OSTEOLOGICAL STUDY OF THE MINKE WHALE FROM THE ANTARCTIC

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ABSTRACT

Two skulls and postcranial bones of the minke whale from the Antarctic were studied, comparing with two specimens from the North Pacific. Characters noted in the skull are: breadth of skull is narrow, rostrum is also narrow and long and the flank is rounded and flat in profile, anterior margin of nasals is concave, at the vertex of skull triangular region is not formed by frontal and parietal between nasals and supraoccipital or in a more advanced stage of telescoping, lachrymal is large and rectangular, hamular process of pterygoid is short and broad. In the vertebrae the 7th cervical lacking parapophysis. Lateral tubercle of the pelvic bone situated towards mid-length of the bone in male.

Above are the main differences which separate it from the minke whale in the northern hemisphere, though the whale in the North Atlantic has also comparatively long rostrum and is separated by this character, together with difference in form of the white band of flipper, from that in the North Pacific. In the light of the present stage of knowledge it is not concluded that the minke whale from the Antarctic (*Balaenoptera bonaerensis*) is a distinct species from *B. acutorostrata*.

INTRODUCTION

The problem whether the little piked or minke whale from the Antarctic (*Balaenoptera bonaerensis*) is a distinct species from the minke in the northern hemisphere (*B. acutorostrata*) has not been finally solved yet, though Utrecht and Spoel (1962) and Ohsumi *et al.* (1970) report the name *B. bonaerensis* is a synonym of *B. acutorostrata*. The conclusion of these authors are mainly based on the external morphological characters, and in addition the latter authors have counted number of vertebrae of three small foetuses and found no distinction in this respect. Detailed osteological study on adult specimen is needed in the light of the present status of affairs.

In the 1971–72 season Dr S. Ohsumi had been in the Antarctic on board Jinyo Maru, a minke whaling expedition and has collected two complete sets of the skeleton. These bones are the main material of this paper. In addition to these, in 1969 I fortunately could collect two sets of skeleton of the minke whale from the North Pacific, by courtesy of Mr T. Miyodori, owner of minke whaling catcher boat operating on the coast of Japan. These bones are also studied for comparison. Dr S. Ohsumi has also collected a number of hyoid bones of the

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minke whale from the Antarctic in the same season. A taxonomic study based on these hyoid bones has already been published by Satake and Omura (1974).

MATERIAL

The particulars of the specimens treated in this paper are shown in Table 1. The specimen 71J2793 and 71J2883 were brought from the Antarctic, kept in a cold storage chamber of Jinyo Maru, and unloaded at Tokyo port from where they were transported to the laboratory in fresh condition on 30 March 1972. A few amount of meat and other soft parts were still attached to bones. Baleen plates were also remained on the beak of the skull. After removal of these, most bones were burried in earth in order to extract oils contained in them. Flippers were enveloped with nylon mosquito nets before burying, in precaution against missing of small phalanges. They were dug out from the earth in December 1973. From small bones e.g. small caudal vertebrae, hyoid bones, chevron bones, sterna, etc. oils were extracted by boiling in laboratory and then soaking in water.

TABLE 1. PARTICULARS OF THE MINKE WHALE SPECIMENS

Specimen no.	Body length (m)	Sex	Date of catch	Position of catch	Age
71J2793	8.5	M	Feb. 12, 1972	65°-21′S, 76°-37′E	Ad. 25 years*
71J2883	9.8	F	Feb. 16, 1972	65°-00′S, 89°-37′E	Ad. 39 years*
AY69B	6.6	M	Apr. 12, 1969	Coast of Japan	Juv.
AY69A	5.4	M	Apr. 28, 1969	Coast of Japan	Juv.

* Age determined by Dr S. Ohsumi by means of ear plug.

Bones of the specimens AY69A and AY69B were buried in sand of beach of Ayukawa by Mr T. Miyodori. They were dug out from sand after 15 months and transported to W.R.I. The specimen AY69A was mounted for display and now being kept at Suginami Kagaku Kyoiku Center, Tokyo, an educational institution for school children in Suginami ward. Other specimens have been kept at W.R.I.

As shown in Table 1 the age of the specimens is quite different between samples from the different hemispheres. Two specimens from the Antarctic are adult and all vertebral epiphyses are completely fused to their centra, whereas two specimens from the North Pacific are very young and none of the epiphyses is fused to the body of the vertebra. Age of the specimens from the Antarctic was determined by Dr S. Ohsumi as being 25 and 39 years respectively by means of ear plug, but for the specimens from the North Pacific no age determination was made.

This difference in age between specimens from different hemispheres makes it difficult to arrive at correct conclusions from only the direct comparison of these bones.

SKULL (Plates I-V)

At the first glance it was noted that the skull of the minke whale from the Antarctic differs from that of the North Pacific in having more rounded or convex outline of the rostrum in dorsal view, and the rostrum itself is flat in profile. According to Tomilin (1967) the most important features of the skull of *Balaenoptera acutorostrata* in the northern hemisphere are the following. " Size small, usually not exceeding

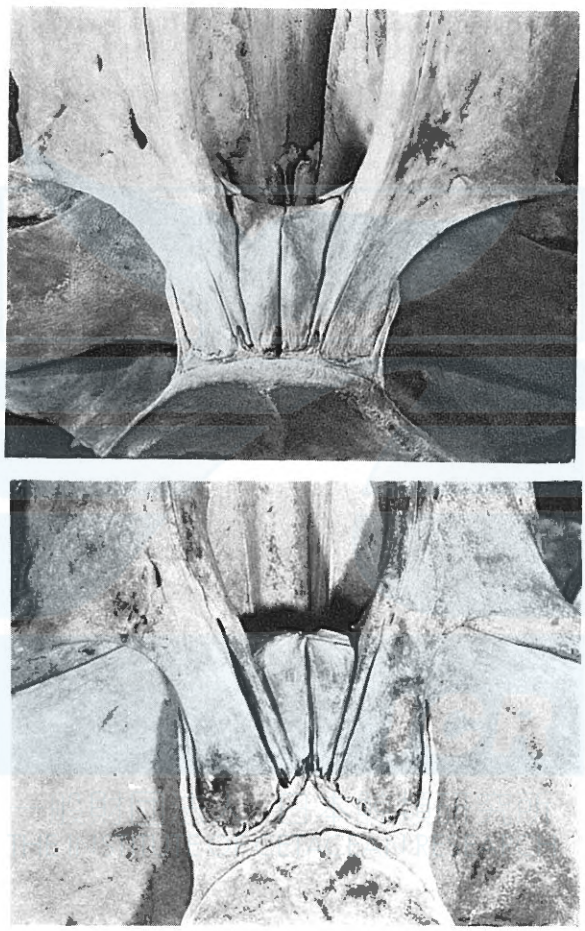

Fig. 1. Dorsal view of nasals of the minke whale. Upper. Specimen 71J2883 from the Antarctic. Lower. Specimen AY69B from the North Pacific.

2 m. Rostrum triangular, pointed, with straight flanks, shorter, and wider at base than in other rorquals. Fronto-nasal process of the maxillary abbreviate. Viewed from above, nasal bones triangular, relatively large, convex or flattened (but not concave) along the anterior margin. Os nasale ca 1.5 in the fronto-nasal process (never 2). Nasal bones produced so far anteriad that their fore ends reach the line

connecting the curves of both maxillaries near the base of the fronto-nasal processes". The two specimens from the North Pacific (AY69A and AY69B) agree with this description well, but the two skulls from the Antarctic are different. Their flanks are not straight, but curved, and nasal bones concave along the anterior margin. Size of the skull is large and both exceed 2 m in length, but this is not striking, because these skulls were obtained from whales of over 8 m in length, and the Tomilin's largest skull (2 m) belonged to a whale of 7.3–8 m.

The most striking feature in the dorsal aspect of the skull is the form of the nasals and arrangements of bones at vertex of skull, between posterior end of nasals and supraoccipital bone. Difference in nasals is also observed in the frontal view.

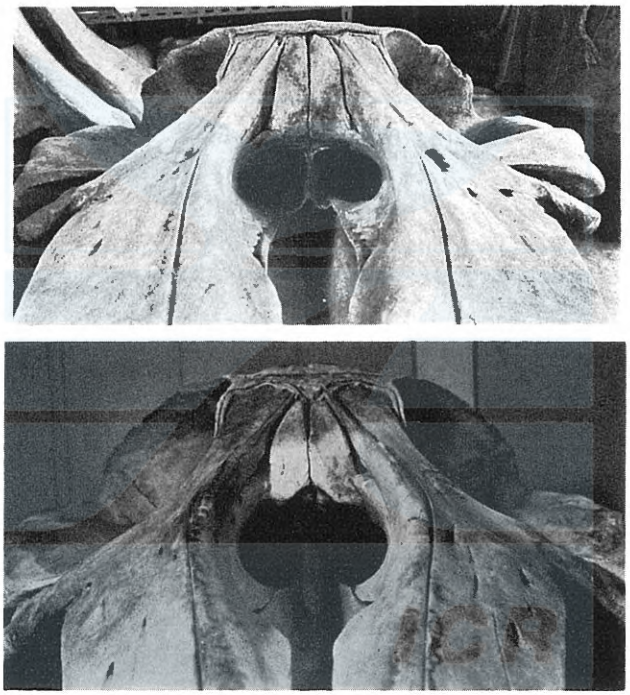

Fig. 2. Frontal view of nasals of the minke whale. Upper. Specimen 71J2883 from the Antarctic. Lower. Specimen AY69B from the North Pacific.

These differences are clearly demonstrated in Figs. 1 and 2. As shown in these figures the anterior margin of the nasals is concave in the specimen from the Antarctic, whereas in those from the North Pacific convex (Fig. 1). The inferior surface of the nasals from the Antarctic is flat and shows no special feature, but in the specimens from the North Pacific anterior and proximal part of the right and left nasals is concave, and together forming a half elliptic groove, as shown in Fig. 3 by dotted line.

Another difference is in the arrangement of bones at the vertex of the skull. In the specimens from the Antarctic posterior ends of nasals, premaxillaries, and

maxillaries are arranged roughly in line, nearly parallel to the margin of the supraoccipital bone. Frontal is present as a narrow band between these bones, but the parietal does not appear in this region of the skull. It covers frontal on the side of the fronto-nasal process of the maxillary. On the other hand in the specimen from the North Pacific the posterior end of nasals is situated more anteriorly, and premaxillaries end posteriorly than nasals, and maxillaries more posteriorly than those bones. Thus triangular region is formed by frontal, but frontal itself is also represented by narrow band and between frontal and supraoccipital there present parietal, also triangular in shape. In Figs. 1 and 2 only the photograph of the specimen AY69B is shown, but in the specimen AY69A too the shape of nasals and arrangement of bones at the vertex of the skull is quite similar. In conclusion above the minke whale from the Antarctic has attained a more advanced stage of telescoping than that from the North Pacific.

Omura (1957) reports three skulls of the minke whale from the coast of Japan, and this time these skulls were reexamined, especially on characters stated above.

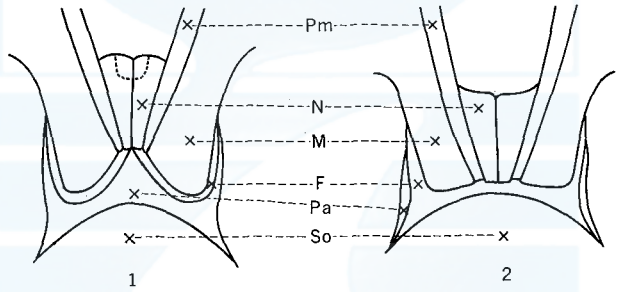

Fig. 3. Schematic drawing of vertex of skull of the minke whale.

1.	From North Pacific.	2.	From Antarctic.
Pm	..... Premaxillary,	N	..... Nasal,
M,	..... Maxillary,	F	..... Frontal,
Pa	..... Parietal,	So	..... Supraoccipital.

In addition I examined three more skulls preserved at various places in Japan. Places where these six skulls preserved are: one at the National Science Museum in Tokyo, one at the Tokyo University of Fisheries, two at the Whale Museum in Ayukawa, one in Shiogama, and one in Matsushima. Length of these skulls are ranged from 1,060 mm to 1,520 mm. The largest specimen is the specimen kept at the National Science Museum, but in this specimen too vertebral epiphyses are only fused to their centra completely in the first three cervicals and last ten caudals. Thus all of the specimens are thought juvenile or semi-adult. In all of the specimens the form and position of nasals are quite similar to those shown in Figs. 1 and 2. The parietal is triangular form at the vertex of the skull in general, but the forward projection on the mid-dorsal line is bifurcated in the specimen AY69A, and in a specimen kept in Matsushima most part of this triangular region of the parietal is covered by supraoccipital (Fig. 4). In the above two specimens, however, the

Fig. 4. Vertex of skull of the Matsushima specimen, showing triangular region between nasals and supraoccipital. (photograph by Dr A. Kawamura).

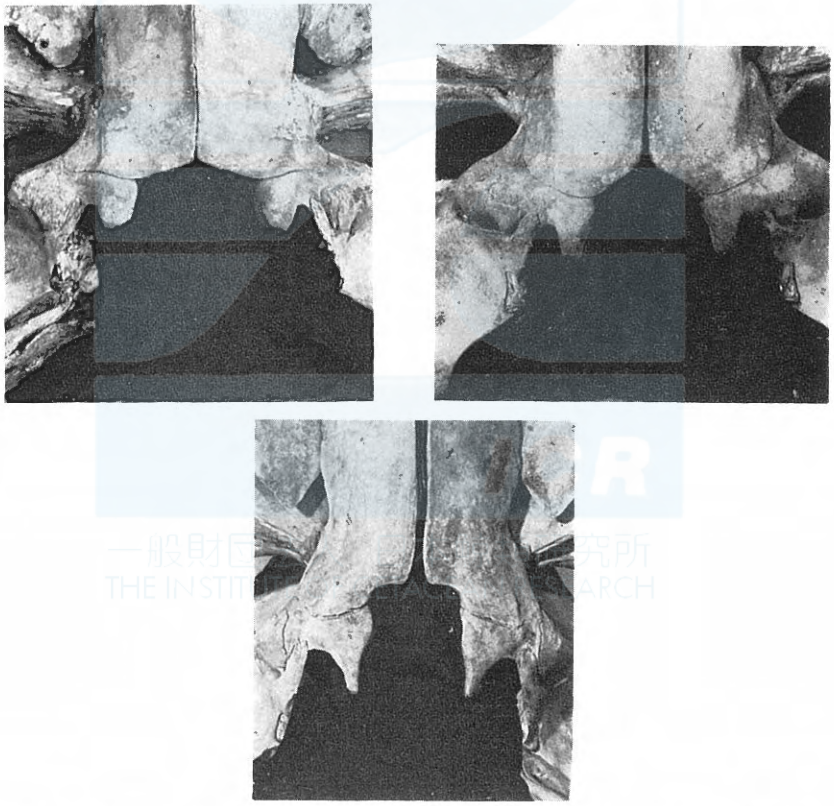

Fig. 5. Ventral view of skull of the minke whale, showing posterior part of palatines and pterygoids. Right. Specimen 71J2793 from the Antarctic. Left. Specimen 71J2883 from the Antarctic. Lower. Specimen AY69B from the North Pacific.

frontal posterior to nasals, premaxillaries, and maxillaries is triangular in dorsal view.

The skull length of the Matsushima specimen is 1,220 mm and it is thought that this specimen came also from a juvenile animal.

