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REPRODUCTION OF THE SPERM WHALE IN THE NORTH—WEST PACIFIC

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It is need to establish the countermeasure for the control of the sperm whale population as well as some baleen whales. For reasonable control of the population, we must make a correct diagnosis of the population size. The problem on the reproduction is one of the needful factors in the stock assessment.

On the reproduction of the sperm whale, there are some reports—Matsuura (1936, 1940), Matthews (1938), Omura (1950), Nishiwaki & Hibiya (1951), Clarke (1956), Nishiwaki, Hibiya & Ohsumi (1969), Chuzhakina (1961), etc. However, on the sexual cycle which is need to stock assessment, we have only few knowledges yet.

Recently, age studies of the sperm whale have been developing (Nishiwaki, Hibiya & Ohsumi, 1958; Ohsumi, Kasuya & Nishiwaki, 1963), and many materials for the reproduction of the sperm whales in the adjacent waters to Japan have been collected with connection to age. Present report is chiefly based on the materials, and the results will be added new informations in some points to poor knowledges on the sperm whale.

To our regrets, we have not yet succeeded to keep sperm whale to study reproductive physiology, and it is very deficult to get true knowledge. We must develope the study on this problem furthermore.

MATERIALS AND METHODS

Whales Research Institute has continued to investigate the whales in adjacent waters to Japan, and present paper is based on the biological data and materials collected in the investigations during the seasons from 1960 to 1962.

Age of sperm whale was shown as the number of growth layers in dentine of maxillary tooth which was prepared with the same method as described by Ohsumi *et al.* (1963).

Sexual maturity of the female was judged with ovaries, that is to say, the female which has one or more than one *corpus luteum* or *corpus albicans* in ovaries was judged as sexually mature. Pregnant female was also judged with ovaries, because in Japanese coastal whaling, whales are opened their belly before they are towed to a land station and foetuses are often lost at that time. The female with *corpora lutea* in ovaries was judged as pregnant, although there will be a possibility to exist some females which is not pregnant with *corpora lutea* in the ovaries. Lactation of the sperm whale was determined by examining mammary gland. Cutting the mammary grand, secretion of white milk was judged as lactation. Number of *corpora lutea* and *corp. albicantia* in the ovaries was counted for the purpose to know number of ovulation of a whale by naked eye, and on some individuals, diametre of the *corpora* were measured to study the involution of corpus albicans.

The records of foetuses in International Whaling Statistics 1937–1961 were used to count the sex ratio of the sperm whale in foetal stage and to draw growth curves of foetuses.

BREEDING SEASON

The breeding season is here defined as the period of pairing. because, in the sperm whale, gestation period extends for 16–17 months, and pairing takes plase in different season with the parturition season as shown in the following chapter.

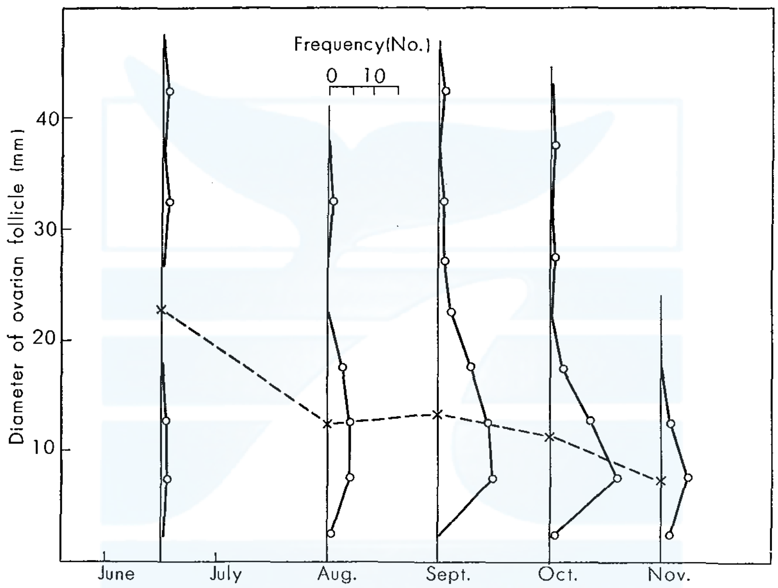

Fig. 1. Frequency distribution of diametre of ovarian follicles in resting and pubertal sperm whales caught in the waters adjacent to Japan.
Cross and broken line: mean diametre.

