. The 1st, 2nd, 17th, and 18th are separated

TABLE 6. MEASUREMENTS OF HYOID BONE OF PYGMY BLUE WHALE

	Actual length (mm)	% of overall length	Other specimens[1]
Combined bone of basihyal and thyrohyals			
Overall length along outer surface	1385	100	
Length, straight	1100	79.4	
Height, greatest	400	28.9	26.5–31.0
Height, center	265	19.1	14.9–18.1
Height, middle of wing, right	219	15.8	13.1–16.6
Height, middle of wing, left	221	16.0	12.8–16.8
Depth, forward notch	135	9.8	8.0–12.7
Thickness at middle of wing, right	139	10.0	8.1–11.2
Thickness at middle of wing, left	139	10.0	8.3–11.6
Stylohyal, right			
Length	586	42.3	36.9–40.8
Breadth	174	29.7[2]	30.5–36.7
Thickness at middle	89	15.2[2]	15.5–22.4
Stylohyal, left			
Length	592	42.7	36.9–40.8
Breadth	171	28.9[2]	30.2–36.1
Thickness at middle	90	15.2[2]	15.5–21.8

1) Cited from Omura (1964).
2) % against their length.

Fig. 9. Hyoid bone of pygmy blue whale.
Left: Stylohyals.
Right: Combined bone of basihyal and thyrohyals.

into two laminae, but in other bones right and left laminae are all united. The size and shape of the chevron bones present no special feature than other species. Miller (1924) reports the height of the 1st and 7th bones of the Newfoundland specimen, and these are 90 and 360 mm respectively. In our specimen the 1st is higher, and the 7th is lower than this specimen. But it is doubtful whether such slight difference in size is of any taxonomic importance. Measurements of the chevron bones are shown in Table 7.

TABLE 7. MEASUREMENTS OF CHEVRON BONE OF PYGMY BLUE WHALE
(in mm)

No.	Height	Breadth, greatest	Distance across two laminae, prox.	Note
1	R. 173	193	—	Left lamina missing
2	R. 231	136	—	Laminae separated
	L. 267	162		
3	341	142	142	
4	341	174	145	
5	341	177	145	
6	326	171	155	
7	323	213	161	
8	332	177	140	
9	347	217	160	
10	230	203	151	
11	243	187	139	
12	221	130	132	
13	194	170	145	
14	151	174	130	
15	142	155	131	
16	108	123	114	
17	R. 63	80	—	Laminae separated
	L. 73	broken		
18	R. 43	55		Laminae separated
	L. 44	55		

Fig. 10. Chevron bone of pygmy blue whale.

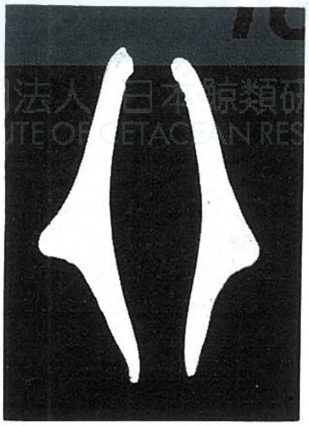


Fig. 11. Pelvic bone of pygmy blue whale.

TABLE 8. MEASUREMENTS OF SCAPULA OF PYGMY BLUE WHALE (in mm)

	Breadth	Height	Acromion		Coracoid		Glenoid fossa	
			Length	Breadth	Length	Breadth	Length	Breadth
Right	1,270	790	365	200	135	95	315	235
Left	1,295	780	365	195	105	95	320	240

TABLE 9. COMPARISON OF SCAPULA, HUMERUS, RADIUS, AND ULNA OF BLUE AND PYGMY BLUE WHALES

Measurements	Actual length in mm			% of skull length		
	OCS	NFS	PB[4]	OCS	NFS	PB
Greatest breadth of scapula	1,257	1,450	1,270	28.20	25.04	26.13
Greatest height of scapula	762	940	790	17.09	16.23	16.26
Length of humerus	—	580	555	—	10.02	11.42
Length of radius	826[1]	1,020[2]	825	18.53	17.62	16.98
Length of ulna, greatest	876[1]	950[3]	890	19.65	16.41	18.31
Breadth of radius at distal end	254	290	255	5.70	5.01	5.25
Breadth of ulna at distal end	203	250	180	4.55	4.32	3.70

OCS: Ocean City specimen (True, 1904). Skull length 4,458 mm.
NFS: Newfoundland specimen (Miller, 1924). Skull length 5,790 mm.
PB: Present specimen of pygmy blue whale. Skull length 4,860 mm.
1) Without epiphyses. 2) Without inferior epiphysis. 3) Length above middle. Without inferior epiphysis. 4) Right side bones.

TABLE 10. MEASUREMENTS OF HUMERUS, RADIUS, AND ULNA OF PYGMY BLUE WHALE (in mm)

	Length, center	Breadth, prox. end	Breadth, dist. end	Breadth, at middle	Thickness, at middle
Humerus					
Right	555	365	315	236	175
Left	555	370	315	245	180
Radius					
Right	825	210	255	159	97
Left	845	220	250	164	99
Ulna					
Right	890	275	180	119	76
Left	890	279	197	129	82

Pelvic bone (Fig. 11) Pelvic bones are different from those of the Newfoundland specimen, judged from a photograph shown by Miller (1924). In our specimen they are more slender and the angle between the cranial and caudal processes is larger, hence less curved than in the Newfoundland specimen, and they resemble more to the pelvic bone of the ordinary blue whale in the Antarctic, as reported by Hosokawa (1951). In our specimen the lengths of right and left bones are 395 and 370 mm respectively and the right bone is somewhat larger than the left.

Scapula (Pl. V, Fig. 1) Scapula is fan-shaped with a convex upper margin, and the acromion is well developed, as in the ordinary blue whale. Measurements of scapula are shown in Table 8. True (1904) reports measurements of scapulae of blue whales from the North Atlantic Ocean, then known to him, and in these specimens the proportion of height to breadth is 60–64.4%. He describes "The discrepancy in proportions, amounting to about 4 per cent, I am unable to account for. It affects both the American and European specimens and is not, apparently, due to difference in age and sex." Further Tomilin (1957) states "Scapula 1.5–1.6 times as wide as high. In the males, the relative size of the scapula, and particularly its processes, is markedly greater than in the females." In the Newfoundland specimen (Miller, 1924) the corresponding figure is 64.8% (1.54 times as wide as high). In our specimen of pygmy blue whale these figures for the right and left scapulae are 62.2% and 60.2% (1.61 and 1.66 times as wide as high), respectively. In this respect, therefore, we find no difference between the pygmy and ordinary blue whales, but it is probable that even in a single specimen there is a slight difference between right and left scapulae.

In the Miller's specimen the lengths of acromion and coracoid are 480 and 200 mm respectively. These are 33.1% and 13.8% of the breadth of scapula. In our specimen the corresponding figures are 28.7–28.2% and 10.6–8.1% respectively. Both specimens are males, but in our specimen of pygmy blue whale the processes are less developed than in the Newfoundland specimen. We can not conclude, however, whether this difference is of significant, due to limited data available.

In Table 9 measurements of scapula, humerus, radius, and ulna of different

TABLE 11. MEASUREMENTS OF PHALANGES OF PYGMY BLUE WHALE (in mm)

	Right				Left			
	I	II	IV	V	I	II	IV	V
Length								
1st phalanx	203	255	235	161	203	248	233	162
2nd ,,	207	219	214	175	197	222	216	168
3rd ,,	167	157	159	117	164	156	156	broken
4th ,,	127	107	82	—	125	111	77	—
5th ,,	68	107	70	—	—	112	74	—
6th ,,	—	59	—	—	—	62	39	—
Breadth at middle								
1st phalanx	81	72	62	60	84	67	65	62
2nd ,,	39	52	49	31	41	53	48	30
3rd ,,	28	44	35	22	29	46	34	broken
4th ,,	18	36	31	—	20	39	30	—
5th ,,	10	25	20	—	—	26	20	—
6th ,,	—	23	—	—	—	24	17	—
Thickness at middle								
1st phalanx	58	56	45	32	59	56	43	30
2nd ,,	44	45	34	18	45	46	33	17
3rd ,,	30	34	25	11	31	34	24	broken
4th ,,	11	23	16	—	19	24	15	—
5th ,,	10	16	9	—	—	15	10	—
6th ,,	—	11	—	—	—	11	7	—

specimens available are compared. In this Table measurements of each bone are also expressed as percentages of skull length. In this Table too our specimen of pygmy blue whale agrees well to the Newfoundland specimen.

Humerus, Radius and Ulna (Pl. V Fig. 2) Comparison of these bones to those of the other specimens are included in Table 9. No special feature which separate the pygmy blue whale from the ordinary blue whale is observed from this Table as well as from a photograph presented by Miller (1924). Detailed measurements of these bones of our specimen are shown in Table 10.

Carpals and Phalanges (Pl. V Fig. 2) Carpals are of no special feature. The phalangeal formula of our specimen is I_5, II_6, IV_5, V_3. Tomilin (1957) gives a formula of the ordinary blue whale, considering the variation in the number of phalanges in the specimens then available: I_{4-5}, II_{5-8}, IV_{5-7}, V_{3-4}. Our phalanx count is within the ranges of this formula. Measurements of phalanges in our specimen are shown in Table 11.

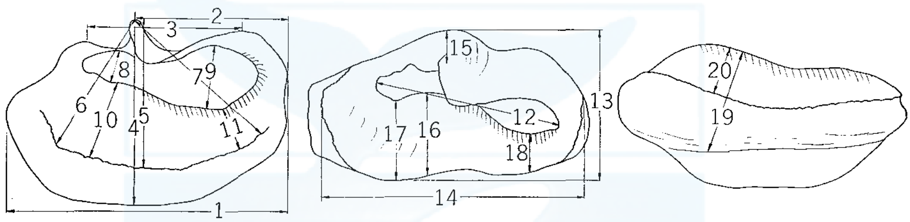


Fig. 12. Measurement portion of tympanic bulla of blue whales.

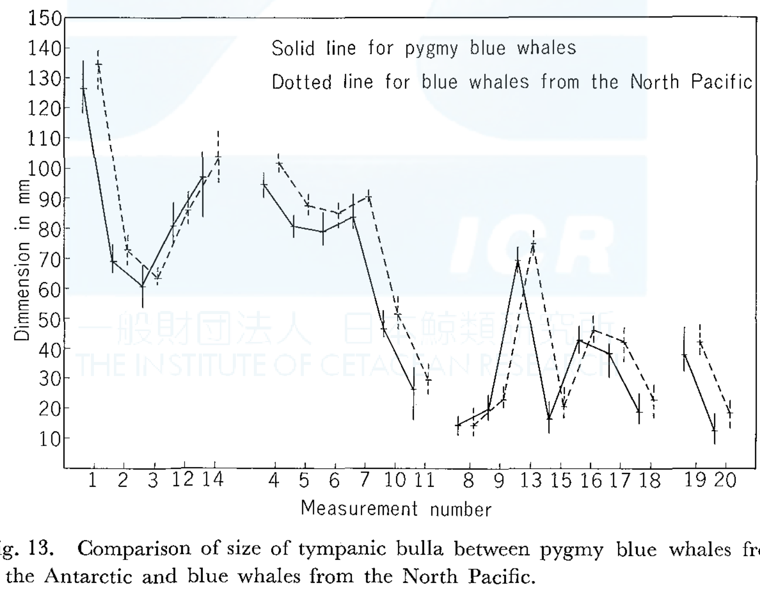


Fig. 13. Comparison of size of tympanic bulla between pygmy blue whales from the Antarctic and blue whales from the North Pacific.

Tympanic bulla. In relation to the rapid development of cetacean auditory sense, the tympanic bulla ceases to grow in the early stage of life, and its size is

TABLE 12. BIOLOGICAL DATA OF BLUE WHALES FROM WHICH TYMPANIC BULLA IS COLLECTED FOR COMPARISON OF SIZE

No.	Sex	Body length	Corpora number in ovaries	Weight of testis
Pygmy blue whales from the Antarctic, season 1963–64				
1	Male	21.3 m	—	1.9, 1.9 kg
2	Male	21.8	—	13.2, 11.7
3	Male	22.4	—	4.6, 4.2
4	Male	23.5	—	17.0, 16.7
5	Female	21.6	3	—
6	Female	21.6	5	—
7	Female	21.9	8	—
8	Female	22.6	2	—
9	Female	23.7	6	—
Blue whales from the North Pacific, season 1965				
1	Male	21.3	—	1.3, 1.2
2	Male	21.5	—	1.0, 1.1
3	Male	22.3	—	20.4, 20.5
4	Female	22.7	0	—
5	Female	23.1	1	—
6	Female	23.6	3	—

TABLE 13. BIOLOGICAL DATA ON THREE PYGMY BLUE WHALES TAKEN UNDER THE SPECIAL PERMISSION.

No.	Date of catch	Position of catch	Sex	Body length	Weight of testis	Laminae number of ear plug
66P1	Dec. 25, 1966	42°–08′S, 44°–09′E	Male	18.6 m	13.4, 13.5 kg	46
66P2	Jan. 13, 1967	41°–56′S, 73°–15′E	Male	16.0	1.7, 1.7	—
66P3	Jan. 17, 1967	42°–02′S, 80°–36′E	Male	20.3	18.8, 19.8	43

maintained throughout the life. Tympanic bullae were collected from 12 pygmy blue whales, of which 9 bullae were taken in the 1963–64 Antarctic season. For comparison, 6 tympanic bullae were collected from 6 blue whales taken by North Pacific expedition in 1965. Table 12 shows the biological data of these whales which are ranging from young to old. It is difficult to express accurately the form of bulla like renal and cowrie-shell. When the bulla is removed from the skull, a small fraction of bulla is usually broken down, however, 20 series as indicated in Fig. 12, can be measured for comparison. Measurement nos. 1, 2, 3, 12 and 14 are dimensions representing portions concerning the length of bulla. Nos. 4, 5, 6, 7, 10 and 11 show portions concerning the width of bulla. Nos. 8, 9, 13, 15, 16, 17 and 18 are related to the height of bulla. Mean value and range for each dimensions are indicated in Fig. 13. In the measurements except for no. 8, the value of the pygmy blue whale is smaller than that of blue whale from the North Pacific. When the mean of each measurement is connected by the line, the shape of bulla is supposed to resemble with each other, indicating a slight difference

TABLE 14. BODY PROPORTIONS OF PYGMY BLUE WHALE (MALE)

Measurements	Actual length (cm)			% of total length		
	66P2	66P1	66P3	66P2	66P1	66P3
Tip of upper jaw to notch of flukes	1600	1860	2030	100.00	100.00	100.00
Tip of upper jaw to blowholes	280	290	390	17.50	15.59	19.21
Tip of upper jaw to eye (center)	315	380	440	19.69	20.43	21.67
Tip of upper jaw to angle of gape	325	390	420	20.31	20.97	20.69
Tip of upper jaw to tip of flipper	670	870	920	41.88	46.77	45.32
Center of eye to ear hole	80	100	105	5.00	5.38	5.17
Notch of flukes to tip of dorsal fin	370	420	430	23.13	22.58	21.18
Notch of flukes to umbilicus	680	790	890	42.50	42.47	43.84
Notch of flukes to end of ventral grooves	670	740	850	41.88	39.78	41.87
Notch of flukes to anus	450	490	520	28.13	26.34	25.62
Notch of flukes to anterior insertion of tail flukes	80	100	100	5.00	5.38	4.93
Reproductive aperture to anus	110	140	160	6.88	7.53	7.88
Dorsal fin, anterior insertion to tip	60	20	50	3.75	1.08	2.46
Dorsal fin, height	30	10	15	1.88	0.54	0.74
Flipper, anterior insertion to tip	205	285	240	12.81	15.32	11.82
Flipper, greatest breadth	55	70	70	3.44	3.76	3.45

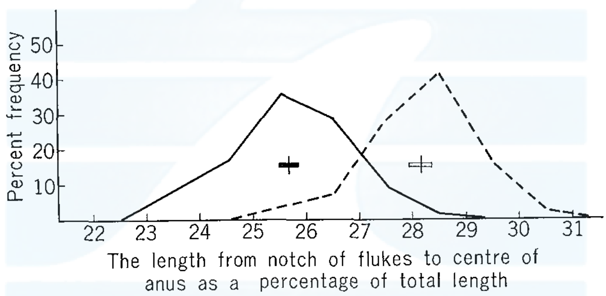


Fig. 14. Comparison of tail length between pygmy blue whales (solid line) and ordinary blue whales (broken line) in the Antarctic.

which the bulla of the pygmy whale is proportionally smaller in measurement nos. 12 and 14, and proportionally larger in measurement no. 8.

Yamada (1953) reports that the size of bulla from the Antarctic ordinary blue whale is 13.7–15.7 cm long and 9.8–11.2 cm wide. The Antarctic ordinary blue whale probably has a slightly larger tympanic bulla than the North Pacific blue whale, but unfortunately we have now no bulla from the former for the purpose of comparison. The mean weight of bulla in dry condition is 575.20 g for the pygmy and 725. 43 g for the North Pacific blue whale.

BODY PROPORTION

Under a special permission three male pygmy blue whales were taken in the Antarctic in the 1966–67 season. Date and position of the catch are listed in Table 13

TABLE 15. BODY WEIGHT OF PYGMY BLUE WHALES TAKEN IN THE 1966–67 ANTARCTIC SEASON

Items	Actual weight (kg)			Percentage of total		
	66P2	66P1	66P3	66P2	66P1	66P3
Blubber						
Body, except ventral grooves	2,200	4,500	5,950	8.89	10.47	10.46
Head	400	1,800	1,450	1.62	4.19	2.55
Lower jaw	700	1,000	3,800	2.83	2.33	6.68
Tail flukes	250	425	350	1.01	0.99	0.62
Ventral grooves	2,700	5,600	6,400	10.91	13.03	11.25
Total	6,300	13,325	17,950	25.47	31.00	31.55
Meat	10,690	15,500	21,355	43.22	36.05	37.53
Internal organs						
Tongue	800	2,600	2,250	3.23	6.05	3.95
Lung	200	150	400	0.81	0.35	0.70
Heart	105	200	250	0.42	0.47	0.44
Liver	300	450	650	1.21	1.05	1.14
Kidneys	90	100	200	0.36	0.23	0.35
Pancreas	7	9	45	0.03	0.02	0.08
Spleen	3	3	30	0.01	0.01	0.05
Stomach	330	400	350	1.33	0.93	0.62
Small intestine	500	650	1,100	2.02	1.51	1.93
Large intestine	200	250	300	0.81	0.58	0.53
Testes	$\left.\begin{matrix}1.7\\1.7\end{matrix}\right\}4$	$\left.\begin{matrix}13.4\\13.5\end{matrix}\right\}27$	$\left.\begin{matrix}18.8\\19.8\end{matrix}\right\}39$	0.02	0.06	0.07
Bladder	3	13	15	0.01	0.03	0.03
Fats	950	1,700	3,000	3.84	3.95	5.27
Others	4	7	45	0.02	0.02	0.08
Total	3,496	6,559	8,674	14.13	15.26	15.25
Bones*						
Skull	1,200	1,710	2,500	4.85	3.98	4.39
Lower jaws	500	1,230	900	2.02	2.86	1.58
Vertebrae	1,500	2,380	2,967	6.06	5.54	5.22
Ribs	231	550	820	0.93	1.29	1.44
Chevron bones	35	40	88	0.14	0.09	0.15
Scapulae	60	100	100	0.24	0.23	0.18
Flippers	200	360	500	0.81	0.84	0.88
Hyoids	25	34	39	0.10	0.08	0.07
Total	3,751	6,404	7,914	15.16	14.90	13.91
Baleen plates	500	1,200	1,000	2.02	2.79	1.76
Total weight	24,737	42,988	56,893	100.00	100.00	100.00

* Weight in dried condition are shown in Appendix Table.

with biological data for each whale. The position of catch indicates that three whales were taken in the Subantarctic area, south of the Indian Ocean. From the histological observation on the tissue of testes, 66 P1 and 66 P3 whales were mature sexually, and 66 P2 immature. Laminae counting of ear plug suggests that 66 P1 and 66 P3 whales are 46 and 43 years old respectively, if we assume one lamina is accumulated per year. No ear plug was collected from young 66 P2

TABLE 16. PERCENT WEIGHT OF EACH ORGAN AGAINST THE TOTAL WEIGHT OF INTERNAL ORGANS FOR PYGMY AND ORDINARY BLUE WHALES FROM THE ANTARCTIC

Item	Pygmy (A)	Ordinary (B)	A/B
Tongue	27.75	24.49	1.13
Lung	4.53	6.25	0.72
Heart	3.77	3.44	1.10
Liver	8.17	8.58	0.95
Kidney	3.07	2.84	1.08
Stomach	5.15	3.23	1.59
Small intestine	12.02*	8.29	1.45
Large intestine	4.01*	2.64	1.52
Others	31.53	40.24	0.78
Total	100.00	100.00	
Individuals examined	8	39	

* from 3 whales

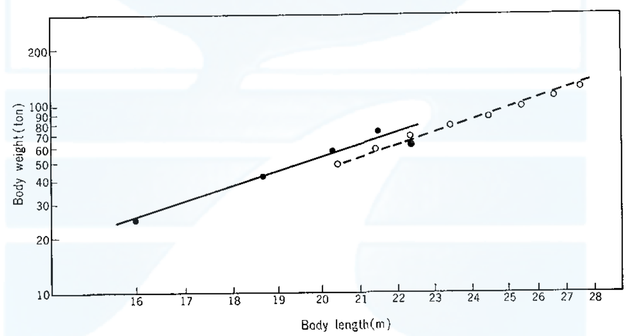


Fig. 15. Length-weight relationship for both pygmy (closed circle) and ordinary (open circle) blue whales in the Antarctic.

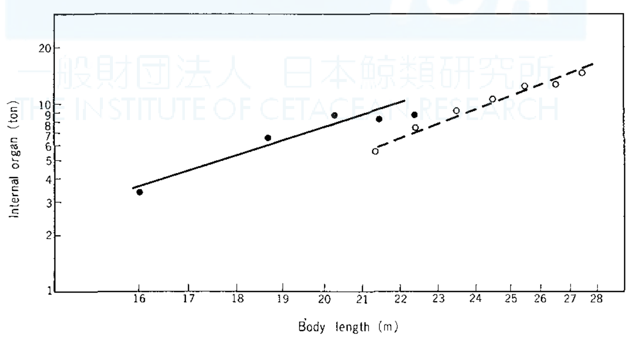


Fig. 16. Length-weight relationship of internal organs for both pygmy (closed circle) and ordinary (open circle) blue whales in the Antarctic.

whale. External measurements of whales were carried out on the deck of the factory ship, and the results are shown in actual length and as the percentages of total body length in Table 14. The length from notch of flukes to center of anus, expressed as a percentage of total length, supports a trend which the tail portion of baleen whale becomes relatively short with the increment of body length. It is clear that 66 P1 whale, 18.6 metre in length, had already attained the physical maturity, as described in the foregoing chapter.

Ichihara (1963, 1966) concludes that the tail length of pygmy blue whale differs remarkably from that of ordinary blue whale in the Antarctic, examining the body proportion from the same length of whale. Since the form of whale body changes with the increment of age, it is desirable to compare the external measurements in full grown whales. As the ordinary male blue whale from the Antarctic attains the physical maturity at 79 feet (24.0 m) in length (Nishiwaki and Hayashi, 1950), we selected the data on the external measurements of larger male than 24 m from the *Appendix* III of Mackintosh and Wheeler (1929). These data were rearranged for the present purpose. Though the body length of physical maturity is not accurately known yet for the pygmy blue whale, we can safely assume that male pygmy of 69 feet (20.9 m) and over are physically matured. On the basis of selected samples, comparison of the tail portion of the pygmy blue with that of the ordinary blue is made in Fig. 14. The size of sample is 109 pygmy and 105 ordinary blue whales. The length from notch of flukes to center of anus as a percentage of total length is 25.68 ± 0.19 (mean and two standard errors) for the pygmy, and 28.15 ± 0.22 for the ordinary blue whale. In the full grown male, the tail region is significantly smaller than that of the ordinary blue whale.

BODY WEIGHT

Body weights of three pygmy blue whales caught in the 1966–67 Antarctic season were measured on the deck of the factory ship. Actual weight and percentages weight are listed in Table 15, for each part of body. As the body weight of five pygmy blue whales was listed in Table 7 of Ichihara's paper (1966), weights of a total of 8 pygmy blue can be compared with those of ordinary blue whales. In the Whales Research Institute are kept data on body weights of 14 male and 24 female ordinary blue whales which were measured in the 1947–48 Antarctic season, most of which were summarized by Nishiwaki (1950). Fig. 15 is obtained, when the mean body weight is plotted against the each meter range of whale length. The logarithmm is used for both body weight and length. As far as pygmy blue whale concerns, the length-weight relationship from the young to the old is not fully drawn for lack of data. The body weight of pygmy blue whale is heavier than that of ordinary blue whale of the same length, however, it is estimated that the rate of weight increment is almost similar between the two subspecies.

In comparison of bones, meats and blubber weight, there is no difference between the two. Fig. 16 suggests that the difference of weight between the two is derived from the growth rate of the internal organs.

The weight of internal organs in the pygmy blue whale at 21 m in length is about equal to that in the ordinary blue whale at 24 m in length. Table 16 shows the percent weight of each organ against the total weight of internal organs, for pygmy and ordinary blue whales. The item of others in Table 16 includes pancreas, spleen, reproductive organ, bladder, fat and etc. Except for the lung, liver and others, the percent weight of each organ from pygmy blue whales is greater than that for the ordinary blue whale. It is noticeable that the pygmy has heavier digestive organs than in the ordinary blue whale, but it is not known yet whether or not this is derived from the divergence of feeding habit.

SUMMARY AND CONCLUSION

From study of a skeleton of pygmy blue whale, mainly comparing with skeletons of blue whale in the North Atlantic reported by various authors, the followings are noted:

1. The body length of this specimen is 18.6 m, but it had attained physical maturity. The corresponding figure of ordinary blue whale in the Antarctic is 24.0 m.
2. The width of the rostrum at middle of its length is as wide, or almost as wide as the width of its base in ordinary blue whale (29–31 % of skull length), but shorter by about 4 % of skull length in pygmy blue whale, though the width at base does not differ from the former.
3. Nasals are concave anteriorly, and the inner and outer border end at nearly the same level in ordinary blue whale, but rather convex and inner borders project more anteriorly than outer borders in pygmy blue whale. In the latter the length of nasals is shorter than in the former.
4. Mandibles are shorter, especially in curved length, than in ordinary blue whale.
5. The number of vertebrae does not differ from that of ordinary blue whale, but it is suggested that the centrum is smaller in general and it decreases more steeply its breadth in lumbar and caudal regions than in ordinary blue whale.
6. Straight lengths of ribs in the anterior portion of thorax are greater than in ordinary blue whale.
7. Tympanic bulla is smaller than that of blue whale in the North Pacific and slight difference in shape is also noted.
8. Malars of this specimen are congenital bipartite.

From study of external and other characteristics the followings are noted:

9. Body proportions are reexamined with additional data and it is confirmed that in the full grown male the tail region is significantly smaller than that of ordinary blue whale.
10. The body weight of pygmy blue whale is heavier than that of ordinary blue whale of the same length in the Antarctic, and this difference is mainly due to the fact that the former has more heavier digestive organs than the latter.

In conclusion above we think there is a good additional reason to separate pygmy blue whale from the ordinary blue whale as a subspecies, i.e. *Balaenoptera musculus brevicauda.*

ACKNOWLEDGEMENTS

Our sincere thanks are due to Fisheries Agency of Japanese government who granted special permit to take three pygmy blue whales in the 1966–67 Antarctic season for scientific researches, and to crew of the Kyokuyo Maru No. 3 expedition who cooperated in the field works.

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APPENDIX TABLE. WEIGHT OF BONES OF PYGMY BLUE WHALE, IN DRIED CONDITION

Skull	700 kg
Mandibles	420
Vertebrae	927
Cervical	57
Dorsal	273
Lumbar	314
Caudal	283
Ribs	229.4
Scapulae	41.0
Humerus	31.8
Ulnae	12.4
Radii	17.7
Carpals and phalanges	10.1
Hyoid bones	26.2
Sternum	2.2
Chevron bones	20.5
Total weight	2,438.3

Note : The bones were weighed in October 1969 before mounting.

EXPLANATION OF PLATES

PLATE I

Fig. 1. Skull of pygmy blue whale. Lateral view.
Fig. 2. The same. Ventral view.
Fig. 3. The same. Dorsal view.

PLATE II

Fig. 1. Skull of pygmy blue whale. Posterior view.
Fig. 2. Mandibles of pygmy blue whale. Dorsal view.

PLATE III

Fig. 1. Atlas, axis, and 3rd cervical of pygmy blue whale.
Fig. 2. 4th–7th cervicals of the same specimen.
Fig. 3. Dorsal vertebrae of the same specimen.
Fig. 4. Lumbar vertebrae of the same specimen.

PLATE IV

Fig. 1. Caudal vertebrae of pygmy blue whale.
Fig. 2. Ribs of the same specimen.

PLATE V

Fig. 1. Scapulae of pygmy blue whale.
Fig. 2. Bones in flipper of the same specimen.

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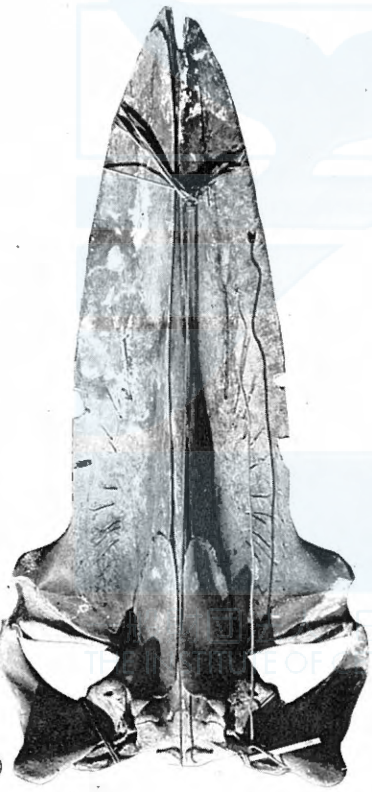

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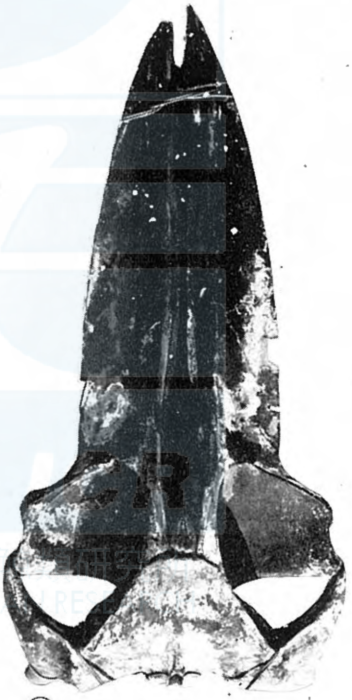

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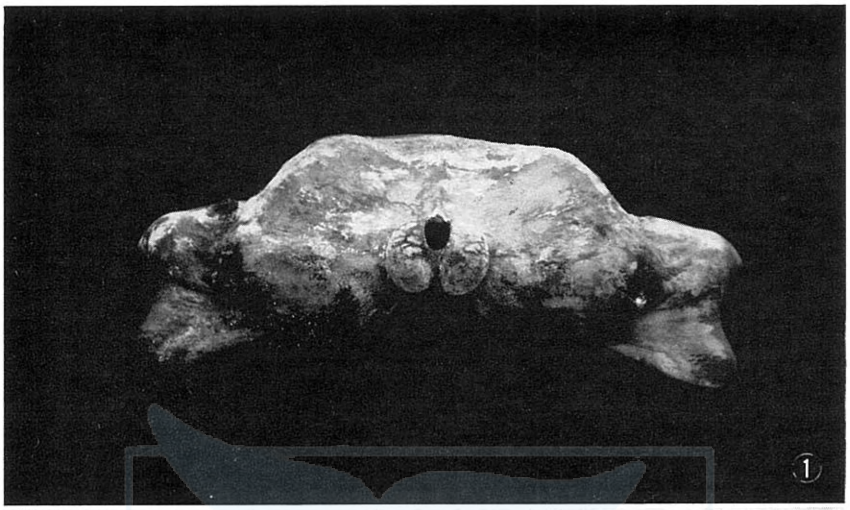

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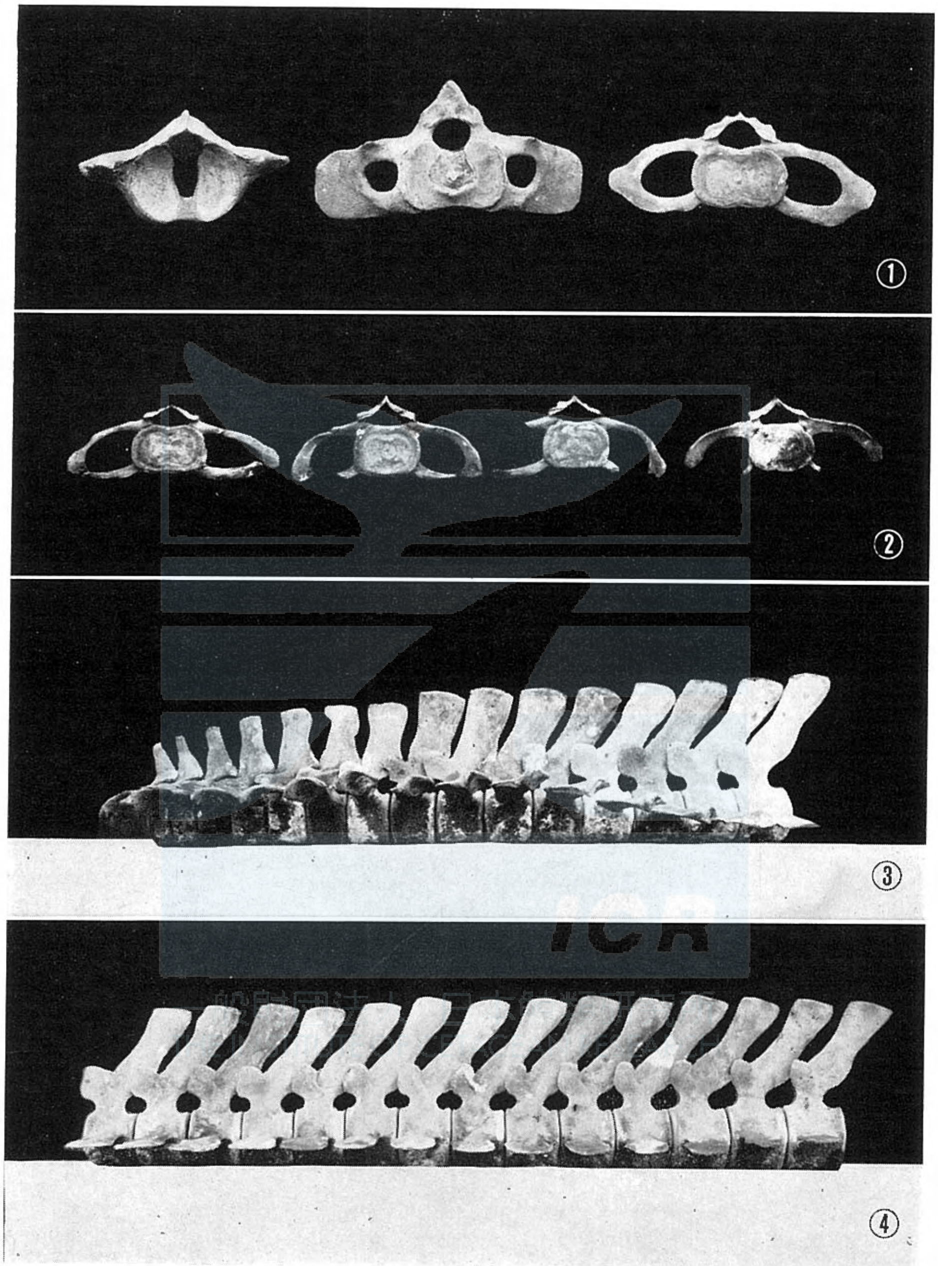
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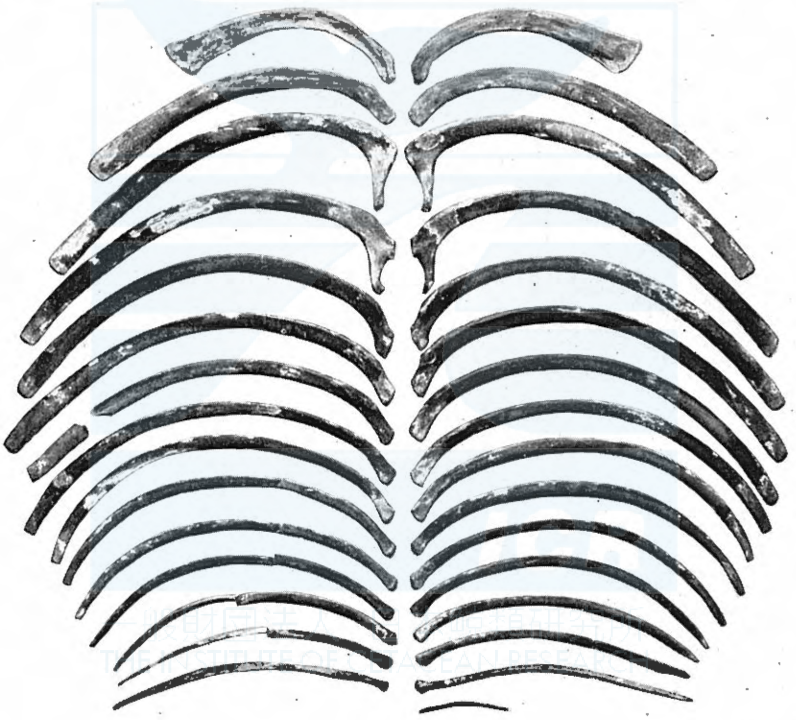

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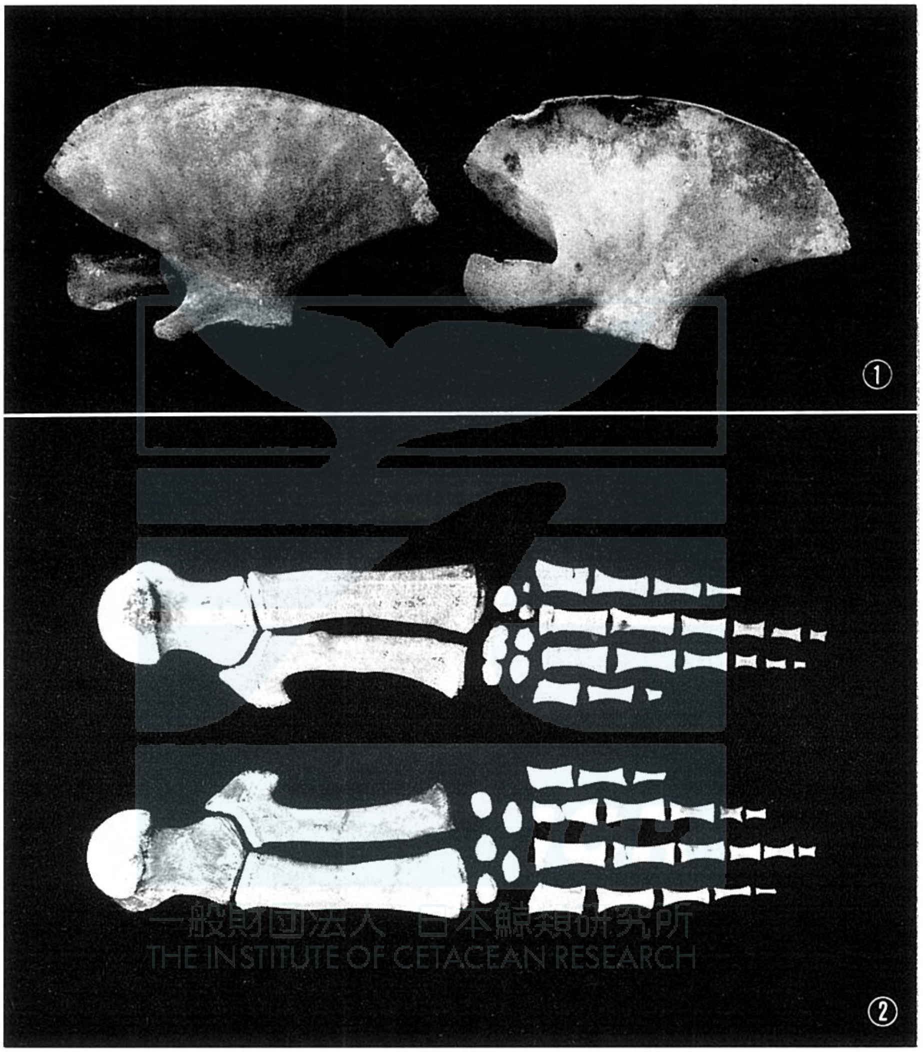
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RECENT RECORD OF GRAY WHALE IN THE ADJACENT WATERS OF JAPAN AND A CONSIDERATION ON ITS MIGRATION

MASAHARU NISHIWAKI* AND TOSHIO KASUYA*

INTRODUCTION

Mizue (1951) made a biological analyses on the catch record of the gray whale in the Korean waters. According to Mizue and Kasahara (1950), there has been no occurrence of this species in that area since 1933 inspite of continuous whaling operation.

Although this species has been protected by the Japanese Government since 1944, record of neither sighting nor stranding had been obtained in the adjacent waters of Japan until recently. The fact had led us to the conception that the gray whale might have been exterminated.

Then two records were obtained from the Pacific coast of Japan. Here are the detailed information of them and our consideration on the migration route of gray whales in the adjacent waters of Japan.

RECENT RECORDS OF THE OCCURRENCE

The first record

The first record was informed by Mr. K. Shimizu, a gunner of a small local whaling boat, Katsu Maru (8 gross tons). He saw a gray whale swimming south at 135° 55′E, 33° 29′N, about 2.5 nautical miles east from Kii-Oshima Island and the nearest distant to the Japanese main land was also about 2.5 miles from the spot.

The water depth of that spot is indicated in a chart as approximately 80 m. The pity was that he could not say in which year the incident happened, only recalled the date and the month, June 10 because an annual event was taken place on that day in his town. He said that it was about 10 years ago, that is nearly 1959.

