A SYSTEMATIC STUDY OF THE HYOID BONES IN THE BALEEN WHALES

HIDEO OMURA

The hyoid bone is accepted as having characteristics which can be used as a taxonomic criterion in the terrestrial mammals (Sprague, 1941; Johnson & Ostenson, 1959). But in the whales it seems that no special importance has been placed on the hyoid bone for systematic studies. It is of interest, therefore, to know taxonomic characteristics of the hyoid bone of the whales. Further in whales, especially in larger cetaceans, it is very difficult to collect a reasonable numbers of skeleton to treat them quantitatively. Accordingly it is also difficult to ascertain whether the differences noted are the individual one or those between subspecies, species or genera.

Hyoid bone is without great difficulty be collected even in the larger whales. In the last four years I could collect them from a total of more than 100 baleen whales, excepting grey, greenland, and pigmy right whales. These were gathered from the Antarctic, Bering Sea and its neighbouring waters, and coast of Japan by my colleague in the Whales Research Institute with assistance of personnel of the whaling companies concerned.

In the present paper these hyoid bones were treated statistically from the viewpoint of the taxonomy.

MATERIAL

The material treated in this study are shown in Table 1.

TABLE 1. NUMBER OF WHALES FROM WHICH HYOID BONE WAS COLLECTED

Species	Locality	Year	Number	Average body length[5)]	Abbreviation
Blue whale *Balaenoptera musculus*	Antarctic[1)]	1961	9	21.77	BmA
Fin whale *B. physalus*	Antarctic	1961	10	21.00	BpA
,, ,, ,, ,,	Bering Sea[2)]	1960	13	19.16	BpB
Sei whale *B. borealis*	Antarctic	1961	9	15.27	BbA
,, ,, ,, ,,	Coast, Japan	1960	10	13.21	BbC
Bryde's whale *B. edeni*	Coast, Japan	1960, 62	22[3)]	13.05	BeC
Minke whale *B. acutorostrata*	Coast, Japan	1962	11	6.24	BaC
Humpback whale *Megaptera novaeangliae*	Bering Sea[2)]	1962	4	13.50	MnB
,, ,, ,, ,,	Coast, Okinawa	1961	9[4)]	11.40	MnB
Black right whale *Eubalaena glacialis*	Bering Sea[2)]	1062, 63	5	15.28	EgB

1) Pigmy blue whale. 2) Includes its nearby waters. 3) In which 7 samples lacking stylohyals. 4) Not complete sets. 5) In meter.

As shown in Table 1 the hyoid bones have been collected from seven species i.e. from blue, fin, sei, Bryde's, minke, humpback, and black right whales. In order to investigate intra-specific differences samples of some species have been gathered from different localities. My first intention was that to collect each ten samples from different species and from different localities for a preliminary study. This has not been completed.

For the blue whale samples were only collected from the pigmy blue whale in the Antarctic. Ichihara (1961, 1963) separates the pigmy blue whale from the ordinary blue whale in the Antarctic. His conclusion is mainly based on the external characters. It is of great interest, therefore, to examine the difference in the hyoid bones between the two groups. But this is not possible in the present paper.

For the humpback whale samples were collected from the Bering Sea and its nearby waters as well as from the waters around Okinawa Islands. But in the former only four samples were collected. From the latter waters a good number were collected, but during the course of transportation these bones were damaged and only parts of them are available for comparison. The results of whale marking suggest that the two stocks are belong to a single population. They are treated in this paper for the time being as a whole accordingly.

For the black right whale I have two additional samples. In 1961 two skeletons of this species have been secured from the same locality, but they are not available for the present study, because they are still burried in the earth for extraction of oil contained in them.

Further it is interesting to compare the hyoid bones of fin whale from the East China Sea to those from other localities, but this was impossible. The whaling operation in that area has been stopped since 1961. I could not collect any sample from the grey whale, *Eschrichtius gibbosus*.

In osteological study of such nature it is very important to compare samples of similar age and preferably those of physically matured animals. But as a matter of fact this was very difficult. If the samples are selected only from the physically matured animals, then the sample number will be reduced considerably and they cannot be treated statistically. In the present study, therefore, I used hyoid bones from animals which already attained sexual maturity or in the state of puberty in principle. Samples from animals younger than these have also been collected in some species, but these were not used in the present study from the above reason. For the minke and humpback (from Okinawa) whales, however, this principle was not applied. They include sexually immature animals because of difficulty in gathering samples. Especially in the case of the minke whale the hyoid bones were obtained mostly from the immature whales. The average body lengths of the whales from which the hyoid bones were collected and used in the present study are also shown in Table 1 and in detail in Appendix 1.

The present paper, under circumstances mentioned above, is of preliminary nature and it should be supplemented or revised in future when more samples are collected.

GENERAL DESCRIPTION

(Plates I–XV)

The hyoid bones of baleen whales are consisted of three separate bones i.e. one combined bone of basihyal and thyrohyals, and two stylohyals. In general the basihyal and thyrohyals are united completely and no suture between them is visible. Omura (1958) reports that in his Ayukawa specimen of the black right whale the basihyal and thyrohyals are not ankylosed into a mass and in his specimen from Kiritappu of the same species the sutures were still visible, though the bones were united completely. They were both sexually immature and the body length of these whales were 11.65 and 12.40 meters respectively. Omura (1957) also reports that his specimen of minke whale (7.50 meter long) had a combined basihyal and thyrohyals in which two shallow notches were present, in addition to the median notch, on the anterior margin of the bone, on the borders of basihyal and thyrohyals. In the hyoid bones used for the present study none of such facts was observed. The basihyal and thyrohyals are united completely into a mass and no suture between them is visible. The smallest black right whale in the present study is 14.10 meter in length. This is much larger than the Ayukawa and Kiritappu specimens. This whale was a female and it had no corpus luteum and c. albicans in its ovaries, but contained in one of the ovaries a ripening follicle. Also in this specimen no sture was visible (Plate XV Fig. 1). It is suggested, therefore, from the above facts that in the black right whale the basihyal and thyrohyals are separated in younger stages as in the case of the toothed whales, but they unite completely before the whale reach puberty.

For the minke whale all of the samples except two were collected from smaller animals than 7.50 meter, but none of them had any additional notch on the anterior margin of the combined bone of basihyal and thyrohyals, except the median notch. It is possible, therefore, that the case of the presence of the two additional notches, as reported by him, is the exceptional one. In the samples from the sei and Bryde's whales, which had not been used in the present study because of immature, also no additional notch is present.

The ankylosed bone of basihyal and thyrohyals is wing-like shape in general. The central portion (basihyal) is dorso-ventrally compressed and has two anterior projections, forming a median notch. The length of the anterior projections is different individually, but in general they are short in the black right and humpback whales and long in whales which blong to genus *Balaenoptera*. I have no specimen from the grey whale, but according to Andrews (1914) they are also short.

In the central portion there also present a pair of projections on the posterior side. These posterior projections are rounded in general, but subject to heavy individual variation. In some specimens they are prominent, but in another specimens they are less prominent and in the extreme case they are jointly forming one roundish median projection. Such cases are observed in the sei and Bryde's whales (Plate VI, Figs. 5, 6, Plate X, Fig. 3, Plate XI, Figs. 1, 8, 10). In the minke whale the posterior projection present as single roundish median projecion or less developed (Plate XIII).

The wing portion (thyrohyals) thickens towards the distal ends in general and in the black right whale it becomes nearly cylindrical, but in the sei, Bryde's and minke whales they are rather flat. In the blue whale it increases its thickness rapidly, but it also increases its breadth in the mid-length. The both distal ends are narrow and thin in the whales belong to the genus *Balaenoptera*, but very massive in the black right whale. In the humpback whale they are more massive than those of the genus *Balaenoptera*, but in lesser degree than in the black right whale.

The ankylosed bone of basihyal and thyrohyals is concave from the dorsal aspect, but the degree of the curvature is seemed more individual than specific, excepting the black right whale in which the bone is nearly straight on the ventral surface. I have used, therefore, the overall length along the outer surface and passing the center of the basihyal as the length of the bone, instead of the straight length between the two distal ends. The overall lengths of the combined bones are generally between five and seven per cent of the body lengths of the whales. No significant difference according to species is noted among these percentages.

The stylohyals are flat in the whales of the genus *Balaenoptera*. Also in the humpback whales they are rather flat, but those of the black right whale are quite different from other species. They are nearly cylindrical and somewhat constricted in the one-thirds portion from the proximal ends. In one occasion among four, however, no such constriction is observed (Plate XV, Fig. 8). In this sample the ventral view of the stylohyal resembles more closely to that of the humpback whale and rather flat in general. But it thickens suddenly towards the distal end and approaches to cylinder.

The stylohyals of the fin, minke, and humpback whales are narrower than those of the blue, sei, and Bryde's whales. But in the fin whale, in some specimens they are broader than the other and very difficult to identify them from those of the blue and sei whales (Plate III Lower, Fig. 3, Plate V, Fig. 7). In the sei whale the stylohyals are much curved forwards and in the Bryde's whale they are less curved and more slender, but there present some exceptinal cases (Plate VII, Fig. 2, Plate XII, Fig. 14).

The surface of the hyoid bones, both the cmbined bone of basihyal and thyrohyals and the stylohyals, are generally smooth in most species. In the humpback whale, however, they are rugose bones. In the blue and fin whales the anterior and posterior projections are more or less corrugated, but in lesser degree than in the humpback whale. Andrews (1914) reports that the hyoid bone of the grey whale is extremely massive and rugose bone. He also describes that the shape of the thyrohyal portion of the combined bone resembles to that of *Eubalaena* and his photograph supports this, but in the present samples from the black right whale the surface of the bone is very smooth. It is suggested, therefore, the rugose hyoid bone is a specific character of the humpback and grey whales.

MEASUREMENTS

The following measurements were made on each hyoid bone collected (see Fig. 1).

A. Ankylosed bone of basihyal and thyrohyals.

a. *Overall length.* This was measured between the tips of the wings (thyrohyals) by a curved line, running along the outer surface of the bone and passing the center of the basihyal.

b. *Straight length.* This was measured by a straight line between the tips of the wings, disregarding the curvature of the bone. This length was only used for checking.

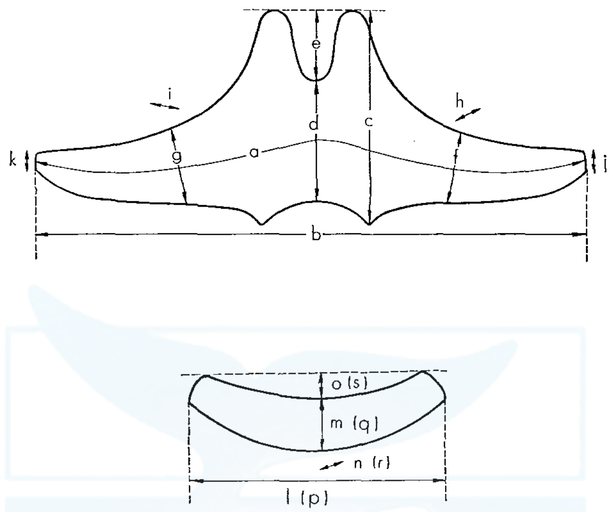


Fig. 1. Showing positions of the measurements.

c. *Greatest height.* Greatest height between tips of the anterior and posterior projections of the basihyal.

d. *Height at center.* Height measured at the center of the bone.

e. *Forward notch, depth.* Depth of the notch between the pair of forward projections of the basihyal.

f. *Height at middle of the wing, right.* Height measured at middle between the center of the basihyal and the tip of the right wing.

g. *Height at middle of the wing, left.* Height measured at middle between the center of the basihyal and tip of the left wing.

h. *Thickness at middle of the wing, right.* Thickness of the right thyrohyal on the line of the measurement f.

i. *Thickness at middle of the wing, left.* Thickness of the left thyrohyal on the line of the measurement g.

j. *Height at distal end, right.* Height of right thyrohyal at its distal end.

k. *Height at distal end, left.* Height of left thyrohyal at its distal end.

B. Styohyal

l. *Total length, right.* Length measured by a straight line between the tips of the right stylohyal.

m. *Height at middle, right.* Height at middle of the right stylohyal.

n. *Thickness at middle, right.* Thickness of the right stylohyal measured on the line of the measurement m.

o. *Degree of curvature, right.* Greatest distance between the straight line which pass the most prominent parts of the right stylohyal and its forward surface.
p. *Total length, left.* Corresponding measurement of l of the lef stylohyal.
q. *Height at middle, left.* Corresponding measurement of m of the left stylohyal.
r. *Thickness at middle, left.* Corresponding measurement of n of the left stylohyal.
s. *Degree of curvature, left.* Corresponding measurement of o of the left stylohyal.

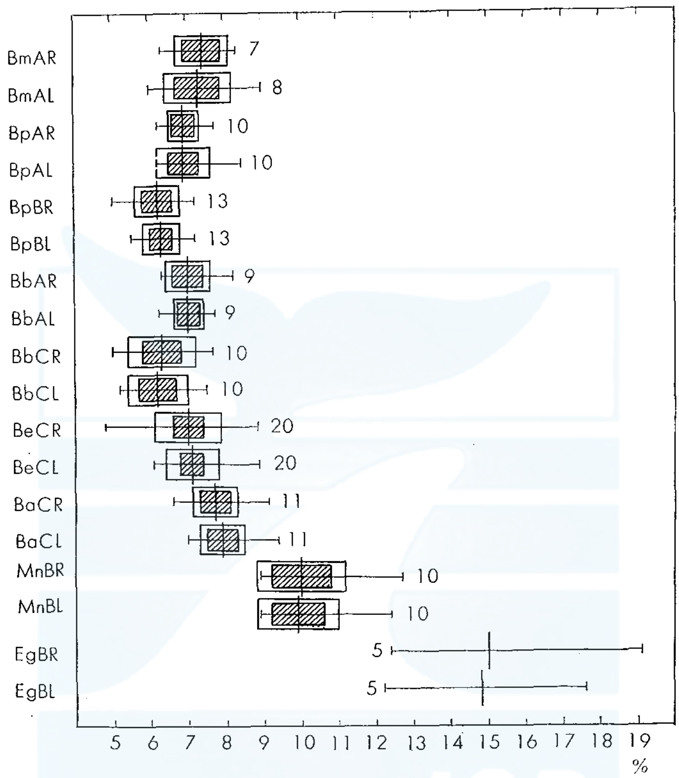


Fig. 2. Combined bone of basihyal and thyrohals.
Proportional height at distal ends against overall length.
The horizontal line represents the ranges ; the vertical midline the arithmetic mean ; the outer box one standard deviation on either side of the mean ; the inner box two standard errors on either side of the mean ; the figures are the sample numbers.
See Table 1 for explanation of abbreviation. R and L attached mean the right and left sides respectively.

Above measurements were then calculated of their percentages against the overall length in the case of the combined bone of the basihyal and thyrohyals. For the stylohyals also were calculated percentages of their length against the overall length of the combined bones, but their heights, thickness and the degree of curvature were calculated as the percentages of the total length of the stylohyals. Further for each measurement the arithmetic mean, standard deviation and the two standard errors were calculated. The results are shown in Figs. 2–11, together with the ranges f the value. The details of the measurements are shown in Appendix 1 and the esults of the calculations in Appendix 2.