Seasonal change of genital organ

Males: Matthews (1938) reported that there was no definit reproductive activity in the males examining histologically the testes of the sperm whale in the southern hemisphere. That is to say, testes are active in the all seasons. Nishiwaki & Hibiya (1951, 1952) examined the testis tissue of the sperm whale in Japanese coastal waters, and described the possibility of a periodicity in the activity of testis. Clarke (1956) examined the seasonal change of diameter of semineferous tubules in the testes of the sperm whale in the Azores waters, and stated that there was sexual cycle in the male of sperm whale, and the breeding season existed during October to June.

According to Chittleborough (1955), there is quite difference in the weight between testes in feeding season and breeding season for the humpback whale. Meek (1918) reported that weight of testes of *Phocaena communis* increased remarkably in summer. On the contrary, Mackintosh & Wheeler (1929) describe that amount of sperm is more in breeding season than in feeding season, but there is no seasonal change in the weight of testes for the southern blue and fin whales.

Comparing the relations between age and weight of testes for the sperm whales caught in adjacent waters to Japan during the months April-June and September-November, there is no difference between them, although it is not yet concluded because of scanty of the materials of the former.

Further investigation will be need on this problem in the sperm whale.

TABLE 1. FERTILIZED DATES (MONTH/DECADE) OF SPERM WHALE FOETUSES ACCORDING TO THE FOETAL LENGTHS AND MONTHS KILLED

Body length (feet)	Gestation month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	1.0	12/2	1/2	2/2	3/2	4/2	5/2	6/2	7/2	8/2	9/2	10/2	11/2
1	2.3	11/1	12/1	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1
2	3.4	10/1	11/1	12/1	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1
3	4.5	8/3	9/3	10/3	11/3	12/3	1/3	2/3	3/3	4/3	5/3	6/3	7/3
4	5.8	7/3	8/3	9/3	10/3	11/3	12/3	1/3	2/3	3/3	4/3	5/3	6/3
5	6.9	6/2	7/2	8/2	9/2	10/2	11/2	12/2	1/2	2/2	3/2	4/2	5/2
6	8.0	5/2	6/2	7/2	8/2	9/2	10/2	11/2	12/2	1/2	2/2	3/2	4/2
7	9.2	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1	1/1	2/1	3/1
8	10.3	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1	1/1	2/1
9	11.5	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1	1/1
10	12.6	12/3	1/3	2/3	3/3	4/3	5/3	6/3	7/3	8/3	9/3	10/3	11/3
11	13.8	11/3	12/3	1/3	2/3	3/3	4/3	5/3	6/3	7/3	8/3	9/3	10/3
12	14.9	10/2	11/2	12/2	1/2	2/2	3/2	4/2	5/2	6/2	7/2	8/2	9/2
13	16.1	9/2	10/2	11/2	12/2	1/2	2/2	3/2	4/2	5/2	6/2	7/2	8/2
14	17.2	8/1	9/1	10/1	11/1	12/1	1/1	2/1	3/1	4/1	5/1	6/1	7/1
15	18.4	7/1	8/1	9/1	10/1	11/1	12/1	1/1	2/1	3/1	4/1	5/1	6/1
16	19.5	5/3	6/3	7/3	8/3	9/3	10/3	11/3	12/3	1/3	2/3	3/3	4/3
17	20.7	4/3	5/3	6/3	7/3	8/3	9/3	10/3	11/3	12/3	1/3	2/3	3/3