The second record

The second record of a gray whale was obtained off the estuary of the Kumano River, 136°01.7′E, 33°43′N, where sand beach was on the both sides of the estuary and a small lagoon was inside the dunes.

In the morning of Feb. 2, 1968, a gray whale staying by a drag-net for sardine fishing, was discovered by the local fishermen, at about half a mile from the land, and the water depth around there was nearly 10 m. According to the fishermen's report, the whale was staying around the spot of discovery more than 9 hours, never entered into the river, and finally died. Death might be caused by the wound

* Ocean Research Institute, University of Tokyo

made by someone during the evening of the day.

By the effort of some certain people of the near by town, body length measurement and sex check were done and an almost complete skeleton was preserved. It is now kept at the Taiji Whale Museum.

NAMING AND AGE

The whale which was named as Shingu specimen thereafter, was a female, quite young, 9.0 m in total body length and the longest baleen plate of it was measured along the lateral edge as 15.0 cm from gum to the tip. Two growth ridges and a neonatal mark are observed on the plates. The age of this whale is, therefore, presumed as more than one year old but younger than two.

OSTEOLOGICAL NOTE

Skull

General feature of the skull of Shingu specimen is little different from that reported by Andrews (1914).

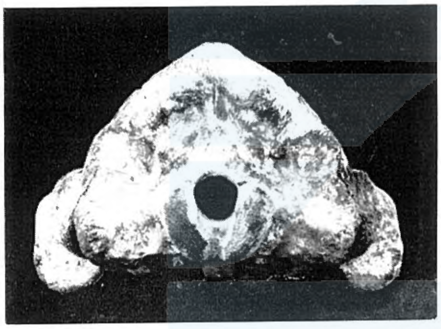

Fig. 1. Posterior view of the skull of Shingu specimen.

Fig. 2. Inner surface of the sternum of Shingu specimen.

In the photograph of his skull from California, the nasals are fused at the mesial surface, and the anterior border of the nasals is protruded in the middle. However, in his Korean specimen, although the length of the skull is nearly same value as that of the Californian, the nasals are not fused and no conspicuous protrusion. Though Shingu specimen was very young, nasals of which are fused and the shape of anterior surface of the nasals resembles to that of the Californian. To reach a conclusion on the problem of the populations by the feature of the nasals, we need more data.

Vertebrae

The vertebral formula of Shingu specimen is C 7+D 14+L 12+Ca 23=56. This formula coincides quite well with the formula presented by Andrews. At the spot of excavation of the skeleton, though the last caudal vertebra was confirmed and number of the vertebrae was counted, the last one was lost afterward.

All the epiphyses of the vertebrae, from the 2nd cervical to the last caudal, are not fused to the centrums. Seven cervical vertebrae are all independent.

The transverse processes of the 14th, the last, thoracic vertebra, have no articular facet for the heads of the ribs, they have only a slight swelling at each distal end. The widest stretch of the transverse processes is in the 8th Lumbar. The highest spinal process is in the 10th Lumbar. The tranceverse processes disappear from the 12th caudal toward the rear, the neural arch opens and the canal disappears from the same vertebra. The ratio of each section in the length of the vertebral column are C:5.2% D:23.0% L:29.5% Ca:42.3%.

Length of all centrums in the vertebral column are summed up as 645 cm, add the length of skull to this value, the total length of the whole skeleton is 848 cm. If the length of the removed connective tissue is added, the body length of the whale must be about 9.00 m.

Ribs

14 pair of ribs are in Shingu specimen. Among them, the 3rd, the 4th, the 5th and the 6th are two headed. The 14th ribs are not articulated with the transverse process of the vertebra.

Chevron bones

There are 11 pairs of chevron bones, among which the 1st, the 9th, the 10th and the 11th are separated into two laminae. The laminae of the 1st is fused to

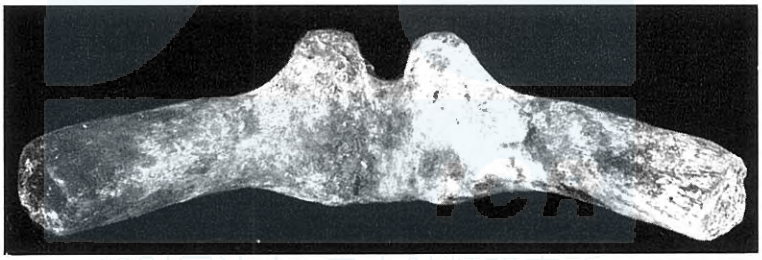

Fig. 3. Hyoid bones of Shinga specimen, Basi and thyrohyals are fused.

Fig. 4. Left lateral view of chevron bones of Shingu specimen.

the centrum of the 1st caudal vertebra. This phenomenon is reported by Andrew (1914) and seems to be common to the whales of this species.

TABLE 1. SKULL MEASUREMENTS OF THE GRAY WHALE FROM SHINGU

			in mm	% of total length
1.	Total length, from tip of pmx. to occipital condyle (straight)		2000	100
2.	Greatest breadth of skull		890	44.5
3.	Length of rostrum		1314	65.7
4.	Breadth of rostrum at base		466	23.3
5.	Breadth of rostrum at mid-length of rostrum		288	14.4
6.	Breadth of pmx. at the same point		143	7.2
7.	Breadth of pmx. across superior nares		253	12.7
8.	Length of the mx. from frontal border	R.	1281+	64.1+
		L.	1283	64.2
9.	Greatest breadth across mx. proximally		708	35.4
10.	Length of pmx.	R.	1580	79.0
		L.	1556	77.8
11.	Length of nasals in median line		297	14.9
12.	Breadth of nasals at anterior ends		121	6.1
13.	Distance from anterior end of nasals to anterior end of supraoccipital		342	17.1
14.	Length of orbit (least)	R.	154	7.7
		L.	153	7.7
15.	Length of paratine bones visible on palate	R. & L.	375	18.8
16.	Breadth across anterior ends of zygomatic proc. of squamosal		823	41.2
17.	Breadth across anterior angles of orbital proc. of frontal		726	36.3
18.	Breadth across posterior angles of orbital proc. of frontal		815	40.8
19.	Depth of skull from crest of supraoccipital to lowest point of pterygiod		608	30.4
20.	Greatest breadth of superior nares		178	8.9
21.	Breadth of occipital condyles		265	13.3
22.	Height of occipital condyles		185	9.3
23.	Breadth of foramen magnum		100	5.0
24.	Height of foramen magnum		107	5.4
25.	Length of mandible (straight)	R.	1781	89.1
		L.	1750	87.5
26.	Length of mandible (along the curve)	R.	1835	91.8
		L.	1810	90.5
27.	Straight length from tip of mandible to end of coronoid proc.	R.	1373	68.7
		L.	1352	67.6
28.	Depth of mandible at middle	R.	192	9.6
		L.	200	10.0
29.	Depth of mandibular condyle	R.	286	14.3
		L.	283	14.2
30.	Greatest length of tympanic bulla	R. & L.	106	5.3
31.	Greatest width of tympanic bulla	R. & L.	88	4.4

TABLE 2. VERTEBRAL MEASUREMENTS OF OF THE GRAY WHALE FROM SHINGU (mm)

Vertebral No.	Position of measurement			Vertebral No.	Position of measurement		
	1	2	3		1	2	3
C 1	357	295	60	8	634	433	162
2	471	297	64	9	618	425	166
3	399	262	42	10	603	435	173
4	395	258	35	11	585	430	175
5	395	262	40	12	567	424	175
6	382	262	46	Ca 1	533	421	187
7	386	270	51	2	493	406	182
D 1	397	282	55	3	461	400	184
2	419	288	65	4	429	377	187
3	420	298	75	5	391	358	186
4	422	313	84	6	340+	339	184
5	401	324	91	7	334	320	171
6	410	333	96	8	298	315	167
7	410	345	111	9	265	288	160
8	432	367	120	10	246	270	158
9	470	376	126	11	224	242	149
10	507	381	129	12	208	204	133
11	526	383	131	13	184	163	111
12	550	390	133	14	160	124	93
13	575	388	131	15	138	109	80
14	595	368	142	16	122	108	76
L 1	598	392	140	17	113	88	71
2	576	398	143	18	102	80	66
3	580	409	147	19	87	68	62
4	589	417	155	20	72	53	51
5	598	427	154	21	56	44	43
6	605	424	163	22	41	30	35+
7	628	428	158	23	+	+	+

1 : breadth across transverse proc.
2 : greatest height.
3 : length of centrum.

TABLE 3. MEASUREMENTS OF RIBS OF THE GRAY WHALE FROM SHINGU (mm)

No. of ribs	Right		Left	
	A	B	A	B
1	885	—	910	—
2	1020	—	1155	—
3*	1350	195	1365	190+
4*	1500	180	1500	190
5*	1565	180	1570	175
6*	1640	145	1625	140
7	1630	—	1610	—
8	1545	—	1575	—
9	1470	—	1500	—
10	1400	—	1410	—
11	1295	—	1315	—
12	1210	—	1220	—
13	1145	—	1145	—
14	1050	—	1060	—

A: length from dorsal tubarcle to distal end along lateral border.
B: distance from tip of head to dorsal tubercle.
* two headed rib.

TABLE 4. MEASUREMENTS OF HYOID BONES (mm)

Measurements	
1. Extreme breath of base (thyro-and basihyal)	439
2. Breadth of base between medial borders of distal facet of thyrohyal	347
3. Antero-posterior length of basihyal, at the notch	78
4. Antero-posterior length of basihyal, at the anterior protuberance (R. and L.)	109
5. Width across the anterior protuberances of basihyal	107
6. Width between the anterior protuberances of basihyal	33
7. Antero-posterior length of the facet of distal end of thyrohyal	R. 55 L. 60

TABLE 5. MEASUREMENTS OF CHEVRON BONES OF THE GRAY WHALE FROM SHINGU (mm)

No.	Height	Length	Breadth
1*	63	72	77
2	126	77	107
3	183+	96	117
4	140	100	112
5	127	122	108
6	119	99	109
7	100	88	104
8	76	92	97
9**	94	80	—
10**	57	59	—
11**	31	41	—

* Fused to 1st caudal vertebra
** Both laminae are separated

TABLE 6. MEASUREMENTS OF SCAPULAE OF THE GRAY WHALE FROM SHINGU (mm)

	Right	Left
1. Greatest hight (vertical)	495	514
2. Greatest breadth	757	761
3. Distance from antero-dorsal angle to anterior point of glenoid fossa	431	438
4. Distance from postero-dorsal angle to posterior point of glenoid fossa	406	407
5. Length of acromion (inferior edge)	193	190
6. Breadth of acromion, distal	132	145
7. Length of coracoid (inferior edge)	58	62
8. Length of glenoid fossa	253	245
9. Breadth of glenoid fossa	202	198

TABLE 7. MEASUREMENTS OF PECTORAL LIMB BONES OF THE GRAY WHALE FROM SHINGU (mm)

	Right	Left
Humerus		
Greatest length	391	390
Greatest breadth, proximal*	218	216
Greatest breadth, distal*	237	237
Radius		
Greatest length	567	556
Greatest breadth, proximal	152	152
Greatest breadth, distal	182	185
Ulna		
Greatest length	502	514
Greatest breadth, proximal	144	141
Greatest breadth, distal	177	177

* Excluding the epiphysis.

DISCUSSION

General opinion of scientists is that gray whales in Asian side of the Pacific are of different stock from those in American side. In Asian side, they had been caught continuously in the Sea of Japan and the Yellow Sea, until 1933. Most of them migrated along the Korean coast and a few did along the northern Kyushu coast (Kasahara 1950; Mizue 1951). Dr. K. Nasu of the Far Seas Fisheries Research Laboratory got an old statistics of the whaling operated in every winter at Tsuro (33°32′N, 134°09′E) and Kubotsu (32°46′N, 133°00′E), Shikoku, Japan. According to his private information, 101 gray whales were caught by a net or a hand harpoon during the 16 years from 1849 to 1865, annual number of the catch fluctuated from one to ten. He told in his another private information that 64 whales were caught during the 22 years from 1875 to 1897 by the same whaling party. However, inspite of continuous whaling operation, in the waters of Shikoku and of southern Kyushu, no catch has been reported since 1911 (Kasahara 1950). At the northern Pacific coast of Japan, 5 gray whales were caught between 1911 and 1942, one at the Kuril Is., one at Nemuro, Hokkaido and three at Ayukawa, Miyagi Pref. (Mizue 1951). These pieces of information indicate the fact that the gray whale in the Pacific coast of southeast Japan, once comparatively abundant, was reduced and nearly exterminated by the end of 19th century while still abundant in the Korean coast.

The present records tell the fact that there are few gray whales migrating to the Pacific coast of Japan in recent years. Considered the above mentioned records of catch, it is possible for us to assume a migration route from the Kuril Islands to Shikoku along the Pacific coast.

Though a question of what population were they belonged to is still left, we are inclined to think that the gray whales of the present records may have been the strayed individuals from the Bering Sea.

ACKNOWLEDGEMENT

We acknowledged the kind cooparation of the staff members of the Taiji Whale Museum (Director: Mr. Tamaji Higashi). Without their help, works on the heavy skeleton, measuring and picture taking etc., should not have been accomplished.

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EXPLANATION OF PLATES

PLATE I

Dorsal, lateral and ventral views of the skull, and innerlateral view of the right mandible of the gray whale from Shingu.

PLATE II

Lateral views of cervical and thoracic, lumbar, caudal and caudal vertebrae. Anterior view of atlas and axis, posterior views of atlas, axis and the first caudal vertebrae. (top to bottom)

PLATE III

1. Outer-lateral views of left and right scapulae.
2. Lateral view of the left series of the ribs.

PLATE IV

Left and right humerus, ulna, radius and phalanges of the Shingu specimen.

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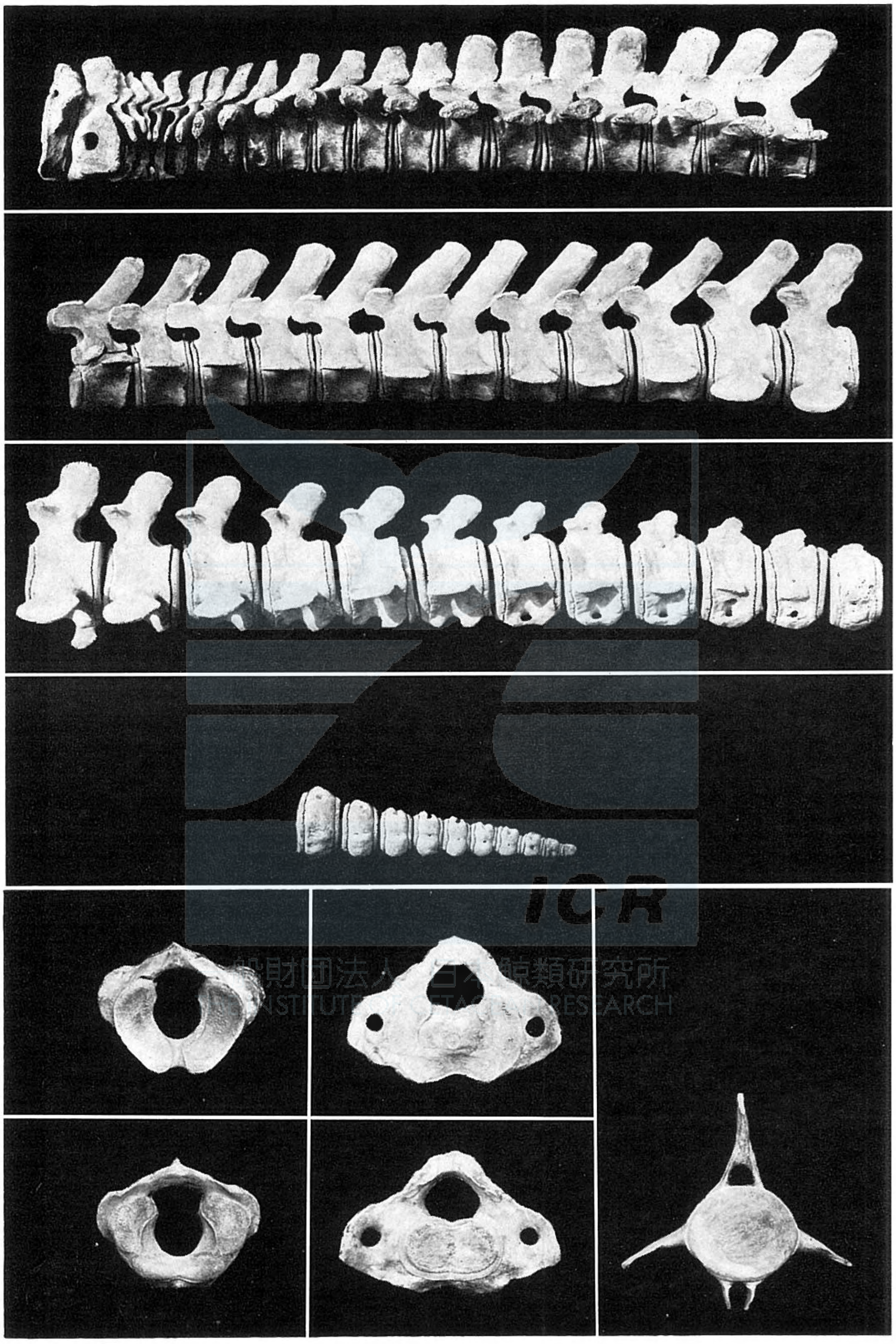

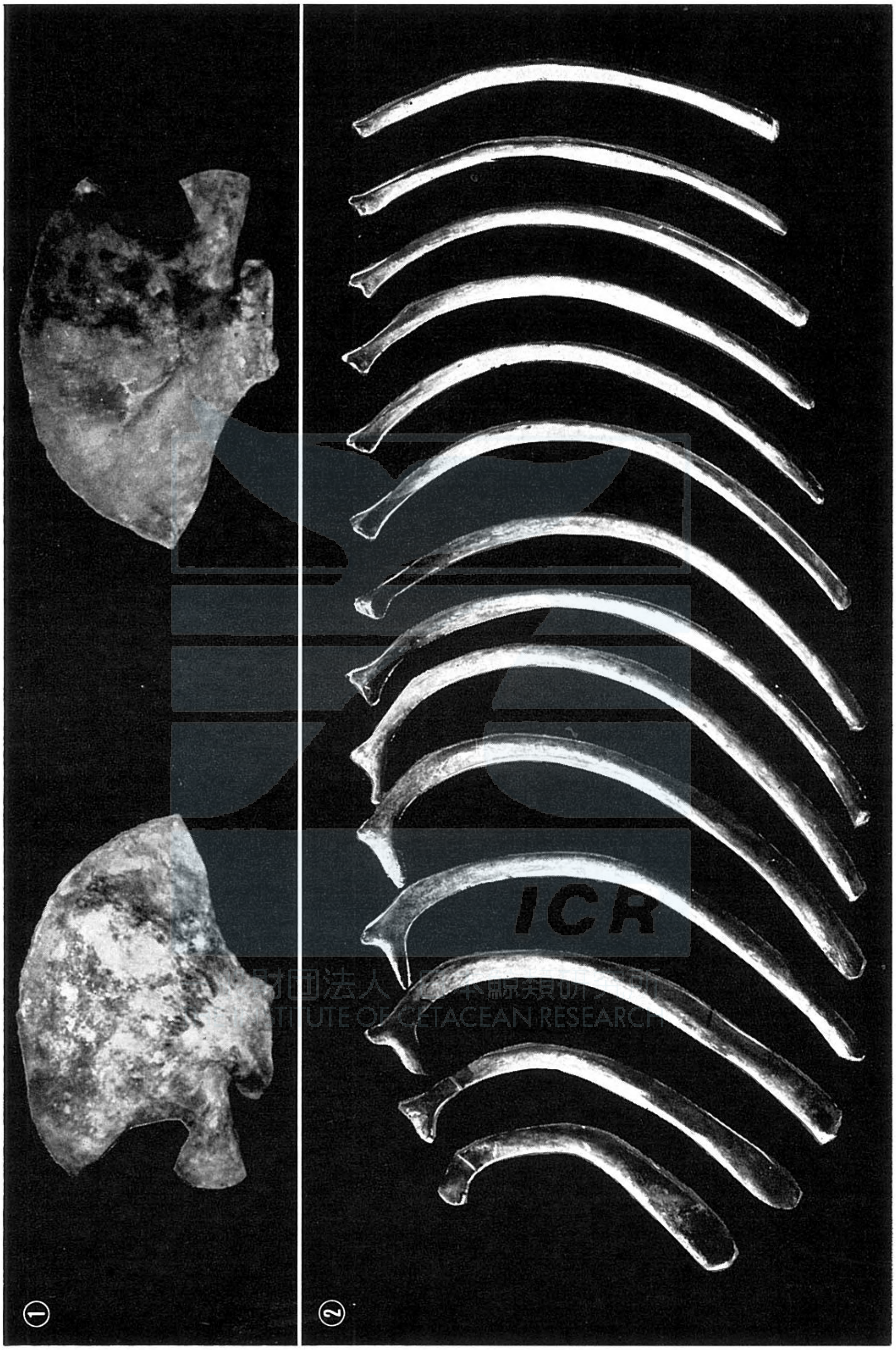
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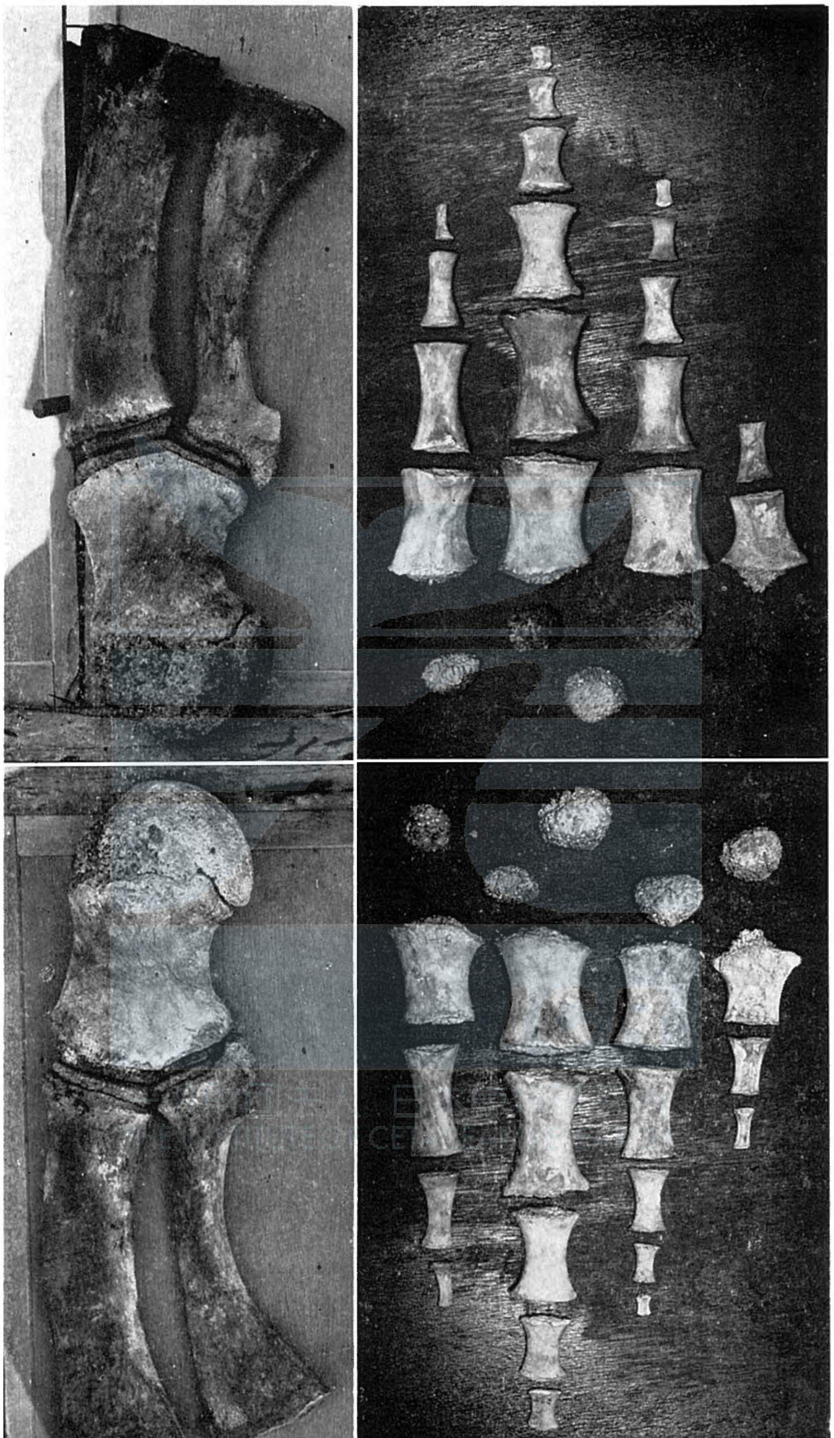

NOTES ON BALEEN PLATES AND ON ARRANGEMENT OF PARASITIC BARNACLES OF GRAY WHALE

TOSHIO KASUYA* AND DALE W. RICE**

INTRODUCTION

While we were investigating gray whales (*Eschrichtius robustus*) caught during the winter of 1966–67 at the shore station of the Del Monte Fishing Company, Richmond, California, under a special scientific permit issued to the Marine Mammal Biological Laboratory of the U. S. Bureau of Commercial Fisheries, we made some observations on the baleen plates and parasitic barnacles. These results are reported here.

THE ASYMMETRY OF WEAR OF BALEEN PLATES

Fig. 1 shows the length of the baleen plates of two gray whales. Measurements were made on every 5th or 10th plate, from the gum line to the tip of the

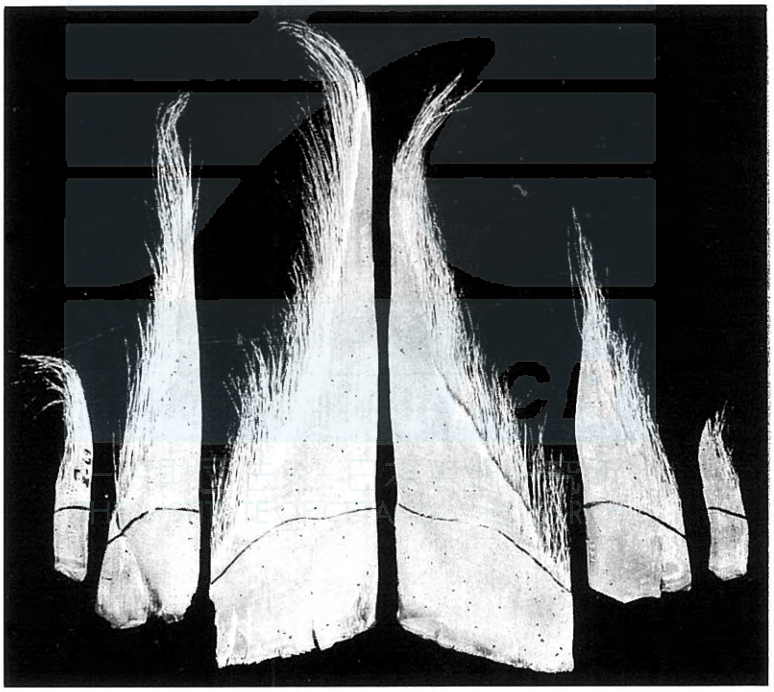

Fig. 1. 10th, 50th and 90th baleen plates of a gray whale (sides to center), No. 1967–8, posterior view. Black line indicates the gum line.

* Ocean Research Institute, University of Tokyo.
** Marine Mammal Biological Laboratory, Bureau of Commercial Fisheries.

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plate along the lateral edge. As seen in this figure, the length of the baleen plates in the anterior part of the series is not bilaterally symmetrical. The plates on the right side are shorter than those in the corresponding positions on the left side. This asymmetry appears to be the rule among the California gray whales, for among 31 whales observed by us, there were only 3 animals in which the baleen plates of the anterior part of the right side were longer or nearly equal with those of the left.

As seen in Fig. 2 the distance between growth marks on the surface of the baleen plates is the same on the left and right sides, but the plates on the right side show heavier wear on the lingual edge. So it is reasonable to conclude that this asymmetry has been caused not by the slower growth of the right plates but by heavier wear on the right.

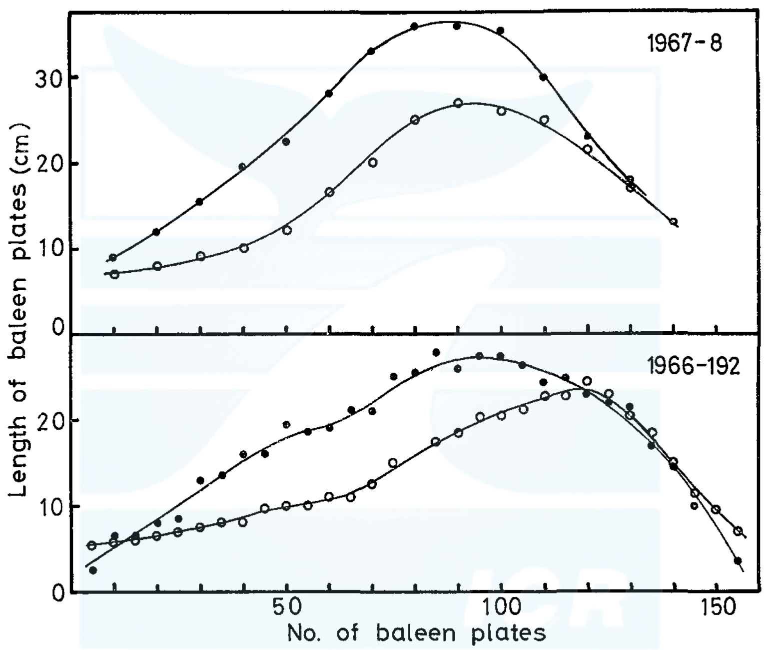

Fig. 2. Length of baleen plates of gray whales, no. 1967–8 12.6 m female and no. 1966–192 13.6 m female. Opencircle indicates the right and the closed the left. Curves are drawn by hand.

The gray whale feeds on benthic organisms and sometimes even swallows sand or pebbles (Tomilin, 1954; Pike, 1962; Rice and Wolman, in press). Scammon (1874) and Wilke and Fiscus (1961) reported that feeding gray whales had surfaced with head and lips besmeared with mud, and that they apparently had expelled mud through the baleen. These observations suggest that gray whales scoop the mud or sand on the bottom to collect benthic organisms.

Gunther (1949) mentioned that the movements of the rorquals from side to side appears to be restricted by the structure of body and that fin whales have the

TABLE 1. MEASUREMENTS OF BALEEN PLATES OF CALIFORNIAN GRAY WHALE

	% of length of right to the left			No. of baleen plates	
	A	B	C	Right	Left
Sample no.	31	16	20	9	11
Range	60.9–105.6	51.1–120.0	55.6–116.7	139–172	138–163
Mean	86.6	82.2	74.5	155.8	155.5
Standard error	1.92	4.29	3.31	—	—

A: Maximum length. B: Length at middle of series.
C: At 50 cm from anterior-most bristle.

Fig. 3. Rostrum region of the gray whale, Top: left side, bottom: right side. For explanation see text.

tendency to swim on one side to turn sharply to one direction. The same would be true also for gray whales feeding at the bottom, and it would be difficult for them to scoop the bottom with the anterior part of the lower lip while swimming in normal posture. This is supported by the observation that the number of colonies of barnacles infesting the left side of the head region exceeds that of the right side. On the skin of the right side of the rostrum we often observed many healed or open wounds, probably scratches caused by hard substances on the bottom.

From these considerations we speculate that the asymmetric wear of the baleen plates of the gray whale is the result of feeding movements in which the whales scoop the sediment mostly with the right anterior region of the baleen plate rows.

No asymmetry was found in the number of baleen plates (Table 1).

WATER CURRENT ON THE BODY SURFACE SUGGESTED BY THE ORIENTATION OF THE BARNACLES

There are many colonies of barnacles, *Cryptolepas rhachianecti* DALL, on the skin of gray whales. They are especially numerous on the rostrum and flippers, fairly numerous on the upper edge of the lower lip, the area between the eye and the base of the flipper, and on the tail peduncle. There are few barnacles on the other parts of the body.

These barnacles are directed approximately towards the anterior end of the whale, and all the barnacles in a colony are oriented in the same direction. The orientation of barnacles at any point on the body is nearly the same in all whales.

We think that the orientation of the barances is affected by the direction of the water current at the point where the barnacles are growing, and the anterior end of the barnacles coincides with the mean direction of the current.

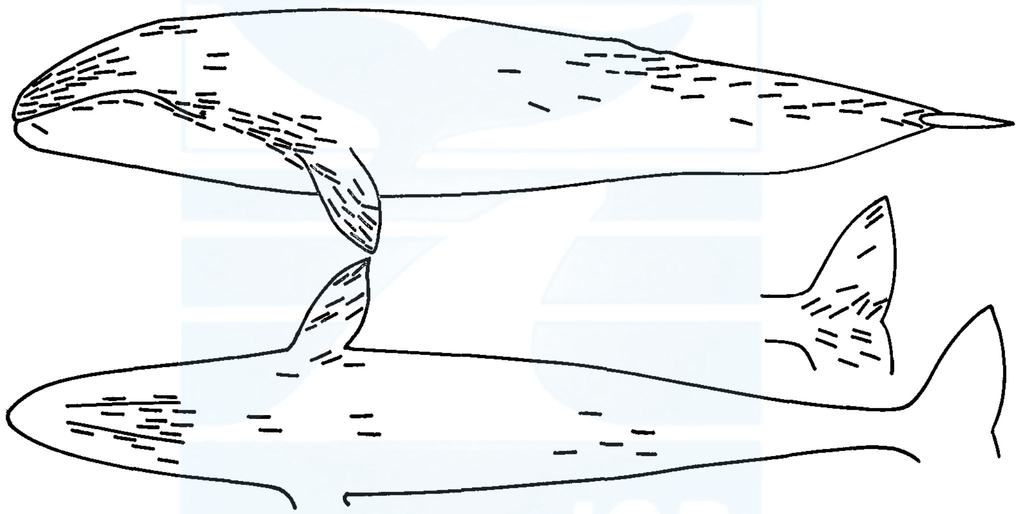

Fig. 4. Diagramatic figure of the orientation of barnacles on the gray whale

Fig. 4 is a diagrammatic figure of the orientation of the barnacles on the gray whale. This figure is based on sketches of each part of the body of six animals, and some photographs taken in the same whaling season. Each small rod represents approximately one colony. We found no significant bilateral asymmetry in the orientation.

On the upper jaw and the dorsal side of the tail peduncle the water seems to flow obliquely upward. But in the area between the angle of the gape and the anterior insertion of the flipper, the water seems to flow obliquely downward from the gape to the flipper. These flow patterns agree with those on the body of *Delphinus* and *Phocoenoides*, as determined from the arrangement of dermal ridges and from a photograph of a swimming *Delphinus* (Purves, 1963). Purves (*loc. cit.*)

reported that the dermal ridges on the flippers and flukes are arranged perpendicular to the leading edge. But in the case of the gray whale the barnacles are oriented obliquely from the anteroproximal to the posterodistal edge of the fins on both dorsal and ventral sides. Probably the gray whale usually holds its flippers in a ventroposterior position, so the mean direction of the current will be oblique to the long axis of the flipper. On the tail flukes it is not unreasonable to think that the current moves in a posterodistal direction, when the flexibility and somewhat posteriorly convex shape of the flukes are considered.

On the ventral side of the body the water seems to flow parallel with the body axis. The orientation of some colonies of barnacles suggests a downward flow slightly below the mid-line of the tail peduncle.

ACKNOWLEDGEMENT

Greatest thanks are due to Mr. Allen A. Wolman of the Marine Mammal Biological Laboratory, who kindly assisted at the whaling station. Without his help, our study would not have been accomplished. We owe very much to Prof. Masaharu Nishiwaki of the Ocean Research Institute, who provided the opportunity for Kasuya to study the gray whale in the United States. The cooperation of Mr. John Caito and Mr. Charles Caito of the Del Monte Fishing Company is also acknowledged. They provided the facilities to collect and study the gray whales.

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A GREENLAND RIGHT WHALE CAUGHT AT OSAKA BAY

MASAHARU NISHIWAKI* AND TOSHIO KASUYA*

INTRODUCTION

A strange whale was captured alive at Osaka Bay by the fishermen. But it died in the next morning and was hauld ashore. Information of the incident reached us and we happend to get a valuable chance to investigate a whale (*Balaena mysticetus* LINNAEUS, 1758), very rare in Japan, even in the world.

Fig. 1. The Greenland right whale tethered at Hamadera fishing port. (Photo by Yomiuri Press, Osaka)

It seemd that the whale had strayed from north and came into the adjacent waters of Japan, but did not through the Seto Inland Sea. If he had passed through the Inland Sea, there must have been many islands and boat or set nets on the route, so he should have tangled in a net or should have been seen by the people. There was no such report from there, so he had no other way but through around the Point Shionomisaki and got into the Osaka Bay, that is, he did occur at the south of 33°28′N.

* Ocean Research Institute, University of Tokyo.

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Hitherto, this species has occurred no other place in the world on 33°28′ N. around, San Diego and Casabranca for example.

Our news was not only the evidence of this occurrence. When an experienced whaling worker Mr. Shiozaki came from Taiji for flensing and saw the whale, he cried " Oh Isozemi." Then I asked him what Isozemi was. He told me that Isozemi, a kind of whale, has been really rare, but he has seen an individual once on the beach of Taiji just after the World War II. He had seen either black right whales and gray whales. Then he found Isozemi which was resemble to the black right whale but had no bonnet, had protruded blow hole. The whale was smaller than the present one and had darker and shorter baleen plates.
We can not record this as a scientific evidence but it can be presumed that a whale, apparently different from black right whale or gray whale, was captured at Taiji.

More study is necessary to make it clear whether Isozemi and Greenland right whale are same species. Mr. T. Higashi, Director of the Taiji Whale Museum, is investigating if another Isozemi evidence might be found in the Record of Ancient Whaling at Taiji. In any case, considered from above, another Greenland right whale might have come to the Pacific coast of Japan.

DISCOVERY AND CAPTURE

On June 23, 1969, the Miyatamaru No. 1 and No. 2, both were 20 gross tons fishing boats, equipped with a circular net, belonged to Hamadera Fishermens Union in Sakai City, had been operating " Konoshiro " (*Konosirus punctatus* TEMMINCK *et* SCHLEGEL) fishing. Then the fishermen caught a short wave radio from another boat saying " a whale is in sight". The visibility at that time was, however, so poor that they could not find the whale. At about 8 a.m., they happend to find a school of " Konoshiro " and wound the net. Then they saw the whale floating and spouting at the center of the circular net and caught him at about 10 a.m.

According to the fishermen's talk, the story was as that, but considering from the fact that the able distant of swimming underwater by this whale is not great, we have some doubt on this story. According to the Osaka meteorological observatory the weather at 10 a.m. on that day was cloudy with light south wind about 3 m/sec and visibility was 7 km. We can not immagine the fishermen failed to find the whale in that weather condition. Although fishermen themselves knew little about the International Whaling Convention someone might have warned them that they should be punished if they had intended to catch the whale. Then they might have made up the story. But we have no other way than trust them. The whale was towed to the port after the catch and died in the next morning at about 5 a.m.

CAUSE OF DEATH

The whale died 20 hours after its capture.
The question of what made this whale die, was asked by many people at the spot.

It may be that he was dragged in the water to the reverse direction by a power of the machinery. To be dragged to the entirely reverse direction makes severe damage to the vertebrae of a whale. A rope which had constricted the tail peduncle at capture had not been untied until death.

Moreover, it was suspected that the whale might have got pneumonia caused by inhaled water into the lung which was sucked at the reverse dragging. The intestine had been so decomposed as well as, or more than, the muscles that no special evidence was found from anatomical examination. However, it is proper to say that the whale died rather instantly without receiving a damage from harpoon or gun.

EXTERNAL OBSERVATION

External measurement

The external measurement of this whale is shown in Table 1.

TABLE 1. EXTERNAL MEASUREMENTS OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

	Measurements	Length	% of total length
1.	Total length	640	100.0
2.	Tip of rostrum to blowhole	132	19.2
3.	Tip of rostrum to eye	172	27.2
4.	Tip of rostrum to angle of gape	186	29.1
5.	Tip of rostrum to ear	190	29.7
6.	Tip of rostrum to anterior insertion of flipper	204	31.9
7.	Tip of rostrum to axilla	245	38.3
8.	Distance between eye and ear	24	3.75
9.	Anus to reproductive aperture	63	9.8
10.	Anus to anterior end of reproductive groove	115	18.0
11.	Total spread of tail flukes	182	28.4
12.	Notch of tail flukes to anterior insertion of tail flukes	56	8.8
13.	Notch of tail flukes to tip of tail fluke	L. 99	15.5
		R. 94	14.7
14.	Tip of flipper to anterior insertion of flipper	97	15.2
15.	Tip of flipper to axilla	77	12.0
16.	Greatest width of flipper	43	6.7
17.	Height of body, at the insertion of tail flukes	35	5.5
18.	Height of body, at anus	80	12.5
19.	Height of body, at umbilicus	90	14.1
20.	Depth of body above the eye	70	10.9
21.	Depth of rostrum at browhole	53	8.3
22.	Greatest height of lower lip	55	8.6
23.	Depth of body below the angle of gape	40	6.3
24.	Depth of body below the anterior insertion of flipper	30	4.7
25.	Distance between the anterior insertions of flipper along dorsal surface	260	40.6
26.	Straight length of nostril	10	1.6
26.	Distance between nostrils, at anterior ends	2	0.3
27.	Distance between nostrils, at posterior ends	10	1.6

TABLE 2. NUMBER OF HAIRS OF GREENLAND RIGHT WHALE FROM OSAKA BAY

Upper jaw, tip (Right half)	25
Upper jaw, behind the nostril (Left half)	9
Lower jaw, tip (Right half)	42
Lower jaw, along mandible (Right half)	21

Body color and scars

Body color was bluish grey all over, but not jet black, darker on the dorsal and slightly lighter toward the ventral, and exceptional white portions were at the tip of the lower jaw, at the base of the flippers and around the tail peduncle a little anterior than the flukes. White areas at the tip of the lower jaw and around the nabel were distincet and clearly seen in the dark body colour. At the insertion of the flippers, white color was less distinct and fading away toward the periphery. A white band, 25 cm wide, around the tail peduncle was also less distinct or rather vague.