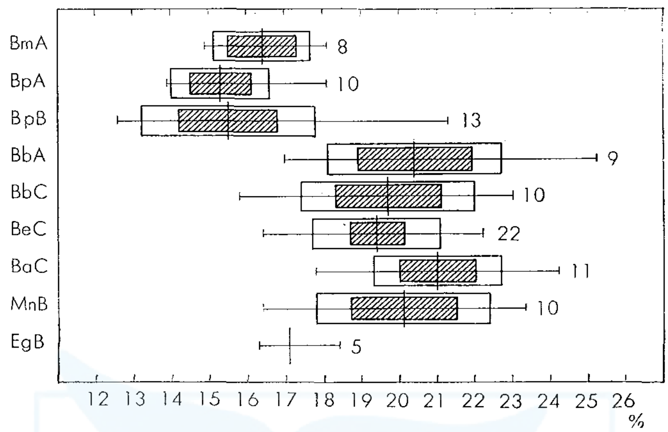


Fig. 3. Combined bone of basihyal and thyrohyals. Proportional height at center against overall length. See Fig. 2 for explanation.

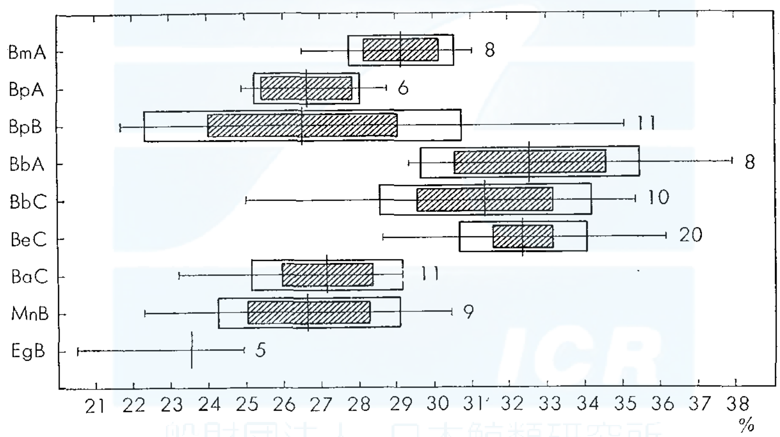


Fig. 4. Combined bone of basihyal and thyrohyals. Proportional height (greatest) against overall length. See Fig. 2 for explanation.

A. *The combined bone of basihyal and thyrohyals.*

1. *Proportonal height at distal ends* (Fig. 2). As seen in Fig. 2 the whales are divided into three groups in this character. The blue, fin, sei, Bryde's and minke whales (genus *Balaenoptera*) are all belong to one group. The humpback whale (genus *Megaptera*) are separated significantly from this group. It is highly possible that the black right whale (genus *Eubalaena*) is distinct from the above two groups, though the sample number is fewer than any other

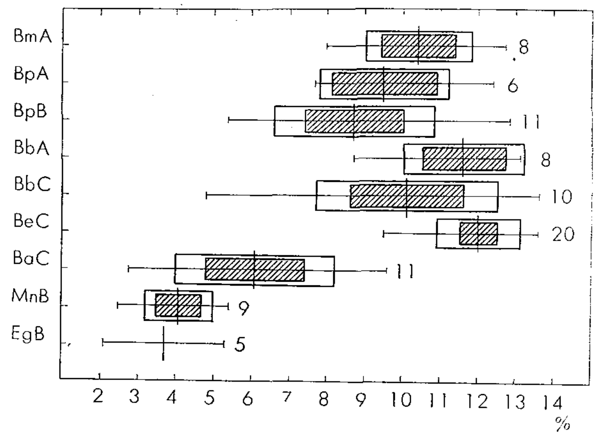


Fig. 5. Combined bone of basihyal and thyrohyals.
Proportional depth of forward notch against overall length.
See Fig. 2 for explanation.

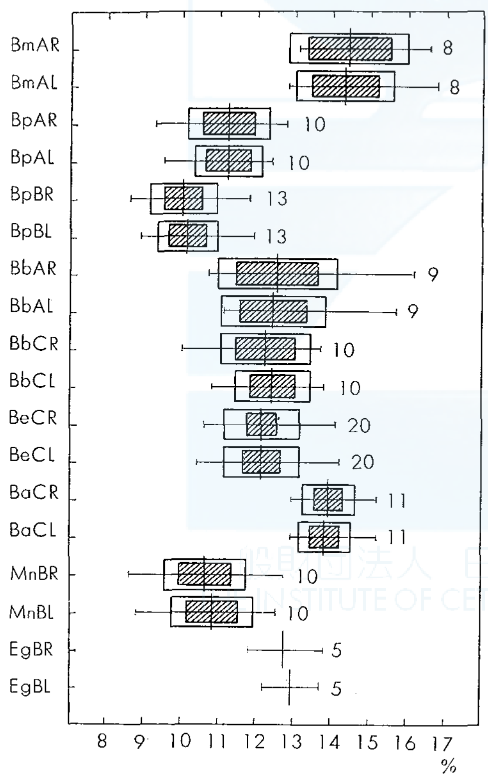


Fig. 6. Combined bone of basihyal and thyrohyals. Proportional height at middle of the wing against overall length.
See Fig. 2 for explanation.

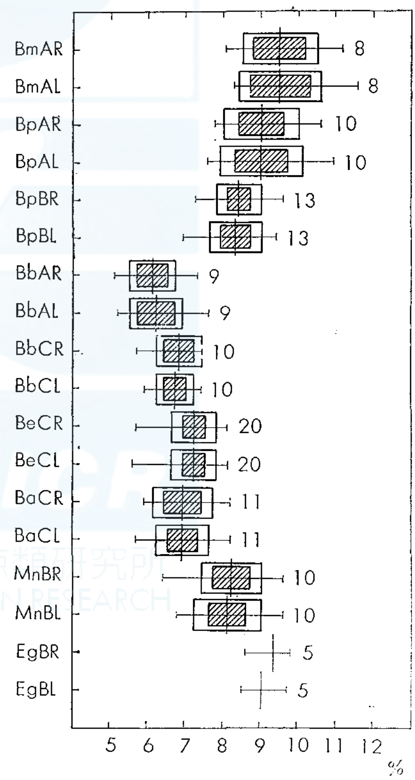


Fig. 7. Combined bone of basihyal and thyrohyals.
Proportionl thickness at middle of the wing against overall length.
See Fig. 2 for explanation.

species. In the fin and sei whales, those from the Antarctic show somewhat different value of the arithmetic mean from those from the Bering Sea or the coast of Japan, but they cannot be separated, because the two standard errors are overlappng each other. In other words neither racial nor subspecific difference is noted within the same species. But there is a significant difference between the minke whale from the coast of Japan (BaC) and the sei whale from the same locality (BbC), though no difference is present between the

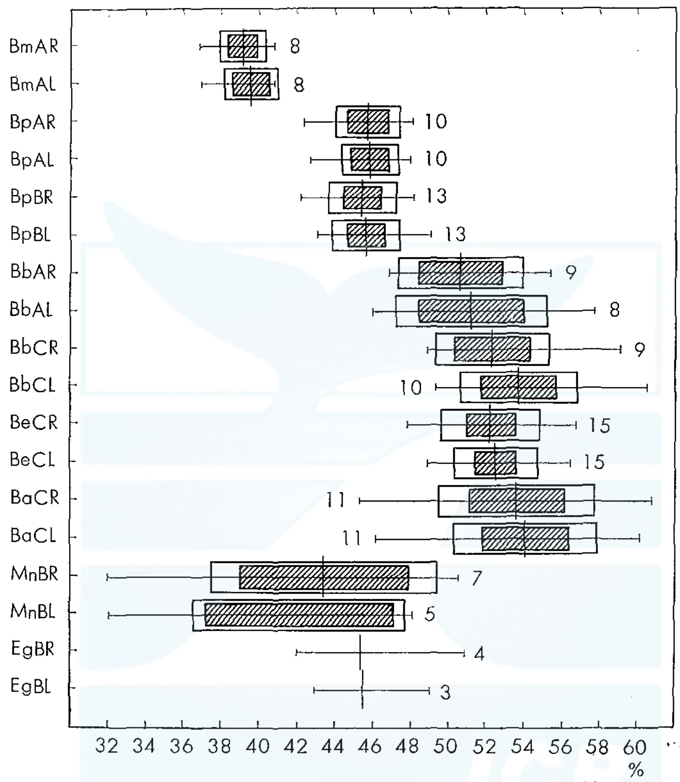


Fig. 8. Stylohyals. Proportional length of stylohyals against the overall length of the combined bone. See Fig. 2 for explanation.

former and the sei whale from the Antarctic (BbA). The same is applied also to the fin whale. In general no significant difference is noted in this character among the species of the genus *Balaenoptera*.

The values for the right and left sides are coincide fairly well in each species.

2. *Proportional height at center* (Fig. 3). In this character the whales are divided ino two groups. The blue and fin whales are belong to the same group and the sei, Bryde's, minke and humpback whales to the another. The black right whale is probably be included in the former group. No difference is noted in the fin and sei whales between those from different localities.

3. *Proportional height* (*greatest*) (Fig. 4). In this character all species except the blue whale are grouped into two. The fin, minke, humpback and black right whales are belong to one group and the sei and Bryde's whales to the another. Also in this character no difference is noted in the fin and sei whales between whale stocks in different localities.

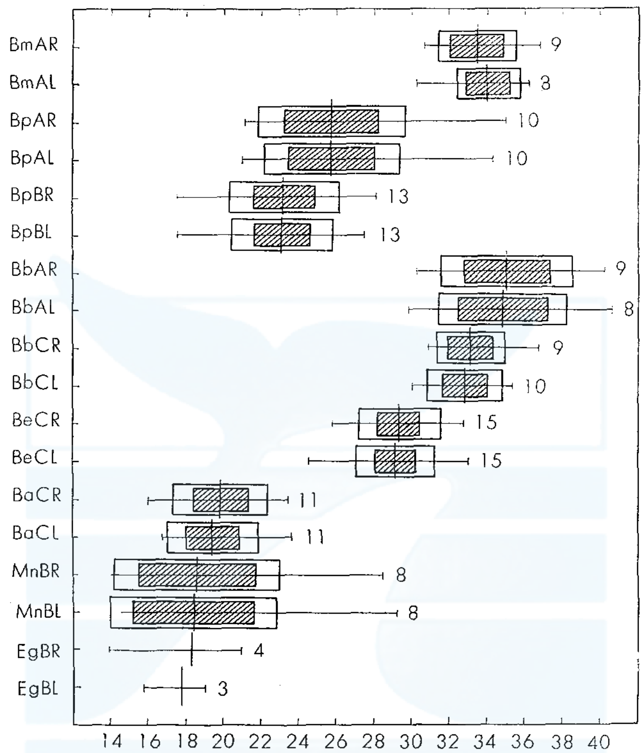


Fig. 9. Stylohyals. Proportional height at middle against its length. See Fig. 2 for explanation.

4. *Proportional depth of forward notch* (Fig. 5). In this character the humpback and black right whales are forming one group, distinctly different from the blue, fin, sei and Bryde's whales. In other words the forward projections are generally much longer in the genus *Balaenoptera* than *Megaptera* and *Eubalaena*. One exception of this is the minke whale. It has much shorter forward projections than any other species of that genus. It should be reminded, however, that the samples from the minke whale were mostly collected from the immature whales as stated before.

5. *Proportional height at middle of the wing* (Fig. 6). In this character there can be noted two distinct groups and one overlapping group. The blue and minke whales belong to one group and the fin and humpback whales to the another. The other species i.e. the sei, Bryde's and black right whales are over-

lapping to these groups. I cannot separate the fin whales in the Antarctic from those from the Bering Sea. The two standard errors are overlapping each other, though very slightly. But probably they can be separated when more samples are collected in future. The blue whale is distinctly separated from the fin whale in this character. No difference is noted between right and left sides in each species.

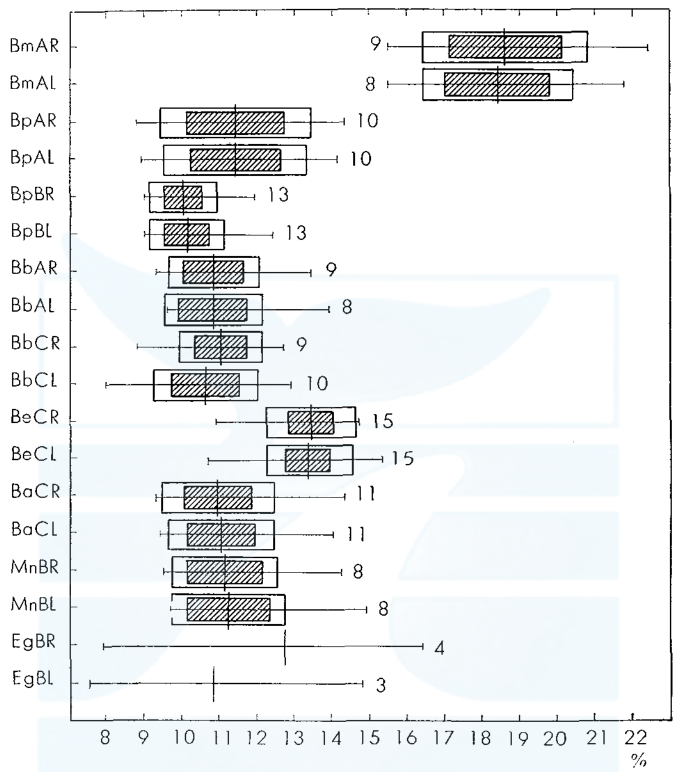


Fig. 10. Stylohyals. Proportional thickness at middle against its length. See Fig. 2 for explanation.

6. *Proportional thickness at middle of the wing* (Fig. 7). In this character the genus *Balaenoptera* is divided into two groups. The blue and fin whales belong to one group and the other species to the another. The humpback and black right whales are also belong to the former group. But this character might be of little value for comparison of the genera. In the genus *Balaenoptera* the thickness is usually the greatest towards the middle of the wing, whereas in the genus *Megaptera* and *Eubalaena* the distal end is the thickest.

B. *Stylohyals*

7. *Proportional length of stylohyals* (Fig. 8). The genus *Balaenoptera* is devided into three groups in this character. The blue whale has the shortest stylohyals, the

fin whales comes next, and the sei, Bryde's and minke whales have longer stylohyals than other species. The humpback whale has wider ranges of variation and they are overlapping to the values for the blue and fin whales. The black right whale seems to have little longer stylohyals than the humpback whale. No difference is noted between the right and left sides. No difference is also observed in the fin and sei whales between those from different localities.