Females: Diameters of the largest graafian follicles were measured for 89 sperm whales in resting and pubertal stages. They were caught in the adjacent waters to Japan during the months June-November. Monthly frequencies of the diameters are shown in Fig. 1. Mean diameter has a tendency to decrease with the increase of month. Although there is no data on the measurement in other months, it is estimated that there is a periodic change in the diameter of graafian follicle. If the season when the whale has the largest graafin follicle agrees with breeding season, it is estimated to be before June. In the other hand, in the frequency distribution of the size of graafian follicles there are two modes. If the ovarian follicle over 25 mm in diameter is near the maturity, such follicles are observed during June-Ocotober. This phenomenon will show a possibility that there are some individuals which ovulate during the seasons.

TABLE 2. RECORDS OF FOETAL LENGTHS OF THE NORTHERN HEMISPHERE SPERM WHALES GIVEN IN THE INTERNATIONAL WHALING STATISTICS 1937-61

Foetal length (feet)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
0	—	—	1	5	—	2	2	4	—	—	—	—	14
1	—	—	1	—	3	8	23	22	22	8	2	—	89
2	—	—	—	2	—	2	9	47	45	16	7	3	131
3	—	1	—	1	1	1	3	27	50	25	16	1	126
4	1	—	—	—	7	3	4	11	30	29	13	2	100
5	—	2	3	4	2	4	—	5	11	30	14	1	76
6	1	1	1	1	5	6	3	9	7	7	8	7	56
7	2	—	1	5	7	3	2	3	2	1	7	3	36
8	4	1	6	6	8	4	3	5	2	—	—	1	40
9	1	3	2	16	12	6	4	7	4	5	—	—	60
10	2	6	9	16	20	3	8	6	5	2	1	3	81
11	—	1	4	18	14	5	10	9	11	3	—	—	75
12	—	1	6	19	19	6	17	18	13	2	—	—	101
13	—	—	1	4	13	10	16	14	9	1	—	—	68
14	—	—	—	—	3	4	11	10	4	3	—	—	35
15	—	—	—	1	2	1	2	2	4	1	—	—	13
16	—	—	—	—	1	—	—	—	1	—	—	—	2
17	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	11	16	35	98	117	68	117	199	220	133	68	21	1,103

TABLE 3. RECORDS OF FOETAL LENGTHS OF SOUTHERN HEMISPHERE SPERM WHALES GIVEN IN THE INTERNATIONAL WHALING STATISTICS, 1937-61

Foetal length (feet)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
0	—	1	1	—	—	—	—	—	—	1	5	—	8
1	1	5	6	7	3	—	—	1	—	4	2	—	29
2	2	6	11	14	13	—	1	—	2	2	1	1	53
3	5	7	22	22	23	12	4	3	4	4	2	—	100
4	2	5	13	21	38	29	8	11	3	4	—	—	134
5	1	3	7	19	34	27	13	10	14	8	8	1	145
6	2	1	1	14	22	19	22	29	19	29	10	2	170
7	2	3	4	7	14	12	17	24	24	24	14	3	148
8	5	2	—	4	2	16	21	44	41	45	32	1	213
9	5	1	2	—	—	8	11	26	36	35	20	4	148
10	5	2	2	1	2	1	7	14	19	37	35	8	133
11	8	3	2	1	—	—	4	2	20	26	17	8	91
12	14	3	2	5	3	1	2	6	7	27	27	6	103
13	13	4	5	—	3	1	—	—	3	13	19	6	67
14	3	1	2	—	2	—	1	—	3	4	6	5	27
15	3	—	1	—	1	—	—	—	—	4	1	—	10
16	—	—	—	—	—	—	—	—	—	—	—	1	1
17	—	—	—	—	—	—	—	—	1	—	—	2	3
20	—	—	1	—	—	—	—	—	—	—	—	—	1
Total	71	47	82	115	160	126	111	170	196	267	199	48	1,592

Estimation of pairing season from body lengths of foetuses

In the following chapter, growth curves in the gestation period will be shown. In Fig. 7, the growth curves of foetuses in northern and southern sperm whales agree with each other sliding the time axis to 6 months. This means that the pairing season in the northern and southern hemispheres are opposite in time but the same in season of the year as shown by Clarke (1956).