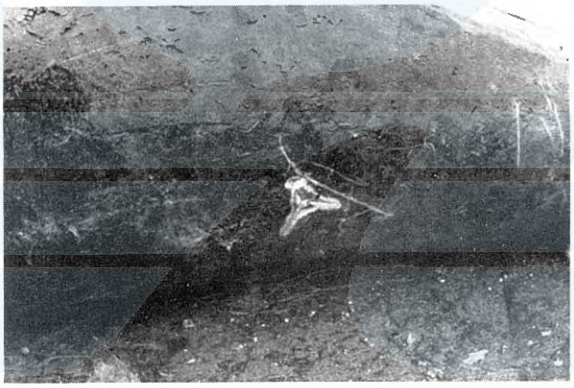

Fig. 2. Half heald triangular scar presumed to have been shot by a bomblance of Eskimo.

Fig. 3. Half heald three lined scars presumed to have been injured by the screw of a catcher boat of Eskimo.

In the left side of the caudal trunk, a triangular scar was seen, shape of which was fitted to that of a " *Bomblance* " harpoon of Eskimo. In the middle of the back, slightly left of the dorsal ridge, three lines of half heald scars, were seen. It may be suspected that a catcher boat which must have been with outboat engin, for five men or so, and belonged to the Eskimo who shot the bomlance, passed on the back of the whale and made it injured by the screw.

The skin was rough and warty with tiny spots, which looked like the skin of a manatee, but, observed closely, the spots were neither bulbs nor pores.

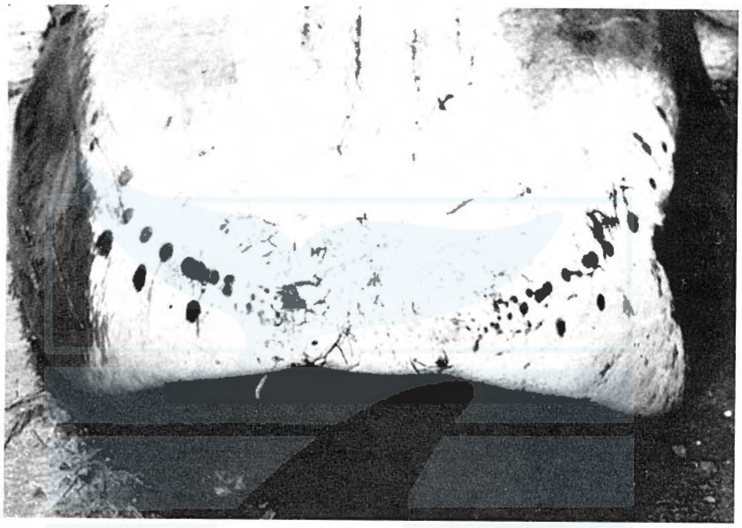

Fig. 4. White colored portion at the tip of the lower jaw of the Osaka specimen.

Hair

The whale had no black right whale-like bonnet nor humpback-like swellings of bulbs but about ten pieces of hair around the outer nostrils. In the white area at the lower jaw, there were black dots scattered and a piece of hair grew from each of them. As we noticed an onlooker picked one of the hair up, something might have been lost or overlooked at the spot.

Nostrils

Taking a side view, the nostrils of the Greenland right whale are seen at the top of the arched head, while those of black right whale are seen slightly backward than the top. Nostrils of this whale were seen at the top in a pent-house shape in down view and there was a longitudinal depression between the slits. While we were dissecting the whale, it was noticed that the cartilage of vomer formed the nostrils and stretched into the blubber just beneath the black skin.

External ear meatus

The ear hole were very small at the point a little higher than and a little back-

Fig. 5. Dorsal view of the upper jaw, showing the nostrils.

ward from the eye. The external meatus was collected and dissected, and tender, greyish black, claylike substance was found stuffed in it. This phenomenon is common to the black right whale.

Thickness of the blubber

The blubber which covered the whole body, showed almost same thickness in every part; when the blubber was cut opened from the angle of gape to the tail flukes, thickness of the opened surface along the line was nearly constant. In this case, thickness of the black portion of the blubber was included in the measured value which is 9.0 cm.

WEIGHT

Weighing of the body had been desired, however, urgent treatment was required. Moreover, when the flensing was commenced, we had to work in a hurry because the specimen was so decomposed that muddy fluid dripped when the muscles and intestine were taken in hand. So weighing was regretfully given up. But considered of the body length, 6.4 m, this whale may be presumed as 3 tons.

INTERNAL ORGANS

The liver and the kidney were completely decomposed. The stomach had been broken and the content could not be discriminated, only the fact that there was no bone of a fish nor other boney substance, was made sure. The tongue was also decomposed and was swelling, but at its tip, waving fringe of the lactating stage was slightly remained.

Testes and penis

Only right side of the testes was found and weighed as 0.65 Kg, the left side of it may have been lost in the maddy inner organs. The penis was very thin, 6 cm in dimeter at the corona of the glans. The length of the glans was about 20 cm and total length of the penis was 65 cm.

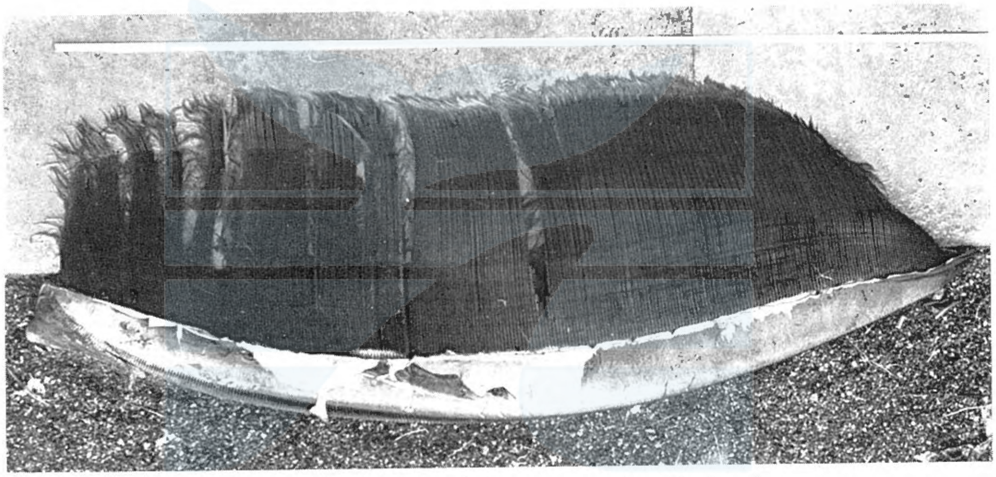

Fig. 6. Left series of the baleen plates (up side down).

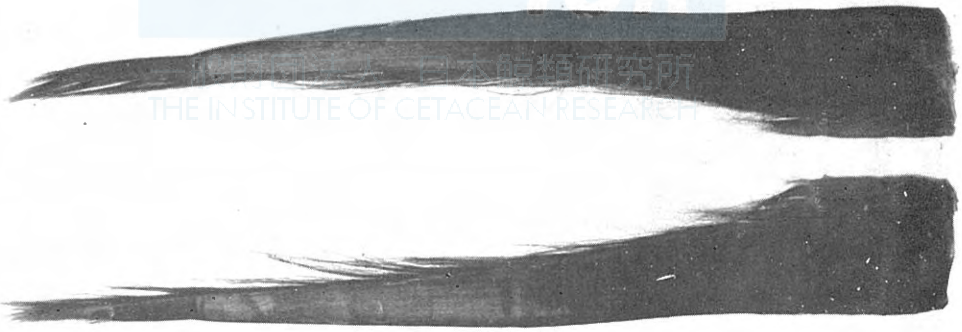

Fig. 7. The longest baleen plate of both sides.

BALEEN PLATES AND THE AGE DETERMINATION

The number of the baleen plates, 311 plates in the left side and 305 plates in the right side, was greater than that of black right whale or gray whale. Length of the plates are indicated in the Table 3. At the tip of the baleens, a characteristic portion

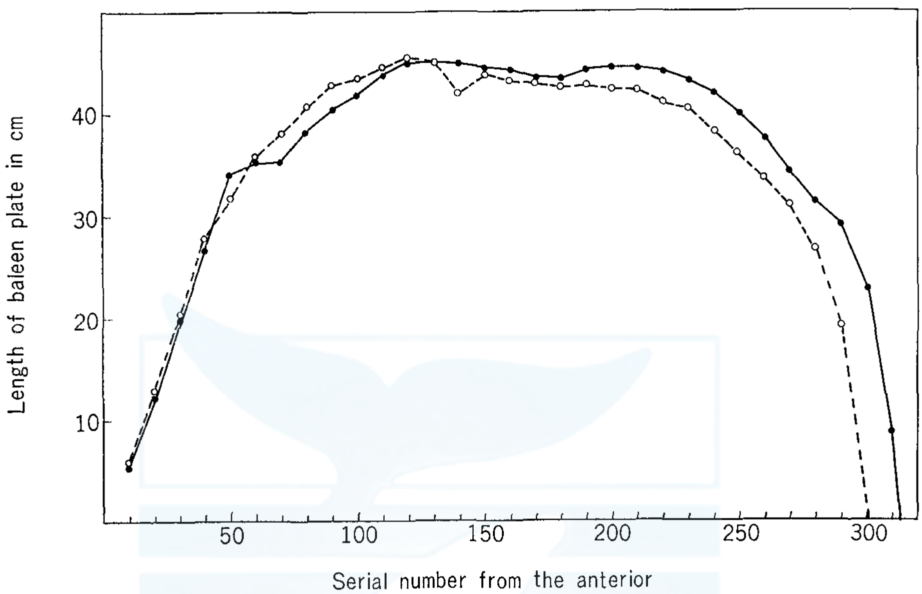

Fig. 8. Length of the baleen plates of the Osaka specimen.
Open circles and dotted line indicate the right side, and closed circles and solid line do the left.

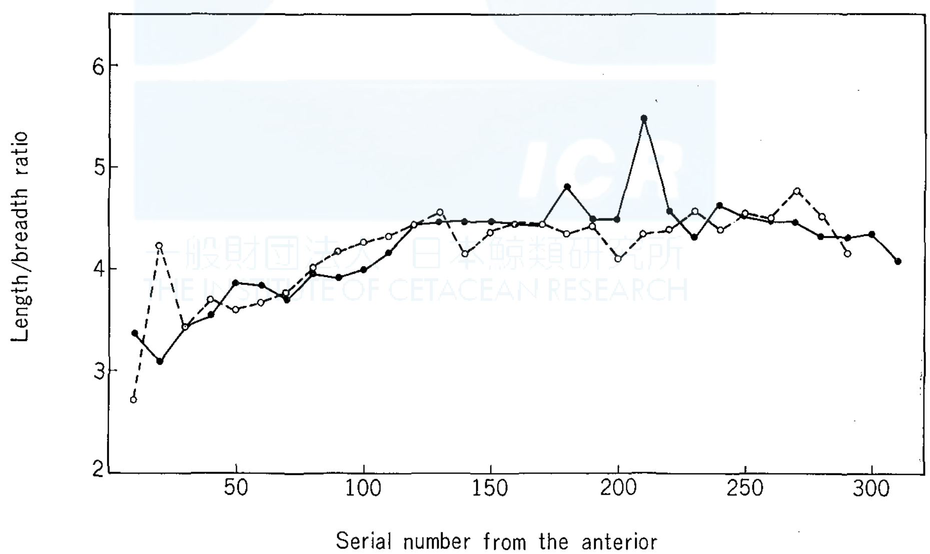

Fig. 9. Ratio of the length to the breadth of baleen plate, simbols are same with Fig. 8.

which grow only in prenatal period, was seen. Two annual growth ridges were observed on the each plates and the first ridge was at the border which divided the prenatally grown portion from the one grew after birth. The second ridge was at 13.5 cm from the root. The distance between the two ridges was 34.5 cm and the lateral edge of that portion convexed considerably, which may indicate an annual growth period, one year.

Like other whales, those ridges are considered to be created during every winter. Supporsing the growth rate of the first one year is little different from that of the second one, age of this whale can be presumed as about 1.36 year old, that

TABLE 3. MEASUREMENTS OF BALEEN PLATES OF GREENLAND RIGHT WHALE FROM OSAKA BAY (mm)

Serial number	Left				Right			
	A	B	C	A/B	A	B	C	A/B
10	54	16	32	3.38	57	21	30	2.71
20	121	39	43	3.10	131	31	42	4.23
30	197	58	56	3.40	201	59	56	3.41
40	266	75	72	3.55	278	75	76	3.71
50	340	88	62	3.86	318	88	90	3.61
60	352	92	100	3.83	356	97	100	3.67
70	352	95	102	3.71	382	101	104	3.78
80	380	96	106	3.96	407	102	102	3.99
90	404	103	104	3.92	429	103	111	4.17
100	423	106	110	3.99	434	102	116	4.25
110	438	105	112	4.17	445	103	118	4.32
120	450	102	114	4.41	451	102	121	4.42
130	450	101	121	4.46	450	99	122	4.55
140	447	100	119	4.47	420	101	123	4.16
150	444	99	122	4.48	437	100	122	4.37
160	442	100	117	4.42	432	97	120	4.45
170	435	98	115	4.44	431	97	117	4.44
180	432	90	112	4.80	426	98	112	4.35
190	442	98	89	4.51	429	97	109	4.42
200	445	99	98	4.49	422	103	106	4.10
210	444	81	84	5.48	422	97	102	4.35
220	440	96	83	4.58	410	93	100	4.41
230	432	100	83	4.32	404	88	98	4.58
240	421	91	79	4.63	382	87	96	4.39
250	399	88	80	4.53	363	86	91	4.54
260	376	84	89	4.48	337	75	83	4.49
270	344	77	83	4.47	310	65	74	4.77
280	316	73	75	4.33	267	59	59	4.53
290	291	67	65	4.34	192	46	50	4.17
300	231	53	56	4.36				
310	86	21	46	4.10				
Total number of plate		311				305		

A: length of plate, from gum line to tip along lateral edge.
B: breadth of plate at gum line, at right angle to the lateral edge.
C: length of root along lateral edge.

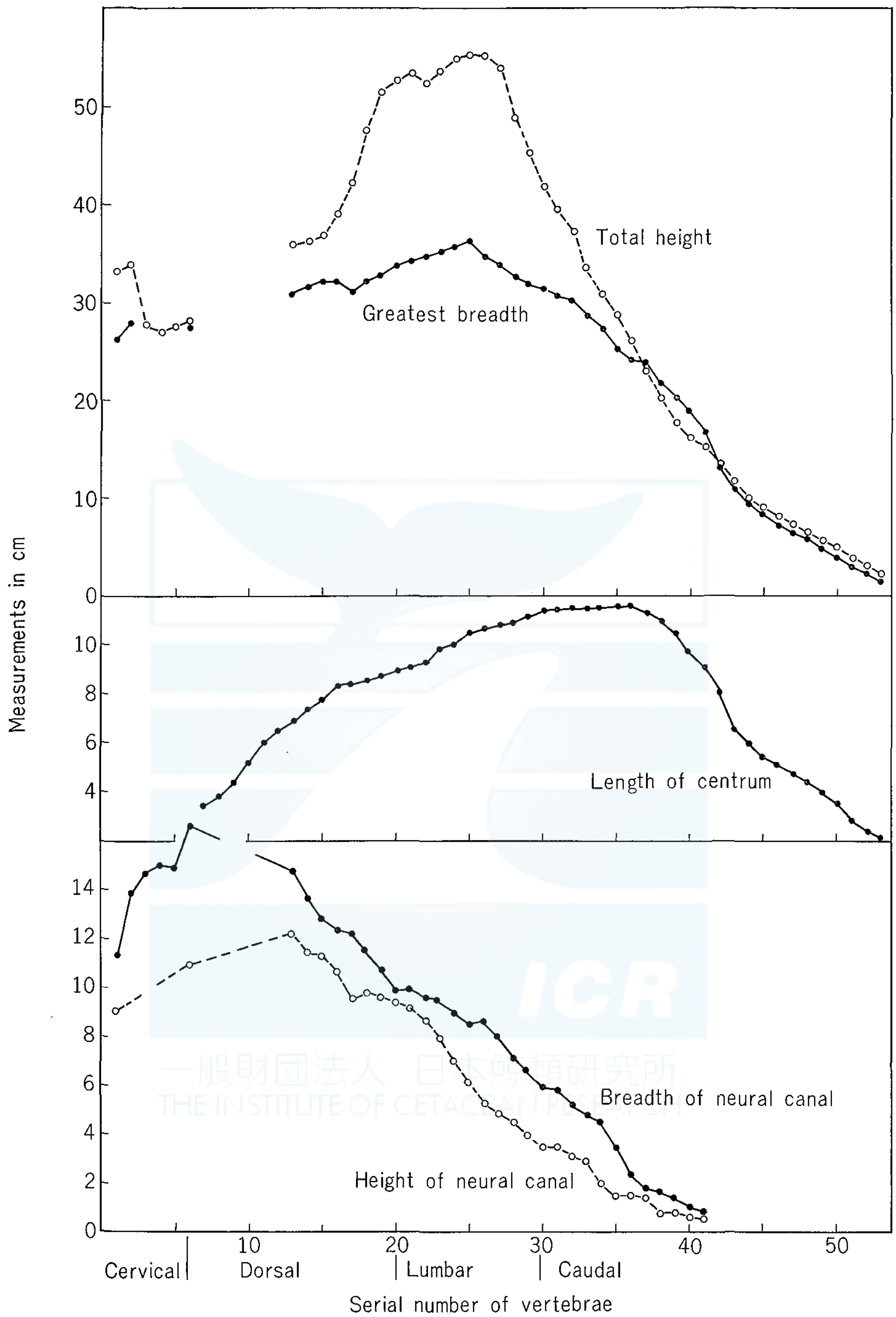

Fig. 10. Dimensions of the vertebrae of the Osaka specimen.

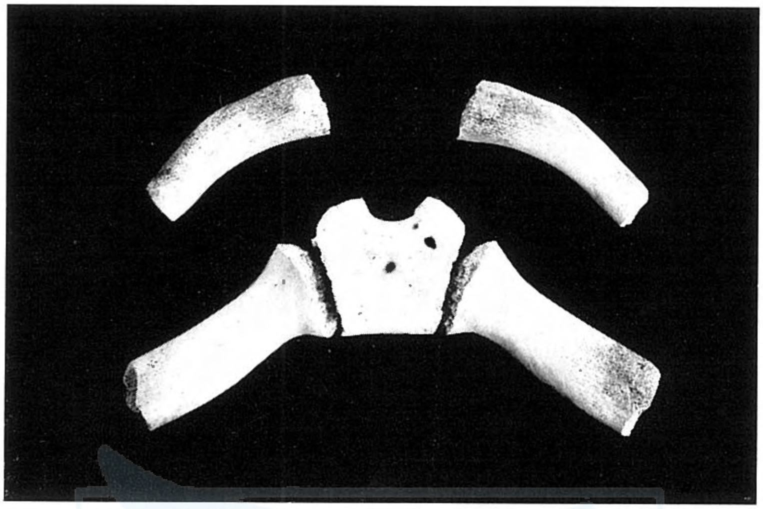

Fig. 11. Hyoid bones of the Osaka specimen.

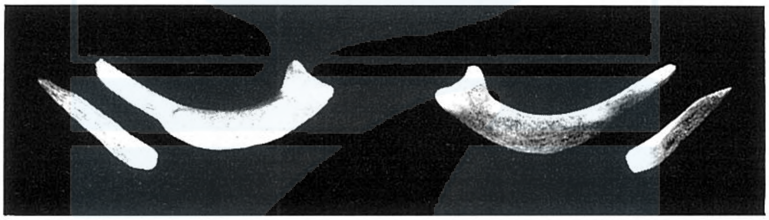

Fig. 12. Left and right lachrymals and malars of the Osaka specimen.

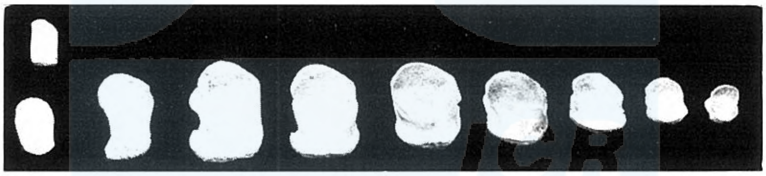

Fig. 13. Chevron bones of the Osaka specimen.

is one year and four month.

EXTERNAL AND INTERNAL PARASITES

External observation was done carefully, but, neither *Cyamus* nor *Pennella*, Barnacle nor *Conchoderma* was found. Only thin membrane of diatoms were seen on the parts of the body surface. White scars injured by microparasites were seen at the angle of gape and the abdominal side.

Internal parasites could not be discriminated because of decomposition of the internal organs.

TABLE 4. SKULL DIMENSIONS OF GREENLAND RIGHT WHALE FROM OSAKA BAY.

	Measurements		in cm	% of skull length
1.	Straight length of skull, tip of rostrum to condyle		198.0	100.0
2.	Straight length of rostrum		146.0	73.7
3.	*Length parallel with the axis of skull, from tip or rostrum* to posterior end of premaxillae	L.	152.7	77.1
		R.	152.8	77.1
4.	——— to anterior end of nasal, median		128.5	64.9
5.	——— to anterior orbital margin	L.	158.3	79.9
		R.	159.5	80.5
6.	——— to ant-orbital proc. of maxilla	L. & R.	154.4	77.9
7.	——— to anterior most point of occipital		159.0	80.3
8.	——— to posterior ends of pterygoid, median		174.2	87.9
9.	——— to posterior ends of palatine, median		170.5	86.1
10.	——— to anterior ends of palatine, median		146.4	73.9
11.	Length of maxilla, along superior lateral surface	L. & R.	156.0	78.7
12.	Straight length of premaxilla	L.	157.2	79.4
		R.	158.2	79.9
13.	Length of premaxilla, along superior surface	L.	163.0	82.3
		R.	163.5	82.5
14.	Straight length from tip of rostrum to anterior end of nasals, median		133.5	67.4
15.	Length from anterior ends of nasal to tip of rostrum along superior curve		144.0	72.7
16.	Straight length from tip of rostrum to anterior end of vomer visible on palate		83.7	42.3
17.	Length of vomer visible on palate		89.7	45.3
18.	Length of nasals, median		21.0	10.6
19.	Breadth of nasals, distal		11.1	5.6
20.	Breadth of nasals, proximal		7.7	3.9
21.	Breadth of rostrum at middle of rostrum		18.0	9.1
22.	,, at base		37.7	19.0
23.	Greatest breadth of superior nares		12.9	6.5
24.	Greatest breadth of premaxillae opposite superior nares		24.7	12.5
25.	Breadth of premaxillae at middle of rostrum		13.6	6.9
26.	Breadth between aterior ends of orbital proc. of frontal		100.2	50.6
27.	Breadth between centers of orbit		97.5	49.2
28.	Breadth between posterior ends of orbital proc. of frontal (greatest)		103.4	52.3
29.	Breadth of skull at orbital proc. of maxilla		100.0	50.5
30.	Breadth of skull at squamosals		102.1	51.5
32.	Straight length of lacrimal	L.	7.0	3.5
		R.	7.7	3.9
33.	Straight length of malar	L.	12.5	6.3
		R.	12.3	6.2
34.	Breadth between the highest points of squamosal		47.8	24.1
35.	Breadth of orbital proc. of frontal at distal end	L. & R.	11.8	6.0
36.	Greatest breadth of occipital		61.7	31.1
37.	Distance between anterior most point of supraoccipital to foramen magnum		44.8	22.6
38.	Breadth of occipital condyles		27.5	13.9

Continued . . .

TABLE 4. Continued.

	Measurements		in cm	% of skull length
40.	Breadth of foramen magnum		9.0	4.5
41.	Height of foramen magnum		7.5	3.8
42.	Height to skull at the highest point of occipital, when tip of rostrum and center of foramen magnum are put horizontal		68.0	34.3
43.	Height of skull at superior nares (maximum), at same posture		72.8	36.7
44.	Mandible, straight length	L.	185.2	93.5
		R.	184.2	93.0
45.	„ , length along lateral border	L.	191.5	96.7
		R.	193.0	97.4
46.	„ , length along internal border	L. & R.	186.0	93.9
47.	„ , depth at middle	L.	9.6	4.8
		R.	9.8	4.9
48.	„ , depth at coronoid proc.	L. & R.	19.6	9.9
49.	„ , depth at condyle	L.	25.3	12.8
		R.	25.4	12.8
50.	„ , breadth at condyle	L.	22.4	11.3
		R.	22.5	11.4

SKELETON

Vertebral formula of this whale indicate a little difference from that of Greenland right whale reported before. The first six cervical vertebrae were fused and the seventh was independent. This may have been caused by the very young age of this animal. There were 12 pairs of ribs which consisted of 10 pairs of two-headed ribs and 2 pairs of single-headed ribs. So the number of thoracic vertebrae was decided as 12. Generally, in other species of baleen whales, the last pair of ribs do not join to the vertebrae and found separately in the nearly abdominal part of the body. However, in this whale, when carefully observed, the last pair of ribs were attached to the vertebra. There were 10 lumbar vertebrae and 24 caudal ones with which 9 pairs of chevrons were attached. In most other species of whales, cranial chevrons and also caudal ones are separated into two laminae. In this whale only the first (cranial) chevron bone was separated.

The number of the digits also indicated a little difference from the number which had been reported by other scientists. Considering of the very young age of this whale, and some change were to be achieved in this whale later, the number is presented in a table only for reference.

The carpals had not been ossified, this may also because of the very young age.

Measured value of the skull is shown in Table 4, and those of vertebrae, ribs hyoid bones, chevron bones, scapulae and pectoral bones are shown in Tables 5, 6, 7, 8, 9 and 10 respectively.

As to the pelvic bones, taking X-ray photograph had been desired and kept into the refrigerator of the Taiji Whale Museum, however, when the refrigerator was repaired, the bones were taken for other useless things and were thrown away. Whenever we recall this accident we are fallen into deep regret. A question of how

TABLE 5. MEASUREMENTS OF VERTEBRAE OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

Vertebral number		Length of centrum	Breadth between transverse proc.	Total height	Breadth of neural canal	Height of neural canal
C[1]	1	14.0	33.3	26.3	11.3	9.0
	2		33.8	28.0	13.9	
	3		27.7		14.7	
	4		27.0		15.0	
	5		27.5		14.9	
	6		28.0	27.7	16.6	10.9
	7	3.4				
D[2]	1	3.8				
	2	4.4				
	3	5.2				
	4	6.0				
	5	6.5				
	6	6.9	36.0	31.0	14.8	12.2
	7	7.4	36.2	31.8	13.7	11.4
	8	7.8	37.0	32.2	12.8	11.3
	9	8.4	39.0	31.8	12.4	10.6
	10	8.4	42.2	31.1	12.2	9.5
	11	8.5	47.4	32.2	11.5	9.8
	12	8.7	51.6	32.9	10.7	9.6
L	1	8.9	52.7	33.9	9.9	9.4
	2	9.1	53.5	34.2	10.0	9.2
	3	9.3	52.4	34.7	9.6	8.6
	4	9.9	53.6	35.0	9.5	7.9
	5	10.0	54.9	35.6	9.0	7.0
	6	10.5	55.3	36.2	8.5	6.1
	7	10.7	55.3	34.7	8.6	5.3
	8	10.8	54.0	33.8	8.1	4.9
	9	10.9	48.8	32.6	7.2	4.5
	10	11.2	45.3	31.7	6.6	4.0
Ca	1	11.4	41.7	31.4	6.0	3.5
	2	11.4	39.4	30.6	5.8	3.5
	3	11.5	37.2	30.3	5.2	3.2
	4	11.5	33.5	28.8	4.8	2.9
	5	11.5	30.8	27.3	4.5	2.0
	6	11.6	28.6	25.3	3.5	1.5
	7	11.6	26.1	24.3	2.4	1.5
	8	11.3	23.0	23.7	1.8	1.4
	9	11.0	20.2	21.7	1.6	0.8
	10	10.5	17.8	20.4	1.4	0.8
	11[3]	9.8	16.1	19.0	1.1	0.6
	12	9.1	15.1	16.7	0.8	0.5
	13	8.0	13.4	13.3	—	—
	14	6.6	11.8	11.0	—	—
	15	6.0	10.0	9.4	—	—
	16	5.4	9.0	8.4	—	—
	17	5.1	8.1	—	—	—
	18	4.8	7.3	—	—	—

Continued . . .

TABLE 5. Continued.

Vertebral number	Length of centrum	Breadth between transverse proc.	Total height	Breadth of neural canal	Height of neural canal
Ca 19	4.4	6.4	—	—	—
20	4.0	5.8	—	—	—
21	3.5	5.0	—	—	—
22	2.8	3.9	—	—	—
23	2.4	3.1	—	—	—
24	2.1	2.2	—	—	—

1) 1st to 6th are fused.
2) Rami of neural arche and centrum of 1st to 5th are separated each other. Neural arches of 6 and 7th are not fused to the centrum.
3) Transverse proc. disapper.

TABLE 6. MEASUREMENTS OF RIBS OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

Serial number	Left			Right		
	Straight length	Length along visceral border	Largest breadth at the position near the distal end	Straight length	Length along visceral border	Largest breadth at the position near the distal end
1	66.5	70.0	9.4	62.5	69.5	10.3
2	73.0	93.0	12.1	72.5	94.5	12.0
3	77.0	112.0	11.0	76.0	113.0	11.4
4	82.5	119.5	9.6	81.0	120.5	9.6
5	86.0	124.5	7.8	85.0	124.0	8.7
6	85.0	125.0	8.5	87.0	125.0	7.9
7	85.0	123.0	6.4	86.5	124.5	6.9
8	83.0	118.5	5.0	83.0	119.5	4.9
9	80.0	109.0	5.1	79.5	108.5	4.7
10	76.5	92.5	5.7	76.5	92.0	5.4
11	74.0	80.0	6.6	73.0	80.5	6.6
12	68.0	70.0	6.1	68.0	70.0	6.2

TABLE 7. MEASUREMENTS OF HYOID BONES OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

	Left		Right
Stylohyoids, straight length	12.2		11.5
„ , width at distal end	3.2		3.2
„ , width at praximal end	4.0		3.5
Thyrohyoids, straight length	13.0		12.5
„ width at distal end	4.3		4.7
„ , width at proximal end	6.6		6.5
Basihyoid, Length at anterior process	8.8		8.8
„ , width between anterior proc.		4.2	
„ , greatest width		9.4	
„ , width at posterior edge		5.8	

TABLE 8. MEASUREMENTS OF CHEVRON BONES OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

Number	Height	Antero-posterior breadth at proximal end.	Transverse breadth
1	L. 6.3	3.2	—
	R. 6.9	4.7	
2	9.9	6.0	11.7
3	9.1	7.9	10.7
4	10.9	7.3	11.6
5	10.0	7.9	11.1
6	7.6	7.1	10.1
7	5.9	6.2	6.6
8	4.7	4.3	6.8
9	3.9	3.4	5.9

TABLE 9. MEASUREMENTS OF SCAPULAE OF GREENLAND RIGHT WHALE FROM OSAKA BAY (cm)

Measurements	Left	Right
Length	47.5	47.7
Height	38.0	37.8
Acromion proc., length	8.2	8.7
„ , breadth at distal end	3.7	3.7
Coracoid proc., length	3.2	2.4
Glenoid cavity, length	14.4	14.4
Glenoid cavity, breadth	12.2	12.2

TABLE 10. MEASUREMENTS OF BONES IN FLIPPERS (cm)

Measurements	Left	Right
Humerus, length	20.2	20.6
„ , proximal breadth	15.6	15.5
„ , distal breadth	14.9	15.0
Radius, length	26.3	26.4
„ , proximal breadth	10.6	10.6
„ , distal breadth	11.0	10.9
Ulna, length	26.4	26.0
„ , proximal breadth	9.5	9.3
„ , distal breadth	9.9	9.4

much above mentiond cartilages were to be occified later, was left.

The skeletal specimen was mounted and kept at the Taiji Whale Museum.

SUMMARY

A very young Greenland Right Whale, (*Balaena mysticetus* LINNAEUS, 1758), 6,4 m in body length, was caught at Osaka Bay in June 23, 1969. Here is the report of the morphological and osteological study done on this whale. It was a great pleas-

ure to investigate a rare species of a whale by a precious chance. It was a matter for some regret that the most internal organs were hardly examined because of complete decomposition and no organic specimen was collected. However, a complete skeleton was collected (pelvic bones were accidentally lost later) and measured. The skeleton is now kept and exhibited at the Taiji Whale Museum.

ACKNOWLEDGEMENTS

We extend our sincere gratitude to the Hamadera Fishermen's Union in Sakai City for its kind co-operation. Our gratitude and respect should also be presented to Messrs. Kazumi Kunishige, Masao Takeshige of Fishery and Forestry Boad of the Agriculture and Forestry Bureau of Osaka, and Ginzo Ito of Agriculture and Fishery Boad of Sakai City for their kind treatment which made us possible to investigate the precious whale. At the end, we can not forget the stuff members of the Taiji Whale Museum (Director: Mr. T. Higashi). They gave us kindest co-operation to our research.

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EXPLANATION OF PLATES

PLATE I

1. Greenland right whale, Osaka specimen, Male.
2. Dorsal view of the Greenland right whale, just after expiration.
(Photo by Yomiuri Press, Osaka)
3. Spouting of the Greenland right whale, only nostrils were seen above the water surface.
(Photo by Sankei Press, Tokyo)

PLATE II

Dorsal, lateral and ventral views of the skull of the Greenland right whale.

PLATE III

1. Lateral view of the skull of the Greenland right whale, mandible attached.
2. Dorsal view of the mandibles of the Greenland right whale.
3. Posterial view of the skull of the Greenland right whale.

PLATE IV

Anterior (1), lateral (2) and posterior (3) views of the cervical vertebrae of the Greenland right whale.
Lateral views of the thoracic (4), lumber (5) and caudal (6) vertebrae of the Greenland right whale.

PLATE V

Outer view of the ribs and the sternum of the Greenland right whale.

PLATE VI

1. Lateral view of the left scapula of the Greenland right whale.
2. Lateral view of the right scapula of the Greenland right whale.
3. Dorso-lateral view of the right flipper of the Greenland right whale.
4. Bones in the left flipper of the Greenland right whale.


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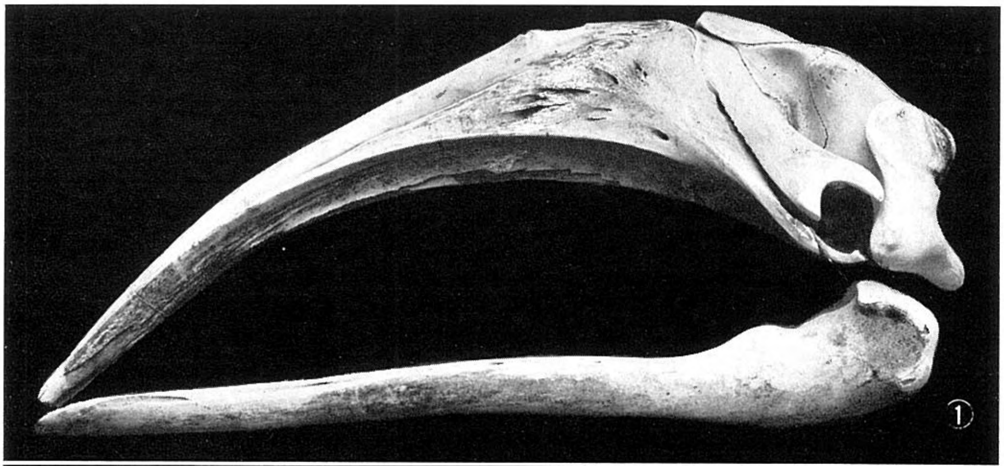
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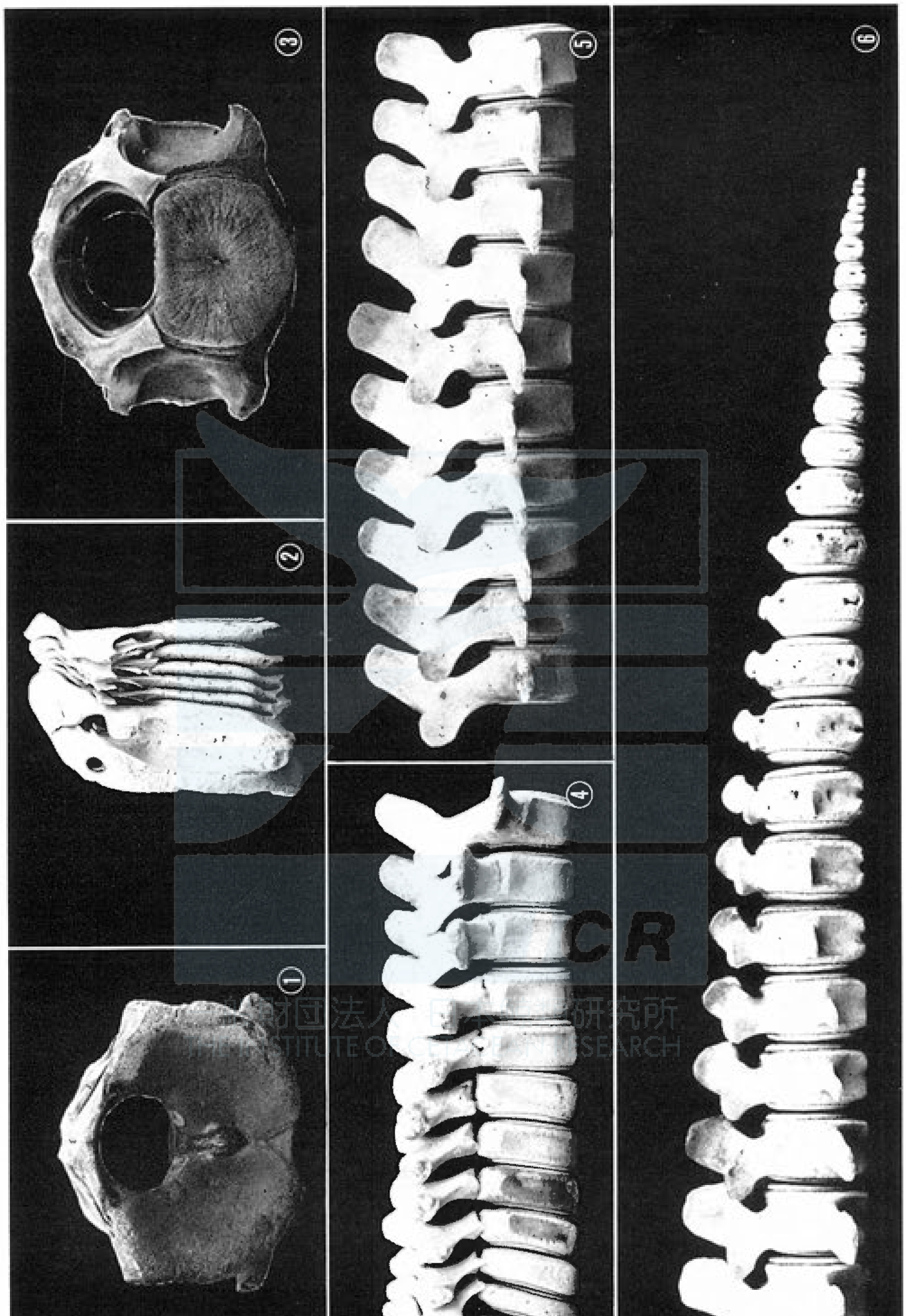
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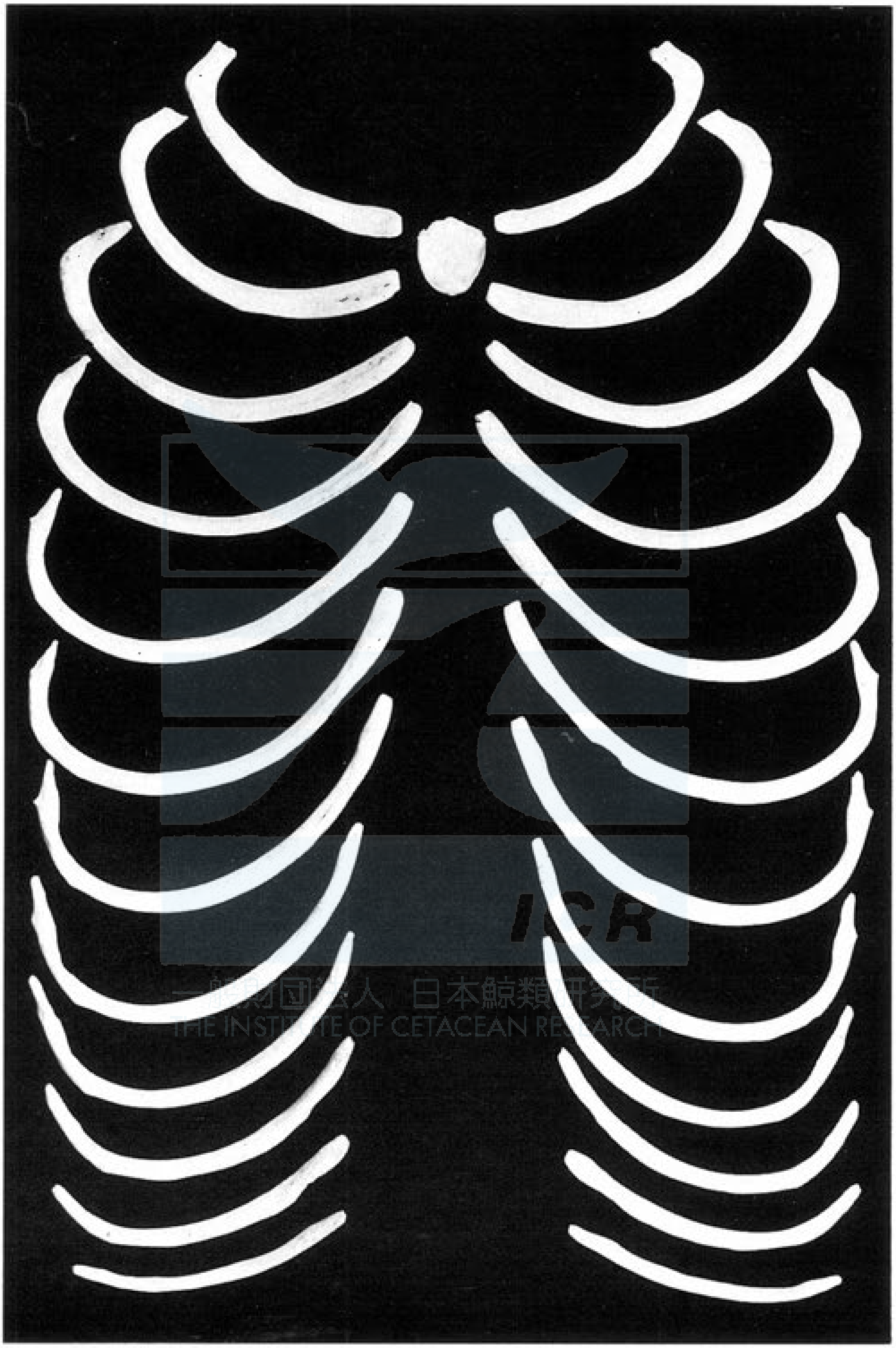

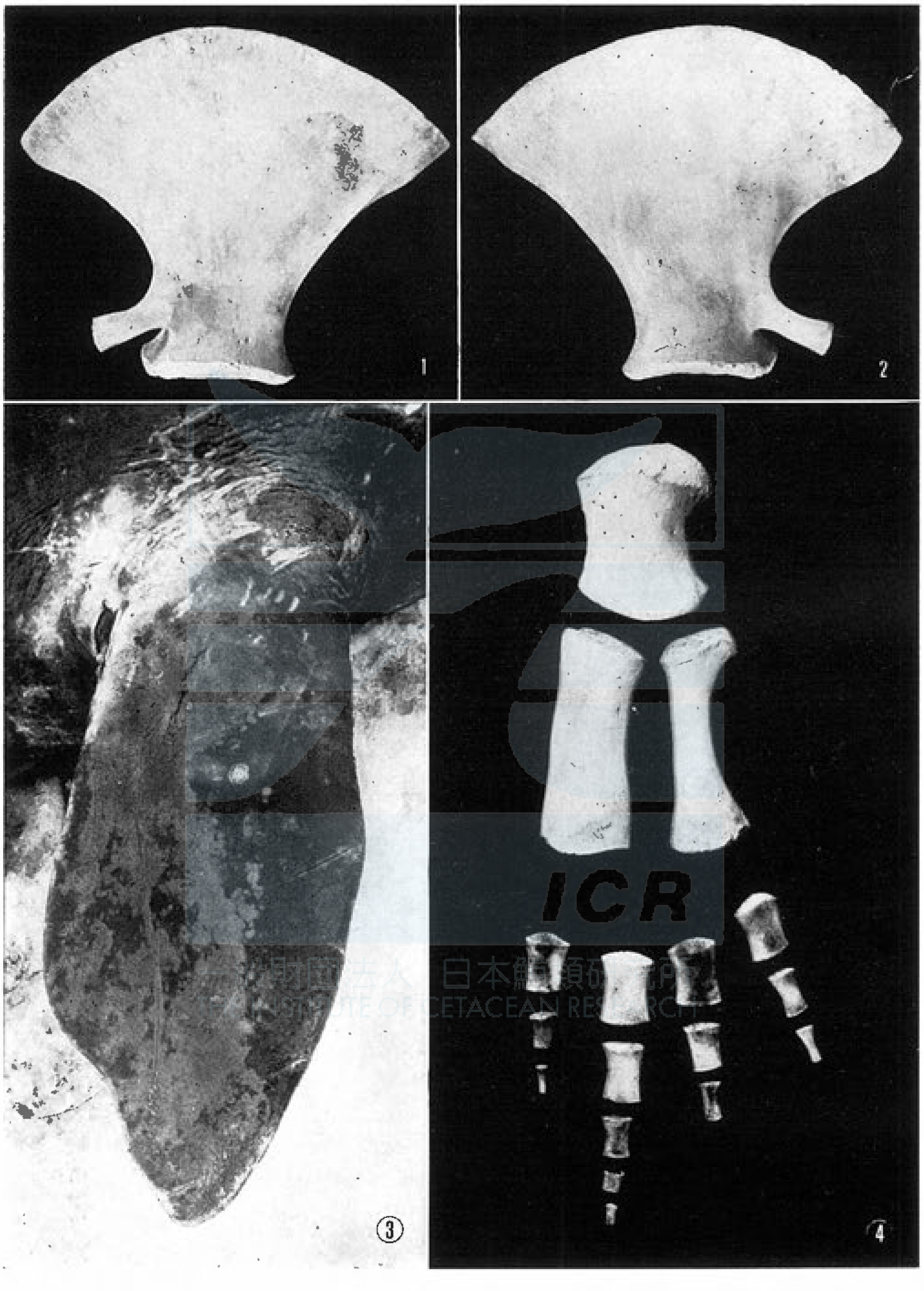
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SOME BIOLOGICAL PARAMETERS FOR STOCK ASSESSMENT OF THE ANTARCTIC SEI WHALE

KEIJI NASU* AND YASUAKI MASAKI*

INTRODUCTION

The industrial significance of sei whales in the Antarctic has grown considerably in recent years and at the same time whale resource control is emerging as an important problem. However, the knowledge concerning biological parameters which are fundamental to stock assessment is still very limited, so that the knowledge related to age characteristics is practically little.