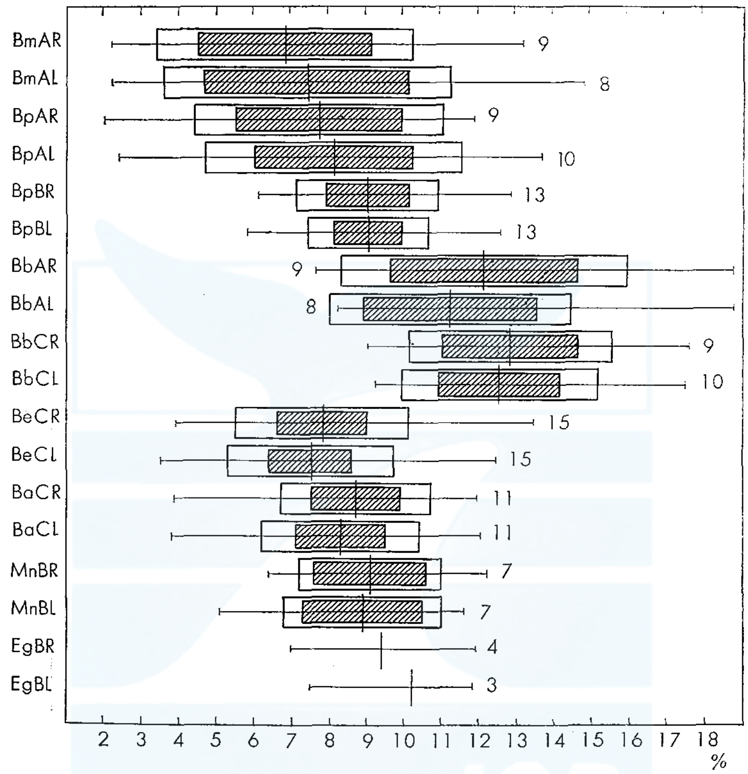


Fig. 11. Stylohyals. Degree of curvature.
See text and Fig. 2 for explanation.

8. *Proportional height at middle* (Fig. 9). In this character all whale species except the Bryde's whale are classified into two groups. The blue and sei whales have broader stylohyals than other species. The Bryde's whale has a greater vaue than fin whale, but they are still separated from the sei whale in this character. Again no difference is noted between the right and left stylohyals and between those from different localities within the same species.

9. *Proportional thickness at middle* (Fig. 10). As seen in Fig. 10 the blue whale has thicker stylohyals proportionally than any other species. It should be noted that the Bryde's whale is separated from the sei whale in this character too.

10. *Degree of curvature* (Fig. 11). The stylohyals are usually curved forwards and the degree of the curvature was expressed as percentage of the length stated already (measuremens o and s) against the length of the stylohyal. Rather wide ranges of variation are observed in each species. The Bryde's whale is separated from the sei whale from the coast of Japan, but the two standard errors are very slightly overlapping to that of the sei whale in the Antarctic. It seems that this character is of less importance in other species.

CONCLUSION

In Table 2 the results of the measurements are summarized briefly. As seen in this table most whale species, from which the hyoid bones were collected, are separated from each other by the combined bone of basihyal and thyrohyals. One exception of this is the distinction of the Bryde's whale from the sei whale. The combined bone of basihyal and thyrohyals of the both species resembles each other very closely and they cannot be identified by this bone. But in the stylohyals the Bryde's whale is separated from the sei whale, having less broader, much thicker and less forwardly curved stylohyals. As already noted, however, there

TABLE 2. SUMMARY OF COMPARISON

Items	Species and locality								
	BmA	BpA	BpB	BbA	BbC	BeC	BaC	MnB	EgB
A. Combined bone of basihyal and thyrohyals									
1. Proportional height at distal ends	0	0	0	0	0	0	0	*Δ*	*X*
2. Proportional height at center	0	0	0	*Δ*	*Δ*	*Δ*	*Δ*	*Δ*	0?
3. Proportional height (greatest)	0*Δ*	0	0	*Δ*	*Δ*	*Δ*	0	0	0
4. Proportional depth of forward notch......	0	0	0	0	0	0	0*Δ*	*Δ*	*Δ*
5. Proportional height at middle of wing ...	0	*Δ*	*Δ*	0*Δ*	0*Δ*	0*Δ*	0	*Δ*	0*Δ*
6. Proportional thickness at middle of wing	0	0	0	*Δ*	*Δ*	*Δ*	*Δ*	0?	0
B, Stylohyals									
7. Proportional length of stylohyals...........	0	*Δ*	*Δ*	*X*	*X*	*X*	*X*	0*Δ*	*ΔX*
8. Proportional height at middle...............	0	*Δ*	*Δ*	*X*	*X*	*Δ*'	*Δ*	*Δ*	*Δ*
9. Proportional thickness at middle...........	0	*Δ*	*Δ*	*Δ*	*Δ*	*Δ*'	*Δ*	*Δ*	*Δ*
10. Degree of curvature	0	0	0	0*Δ*	*Δ*	0	0	0*Δ*	0*Δ*

See Table 1 for species and locality.
0, *Δ*, *X*, showing groups of species of similar value.

are some exceptional cases in which the identification is very difficult. The stylohyals reported by Lönnberg (1931), Junge (1950) and Omura (1959) show the typical shape in the Bryde's whale and that reported by Andrews (1916) shows that in the sei whale.

On the whole the most important character seems to be the proportional height at the distal end of the combined bone of basihyal and thyrohyals. The genera *Balaenoptera*, *Megaptera* and *Eubalaena* are separated in this character and the proportions in these genera can be expressed as 5–9, 9–12 and 12–19 per cent respectively of the overall length of the combined bone. I have no material from the grey whale (genus *Eschrichtius*), but according to the report by Andrews (1914) the combined bone of this species resembles very closely to that of *Eubalaena*. It is thought that it cannot be separated from the black right whale in this character. He further reports, however, that in the grey whale the combined bone and stylohyals are rugose bones. He also reports that the stylohyals are decidedly more like to those of the genus *Balaenoptera* than the genus *Eubalaena*. The above two facts may be the distinction between the two genera (or families).

The genus *Balaenoptera* is further devided into two groups by the proportional height at center of the combined bone. The blue (*B. musculus*) and fin (*B. physalus*) whales belong to one group and the rest to the another. The blue and fin whales are then separated decidedly from each other by the proportional height at the middle of the wing of the combined bone.

Among the another group i.e. the sei (*B. borealis*), Bryde's (*B. edeni*) and minke (*B. acutorostrata*) whales, the minke whale is separated from the other two by the total height of the combined bone. The remaining two species are not separated from each other in the combined bone as stated already.

In the stylohyals each species of the genus *Balaenoptera* is separated by the proportional length of stylohyals and then by the proportional height at middle of the bone. Further the blue whale is separated very clearly from the other species by the proportional thickness at middle of the stylohyals.

The above is arranged in the order of the following systematic key.

Key to the genera and species of mystacoceti
by means of hyoid bone

1. Height at distal end of the combined bone of basihyal and thyrohyals more than 12 per cent of its overall length. 2

—. The same height 9–12 per cent. Bone surface much corrugated.
Genus *Megaptera*. Single species. . . . . *M. novaeangliae*

—. The same height less than 9 per cent. Bone surface smooth.
Genus *Balaenoptera*. 3

2. Bone surface much corrugated. Stylohyals massive but not cylindrical.
Genus *Eschrichtius*. Single species. . . . . *E. gibbosus*

—. Bone surface smooth. Stylohyals roughly cylindrical. Basihyal and thyrohyals separated in younger stages.
Genus *Eubalaena*. Single species . . . . *E. glacialis*

3. Height at center of the combined bone less than 18 per cent of its length. . 4

—. The same height more than 18 per cent. 5

4. Height at middle of the wing of the combined bone less than 12.5 per cent of the length. Stylohyals long and narrow. . . . . *B. physalus*

—. The same height more than 12.5 per cent. Stylohyals short,
broad and massive. . . . . *B. musculus*

5. Greatest height of the combined bne less than 29 per cent
of the length. . . . . *B. acutorostrata*

—. The same height more than 29 per cent. 6

6. Stylohyals broad, flat and much curved forwards . . . . *B. borealis*
—. Stylohyals less broad, rather thick and less curved. . . . . *B. edeni*

In the above key the greenland whale (*Balaena mysticetus*) and the pigmy right whale (*Caperea* (*Neobalaena*) *marginata*) are not included. These two are very rare species, at least at present. The key was made for the convenience of the identification of the species by means of the hyoid bone, disregarding families. It is clear that taxonomic studies on the specific level and above must be based on more than single morphologic comparison and any single taxonomic criterion is less important. My first intention was that to study whether there present any skeletal difference between the whale populations from the different localities within the same species. As already stated before any such racial difference was not proved. But in the case of the fin whale the population in the Bering Sea show lower value than that in the Antarctic in the proportional height at middle of the wing (Fig. 6) and also in the proportional height at distal ends of the combined bone (Fig. 2). These give the former bone a slender appearance than the latter. The two standard errors calculated for the both are overlapping very slightly. The sample number used for the present study is rather limited and it is thought probable that a significant difference might be proved when more samples are gathered. Also in the sei whale collection of more samples are needed in order to discuss the difference between that from the Antarctic and that from the coast of Japan. It might be most interesting to compare the hyoid bone from the usual blue whale in the Antarctic to that of the pigmy blue whale.

In conclusion more attention than bebore should be paid on the morphological study of the hyoid bone in establishing relationships of subspecies, species and genera of the baleen whales.

SUMMARY

The hyoid bones of the baleen whales were collected from seven species. These are the blue, fin, sei, Bryde's, minke, humpback and black right whales. For the fin and sei whales they are collected from the two different localities. Total number of whales from which the bones were sampled had amounted a little over 100. Various measurements were made on each bone and then they were treated statistically. Distinctions among species were studied and a key to the genera and species of baleen whales (mystacoceti) by means of hyoid bone was prepared. Distinction between different populations within the same species was not proved statistically, but it is thought more collection is necessary in order to obtain a conclusion on this matter.

ACKNOWLEDGEMENT

Sincere thanks are due to my colleague in the Whales Research Institute. They helped me in the collection and measurement of the samples. Especially I am very grateful for Drs. K. Fujino and T. Nemoto. They also took photographs shown in Plates I–XV.

REFERENCES

ANDREWS, R.C. (1914). The California gray whale (*Rhachianectes glaucus* Cope). *Mem. Amer. Mus. Nat. Hist., New series*, 1(V): 229–87.

—— (1916). The sei whale (*Balaenoptera borealis* Lesson). *Mem. Amer. Mus. Nat. Hist., New series*, 1(IV): 291–388.

ICHIHARA, T. (1961). Blue whales in the waters around Kerguelen Island. *Norsk Hvalfangst-Tid.*, 50(1): 1–20.

—— (1963). Identification of the pigmy blue whale in the Antarctic. *Norsk Hvalfangst-Tid.*, 52(5): 128–30.

JOHNSON, M.L. & OSTENSON, B.T. (1959). Comments on the nomenclature of some mammals of the Pacific Northwest. *J. Mamm.* 40: 571–7.

JUNGE, G.C.A. (1950). On a specimen of the rare fin whale, *Balaenoptera edeni* Anderson, stranded on Pulu Sugi near Singapore. *Zoologische Verhandelingen*, no. 9: 1–26.

LÖNNBERG, E. (1931). The skeleton of *Balaenoptera brydei* O. Olsen. *Arkiv f. Zoologi*, 23(1): 1–23.

OMURA, H. (1957). Osteological study of the little piked whale from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 12: 1–21.

—— (1958). North Pacific right whale. *Sci. Rep. Whales Res. Inst.*, no. 13: 1–52.

—— (1959). Bryde's whale from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 14: 1–33.

SPRAGUE, J.M. (1941). A study of the hyoid apparatus of the Cricetinae. *J. Mamm.* 22: 296–310.

APPENDIX 1. MEASUREMENTS OF HYOID BONE (in cm.)
See text for explanation of abbreviation and measurements number

Species, locality	No.	Body length	Sex	Measurement a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
BmA	1	2000	M	136.0	113.0	38.0	20.2	13.7	19.8	19.5	12.2	12.1	10.3	9.7	55.5	17.6	9.5	2.2	55.0	18.3	9.3	2.7
	2	2100	F	150.0	127.0	42.4	22.7	17.0	20.0	19.3	12.2	12.5	11.3	11.9	60.0	18.3	10.9	3.5	61.0	18.4	11.2	4.0
	3	2100	M	147.0	120.0	44.4	26.2	14.5	22.5	22.7	15.2	14.6	9.3	9.9	55.0	20.2	12.3	3.1	56.0	20.2	12.2	3.0
	4	2230	M	—[3]	—	43.5	26.5	14.0	22.2	23.2	14.3	14.6	—	—	65.0	19.8	12.1	3.5	—	—	—	—
	5	2280	F	146.0	120.0	43.8	25.5	15.4	22.6	21.8	16.4	16.9	11.2	11.4	57.0	20.5	12.2	3.5	59.5	20.7	12.1	4.0
	6	2280	M	115.0	129.0	45.3	28.0	14.0	25.8	26.0	16.5	16.8	11.8	11.0	63.0	21.2	12.3	1.4	62.5	21.5	12.5	1.4
	7	2300	F	168.0[4]	—	44.6	25.6	13.4	22.0	22.6	15.8	15.3	—	10.1	62.0	21.4	9.6	4.0	62.0	21.8	10.1	4.1
	8	2050	F	144.0	112.0	44.6	24.8	17.0	19.2	18.5	12.5	12.5	12.0	13.0	56.5	19.0	9.0	7.0	58.0	19.9	9.0	7.0
	9	2250	F	158.0	133.0	46.3	24.3	20.0	21.2	21.4	13.4	13.1	10.3	10.7	61.0	20.6	11.3	8.0	60.5	20.4	11.0	8.9
BpA	1	1940	F	104.0	88.0	—	16.0	—	12.6	12.4	10.4	10.0	7.2	7.4	47.0	12.5	6.7	1.3	48.0	12.5	6.4	1.3
	2	1950	M	119.0	99.0	29.8	18.8	10.5	12.7	12.7	10.6	10.2	7.4	7.4	54.0	11.4	7.1	1.1	54.0	11.3	7.0	1.3
	3	2040	M	130.0	109.0	38.8+	23.0	7.8+	14.3	14.7	12.3	13.0	10.0	10.9	55.0	19.2	6.3	4.2	55.5	19.0	6.4	4.0
	4	2090	M	124.0	108.0	34.8	22.5	9.5	13.3	13.4	9.9	9.9	8.2	7.8	55.0	14.7	5.3	6.5	55.0	14.5	5.7	7.5
	5	2110	F	119.0	104.0	—	17.3	—	15.2	14.8	12.6	13.0	8.0	7.8	55.0	12.8	7.6	4.0	54.0	13.4	7.6	3.9
	6	2110	M	133.0	109.0	33.1	19.4	11.2	12.9	13.4	11.3	11.5	8.8	8.7	64.0	17.3	5.8	4.5	63.0	17.4	5.6	4.2
	7	2130	M	128.0	109.0	33.6	19.1	11.0	14.9	14.7	10.0	9.7	9.0	8.5	56.0	11.8	6.2	—	57.5	12.5	5.6	5.7
	8	2170	F	124.0[4]	—	—	17.6	—	15.6	15.4	13.0	12.7	9.4	9.2	59.0	16.2	8.0	5.8	59.0	16.0	8.0	6.0
	9	2190	F	123.0	109.0	35.3	17.2	13.5	11.5	11.7	9.6	9.9	8.7	9.2	57.0	15.0	5.0	5.8	57.0	14.9	5.4	5.7
	10	2270	F	125.0	109.0	33.5	17.4	15.5	14.3	13.8	10.8	10.6	8.4	8.3	59.0	13.3	5.6	6.6	60.0	13.5	5.8	6.5
BpB	11	720	M	108.0	91.0	33.0	17.3	11.4	9.7	10.1	7.9	7.5	5.9	5.9	50.0	12.0	4.5	5.3	50.0	12.3	4.8	5.4
	2	1790	M	118.0	97.0	26.3	16.3	9.0	11.5	12.2	10.4	10.0	7.9	8.1	56.0	13.0	5.2	5.0	56.0	13.0	5.2	5.0
	3	1850	M	106.0	90.0	25.3	17.3	7.2	10.6	10.5	8.8	8.6	6.1	6.2	47.0	12.3	4.4	3.6	48.0	12.1	4.5	4.1
	4	1870	M	109.0	91.0	27.0+	16.7	8.2+	10.5	10.5	9.0	8.9	6.5	6.5	48.0	8.4	4.8	4.6	48.0	8.4	4.8	4.7
	5	1890	F	120.0	101.0	42.0	25.5	15.3	14.1	14.3	11.5	11.3	6.9	7.2	54.0	11.1	6.4	4.3	54.0	12.0	6.7	4.3
	6	2010	M	118.0	100.0	29.0+	15.5	10.6+	12.0	11.1	9.0	8.4	7.9	7.9	53.5	13.0	5.2	4.2	53.0	13.5	5.3	4.0
	7	2020	F	124.0	106.0	38.0	18.3	13.5	14.0	13.3	11.1	11.3	6.2	7.1	57.0	15.2	6.3	7.2	56.0	14.7	6.2	7.0
	8	2180	F	135.0	110.0	32.3	17.0	10.5	12.3	13.0	12.2	12.2	7.6	8.3	60.0	15.5	6.7	6.7	60.0	14.5	7.1	5.8
	9	—[2]	—[2]	123.0	99.0	37.3	23.2	12.4	14.2	14.3	9.7	9.6	8.4	8.2	56.0	15.7	5.2	3.4	56.0	15.3	5.5	4.8
	10	—[2]	—[2]	111.0	97.0	25.6	17.7	6.0	10.9	10.8	9.8	9.4	8.0	8.0	53.5	12.1	5.6	4.0	54.0	12.1	5.6	4.0
	11	—[2]	—[2]	116.0	92.0	25.2	16.2	7.5	10.0	10.3	10.0	9.7	7.2	7.0	50.0	10.6	4.6	5.5	50.0	11.0	4.5	5.1