On the inferior side of the skull differences are noted by visual comparison between specimens from different oceans, at the posterior margin of palatines and in the form of the hamular process of pterygoid. In the skulls from the Antarctic the posterior margin of palatines, from mid-ventral point to articulating point with pterygoid, is roughly straight, whereas in the specimen from the North Pacific this line is much concave. The hamular process of pterygoid is short and broad in the specimens from the Antarctic, but it is slender and pointing in the specimen from the North Pacific (Fig. 5). The posterior margin of palatines, however, subject to individual variation, and in the specimen AY69A this line is convex rather than concave. Among other specimens noted before the lines are concave in five specimens and convex in one specimen. But the hamular process of pterygoid is slender and pointing in all specimens, in which this part of the skull remaining unbroken.

Skull measurements and calculated percentages against skull length are shown in Table 2. There are rather wide ranges of individual variation, and in some measurements values of the two Antarctic skulls and the two North Pacific skulls are overlap each other. But there are a number of measurements in which values are not overlap between the specimens from different oceans. In the specimens from the Antarctic the length of the rostrum and breadth at its middle are larger than others (Measurement nos. 7, 10, and 11), though practically no difference is noted in its width at base (M. no. 12). These differences are large, especially in the specimen 71J2883, the larger whale, but see also Fig. 6. Mandibles are also larger than in the specimens from the North Pacific (M. nos. 33–36), and they have a bit higher coronoid process (M. nos. 37 and 38). There seems no proportional difference in the breadth of the skull (M. nos. 16, 17 and 18), but the breadth of occipital bone is larger in the specimens from the North Pacific (M. no. 21). Size of occipital condyles as well as foramen magnum are also larger proportionally (M. nos. 22–26). But the proportion of these bones in posterior part of skull subject to age. In the black right whale proportional length in these bones decreases with age (Omura *et al.*, 1971).

The breadth of the vertex of skull or breadth across the fronto-nasal processes of maxillaries is broader in the North Pacific whale (M. nos. 13 and 14), and length of orbit, measured at distal end of frontal, is larger also. But no conclusion could be reached due to scanty number of material. Anterior breadth of nasal seems to be greater in the North Pacific specimens (M. no. 9), but this can not be concluded so, because it is very difficult to measure correctly in the specimens from the Antarctic.

On the inferior side of the skull significant differences are noted. In the skulls from the Antarctic the vomer extends more forward, hence larger (M. no. 28), and palatines and pterygoids are situated more posteriorly than in the speci-

TABLE 2. SKULL MEASUREMENTS OF THE MINKE WHALE

Measurements	Actual length: Antarctic 71J2793 M 8.5 m Ad.	Actual length: Antarctic 71J2883 F 9.8 m Ad.
1. Codylo-premaxillary length	2,115	2,350
2. Length of premaxillary, right	1,490	1,710
3. „ „ „ , left	1,510	1,707
4. „ „ maxillary, superior, right	1,450	1,645
5. „ „ „ „ , left	1,390+	1,645
6. Tip of premaxillary to vertex	1,520	1,710
7. „ „ „ „ nasals	1,364	1,550
8. Length of nasals, median	133	170
9. Breadth of nasals, anterior	98	137
10. Length of rostrum	1,354	1,630
11. Breadth of rostrum at middle	399	534
12. Breadth of rostrum at base	630	770
13. Breadth across maxillaries at vertex	187	237
14. Breadth of frontal across nasals	231	261
15. Breadth between maxillaries at nares	237	307
16. Breadth of skull, squamosal	1,075	1,256
17. „ „ „ , frontal	1,047	1,219
18. „ „ „ , maxillaries	991	1,144
19. Length of orbit, frontal, right	188	207
20. „ „ „ „ , left	190	207
21. Breadth of occipital bone	760	886
22. Breadth across occipital condyles	203	228
23. Height of occipital condyle, right	131	145
24. „ „ „ „ , left	124	142
25. Breadth of foramen magnum	70	79
26. Height of foramen magnum	97	127
27. Length from foramen magnum to vertex	605	650
28. Tip of premax. to anterior end of vomer, median	258	290
29. „ „ „ „ „ „ „ palatine, median	1,505	1,642
30. „ „ „ „ posterior „ „ „ „	1,782	2,055
31. „ „ „ „ „ „ „ pterygoid	1,935	2,150
32. Breadth across hamular processes of pterygoid	210	236
33. Length of mandible, straight, right	2,063	2,285
34. „ „ „ „, left	2,075	2,265
35. „ „ „ , curved, right	2,247	2,454
36. „ „ „ „ , left	2,260	2,445
37. Height of mandible at coronoid, right	303	311
38. „ „ „ „ „ , left	302	315
39. „ „ „ „ condyle, right	201	220
40. „ „ „ „ „ , left	204	233

mens from the North Pacific (M. nos. 29, 30 and 31).

Above are the major differences noted in Table 2. Tomilin (1967) presents a table comparing cranial indices of the Atlantic and Pacific populations in the northern hemisphere, and noted that the Atlantic individuals are characterized

FROM THE ANTARCTIC AND NORTH PACIFIC

in mm		% of skull length			
N. Pacific AY69B M 6.6 m Juv.	N. Pacific AY69A M 5.4 m Juv.	71J2793	71J2883	AY69B	AY69A
1,382	1,140	100.0	100.0	100.0	100.0
986	797	70.4	72.8	71.3	69.9
984	798	71.4	72.6	71.2	70.0
939	780	68.6	70.0	67.9	68.4
933+	755	—	70.0	—	68.0
1,017	834	71.9	72.8	73.6	73.2
872	692	64.5	66.0	63.1	60.7
94	87	6.3	7.2	6.8	7.6
97	71	4.6	5.8	7.0	6.2
869	687	64.0	69.4	62.9	60.3
252	210	18.9	22.7	18.2	18.4
441	367	29.8	32.8	31.9	32.2
152	138	8.8	10.1	11.0	12.1
174	137	10.9	11.1	12.6	12.0
178	115	11.2	13.1	12.9	10.1
708	613	50.8	53.4	51.2	53.8
703	597	49.5	51.9	50.9	52.4
625	535	46.9	48.7	45.2	46.9
156	146	8.9	8.8	11.3	12.8
157	146	9.0	8.8	11.4	12.8
563	473	35.9	37.7	40.7	41.5
157	154	9.6	9.7	11.4	13.5
98	120	6.2	6.2	7.1	10.5
96	100	5.9	6.0	6.9	8.8
83	80	3.3	3.4	6.0	7.0
90	85	4.6	5.4	6.5	7.5
376	297	28.6	27.7	27.2	26.1
219	206	12.2	12.3	15.8	18.1
856	700	71.2	69.9	61.9	61.4
1,102	910	84.3	87.4	79.7	79.8
1,205	990	91.5	91.5	87.2	86.8
127	—	9.9	10.0	9.2	—
1,330	1,005	97.5	97.2	96.2	88.2
1,330	1,010	98.1	96.4	96.2	88.6
1,400	1,045	106.2	104.4	101.3	91.7
1,390	1,050	106.9	104.0	100.6	92.1
170	148	14.3	13.2	12.3	13.0
179	150	14.3	13.4	13.0	13.2
135	115	9.5	9.4	9.8	10.1
132	116	9.6	9.9	9.6	10.2

by a relatively longer rostrum.

In Fig. 6 I have compared several cranial indices of the minke whales from the North Atlantic, North Pacific, and from the Antarctic. Figures for the North Atlantic and North Pacific are cited from Tomilin (1967). For the North Pacific

whales, among four specimens he used, two were cited from True (1904) and two from Cowan (1939), and my previous data (Omura, 1957) were not included. In Fig. 6, therefore, all data obtained from the coast of Japan are also shown, but separately from Tomilin's figures. Further he grouped specimens into two categories of juvenile (skull length less than 133 cm) and adult (skull length over 150 cm) and calculated mean value for each group, but since samples are limited in number so in Fig. 6 only ranges of value are shown. From his table only figures for adult whales are cited, because the specimens from the Antarctic are all adult. But specimens from the coast of Japan are all juvenile, except one specimen in which the skull length is 1,520 mm and exceeds his criteria.

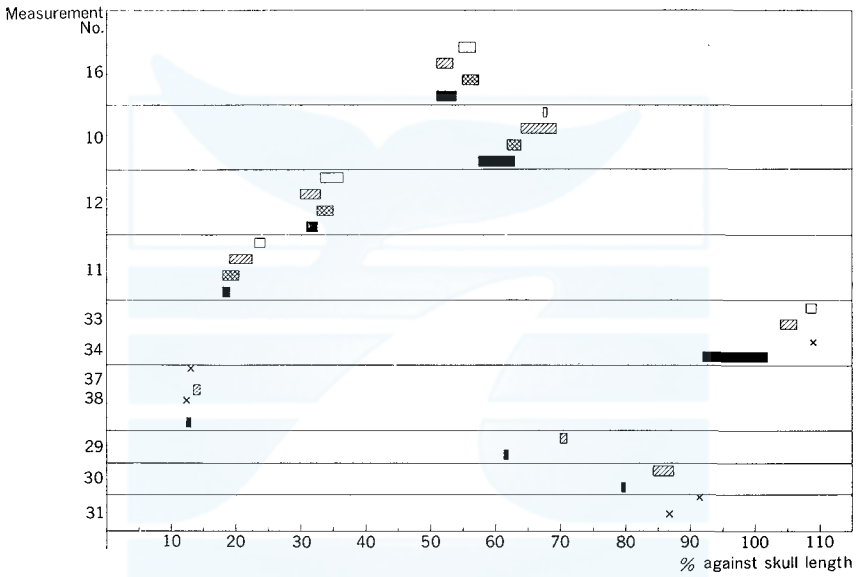

Fig. 6. Comparative cranial indices of the minke whale populations in the North Atlantic, Antarctic, and North Pacific. White . . . North Atlantic, Hatched . . . Antarctic, Double hatched . . . North Pacific (from Tomilin), Black . . . North Pacific (coast of Japan). Each square denotes ranges of value, and cross single value. For measurement number see text.

The measurements compared in this fugure are the following.

Measurement no.	16.	Breadth of skull, squamosal.
,,	,, 10.	Length of rostrum.
,,	,, 12.	Breadth of rostrum at base.
,,	,, 11.	Breadth of rostrum at middle.
,,	,, 33, 34	Length of mandible, curved.
,,	,, 37, 38	Height of mandible at coronoid.
,,	,, 29.	Tip of premaxillaries to anterior end of palatine.

„ „ 30. Tip of premaxillaries to posterior end of palatine.

„ „ 31. Tip of premaxillaries to posterior end of ptergoid.

For the measurements 29, 30, and 31 only the data in the present paper are available.

In the greatest breadth of the skull at squamosal the Antarctic specimens differ from those from the North Atlantic and North Pacific (adult), but similar to those of the juvenile specimens from the North Pacific (M. no. 16). Tomilin (1967) found relatively faster growth of the zygomatic and orbital width and in his juvenile specimen (cited from Cowan, 1939) this value is 52.7 percent of the skull length and come into ranges of specimens from the coast of Japan. If this is true the minke whale from the Antarctic has more narrower skull than those from the northern hemisphere. The length of rostrum is greater in the North Atlantic and

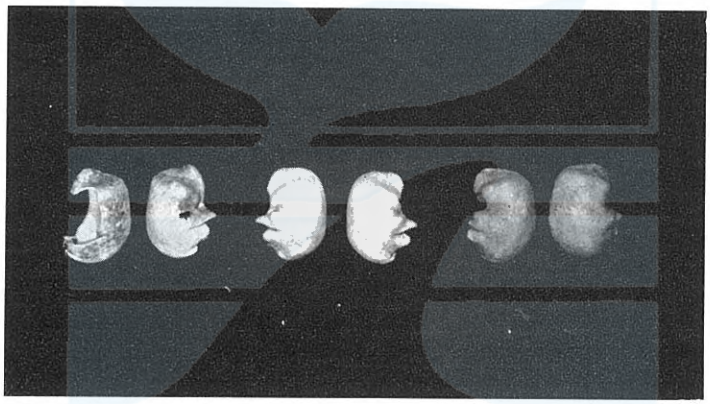

Fig. 7. Tympanic bullae of the minke whale. From left to right. Specimens 71J2793, 71J2883 both from the Antarctic, and AY69B from the North Pacific.

Antarctic specimens than in the North Pacific specimens. The breadth of the rostrum at its base as well as at middle is shorter in the Antarctic specimen than in the North Atlantic specimen, but rather dubious when compared with the North Pacific specimen. In the figure some differences are also noted in the length of the mandible, but it seems to me that there are some differences in method of measurement, because this length is the length measured along the outer curve of mandible, which is rather difficult to measure correctly. Height of mandible at coronoid seems higher in the Antactic specimen, but samples are very limited and it is premature to arrive at any conclusion.

On the inferior side of skull no data is available for the specimen from the North Atlantic. In Fig. 6 are shown, therefore, only measurements of the present specimen. As stated already the vomer extends more anteriorly in the Antarctic specimen, but this is probably due to a difference in age, if an assumption is made that the vomer attains larger size with age independently from premaxillaries and

maxillaries. Difference in the relative position of palatine and pterygoid is thought due to the difference in rostrum length. In the Antarctic specimens these bones are situated more posterior part of skull than in the North Pacific specimens. But when the rostrum length is subtracted from these values no dif-

TABLE 3. MEASUREMENTS OF TYMPANIC BULLAE OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

Specimen	Length		Greatest breadth		Thickness at middle	
	Right	Left	Right	Left	Right	Left
Antarctic						
71J2793	90	92	68	69	47	48
71J2883	94	95	65+*	74	50	48
N. Pacific						
AY69B	90	90	−*	71	46	46

* Broken.

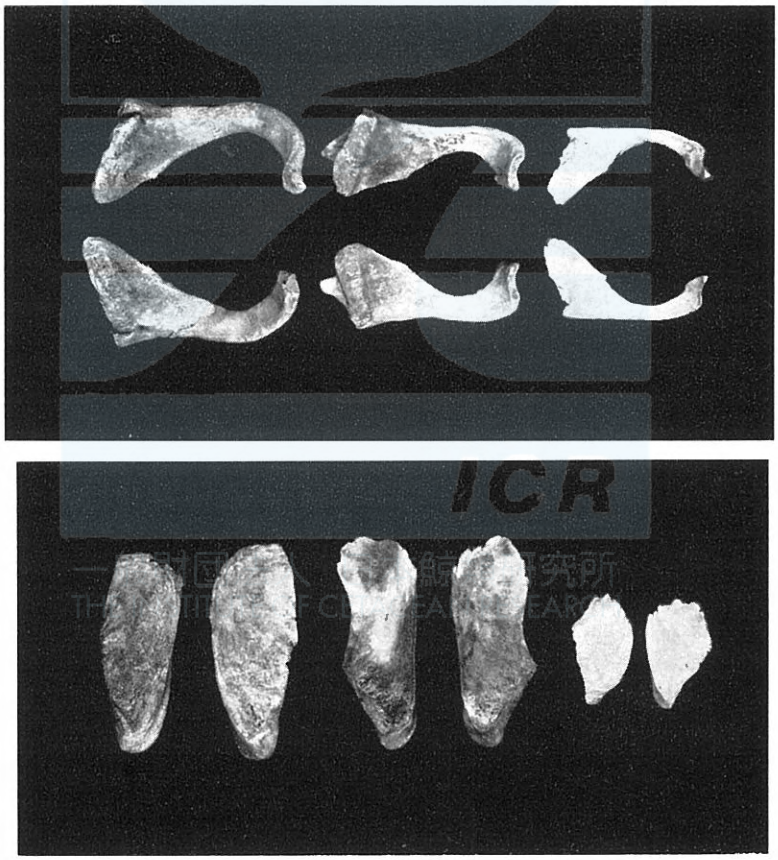

Fig. 8. Malars (upper) and lachrymals (lower) of the minke whale. From left to right. Specimens 71J2883, 71J2793 both from the Antarctic, and AY69B from the North Pacific.

ference is noted between specimens from different oceans.