One biological report on the sei whales in the Southern Hemisphere has been presented by Mattews (1938). He reported on the external characters, food, blubber, parasites, reproduction, growth and migration observed from the 220 whales caught in South Georgia and South Africa.

There has been other reports also by Bannister and Gambell (1965) and by Gambell (1968) on abundance, seasonal cycle and reproduction, but the data for these have been obtained from Antarctic Area II, excluding South Africa.

In this report, specimen obtained by the Japanese expeditions from Area II to IV were used. Examination was made on, sex ratio, size composition, length at sexual maturity, sexual maturity rate, pregnancy rate, number of corpora lutea and, lamination of ear plug and length at recruitment. It is especially importance that the relationship of race between sei whales found in Area V, the Tasman Sea and the eastern waters off New Zealand, and those found in other Areas should be understood, and that operations in that Area by the Japanese expeditions only started in the 1967/68 season.

MATERIAL

Data used were obtained by the Japanese expeditions in the Antarctic whaling seasons in 1963/64, 1964/65, 1967/68, and 1968/69. In Table 1 N indicates northern area of 50°S and S does southern one of 50°S.

SURFACE OCEANOGRAPHIC CONDITION IN RELATION TO THE DISTRIBUTION OF SEI WHALES CAUGHT

Fig. 1 indicates the number of sei whales caught in the area of every 5 degree of longitude and latitude by the Japanese expeditions in the whaling season extending from 1963/64 to 1968/69.

Fig. 2 and 3 indicate the number of whales caught in the area of every degree of latitude and longitude in Areas II, part of V and VI; and the distribution of surface temperature obtained by the Japanese expeditions. The main whaling ground in the low latitude of Area IIW consists of a warm water mass which is

* Far Seas Fisheries Research Laboratory, Fisheries Agency.

considered to be an extension of the Brazil Current. If the Antarctic Convergence is considered to be at surface temperature of 4.5°C, the favourable ground for sei whales in Area II W is located in the north of the Antarctic Convergence.

According to Fig. 3 heavy catch area in the eastern waters of Tasman Sea is adjacent to the surface temperature of 15°C, but in the western waters it is adjacent to the 12°C, which is equivalent to the north of Subtropical Convergence. In Area VI, favourable ground is located in the region of the surface temperature of 8°–10°C.

In this area warm water mass generally extends southwards and the latitudinal position of the Antarctic Convergence extends toward the south as in Area I and II. These are features particular to the oceanographic environment of Area VI.

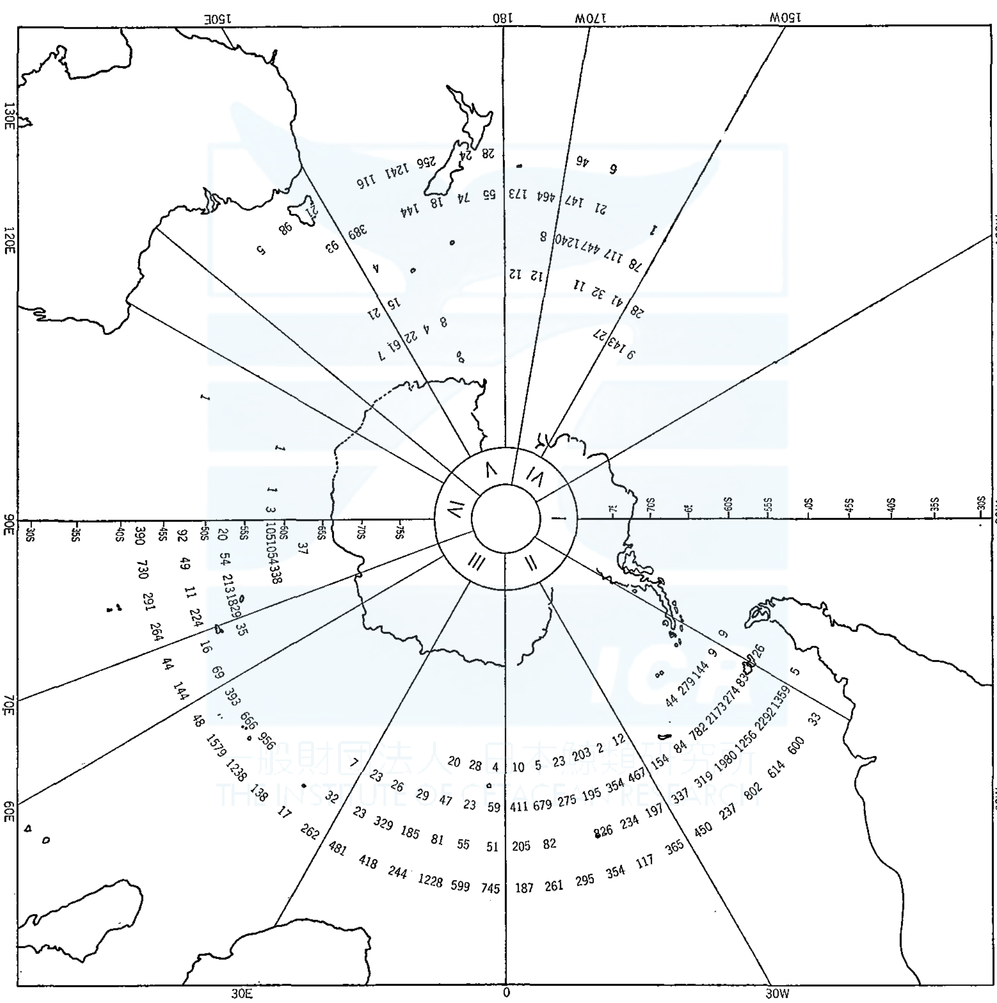

Fig. 1. Number of sei whales caught in the area of every 5 degree of longtitude and latitude by the Japanese expeditions in the Antarctic whaling seasons from 1963/64 to 1968/69.

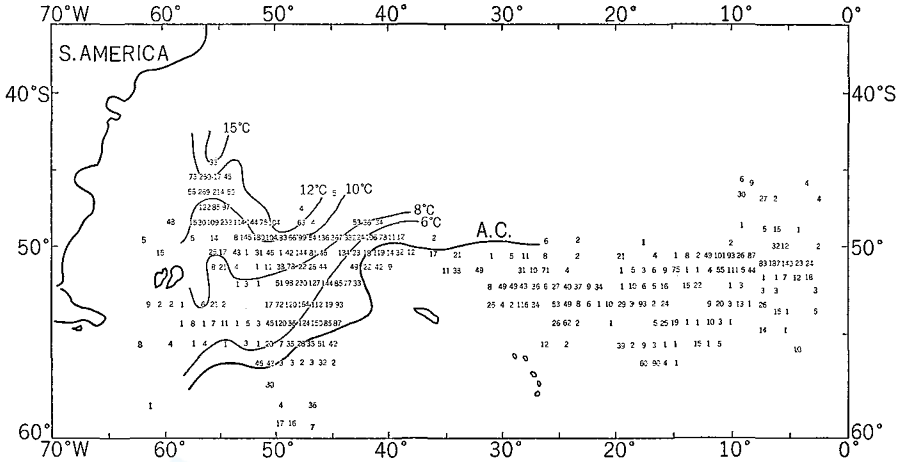

Fig. 2. The distribution of sei whales caught by Japanese expeditions in the Antarctic season 1962/63 to 1964/65 and the surface temperature.

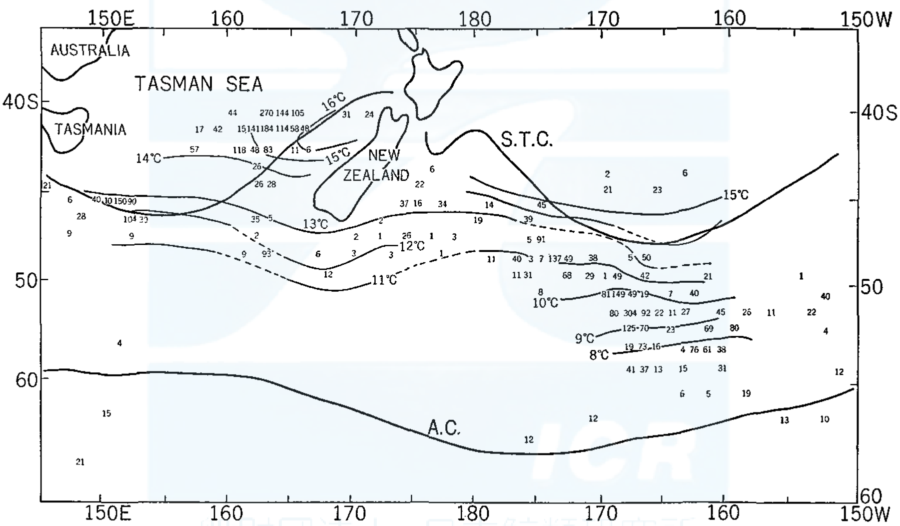

Fig. 3. The distribution of sei whales caught by the Japanese expeditions in the Antarctic season 1967/68 to 1968/69 and the surface temperature.

SEX RATIO

Table 1 shows the male sex ratio by Area, north and south of 50°S. No particular difference by Area can be observed but some differences can be noticed in the south and north of 50°S. It indicates that in the region excluded Areas II W and V male whales are seen in greater numbers in the high latitude sea region of 50°S. The average value for the total Area extending from Area II W to VI is 55.5 % in the north and 57.7 % in the south with difference of 2.2 %. The male foetus

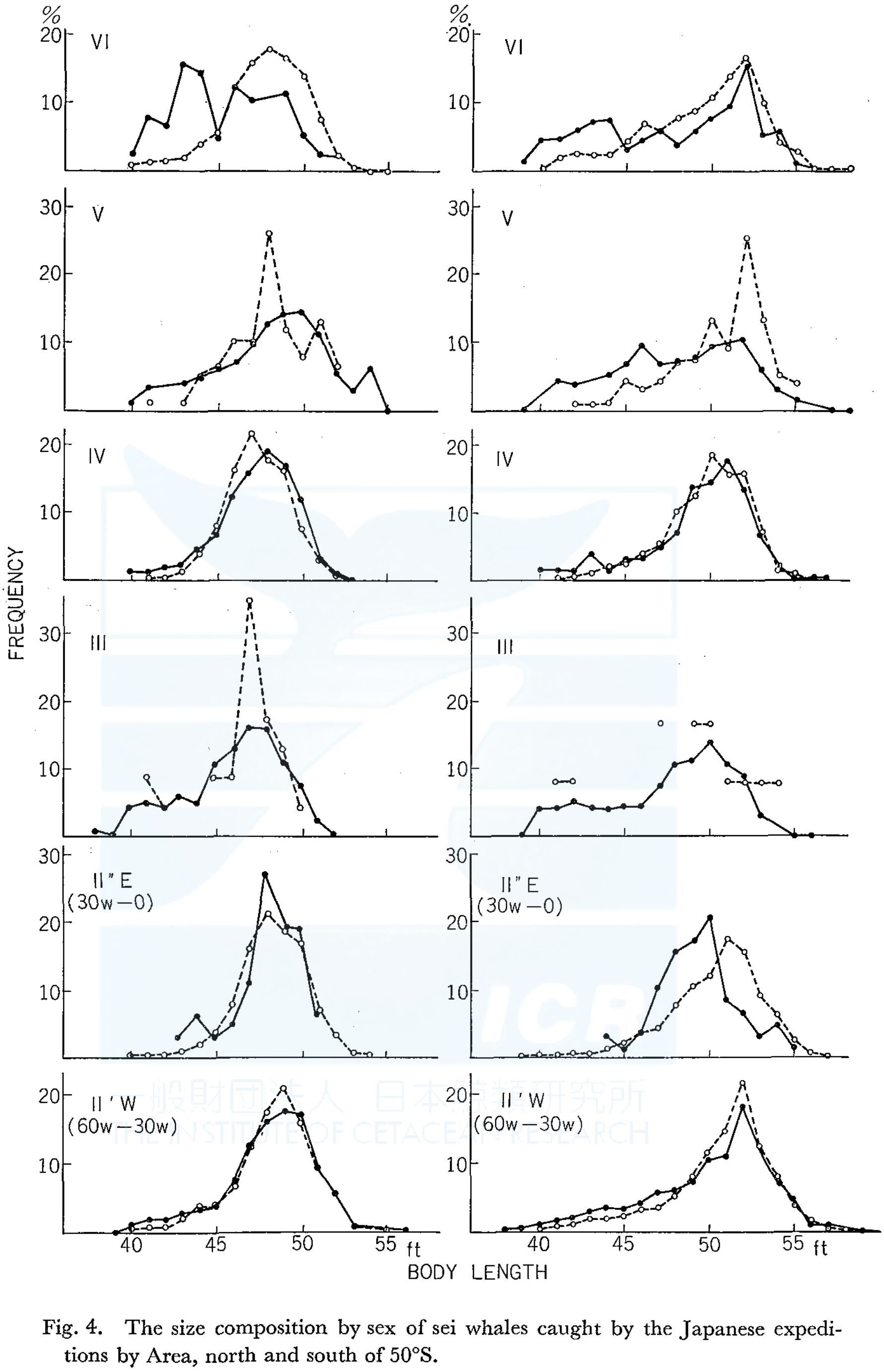

Fig. 4. The size composition by sex of sei whales caught by the Japanese expeditions by Area, north and south of 50°S.
Left side : male, Right side : female.
Solid line : North of 50°S
Dotted line : South of 50°S

sex ratio of sei whales in the Antarctic whaling season in 1934/35 to 1965/66 is 49.7% (Gambell 1968), and this ratio is considered to be indicative of natural state, so that in the Southern Hemisphere it can be said that there is a tendency for the male whales to migrate further into higher latitudes than the female ones.

SIZE COMPOSITION

The size composition by sex of sei whales caught by the Japanese expeditions by Area, north and south of 50°S is shown in Fig. 4. The distribution of body length for the total Area extends from 38 to 58 ft. for male and 37–59 ft. for female. The modes for both are 48–49 ft. and 51 ft. respectively. The ratio of smaller male whales under 45 ft. is 21 % in the north of 50°S and 12 % in the south of 50°S, but the ratio for larger whales over 50 ft. is 27.1 % in the south and 26.4 % in the north. The difference between north and south of 50°S is found to be slightly greater in the number of male in the north of 50°S, but it shows almost the same

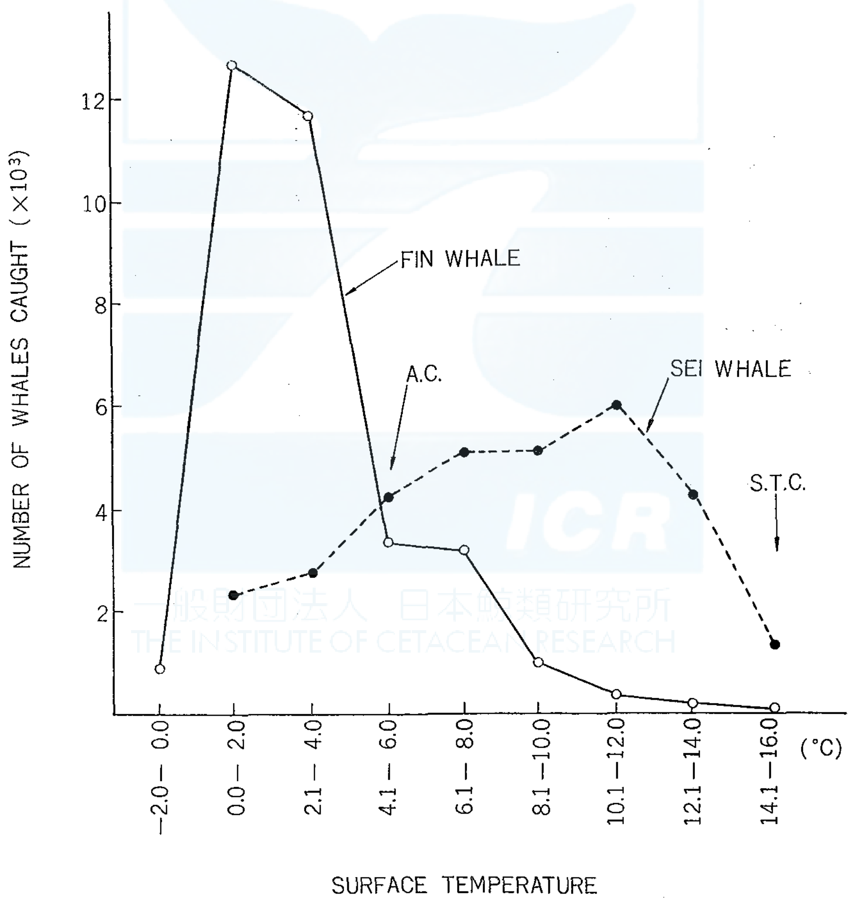

Fig. 5. Relationship between the surface temperature and the number of whales caught by species.

TABLE 1. BIOLOGICAL PARAMETERS OF SEI WHALES IN THE ANTARCTIC BASED ON JAPANESE EXPEDITIONS

Area		II W		II E		III		IV		V		VI		Total	
Region		N	S	N	S	N	S	N	S	N	S	N	S	N	S
Sex ratio of male		58.0*	57.2*	52.5*	61.7*	52.2	65.7	53.3	56.7	54.2	44.3	52.3	57.1	55.5	57.7
Mean body length	M	48.1*	48.3	49.8*	48.3*	46.2	46.6	47.4	47.3	47.8	48.1	45.7	47.7	47.6	48.0
	F	50.0	50.7	49.3	50.3	47.8	48.8	49.3	49.7	48.1	50.5	47.8	49.6	48.9	50.2
Sexual maturity rate	M			95.3**		85.2	100.0	92.5	97.9	84.4	90.9	67.9	92.0	85.9	94.3
	F			96.0**		71.2	75.0	83.6	92.9	58.4	86.6	64.6	76.3	68.1	83.0
Body length at sexual maturity	M			—		43.4		42.3		43.5		43.5		43.5	
	F			—		45.6		45.4		46.8		47.4		46.0	
Pregnancy rate				65.0**		53.3	44.4	55.3	63.2	61.2	73.8	63.4	53.6	57.2	58.9
Mean number of corpola lutea				—		4.60	7.33	6.41	7.19	5.42	7.41	4.72	5.94	5.43	6.52

* 1964/65
** 1963/64
No mark 1967/68, 1968/69.

TABLE 2. AGE AND BODY LENGTH AT RECRUITMENT OF SEI WHALES BY AREA

Age at recruitment

Area	III		IV		V		VI		Total	
Recruitment	Total	50%	Total	50%	Total	50%	Total	50%	Total	50%
Male	20.0	14.9	22.0	16.3	22.0	12.6	20.0	13.8	22.0	15.0
Female	18.0	13.5	20.0	14.4	19.0	14.5	23.0	16.9	20.0	15.4

Body length at recruitment

Area	II W		II E		III		IV		V		VI		Total	
Recruitment	Total	50%	Total	50%	Total	50%	Total	50%	Total	50%	Total	50%	Total	50%
Male	49.0	38.1	48.0	47.7	47.0	45.7	47.5	46.5	49.5	47.1	48.0	46.1	48.0	46.9
Female	52.0	50.6	51.0	50.5	50.0	47.8	51.0	49.7	52.0	48.3	52.0	49.8	52.0	49.6

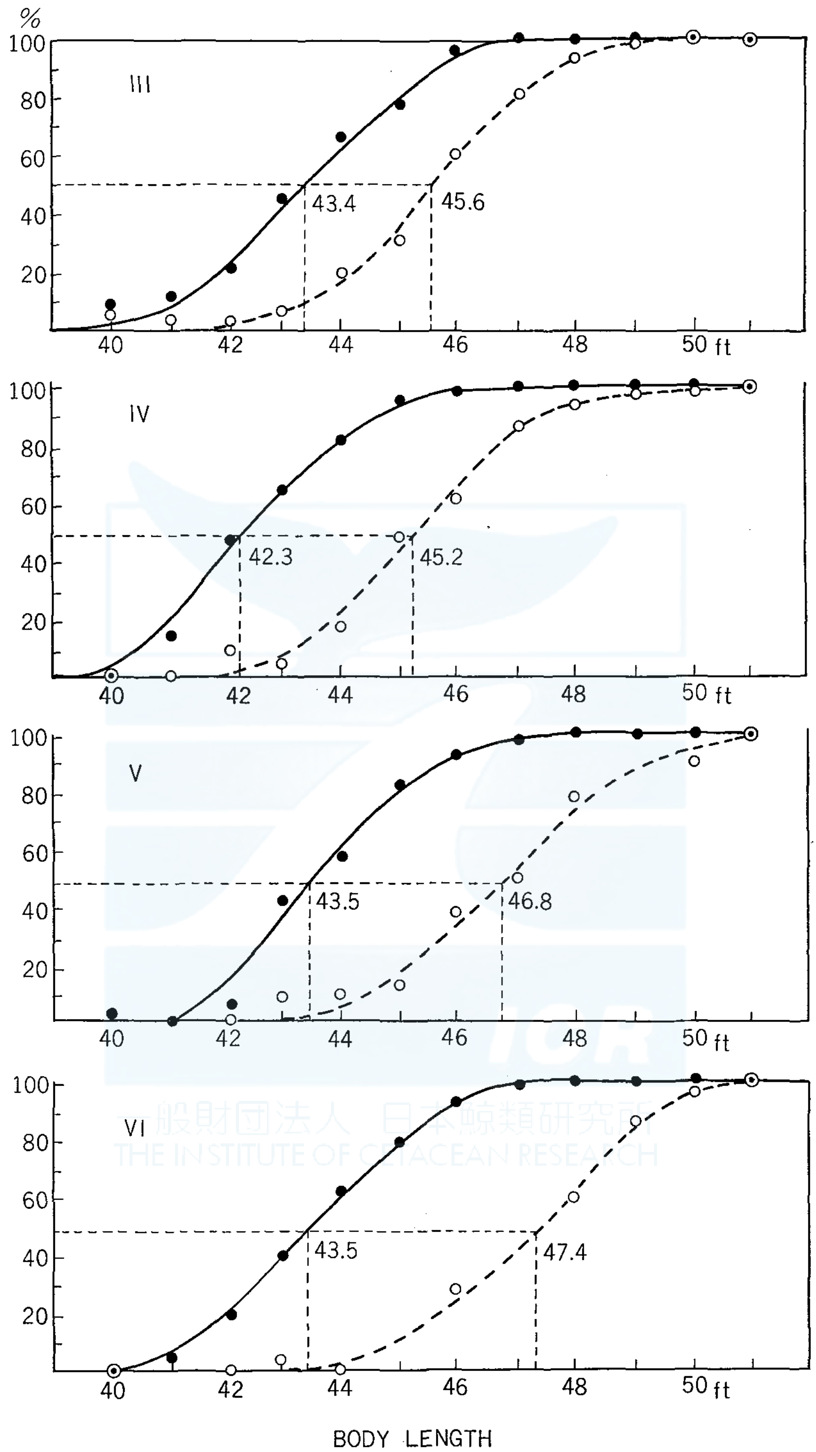

Fig. 6. Body length at sexual maturity

ratio. The ratio of medium size whales of 45 to 50 ft. is large in the south of 50°S.

The small size whales under 47 ft. are 32 % in the north of 50°S and 22 % in the south of 50°S and show a larger concentration in low latitudes. Medium size whales are found in greater numbers in the south of 50°S and larger whales show figures of 31 % in the north of 50°S and 29 % in the south of 50°S respectively. They fairly uniformly distribute regardless of latitude.

In summarizing the latitudinal distribution of sei whales in the Antarctic can generally be explained that smaller whales distribute in low latitude, medium whales are in high latitude and larger whales evenly distribute in low and high latitude. The difference of mean body length between the low and high latitude is summarized in Table 1.

Based on the size composition in Fig. 4 examination of the composition by Area shows that in Area II W and VI small group found in the south of 50°S. This phenomena may be considered to arise from oceanographic conditions.

This means that according to data obtained by Japanese expeditions, as seen in Fig. 5, sei whales are distributed in the north of the Antarctic Convergence, and the Antarctic Convergence in Area II W and VI is found in higher latitudes than in other Areas.

When the forementioned tendency in the latitudinal distribution of body length is takes into consideration, a heavy distribution of small group in higher latitudes can be thought to be derived from the fact that there is a water mass which possesses low latitude features extending southward into high latitudes.

Mean length by Area in Table 1 shows that in the whole of Area II to VI male is 47.6 ft. and female is 48.9 ft. in the north of 50°S and, in the south of 50°S those are 48.0 ft (male) and 50.2 ft (female) respectively. On the mean there are higher values in high latitudes as shown in Fig. 4.

In the north of 50°S in Areas III and VI the body length is short for male with figures of 46.2 ft. and 45.7 ft. This derives from the fact that the ratio of small group is higher as shown in Fig. 4. The mean length for female in Areas III, V and VI is short because of the same reason.

SEXUAL MATURITY

a) *Sexual maturity rate*

As shown in Table 1, the sexual maturity rate in the north of 50°S is both male and female larger than that in the south of 50°S. Those maturity rates by Area show the largest in the Antarctic Areas II and IV, which it may be considered that the old year group are more than other Area.

b) *Mean length at sexual maturity*

The analysis on this problem was done using data resulting from examination of testis and ovary material sampled in 1963/64, 1964/65, 1967/68, and 1968/69. As the index of sexual maturity were used, the animals with 1 Kg. or more testis weight in male and one or more corpora in ovaries of female were sexual mature.

The percentage of mature animal at each length for male and female sei whales was plotted as shown in Fig. 6. From Fig. 6 the length at which 50 % of whales are mature, and which is taken as the mean length at sexual maturity, is obtained. These length are shown in Table 1. The mean length in Area IV shows both male and female had the minimum value with 42.3 ft. and 45. 2 ft., respectively. The mean length in Tasman Sea and east sea region of New Zealand corresponding to Area V and VI are higher than the figures in Areas III and IV.

Consequently, it must be caused by large length at sexual maturity that the figures of mean length in Tasman Sea and east sea region of New Zealand are small.

The figure of male in each Area except Area IV agree closely each other, but

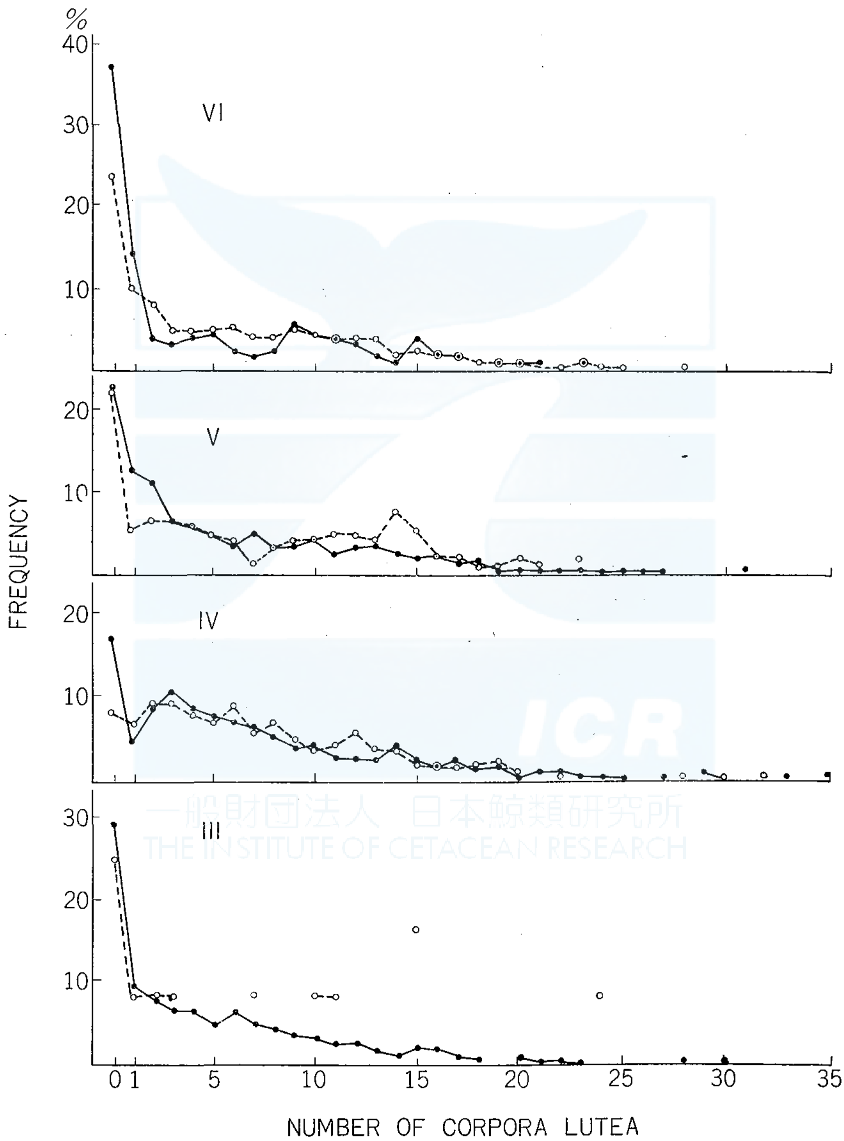

Fig. 7. Frequency of number of corpora lutea.

there are difference between the female in Area III, 45.6 ft. and Area VI, 47.4 ft.

This is one of the cause which occured with the difference of sexual maturity by Area. The mean length at sexual maturity length of female in Area III agree closely with that from Durban (Bannister and Gambell 1965) and such phenomena may be caused by same race, because these sea regions locate nearly each other. However, the problem on the race between Durban and Area III must be analyzed from other data.

PREGNANCY RATE

Pregnant whales constituted 57.2 % and 58.9 % respectively of mature females in the north and south regions of 50°S, so we can find that the pregnancy rate in the south region of 50°S is barely higher than that in the north region. The pregnancy rate in all Areas was estimated about 58 %, but the pregnant whales have a tendency to leave earlier from Antarctic in the whaling season. From that reason, the figure of pregnancy rate should be discussed from the point of whaling season and Area.

COMPOSITION OF NUMBER OF CORPORA IN THE OVARIES

Table 1 shows the mean number of corpora by Area. Fig. 7 shows the frequency of number of corpora. The proportions of young group derived from the number of corpora in Area III and VI are larger than that in Areas IV and V. It is just similar with the size compositions. The mean number of corpora in the north of 50°S in Areas III and VI are low, and that in the south region of 50°S in Area VI is also low compared with other Areas. The number of corpora in all Area, generally speaking, increase with latitude.

AGE AND LENGTH AT RECRUITMENT

Table 2 shows the age and length at recruitment by Area. The mean age and length at recruitment in all Areas are 22.0 years, 48.0 ft. in male and 20.0 years, 52.0 ft. in female, respectively. Furthermore the age and length at 50 % recruitment are 15.0 years, 46.9 ft. in male and 15.4 years, 49.6 ft. in female, respectively.

The age at total recuitment of male in Areas III and IV, 20.0 years is younger than that in Areas IV and V, 22.0 years. This is explained by Fig. 4, in which the mode of size composition shows the large value in Areas IV and V. On the other hand, the age at the youngest and oldest on the female were found in Area III, 18.0 years and in Area VI, 23.0 years, respectively.

The characters on the length at recruitment by Area are as follows;

Male; minimum in Area III, 47.0 ft., maximum in Area V, 49.5 ft.

The case of female also shows a tendency to similar with male. From above mentioned, it can be concluded that the age at recruitment is older than the age at sexual maturity.

The age and length at total, and 50 % recruitment were obtained by each composition of age and size. Here the age at total recuitment took the mode *b* in Fig. 8 showed the frequency of age. The age at 50 % recruitment was obtained by point *a* which means that the numbers of whale from 0 to 5 years equal to that from *a* to *b* years.

Furthermore the length at recruitment is obtained by the similar to the case of age.

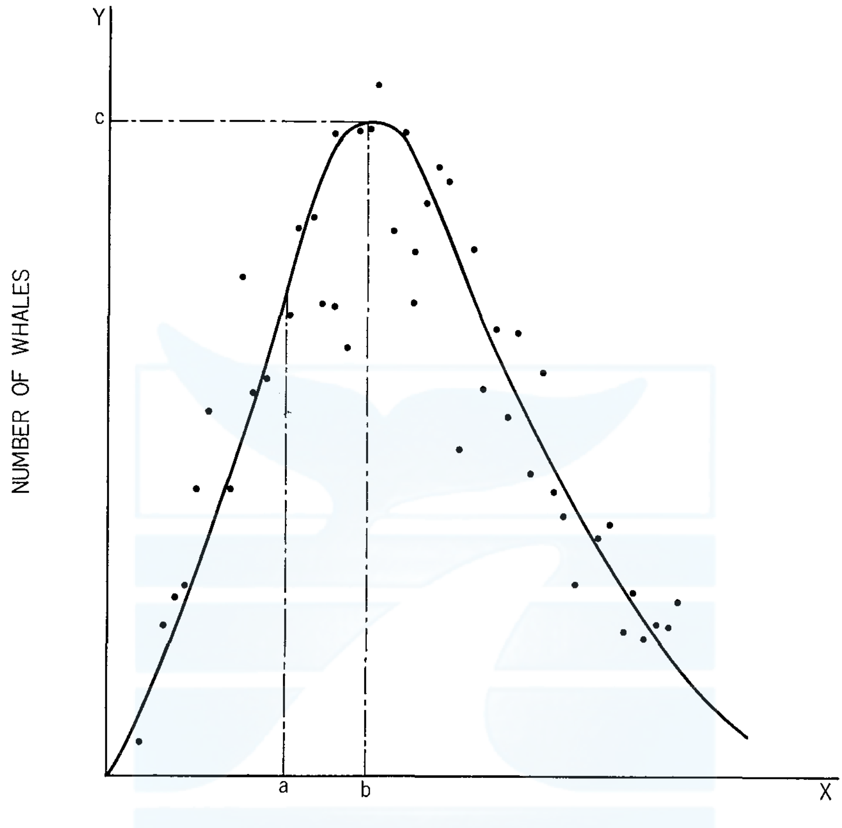

Fig. 8. Age at recruitment

SUMMARY

1) The biological paremeters of sei whales in the Antarctic were analyzed based on the data sampled by Japanese expeditions.

2) The favourable ground of sei whales, in general, occurred in the north sea region of Antarctic Convergence.

3) The foetus male sex ratio of sei whales in the Antarctic showed 49.7% (Gambell 1968), but that of whales caught have tendency increases with latitude.

4) The small group less than 45 ft. dominates in the northern region of 50°S, while the large group more than 50 ft. distributes of a uniform both north and south region of 50°S.

5) The sexual maturity rate is both male and female larger than that in the south region of 50°S, and shows the maximum value in Areas II and IV.

The length at sexual maturity is large both male and female in Area IV and small in Area VI

6) The mean pregnancy rate in all Areas was estimated to be about 58%, but the figure should be discussed from the point of whaling season and Area.

7) The proportion of young group derived from the number of corpora in Areas III and VI are larger than that in Areas IV and V. The number of corpora, in generaly speaking, increases with latitude.

8) The age and length at total and 50% recruitment are estimated, and those mean values in all Areas are as follows;

		Total	50%
Age	male	22.0	15.0
	female	20.0	15.4
Length	male	48.0	46.9
	female	52.0	49.6

Where it was assumed that one lamina in ear plug accumulated a year.

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STOCK OF THE ANTARCTIC MINKE WHALE

SEIJI OHSUMI*, YASUAKI MASAKI*
AND AKITO KAWAMURA

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.

* Far Seas Fisheries Research Laboratory, Fisheries Agency.

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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 accompanied 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*).