				a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
BpB	12	—[2]	—[2]	106.0	92.0	26.8	15.2	9.8	10.9	10.6	8.8	9.1	7.4	7.4	51.0	10.2	4.6	3.1	52.0	10.1	4.8	3.0
	13	—[2]	—[2]	109.0	97.0	26.9	17.1	8.8	11.1	10.9	8.9	8.8	6.8	6.6	46.0	9.9	4.7	4.3	47.5	10.0	4.6	4.2
BbA	1	1300	F	91.0	79.0	25.6+	18.0	6.3+	12.5	11.8	6.3	6.3	6.7	6.7	45.0	14.2	4.3	5.7	45.0	14.1	4.5	5.3
	2	1450	F	85.0	76.0	30.2	19.2	10.5	10.9	10.3	5.0	5.1	5.8	6.0	46.0	16.5	5.0	3.5	47.0	16.8	5.0	4.0
	3	1450	F	88.0	72.0	26.8	15.0	10.7	10.0	10.4	4.5	4.6	6.5	6.1	42.0	15.3	4.7	5.3	42.0	15.7	4.8	5.1
	4	1520	F	87.0	78.0	33.0	21.9	10.5	14.1	13.7	5.4	5.2	6.3	6.0	48.0	16.4	4.8	5.4	48.0	16.2	4.6	5.2
	5	1560	F	83.0	79.0	25.9	15.1	10.8	10.9	10.9	6.1	6.3	6.8	6.4	46.0	14.2	5.0	5.3	48.0	14.3	4.9	5.2
	6	1570	F	92.0	79.0	27.0	19.5	8.0	9.8	10.3	5.6	5.6	6.3	6.4	45.0	16.2	4.2	4.0	45.0	16.9	4.7	3.8
	7	1610	F	99.0	84.0	33.3	18.8	13.0	11.0	11.1	6.1	5.9	6.3	6.9	50.0	20.1	6.7	3.9	49.0	19.9	6.8	4.0
	8	1610	F	96.0	79.0	28.1	18.9	8.7	11.9	12.3	5.8	6.4	6.0	6.6	45.0	18.0	5.4	8.0	—	—	—	—
	9	1670	F	100.0	82.0	33.0	20.5	12.5	11.3	11.1	5.6	5.6	6.8	6.2	47.0	14.2	4.8	8.8	46.0	14.8	4.8	8.6
BbC	1	1280	F	66.0	61.0	22.7	15.2	7.0	8.0	8.3	4.6	4.5	4.7	4.6	39.0	12.0	4.3	4.8	40.0	12.0	4.5	4.5
	2	1280	F	69.0	61.0	22.2	10.9	9.4	9.4	9.3	4.4	4.2	3.8	3.6	37.0	11.8	4.0	5.8	37.0	11.9	3.9	5.9
	3	1290	M	75.0	66.0	23.0	12.2	9.2	9.2	9.1	5.2	5.1	5.1	5.3	40.0	13.0	4.5	3.9	40.0	13.3	4.3	3.9
	4	1300	M	74.0	66.0	23.9	16.6	6.3	10.0	9.9	5.5	5.5	5.0	4.8	37.0	12.5	4.7	4.1	38.0	12.6	4.9	3.5
	5	1340	M	75.0	64.0	21.5	14.0	6.4	7.5	8.1	5.4	5.3	5.8	5.6	39.0	12.9	4.0	5.8	40.0	13.5	4.0	5.7
	6	1350	F	81.0	70.0	26.2	17.0	8.2	10.1	10.5	6.0	5.9	5.4	5.0	40.0	13.2	4.1	3.6	40.0	14.1	4.4	4.5
	7	1360	M	76.0	64.0	26.8	16.2	9.6	10.4	10.5	4.8	4.7	3.8	4.0	41.0	12.8	3.6	5.7	42.0	12.8	3.6	5.3
	8	1370	M	77.0	67.0	24.4	14.8	8.0	8.3	8.8	4.8	4.8	4.9	5.1	38.0+	13.6	3.5	3.4	44.0	13.2	3.5	5.5
	9	—[2]	—[2]	81.0	70.0	24.6	15.7	7.6	8.9	9.1	4.6	4.8	4.3	4.5	41.0	14.4	5.1	4.4	42.0	14.6	5.0	4.3
	10	—[2]	—[2]	90.0	75.0	22.5	17.5	4.3	11.0	11.1	6.5	6.4	4.9	4.9	44.0	16.1	5.0	7.7	46.0	16.1	5.1	8.0
BeC	1	1230	M	78.0	67.0	—	13.6	—	9.6	10.1	6.0	5.8	5.2	5.3	38.5	12.3	5.3	2.5	39.0	11.9	5.2	2.1
	2	1290	F	78.0	70.0	25.5	14.6	10.6	8.3	8.4	6.0	6.1	5.5	5.1	41.0	11.8	5.1	1.6	40.0	11.5	5.2	1.4
	3	1200	M	72.0	64.0	22.5	13.7	8.7	8.6	8.6	5.2	4.9	5.7	5.8	—	—	—	—	—	—	—	—
	4	1230	F	75.0	64.0	23.2	12.6	9.3	8.6	8.7	5.5	5.5	5.6	5.5	—	—	—	—	—	—	—	—
	5	1260	F	73.0	67.0	23.1	15.2	7.0	9.0	9.5	4.8	4.7	4.7	4.9	—	—	—	—	—	—	—	—
	6	1270	M	72.0	62.0	25.2	16.0	9.3	9.9	10.2	5.8	5.8	6.4	6.0	—	—	—	—	—	—	—	—
	7	1270	M	75.0	64.0	27.1	15.7	9.7	10.6	10.4	4.3	4.2	5.5	5.5	—	—	—	—	—	—	—	—
	8	1360	F	85.0	73.0	24.3	13.9	10.0	9.2	9.5	6.5	6.7	6.1	6.0	—	—	—	—	—	—	—	—
	9	1360	F	89.0	78.0	—	17.3	—	10.3	10.1	6.6	6.8	6.2	6.0	—	—	—	—	—	—	—	—
	10	1230	M	75.0	64.5	24.2	15.6	8.2	8.8	9.2	5.5	5.3	4.8	5.1	39.6	11.4	5.1	2.9	40.0	11.8	5.1	2.7
	11	1250	M	74.5	66.7	25.3	15.1	9.1	9.3	9.5	5.1	5.1	5.5	5.2	41.4	11.7	6.0	2.1	41.3	11.6	6.3	2.1
	12	1270	M	79.3	70.5	24.0	13.5	10.5	8.6	9.0	6.0	5.9	4.8	5.5	42.8	11.0	5.1	3.6	43.2	10.6	5.0	3.8
	13	1290	F	77.4[4]	—	25.1	15.9	9.1	9.8	—	6.3	—	5.8	—	42.1	11.2	6.2	4.0	41.7	11.0	5.9	3.8

				a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
BeC	14	1300	M	83.0	70.7	25.6	14.8	10.7	9.6	9.6	5.6	5.7	5.4	5.5	45.0	12.8	5.6	3.1	45.0	12.9	5.8	2.8
	15	1310	F	82.6[4]	—	25.8	14.3	10.3	8.8	—	5.5	—	4.0	—	39.6	11.3	5.7	3.4	41.0	11.8	6.0	2.9
	16	1330	F	80.4[4]	—	25.2	16.8	7.6	—	8.4	—	6.0	4.4	5.0	40.5	12.3	5.9	3.9	42.0	12.1	5.6	3.2
	17	1330	F	85.2[4]	—	27.8	17.6	8.9	9.7	9.8	6.2	6.0	—	5.6	42.5	13.9	5.9	3.7	43.1	13.9	6.2	4.1
	18	1340	F	79.2	69.3	24.6	14.5	9.2	9.6	9.4	5.6	5.9	5.5	5.8	40.7	13.2	5.8	3.1	40.7	13.4	5.8	3.5
	19	1370	F	76.4	69.8	25.2	14.6	9.8	9.6	9.9	5.9	6.1	6.2	6.8	43.4	13.0	5.8	2.9	43.2	12.6	5.8	3.1
	20	1380	F	80.0	73.7	27.5	17.4	10.1	10.5	9.9	5.7	5.9	5.4	5.5	39.4	12.8	5.7	3.9	40.6	12.7	5.7	4.0
	21	1390	F	87.0[4]	—	28.3	17.5	10.3	—	9.1	—	5.6	—	5.3	43.4	12.0	5.3	5.8	42.6	12.2	5.2	5.3
	22	1440	F	84.4[4]	—	28.4	18.2	10.2	11.1	11.0	5.5	5.6	6.5	6.0	45.9	12.5	5.0	2.5	45.9	12.8	4.9	2.6
BaC	1	500	F	34.0	29.2	9.9	7.6	2.5	4.6	4.4	2.6	2.6	2.7	2.7	18.2	3.5	1.8	1.8	18.6	3.5	2.0	1.6
	2	540	F	34.0	30.0	7.9	6.8	1.2	4.6	4.6	2.8	2.8	2.6	2.7	15.4	3.6	2.2	0.6	15.7	3.7	2.2	0.6
	3	576	M	31.9	28.9	9.1	6.8	2.6	4.5	4.5	2.5	2.4	2.9	3.0	19.4	3.1	1.8	2.3	19.2	3.2	1.8	2.3
	4	578	F	32.9	28.6	8.1	6.5	1.3	5.0	5.0	2.4	2.3	2.6	2.7	17.9	3.3	2.0	1.6	17.9	3.4	1.9	1.7
	5	580	M	33.8	31.2	9.3	7.2	2.1	4.6	5.0	2.4	2.5	2.7	2.7	19.3	4.1	1.8	1.5	20.1	3.7	1.9	1.5
	6	590	M	34.8	30.8	8.3	6.8	1.5	4.5	4.5	2.1	2.0	2.3	2.5	19.4	3.2	2.0	1.9	19.5	3.3	2.1	1.8
	7	637	M	37.2	33.5	10.5	7.5	3.0	5.5	5.3	2.5	2.5	2.9	2.8	19.4	4.4	2.4	1.6	19.3	4.3	2.5	1.5
	8	670	M	41.5	37.5	11.9	9.2	2.7	5.8	5.7	2.5	2.6	3.0	2.9	20.3	3.7	1.9	1.4	21.3	3.6	2.0	1.3
	9	710	F	43.2	40.7	12.4	9.6	2.9	6.2	5.8	3.0	3.1	3.3	3.3	24.6	4.5	2.5	2.2	24.5	4.3	2.5	1.9
	10	718	M	42.2	38.2	11.6	10.2	1.2	5.9	5.8	2.7	2.8	3.0	3.1	21.3	4.9	2.6	2.2	21.6	4.9	2.6	2.2
	11	768	M	48.8	42.0	13.5	8.7	4.7	6.5	6.3	2.9	3.0	3.9	4.1	26.3	5.4	2.9	2.4	26.1	5.3	2.9	2.4
MnB[1]	1	1410	F	83.8	80.0	20.9	15.5	3.1	8.5	8.2	6.6	6.5	7.8	7.5	36.7	5.8	3.7	3.8	37.3	5.5	3.8	3.9
	2	1290	M	81.5	76.8	22.7	16.4	3.4	7.9	7.9	6.4	6.1	7.7	7.6	38.6	5.4	4.0	4.7	37.2	5.4	4.3	4.3
	3	1290	M	73.0	69.5	20.6	16.3	1.8	8.4	8.6	6.2	6.1	7.2	7.1	28.2	5.2	4.0	1.8	29.6	5.1	4.4	1.5
	4	1410	F	89.5	81.3	27.2	20.3	4.5	9.9	10.7	7.7	7.7	8.2	8.2	43.5	6.4	4.3	3.1	43.0	6.7	4.3	3.0
	5	1070	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	33.0	5.8	3.5	3.3
	6	1070	F	48.0	42.0	10.7	8.6	1.3	5.2	5.4	4.2	4.2	5.6	5.5	—	—	—	—	—	—	—	—
	7	1130	F	79.0	74.0	—	13.9	—	7.8	8.3	6.1	6.1	7.1	7.1	34.0	6.8	4.0	3.1	—	—	—	—
	8	1130	M	—	—	—	—	—	—	—	—	—	—	—	24.0	5.1	2.7	1.9	24.5	5.1	2.7	1.9
	9	1190	M	81.0	62.0	19.2	13.3	3.8	7.0	7.1	5.2	5.5	7.8	7.9	26.0	7.4	3.0	—	26.0	7.6	2.9	—
	10	1250	M	72.0	62.0	19.7	16.8	3.9	8.1	8.2	6.3	6.4	6.4	6.5	—	—	—	—	—	—	—	—
	11	—[2]	—[2]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	37.0	6.5	3.6	3.7
	12	—[2]	—[2]	55.0	50.0	14.4	11.6	2.4	7.0	6.9	5.3	5.3	7.0	6.8	—	—	—	—	—	—	—	—
	13	—[2]	—[2]	79.0	70.0	22.4	16.5	3.3	8.0	7.8	6.0	5.5	7.8	7.8	40.0	6.5	3.8	4.2	—	—	—	—

				a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
EgB	1	1410	F	80.5	74.6	19.2	13.3	1.7	10.0	10.2	7.9	7.8	15.4	14.2	35.3	7.0	5.8	4.2	35.7	6.8	5.3	4.2
	2	1470	M	79.0[4]	—	16.2	12.9	3.1	9.3	9.6	7.0	6.9	11.7	11.4	40.2	5.6	4.5	2.8	38.8	6.1	3.9	2.9
	3	1610	M	93.0	90.0	23.2	15.8	3.4	11.9	11.5	8.0	8.0	11.5	11.3	41.7	7.8	3.3	4.1	40.0	7.5	3.0	4.5
	4	1610	F	81.0	80.0	20.0	14.2	4.3	11.2	11.1	7.6	6.9	12.2	12.3	34.0	7.1	5.2	3.0	—	—	—	—
	5	1540	F	77.0	74.0	18.0	14.2	2.6	9.9	10.4	7.5	7.3	10.5	11.1	—	—	—	—	—	—	—	—

1) 1-4 from Bering Sea, 5-10 from Okinawa.
2) Body length and sex unknown. Identification tag was lost during transportation.
3) Each tip of wings cut off slightly.
4) Double of right or left half. One wing broken.