In Fig. 7 are shown the tympanic bullae of the minke whale from the Antarctic, compared with those from the North Pacific. As seen from the photograph and measurements in Table 3 no special difference is noted between bullae from different oceans. Bullae of the specimen 71J2883 are larger than other specimens, but in the remaining specimens the size is nearly the same. Compared with other three specimens reported by Omura (1957) also no special feature is noted in the size of bulla, notwithstanding differences in the size of whale body.

The malars and lachrymals are shown in Fig. 8. As seen in the photograph malars are quite similar in shape in general but lachrymals are of some interest. In the Antarctic specimen lachrymals are comparatively large and roughly rectangular in shape, like in other balaenopterid whales, but those from the North Pacific are short and one end is pointing and they resemble closely to another specimen reported by Omura (1957). It is suggested, therefore, this character is of some importance in taxonomic consideration. Measurements of malars and lachrymals are shown in Table 4.

TABLE 4. MEASUREMENTS OF MALARS AND LACHRYMALS OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

Specimen	Malar				Lachrymal			
	Length 1)		Breadth 2)		Length		Breadth	
	Right	Left	Right	Left	Right	Left	Right	Left
Antarctic								
71J2793	244	240	31	30	264	258	81	82
71J2883	254	253	40	38	247	265	99	104
N. Pacific								
AY69B	169	181	18	17	115	113	63	61

1) Greatest 2) At mid-length

VERTEBRAE (Plates VI-IX)

The vertebral formulae of the present specimens are as follows:

Antarctic specimen

71J2793 C 7, D 12, L 10, Ca 20, Total 49.

71J2883 C 7, D 11, L 12, Ca 20, Total 50.

North Pacific specimen

AY69B C 7, D 11, L 12, Ca 18, Total 48.

AY69A C 7, D 11, L 11, Ca 19, Total 48.

Thus among these specimens from different oceans there is a difference in total number by 1–2. In two specimens from the North Pacific reported by Omura (1957) the total number of vertebrae are 48 and 47. Both have 7 cervicals, 11 dorsals, 12 lumbars, and caudals are 18 and 17 respectively. Tomilin (1967) describes that "Vertebral formula reduced as compared to other rorquals: C 7, D 11, L 12, Ca 18, total 48. However, the vertebral count may reach 50 owing

to additional vertebrae in the lumbar (up to 13) and caudal (19–20) regions ".

True (1904) lists up the vertebral formulae by various authors then known to him, and among them the largest number is 50, reported by Turner (1892) from Granton, Scotland. To this specimen he describes that " The enumeration of Sir Wm Turner is probably the most accurate, having been made under favorable circumstances, and with the intent of correcting previous errors ". This may be the basis of the above statement of Tomilin. In any case 50 might be rather exceptional number in the northern hemisphere.

The present specimens from the Antarctic have 49 and 50 vertebrae in total respectively, suggesting a difference in this respect. But Ohsumi *et al.* (1970) counted number of vertebrae of three fetuses of the minke whale from the Antarctic. Among these two had 48, and one 49 vertebrae. These fetuses are small and their body length has ranged from 46.5 to 50.5 cm, and the number of caudal vertebrae was uniformly 18. This number of 18 caudals is smaller by two, compared with the present specimens. Further study is needed, therefore, and it may be premature at present to conclude definitely in this character.

The two specimens from the Antarctic have already attained their physical maturity, and vertebral epiphyses are ankylosed to their centra completely. On the other hand the specimens from the North Pacific are both immature, and none of the epiphyses fused to their centra.

Anterior view of cervicals of the specimens 71J2793, 71J2883, and AY69B are shown in Plate VI. As seen in these photographs there are some individual variation in the stage of development of neural spines. In the specimen 71J2793 the neural spine is not developed completely in the 3rd and 4th cervicals. In these vertebrae the right and left spines do not united at their tips, whereas in other two specimens they fused completely. Development of the diapophyses and parapophyses is also subject to individual variation, though it seems certain that the development subject to growth of whale body in general. For example these processes do not fused at their tips on the left side of the 3rd cervical of the specimen 71J2793, whereas complete ring is formed in the specimen 71J2883. But in the 5th cervical complete ring is formed on both sides in the former specimen, whereas ring is not formed on both sides in the latter specimen. In the North Pacific specimen complete ring is formed in the 5th cervical on both sides and on the right side of the 6th. In another two specimens from the North Pacific reported by Omura (1957) none of these rings is formed, even in the axis. A 25 feet (7.5 m) male specimen had cervicals of lesser develpoment than in a 6.6 m male whale.

Accordingly differences in form of cervicals, especially of the development stages of processes, are not thought as important from the taxonomic stand point. However there is one thing to note. In the specimens from the Antarctic the 7th cervicals are lacking parapophysis and there is no sign of tubercle. But in the North Pacific specimen this process is present also on the 7th cervical, as shown in Plate VI. In the another two specimens from the North Pacific also parapophysis is present on both sides, though it is reduced to a tubercle (Omura, 1957). Cowan (1939) states that " in 7 (7th cervical) it (parapophysis) is reduced to a

tubercle (in his two specimens from British Columbia, Canada) ". For the specimens of *Balaenoptera acutorostrata* (in the North Atlantic) True (1904) describes that " parapophyses of the 7th cervical reduced to a tubercle ".

Number of the dorsal vertebrae of the minke whale from the Antarctic is 11 in the specimen 71J2883, but 12 in the specimen 71J2793. The former specimen has 11 pairs of ribs and the latter specimen has 11 pairs and one additional rib. The articulating facet with rib on the distal end of transverse processes appears from the 3rd dorsal vertebra in both specimens. In the former specimen the last dorsal vertebra with the facet is the 9th, and the largest is the 4th. In the latter specimen the corresponding vertebra is 11th and 5th. Both specimens from the North Pacific have 11 dorsals and they coincide with other two specimens reported by Omura (1957).

The number of the lumbar vertebrae is 10 and 12 in the specimens from the

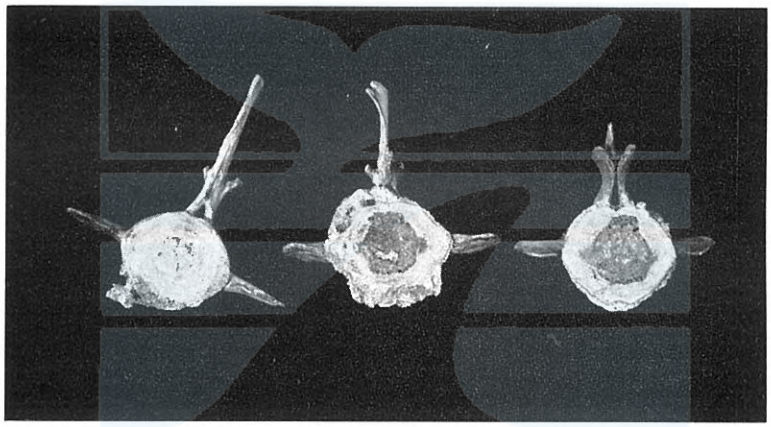

Fig. 9. 2nd, 3rd, and 4th caudal vertebrae of the specimen 71J2883 from the Antarctic. From left to right. 2nd (posterior view), 3rd (posterior view), and 4th (anterior view).

Antarctic, and 11 and 12 in the specimens from the North Pacific. If the additional rib in the specimen 71J2793 deemed as accessory and the number of dorsal vertebrae is counted as 11 instead of 12, then the number of dorsal and lumbar vertebrae is not different between the specimens from the different oceans, only the difference is in the number of caudal vertebrae.

The first caudal vertebra perforated with vertical foramen on transverse processes is the 5th caudal in both specimens from the Antarctic. But in the specimen 71J2793 only the right transverse process is perforated and from 6th both processes have the foramen. The last vertebra with transverse processes is the 7th caudal in both specimens, and the last vertebra with spinous process is the 10th (71J2883) and 11th (71J2793) respectively. In the specimens AY69B and AY69A from the North Pacific the transverse processes perforated from 3rd and 4th caudal vertebrae, and the last vertebra with transverse processes is 7th and 8th,

and the last vertebra with spinous process is 10th and 9th caudal respectively. However these character may subject to individual variation and less important from the taxonomic standpoint.

The specimen 71J2883 from the Antarctic is of some interest from the pathological view. In this specimen 2nd, 3rd, and 4th caudal vertebrae are developed abnormally, possibly from some pathological cause (Fig. 9). The posterior and inferior part of the centrum or the articulating facet with chevron bone developed extraordinarilly, forming tubercles. The articlating part of the chevron bone also developed into tubercular large face. The posterior margin of the 3rd

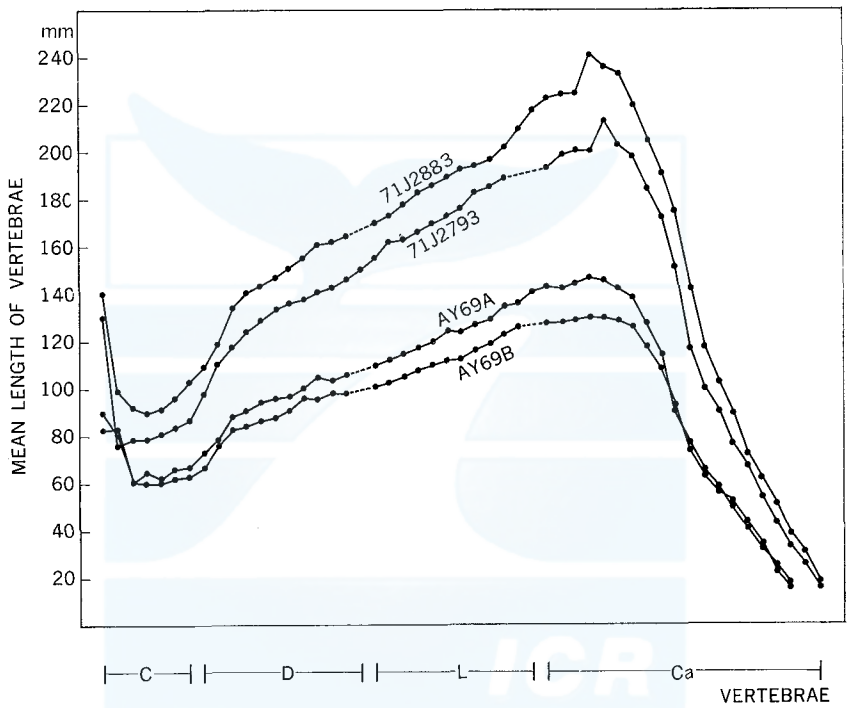

Fig. 10. Comparison of size of vertebrae of minke whales from the Antarctic and North Pacific. Upper two lines denote specimens from the Antarctic, and lower two lines specimens from the North Pacific.

caudal also developed and it covers anterior margin of the 4th partly. Similar abnormality was also observed in 2nd and 3rd caudals of a *Ziphius cavirostris* (Omura, 1972)

Measurements of vertebrae are shown in Appendix. From these measurements I have calculated the mean length of each centrum using the following formula reported before (Omura, 1971), in order to compare volume of each vertebra.

$$\text{Mean length} = (a \times b \times c)^{1/3}$$

where a, b, and c are the breadth, height, and length of the centrum respectively.

Results of calculation are shown in Fig. 10. I also calculated percentages against their first lumbar, but in this case four lines are overlapping in most parts, except in cervical and 4th-6th caudal regions. The 4th caudal of the specimen 71J2883 shows somewhat higher value compared with neighboring vertebrae, but this is partly due to extraordinary growth as stated already. Also in the specimen 71J2797 the 5th caudal shows high value. In this vertebra the breadth of centrum is the largest among the series of vertebrae. On the other hand two specimens from the North Pacific draw more smoothed curve in these regions. Such differences may be attributable to the difference of age partly, but in general the trend of four curves does not differ materially and such differences shown by Omura (1971) among different species of baleen whales are not noted.

TABLE 5. SKULL AND VERTEBRAL LENGTH OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC

Specimen	Skull	Cervical	Dorsal	Lumbar	Caudal	Total
			(Actual figures in mm)			
71J2883	2,350	315 (7)	1,335 (11)	2,309 (12)	2,782 (20)	9,091
71J2793	2,115	280 (7)	1,389 (12)	1,764 (10)	2,439 (20)	7,987
AY69B	1,382	223 (7)	935 (11)	1,646 (12)	1,720 (18)	5,906
AY69A	1,140	209 (7)	862 (11)	1,302 (11)	1,590 (19)	5,103
			(Percentage)			
71J2883	25.85	3.47	14.68	25.40	30.60	100.0
71J2793	26.48	3.50	17.39	22.09	30.54	100.0
AY69B	23.40	3.78	15.83	27.87	29.12	100.0
AY69A	22.34	4.10	16.89	25.51	31.16	100.0

Figures in parentheses show number of vertebrae.

In Table 5 are shown the total length of skull and vertebrae of the minke whale from the Antarctic and North Pacific. The vertebral length is the total of the length of each centrum. Accordingly this length does not show actual length *in situ*. Further the vertebral length is shown dividing into four regions of cervical, dorsal, lumbar, and caudals. The length of skull and each region of vertebrae are also shown their percentage figures against total length of skul and vertebrae. In comparing these figures it will be noted that in the length of cervicals and caudals there is no significant difference between specimens from the Antarctic and North Pacific. The skull length is somewhat larger in the specimens from the Antarctic than those from the North Pacific. The dorsal and lumbar regions show individual variation, reflected by different number of vertebrae, but when the two regions are considered together, then the specimens from the North Pacific have somewhat larger dorsal and lumbar regions than those from the Antarctic. The combined

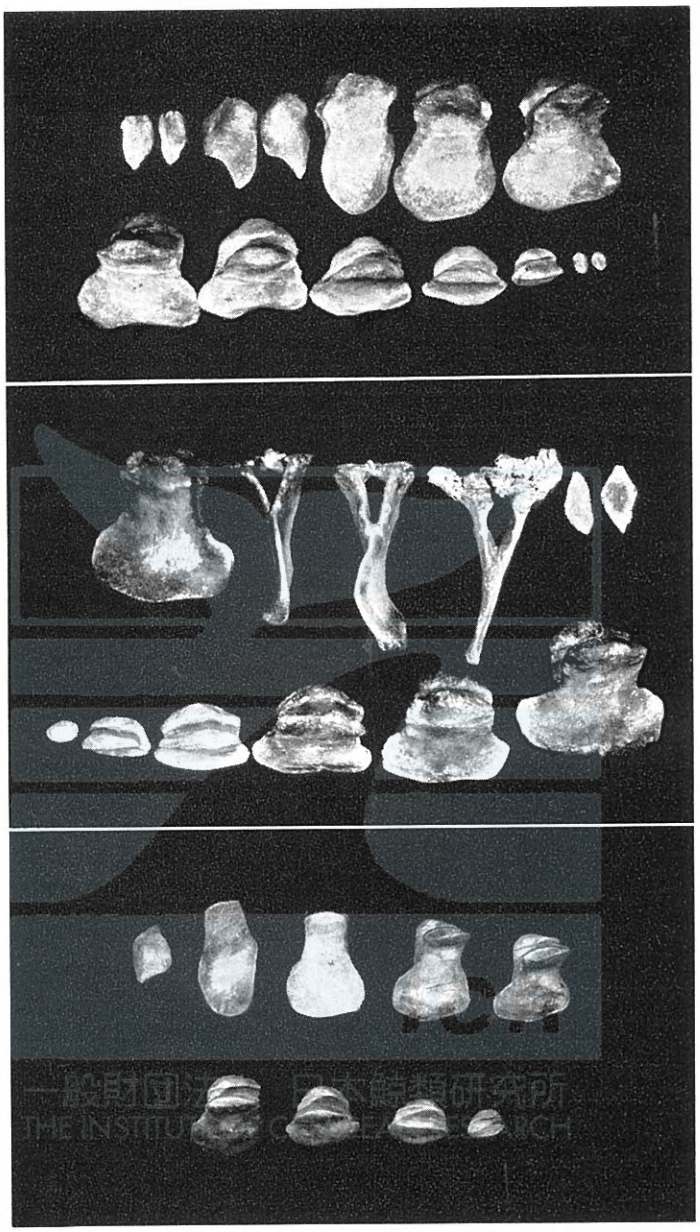

Fig. 11. Chevron bones of the minke whale. Upper. Specimen 71J2793 from the Antarctic. Center. Specimen 71J2883 from the Antarctic. Lower. Specimen AY69B from the North Pacific. From left to right. 1st, 2nd, 3rd and so on, but in the center photograph from right to left. The 2nd, 3rd, and 4th chevrons of 71J2883 are anterior view, showing bone bridge at proximal end of laminae.

percentages of these regions are around 40 percent in the specimen from the Antarctic and the corresponding figure from the North Pacific exceed 42 percent. In the specimen reported by Omura (1971) this figure is 44.66 percent of the total length, and the skull length occupies 22.25 percent of the total.