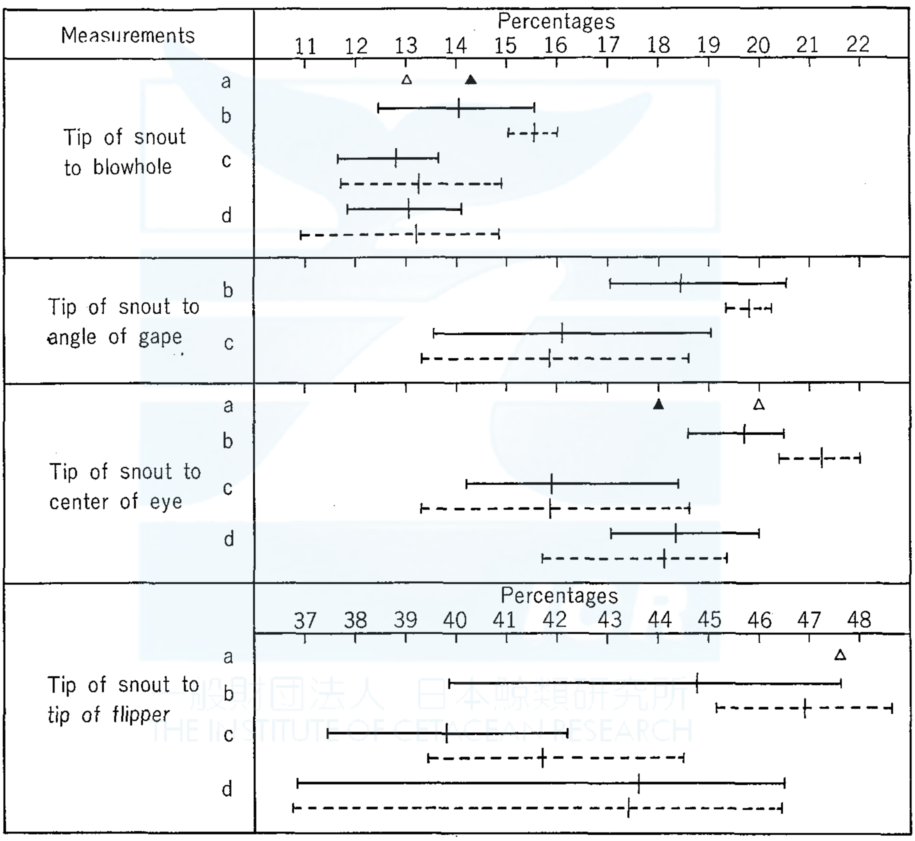

Fig. 1. Proportions related to head length on minke whales from the Antarctic, North Pacific and Atlantic Oceans.
——— Males. ············ Females. *Antarctic* a: Williamson (1959) ▲, and Utrecht and Spoel (1962) △, b: Present study. *North Pacific* c: Omura and Sakiura (1956). *North Atlantic* d: Jonsgård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

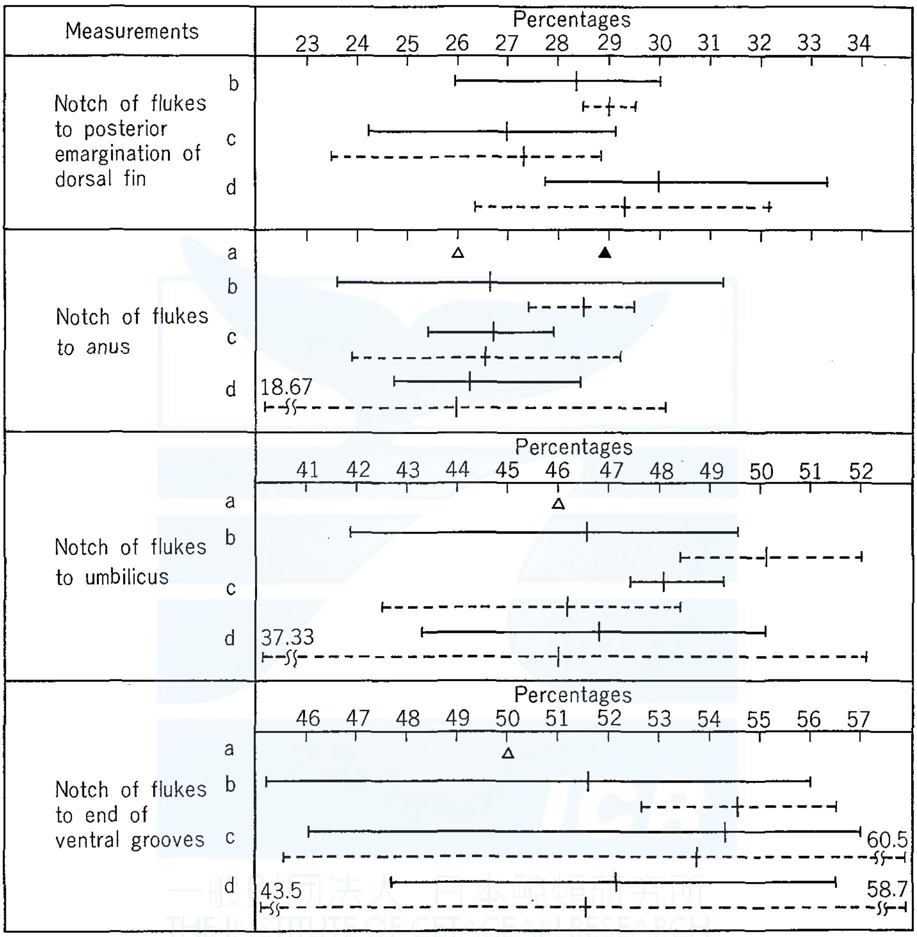

Fig. 2. Abdominal proportions on minke whales from the Antarctic, North Pacific and Atlantic Oceans. Legend as in Figure 1.

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.

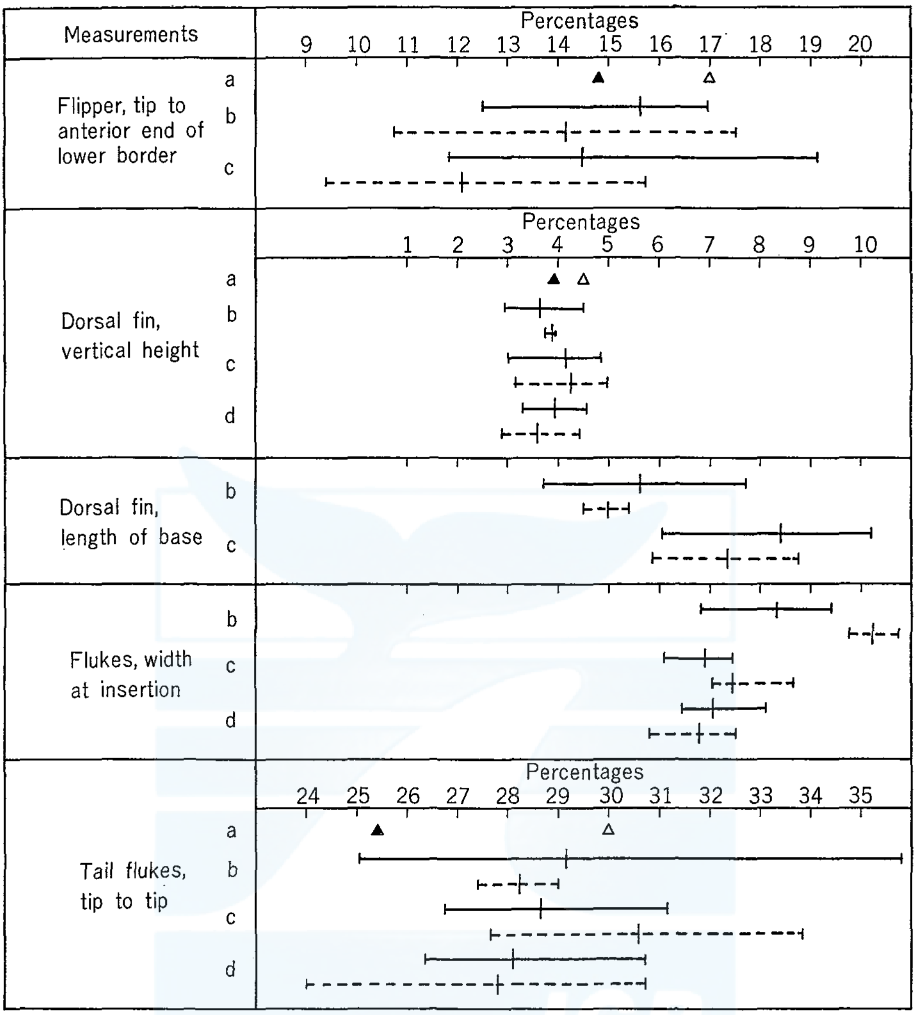

Fig. 3. Proportions of appendages on minke whales from the Antarctic, North Pacific and Atlantic Oceans. Legend as in Figure 1.

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

Workers	Present authors			
Sex	Males			
Measurements	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.

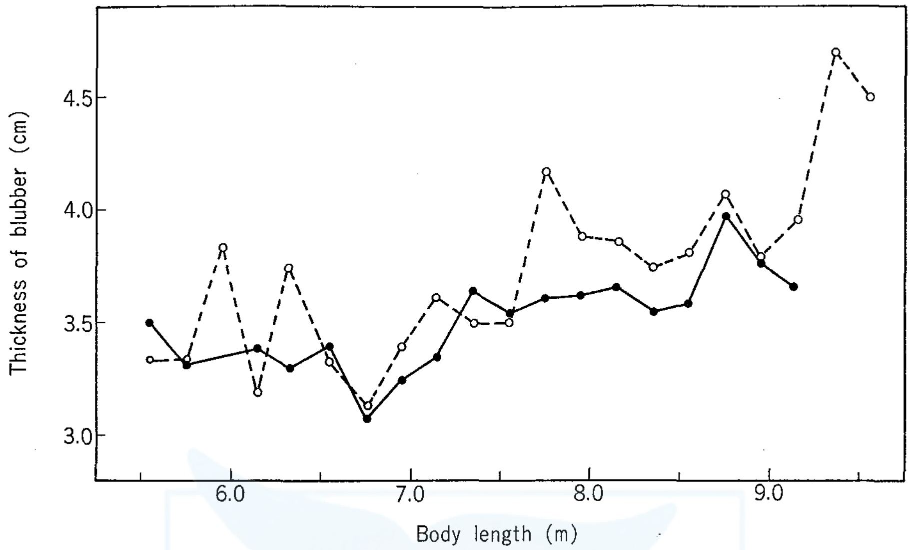

Fig. 4. Mean thickness of blubber at each body length in the Antarctic in December, 1967/68. Open circle and broken line: females, Closed circle and solid line: males.

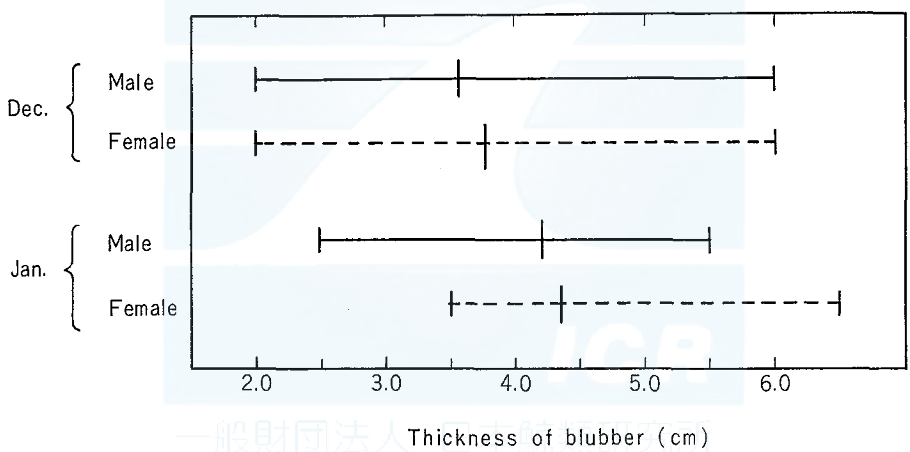

Fig. 5. Range and mean of blubber thickness in minke whales in the Antarctic.

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.

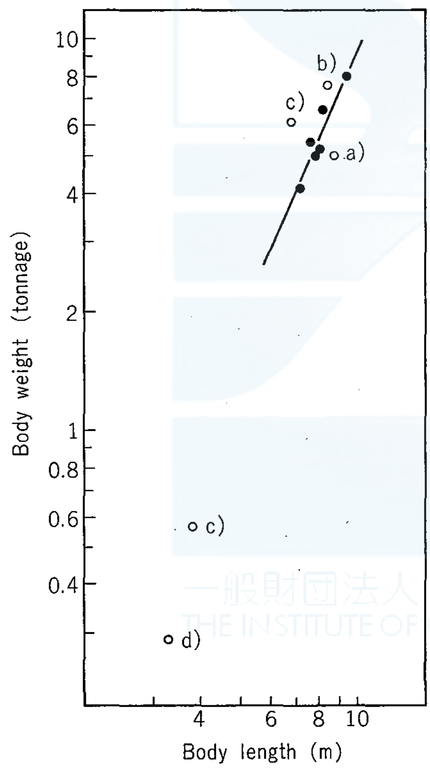

Fig. 6. Plot of body weight against body length for minke whales.
Closed circle: Antarctic Open circle: a) Tomilin (1957), b) Zenkovich (1955), c) Scheffer and Slipp (1948), d) Fry (1935).

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,

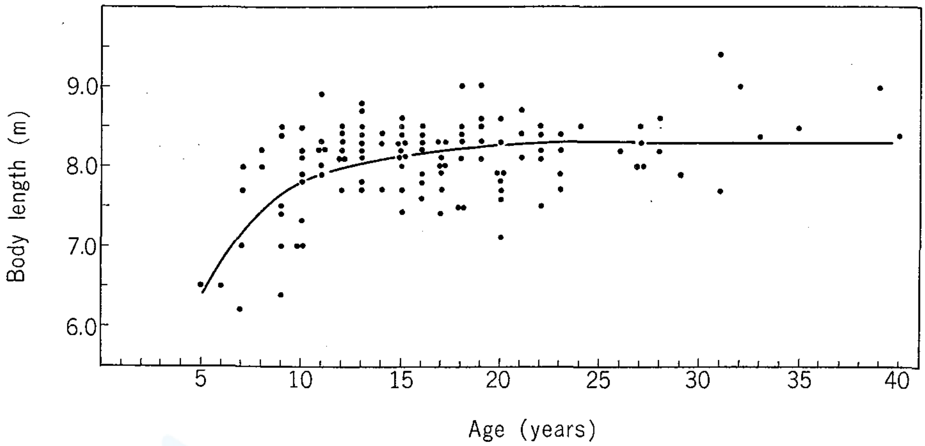

Fig. 7a. Growth curve of the male minke whales in the Antarctic.

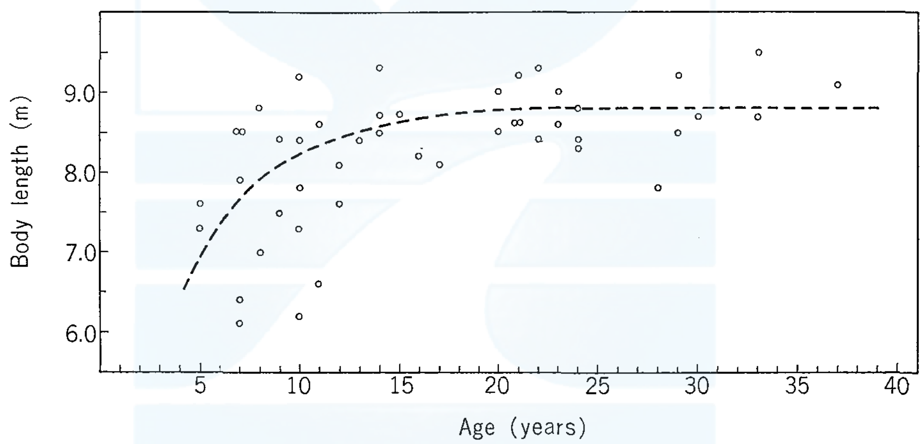

Fig. 7b. Growth curve of the female minke whales in the Antarctic.

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 immature 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.

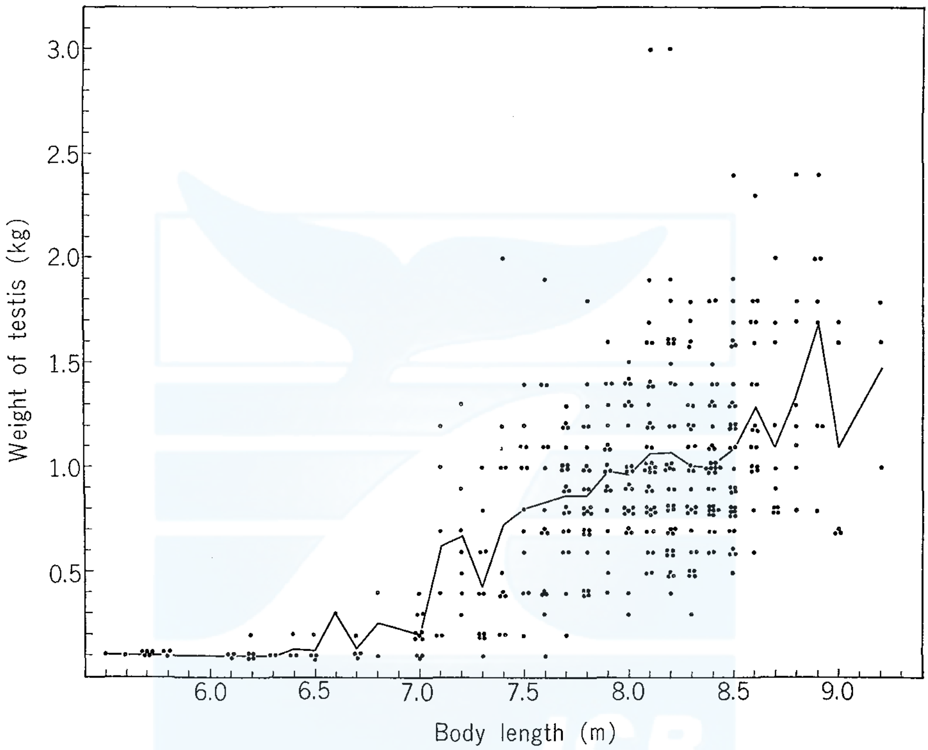

Fig. 8. Relation between body length and weight of larger testis in the males.

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

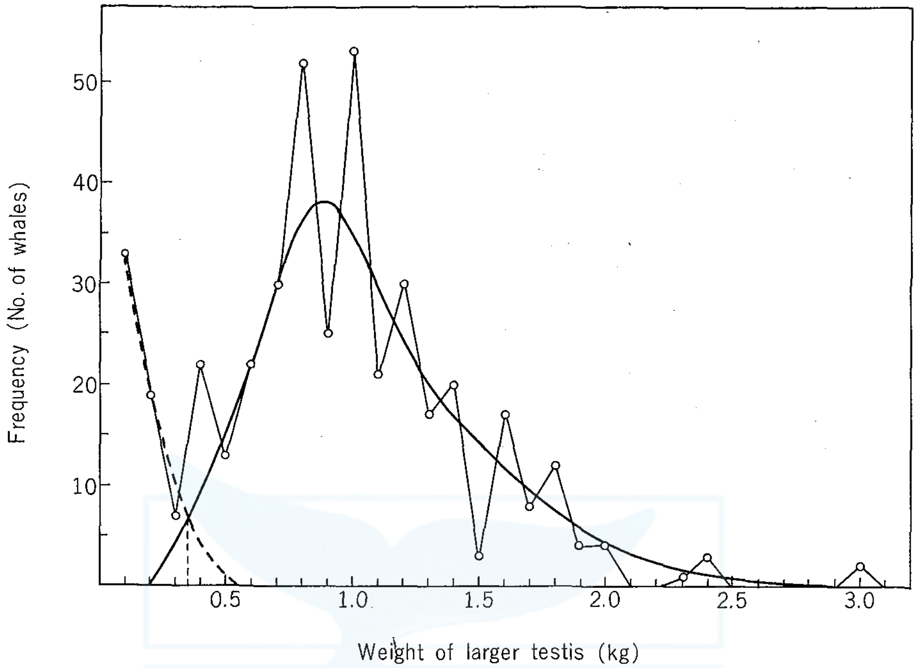

Fig. 9. Frequency of weight of larger testis in the southern minke whales and the estimation of testis weight at maturity. Broken curve: Immature, Solid curve: Mature

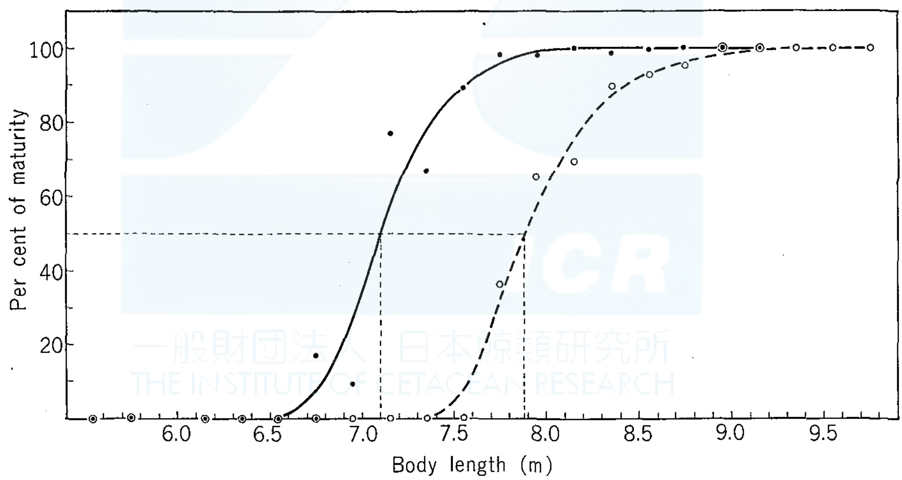

Fig. 10. Proportion of sexually mature minke whales at each length in the Antarctic Area IV. Closed circle and solid curve: males, Open circle and broken curve: female.

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 ANTARICTIC

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.

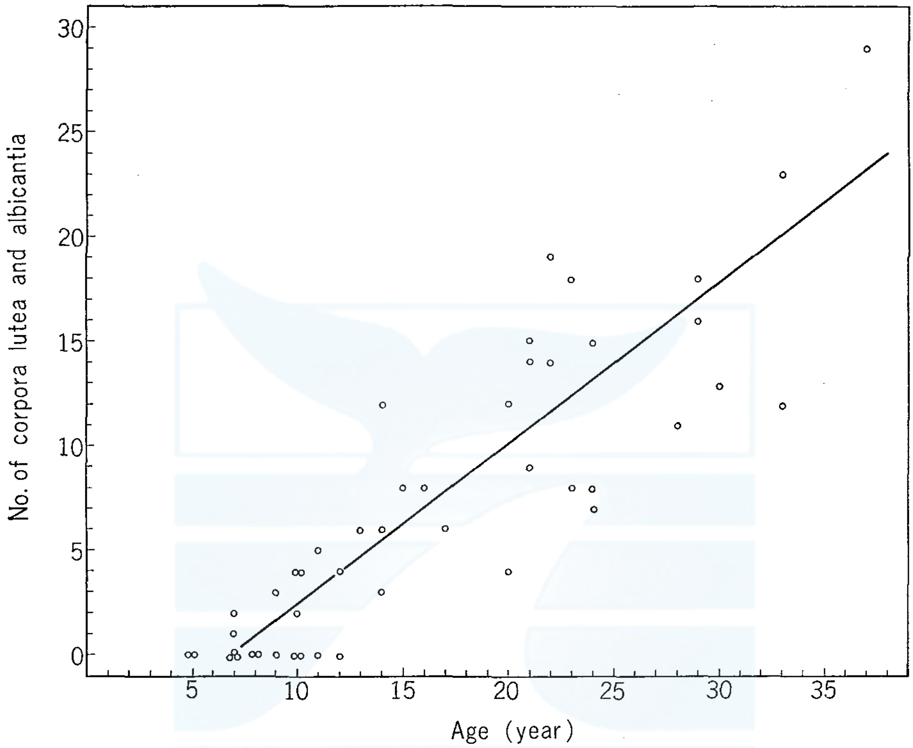

Fig. 11. Relation between age and number of ovulations in the Antarctic minke whales.

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.

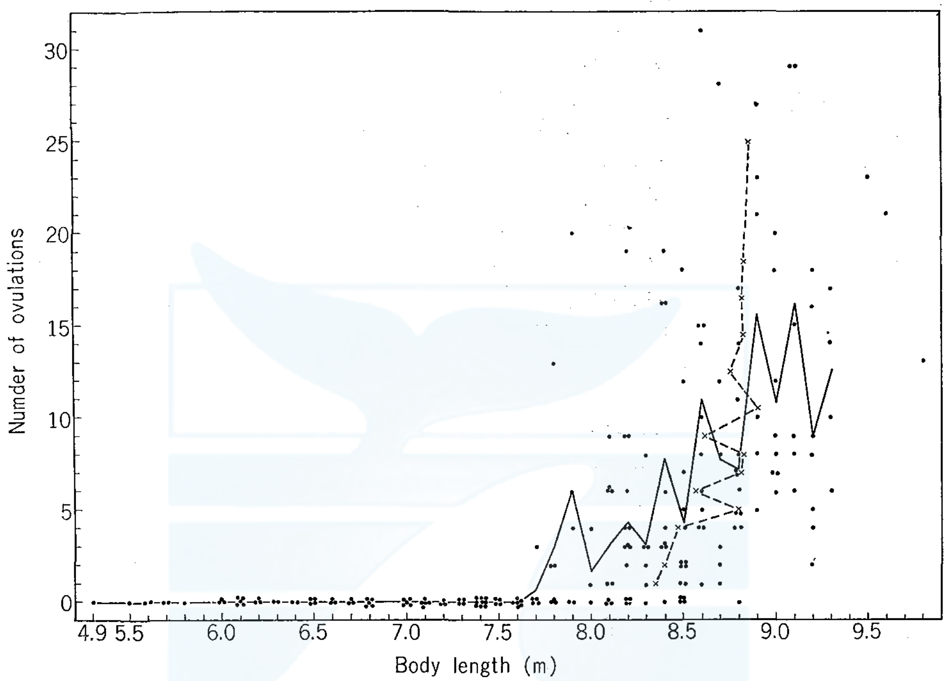

Fig. 12. Relation between body length and number of ovulations in the females.
Solid line : Average number of ovulation, Broken line : Average body length

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

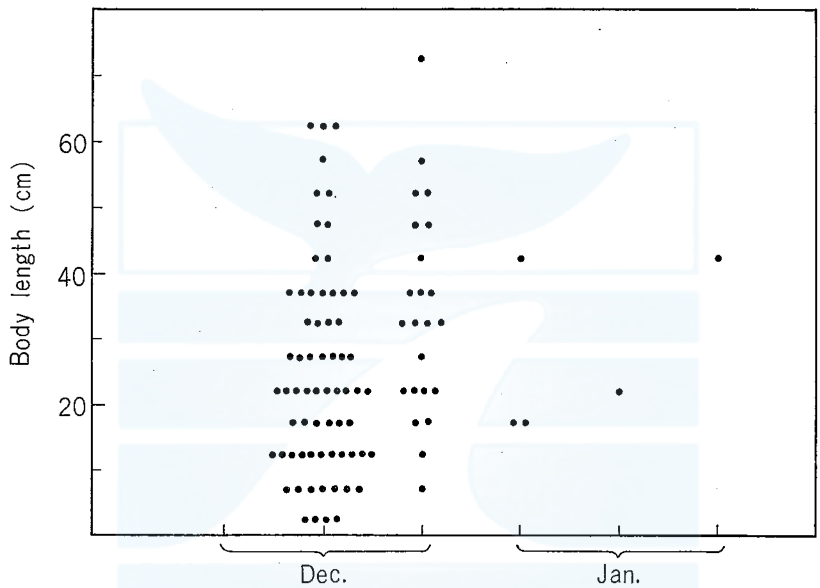

Fig. 13. Length of foetuses and decade of occurrence in the Antarctic

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

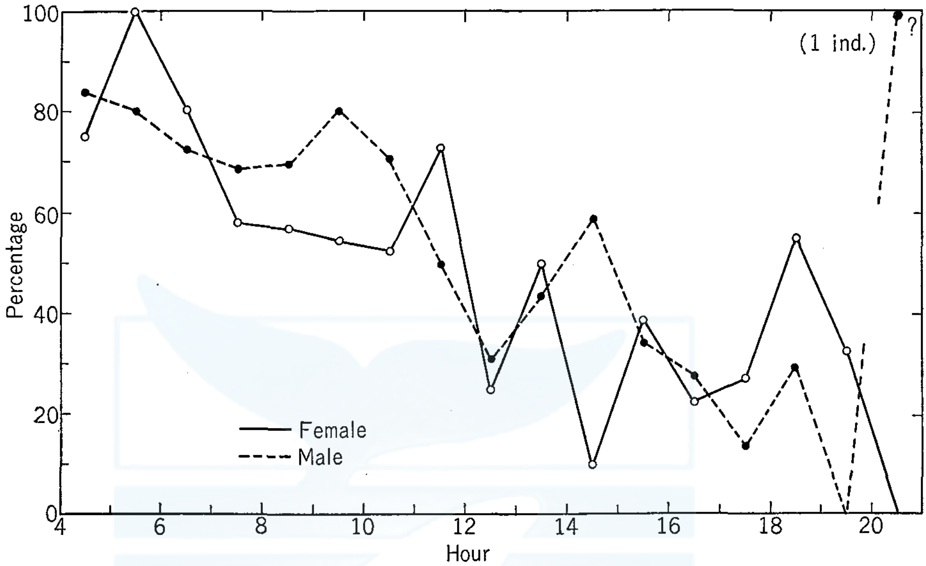

Fig. 14. Feeding percentages of minke whales caught in the Antarctic (1967/68; 1968/69). Open circle: female, Closed circle: male.

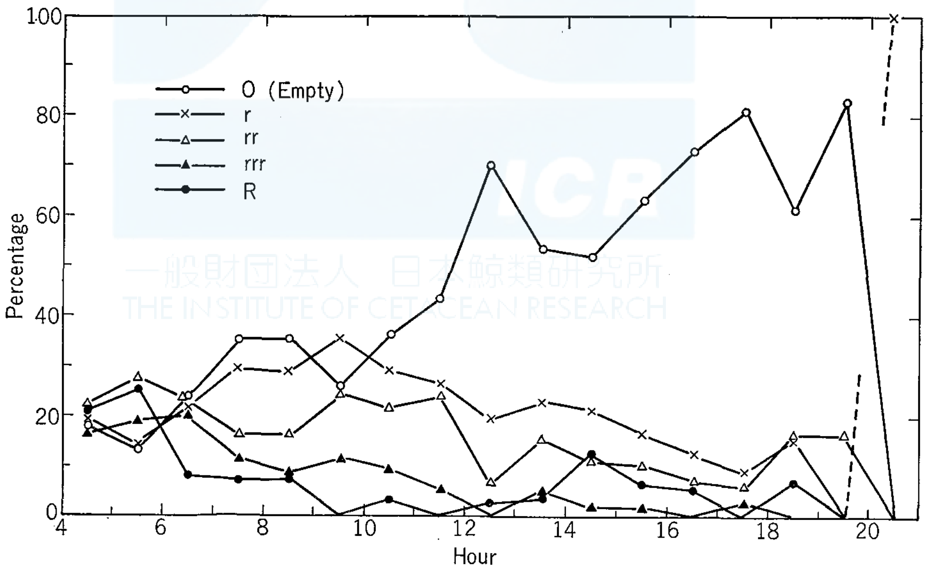

Fig. 15. Feeding percentages of minke whales caught in the Antarctic in terms of the degree of repletion in the first stomach.

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.

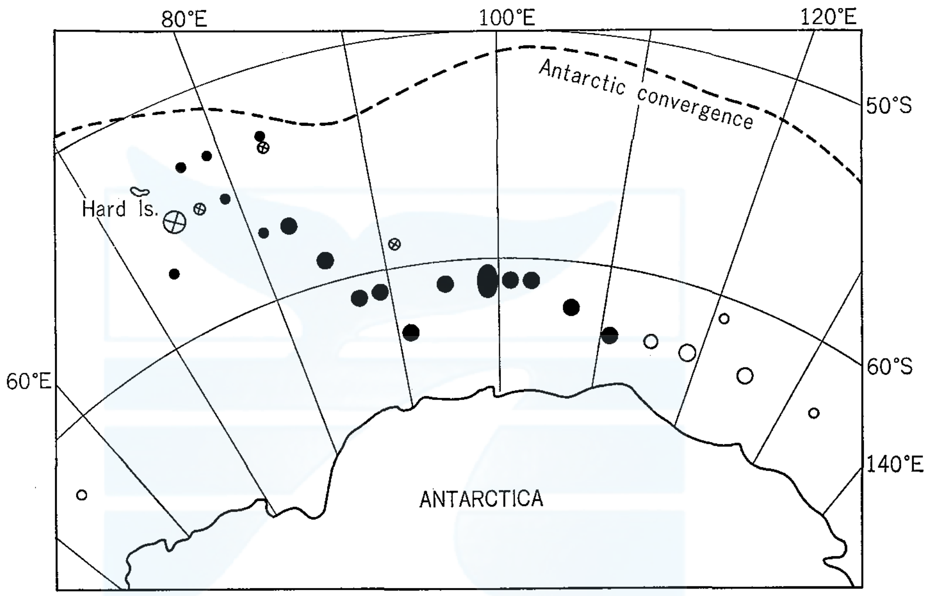

Fig. 16. Positions of minke whales caught by Japanese expeditions.
Open circle: 1963/64, Closed circle: 1967/68, Circle and cross: 1968/69.

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

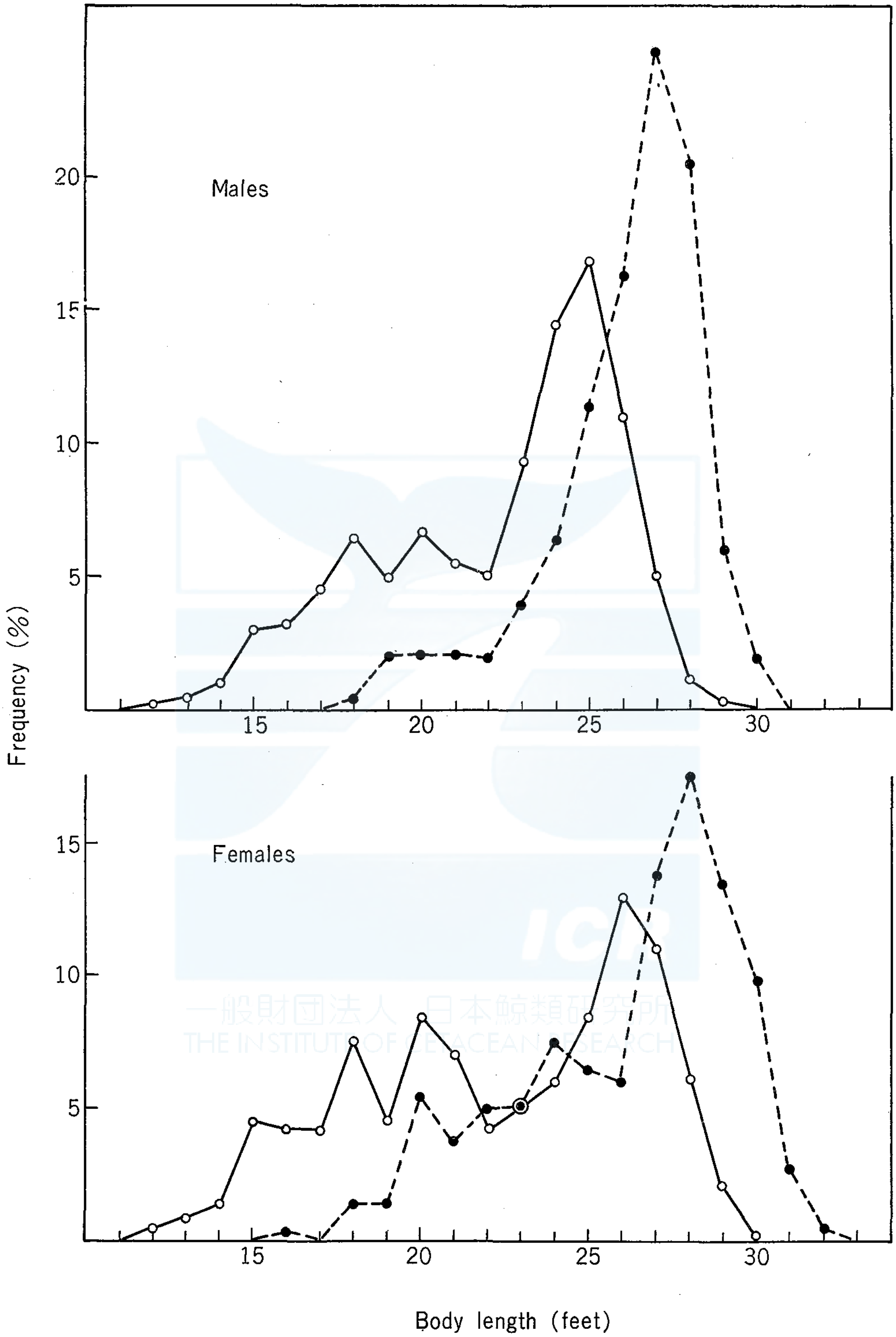

Fig. 17. Comparison of size distributions between the minke whales from the Antarctic and the coast of Japan.
Open circle and solid line: from the coast of Japan, Closed circle and broken line: from the Antarctic

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.

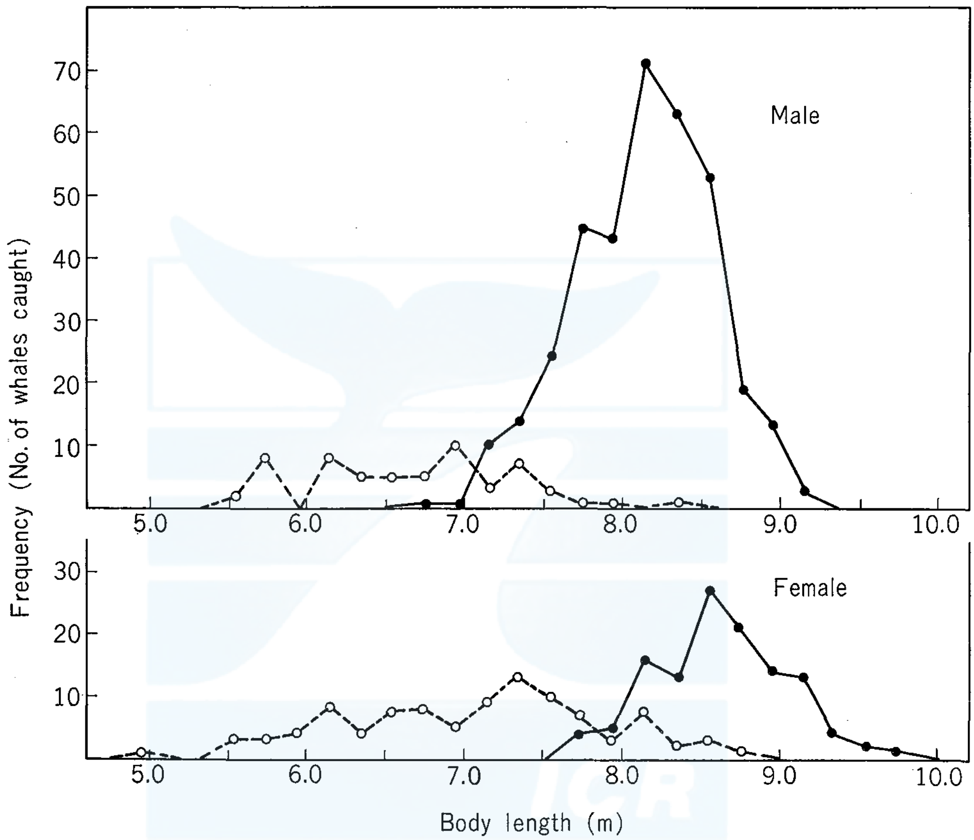

Fig. 18. Size distributions of minke whales caught in the Antarctic in 1967/68 and 1968/69 seasons. Open circle and broken line: Immature, Closed circle and solid line: Mature.

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

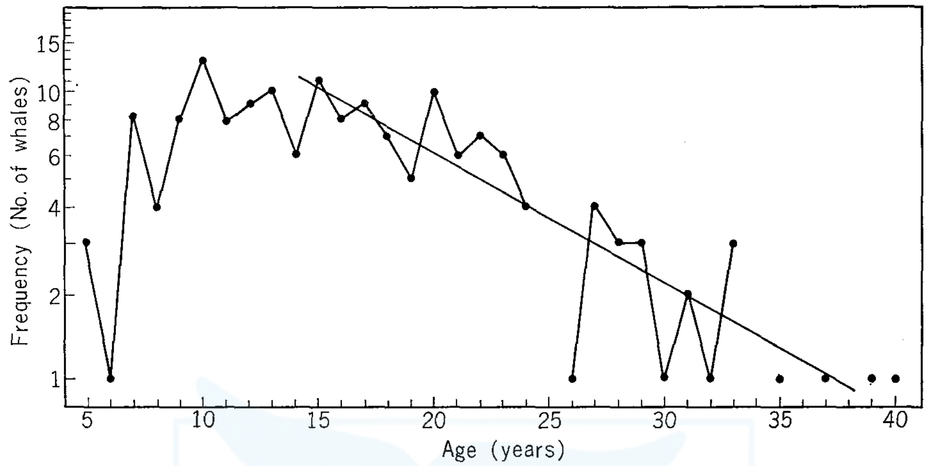

Fig. 19. Age distribution of male and female minke whales caught in the Antarctic in 1967/68 season.

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.

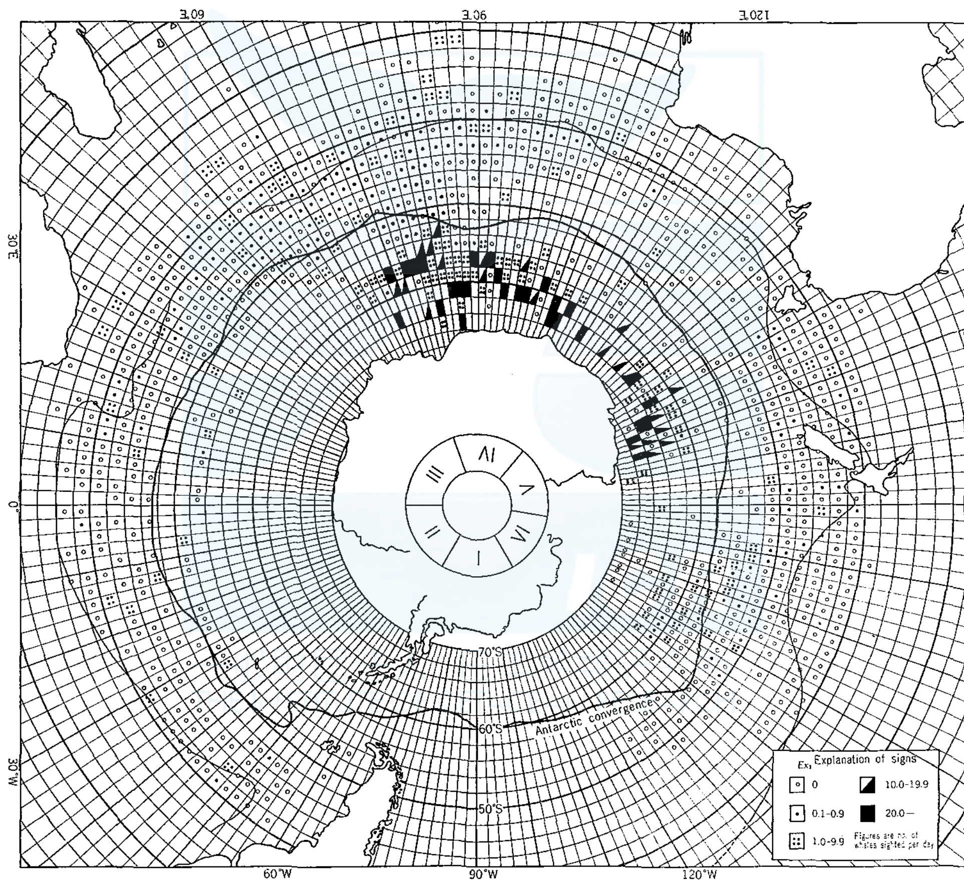

Fig. 21. Distribution of minke whales sighted by Japanese scouting boats in the Antarctic seasons 1965/66–1968/69.