APPENDIX 2. RESULTS OF CALCULATIONS

AM Arithmetic mean, N Sample number, SR Sample range,
SD Standard deviation, 2SE Two standard errors.
See text for explanation of other abbreviation and calculation number

Species, locality		1 R	1 L	2	3	4	5 R	5 L	6 R	6 L	7 R	7 L	8 R	8 L	9 R	9 L	10 R	10 L
BmA	AM	7.4	7.3	16.4	29.1	10.4	14.4	14.3	9.5	9.5	39.1	39.5	33.4	34.0	18.6	18.4	6.8	7.4
	N	7	8	8	8	8	8	8	8	8	8	8	9	8	9	8	9	8
	SR	6.3~8.3	6.0~9.0	14.9~18.1	26.5~31.0	8.0~12.7	13.1~16.6	12.8~16.8	8.1~11.2	8.3~11.6	36.9~40.8	36.9~40.8	30.5~36.7	30.2~36.1	15.5~22.4	15.5~21.8	2.2~13.1	2.2~14.7
	SD	0.66	0.86	1.28	1.35	1.42	1.58	1.29	1.04	1.14	1.15	1.39	2.08	1.65	2.17	2.03	3.42	3.78
	2SE	0.50	0.61	0.90	0.95	1.00	1.12	0.91	0.73	0.81	0.81	0.98	1.39	1.17	1.45	1.43	2.28	2.67
BpA	AM	6.9	6.9	15.3	26.6	9.5	11.2	11.2	9.0	9.0	45.7	45.8	25.7	25.7	11.4	11.4	7.7	8.1
	N	10	10	10	6	6	10	10	10	10	10	10	10	10	10	10	9	10
	SR	6.2~7.7	6.2~8.4	13.9~18.1	24.9~28.7	7.7~12.4	9.3~12.8	9·5~12.4	7.8~10.6	7.6~10.9	42.3~48.1	42.7~48.0	21.1~34.9	20.9~34.2	8.8~14.3	8.9~14.1	2.0~11.8	2.4~13.6
	SD	0.43	0.65	1.32	1.43	1.66	1.09	0.90	1.02	1.05	1.72	1.54	3.87	3.59	2.01	1.87	3.28	3.38
	2SE	0.27	0.41	0.84	1.17	1.35	0.69	0.57	0.64	0.66	1.08	0.97	2.45	2.27	1.27	1.18	2.19	2.14
BpB	AM	6.2	6.3	15.5	26.5	8.7	10.0	10.1	8.4	8.3	45.4	45.6	23.2	23.1	10.0	10.1	9.0	9.0
	N	13	13	13	11	11	13	13	13	13	13	13	13	13	13	13	13	13
	SR	5.0~7.2	5.5~7.2	12.6~21.3	21.7~35.0	5.4~12.8	8.6~11.8	8.9~11.9	7.3~9.6	6.9~9.4	42.2~48.2	43.1~49.1	17.5~28.0	17.5~27.3	9.0~11.9	9.0~12.4	6.1~12.6	5.8~12.5
	SD	0.63	0.52	2.28	4.17	2.12	0.94	0.83	0.60	0.69	1.77	1.77	2.90	2.68	0.90	1.00	1.92	1.63
	2SD	0.35	0.29	1.27	2.51	1.28	0.52	0.46	0.33	0.39	0.98	0.98	1.61	1.48	0.50	0.55	1.06	0.90
BbA	AM	7.0	7.0	20.4	32.5	11.6	12.5	12.4	6.1	6.2	50.6	51.2	35.0	34.8	10.8	10.8	12.1	11.2
	N	9	9	9	8	8	9	9	9	9	9	8	9	8	9	8	9	8
	SR	6.3~8.2	6.2~7.7	17.0~25.2	29.3~37.9	8.7~13.1	10.7~16.2	11.1~15.7	5.1~7.3	5.2~7.6	46.9~55.4	46.0~57.8	30.2~40.2	29.8~40.6	9.3~13.4	9.6~13.9	7.6~18.7	8.2~18.7
	SD	0.56	0.39	2.30	2.87	1.62	1.61	1.37	0.62	0.68	3.26	3.98	3.46	3.43	1.21	1.26	3.75	3.20
	2SE	0.37	0.26	1.54	2.03	1.14	1.08	0.91	0.41	0.46	2.17	2.81	2.31	2.43	0.80	0.89	2.50	2.26
BbC	AM	6.3	6.2	19.7	31.3	10.1	12.2	12.4	6.8	6.7	52.3	53.7	23.1	32.8	11.0	10.6	12.8	12.5
	N	10	10	10	10	10	10	10	10	10	9	10	9	10	9	10	9	10
	SR	5.0~7.7	5.2~7.5	15.8~23.0	25.0~35.3	4.8~13.6	10.0~13.7	10.8~13.8	5.7~7.4	5.9~7.4	48.9~59.1	49.4~60.6	30.8~36.6	30.0~35.3	8.8~12.7	8.0~12.9	9.0~17.5	9.2~17.4
	SD	0.86	0.79	2.25	2.76	2.40	1.19	0.98	0.55	0.52	2.98	3.10	1.75	1.95	1.10	1.38	2.73	2.55
	2SE	0.54	0.50	1.42	1.75	1.51	0.75	0.62	0.35	0.33	1.98	1.96	1.16	1.23	0.74	0.87	1.82	1.61
BcC	AM	7.0	7.1	19.4	32.3	12.0	12.1	12.1	7.2	7.2	52.2	52.5	29.3	29.1	13.4	13.3	7.8	7.5
	N	20	20	22	20	20	20	20	20	20	15	15	15	15	15	15	15	15
	SR	4.8~8.9	6.1~8.9	16.4~22.2	28.6~36.1	9.5~13.6	10.6~14.1	10.4~14.2	5.7~8.1	5.6~8.1	47.9~56.8	49.0~56.5	25.7~32.7	24.5~32.9	10.9~14.7	10.7~15.3	3.9~13.4	3.5~12.4
	SD	0.89	0.67	1.73	1.71	1.10	0.98	1.04	0.57	0.61	2.57	2.22	2.17	2.05	1.15	1.17	2.25	2.18
	2SE	0.40	0.30	0.74	0.77	0.49	0.44	0.46	0.26	0.27	1.33	1.14	1.12	1.06	0.60	0.60	1.16	1.12
BaC	AM	7.7	7.9	21.0	27.1	6.1	13.9	13.8	6.9	6.9	53.6	54.1	19.8	19.4	10.9	11.0	8.7	8.3
	N	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
	SR	6.6~9.1	7.0~9.4	17.8~24.2	23.2~29.1	2.8~9.6	12.9~15.2	12.9~15.2	5.9~8.2	5.7~8.2	45.3~60.8	46.2~60.2	16.0~23.4	16.7~23.6	9.3~14.3	9.4~14.0	3.9~11.9	3.8~12.0
	SD	0.61	0.64	1.67	2.02	2.09	0.65	0.73	0.75	0.70	4.08	3.83	2.46	2.38	1.50	1.42	1.98	2.06
	2SE	0.37	0.39	1.01	1.21	1.26	0.39	0.44	0.45	0.42	2.46	2.31	1.48	1.44	0.91	0.86	1.19	1.24
MnB	AM	10.0	9.9	20.1	26.6	4.1	10.6	10.8	8.2	8.1	43.4	42.1	18.6	18.4	11.1	11.2	9.1	8.9
	N	10	10	10	9	9	10	10	10	10	7	5	8	8	8	8	7	7
	SR	8.9~12.7	8.9~12.4	16.4~23.3	22.3~30.4	2.5~5.4	8.6~12.7	8.8~12.5	6.4~9.6	6.8~9.6	32.0~50.6	32.0~48.0	14.0~28.5	14.5~29.2	9.5~14.2	9.7~14.9	6.4~12.2	5.1~11.6
	SD	1.19	1.11	2.25	2.42	0.92	1.09	1.14	0.83	0.85	5.95	5.61	4.43	4.50	1.41	1.54	1.93	2.12
	2SE	0.75	0.70	1.43	1.61	0.61	0.69	0.72	0.53	0.54	4.50	5.02	3.13	3.18	0.99	1.09	1.46	1.60
EgB	AM	15.0	14.8	17.1	23.5	3.7	12.7	12.9	9.3	9.0	45.4	45.5	18.3	17.8	12.7	10.8	9.4	10.2
	N	5	5	5	5	5	5	5	5	5	4	3	4	3	4	3	4	3
	SR	12.4~19.1	12.2~17.6	16.3~18.4	20.5~24.9	2.1~5.3	11.8~13.8	12.2~13.7	8.6~9.8	8.5~9.7	42.0~50.9	43.0~49.1	13.9~20.9	15.7~19.0	7.9~16.4	7.5~14.8	7.0~11.9	7.5~11.8
	SD																	
	2SE																	

EXPLANATION OF PLATES

The photographs shown in the Plates were all taken from the ventral side. Details of the measurements are shown in Appendix 1.

Plate I. The combined bone of basihyal and thyrohyals of the blue whale (pigmy) from the Antarctic (BmA). Figs. 1–9 are the order of BmA 1–9.

Plate II. The combined bone of basihyal and thyrohyals of the fin whale from the Antarctic (BpA). Figs. 1–7 are the order of BpA 1–7, Fig. 8 BpA 9 and Fig. 9 BpA 10.

Plate III. Upper. The stylohyals of the blue whale (pigmy) from the Antarctic (BmA). Figs. 1–9 are the order of BmA 1–9.

Plate III. Lower. The stylohyals of the fin whale from the Antarctic (BpA). Figs. 1–10 are the order of BpA 1–10.

Plate IV. The combined bone of basihyal and thyrohyals of the fin whale from the Bering Sea (BpB). Figs. 1–13 are the order of BpB 1–13.

Plate V. The stylohyals of the fin whale from the Bering Sea (BpB). Figs. 1–13 are the order of BpB 1–13.

Plate VI. The combined bone of basihyal and thyrohyals of the sei whale from the Antarctic (BbA). Figs. 1–9 are the order of BbA 1–9.

Plate VII. The stylohyals of the sei whale from the Antarctic (BbA). Figs. 1–7 are the order of BbA 1–7 and Fig. 8 BbA 9.

Plate VIII. The combined bone of basihyal and thyrohyals of the sei whale from the coast of Japan (BbC). Figs. 1–10 are the order of BbC 1–10.

Plate IX. The sytlohyals of the sei whale from the coast of Japan (BbC). Figs. 1–10 are the order of BbC 1–10.

Plate X. The combined bone of basihyal and thyrohyals of the Bryde's whale from the coast of Japan (BeC). Figs. 1–12 are the order of BeC 1–12.

Plate XI. The combined bone of basihyal and thyrohyals of the Bryde's whale from the coast of Japan (BeC). Figs. 1–10 are the order of Bec 13–22.

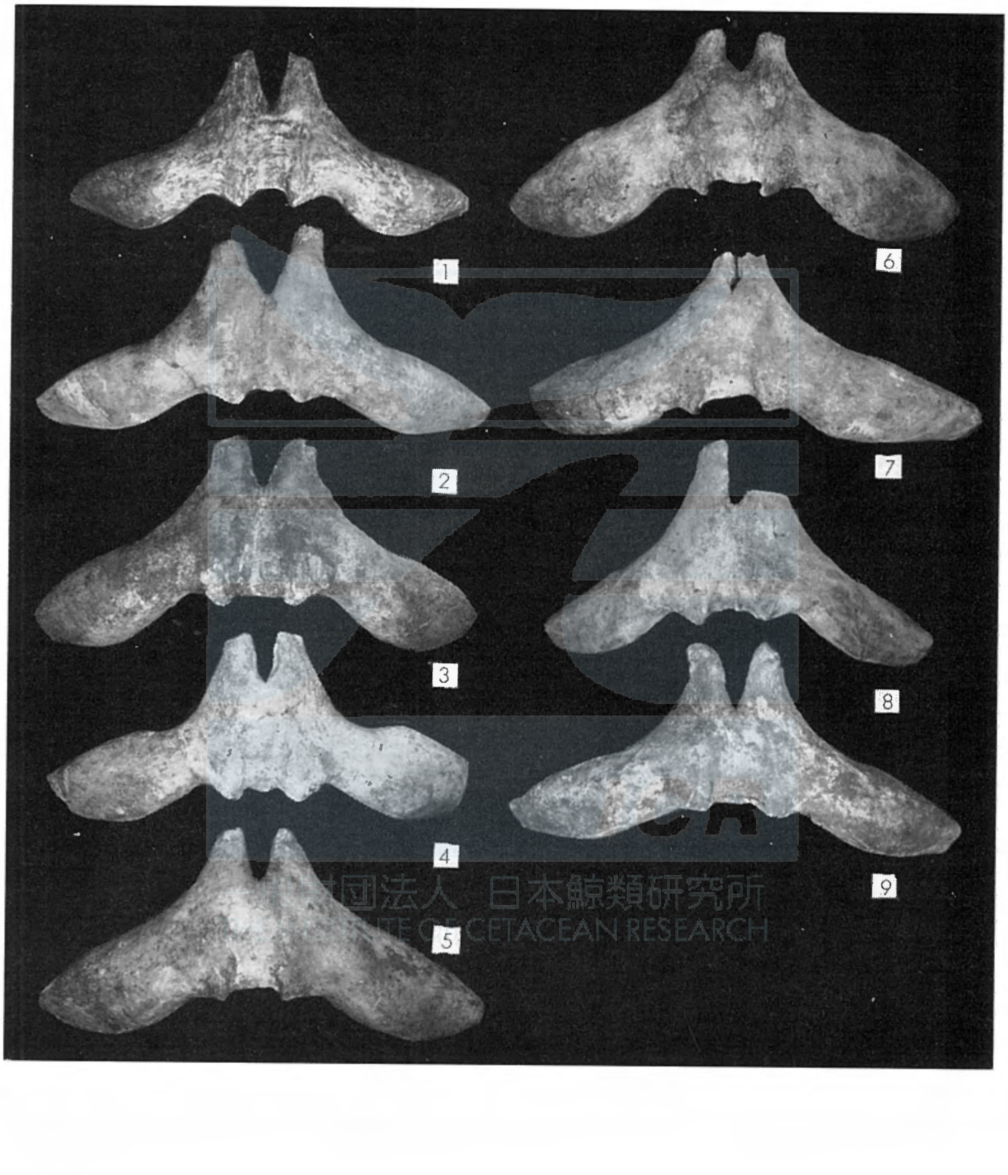
Plate XII. The stylohyals of the Bryde's whale from the coast of Japan (BeC). Fig. 1 BeC 1, Fig. 2 BeC 2 and Figs. 3–15 are the order of BeC 10–22.