The proportional length of skull and vertebrae may differ between adult and juvenile specimens even in the same species or population, and definite conclusion is very difficult to reach. But the last mentioned specimen is the largest among I have ever examined of the minke whale skeleton from the North Pacific and semi-adult as stated already. Its body length is 7.5 m and the skull length is 1,520 mm. It is suggested, therefore, the Antarctic minke whale has more larger

TABLE 6. MEASUREMENTS OF CHEVRON BONES OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

	71J2793		71J2883		AY69B		AY69A	
	Length	Height	Length	Height	Length	Height	Length	Height
1	*{43 {47	*{80 {77	*{38 {52	*{93 {97	*{57 {?	*{86 {?	*{55 {?	*{98 {?
2	*{73 {79	*{124 {132	91	266	78	164	45	101
3	103	202	162	270	108	156	82	134
4	147	213	190	246	112	144	88	128
5	176	186	211	229	110	124	84	112
6	172	149	207	197	99	107	74	96
7	153	119	171	154	104	80	65	82
8	146	101	169	120	86	60	62	67
9	121	80	138	89	52	30	—	—
10	74	46	87	55	—	—	—	—
11	*{32 {29	*{22 {22	*{47 {?	*{33 {?	—	—	—	—

* Not united. Question mark means missing.

skull compared with that from the North Pacific, and this is a reflection of more longer rostrum as shown in Fig. 6. In the external body proportions this is also suggested in the proportional length from tip of snout to center of eye (Ohsumi *et al.*, 1970).

The chevron bones of the two specimens from the Antarctic and a specimen from the North Pacific are shown in Fig. 11. From the minke whale from the Antarctic 11 chevron bones were secured from the both specimens. In the specimen 71J2793 the first two and the last one, and in 71J2883 the first and the last are not united of the right and left laminae. In the specimen from the North Pacific 9 chevrons were obtained and only in the first two laminae separated. Chevron bones are of little taxonomic value, but chevrons of the specimen 71J2883 are of some interest. As seen in Fig. 9 in the 2nd, 3rd, and 4th chevrons there are bony bridges connecting right and left laminae at their proximal ends. In the 2nd it developed abnormally as stated already, but in the 3rd and 4th no such abnormality is observed. One explanation may be, therefore, that the bony bridge

is formed when the whale has attained very high age. Of course this is not conclusive and further study is needed. In Table 6 measurements of chevron bones are given.

RIBS AND STERNUM (Plates X and XI)

Ribs of the minke whale from the Antarctic are massive in general compared with those of the North Pacific specimen, but this may of course be attributable to the

TABLE 7. STRAIGHT LENGTH OF RIBS OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

No.	71J2793		71J2883		AY69B		AY69A	
	Right	Left	Right	Left	Right	Left	Right	Left
1	721	730	794	*570+	505	510	435	417
2	1,060	1,103	1,133	1,153	733	740	627	630
3	1,216	1,229	1,335	1,333	880	875	730	742
4	1,279	1,263	1,384	1,380	907	915	755	762
5	1,163	1,262	1,410	1,381	895	910	753	748
6	1,210	1,206	1,355	1,389	865	875	735	718
7	1,163	1,156	1,326	1,295	838	863	730	714
8	1,096	1,085	1,209	1,219	*715+	830	682	690
9	1,030	1,025	*1,160+	1,155	805	805	643	642
10	*910+	987	1,200	1,160	780	755	630	622
11	*770+	*826+	990	1,202	*752+	*800+	427	352
12	—	*448+	—	—	—	—	—	—

* Broken and not estimated.

TABLE 8. MEASUREMENTS OF STERNUM OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

	71J2793	71J2883	AY69B	AY69A
Length	394	388	275	205
Breadth	348	365	205	167

difference in age. There is no difference in number, having 11 pairs of ribs in specimens from the Antarctic and also from the North Pacific, but as stated already a specimen from the Antarctic (71J2793) had one small accessory rib in addition to 11 pairs. In one specimen from the Antarctic (71J2793) from 2nd to 9th rib are doble-headed, but in other specimen (71J2883) clear double-head is observed only in the 2nd and 3rd. Specimens from the North Pacific are similar to the latter specimen in this respect. Measurements of ribs are shown in Table 7.

The form of the sternum is cruciate in general in the specimens both from the different oceans, but it varies individually and has less taxonomic value. Photographs of sterna of the specimens 71J2793, 71J2883, and AY69B are shown in Plate XI, but quite similar forms are already reported from the minke whale from the North Atlantic (True, 1904; Tomilin, 1967). Measurements of sterna are shown

in Table 8.

SCAPULA AND FLIPPER BONES (Plates XII-XVI)

Scapullae of the two specimens from the Antarctic and one specimen from the North Pacific are shown in Plate XII. They are typical of the balaenopterid whales in form. Acromion and coracoid are well developed. In the specimen 71J2793 the superior margin is somewhat depressed compared with other two specimens. The upper curvature may subject to individual variation, though

TABLE 9. MEASUREMENTS OF SCAPULA OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

	71J2793		71J2883		AY69B		AY69A	
	Right	Left	Right	Left	Right	Left	Right	Left
Greatest breadth	812	805	874	864	535	544	394	391
Greatest height	449	452	491	491	312	307	260	258
Length of acromion, inferior	219	217	253	251	127	132	102	92
Breadth of acromion, distal end	65	69	72	79	39	42	25	26
Length of coracoid, inferior	87	84	95	98	65	69	—	—
Breadth of coracoid, distal end	50	52	59	60	26	28	—	—
Length of glenoid fossa	163	163	182	192	126	129	142*	138*
Breadth of glenoid fossa	121	118	133	133	79	80	69	68
Ratio of breadth against height	1.81	1.78	1.78	1.76	1.72	1.77	1.52	1.52

* Including coracoid.

Tomilin (1967) describes that in the juveniles, the contour of this part of the body is more convex, and in the adults, more or less straightened. In Table 9 measurements of scapullae are shown, together with ratio of breadth against height of the scapula. As seen in this table the specimen AY69A shows somewhat smaller value in this ratio, whereas in other specimens no remarkable difference is noted. But the relative size of the bone increases with age, growing much more intensively in width than in height (Tomilin, 1967). No special difference is noted between scapullae from the different oceans.

Humerus, radius, and ulna (Plates XIII and XIV) also present no noticeable feature between samples from the Antarctic and North Pacific. In the former specimens epiphyses are united to the body in humerus completely, and in radius and ulna only the proximal epiphyses are united, and distal epiphyses are not ankylosed in both specimens. In the specimens from the North Pacific none of the epiphyses is united to the body. Of course this difference is due to the difference in age, and complete ankylosis in these regions of body may occur when the whale reached very high age, long after the completion of vertebrae. Measurements of humerus, radius, and ulna are shown in Table 10.

Carpals are of no special feature. They are shown in Plates XV and XVI, together with phalanges. Measurements of phalanges are shown in Table 11. As seen in Plates and Table no distinction is noted between specimens from

TABLE 10. MEASUREMENTS OF HUMERUS, RADIUS, AND ULNA OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

	71J2793		71J2883		AY69B		AY69A	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
Humerus								
Right	284	152	303	164	232	110	191	118*
Left	288	151	306	161	229	109	190	118*
Radius								
Right	549	89	573	119	379	67	299	50
Left	550	88	577	117	383	67	301	48
Ulna								
Right	501	68	540	85	342	45	301	36
Left	499	67	544	84	345	44	306	35

Note: Length and breadth measured at middle.
* Greatest.

TABLE 11. LENGTH OF PHALANGES OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm)

Specimen	Phalanx	Right				Left			
		I	II	III	IV	I	II	III	IV
71J2793	1	75	99	80	56	75	101	79	56
	2	75	85	77	53	76	88	77	55
	3	62	62	62	46	62	62	62	46
	4	46	43	44	34	46	46	46	31
	5	25	29	32	—	29	31	35	—
	6	—	21	23	—	—	23	24	—
	7	—	15	17	—	—	18	16	—
	8	—	10	—	—	—	11	7	—
71J2883	1	86	109	89	61	89	109	91	61
	2	96	112	98	60	96	114	100	61
	3	77	80	84	63	78	84	84	63
	4	56	59	63	50	53	60	63	50
	5	—	40	47	—	—	41	47	—
	6	—	29	34	—	—	28	34	—
	7	—	—*	21	—	—	20	21	—
	8	—	—*	—	—	—	14	—	—
AY69B	1	51	64	53	45	52	64	55	44
	2	49	57	50	39	49	56	51	38
	3	39	42	40	31	39	41	41	31
	4	26	28	28	17	25	29	28	16
	5	—	19	18	—	—	19	18	—
	6	—	13	11	—	—	12	11	—
	7	—	7	—	—	—	8	—	—
	8	—	—*	—	—	—	6	—	—

Note: Metacarpals are included,
* Possibly missing.

different oceans, except their size. The phalangeal formula of these specimens is I_{4-5}, II_8, III_{6-8}, IV_4, which is in the range of the formula I_{3-5}, II_{6-9}, IV_{5-8}, V_{3-4} given by Tomilin (1967). Of course his IV and V correspond with III and IV in this paper

HYOID AND PELVIC BONES

Hyoid bones of the two specimens from the Antarctic have already been treated by Satake and Omura (1974), together with other specimens, and no further description is needed.

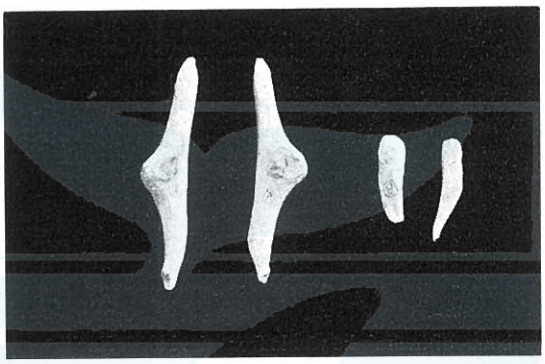

Fig. 12. Pelvic bones of the minke whale from the Antarctic. Left. Specimen 71J2793, a male of 8.5 m long. Right. Specimen 71J2883, a female of 9.8 m long.

Pelvic bone is of some interest morphologically. As seen in Fig. 12 the pelvic bones of the male are much larger than those of female. The spcimen 71J2793 is a male of 8.5 m in length and the specimen 71J2883 is a female of 9.8 m. Their ages are 25 years and 39 years respectively (see Table 1). Accordingly this difference in size and form is attributable to the difference by sex. Hosokawa (1951) found marked sexual and specifical dimorphism in the form of pelvis in the fin and blue whale fetuses. Omura *et al.* (1971) also describe sexual difference of pelvic bones in the black right whale. In this case male has much larger bones than in female.

In the specimen 71J2793 the length of right and left pelvic bones are 200 and 204 mm and their width are 46 and 42 mm respectively. The corresponding figures of the specimen 71J2883 are 78, 93, and 23, 19 mm respectively. The form of the right and left bone is similar in the former specimen, but in the latter somewhat different and one is more slender than the other.

In the specimens from the North Pacific pelvic bones were missing in the specimen AY69B, but in AY69A, a male of 5.4 m long, the length and width of both pelvic bones are 84, 30, and 87, 27 mm respectively. Thus the size is a bit larger than that of the specimen 71J2883. The form resembles to the specimen reported by Omura (1957) from a 18 feet (5.4 m) male. He also presents photo-

graph showing the pelvic bones of a 25 feet (7.5 m) male (Fig. 13). In this specimen the pelvic bones are much elongated. This whale was a semi-adult as already stated, but possibly the whale was mature sexually, because average body length at sexual maturity is 22–23 feet (6.6–6.9 m) in males (Omura and Sakiura, 1956). When the pelvic bones of this specimen are compared with those of the specimen 71J2793 a difference is noted in their form. In the former specimen from the North Pacific the length of pelvic bones are 174 and 181 mm respectively and a bit smaller than the latter specimen from the Antarctic, but still quite comparable.

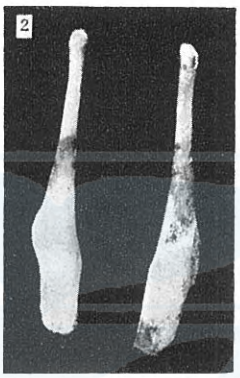

Fig. 13. Pelvic bones of the minke whale from the North Pacific. A male of 7.5 m long (cited from Omura, 1957).

In this specimen the tubercles, tuberculum laterale, are less eminent and situated more posteriorly than the specimen from the Antarctic. Further in the specimen from the North Pacific the cranial processes are long and much slender than in those from the Antarctic. The percentage figures of width against length of right and left pelvic bones are 16 and 14 percent respectively in the specimen from the North Pacific, whereas the corresponding figures of the specimen from the Antarctic are 23 and 21 percent respectively. This difference in ratio is a reflection of less developed lateral tubercles in the specimen from the North Pacific. For the female no comparable material is available for the North Pacific minke whale.

DISCUSSION

In the foregoing chapters the characteristics of the minke whale from the Antarctic are discussed mainly comparing with the whale from the North Pacific. The minke whale from the North Pacific was named *Balaenoptera davidsoni* by Scammon (1872). True (1904) compared two skulls from the North Pacific, including the type of *davidsoni*, with those of *acutorostrata* from the North Atlantic. His conclusion was " there cannot be said to be a constant difference in any of the proportions between the specimens from the two oceans ". Cowan (1939) and Omura (1957) supported this conclusion, but Tomilin (1967) found that " Cranial in-

dices of both populations show that the Atlantic individuals (adult and, particularly, juvenile) are characterized by a relatively longer rostrum ". And he concluded " We consider this character, which is manifested also by the general proportions of the body (Table 61), as a significant difference between the North Atlantic subspecies *Balaenoptera acutorostrata acutorostrata* Lecépède, 1803–1804 and the North Pacific *Balaenoptera acutorostrata davidsoni* Scammon, 1872 ". In this connection I like to point out the difference in the form of the transverse white band on the flipper. This problem was first raised by Scammon (1872), but his description is not explicit as pointed out by True (1904) and his figure (Scammon, 1874) of white band is not correct.