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

Sector	Area 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 management. 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.

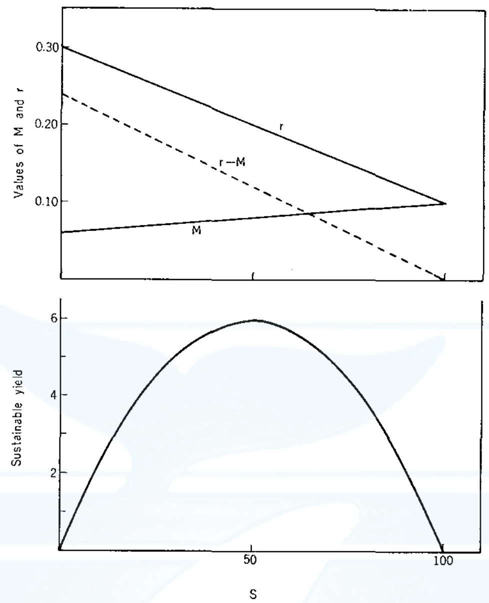

Fig. 22. Estimation of sustainable yield curve for the Antarctic minke whale.

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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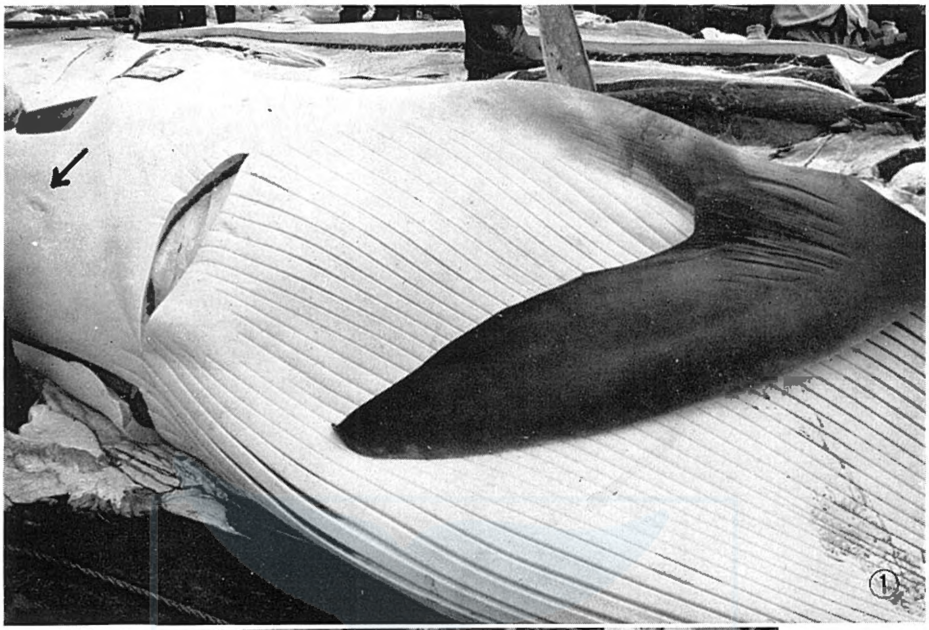
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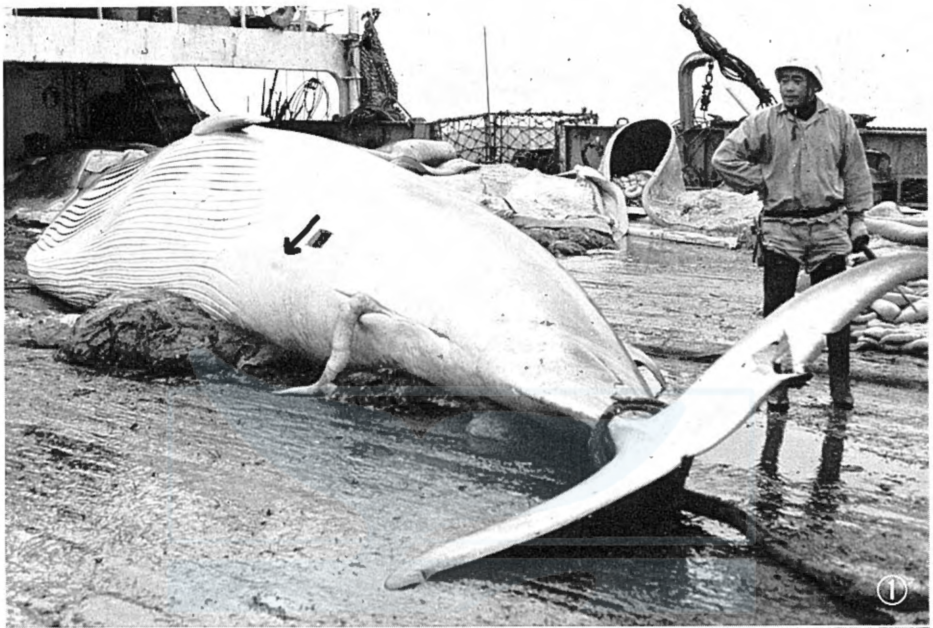

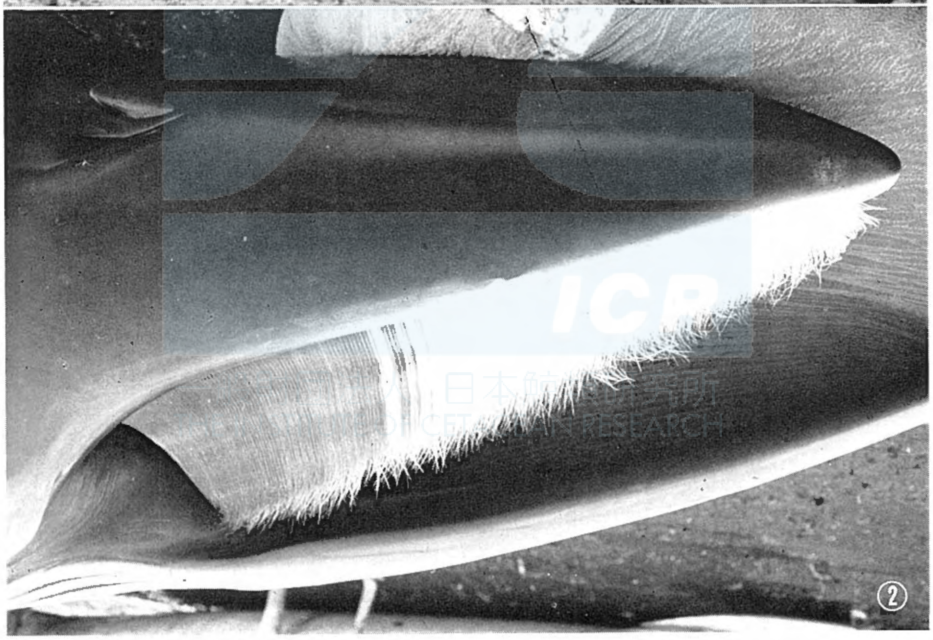

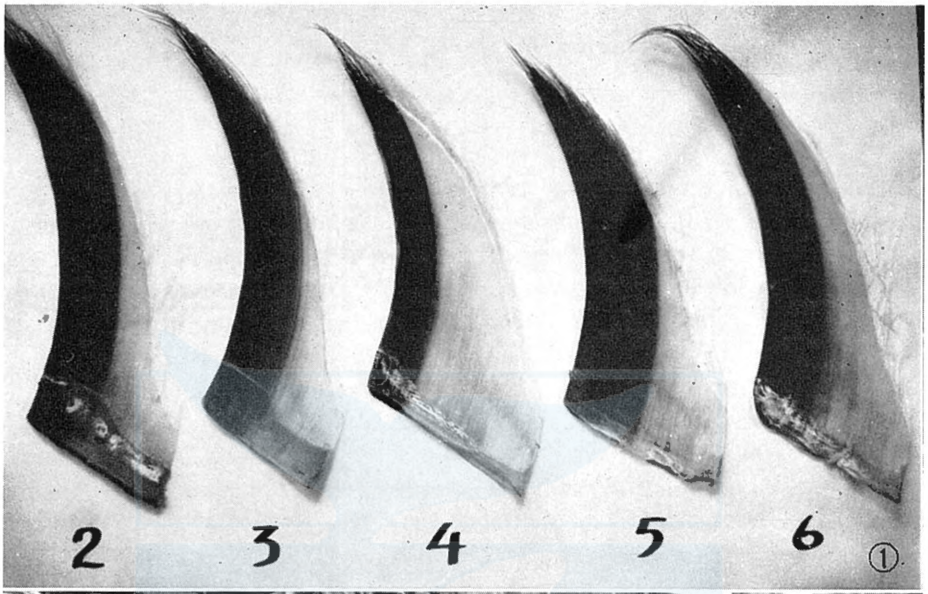
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FOOD OF SEI WHALE TAKEN BY JAPANESE WHALING EXPEDITIONS IN THE ANTARCTIC SEASON 1967/68

AKITO KAWAMURA

INTRODUCTION

The comprehensive study on the food of baleen whales caught in the Antarctic by Japanese fleets has long been treated and analysed chiefly by Dr. T. Nemoto, formerly a staff of the Whales Research Institute, on the materials collected since 1954/55 Antarctic whaling season until 1960/61's, and several number of the important reports have been published in these decades (Abe, 1957; Nemoto, 1959, 1961, 1962, 1966; Nemoto and Nasu, 1958). In addition to these studies a brief observations on the food of baleen whales have been carried out as a part of the general biological investigations of whales (e.g. Nishiwaki and Hayashi, 1950; Nishiwaki and Ohe, 1951 etc.). One of those studies by Nemoto (Nemoto, 1959) was a summarized fine piece of work which was comprised from the available data having been accumulated till then, which greatly contributed to increase our knowledge on the food of baleen whales in both hemispheres. By a series of those elaborate works several number of food organisms such as *Thysanoëssa macrura*, *Parathemisto gaudichaudii*, and *Drepanopus pectinatus* were added to the diet list of baleen whales in the Antarctic. However, no reports on the food of baleen whales by Japanese catch in the Antarctic waters have been appeared since 1961/62 Antarctic season onward as well as those in the northern North Pacific.

In this report I will give a brief result of my observations on the general features of the food of sei whales recently taken in the Antarctic by reasons of as follows: firstly, the catch of sei whales in the Antarctic and also in the northern North Pacific had been so small in proportion to the total catch of baleen whales in the earlier days by which situation our knowledge on the food of sei whales was relatively poor among the other baleen whales; secondly, recent increase of the sei whale catch (see Gambell, 1968) especially by the Japanese fleets resulted a northerly or southerly shifts of the main whaling grounds both in the Antarctic and the North Pacific. The shift of main whaling grounds brought some new situation on the food of sei whales there, and thirdly, there are a gradual tendency to increase the catch of fin whales in place of sei whales in the very recent operations, which may leads to some difficulties of getting a food materials of southern sei whales in near future.

MATERIALS

In 1967/68 season of the Antarctic whaling four Japanese fleets operated in the following areas (Fig. 1):

1) Area III and IV between 49°E and 100°E, chiefly in the surrounding

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waters of Kerguelen and Crozet Islands.

2) Area IV and V between 83°E and 160°W, including Tasman Sea
3) Area V between 160°E and 160°W, in the vicinity of New Zealand

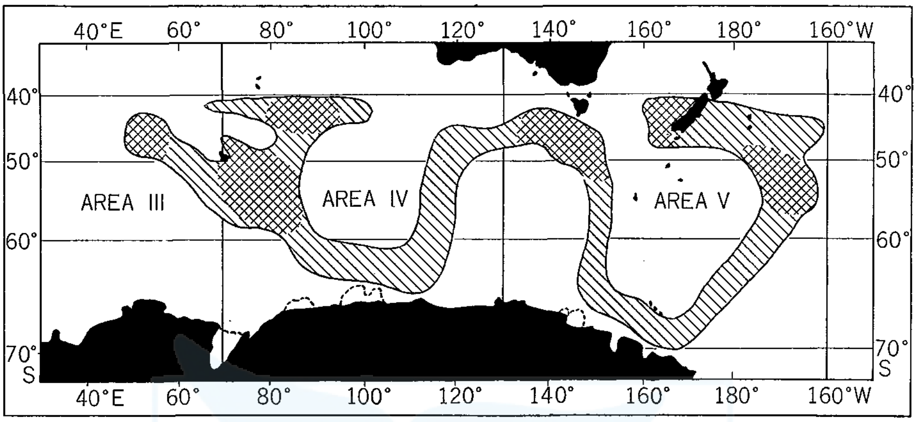

Fig. 1. A schematic map of the Antarctic whaling grounds operated by the four Japanese fleets in 1967/68 season. Shade with cross shows the principal whaling grounds.

The total catch of sei whales by the Japanese fleets throughout the season was 7,119 whales, from which 117 samples of stomach contents were collected, *i.e.* 15 samples by " Nisshin Maru No. 3 " (Area IV & V), 3 samples by " Kyokuyo Maru No. 3 " (Area V), and 99 samples by " Nisshin Maru " (Area III & IV). Being on board of the F.S. " Nisshin Maru " in her 1967/68 operation, I made the observations of whales food on the deck as one of the items of the general biological investigations (e.g. Nishiwaki and Hayashi, 1950) to get a considerable amount of data concerning on the food and feeding habit of sei whales in addition to the food samples.

The food samples were usually collected from the first stomach of whales while they were flensed on the deck. Sometimes the food samples were obtained from the mouth where the stomach contents being retained on the baleen plates by vomit. The stomach contents collected were washed by rinsing them in the clear running sea water to remove the blood or oily materials, and then preserved in vials with 10 percent buffered formalin for later examination.

One of the another materials which I used in the report was a routine record of biological observations on whales compiled by the whalers and by the whaling inspectors of the Fisheries Agency on board. In this record a rough classifications of food organisms such as ' Calanus ' (=copepoda), amphipoda, euphausiids, fish, squids etc. were adopted as a result examined by naked eyes. The positions where the samples were obtained were represented by the every day's position of mother ships at noon.

SPECIES OF FOOD ORGANISMS

Euphausia superba had long been considered as a initial food staff of baleen whales in the Antarctic feeding grounds, for instance, Mackintosh and Wheeler (1929), and

Matthews (1938) found none but *E. superba* as a food of fin or sei whales in the South Georgian waters. However, as the study on the food of baleen whales has been progressed since then with the advent of a shift of main whaling ground in accordance with the composition change of the whale species hunted, several number of euphausiids, copepods, and amphipods were gradually added to the diet list of baleen whales (Marr, 1956; Peters, 1955; Nemoto and Nasu, 1958; Nemoto, 1961, 1962; Bannister and Baker, 1967; Best, 1967; Brown, 1968; Pervushin, 1968).

TABLE 1. SPECIES OF THE FOOD ORGANISMS OF SEI WHALES CAUGHT BY JAPANESE WHALING EXPEDITIONS IN THE ANTARCTIC SEASON 1967/68

Copepods	*Calanus simillimus* GIESBRECHT
	Calanus tonsus BRADY
	Drepanopus pectinatus BRADY
	Clausocalanus laticeps FARRAN
Amphipods	*Parathemisto gaudichaudii* (GUÉRIN)
	f. *compressa*
	f. *bispinosa*
Euphausiids	*Euphausia superba* DANA
	Euphausia vallentini STEBBING
	Thysanoëssa vicina HANSEN
Fishes	*Gymnospelus nicholsi* (GILBERT)
	Myctophum subasperum (GUNTHER)
Others	*Cleodora sulcata* (PFEFFER)
	Clione antarctica E. A. SMITH
	Eukrohnia hamata (MÖBIUS)

In the materials of 1967/68 season the kind of food staff found in the stomach contents of sei whales was relatively poor in the number of species (Table 1). Among those species, however, I may describe the following two copepod species as being found firstly as a presumably staple food staff of sei whale in the Subantarctic waters, *i.e.*, *Calanus tonsus* Brady and *Clausocalanus laticeps* Farran. Judging from the number of whales fed on both *Calanus simillimus* and *Calanus tonsus*, they were considered to be the most important copepods as the staple food of sei whales in the Subantarctic waters of relatively lower latitudes. As *Calanus tonsus* was already described as a food of sei whales in the South African waters in the vicinity of the Cape Province (Best, 1967), this species is known to occur very abundantly in the surface waters of the Subantarctic regions (Brodskii, 1964), especially in the south or south-east waters off New Zealand (Farran, 1929; Jillett, 1968).

Copepods

Although *Calanus tonsus* was firstly described by Brady, there were some taxonomical confusion between *Calanus tonsus* and *Calanus plumchrus* of the North Pacific (Tanaka, 1954; 1956). However, the comparative morphological study of this species on more closer examinations, and the finding of an adult mature male from the southern hemisphere made it possible to distinguish *Calanus tonsus* as a typical endemic species in the surface waters of the Subantarctic (Tanaka, 1954, 1956, 1960; Brodskii, 1964; Vervoot, 1965; Jillett, 1968).

In 1967/68 season *Calanus tonsus* was found in 321 sei whales which were caught at the areas lying in the north-east of Kerguelen Island during December 12–29, and also in the Tasman Sea during January 4 to February 2, then in the south to south-east waters off New Zealand during December 12 to March 22 (Figs. 2a–b). In the

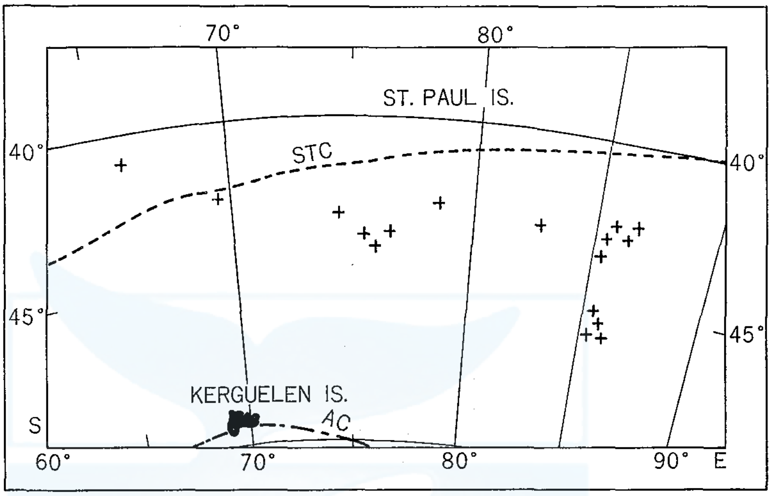

Fig. 2-a. Positions with *Calanus tonsus* in the Areas III and IV.
STC: Subtropical Convergence AC: Antarctic Convergence

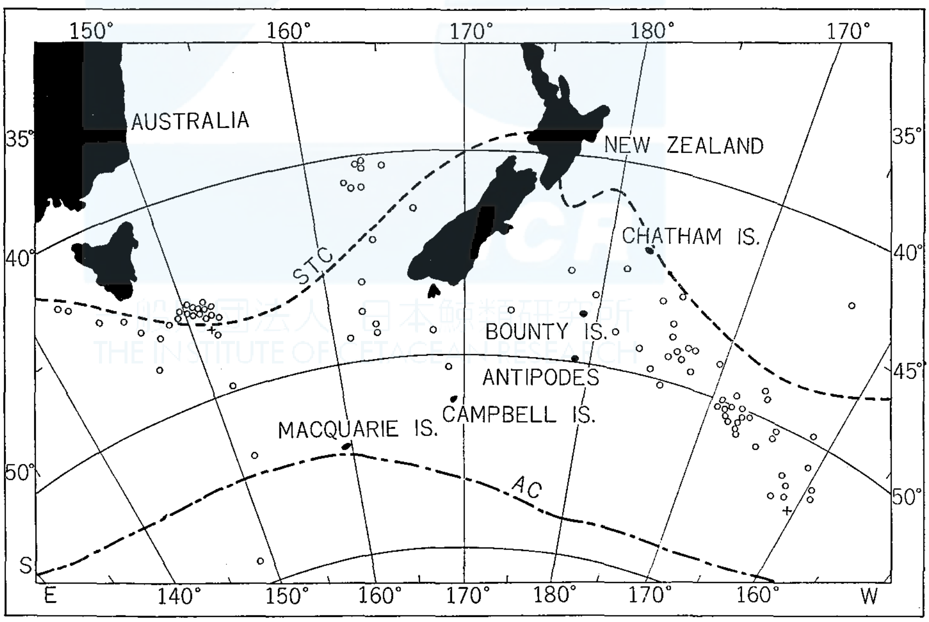

Fig. 2-b. Positions with *Calanus tonsus* (cross), and the possible occurrence (open circle) in the Areas V and VI.

whaling area so called the Area IV sei whale fed almost exclusively on *Calanus tonsus* at least in the early summer season.

Calanus tonsus found in the stomach contents was usually consisted of both adult female and copepodite V though sometimes copepodite IV was found with copepodite V population but very few. The upper and lower extremes of body length in the copepodite V were 4.0 mm and 2.8 mm, and those of adult female were 4.5 mm and 3.4 mm respectively. These body length approximately agrees with the results having been obtained by Vervoot (1957) and Brodskii (1964). As shown in Figs. 2a–b, the principal distributional area of *Calanus tonsus* widely expands in the area between the Subtropical and the Antarctic Convergences with surface temperature of 5°–15°C. According to Jillett (1968) the sea temperature at 25 m depth where the highest number of *Calanus tonsus* occurred was found between 8.5°C and 12.3°C in the waters off South Island of New Zealand. There were no clear differences in the distribution of adult female and copepodite stages.

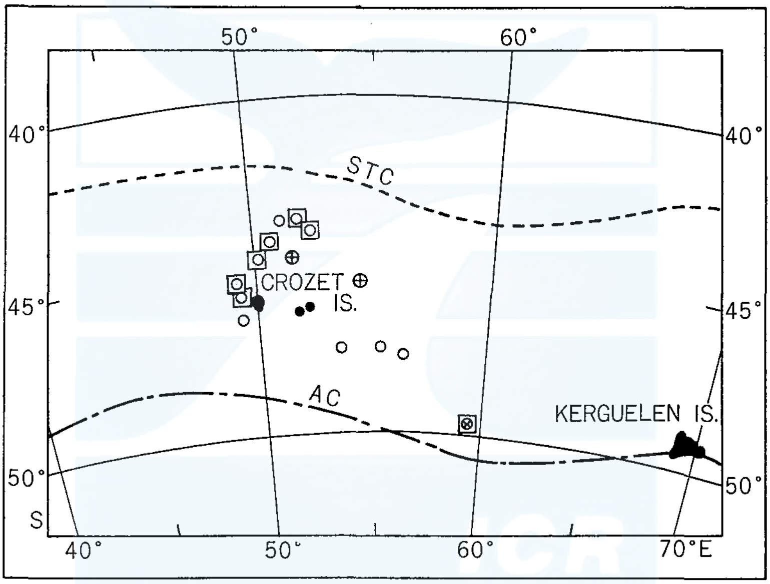

Fig. 3. Positions with *Calanus simillimus* in the Area III.
Copepodite IV (cross), Copepodite V (open circle), Adult female (square)

From the number of whales fed on *Calanus tonsus*, this copepod would be regarded to make one of the most important food sources for the Antarctic sei whales during late spring to early summer. However, since *Calanus tonsus* of copepodite V as well as *Calanus plumchrus* in the North Pacific leave the surface water in late summer for wintering in deep water (Jillett, 1968), the whaling ground formed by this copepod would last for but relatively short period than that formed by another kind of food organisms such as *Euphausia superba* or *Parathemisto gaudichaudii*.

Calanus simillimus is one of the another important endemic species which also predominantly distributes in the Subantarctic waters (Brodskii, 1964; Vervoot, 1965). In 1967/68 season this food species occurred in the surrounding waters of Crozet Islands in late January to mid February when the temperature of surface water was about 5.0°–9.10°C (Fig. 3). In the stomach contents, adult female, copepodites IV and V were occurred together though copepodite V was usually predominant among them as well as the case of *Calanus tonsus*. As shown in Fig. 3 there were no characteristic features in the geographical distributions between adult female and the young copepodite stages. The body length varied between 2.1 mm and 3.2 mm while those obtained by Farran (1929), Vervoot (1951; 1957), Tanaka (1960), and Brodskii (1964), were 2.86–3.42 mm in the male and 2.62–3.65 mm in the female. Relatively small body length found in the present study may be the result that the material was collected at relatively lower latitudes in the Subantarctic waters than those collected by other workers, since the body length of *Calanus simillimus* shows a considerable meridional variations in general (Farran, 1929).

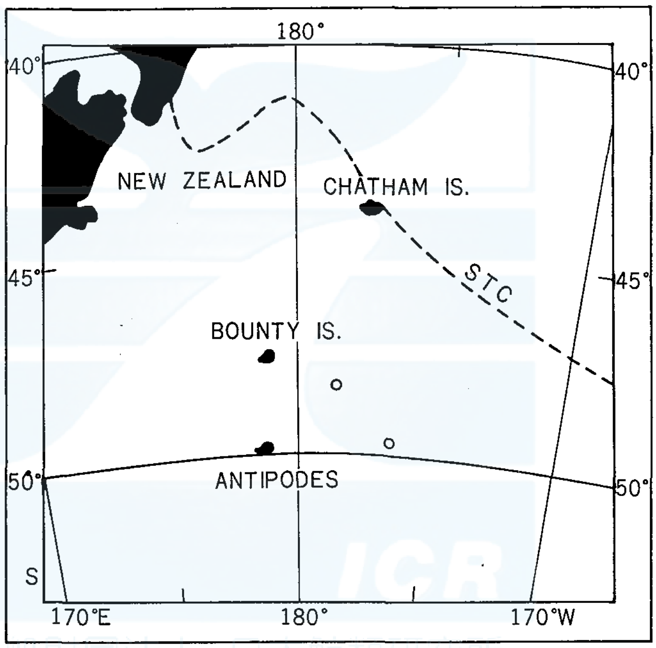

Fig. 4. Positions with *Clausocalanus laticeps* in the Area V.

Both *Calanus tonsus* and *Calanus simillimus* are generally recognized as the typical Subantarctic copepods, and are equally found as a staple food staff of sei whales. It is noticed, however, that there were distinct differences in the geographical distributions betwen these two species; *i.e.*, *Calanus tonsus* was chiefly found in the more warmer northern waters of the Subantarctic close to the Subtropical Convergence, while *Calanus simillimus* was found in the more colder waters with southerly shift of principal distributional area. The sea temperature of 10 m depth at the positions where the bulk of them were found was never overlapped each other (see also p. 131). According to Kawamura and Hoshiai (1969), *Calanus simillimus* in the Indian sector of the

Antarctic disappeared at about 45°S with sea temperature 7.6°C along the meridional line which connects between the Showa Base and Cape Town, while *Calanus tonsus* begin to occur in place of *Calanus simillimus* in the waters north of 45°S. This fact suggests that *Calanus simillimus* prefers more colder waters than *Calanus tonsus*, and that the latter must be regarded as a important food staff in the early whaling season in the Subantarctic waters throughout the area at least Areas IV and V. *Calanus simillimus*, on the other hand, could not observe in the waters south of New Zealand through December to March while their fairly well occurrences have been recorded in the above region (Brodskii, 1964). This species may be regarded as slightly little important than *C. tonsus* since there were another food sources such as *Drepanopus pectinatus*, *Parathemisto gaudichaudii*, and *Euphausia vallentini* in almost the same region.

According to the Russian investigations on the food of sei whales in the area of Crozet Islands, Pervushin (1968) found no whales which fed on Calanoida through December to February. However, as it will be described in the later the sei whales of Japanese catch exclusively fed on copepods; *Calanus tonsus*, *Calanus simillimus*, *Drepanopus pectinatus* and even a so small copeped, *Clausocalanus laticeps* though the amount of stomach contents of these copepods was relatively few when compared with more larger sized organisms such as euphausiids or amphipods.

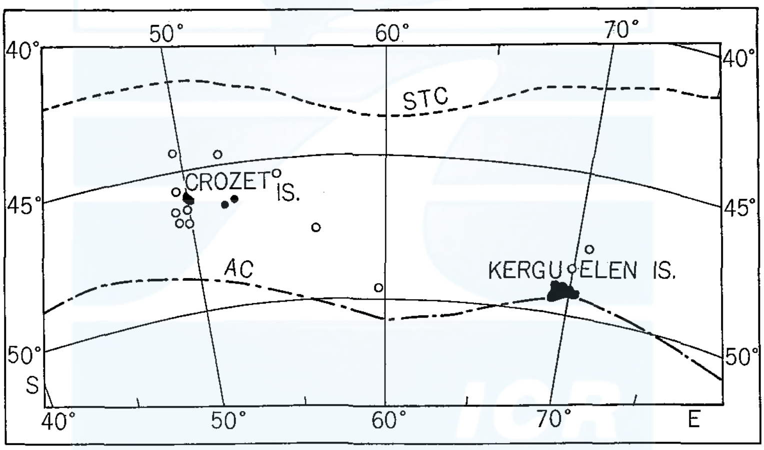

Fig. 5. Positions with *Drepanopus pectinatus* in the Areas III and IV.

The most small sized food, *Clausocalanus laticeps* was found in two whales which were caught in the waters east of Bounty and Antipodes Islands (Fig. 4). This food, like others was exclusively consisted of *Clausocalanus laticeps* of adult male, female and copepodite V. The body length were 1.15–1.37 mm on an average. This fact suggests that *Clausocalanus laticeps*, like other food species, sometimes occurs in a quite dense shoals, so called 'patchy distribution' as to be fed by baleen whales. In the waters off Cape Province, South Africa, the copepod, *Clausocalanus arcuicornis* was fed by sei whales (Best, 1967). In South Georgian waters this species is regarded as one of the important copepods (Hardy and Gunther, 1935), and vast numbers of occurrence was reported from the Bouvet Area and from Tasman

Sea (Vervoot, 1951, 1957). From these facts the copepods genus *Clausocalanus* could be considered to have a important role as the food sources for sei whales in the Subantarctic waters or at least in the lower latitudes of the whaling Area V.

One of the another small copepods, *Drepanopus pectinatus* was firstly introduced to the diet list of sei whales caught in the surrounding waters of Kerguelen Island (Nemoto, 1962). It is proved that this food was found again in 1967/68 season being fed by a considerable number of sei whales caught in the waters between Crozet and Kerguelen Islands. The occurrence of this copepod was more distinct in the Crozet whaling ground than the Kerguelen's (Fig. 5). In the east of the Area IV and V no whales fed on this species. It is considered that *Drepanopus pectinatus* make up a part of important food sources in the Kerguelen-Crozet whaling ground. It could be said in general that the epi-planktonic copepods in relatively lower latitudes of the Subantarctic waters in the Areas III to V carry out a quite important role as the staple food sources of sei whales which entered into the region from the north.

Amphipods

Both *Parathemisto gaudichaudii* forma *compressa* and forma *bispinosa*, were found in the stomach contents of sei whales. In contrast to the northerly occurrence of copepod food, *Parathemisto gaudichaudii* was fed preferably in the more southerly waters especially in the out side from the Antarctic Convergenge (Figs. 6a–b). This species

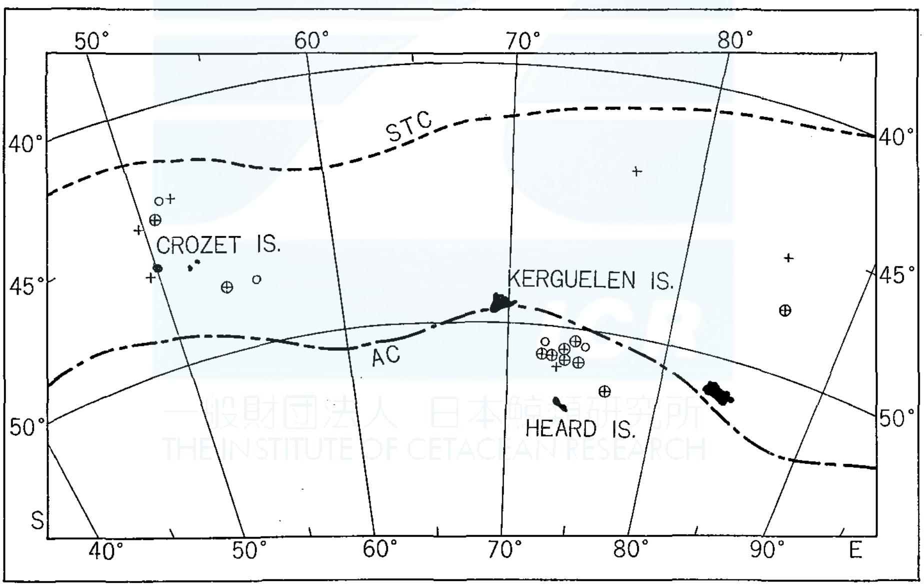

Fig. 6-a. Positions with *Parathemisto gaudichaudii* f. *compressa* (cross), and f. *bispinosa* (opencircle) in the Areas III and IV.

is well known by its cosmopolitic bipolar distribution (Stephensen, 1947) extending far to the Hudson Strait where the northern most occurrence of *P. gaudichaudii* f. *compressa* was found at 60° 23.5′ N, 64° 50.5′ W in Forbes Sound (Dumbar and Grainger, 1952; Dumbar, 1954). In the southen ocean, Baker (1954) showed its circumpolar distribution which covers far north to the Subtropical Convergence. In the latitudinal distributions, however, Kane (1966) demonstrated a quantitative discontinuity of occurrence where *Parathemisto gaudichaudii* is scarce at the Antarctic Convergence,

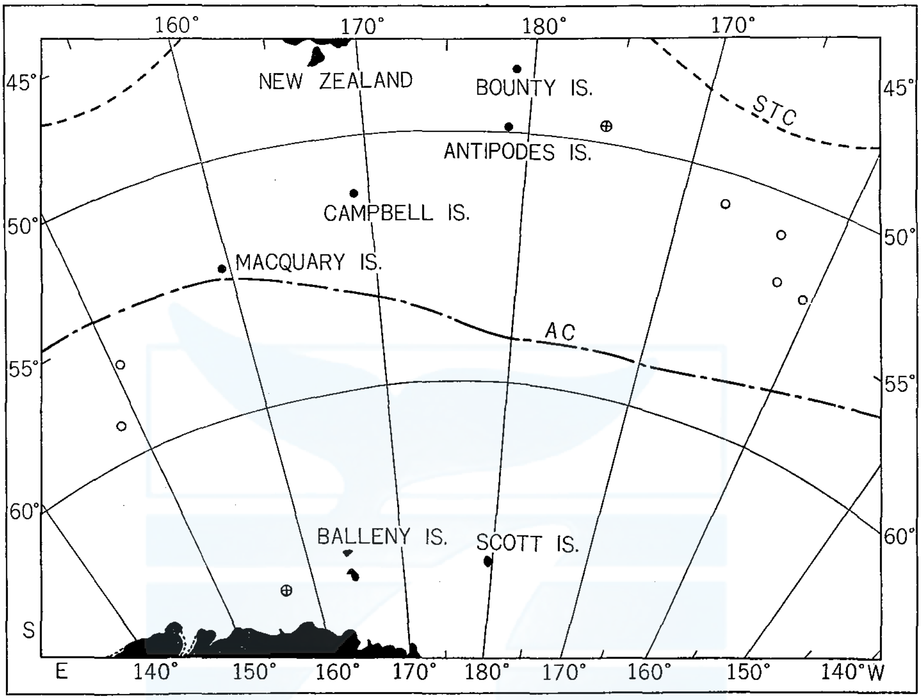

Fig. 6-b. Positions with *Parathemisto gaudichaudii* f. *compressa* (cross), and f. *bispinosa* (open circle) in the Area V.

while they are rich in the north or south from the convergence. However, there were much cases of the sei whale to feed *Parathemisto gaudichaudii* in the south of the Antarctic Convergence while it is expected more abundant distribution in the north of the Antarctic Convergence. There are no fact to explain this curiosity. One of a possible causes is the selective feeding by sei whales as observed between *E. recurva* and *Thysanoëssa gregaria* in the South African waters (Bannister and Baker, 1967), *i.e.*, the sei whale feed preferabley on copepod than amphipod when they occur in the same water bodies.

Euphausiids

Three species of euphausiids which were reported previously were found in the stomach contents (Table 1) though the occurrence of *Thysanoëssa vicina* is in some doubtful because of the ill condition of materials due to heavy digestion. *Euphausia vallentini* was recorded in 1960/61 season as a principal food of pygmy blue whale (*Balaenoptera musculus brevicauda*) in the Kerguelen whaling ground (Nemoto, 1961), though Mackintosh (1960) had mentioned the importance of *E. vallentini* as a food of blue whale in the Kerguelen waters preceeding to Nemoto's report. At any rate *Euphausia vallentini* could be regarded as quite important food for baleen whales in the neritic waters of the Subantarctic as well as copepods.

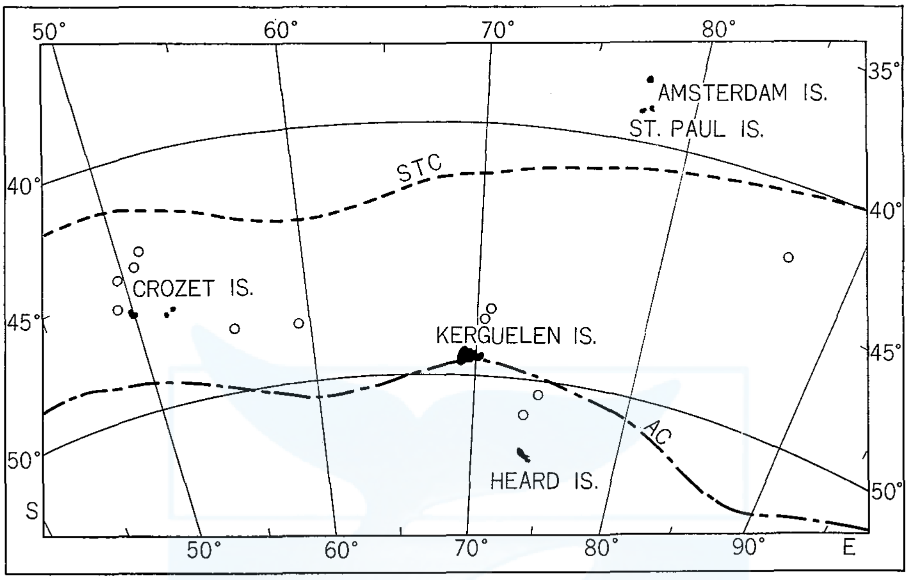

Fig. 7. Positions with *Euphausia vallentini* in the Areas III and IV.

In 1967/68 season *Euphausia vallentini* was found chiefly in the waters between Kerguelen and Crozet whaling grounds especially in the waters north of Crozet Islands (Fig. 7). It was also found in the Area V between 51°–53°S and 166°–167°W though very few. The northern and southern extremes of the occurrence of *Euphausia vallentini* through the Areas III to IV were 43°44′S, 51°26′S, and those in the Area V were 51°22′, 53°20′S respectively. The result of Russian investigations in the waters of Crozet Islands also shows the occurrence of *Euphausia vallentini* in the stomachs of sei, fin and blue whales (Pervushin, 1968). It is considered from this facts that *Euphausia vallentini* is quite important as a staple food source for sei whales in the surrounding waters of Crozet Islands.

Euphausia superba, on the other hand, seems to be minor importance as a food of sei whales when it is compared with *Euphausia vallentini* since the most sei whales were catched in the far north apart from the principal distributional area of *Euphausia superba*. In the Area IV *Euphausia superba* was exclusively found in the far more south of the Antarctic Convergence between 53°S and 59°S than the area of *Parathemisto gaudichaudii*. In the Area V close to the Antarctica near by Balleny Islands there were only four feeding records of *Euphausia superba*.

Others

The small fish, *Gymnospelus nicholsi*, *Myctophum subasperum* and other organisms; *Cleodora antarctica*, *Clione antarctica*, and *Eukrohnia hamata* were found in the stomach but very few. They showed only a occasional occurrence such as *Electrona* fishes observed in South Georgian waters (Brown, 1968), and are considered to be a minor importance among the food of copepods or euphausiids since these organisms were presumably fed by a chance while they were swarming in the surface waters to feed on those copepods or euphausiids in such a situation as Currie (1953) showed in his report.

COMBINATION OF FOOD ORGANISMS

The stomach contents of baleen whales usually consisted of a definite organisms which

TABLE 2. STOMACH CONTENTS OF SEI WHALES CAUGHT IN THE ANTARCTIC OCEAN DURING DECEMBER 12, 1967 TO MARCH 20, 1968

Kinds of stomach contents*	Number of whales examined	Dominant forms of the food organisms		
		I	II	III
Calanus tonsus	23	CV & F		
C. tonsus—Parathemisto gaudichaudii f. compressa	1	CV	F	
C. tonsus—P. gaudichaudii f. bispinosa	1	CV	F	
C. tonsus—Euphausia vallentini	2	CV & F	F & Juv	
C. tonsus—Euphausia sp.	2	CV & F	Furcilia	
C. tonsus—E. vallentini—Eukrohnia hamata	1	CV	F	
C. tonsus—P. gaudichaudii f. compressa—E. vallentini	1	CV	F	M, F & Juv
C. tonsus—E. hamata—Clione antarctica & Cleodora sulcata	1	CIV & V		
Calanus simillimus	4	CV & F		
C. simillimus—Drepanopus pectinatus	3	CIV & V	Juv	
C. simillimus—E. vallentini	2	CV	M, F & Juv	
C. simillimus—Euphausia sp.	1	CV	M & Furcilia	
C. simillimus—P. gaudichaudii f. compressa	2	CV	M & F	
C. simillimus—P. gaudichaudii f. bispinosa	2	CV	F	
C. simillimus—Gymnospelus nicholsi	1	CV		
C. simillimus—P. gaudichaudii f. compressa—E. vallentini	1	CV	M & F	Juv
Drepanopus pectinatus	4	M, F & Juv		
D. pectinatus—C. simillimus	2	Juv	CIV, V & F	
Clausocalanus laticeps	2	F & Juv		
P. gaudichaudii f. compressa	9	F		
P. gaudichaudii f. bispinosa—f. compressa	18	F	F	
P. gaudichaudii f. bispinosa—E. vallentini	1	F	M & Juv	
P. gaudichaudii f. compressa—P. gaudichaudii f. bispinosa—E. superba	1	M & F	M & F	M & F
P. gaudichaudii f. compressa—P. gaudichaudii f. bispinosa—E. vallentini	1	F	F	M, F & Juv
P. gaudichaudii f. bispinosa—E. vallentini—C. simillimus	1	F	Juv	CV
Euphausia superba	14	M, F & Juv		
E. superba—Myctophum subasperum & Gymnospelum nicholsi	1	M, F & Juv		
Euphausia vallentini	10	M & F		
E. vallentini—D. pectinatus	1	Juv	Juv	

* Quantitative importance of each food species is on decrease from left to right.

are liable to swarm in a dense shoals as Hardy and Gunther (1935) called ' patchy distribution '. However, it is often observed that several kinds of food organisms distribute in the same feeding ground to make the stomach contents be complex as having been observed in Japanese waters (Nemoto, 1959), or in the waters near to the Cape Province, South Africa (Best, 1967). The sei whales, different from the case of blue and fin whales, are considered as ' microplanktonophagi ' (Tomilin, 1954), and a considerable kinds of organisms might be an object for feeding.