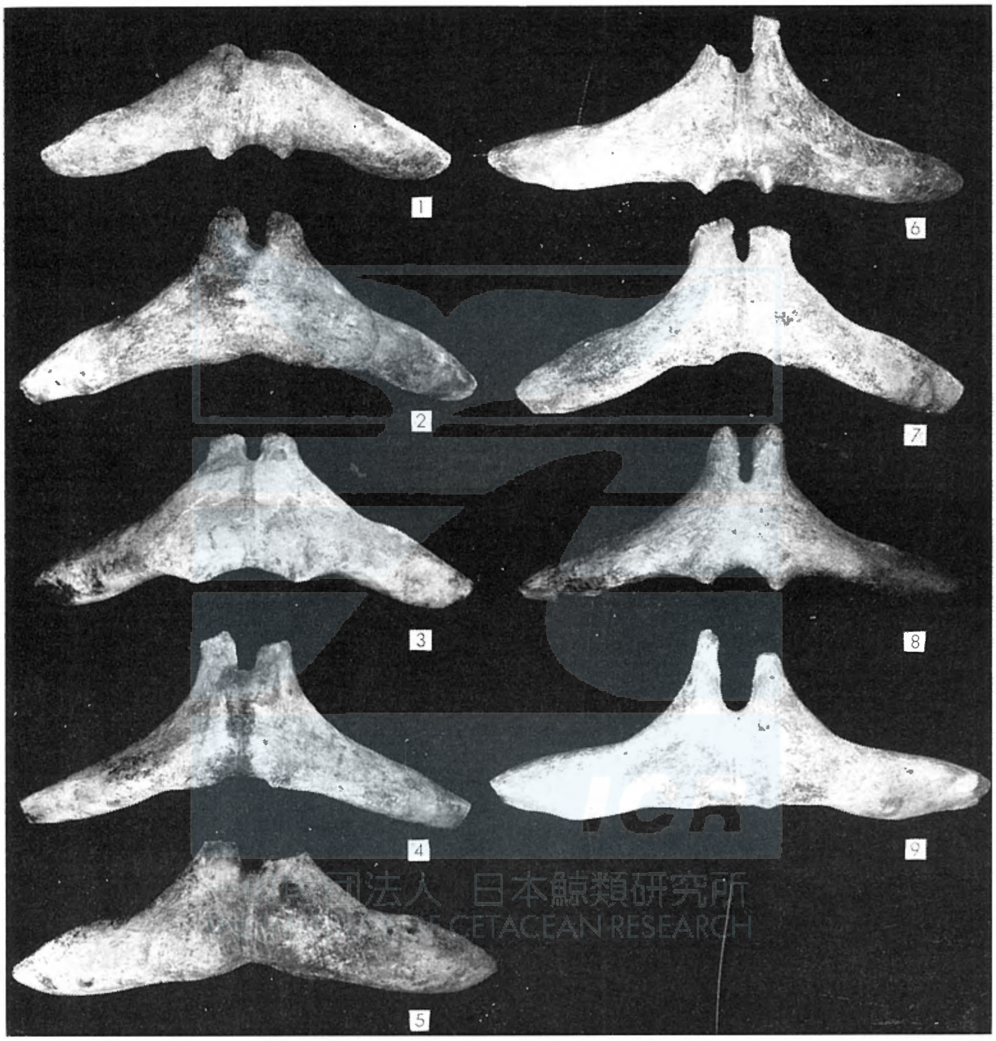
Plate XIII. The combined bone of basihyal and thyrohyals (Figs. 1–11) and stylohyals (Figs. 12–22) of the minke whale from the coast of Japan (BaC). Figs. 1–11 and Figs. 12–22 are the order of BaC 1–11 respectively.

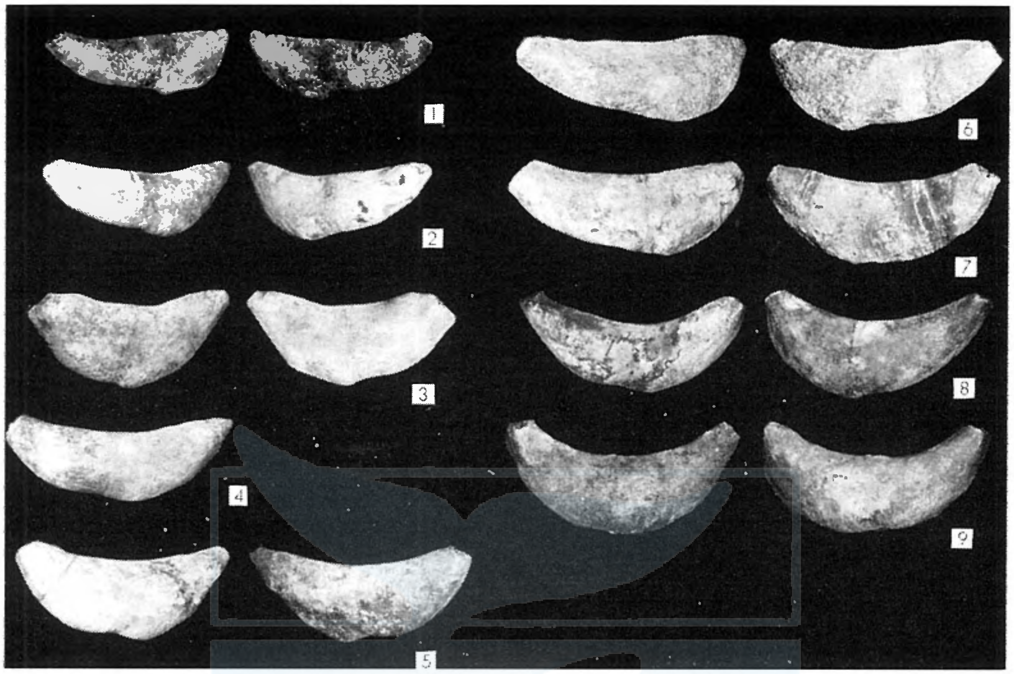
Plate XIV. Upper. The combined bone of basihyal and thyrohyals of the humpback whale from the Bering Sea and on the coast of Okinawa (MnB). Figs. 1–4 are the order of MnB 1–4, Fig. 5 MnB 6, Fig. 6 MnB 7, Fig. 7 MnB 9, Fig. 8 MnB 10, Fig. 9 MnB 12 and Fig. 10 MnB 13.

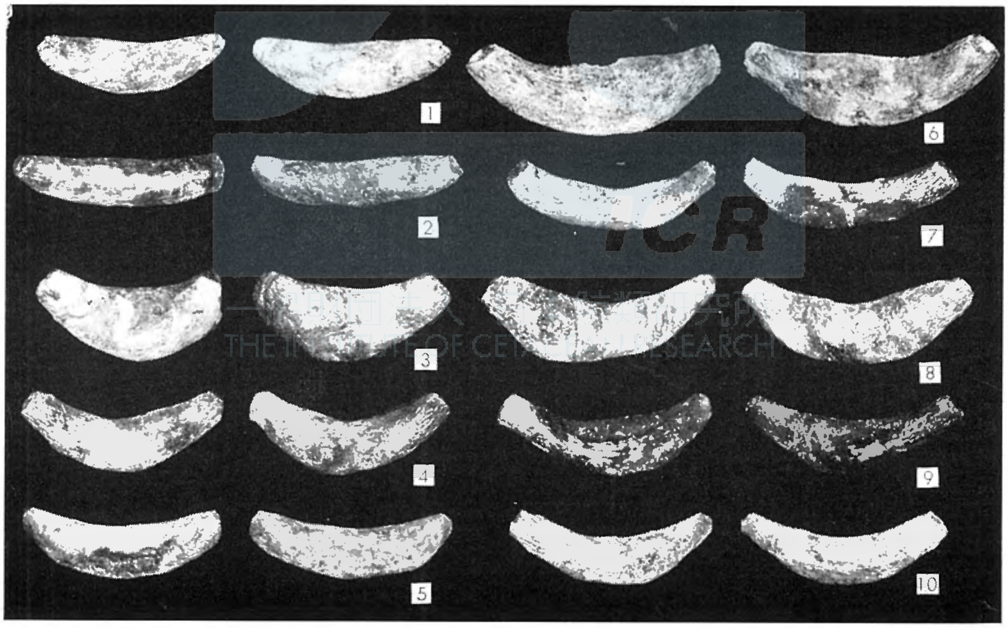
Plate XIV. Lower. Stylohyals of the humpback whale from the Bering Sea (MnB). Figs. 1–4 are the order of MnB 1–4.

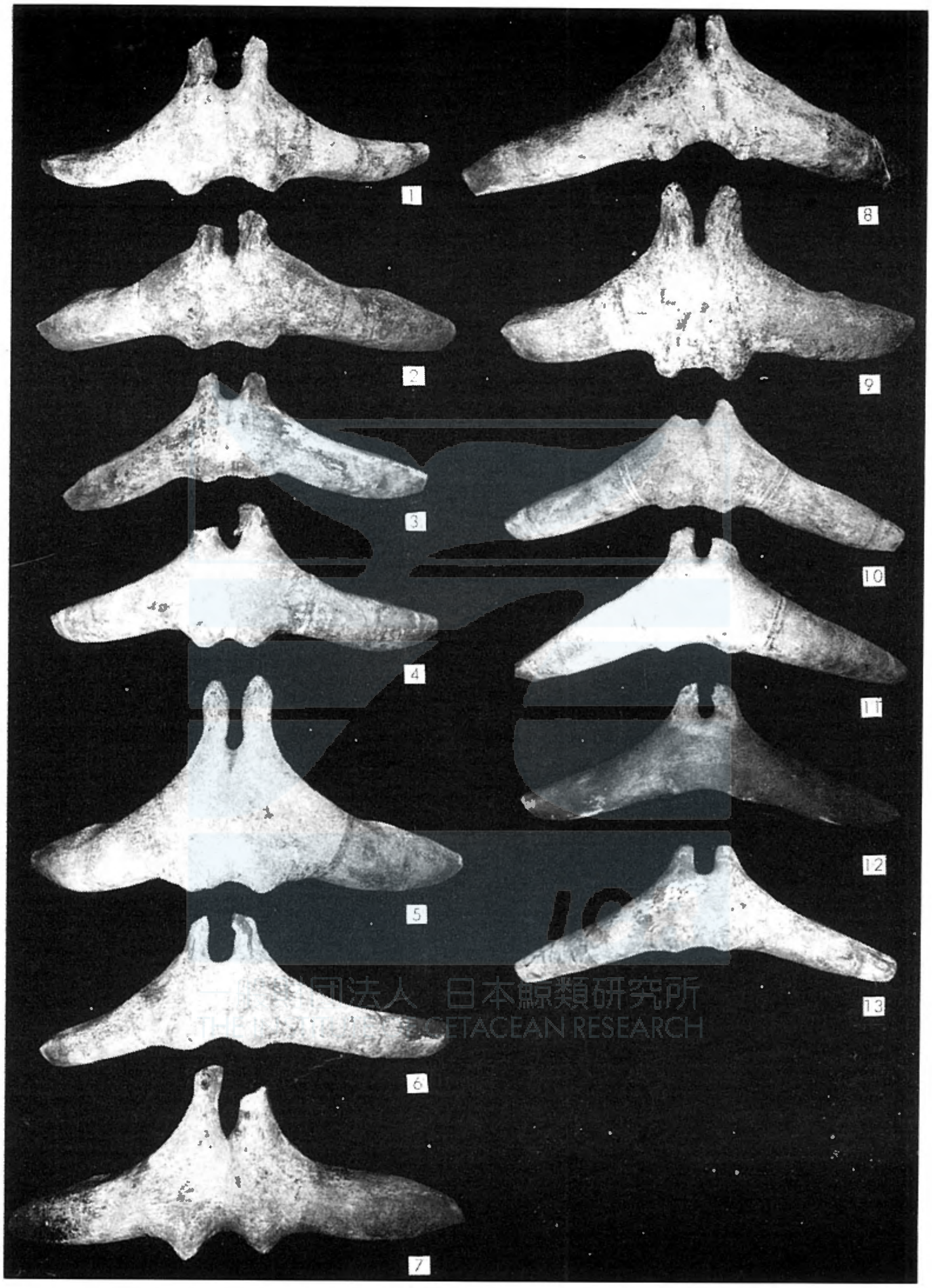
Plate XV. The combined bone of basihyal and thyrohyals (Figs. 1–5) and stylohyals (Figs. 6–9) of the black right whale from the Bering Sea (EgB). Figs. 1–5 are the order of EgB 1–5 and Figs. 6–9 EgB 1–4.