In the minke whale from the North Pacific the anterior margin of this white band runs nearly perpendicular to the flipper and there is a promontory or projection of white area into the black, towards the mid-line. This is well shown in Plate II of Omura and Sakiura (1956). Almost all minke whales from the North Pacific investigated by myself and my colleague exhibit this pattern. The minke whale taken at Los Angeles Harbor also has similar pattern (Fig. 2 of Fry, 1935). On the other hand in the minke whale from the North Atlantic the margin of the white band draws roughly semi-circle and no forward projection of white area is noted. This form is well demonstrated in the upper photograph of Plate I of Moore and Palmer (1955) and also in Fig. 3 of Sergeant (1963).

In the skull no other difference than that pointed out by Tomilin seems to present between the specimens from the North Pacific and North Atlantic. Judged from the photographs shown by True (1904) the anterior margin of the nasals is flattened as described by Tomilin (1967). The triangular region formed by frontal and parietal on the vertex of the skull, between nasals and supraoccipital which shows lesser degree of telescoping, seems also present, although I could not find out any description on this particular point of the skull in other literatures. The form of the hamular process of the Massachusetts specimen is quite similar to my specimen from the North Pacific. In the post-cranial bones differences are noted in two characters between specimens from the Antarctic and North Pacific. One is the presence of parapophyses on the 7th cervical in the specimens from the North Pacific, but lacking in those from the Antarctic. The North Atlantic specimens have also this processes on the 7th cervical, as already stated. Another difference is in the form of the pelvic bones, but I could not examin this on the North Atlantic specimen.

The number of vertebrae does not differ between specimens from the North Atlantic and North Pacific, but further counting is needed in whales from the Antarctic. A distinction is noted in the hyoid bone between specimens from the Antarctic and North Pacific, the former specimen having more longer stylohyals proportionally (Satake and Omura, 1974), but nothing is known of the specimen from the North Atlantic.

In the external morphological characters which separate minke whales from the Antarctic from those from the northern hemisphere are: 1) no white band present on flipper, and 2) baleen plates are white at the front of the series and

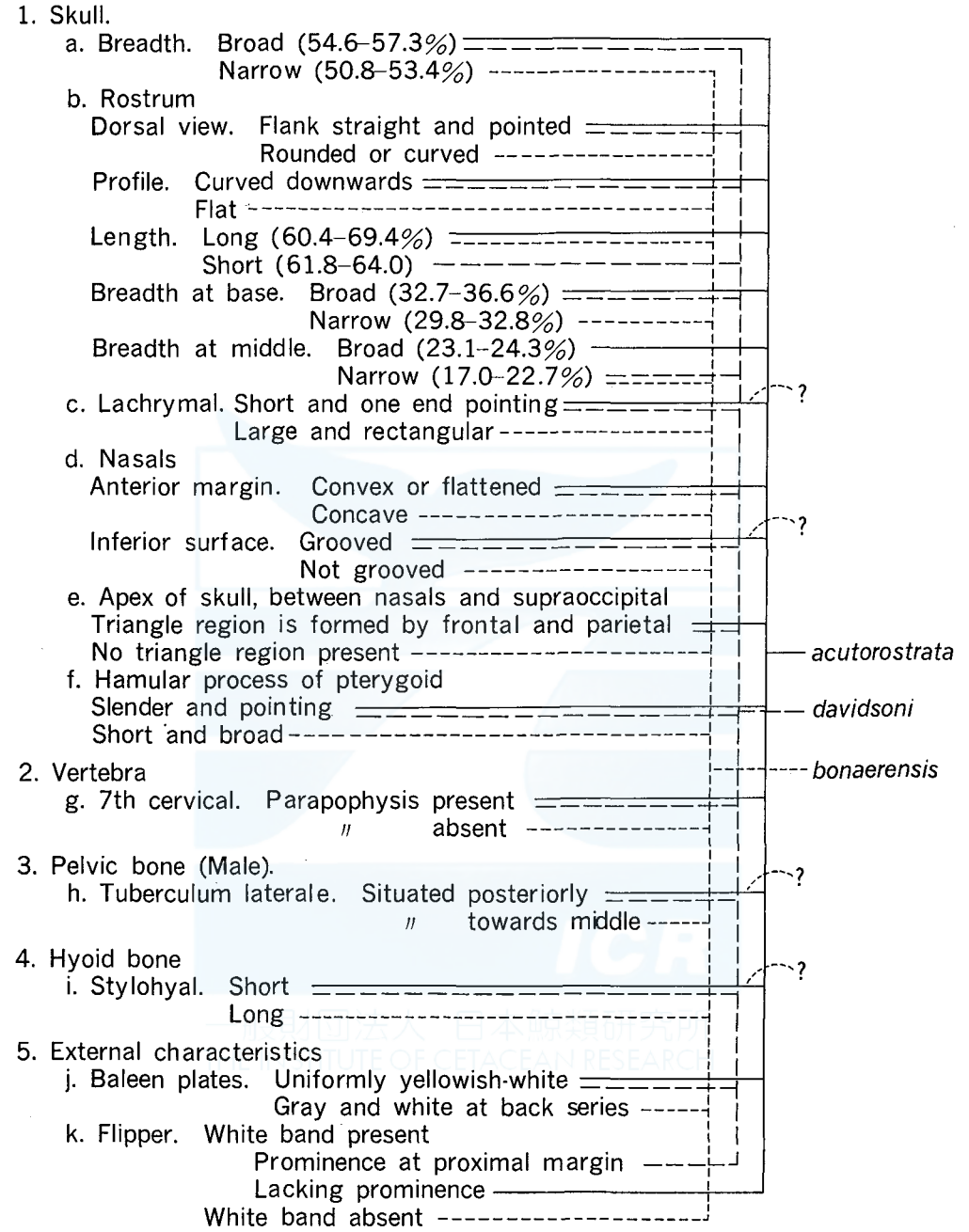

Fig. 14. Relationship among the minke whale populations from the North Atlantic (*acutorostrata*), North Pacific (*davidsoni*), and Antarctic (*bonaerensis*).

gray and white at the back, whereas uniform yellowish-white in whales in the northern hemisphere (Williamson, 1961; Utrecht and Spoel, 1962; Kasuya and Ichihara, 1965; Ohsumi *et al.*, 1970).

In Fig. 14 the relationship among the minke whale populations from the North Atlantic (*acutorostrata*), North Pacific (*davidsoni*), and Antarctic (*bonaerensis*) is shown. In the figure the skull indices are the percentages figures against skull length, and all from the mature specimens, cited from Tomilin (1967. Table 61) for the North Atlantic and North Pacific specimens. These figures are the ranges of one or two groups, for example the breadth of skull shows ranges of two populations of *acutorostrata* and *davidsoni* altogether on one hand (broad) and ranges of another population *bonaerensis* on the other (narrow).

Fig. 14 is a summary of this study and the next problem is the validity of these characters. The most weak point in osteological study of large whales is only limited number of samples are available, and it is difficult to ascertain whether the difference is specific or subspecific or only individual or by growth. There are rather wide individual variations in measurements of skulls and other bones. Form of rostrum and other particular bones would also subject to variation. Relation between form of nasals and flat or bending down rostrum is of some interest. In the sei whale (*Balaenoptera borealis*) nasals are convex and rostrum is bending, whereas in the Bryde's whale (*B. edeni*) nasals are concave and rostrum is flat. It is thought, therefore, these are connected with food and feeding or other ecological matters of whales concerned. But no conclusion cannot be reached at present. Accordingly further study is needed in order to clarify these characters listed in Fig. 14. But even at this stage it can be said that the Antarctic population *bonaerensis* is more distinctly separated from other two populations in the northern hemisphere, i.e. *acutorostrata* and *davidsoni*, though this distinction may not specific level. Further it has attained a more advanced stage of telescoping than the populations in the northern hemisphere.

The North Pacific population *davidsoni* is separated from the North Atlantic population *acutorostrata* in having relatively shorter rostrum and different pattern of white band on the flipper. The Antarctic population *bonaerensis* is separated from the above two populations in having relatively narrow skull and rostrum, and in other 9 characters, as shown in Fig. 14. The habitat of this population is not confined within the Antarctic waters and it follows south and north migration, but possibly it is limited in the southern hemisphere.

Williamson (1961) found great similarity of this population (his « Balaena » whales) *Balaenoptera bonaerensis* Burmeister, 1867, and the likelihood that *B. huttoni* Gray, 1874 is also of the same species, and proposed that all three types be regarded as specimens of *B. bonaerensis* provisionally. But he added that " It has yet to be discovered whether this latter is a true and separate species or a subspecies of *B. acutorostrata* ". As already stated the number of vertebrae is not differ, at least at this stage of study, between *B. acutorostrata* and *B. bonaerensis*, though much differences are found in other particular points, it cannot be concluded that *B. bonaerensis* is a distinct species from *B. acutorostrata*.

Another question is the occurrence of the minke whale with white band on flipper in the southern hemisphere (Williamson, 1961). Taylor (1957) reports observation of rorquals in pools in sea-ice in the Crown Prince Gustav Channel, Antarctic peninsula, and describes that " some of the rorquals had light patches on the upper surface of their flipper ". But no information is available at present to know the relationship between this population of the minke whale in the southern hemisphere and *B. acutorostrata*, nor between this population and *bonaerensis*.

ACKNOWLEDGMENTS

I am much indebted to many persons during the course of this study. First of all my sincere thanks are due to Dr S. Ohsumi, Far Seas Fisheries Research Laboratory, who kindly secured two sets of skeleton of the minke whale from the Antarctic, and to Mr T. Miyodori, owner of minke whale catcher boat operating on the coast of Japan, who supplied also two sets of skeleton from the North Pacific. These four skeletons form the basis of this study.

During the preparation of bones as complete sample many persons helped me greatly, including Dr S. Ohsumi and Dr T. Kasuya and his co-workers at Ocean Research Institute of the University of Tokyo. Dr A. Kawamura, Mr S. Machida and Miss Yuko Satake of Whales Research Institute have assisted not only in preparation of bones but also in taking measurements and photographs. I am very grateful for them all.

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APPENDIX. MEASUREMENTS OF VERTEBRAE OF THE MINKE WHALE FROM THE ANTARCTIC AND NORTH PACIFIC (in mm.)

1. SPECIMEN 71J2793 FROM THE ANTARCTIC

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			$(axbxc)^{1/3}$
				Breadth (a)	Height (b)	Length (c)	
1	C 1	383	222	207	R. 131 L. 133	81	130
2	2	527	220	182	R. 125 L. 126	29	76
3	3	454	176	157	106	30	79
4	4	461	173	149	112	30	79
5	5	454	185	143	115	32	81
6	6	441	211	141	118	35	84
7	7	455	228	142	118	43	87
8	D 1	479	240	149	118	53	98
9	2	470	273	166	117	68	110
10	3	469	332	158	117	88	118
11	4	527	358	159	119	100	124
12	5	608	381	162	119	111	129
13	6	699	408	161	124	121	134
14	7	758	424	165	122	128	137
15	8	791	438	161	121	135	138
16	9	801	435	165	122	140	141
17	10	804	445	166	123	142	143
18	11	790	455	168	125	149	146
19	12	781	474	168	130	154	150
20	L 1	736	492	172	141	153	155
21	2	730	493	176	143	161	162
22	3	723	519	179	145	167	163
23	4	698	511	182	148	170	166
24	5	678	501	186	152	173	170
25	6	646	525	187	157	175	173
26	7	639	525	190	159	181	176
27	8	618	555	194	163	190	183
28	9	601	550	196	165	195	185
29	10	585	550	202	167	199	189
30	Ca 1	521	549	209	170	203	193
31	2	482	518+	208	180	212	199
32	3	445	515	207	182	215	201
33	4	384	403+	212	181	213	201
34	5	326	388	234	193	210	213
35	6	279	330	219	186	204	203
36	7	231	265	216	182	198	198
37	8	T.P. disappear	252	190	177	184	184
38	9		216	165	181	170	172
39	10		189	155	172	130	151
40	11		143	137	133	88	117
41	12		S.P. disappear	124	109	74	100
42	13			109	96	69	90

Continued . . .

APPENDIX. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	$(axbxc)^{1/3}$
43	14			94	83	62	77
44	15			81	70	54	67
45	16			65	54	45	54
46	17			51	42	36	43
47	18			40	31	30	33
48	19			35	21	25	26
49	20			18	15	17	17

2. SPECIMEN 71J2883 FROM THE ANTARCTIC.

1	C 1	386	247	227	{R. 146 L. 137	85	141
2	2	677	260	211	115	39	99
3	3	476	217	187	121	34	92
4	4	559	206	173	123	34	90
5	5	511	221+	172	124	36	92
6	6	541	263	170	132	39	96
7	7	546	266	171	132	48	103
8	D 1	575	258	174	132	56	109
9	2	579	324	181	132	70	119
10	3	538	373	182	137	96	134
11	4	621	408+	183	140	109	141
12	5	705	429	178	140	120	144
13	6	798	445	174	142	129	147
14	7	855	462	173	142	140	151
15	8	896	468	178	142	148	155
16	9	918	480	187	147	151	161
17	10	924	486	183	149	156	162
18	11	918	502	185	151	160	165
19	L 1	786	516	183	165	164	170
20	2	798	533	186	167	167	173
21	3	755+	565	193	167	176	178
22	4	767	575	197	172	180	183
23	5	760	511+	201	173	186	186
24	6	634+	589	202	179	187	189
25	7	723	624	203	186	191	193
26	8	705	622	207	179	198	194
27	9	665+	623	212	178	202	197
28	10	575+	483+	217	183	209	202
29	11	564+	451+	224	188	220	210
30	12	612	616	234	194	229	218
31	Ca 1	561+	553+	239	199	234	223
32	2	534	598	234	205	239	225
33	3	512	561	234	204	239	225
34	4	468	424+	253	236	235	241
35	5	400+	435+	268	208	237	236
36	6	332	350+	266	206	231	233
37	7	266	325+	244	200	219	220

Continued . . .

APPENDIX. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	$(axbxc)^{1/3}$
38	8	T.P. disappear	290	219	195	203	205
39	9		254	187	201	186	191
40	10		220	171	199	157	175
41	11		S.P. disappear	153	174	107	142
42	12			145	127	88	117
43	13			117	112	80	102
44	14			100	98	75	90
45	15			70	81	66	72
46	16			68	66	54	62
47	17			57	52	46	51
48	18			45	35	38	39
49	19			47	22	30	31
50	20			24	14	18	18
3. SPECIMEN AY69B FROM THE NORTH PACIFIC.							
1	C 1	272	176	167	R. 108 / L. 98	41	90
2	2	364	188	152	76	46	81
3	3	319	147	122	79	23	61
4	4	307	138	119	81	29	65
5	5	320	156	117	83	25	62
6	6	314	174	116	85	29	66
7	7	336	185	117	85	30	67
8	D 1	366	193	122	85	38	73
9	2	343	232	117	82	49	78
10	3	345	272	121	82	69	88
11	4	382	288	116	83	78	91
12	5	420	308	116	84	84	94
13	6	466	320	116	83	91	96
14	7	505	330	116	81	96	97
15	8	538	340	118	82	102	100
16	9	559	344	129	85	106	105
17	10	573	360	121	85	109	104
18	11	572	377	120	87	113	106
19	L 1	558	388	124	91	117	110
20	2	564	400	124	94	120	112
21	3	562	414	128	95	124	115
22	4	582	421	129	98	128	119
23	5	546	?	130	101+	131	120
24	6	548	447	133	106	134	124
25	7	533	445	132	105	137	124
26	8	525	440	133	109	141	127
27	9	est. 490	422	135	110	145	129
28	10	est. 462	419	141	113	153	135
29	11	429	425	141	115	156	136
30	12	392	415	147	118	160	141
31	Ca 1	est. 352	392	148	123	161	143

Continued . . .