In the Antarctic as shown in Table 2, most of sei whales caught in the Areas III and IV were found to feed chiefly on small copepods such as *Calanus tonsus*, *Calanus simillimus*, *Drepanopus pectinatus*, and an amphipods, *Parathemisto gaudichaudii* come to the next then euphausiids, *Euphausia superba* and *E. vallentini* follow them. It is noticed in the table that the following four species, *i.e. Calanus tonsus*, *Parathemisto gaudichaudii*, *Euphausia superba*, and *E. vallentini* are more likely to be fed as a monotonous population in many cases, while the others are fed as the mixture composed of more than two species. However, those mixture food being mingled in parallel relationship in terms of the quantity of each species are scarecely found but usually occurred with a remarkable dominant forms among them. So it can be said that the food of sei whales in the recent Antarctic feeding grounds or at least in the Areas III and IV, is represented with *Calanus tonsus*, *Calanus simillimus*, *Parathemisto gaudichaudii*, *Euphausia superba* and *Euphausia vallentini*. The preference of food organisms by sei whale has been known in the northern North Pacific (Nemoto, 1957). Nemoto (*loc. cit.*) described that sei whales prefer to feed on small copepods than euphausiids, and in the subsequent report he (Nemoto, 1959) gave the order for sei whales on this matter, *i.e.* small sized *Calanus* preferred firstly then euphausiids, small fishes or squids follow them. In South African waters, Best (1967) demonstrated the same order for sei whales though there were so scarce instances of mixture of food more than two species. My result agrees in general with the result of those previous workers though I consider that *Parathemisto gaudichaudii* should be added and placed in the next to euphausiids at least in the Indian sector of the Subantarctic waters.

FEEDING PERCENTAGE

The kind of stomach contents of each baleen whales is usually observed by eyes, and recorded according to a rough classifications, *i.e. Calanus* (=copepoda), amphipoda, and euphausiids as shown in Table 3. A symbol " Calanus " in the table does not mean exact taxonomical nomenclature but actually means " copepoda ". Euphausiids are divided into three classes according to their body length after the manner adopted by Mackintosh and Wheeler (1929) and other Japanese workers thereafter; L: large (50 mm—), M: medium (40–50 mm), and S: small (—40 mm). It can be considered in this report that the large and medium sized euphausiids are mostly represented by 1 or 2 year group of *Euphausia superba*, and small one by *Eupahusia vallentini*. Although " empty ", the whales of no stomach contents was the most cases among examined whales, it is noticed in the table that the feeding percentage of *Calanus* gradually increases toward the Pacific sector of the Antarctic (Areas V and

VI) from the Indian sector, while amphipoda makes a important food sources in the Indian sector of the Antarctic (Areas III and IV). It must be noted that relatively low feeding percentages of *Calanus* in the Areas III and IV are the result from a short duration of whaling in the Subantarctic waters. By supposing the case above mentioned, it might be nearly as same with other food species. Euphausiids are also more important in the Areas IV to VI than the Areas III and IV. No occurrence of large and medium sized euphausiids from the Areas V and IV suggests the complete absence of *Eupahusia superba* from these two whaling grounds. It is interesting that the sei whales in the south of New Zealand almost exclusively fed on small sized euphausiids which were consisted of *Euphausia vallentini*. Sei whales in the Areas III and IV chiefly feed on copepods in December.

TABLE 3. NUMBER OF SEI WHALES IN RELATION TO THE KINDS OF FOOD AND WHALING AREAS IN THE ANTARCTIC SEASON 1967/68. THE PERCENTAGES TO THE TOTAL NUMBER OF WHALES EXAMINED ARE GIVEN IN ITALICS.

Area & Sector	Kind of stomach contents							
	"Calanus"	Amphipoda	Euphausiid L	Euphausiid M	Euphausiid S	Unknown[3]	Empty	Total
Area III & IV	207[1]	191	115	23	59	—	919	1518
(Indian Ocean)	*13.64*	*12.58*	*7.58*	*1.52*	*3.89*		*60.54*	
Area IV & V	357[2]	73	61	17	203	—	537	1248
(Tasman Sea & Pacific Ocean)	*28.61*	*5.85*	*4.89*	*1.36*	*16.27*		*43.03*	
Area V & VI	888	70	—	—	575	9	1008	2550
(Pacific Ocean)	*34.82*	*2.75*			*22.55*	*0.35*	*39.53*	

1) Including *Drepanopus pectinatus*.
2) Including *Clausocalanus laticeps*.
3) Not examined.

A considerable high percentages of empty stomach in those areas suggests a poor availability of copepod food, since there is a fact that the Russian investigation made on the sei whale caught in the vicinity of Crozet Islands showed low feeding percentages due to the proportional increase of Calanoida among other food organisms (Pervushin, 1968). It is also noticed that relatively high percentages of amphipoda and large sized euphausiids in the Areas III and IV mean the formation of staple feeding ground of sei whale in relatively higher latitudes. These are, however do not always be accompanied by the distribution of sei whales since they liable to feed on copepod in the lower latitudes by 'skimming' even if the population density of copepods is poor. The most of sei whales caught in the *Calanus* ground in lower latitudes of the Areas III and IV had a small quantity of stomach contents less than 50 percent, and no whales with the stomach of "full" were observed. As it is shown in the Figs. 2a to 5, a chief diet in the lower latitudes of the Area III and the surrounding waters of Crozet Islands during December and late January to mid February was represented by *Calanus tonsus*, *Calanus simillimus*, *Drepanopus pectinatus* and *Euhausia vallentini*. Pervushin (1968) on the other hand, demonstrated a quite different result. Mentioning on the feeding behavior of baleen whales in the area of Crozet Islands, he (Pervushin, 1968) showed that 63.0–88.5 percent of sei whales were proved to feed on euphausiids such as *Euphausia vallentini* and *E. frigida* during December to February. He also showed that the real Antarctic copepods, *Calanus propinquus* and *Calanoides acutus* were found as a food of sei whale in the Crozet whaling ground. However, judging from the negative records of those two species in my collection from those waters, and also the negative record shown by Brodskii (1964), and positive records in the southern waters far beyond the Antarctic Convergence by many workers (e.g. Tanaka, 1960, 1964; Kawamura and Hoshiai, 1969), the occurrence of *Calanus propinquus* and *Calanoides acutus* in the surrounding waters of Crozet Islands is considered in some doubtful, since they are regarded as a real endemic species in the high Antarctic (Ottestad 1932, 1936), and *C. propinquus* is found usually at the depth of 100–250 m in the north of the Antarctic Convergence where the sea temperature lies between −1.6°C and 0.3°C (Vervoot, 1957). On the other hand, the observed temperature in the waters of Crozet Islands during January to February in 1967/68 season was quite high between 5.0°C and 9.0°C, where *Calanus simillimus*, a typical subantarctic species was exclusively fed on.

LATITUDINAL SUCCESSION OF FOOD ORGANISMS

Among four Japanese fleets operated in 1967/68 season two of them fished around so as to cover a relatively wide area in meridional direction. In Figs. 8–9, the succession of food organisms in the north-south direction in terms of the feeding percentages is shown with approximate positions of the Subtropical and the Antarctic Convergences in the area concerned. In the Subantarctic waters of lower latitudes of the Indian sector of the Antarctic, only " Calanus " was fed by sei whale. " Calanus " in this area was represented by a typical Subantarctic endemic species; *Calanus tonsus*, *Calanus simillimus* and *Drepanopus pectinatus*. Although *Calanus tonsus* and *Calanus simillimus* showed somewhat similar charactor in their geographical distribution, it must be kept in mind that there was a time lag about a month in the time of their occurrence, *i.e.*, *Calanus tonsus* was found exclusively in December while *Calanus simillimus* was in mid January to February. Still more, there are the fact to suggest the presence of some ecological differences between these two copepods; the former prefers more warmer water (7.0–13.4°C) than the latter (5.9–9.1°C). According to the plankton data obtained by the 7th Japanese Antarctic Research Expedition (Kawamura and Hoshiai, 1969), the boundary where alternation of the successive occurrence of *Calanus tonsus* to *Calanus simillimus* takes place was found at approximately 45°S with temperature and salinity of 7.5°C and $34.07^{0}/_{00}$ respectively. The high feeding percentages at 45°S as shown in Fig. 8 would be due to the result fed on *Calanus simillimus* and *Drepanopus pectinatus* in the Crozet whaling ground. The dominant occurrence of copepods in the Subantarctic waters is clearly shown in Figs. 8 and 9 though *Euphausia vallentini* makes one of another chief food sources in the Pacific sector of the Antarctic.

An amphipoda, *Parathemisto gaudichaudii* comes next to copepods in fairly narrow latitudinal zone which lies in the slightly north of the Antarctic Convergence. It must be noted that almost complete alternation of chief diet of sei whales from copepods to *Parathemisto gaudichaudii* takes place in the south of Subantarctic waters,

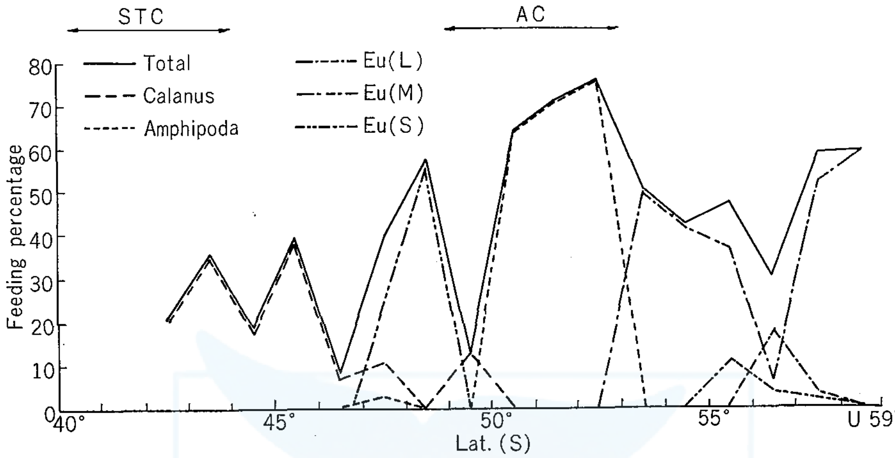

Fig. 8. Latitudinal succession of the food organisms of sei whales in the Indian sector of the Antarctic. STC: Subtropical Convergence AC: Antarctic Convergence

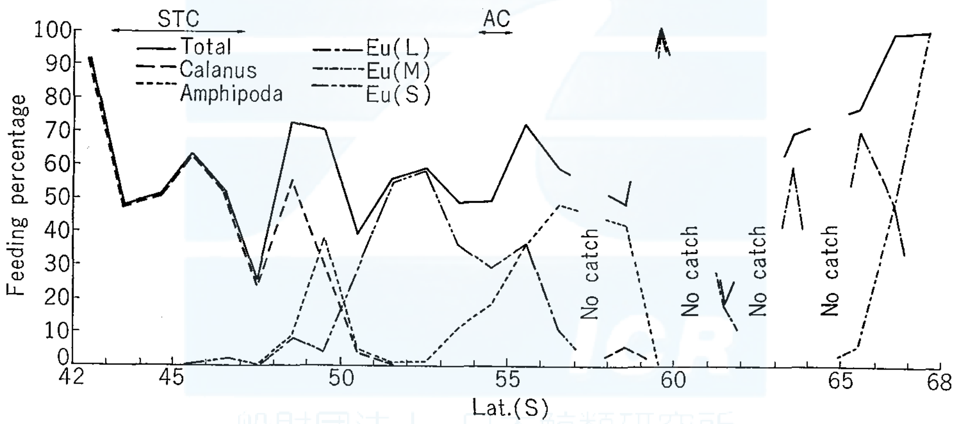

Fig. 9. Latitudinal succession of the food organisms of sei whales in the Pacific sector of the Antarctic including the Tasman Sea.
STC: Subtropical Convergence AC: Antarctic Convergence

i.e., both amphipoda and copepoda hardly coexist with each other so as to make up a food of sei whales in the same area. One of the causative reasons for a quite high feeding percentages in Fig. 9 would be in the curious distributional features of *Parathemisto gaudichaudii* which was demonstrated by Kane (1966, p. 176, Text-fig. 6). He (1966) describes on this matter, " but there are evidently two zones in which it is particularly abundant. These are separated by a belt in the vicinity of the Antarctic Convergence in which the population is small ".

In the south of the Antarctic Convergence higher than 53°S, the large sized euphausiids consisted of *Euphausia superba* begin to appear in place of *Parathemisto gaudichaudii* in the Areas III and IV though sometimes small or medium sized individuals which are represented by adolescent of *Euphausia superba* appear as a supplemental food sources. In the Area IV and V, chiefly the Pacific sector of the Antarcic the general features of latitudinal succession of food organisms could be considered to follow the same pattern with those observed in the Indian sector. It is also noticed in Fig. 9 that small sized euphausiids consisted of *Euphausia vallentini* seems quite important food sources in the Subantarctic waters in the vicinity of the Antarctic Convergence where the sudden diminution of population size of *Parathemisto gaudichaudii* takes place. Brown (1968) thought that *Parathemisto gaudichaudii* fed by sei whales in South Georgia might have been fed in the far northen waters than the food of euphausiids such as *Euphausia superba*. In the southern water far beyond 65°S, a considerable number of medium sized euphausiids consisted of 1-year group of *Euphausia superba* were fed by sei whale.

FEEDING TIME

General features

The fin and blue whales were the main species having been caught previously, and fin whales were the most well studied on their feeding habit. Sei whales on the other hand, were known a little due to so quite few catches among the baleen whales. It has been known that the feeding activity of baleen whales in a day in terms of the percentages varies in general with a bimodal curve which has a maxima in the early morning and in the evening (Nemoto, 1957, 1959). One of his results (Nemoto, 1957) suggests that baleen whales somewhat actively feed twice a day in many cases though each patterns of feeding activity are variable with the kind of food partaining to their diurnal vertical movement, seasons, latitudinal positions, or sometimes with the bottom topography of whaling grounds. Finding myctophid fishes, *Electrona subasper* and *Electrona normani*, Brown (1968) suggested that sei whale is more likely to feed actively in the twilight evening in the South Georgia. Sometimes, however, the baleen whales show a evidence suggesting to feed only once a day (Nishiwaki and Ohe, 1952). In any case, it is considered to be quite important to accumulate the evidences on the feeding habit of baleen whales especially of sei whales in relation to estimating the nutritional budget among the food webs in their feeding grounds. However, it is also nesessary to figure out the feeding patterns of baleen whales by theoretical and experimental methods by assuming such a feeding model as Klumov (1961) instituted for this purpose.

The daily change of feeding activities in terms of the percentages of the stomach with food against the whole number of stomach examined is supposed to be affected chiefly by the diurnal vertical migrations of food organisms, because the most of all food organisms listed in Table 1 were known as to show a quite distinct diurnal vertical migrations in the South Georgian whaling ground (Mackintosh, 1934, 1937; Hardy and Gunther, 1935; Ommanney, 1936). Accordingly, it is necessary to examine the whales food by the species since each food organisms has their own peculiar migratory patterns in a day. The feeding activity by the five kinds of food organisms is shown in Figs. 10a–b. Fig. 10a demonstrates the feeding activity

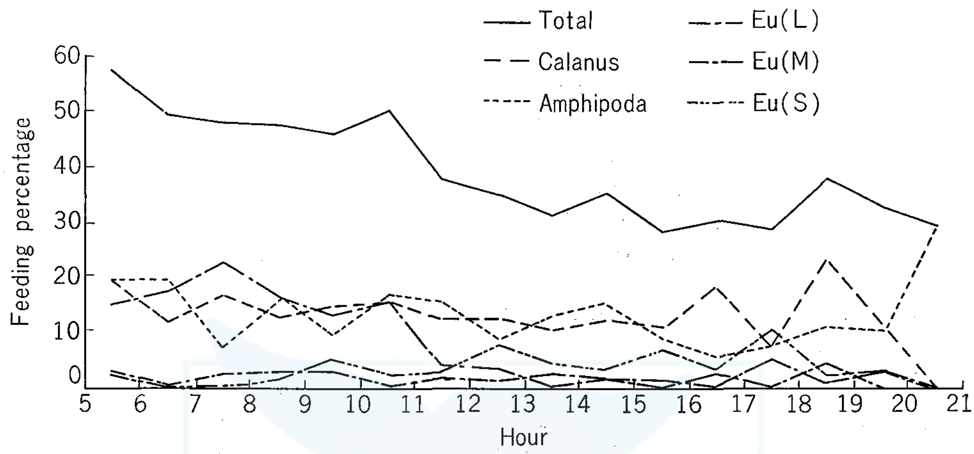

Fig. 10-a. Feeding percentages of sei whales by the kinds of food organisms in the Antarctic, Areas III and IV.

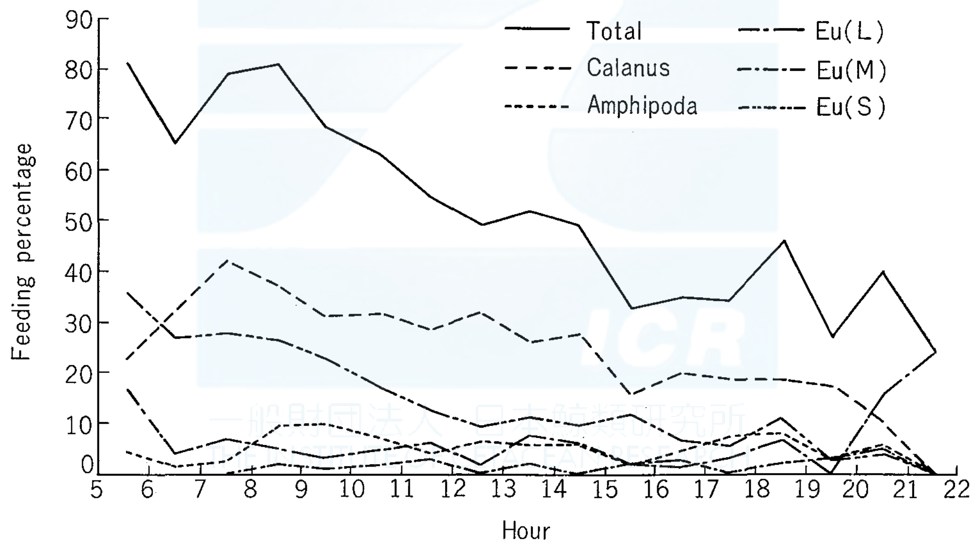

Fig. 10-b. Feeding percentages of sei whales by the kinds of food organisms in the Antarctic, Area V.

in the whaling Areas IV and V, while Fig. 10b does the Areas III and IV. It is noticed in the figures that a quite high feeding percentages are observed in the early morning, and no distinct recovery occurs in the evening. It is also noticed that the most causative organisms to bring on the daily variation of feeding activity are chiefly responsible in the case when amphipoda, large sized euphausiids or "Calanus" were fed. Medium or small sized euphausiids seems to be fed whenever they are available. The upper and lower extremes of feeding percentages were 57 percent and 28 percent in the Areas IV and V, and that in the Areas III and IV were 82 percent and 25 percent respectively. The general trends of feeding activity of sei whales in the Subantactic waters differ considerably from those of fin and sei whales obtained in the northern North Pacific where it varied between 0 to 100 percent in most cases (Nemoto, 1957). This may be attributed partly to the differences of the kind of food organisms taken in both whaling grounds. From the figures, it is naturally considered that the most of sei whales in the Antarctic heavily take a dense population of food once in the morning possibly by ' swallowing ' or ' skimming ', and take a relatively scattered poor population of food organisms by ' skimming ' during the daytime towards the evening, as the manner described by Ingebrigtsen (1929) and Nemoto (1957, 1959).

The case of Calanus tonsus and Calanus simillimus

The components of the " Calanus " food are represented by two dominant species, *Calanus tonsus* and *Calanus simillimus*. In the Indian sector of the Antarctic a considerable number of both *Calanus tonsus* and *Calanus simillimus* occurred as principal food sources of sei whales while only *Calanus tonsus* was observed in the Tasman Sea and in the Pacific sector of the Antarctic (Area IV and V). As there

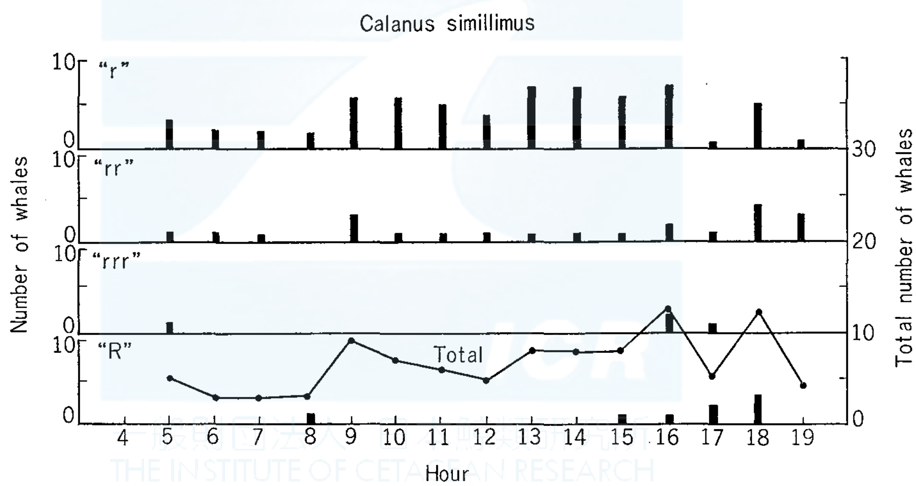

Fig. 11-a. Frequency of the number of whales fed on *Calanus simillimus* by the four different degrees of stomach repletion in a day.
Degree of repletion :
" r " : less than 25 percent " rrr " : 50–75 percent
" rr " : 25–50 percent " R " : 75–100 percent

are considerable differences of the behaviour of diurnal vertical migration between *Calanus tonsus* and *Calanus simillimus* the extent of the repletion of stomach contents by the time was also differed in these two copepod species (Figs. 11a–b). In both *Calanus tonsus* and *Calanus simillimus*, the repletion of stomach was relatively small with the quantity of food less than 50 percent during the daytime. It is noticed clearly that the almost fully repleted stomachs ("rrr"—"R") with *Calanus tonsus* occurred more frequently than *Calanus simillimus*, and the former was fed with a same feeding percentages during the daytime while the bulk of *Calanus simillimus* was exclusively fed only in the evening. This fact would be the result from being exactly followed to the differences of the migratory habit of both species. According to Hardy and Gunther (1935), *Calanus simillimus* is regarded as one of the quantitatively important copepods in the South Georgian waters, and this species shows a distinct diurnal vertical migration as well as *Drepanopus pectinatus;* the bulk of *Calanus simillimus* population begins upward movement at about 1700 hours in the evening and reaches to 10–20 m depth at 1800 hours. They remain at the surface layer during the night then begin to move into the deep down to about 100 m depth in very early morning at least 02–03 hours. This behavior leads to the consideration that there would be only a chance for sei whales to feed on *Calanus simillimus* in the evening in a day. It is interesting to find that the stomach of "full" occurred very frequently in the evening so as to support the consideration of feeding 'once' in a day.

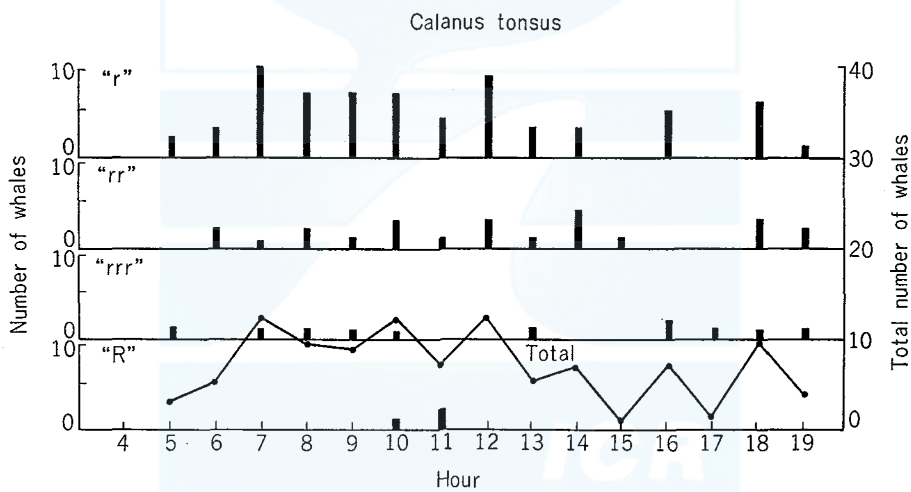

Fig. 11-b. Frequency of the number of whales fed on *Calanus tonsus* by the four different degrees of stomach repletion in a day. Legend as in Figure 11-a.

Calanus tonsus, on the other hand, is a comparable species to *Calanus plumchrus* in the northern North Pacific, and this species is recognized in general to show no such a distinct diurnal vertical migration as *Calanus simillimus.* Judging from its hydrological and taxonomical affinities to *Calanus plumchrus* (Tanaka, 1954, 1956; Jillett, 1968) at least in the 5th copepodite stage, it might presumably be considered that *Calanus tonsus* of 5th copepodite stage does not show any distinct diurnal migration. The occurrence of "full" or "rich" stomachs of *Calanus tonsus* during the daytime suggests a quite well availability of this copopod in the surface waters so as to be fed by sei whale throughout a day.

AMOUNT OF STOMACH CONTENTS

It has long been the obscure mystery or the matter of interest how much the baleen whales take a food in a day. According to Nemoto (1959). Collet (1912) earlily estimated the amount of food taken by the Atlantic blue whale, and showed that they had taken at least 1,000 liters of euphausiids. Betesheva (1954) showed that the North Pacific sei whale can feed 600 kg of squids or 50–370 kg of *Calanus plumchrus*, while Best (1967) given 59 kg of zooplankton from South African waters, and 175 or 305 kg of krill for Antarctic sei whales (Brown, 1968). There are some more data about this problem which has been accumulated on the whales of northern hemisphere though most of them were on fin whales (e.g. Nishimoto, et al., 1952; Nemoto, 1959; Klumov, 1961). Nemoto (1959) demonstrated that the fin whales of 57 feet in the northern North Pacific fed on 759.0 kg. of Alaska Pollack and found a considerable variations in the amount of stomach contents (91.0–759.0 kg) notwithstanding the fact that the majority of all stomachs concerned were repleted as " full " by eyes. His result also suggests that the weight of stomach contents filled with copepods usually very little than those by fishes or euphausiids.

TABLE 4. AN AVERAGE AND THE MAXIMUM AMOUNT OF STOMACH CONTENTS OF SEI AND FIN WHALES IN THE ANTARCTIC

Whale species	Body length (m)	Sex	Number of whale examined	Average		Maximum	
				Total weight (kg)	Volume (l)	Total weight (kg)	Volume (l)
Sei whale	13.0–13.9	F	2	171	202	182	204
		M	0	—	—	—	—
	14.0–14.9	F	2	118	149	141.3	180
		M	5	116	140.4	154.6	200
	15.0–15.9	F	1	152	200	152	200
		M	3	159.2	208.5	228	312
	16.0–16.9	F	1	196.5	255	196.5	255
		M	0	—	—	—	—
Fin whale	18.0–18.9	F	0	—	—	—	—
		M	1	301.3	391	301.3	391
	20.0–20.9	F	1	567	700	567	700
		M	0	—	—	—	—
	21.0–21.9	F	0	—	—	—	—
		M	2	510	700	885	1000
	22.0–22.9	F	1	133	238	133	238
		M	0	—	—	—	—

In the Antarctic, as I showed in a brief note (Kawamura, 1968) the amount of stomach contents of 14 sei whales which fed on *Calanus tonsus*, *Parathemisto gaudichaudii*, *Euphausia superba* and *Euphausia vallentini* was measured (Table 4). The weighing of stomach contents were carried out on the stomachs being judged as " full " by eyes, and full data including fin and minke whales were given in *Appendix*. The highest value observed was 228.0 kg of *Parathemisto gaudichaudii*, which was fed by 15.2 m of male, while it was only 68.0 kg in the *Calanus tonsus* food. Nemoto (1962) mentioned that there were quite well agreement between the weight and the degree of replation of stomach judged by eyes. However, as shown in *Appendix* there were considerable variations in the case of the Antarctic sei whale. It can be said in general that the whales caught before 0900 hours carry somewhat fresh and large amount of stomach contents, and their proportional weight of water gradually increases toward the noon due to digestion.

The highest and averaged amount of stomach contents show that the males of both sei and fin whales likely to feed on much food than the females though feeding percentage seems to be high in the female (Brown, 1968). It is noticed that the stomach is hardly repleted when the whales feed on copepods than fish or euphausiids. This fact leads to a consideration that the larger the size of food organisms, the larger amount of stomach contents is expected. Such a tendency is also shown in the North Pacific fin whales (Nemoto, 1959, Table 24). From my result I may describe the following weights as an approximate amount of stomach contents usually seen in the Antarctic:

Sei whales:	Copepoda	less than 100 kg
	Amphipoda	150—250 kg
	Euphausiids	150—200 kg
Fin whale:	Euphausiids	300—900 kg
Minke whale:	Euphausiids	30 kg

By comparing these values with those obtained by other workers (e.g. Klumov, 1961; Brown 1968), the amount of stomach contents of sei whale in the Antarctic does not differ so much from those obtained in the northern North Pacific.

SUMMARY

1. In the Antarctic whaling season 1967/68 four Japanese fleets operated in the whaling Areas III-V, and 7,119 sei whales were caught during the season.

2. The general biological observations such as the body length, thickness of blubber, mammary gland etc., including the stomach contents were carried out on every whales. In addition to this 117 samples of the stomach contents of sei whale were obtained from three fleets for taxonomical and biogeographical study of food organisms.

3. The quantitatively important food organisms found in the samples were: *Euphausia superba*, *E. vallentini*, *Thysanoëssa vicina*(?), *Calanus tonsus*, *C. simillimus*, *Clausocalanus laticeps*, *Drepanopus pectinatus* and *Parathemisto gaudichaudii*. Two of them, *i.e.*, *C. tonsus* and *Clausocalanus laticeps* seems to be recorded for the first time here as the staple food sources of the Antarctic sei whale.

4. Both *C. tonsus* and *C. simillimus* are recognized as a endemic species of Subantarctic waters. *C. tonsus*, however, seems more characteristic in the northern warmer waters with sea temperature of 9.50–12.0°C while *C. simillimus* is distinct in the more

colder waters with sea temperature of 5.0–9.10°C.

5. In the whaling grounds south of New Zealand and in the Tasman Sea, *Calanus tonsus* is the most important food species for sei whale while *C. simillimus*, *C. tonsus*, *Drepanopus pectinatus* and *Euphausia vallentini* were important in the surrounding waters of Crozet Islands.

6. The occurrence of *Calanus propinquus* and *Calanoides acutus* as the food of sei whale in the waters near to Crozet Islands by Russian investigation seems to be less probable or quite unusual by the fact that those two copepod species are the real Antarctic species being found in more higher latitudes, and also no reports mentioning on the occurrence of these copepods in such a northern warmer waters as 46°S.

7. Judging from the general composition of stomach contents the sei whale chiefly feeds on a monotonous population of food organisms, *i.e.*, there were so few cases of mixture food.

8. The feeding percentages of sei whale were relatively low especially in the case of "Calanus" food. "Calanus" is, however, the most important food in the whaling Area V, while it was replaced by *Parathemisto gaudichaudii* in the Areas III and IV. *Euphausia vallentini*, on the other hand, was preferably fed throughout the Areas III to V.

9. The chief diet of sei whale showed a clear latitudinal succession from the north to the south in the following order: *Calanus tonsus*—(*Clausocalanus laticeps*)—*Calanus simillimus*, *Drepanopus pectinatus*, *Euphausia vallentini*—*Parathemisto gaudichaudii*—(*P. gaudichaudii*, *E. superba*)—*Euphausia superba*

10. Sei whale actively feeds twice a day in general though the feeding activity varies considerably with the kind of food species which have a peculiar pattern of diurnal vertical migration. The sei whale when feeds on *C. simillimus* could presumably feed them once in the evening while it is expected to feed twice or anytime in a day in case of *C. tonsus* food.

11. The amount of stomach contents of sei whale usually large when euphausiids or amphipods are fed. It is considered that the larger the size of food organisms the larger amount of stomach contents are expected. The Antarctic sei whales with " full " stomach proved to carry a crustacean food of approximately 150–200 kg.

ACKNOWLEDGEMENTS

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AUTHORS' NOTE

In the course of this paper being submitted for publication a quite interesting paper by D. E. Sergeant (Feeding rates of cetacea. *FiskDir. Skr. Ser. HavUnders.*, 15 : 246–58, 1969) appeard. Following Ivelev (1961) Sergeant proposed to use the term "Feeding rate" as a index daily ration expressed as percent of body weight.

"Feeding percentage" used in this paper and also in Nemoto (1957, 1959) basically differs from Sergeants', *i.e.*, the term means the ratio : number of whales with food/total number of whales examined.

Although both terms differ as they are, it is considered that Sergeants' proposal would be reasonable, and much care will be payed to avoid any confusion when those matters are expressed in "Feeding percentage".

APPENDIX. AMOUNT OF FOOD TAKEN BY THE ANTARCTIC FIN, SEI AND MINKE WHALES.
(" NISSHIN-MARU " FLEET IN 1967/68)

No. of whales	Species	Sex	Body length (m)	Stomach contents	Position taken	Date taken	Time (L.T.)	Net weight of food (kg)	Water (kg)	Total weight of stomach contents (kg)	Volume (l)	Re-marks
300	Sei	M	14.4	Calanus	45°25′S 85°39′E	28 XII '67	1115	54.0	14.0	68.0	66	a)
427	Sei	M	14.1	Amphipoda	50°37′S 74°05′E	6 I '68	0600	136.5	18.1	154.6	171	b)
609	Sei	M	14.2	Amphipoda	51°05′S 73°25′E	15 I '68	0800	73.5	14.5	88.0	109.2	c)
324	Sei	M	14.6	Amphipoda	47°21′S 86°06′E	30 XII '67	1105	98.0	30.0	128.0	156	a)
462	Sei	M	15.2	Amphipoda	51°12′S 72°51′E	7 I '68	0925	200.0	28.0	228.0	312	
612	Sei	M	15.1	Amphipoda	51°05′S 72°25′E	15 I '68	1455	57.6	13.8	71.4	93.6	
1397	Sei	M	14.7	Eu-L	56°14′S 81°00′E	21 II '68	1050	142.0	0.0	142.0	200	
554	Sei	M	15.1	Eu-S	47°50′S 70°36′E	13 I '68	1345	149.6	28.6	178.2	220	d)
1477	Sei	F	13.0	Eu-L	57°10′S 83°38′E	23 II '68	0830	149.0	33.0	182.0	200	
534	Sei	F	13.2	Eu-S	47°52′S 70°33′E	12 I '68	1940	135.6	24.4	160.0	204	d)

(Continued)

1437	Sei	F	14.3	Eu-L	56°24′S 80°46′E	22	II ’68	0925	128.7	12.6	141.3	180	e)
532	Sei	F	14.7	Eu-S	47°52′S 70°33′E	12	I ’68	1745	79.1	15.4	94.5	119	
1471	Sei	F	15.6	Eu-L	57°10′S 83°38′E	23	II ’68	0540	148.0	4.0	152.0	200	
665	Sei	F	16.2	Eu-LMS	55°10′S 78°21′E	18	I ’68	0855	159.0	37.5	196.5	255	
699	Fin	M	18.6	Eu-L	57°11′S 72°22′E	21	I ’68	1015	273.7	27.6	301.3	391	e)
1608	Fin	M	21.0	Eu-L	54°36′S 80°42′E	2	III ’68	0820	785.0	100	885	1000	
1376	Fin	M	21.1	Eu-L	54°12′S 79°35′E	20	II ’68	0640	286.0	28.0	314.0	400	e)
1384	Fin	F	20.2	Eu-L	56°14′S 81°00′E	21	II ’68	0550	556.5	10.5	567	700	
706	Fin	F	22.1	Eu-L	57°11′S 72°22′E	21	I ’68	1115	127.4	5.6	133.0	238	
6	Minke	F	8.0	Eu-L	57°11′S 72°22′E	21	I ’68	1805	22.4	4.0	26.4	31.2	

Calanus: *Calanus tonsus*, Amphipoda: *Parathemisto gaudichaudii*, Eu-L or -M: *Euphausia superba*, Eu-S: *Euphausia vallentini* (except no. 665)

a) Approximate values.

b) Estimated by the stomach volume averaged on 13 sei whales.

c) Calculated by the mean weight of a unit volume of amphipod food of 4 sei whales.

d) Calculated by the mean weight of a unit volume of small-sized euphausiids taken by no. 532 sei whale.

e) Calculated by the mean weight of a unit volume of large-sized euphausiids taken by 6 fin whales and 1 minke whale.

AN AMPHIPOD, (*PARATHEMISTO GAUDICHAUDII*) AS A FOOD OF THE ANTARCTIC SEI WHALE

TAKAHISA NEMOTO* AND KWANG IL YOO*

An Antarctic amphipod, *Parathemisto gaudichaudii* (Guér.) is extremely abundant in the circumpolar belt around the Antarctic convergence (Baker, 1954; Kane, 1966). It forms a considerable part of the food of sei whales in the Antarctic as well as in the waters between the Antarctic and subantarctic convergence (Nemoto, 1959; 1962).

All materials treated here have been collected mainly from the stomach content of sei whales caught by Japanese whaling expeditions from 1964 to 1967 in the Antarctic. Some other specimens collected from plantkon tows carried in 1957 and the stomach content of baleen whales were also examined.

These data on the food of sei whales reveal the distribution of *P. gaudichaudii* which is very important as the food of sei whales, and covers the lower subantarctic waters. A short discussion on the feeding habit of this species is also given.

FOOD OF SEI WHALES

P. gaudichaudii was reported as the food of sei whales in the Antarctic waters by Nemoto (1959), and its occurrence has been summarized in recent works (Nemoto, 1962; Doi, Ohsumi, and Nemoto, 1967).

The occurrence of *P. gaudichaudii* as the food of sei whales (*Balaenoptera borealis*) is shown in Table 1 and 2, in which the amphipod forms a considerable part of the food. The occurrence of this amphipod as the whale's food in recent years is evidently due to the shift of the whaling ground from the higher Antarctic wates to the comparatively lower latitudes of the Antarctic and northern waters of the Antarctic convergence.

The catch of sei whales in 1964–1965 season was concentrated somewhat in the waters south of the Antarctic convergence, but the main catch of sei whales in 1965–1966 was obtained from the northern waters of the convergence. This may be due to the fact that the copepods and amphipods form a major part of the food species, although there may be some misidentification of food species. In 1964 most of the occurrence of *P. gaudichaudii* was observed along the Antarctic convergence (Figs. 1 and 2).

DISTRIBUTION OF *P. GAUDICHAUDII*

P. gaudichaudii is an oceanic swarming species of the *Amphipoda-Hyperiidea* and is found mainly in surface waters (Kane, 1966). This species has been described not only in plankton collections, but also in many fish stomachs (Hurley, 1959). The

* Ocean Research Institute, University of Tokyo.

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southern limit of this species has been discussed by various authors (Bowman, 1960; Hurley, 1961; Kane, 1966). It is suggested that it might occur south of the Antarctic convergence or divergence (Barnard, 1930). Bary (1959) also described the occurrence of *P. gaudichaudii* in the south of subtropical convergence according to temperature-salinity and plankton diagram. Hurley (1961) and Kane (1966) considered further that *P. gaudichaudii* is the species distributing in warm water north of or in the subtropical convergence region, in the oceanic cold water south of the subtropical convergence region and colder water south of the Antarctic divergence.

TABLE 1. STOMACH CONTENTS OF SEI WHALES CAUGHT BY TWO JAPANESE WHALING EXPEDITIONS IN THE SOUTHERN OCEAN IN RECENT YEARS

	1964–'65 season	1965–'66 season
None	5356	7152
Copepods	23	2180
Euphausiids	3693	774
Decapods	6	65
Squids	0	5
Fish	16	2
Amphipods	111	1138
Total	9205	11316

TABLE 2. STOMACH CONTENTS OF SEI WHALES CAUGHT BY JAPANESE WHALING EXPEDITIONS IN THE SOUTHERN OCEAN IN 1966/1967 SEASON

Food Species	Quantity*				
	o	r	rr	rrr	R
None	1130	—	—	—	—
Copepods	—	308	190	73	44
Euphausiids	—	24	16	3	7
Amphipods	—	43	17	18	21
Amphipods and Copepods	—	4	4	3	2

* R : Much, rrr : More than half, rr : less than half, r : little.

In the north hemisphere, the records of *P. gaudichaudii* was only from the Atlantic, but has not been recorded in the North Pacific (Dunbar, 1954; Kane, 1966), and this would be one problem to be solved in the future investigation.

FEEDING HABIT OF *P. GAUDICHAUDII*

Three forms of the species *P. gaudichaudii* have been considered by recent investigations (Hurley, 1959), however, most of the observed specimens are f. *thomsoni* or " long-legged " form, which is referred to as f. *bispinosa* (Kane, 1966).