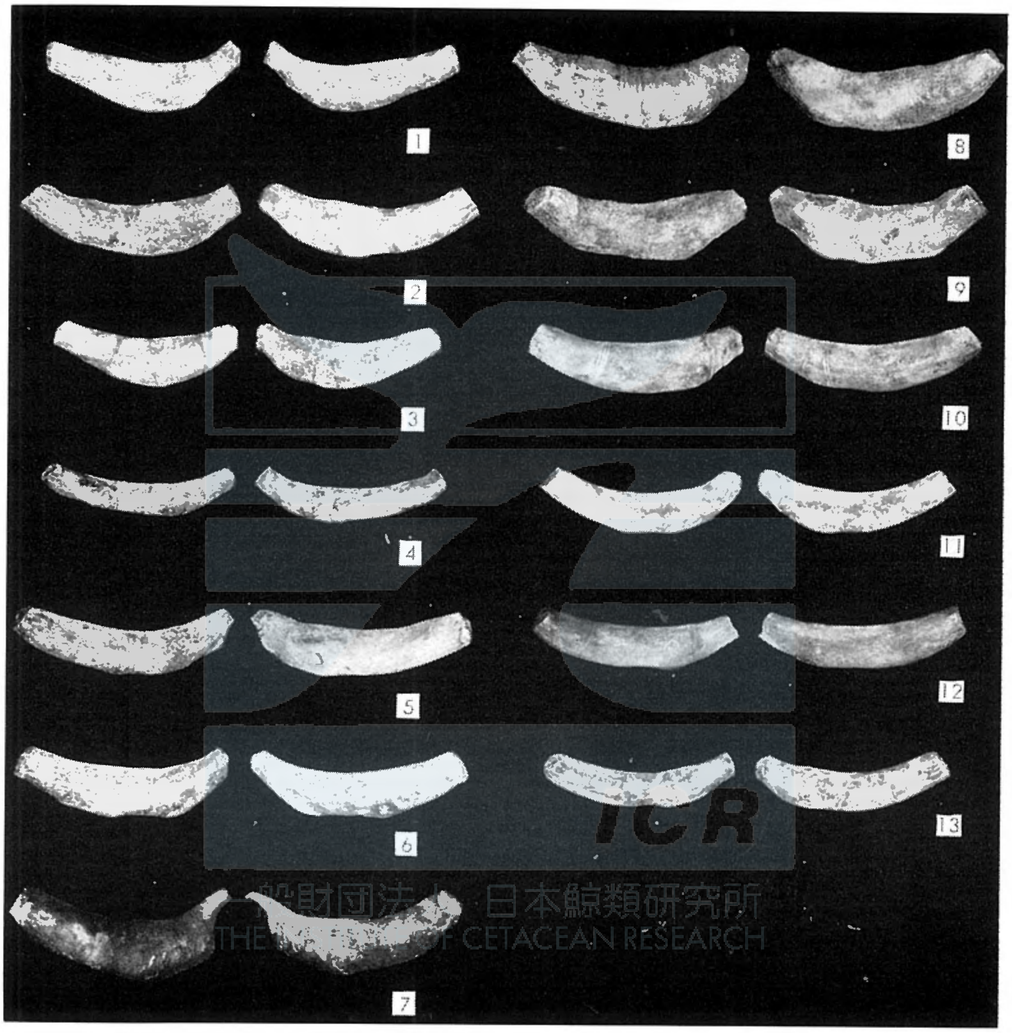

1
2
3
4
5
6
7
8
9

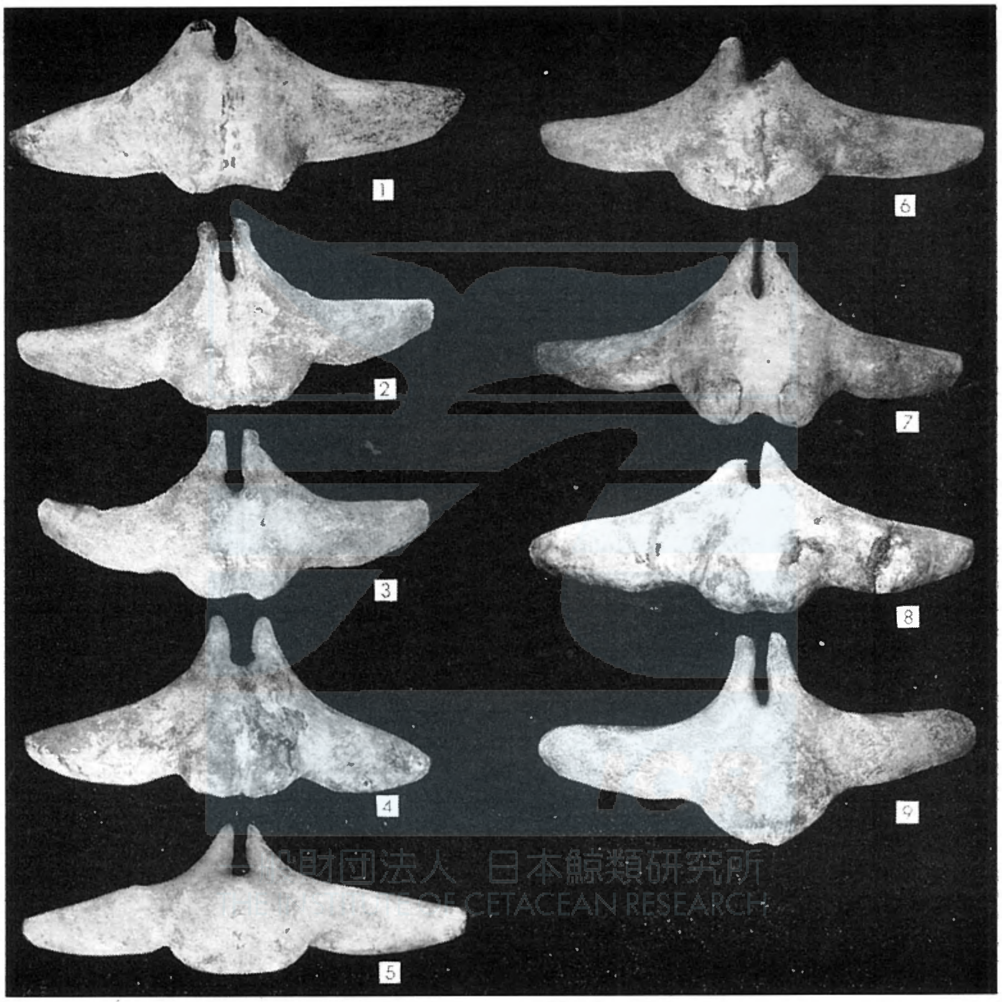


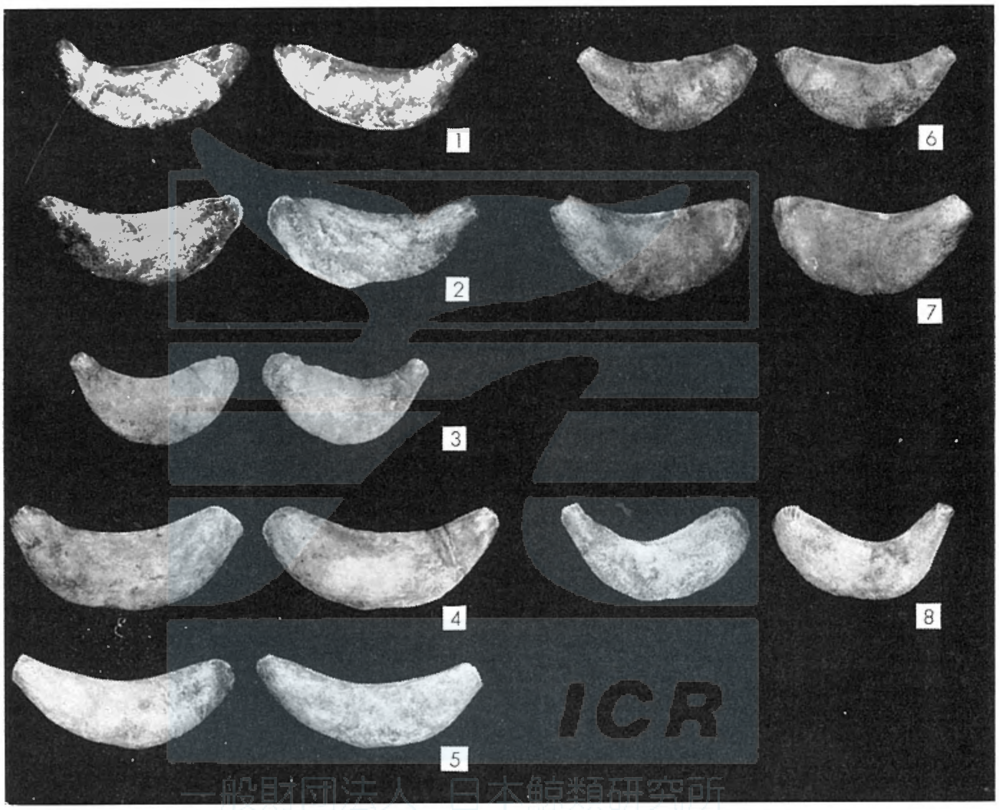

1
2
3
4
5
6
7
8
9

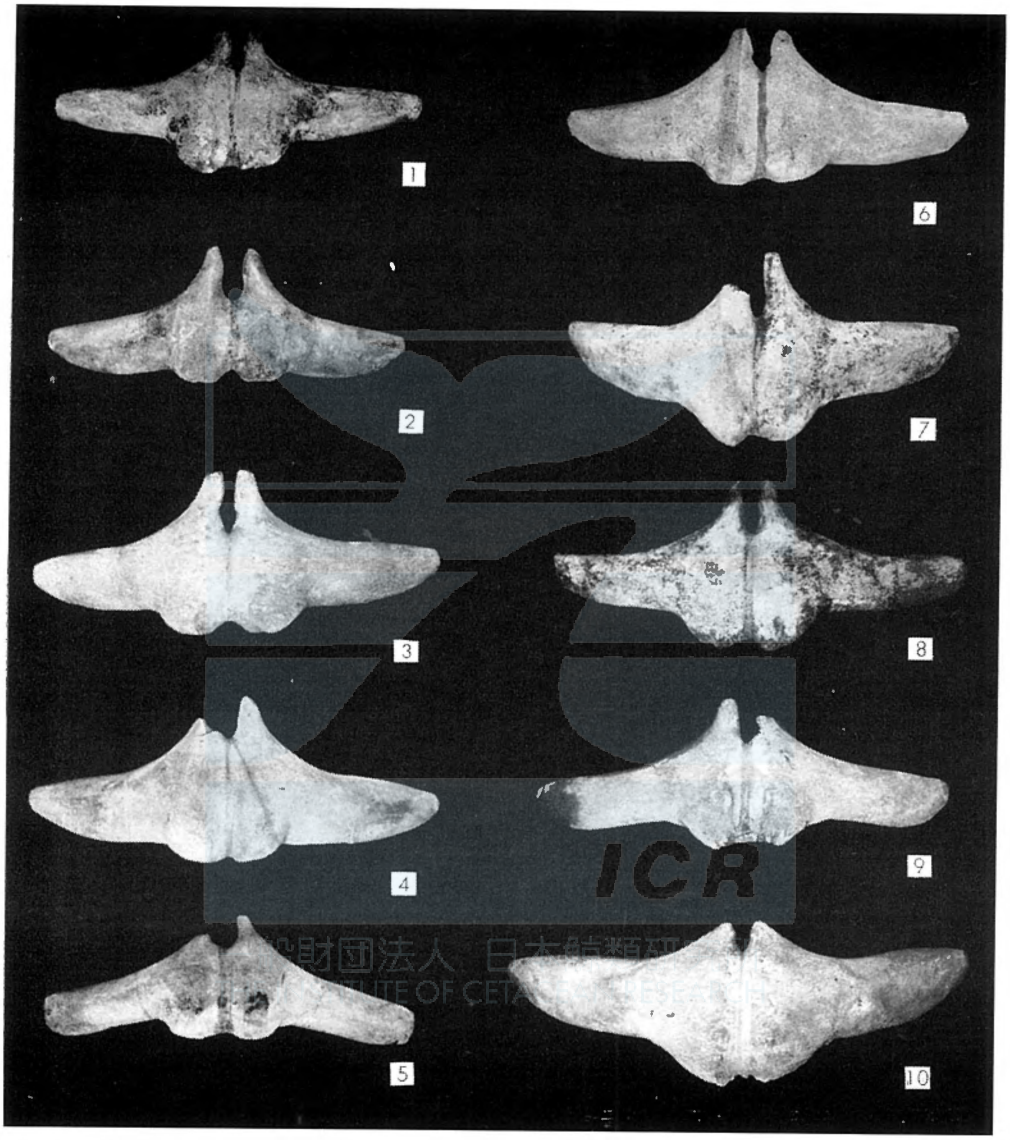

1
2
3
4
5
6
7
8
9
10

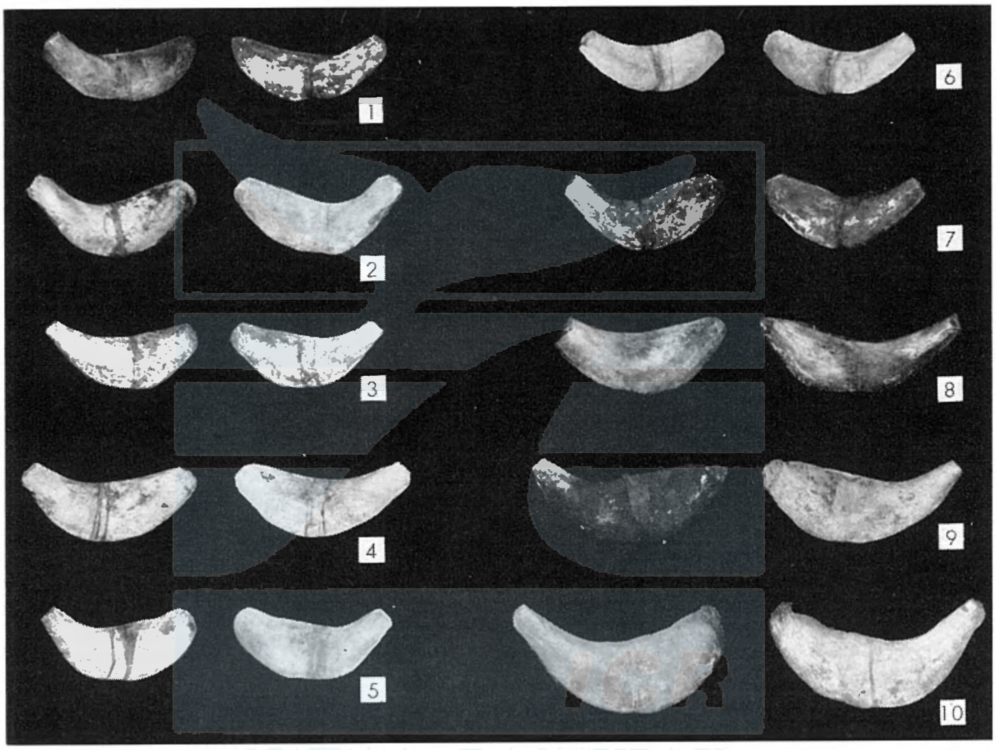

1
2
3
4
5
6
7
8
9
10
11
12
13

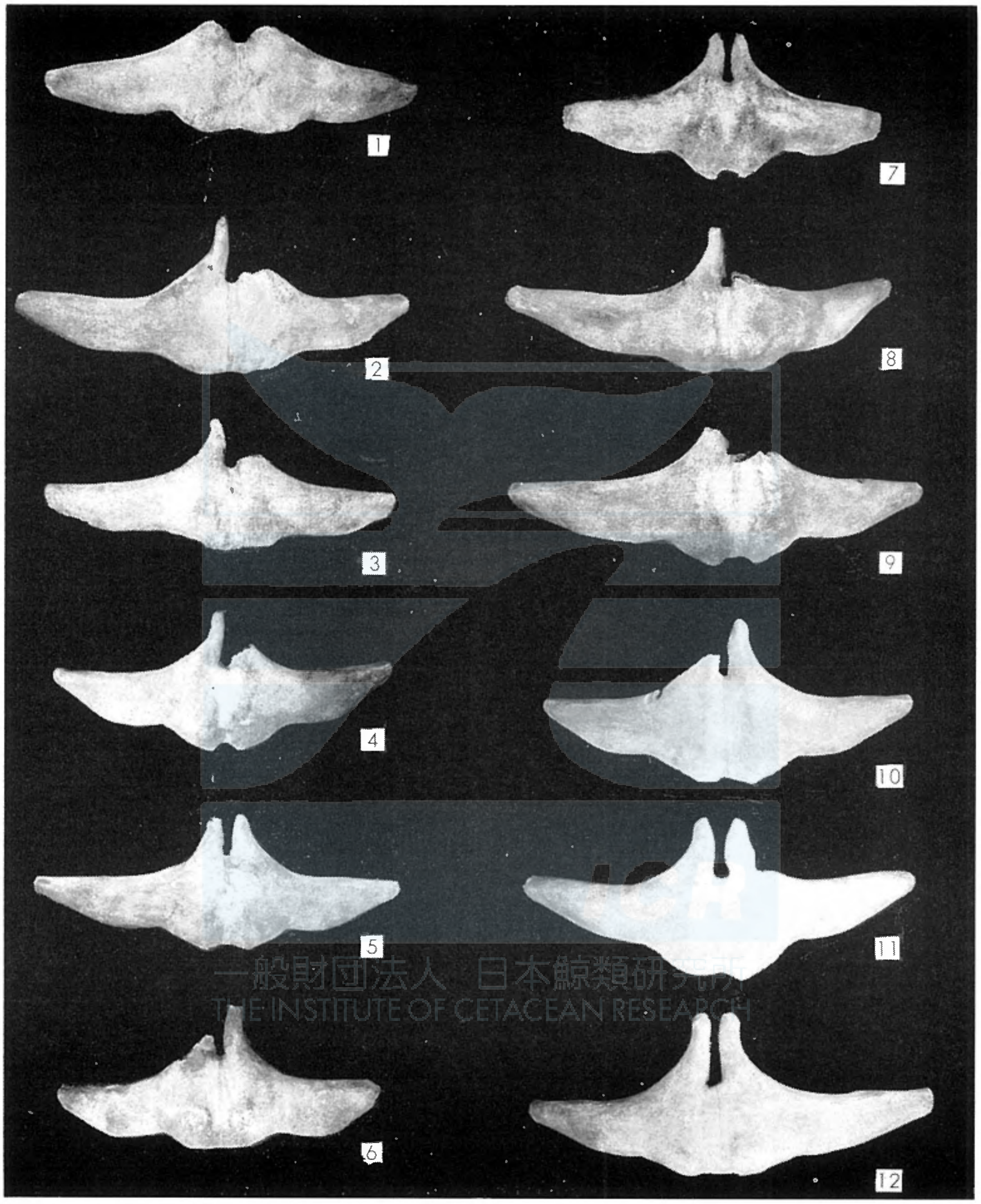

1
2
3
4
5
6
7
8
9
10
11
12
13