APPENDIX. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	$(axbxc)^{1/3}$
32	2	325	366	145	123	162	142
33	3	302	327	151	126	161	145
34	4	255	286	157	129	157	147
35	5	221	252	157	128	154	146
36	6	178	225	153	126	149	142
37	7	146	200	144	128	142	138
38	8	T.P. disappear	175	126	127	129	127
39	9		147	117	121	105	114
40	10		108	101	100	72	90
41	11		S.P. disappear	87	83	62	77
42	12			74	68	55	65
43	13			67	58	51	58
44	14			54	52	45	50
45	15			43	41	39	41
46	16			35	30	31	32
47	17			25	22	27	25
48	18			20	16	18	18
4. SPECIMEN AY69A FROM THE NORTH PACIFIC.							
1	C 1	260	170	159	R. 107 / L. 107	34	83
2	2	305	169	152	81	47	83
3	3	286	148	115	80	24	60
4	4	288	149	111	81	24	60
5	5	285	163	108	82	26	61
6	6	293	174	109	83	26	62
7	7	306	175	110	82	28	63
8	D 1	312	180+	114	79	34	67
9	2	308	204	119	78	48	76
10	3	321	235	119	77	63	83
11	4	368	248	115	75	72	85
12	5	404	254	112	75	78	87
13	6	444	264	110	74	85	88
14	7	466	273	110	76	89	91
15	8	494	283	116	80	94	96
16	9	502	290	113	78	96	95
17	10	496	297	113	84	100	98
18	11	480	303	112	82	103	98
19	L 1	est. 460	314	114	86	105	101
20	2	460	320	115	89	108	103
21	3	460	326	116	92	110	105
22	4	452	335	117	95	113	108
23	5	449	292+	117	98	115	110
24	6	441	353	122	99	117	112
25	7	429	350	121	99	119	113
26	8	414	350	124	102	122	116
27	9	390	349	130	103	127	119

Continued . . .

APPENDIX. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			$(axbxc)^{1/3}$
				Breadth (a)	Height (b)	Length (c)	
28	10	377	343	131	108	131	123
29	11	361	333	133	112	135	126
30	Ca 1	318	329	132	115	138	128
31	2	285	304	129	115	140	128
32	3	265	275	131	115	144	129
33	4	230	250	135	115	140	130
34	5	197	229	138	117	136	130
35	6	173	206	140	116	133	129
36	7	144	179	135	114	129	126
37	8	120	154	119	114	120	118
38	9	T.P. disappear	132	103	115	108	109
39	10		S.P. disappear	94	103	80	92
40	11			82	82	61	74
41	12			68	69	53	63
42	13			65	58	49	57
43	14			59	50	45	51
44	15			51	41	38	43
45	16			39	31	31	33
46	17			23	23	21	22
47	18			17	14	16	16
48	19			10	9	8	9

EXPLANATION OF PLATES

PLATE I

Dorsal view of skull of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE II

Ventral view of skull of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE III

Lateral view of skull of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE IV

Posterior view of skull of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE V

Dorsal view of mandibles of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE VI

Anterior view of cervical vertebrae of the minke whale from the Antarctic and North Pacific.
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE VII

Lateral view of vertebrae of the minke whale from the Antarctic. Specimen 71J2793.
Fig. 1. Cervical and dorsal vertebrae.
Fig. 2. Lumbar vertebrae.
Fig. 3. Caudal vertebrae.

PLATE VIII

Lateral view of vertebrae of the minke whale from the Antarctic. Specimen 71J2883.
Fig. 1. Cervical and dorsal vertebrae.
Fig. 2. Lumbar vertebrae.
Fig. 3. Caudal vertebrae.

PLATE IX

Lateral view of vertebrae of the minke whale from the North Pacific. Specimen AY69B.

Fig. 1. Cervical and dorsal vertebrae.
Fig. 2. Lumbar vertebrae.
Fig. 3. Caudal vertebrae.

PLATE X

Ribs of the minke whale from the Antarctic.

Fig. 1. Specimen 71J2793.
Fig. 2. ,, 71J2883.

PLATE XI

Ribs and sternum of the minke whale.

Fig. 1. Ribs of specimen AY69B from the North Pacific.
Fig. 2. Sternum of specimen 71J2793 from the Antarctic.
Fig. 3. Sternum of specimen 71J2883 from the Antarctic.
Fig. 4. Sternum of specimen AY69B from the North Pacific.

PLATE XII

Scapullae of the minke whale from the Antarctic and North Pacific.

Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE XIII

Humerus, radius, and ulna of the minke whale from the Antarctic and North Pacific. Right side.

Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE XIV

Humerus, radius, and ulna of the minke whale from the Antarctic and North Pacific. Left side.

Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

PLATE XV

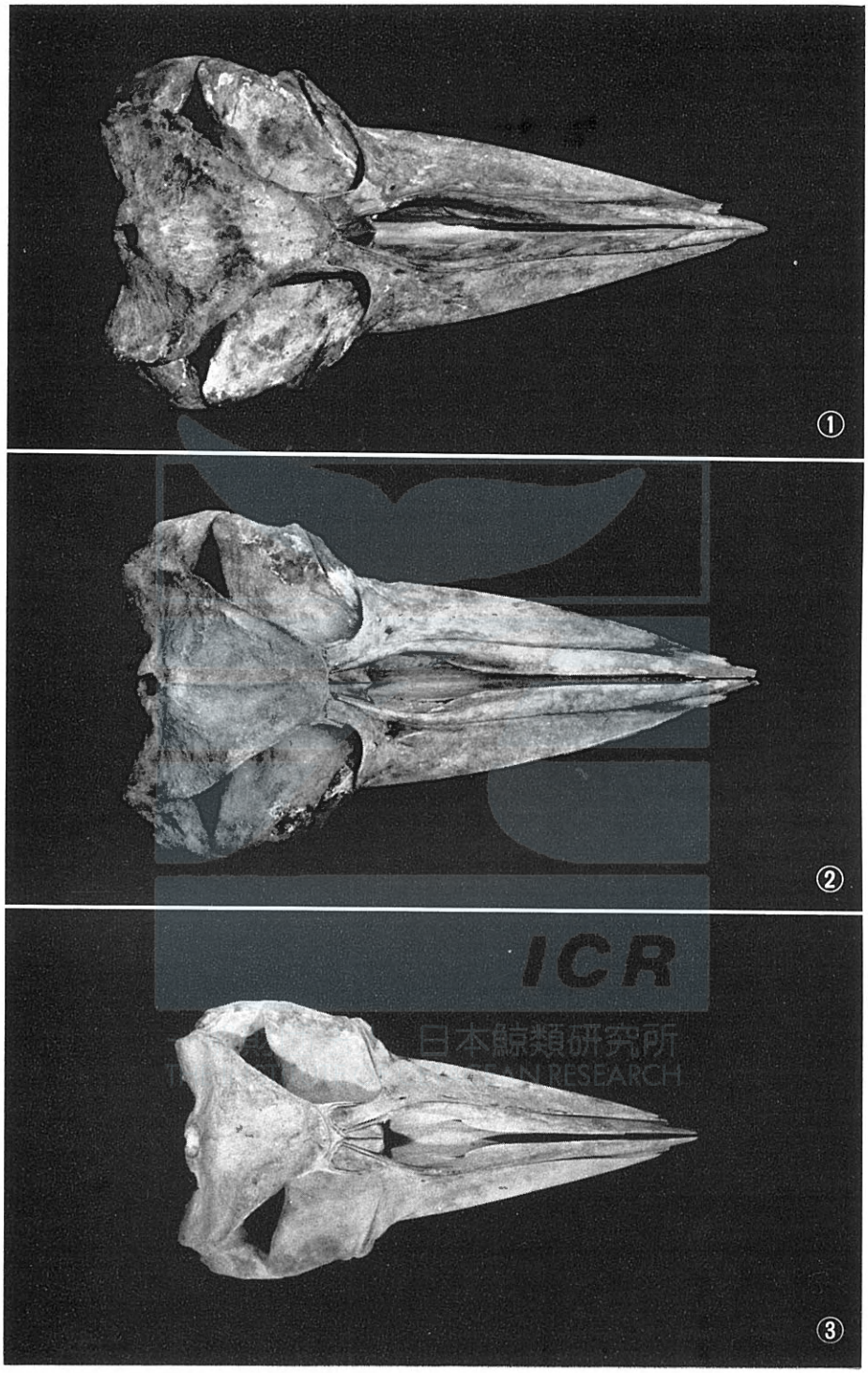
Carpals and phalanges of the minke whale from the Antarctic and North Pacific. Right side.

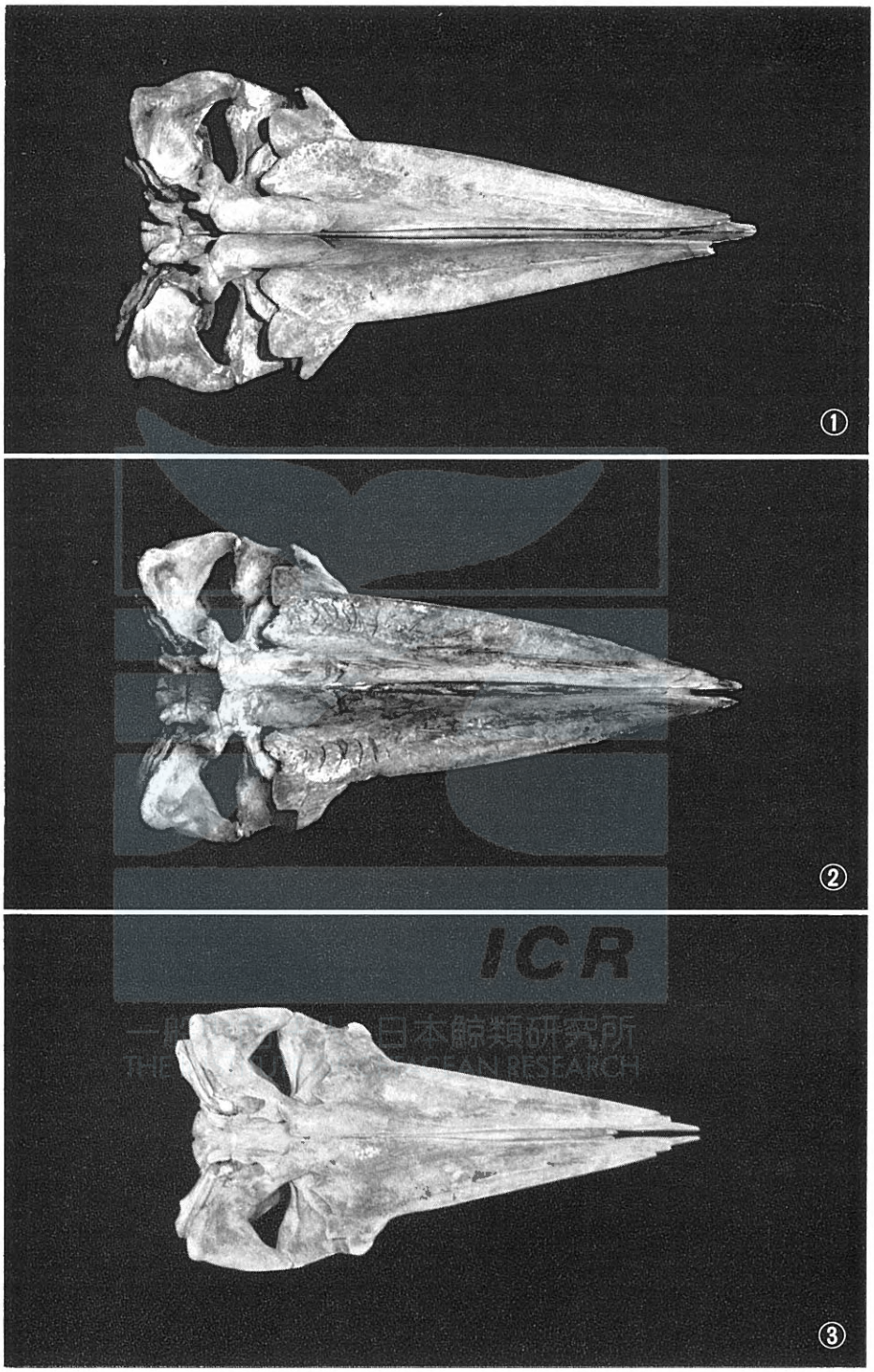
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