The observation of feeding habit in living specimens shows that the third peraeopod acts very quickly to seize zooplanktons, the action ranges of each peraeopod are schematically in Fig. 3, as semi-circle. The fourth and fifth peraeopods also play some part in the action, but their spines and setae along the inner edge of the legs are not so well-developed as third peraeopod. The third peraeopod has well-developed seizing setae and spines (Plate I–1), the wide range of the reach is effective for the active zooplanktons. The first and second peraeopods have well-developed sickle-shaped terminal segments and they are considered to hold the caught prey

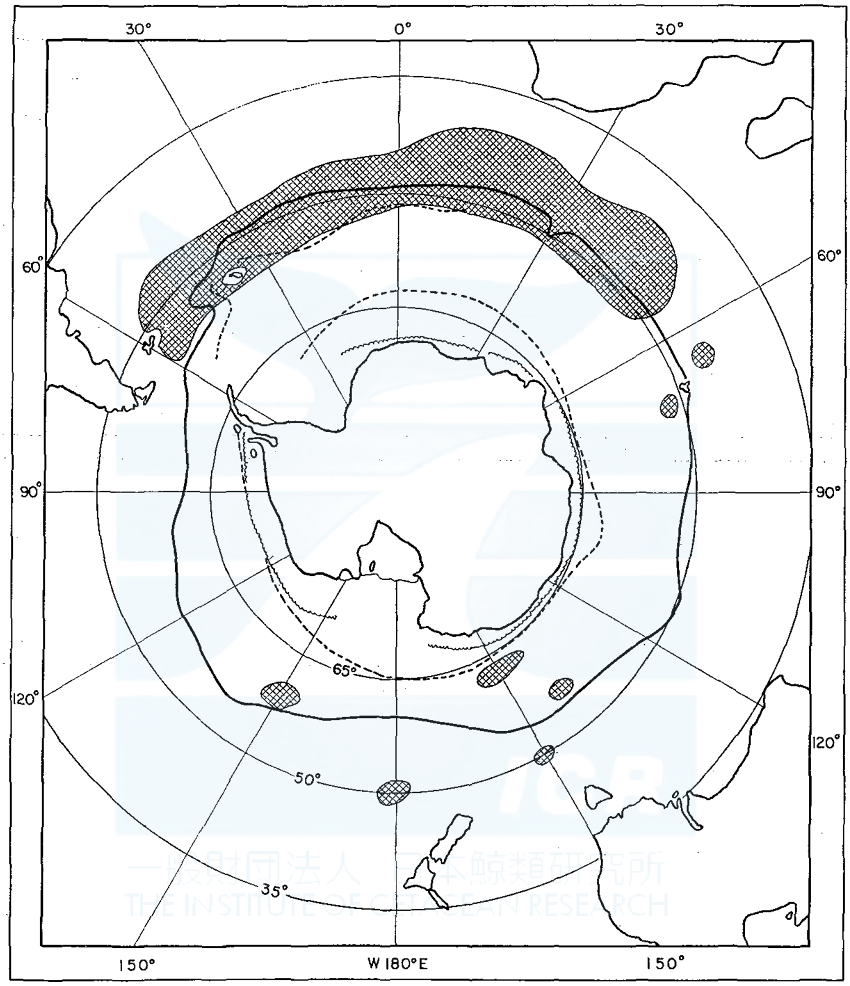

Fig. 1. Distribution of amphipods as the food of sei whales in the southern hemisphere.

and carry it to the mouth-part. The chellae in the terminal segment of the second gnathopod may tear the prey and carry to the mouthpart. The chellae in gnathopods confirm it. In addition to the feeding action, the sixth peraeopod keeps the body in right position in their swimming and feeding. The feeding habit in *P. gaudichaudii* is very similar to that described for *P. gracilipes* by Kane (1963) who says " The posterior peraeopods were used to grasp and hold the prey and the first two peraeopods to hold it in place and direct the part to be eaten towards the gnathopods. These in turn seemed to be tearing off pieces which were pushed towards the continuously active mouthparts ".

The mandible of *P. gaudichaudii* is typical carnivorous one. It completely lacks the pars molaris of the same type of euphausiids which is very effective in crushing hard shells like diatom.

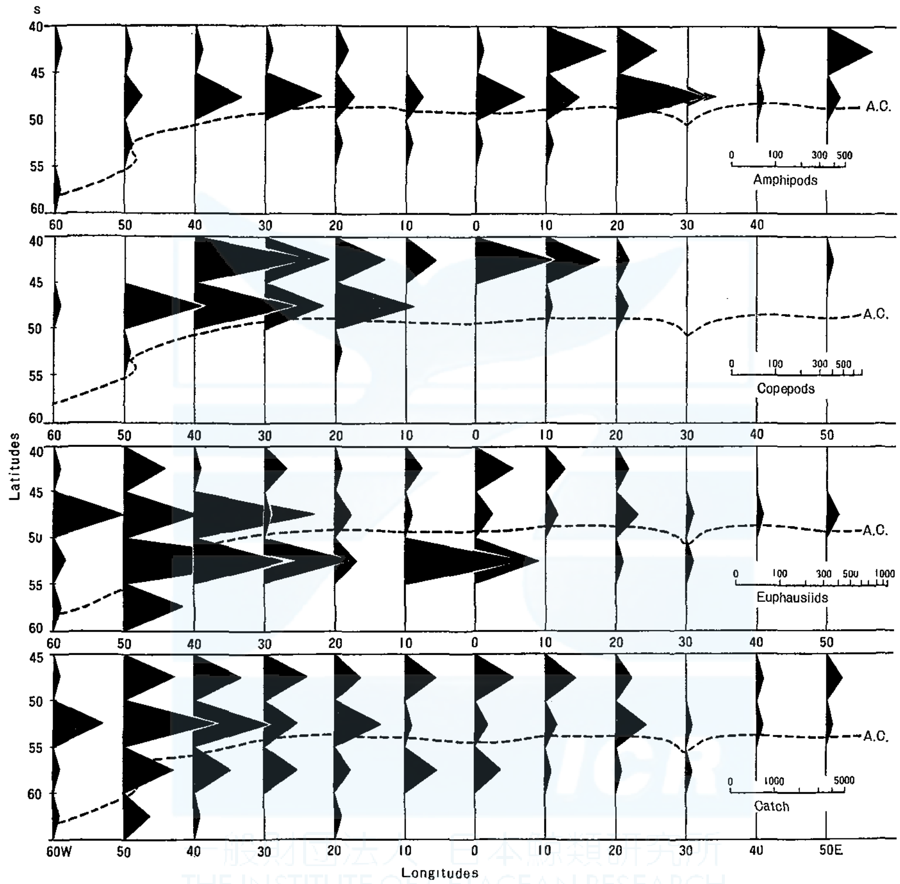

Fig. 2. Occurrence of food planktons in the stomach of sei whales in the Antarctic in 1964–65 and 1965–66 seasons.

The stomach also lacks the inner spines and mill-like cluster spines (Plate I–2) which are common in herbivorous euphausiid species such as *Euphausia superba* (Nemoto, 1967). The examination of stomach contents of *P. gaudichaudii* reveals that they mainly feed on zooplankton, especially copepod (Plate I–3, 4,). In the stomach of large *P. gaudichaudii* three or more copepods of 3 mm in cephalothorax length were often observed (Plate I–3). In some cases, appendages of euphausiid were also found in its stomach (Plate I–5). Plate I–6 shows diatoms in the stomach of young amphipod, and it suggests that the phytoplankton fragments are originated from the fed copepod or else, that the young *P. gaudichaudii* might take phytoplankton.

The specimens in the same patch were often found to have fed on equal quantity of copepod, suggesting that they came across the patch of copepod and took the patch all at once.

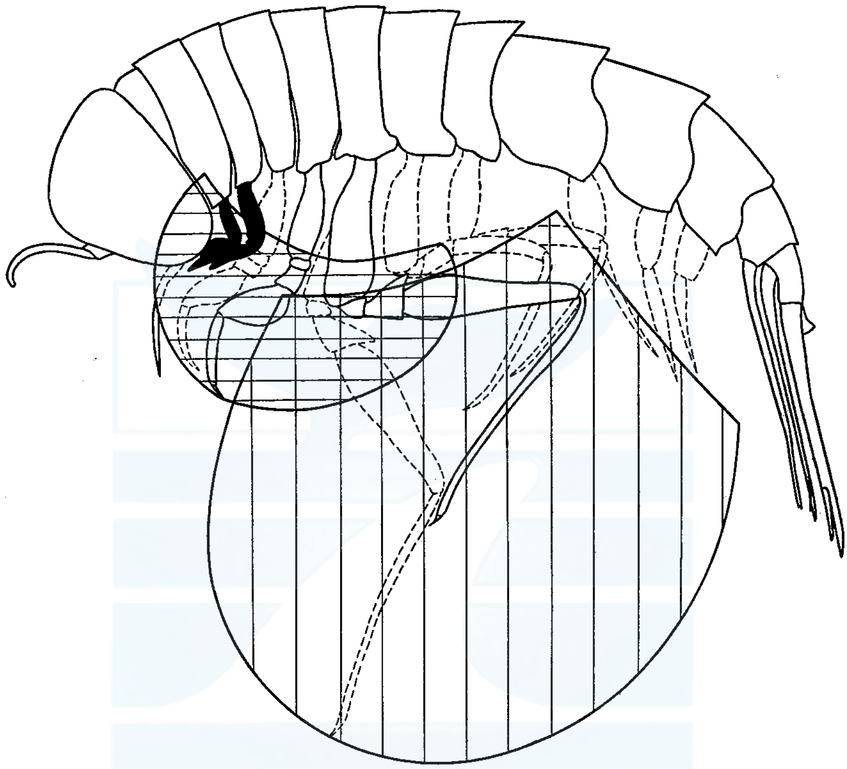

Fig. 3. Schematic illustration of movement of thoracic legs of *Parathemisto gaudichaudii* in feeding.

In conclusion it can be said that *P. gaudichaudii* is one of the typical voracious carnivorous zooplankton species, and it constitutes a considerable part of sei whale's food in the Antarctic. Sei whales feed also on carnivorous zooplankton, *P. gaudichaudii* in the southern hemisphere, and their feeding behavior is different from that of the other baleen whales such as blue and fin whales that feed on herbivorous euphausiid, *Euphausia superba* and *Euphausia vallentini.*

It is also suggested that *P. gaudichaudii* consists of another pathway in food chain as well as euphausiid groups in the southern hemisphere (Nemoto, 1966), while correlations in food web are present as following series: Phytoplankton—small-sized zooplankton, Copepod—carnivorous Amphipod, *P. gaudichaudii*—Sei whales. This chain is the typical one which is related to the carnivorous zooplankton in the open ocean.

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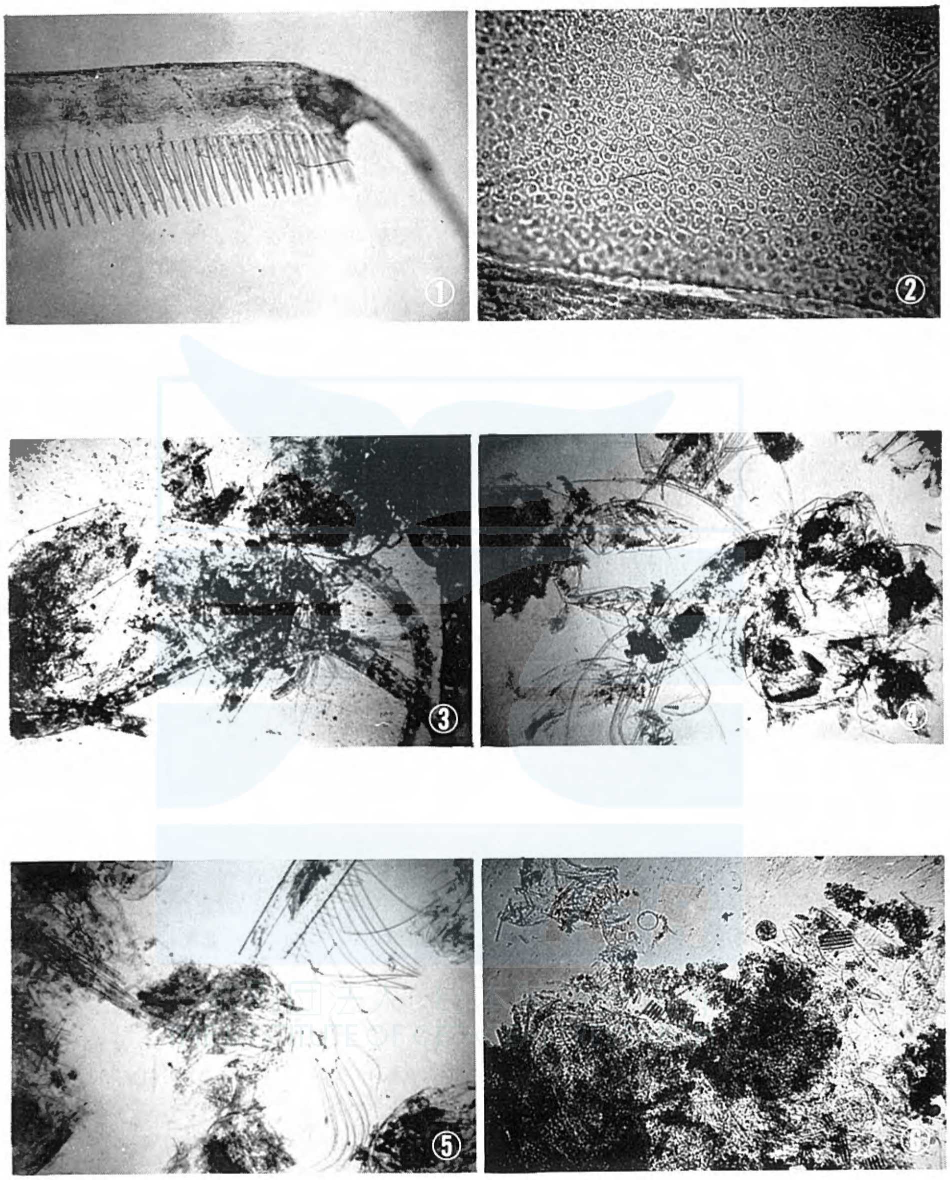
EXPLANATION OF PLATE

1—Seizing spines in third peraeopod. 2—Stomach wall of *Parathemisto gaudichaudii*. 3—Stomach contents of *P. gaudichaudii*. 4—Stomach contents of *P. gaudichaudii*. 5—Stomach contents of *P. gaudichaudii*. 6—Stomach contents of *P. gaudichaudii*.



一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

TWIN FOETUSES FROM A BLUE WHITE DOLPHIN

TERUO TOBAYAMA*, SENZO UCHIDA*
AND MASAHARU NISHIWAKI**

Twin foetuses of blue white dolphin were found in a school of about 2000 dolphins captured at Kawana, Ito city, Shizuoka Pref. on December 17, 1966. Though umbilical cords had been cut by a fisherman, we were fortunate enough to get the foetuses, the mother, the uterus and the placenta with two umbilical cords. We recognized the foetuses were undoubtedly twin and got a pleasure of investigating the rare phenomenon of twin dolphins. Twin or multiple foetuses of baleen whales have been reported comparatively frequently. But, so far as we know, no scientific report of twin dolphins have been obtained only some incidents of them have been heard from local people. We have discovered no twin foetuses in about 30000 dolphins investigated within recent three years.

The external measurement and the body proportion of the mother are shown in Table 1. There is no distinct difference in the body proportion of the mother from that of other common ones with single foetus. Color pattern of the body surface is also common to the others. As the external measurement and the body proportion of the foetuses are shown in Table 2, body length are 43.5 cm and 39.7 cm respectively. Since the umbilical cords were cut, we could not aware of which one had been connected to which cord. Compared them with a common single foetus of this species, both ones show some differences in the length of snout, dorsal fin at its base and the tail flukes from anterior insertion to the tip. A little difference is also recognized in the length from the tip of snout to the blowhole. But, it seems those differences were caused by the individual variation or by the measuring error, and judging this matter from the reports by Ohsumi (1960), Nakajima (1959), are not significant. There is least difference between the body proportion of the foetuses except in the length from the tip of snout to the blowhole. The individual of BL39.7 cm has longer snout than the other of BL 43.5 cm. And the shorter one has greater girth, naturally, the former looked more plump than the latter. Although we have not done anatomical examination, on the ovaries of the mother yet, one corpus luteum and one corpus albicans were found in the left ovary. We have done macroscopical observation already as reported here, anatomical and some other studies on the dolphins will be done in future.

We are much indebted to the Kawana Fishermen's Union for kind help given to our collection.

* Terushima Biological Station, Terushimaland.
** Ocean Research Institute, University of Tokyo.

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TABLE 1. MEASUREMENT OF BODY PROPORTIONS OF THE MOTHER OF THE TWIN FOETUSES COMPARED WITH THE NORMAL SPECIMENS IN *STENELLA CAERULEOALBA*

No.	Point of measurement	Mother of twins		Normal (14 females)		
		mm.	%	N	mean %	range %
1.	Body length	2210	100.0	14	2003	1770–2260
2.	Length of rostrum	130	5.9	14	5.5	4.2– 6.3
3.	Tip of rostrum to angle of gape	285	12.9	14	13.6	11.1–14.7
4.	Tip of rostrum to blow hole	345	15.6	14	16.2	13.7–18.2
5.	Tip of rostrum to center of eye	345	15.6	14	16.1	13.2–18.1
6.	Tip of rostrum to anterior margin of flipper	510	23.1	14	23.7	21.2–26.1
7.	Center of eye to ear hole	60	2.7	14	2.8	2.1– 4.1
8.	Notch of the flukes to posterior end of dorsal fin	925	41.9	14	40.5	34.6–43.8
9.	Notch of flukes to anus	655	29.8	14	30.3	28.2–32.7
10.	Notch of flukes to umbilicus	1245	56.4	14	54.9	50.9–60.0
11.	Anus to genital opening	80	3.6	14	2.9	1.7– 3.4
12.	Dorsal fin; base length	300	13.6	14	13.2	12.0–14.0
13.	Dorsal fin; height	190	8.6	14	7.5	6.2– 8.7
14.	Flukes; notch to tip	270	12.2	14	11.6	9.6–12.3
15.	Flukes; width at insertion	145	6.6	14	7.1	6.6– 7.6
16.	Flukes; anterior insertion to tip	327	14.8	14	14.5	12.6–15.6
17.	Flukes; tip to tip	480	21.7	14	22.4	18.6–24.8
18.	Flipper; anterior insertion to tip	296	13.4	14	14.4	13.4–15.5
19.	Flipper; axilla to tip	210	9.5	14	10.2	9.1–11.7
20.	Flipper; greatest width	100	4.5	14	4.8	4.0– 5.8
21.	Maximum height of body	550	24.8	14	23.2	21.2–26.6
22.	Girth at anterior insertion of dorsal fin	1130	51.0	14	50.2	45.1–53.8
23.	Number of teeth	38 39		14	43 43	39–49 38–49
		39 38			43 44	39–46 40–46

TABLE 2. MESUREMENT OF BODY PROPORTIONS OF THE TWINS COMPARED WITH THE NORMAL SPECIMENS

No.	Point of measurement	Present twins A mm.	A %	Present twins B mm.	B %	Normal (2 M. 1 F.) n.	mean %	range %
	B. L.	435 mm		397 mm				
	B. W.	1000 g		950 g				
1.	Body length	435	100.0	397	100.0	3	408 mm	366–489 mm
2.	Length of rostrum	23	5.3	21	5.1	3	4.0	3.3– 4.5
3.	Tip of rostrum to angle of gape	68	16.2	65	16.4	3	15.0	14.8–16.6
4.	Tip of rostrum to blowhole	64	14.7	72	18.1	3	14.7	12.7–16.4
5.	Tip of rostrum to center of eye	81	18.6	78	19.4	3	17.6	17.0–18.3
6.	Tip of rostrum to anterior margin of flipper	123	28.3	109	27.4	3	26.7	24.8–28.2
7.	Center of eye to ear hole	15	3.4	16	4.0	3	3.4	2.7– 4.3
8.	Notch of flukes to posterior end of dorsal fin	165	38.0	149	37.4	3	39.4	35.8–39.6
9.	Notch of flukes to anus	125	28.3	113	28.4	3	30.2	29.2–31.6
10.	Notch of flukes to umbilicus	215	49.4	203	50.5	3	47.1	45.4–49.8
11.	Anus to genital opening	28	6.4	25	6.3	3	6.7	6.5– 6.8
12.	Dorsal fin; base length	55	12.7	56	14.1	3	10.2	9.2–10.8
13.	Dorsal fin; height	28	6.4	29	7.3	3	6.6	5.7– 7.8
14.	Flukes; notch to tip	50	11.3	41	10.3	3	12.4	10.4–15.4
15.	Flukes; width at insertion	37	8.5	33	8.3	3	9.1	8.5– 9.7
16.	Flukes; anterior insertion to tip	78	17.9	69	17.4	3	14.7	13.9–15.5
17.	Flukes; tip to tip	67	15.4	59	14.9	3	18.2	15.4–20.5
18.	Flipper; anterior insertion to tip	68	16.2	65	16.4	3	15.7	15.0–16.4
19.	Flipper; axilla to tip	46	10.6	42	10.6	3	11.3	10.1–12.5
20.	Flipper; greatest width	22	5.5	20	5.0	3	4.8	4.5– 5.4
21.	Maximum height of body	105	24.2	92	22.6	3	22.2	19.1–25.7
22.	Girth at anterior insertion of dorsal fin	230	53.0	232	58.0	3	53.0	47.5–61.1
23.	Number of hairs	L. 6 R. 5		L. 5 R. 5				

Umbilical cord.

	A	B
Length;	190 mm	215 mm
Diameter;	12 mm	11 mm

Uterus weight; 1045 g
Placenta weight; 500 g

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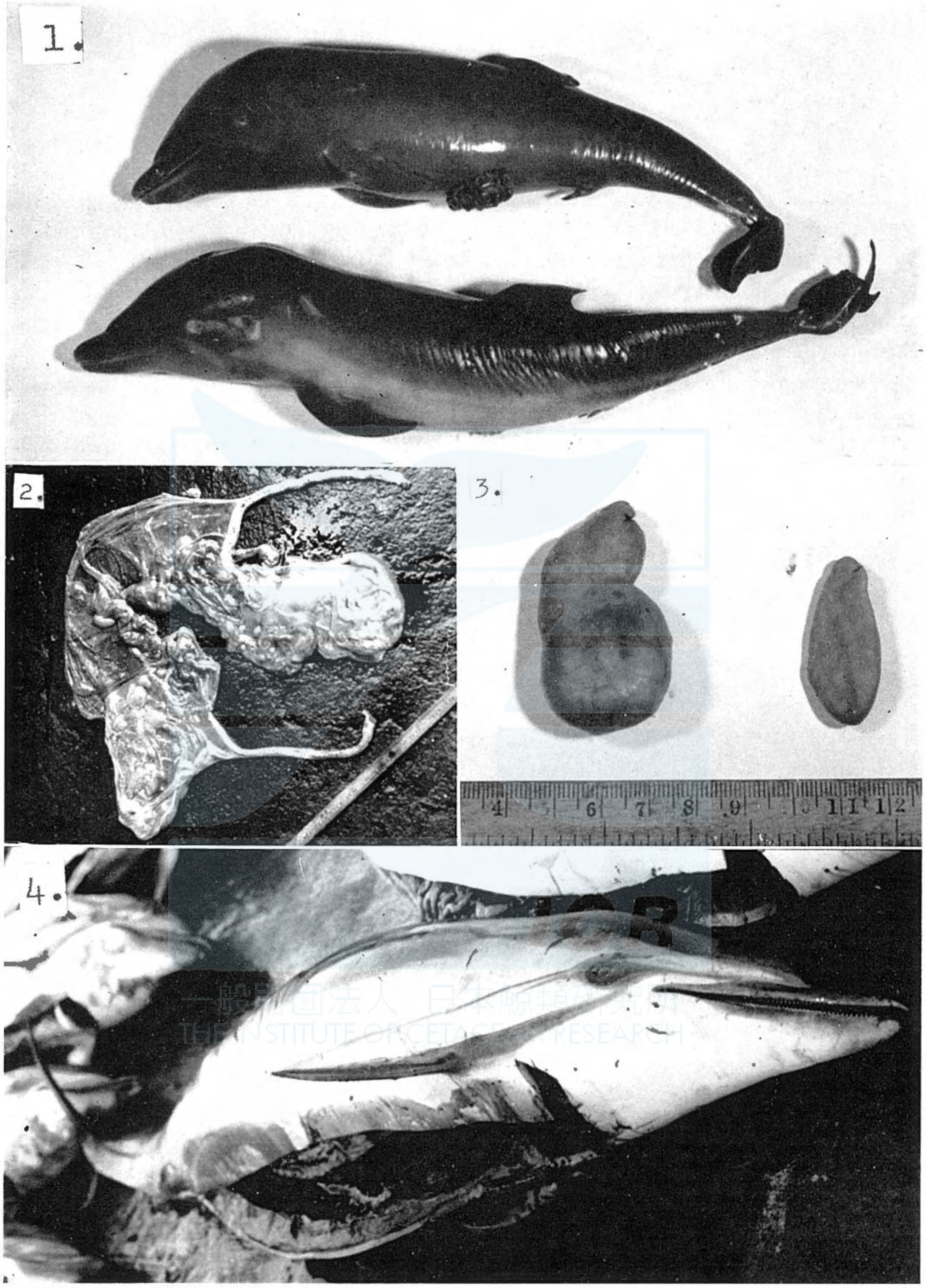
EXPLANATION OF PLATE

Fig. 1. Twin foetuses of a blue white dolphin.
Upper ; male, body length 39.7 cm.
Lower ; male, body length 43.5 cm.

Fig. 2. Placenta of the twin's mother with two umbilical cords.

Fig. 3. Ovaries of the twin's mother.

Fig. 4. Mother of the twins, ventral view from the head.



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A SWORD-FISH SWORD FOUND FROM A NORTH PACIFIC SEI WHALE

SABURO MACHIDA

On July 14, 1969, a part of sword (rostrum) from a sword-fish was found in a sei whale, immature male and 40 feet in length, treated on the factory ship " Nisshin Maru ". The sword was found in the musculature of the left side neck, close to the cervical vertebrae, and the surrounding meat was in abscess filled with yellowish pus. No visible external wound was observed on the surface of the whale body.

This sword was broken into two pieces. Its total length was 30.5 cm, and it is seemed to be an anterior of the sword (Fig. 1). This sei whale was taken at a position of 50°52′ N, 169°12′ W. It is possible that the whale was stabbed by a sword-fish while the former was staying in warmer waters, presumably to the south of 45°N, judging from the known distribution of the sword-fish.

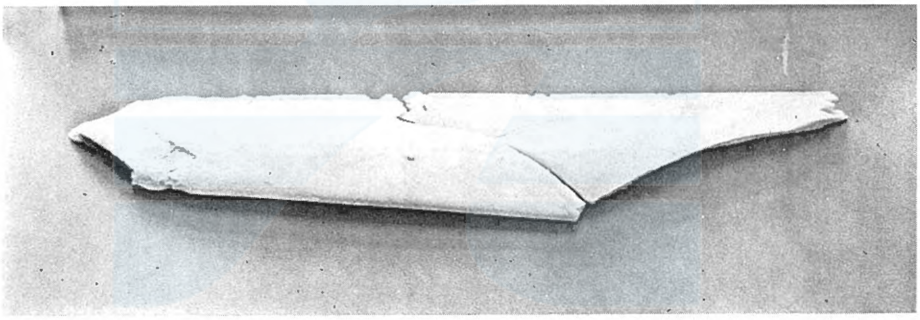

Fig. 1. A sword from a sword-fish found in a sei whale.

The occurrence of the sword of the sword-fish in whale body has already been reported by Ruud (1952), Nemoto (1959), and Jonsgård (1959, 1962), amounting to four occasions in fin whale and two in blue whale. This recovery will add one instance in sei whale. Attacking of the sword-fish on the whale was discussed by Brown (1960).

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Ruud, J. T., 1952. Do sword-fish attack the large whales? *Norsk Hvalfangst-Tid.*, 41 (4) : 191–3.

FATTY ACID COMPONENTS OF BLACK RIGHT WHALE OIL BY GAS CHROMATOGRAPHY

HIDEO TSUYUKI* AND SHINGO ITOH*

INTRODUCTION

There have been a number of studies on whale oil. However, there are a few studies on black right whale oil. As to the study on black right whale oil, we can find the following reports; Studies on the oil of black right whale in the Northern Pacific Ocean (Tsuyuki and Naruse, 1963), Studies on the lipids in brain of black right whale in the Northern Pacific Ocean (Tsuyuki and Naruse, 1964), Studies on liver oil of black right whale (Tsuyuki, Naruse, Mochizuki and Itoh, 1964).

So far as these works concerned with chemical properties of oils and fatty acid components by fractional distillation, minute examinations of fatty acid components have not been reported yet.

So the purpose of the present work is a minute examination of the fatty acid components of black right whale oil by gas-liquid chromatography using a hydrogen ionization detector.

It is pleasure that we express here our thanks to Dr. H. Omura and Dr. S. Ohsumi in the Whales Research Institute who were kind enough to present us black right whale oils.

MATERIAL AND METHOD

Sample used

Material is the black right whale, *Eubalaena glacialis*, (male, body length: 17.1 m, presumed age: more than 12 years old) which was caught at the southern sea of Kodiak Island in the Northern Pacific Ocean in 1962 (Tsuyuki and Naruse, 1963).

The oils contained in 9 parts of blubbers were obtained by boiling these blubbers with water and those in 3 kinds of organs were extracted with acetone in an atmosphere of nitrogen gas. The oils used in the present report were stocks used in previous reports (Tsuyuki and Naruse, 1963, 1964). The bottles of sample oils have been filled up with nitrogen gas and preserved in refrigerator at low temperature.

Used sample oils are the oils contained in 3 kinds of organs (stomach, liver and tongue), and 9 parts of blubbers (middle back, thoracic, abdominal, brain, hind part of blow-hole, umbilicus, anterior abdominal, fore part of genital aperture and posterior back). The properties of 9 blubber oils and 3 organ oils are shown in Table 1.

* Department of Food Engineering, College of Agriculture & Veterinary Medicine, Nihon University.

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TABLE 1. PROPERTIES OF THE OILS CONTAINED IN VARIOUS BLUBBERS AND ORGANS OF BLACK RIGHT WHALE

Kinds of blubber and organ	Acid value	Saponification value	Iodine value	Unsaponifiable Matter (%)
Stomach	0.8	192.6	131.5	1.02
Liver	2.5	189.5	131.4	1.45
Tongue	2.1	195.4	115.1	1.18
Middle back blubber	1.2	196.6	126.6	0.77
Thoracic blubber	1.1	191.8	123.8	1.05
Abdominal blubber	0.7	187.6	130.5	0.94
Brain blubber	1.1	182.4	134.0	0.80
Blubber of hind part of blow-hole	1.5	194.1	127.1	1.14
Umbilicus blubber	1.6	190.4	128.6	1.05
Anterior abdominal blubber	1.6	190.7	134.9	0.80
Blubber of fore part of genital aperture	1.9	193.7	132.6	0.91
Posterior back blubber	1.8	190.0	129.7	0.70

Preparation of methyl ester of fatty acid

The methyl esters of the fatty acids of sample oils were prepared by a semimicro methanolysis adapted to the method of Gauglitz and Lehmann (1963) for use in gas-liquid chromatography analysis. Then, to remove colesterol, coloring materials, impurities and others, the methyl esters were refined by passing through in glass column packed with silicic acid.

Gas-liquid chromatography

The methyl esters of the fatty acids of the black right whale oils were analyzed with a Shimadzu Gas Chromatograph Apparatus, Model GC–1 C. The instrument was equipped with a hydrogen ionization detector. The column used was composed of 3 mm in diameter by 225 cm U shaped stainless steel column containing 20% diethylene glycol succinate polyester (DEGS from Shimadzu Seisakusyo Co.) supported on 60–80 mesh Shimalite. Operating conditions were as follows; column temp. 210°C, injector temp. 260°C, detector temp. 240°C. A column inlet pressure of 1.80 kg/cm^2 N_2 was used, which measured 70–74 ml/min. at the flow rate.

Each peak was identified by comparing retention time with those in a known mixture of standard fatty acid methyl esters (C_{10} to C_{24} as saturated fatty acids, and C_{16} monoenoic acid and C_{18} mono-, di- and trienoic acids as unsaturated fatty acids), and semilogarithmic plots of carbon number *vs* relative retention time were used for identification by the method of Nelson and Freeman (1960). Also, for the purpose of identification of odd carbon chain length fatty acids, the hydrogenation was operated as follows; the *n*-hexanate solution of methyl esters was added a pinch of palladium on activated carbon as a catalyst. The mixture was shaken in a small flask for 5–6 hours under hydrogen atmosphere (approximate 1.5 kg/cm^2) at room temperature, and then filtered. The hydrogenated methyl esters were operated by gas chromatograph at the same condition.

TABLE 2. FATTY ACID COMPONENTS OF OILS CONTAINED IN VARIOUS BLUBBERS AND ORGANS OF BLACK RIGHT WHALE

Fatty acid chain length	Double bond	Stomach	Liver	Tongue	Middle back blubber	Thoracic blubber	Abdominal blubber	Brain blubber	Blubber of hind part of blow-hole	Umbilicus blubber	Anterior abdominal blubber	Blubber of fore part of genital aperture	Posterior back blubber
No. C atoms	No. per molecule	Weight per cent of total fatty acids											
10	0	1.21	0.63	0.34	0.78	0.40	0.54	0.66	0.33	0.81	0.78	0.37	0.82
12	0	0.72	0.16	0.12	0.19	0.35	0.26	0.53	0.15	0.26	0.21	0.17	0.28
13	0	0.01	trace	0.03	trace	0.18	trace	0.14	trace	0.03	0.12	trace	0.12
14	0	5.48	6.22	6.40	6.60	5.37	5.76	6.61	5.24	5.83	6.93	8.11	6.10
14	1	1.51	1.39	1.52	0.49	1.02	0.68	0.76	0.38	0.82	1.30	0.72	2.04
14	2	1.02	0.81	0.31	0.17	0.64	0.65	0.51	0.45	0.46	1.08	0.34	1.06
15	0	0.26	0.21	0.16	0.21	0.24	0.35	0.09	0.19	0.33	0.17	0.13	0.11
16	0	6.26	6.69	6.90	8.85	6.51	6.26	8.37	5.95	6.50	6.49	6.96	5.20
16	1	6.09	4.80	5.53	4.05	8.40	5.15	7.04	3.60	4.57	5.81	5.03	6.75
16	2	2.66	2.48	2.10	1.16	1.63	1.12	1.45	1.13	1.91	2.53	1.30	1.79
17	0	1.22	0.90	0.80	1.37	1.31	0.81	1.36	1.03	1.06	1.07	1.40	1.05
18	0	1.08	1.21	1.27	2.93	1.92	1.14	1.26	1.81	1.19	1.15	1.54	1.63
18	1	17.74	18.93	18.97	17.79	22.62	21.26	17.61	21.55	17.96	18.51	19.56	18.50
18	2	1.64	1.34	1.33	1.96	1.99	1.30	1.64	1.16	2.01	1.75	1.41	1.72
18	3	2.42	2.36	2.31	3.12	1.80	1.32	2.43	1.61	2.44	2.18	1.99	2.37
19	0	1.11	1.90	1.29	1.01	0.87	0.65	1.39	1.15	0.97	0.93	1.17	1.50
20	0	0.90	1.82	1.07	2.56	2.26	1.81	1.25	2.31	1.37	1.26	1.63	1.53
20	1	19.03	21.83	21.41	21.44	19.39	23.39	18.23	21.15	21.26	18.91	20.90	20.36
20	2	0.75	0.94	0.65	0.82	0.21	1.73	1.22	1.18	0.97	1.22	1.34	1.66
20	3	2.29	0.73	0.90	0.73	0.19	1.30	0.57	1.37	1.02	2.54	1.50	1.94
20	4	1.51	1.65	1.00	1.46	2.01	2.52	1.46	2.01	1.10	1.76	2.21	2.32
20	5	18.62	16.64	17.98	16.65	16.26	15.56	17.66	18.47	18.67	16.94	15.17	16.76
22	1	1.34	0.85	1.25	1.14	—	1.17	1.06	2.62	1.05	1.41	1.91	0.98
22	5	1.83	1.86	2.01	1.68	1.20	1.03	1.78	1.37	3.15	1.89	1.26	1.11
22	6	3.30	3.67	4.35	2.84	3.23	4.16	4.92	3.79	4.26	3.06	3.88	2.30

The each peak was quantitated by the method of Magidmann *et al* (1962). All fatty acids were calculated as weight percentages of the total known fatty acids present.

RESULTS AND DISCUSSION

In this investigation, we confirmed about 25 kinds of fatty acids in the black right whale oil, as the results of the analysis are reported in Table 2. There are as saturated fatty acids, C_{10}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19} and C_{20}, and as unsaturated fatty acids, C_{14} monoenoic, C_{14} dienoic, C_{16} monoenoic, C_{16} dienoic, C_{18} monoenoic, C_{18} dienoic, C_{18} trienoic, C_{20} monoenoic, C_{20} dienoic, C_{20} trienoic, C_{20} tetraenoic, C_{20} pentaenoic, C_{22} monoenoic, C_{22} pentaenoic and C_{22} hexaenoic.

There is no remarkable difference in the fatty acid components of oils contained in various parts of the black right whale body. As the main component fatty acids belong to unsaturated fatty acids, these are C_{20} monoenoic 18.23-23.46% (average 20.7%), C_{18} monoenoic 17.74–22.62% (av. 19.25%) and C_{20} pentaenoic 15.17–18.67% (av. 17.12%). The next prominent fatty acids are C_{16} saturated 5.20–

TABLE 3. EACH FATTY ACID CONTENT OF OILS IN VARIOUS BLUBBERS AND ORGANS (in order of high percentages)

Order	Fatty acid chain length No. C atoms	Double bond No. per molecule	Weight par cent of total fatty acids	Average percentages
1	20	1	18.23–23.46	20.70
2	18	1	17.74–22.62	19.25
3	20	5	15.17–18.67	17.12
4	16	0	5.20– 8.85	6.75
5	14	0	5.24– 6.93	6.22
6	16	1	3.60– 8.40	5.57
7	22	6	2.30– 4.92	3.65
8	18	3	2.32– 3.12	2.20
9	16	2	1.12– 2.66	1.77
10	20	4	1.00– 2.52	1.75
11	22	5	1.03– 2.01	1.68
12	20	0	0.90– 2.56	1.65
13	18	2	1.16– 2.01	1.60
14	18	0	1.08– 2.93	1.51
15	20	3	0.19– 2.29	1.26
16	22	1	0.85– 2.62	1.23
17	19	0	0.65– 1.90	1.16
18	17	0	0.80– 1.37	1.12
19	20	2	0.21– 1.73	1.12
20	14	1	0.38– 1.52	1.06
21	14	2	0.17– 1.08	1.05
22	10	0	0.33– 1.21	0.61
23	12	0	0.12– 1.21	0.28
24	15	0	0.09– 0.35	0.20
25	13	0	trace– 0.18	0.05

TABLE 4. A COMPARISON OF SATURATED AND UNSATURATED FATTY ACID OF BLACK RIGHT WHALE OIL

Fatty acid chain length No. C atoms	Weight per cent of total fatty acids			
	Saturated	Averages	Unsaturated	Averages
10	0.33–1.21	0.61	—	—
12	0.12–0.72	0.28	—	—
13	trace–0.18	0.05	—	—
14	5.24–6.93	6.22	0.38– 1.52	1.05
15	0.09–0.35	0.20	—	—
16	5.20–8.85	6.75	4.60–10.92	7.34
17	0.80–1.37	1.12	—	—
18	1.08–2.93	1.51	10.02–27.29	23.05
19	0.65–1.90	1.16	—	—
20	0.90–2.56	1.65	34.83–48.16	41.89
22	—	—	4.05–10.10	6.53
Total		19.55		79.86

8.85% (av. 6.75%), C_{14} saturated 5.24–6.93% (av. 6.22%) and C_{16} monoenoic 3.60–8.40% (av. 5.57%). The total of the above mentioned fatty acids holds really 64.18–88.93% (av. 75.61%) of all total fatty acids. (Table 3)

In comparison with saturated and unsaturated fatty acids, the proportions of total saturated fatty acids are 19.55% (average), and those of total unsaturated fatty acids are 79.86% (average) as shown in Table 4. In view of these facts, the principal fatty acids of the black right whale oil are monoenoic and polyenoic unsaturated fatty acids.

SUMMARY

1. Fatty acid components of oils contained in 9 parts of blubbers and 3 kinds of organs of black right whale, *Eubalaena glacialis*, caught in the Northern Pacific Ocean were analyzed by gas-liquid chromatograph using a hydrogen ionization detector on a DEGS column.

2. Fatty acid components of the above mentioned sample oils were as follows;

C_{20} monoenoic	18.23–23.46% (av. 20.70%)
C_{18} monoenoic	17.74–22.62% (av. 19.25%)
C_{20} pentaenoic	15.17–18.67% (av. 17.12%)
C_{16} saturated	5.20– 8.85% (av. 6.75%)
C_{14} saturated	5.24– 6.93% (av. 6.22%)
C_{16} monoenoic	3.60– 8.40% (av. 5.57%)
C_{22} hexaenoic	2.30– 4.92% (av. 3.65%)
C_{18} trienoic	2.32– 3.12% (av. 2.20%)
C_{16} dienoic	1.12– 2.66% (av. 1.77%)
C_{20} tetraenoic	1.00– 2.52% (av. 1.75%)
C_{22} pentaenoic	1.03– 2.01% (av. 1.68%)
C_{20} saturated	0.90– 2.56% (av. 1.65%)

C_{18} dienoic	1.16– 2.01% (av. 1.60%)
C_{18} saturated	1.08– 2.93% (av. 1.51%)
C_{20} trienoic	0.19– 2.29% (av. 1.26%)
C_{22} monoenoic	0.85– 2.62% (av. 1.23%)
C_{19} saturated	0.65– 1.90% (av. 1.16%)
C_{17} saturated	0.80– 1.37% (av. 1.12%)
C_{20} dienoic	0.21– 1.73% (av. 1.06%)
C_{14} monoenoic	0.38– 1.52% (av. 1.05%)
C_{14} dienoic	0.17– 1.08% (av. 0.63%)
C_{10} saturated	0.33– 1.21% (av. 0.61%)
C_{12} saturated	0.12– 0.72% (av. 0.28%)
C_{15} saturated	0.09– 0.35% (av. 0.20%)
C_{13} saturated	trace– 0.18% (av. 0.05%)

3. A substantial part of the saturated acids were hexadecanoic (5.20–8.85%) and tetradecanoic (5.24–6.93%). On the other hand, that of the unsaturated acids were nonadecamonoenoic (18.23–23.46%), octadecamonoenoic (17.74–22.62%) and nonadecapentaenoic (15.17–18.67%).

4. The difference in the fatty acid components of various blubbers and organs of the black right whale was not found clearly.

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