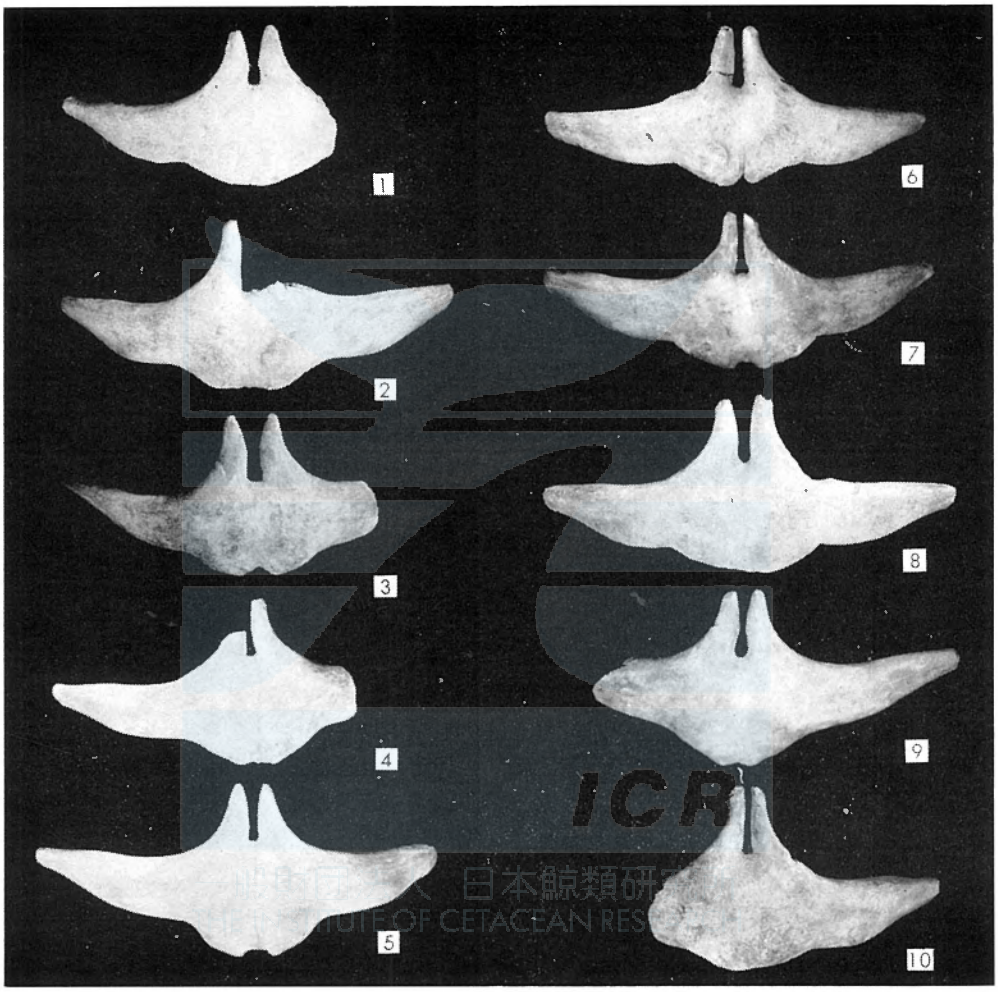

1
2
3
4
5
6
7
8
9

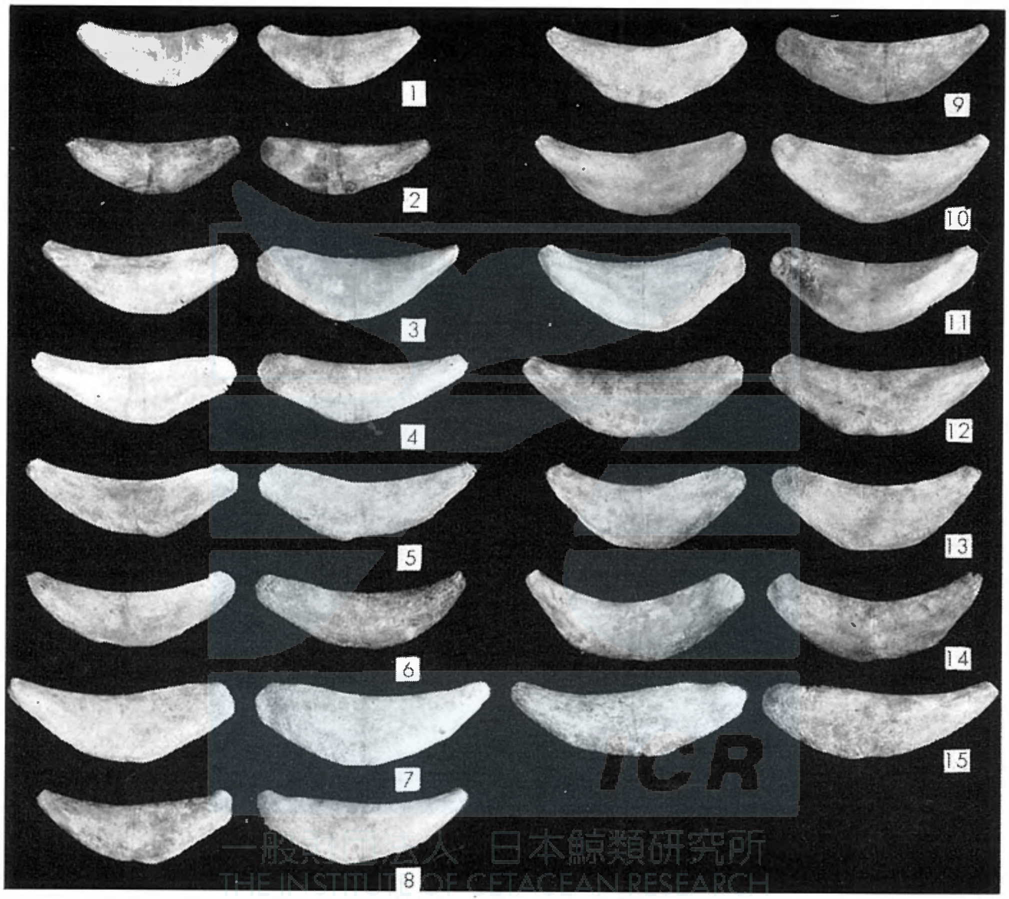

1
2
3
4
5
6
7
8

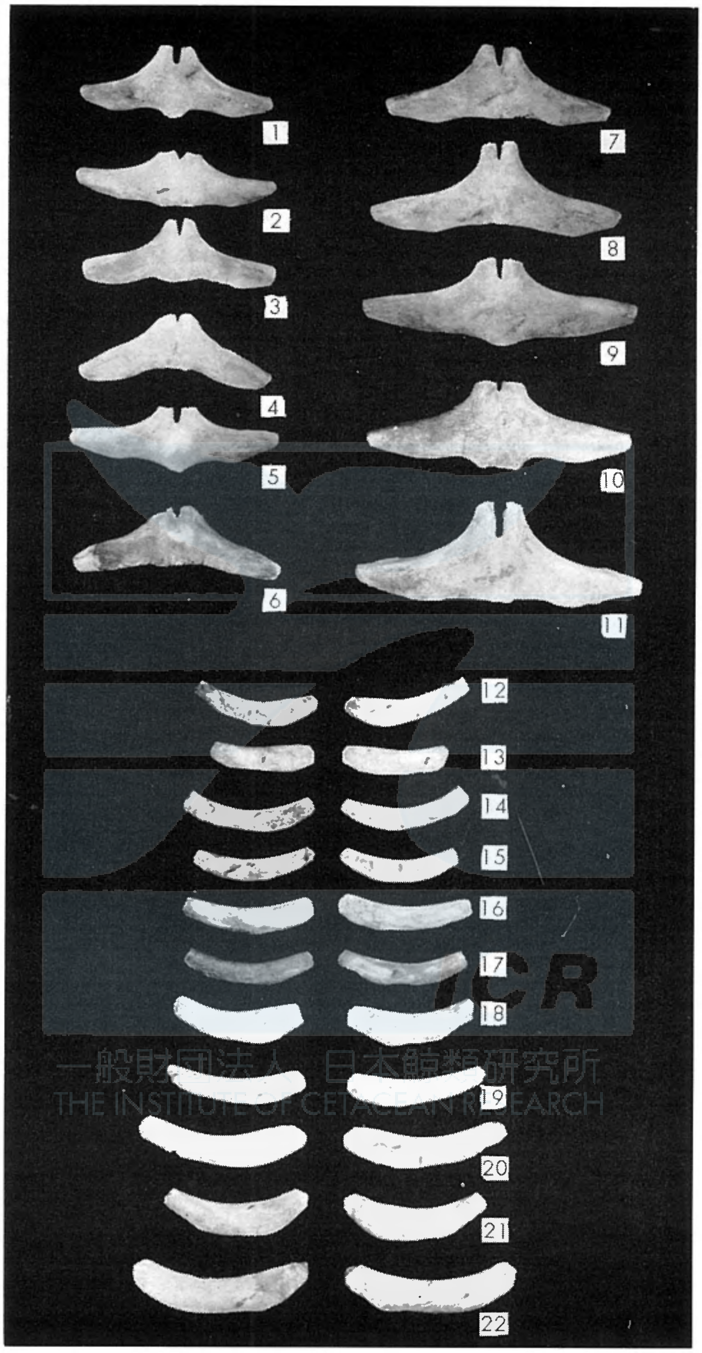

1
2
3
4
5
6
7
8
9
10

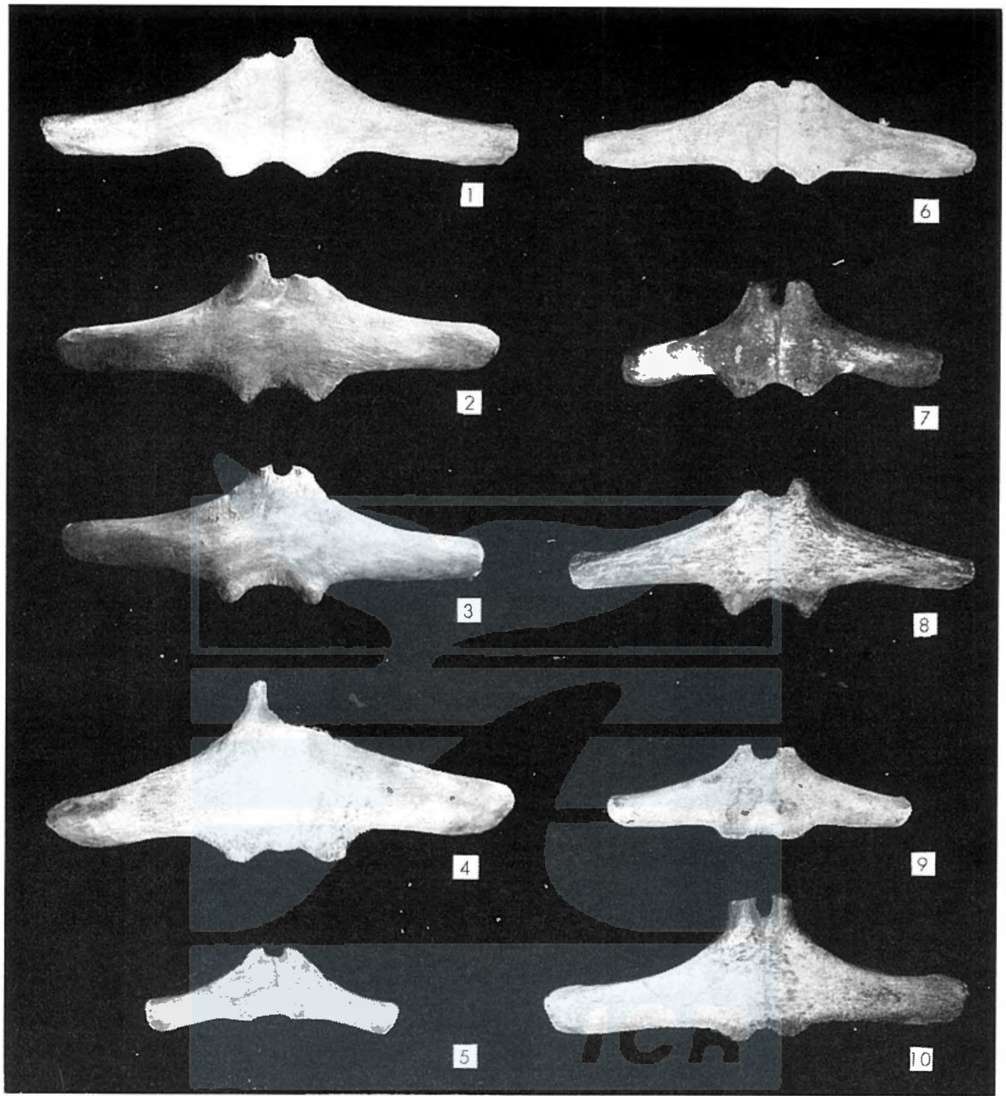

1
2
3
4
5
6
7
8
9
10


1
2
3
4
5
6
7
8
9
10
11
12


1
2
3
4
5
6
7
8
9
10


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22


1
6
2
7
3
8
4
9
5
10


1
2
3
4


1
2
3
4
5
6
7
8
9