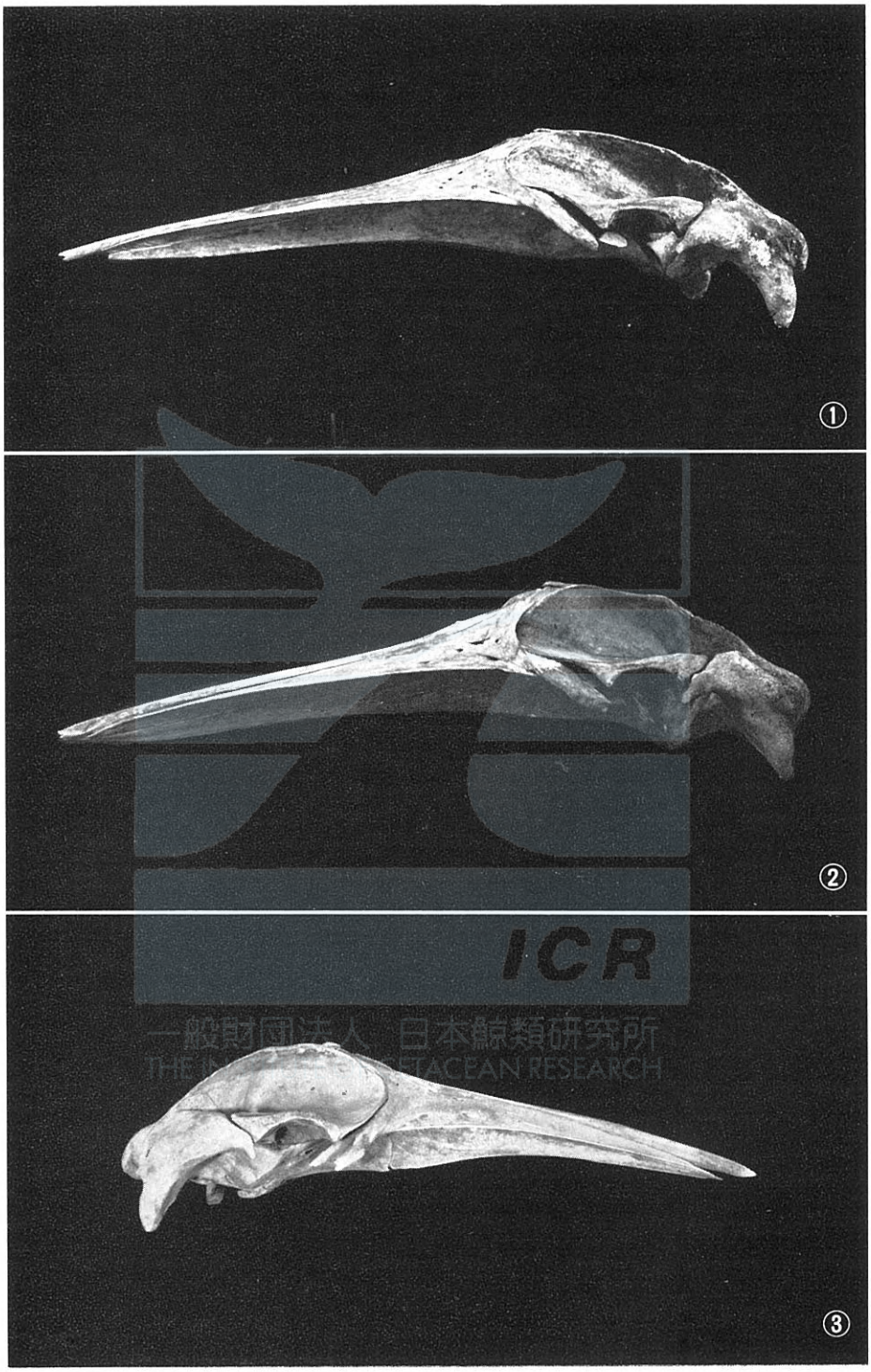
PLATE XVI

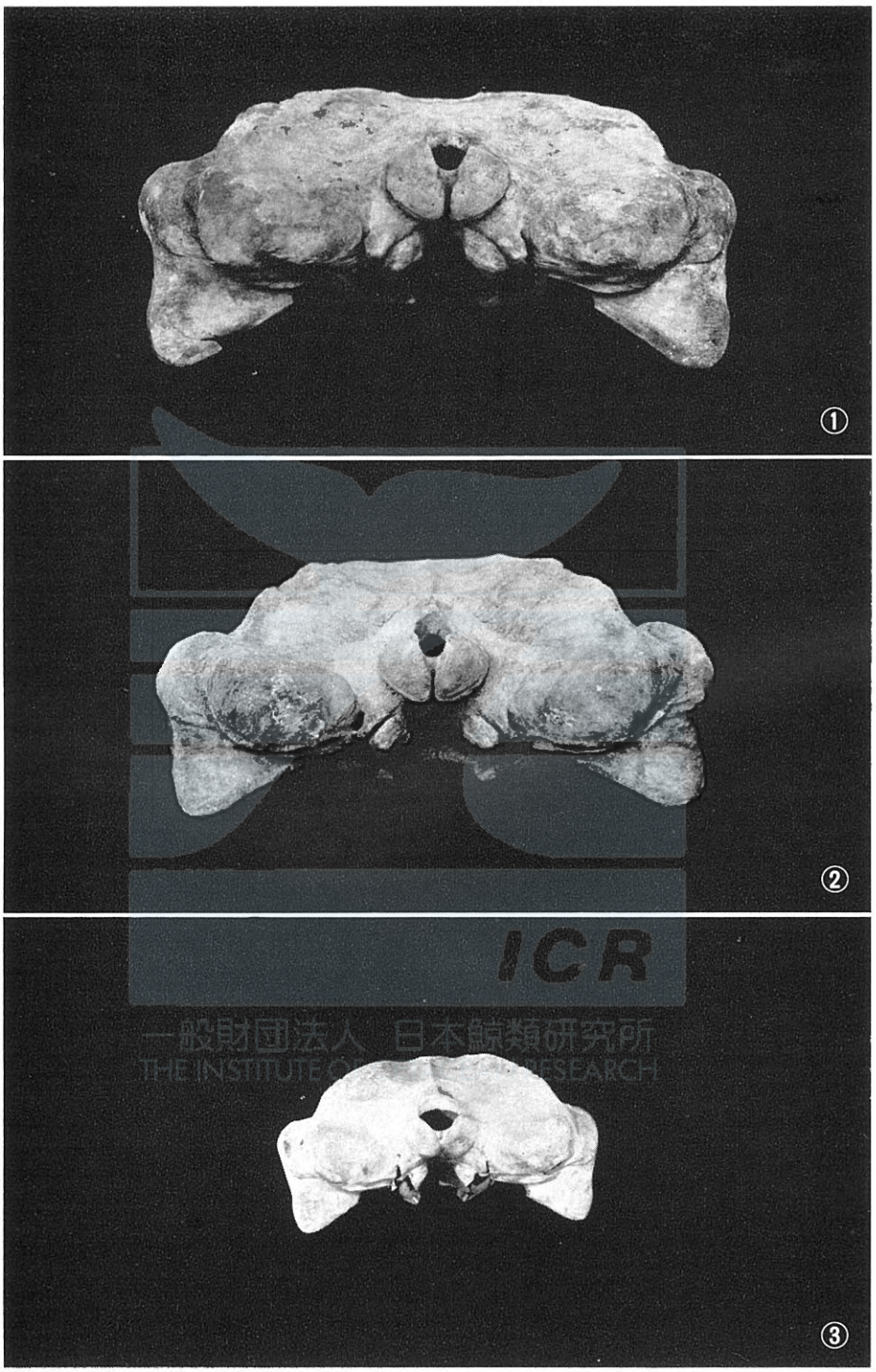
Carpals and phalanges of the minke whale from the Antarctic and North Pacific. Left side.

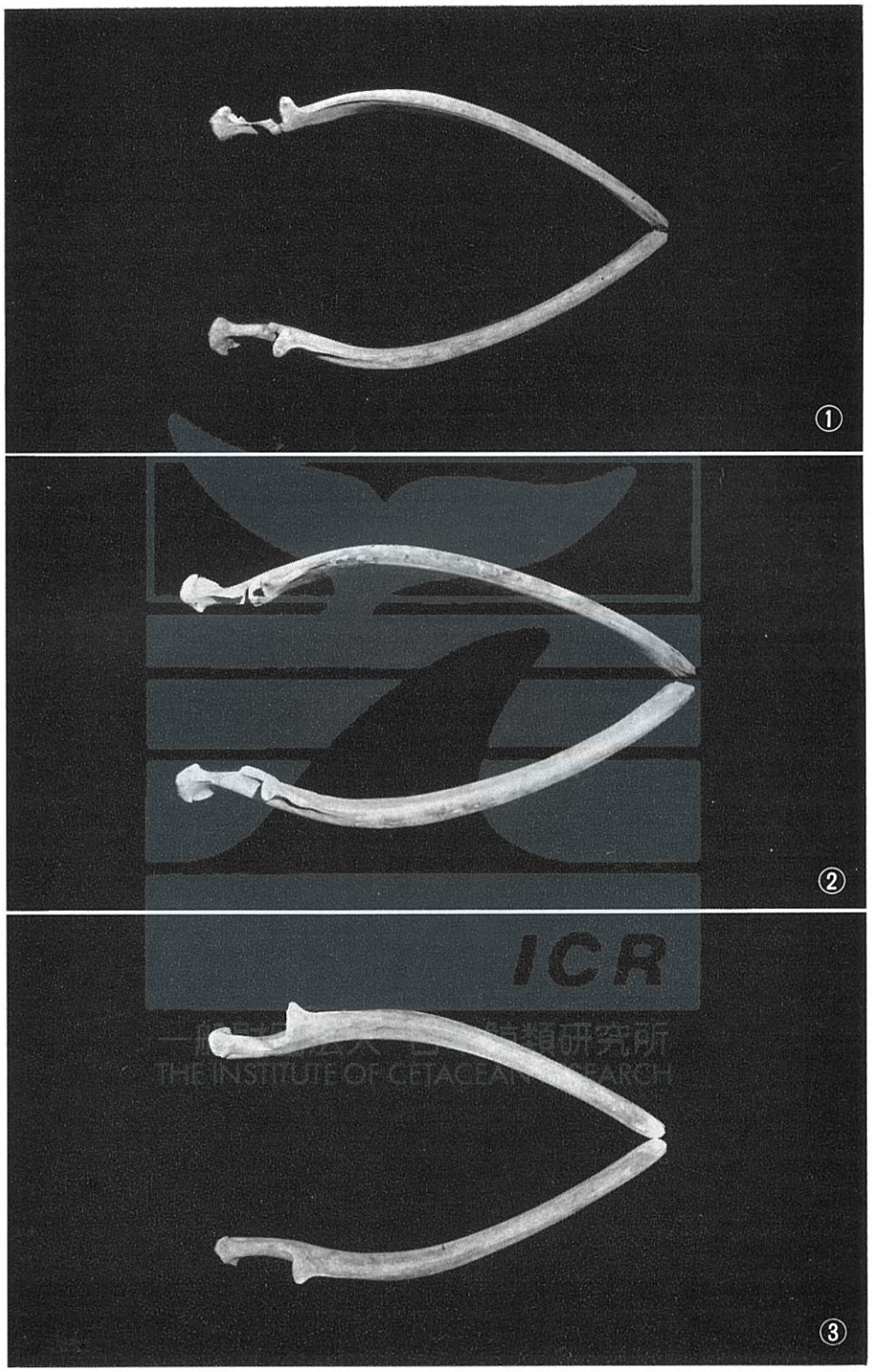
Fig. 1. Specimen 71J2793 from the Antarctic.
Fig. 2. ,, 71J2883 ,, ,, ,,
Fig. 3. ,, AY69B ,, ,, North Pacific.

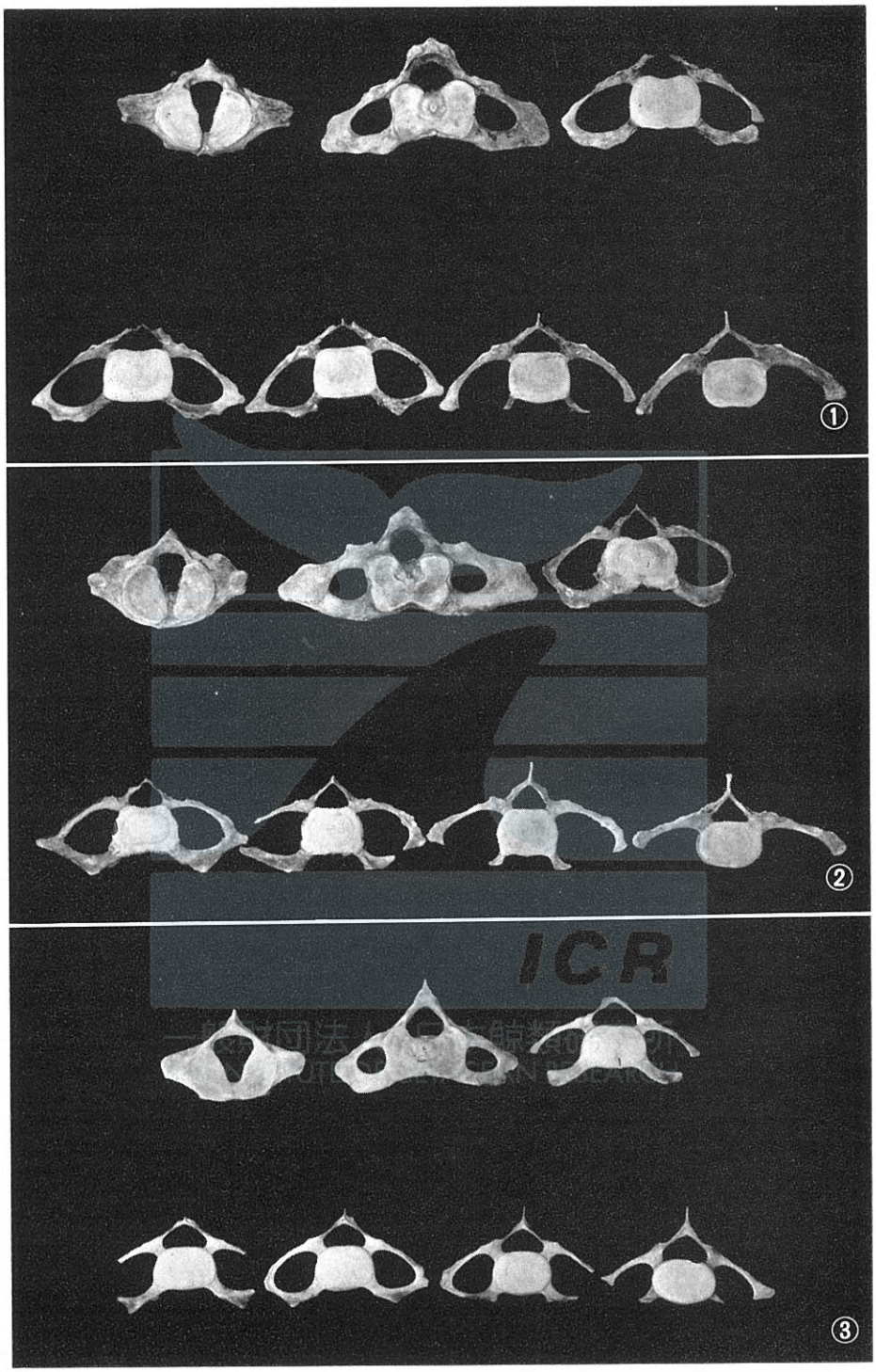


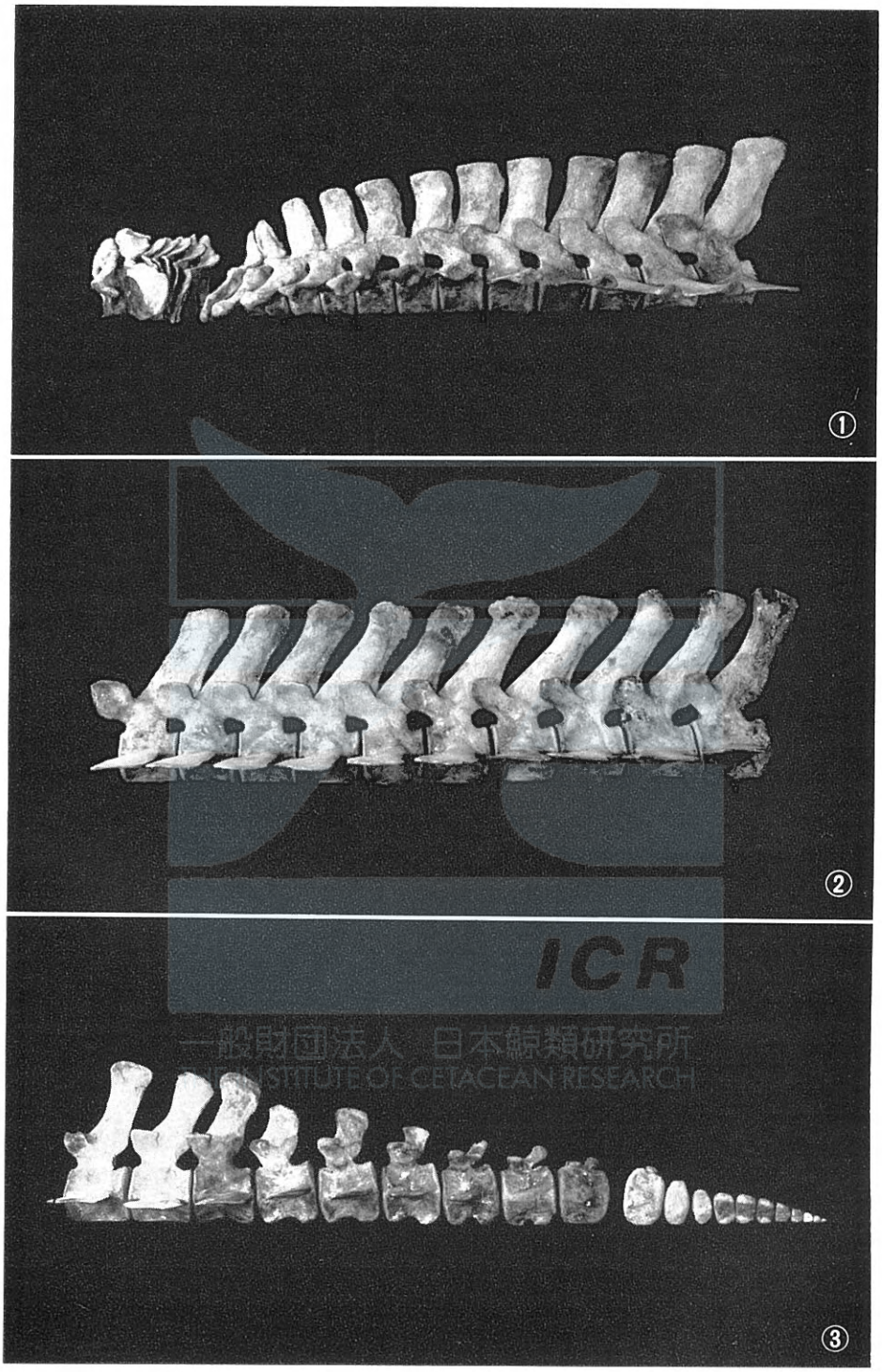


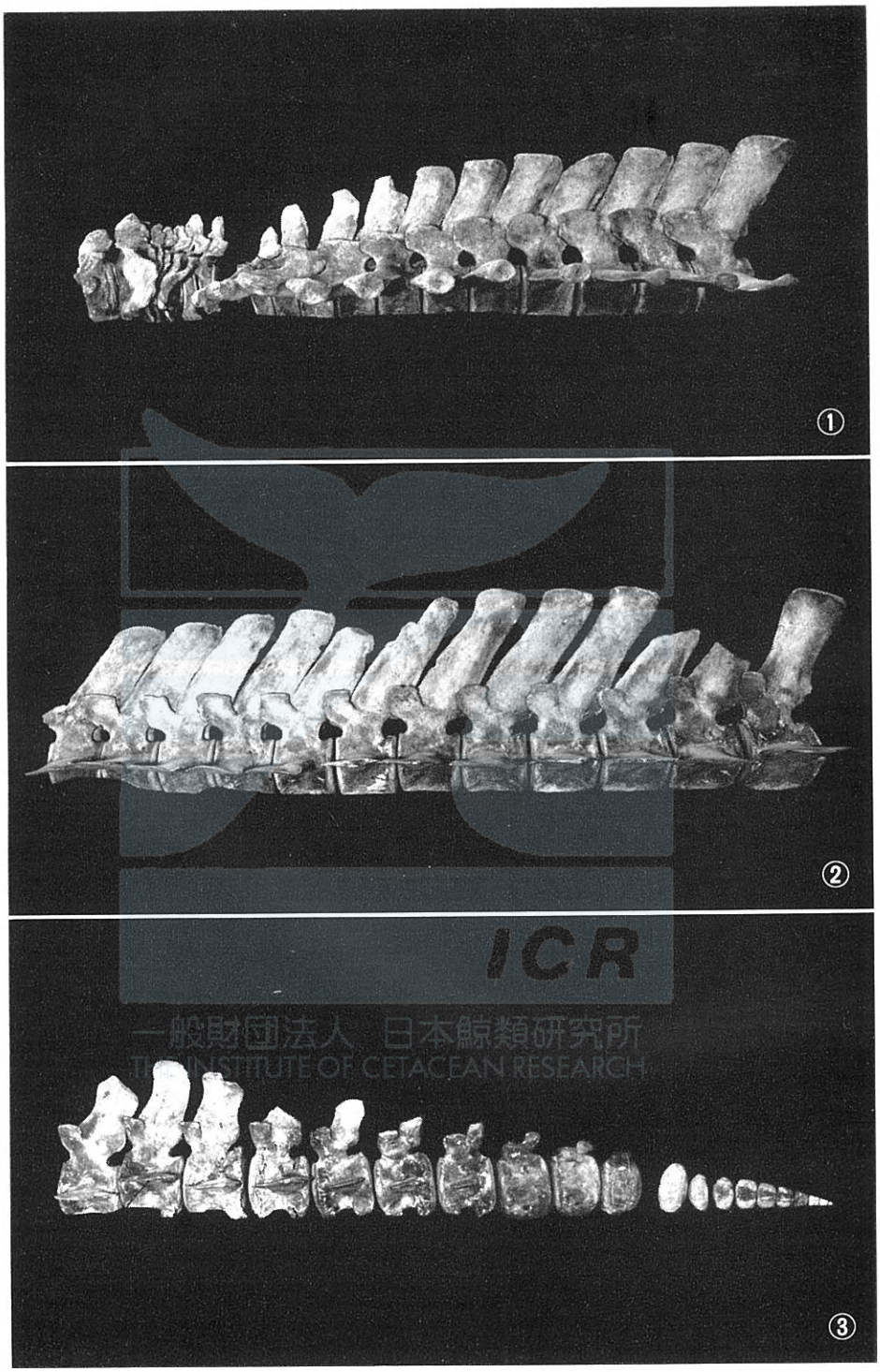


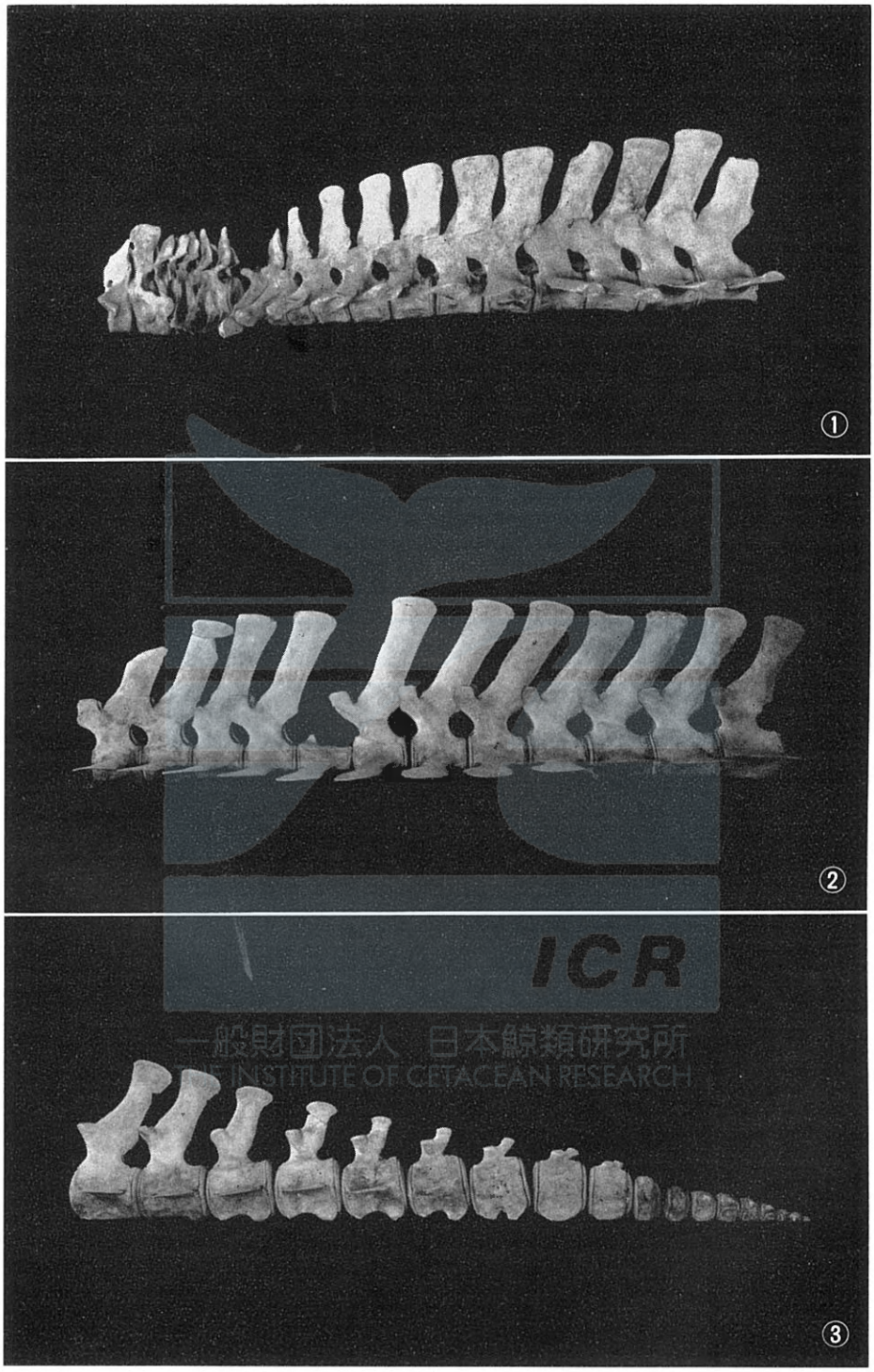


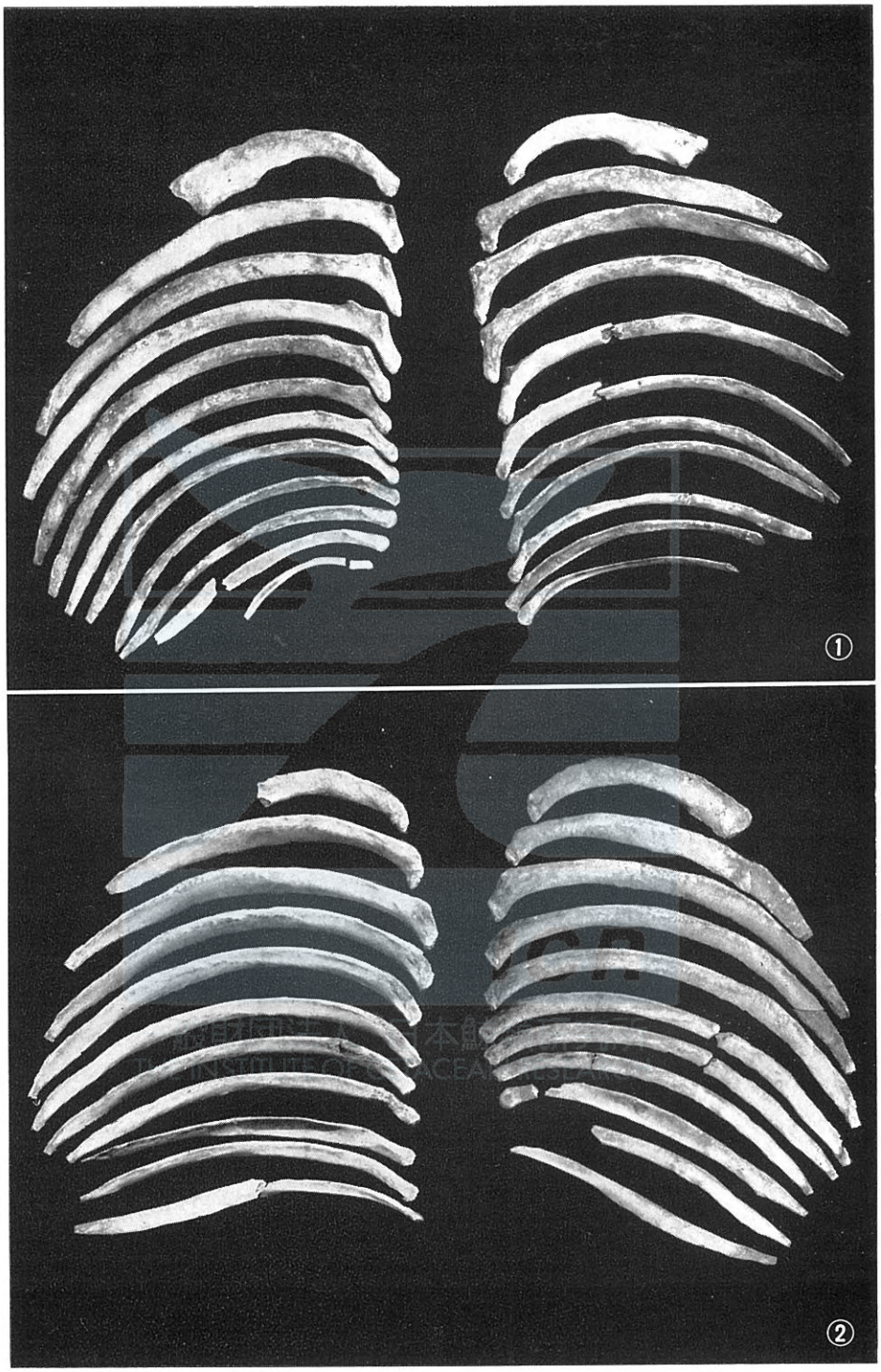








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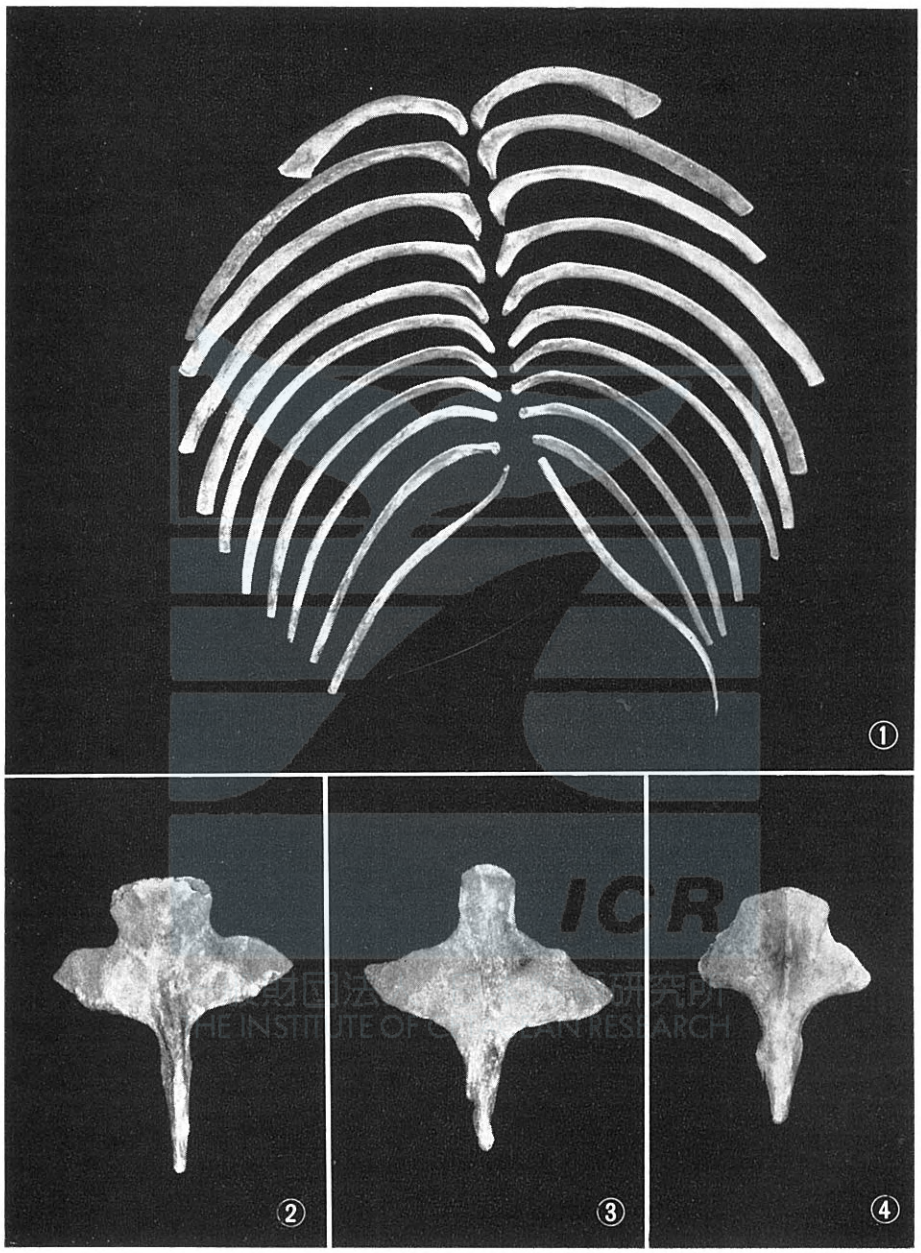
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