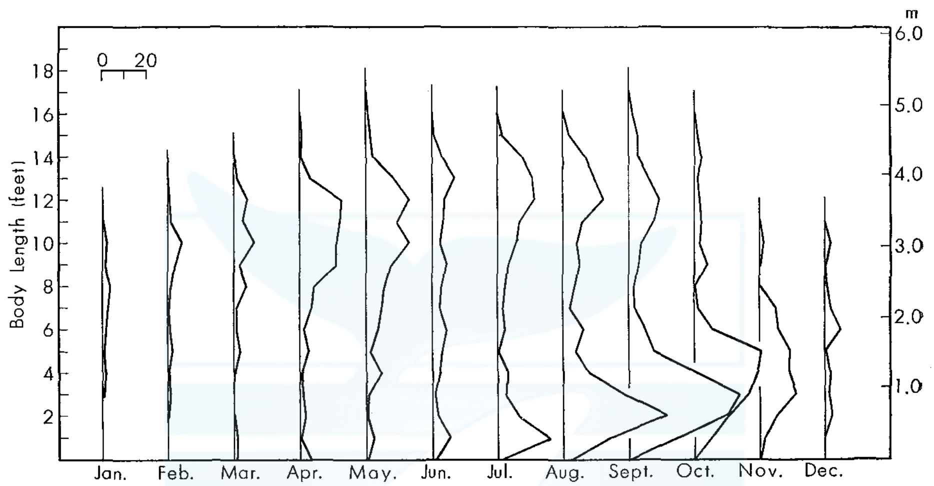

Fig. 2. Monthly foetal length frequencies of the northern hemisphere sperm whale.

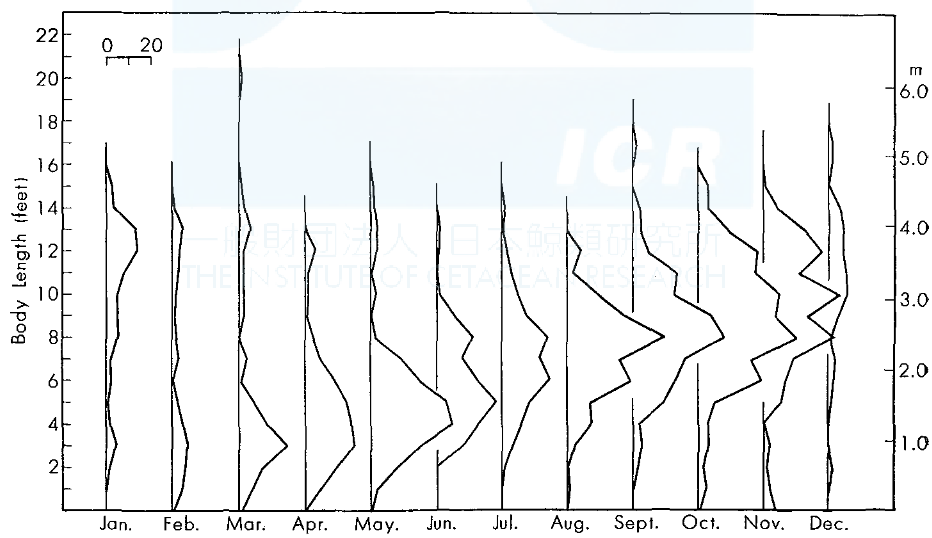

Fig. 3. Monthly foetal length frequencies of the southern hemisphere sperm whale.

Conception date will be calculated with the method of Huggett & Widdas (1951) in the following chapter. According the result, peak of conception date is middle-late decade of April in the northern hemisphere, and middle-late decade of October in the southern hemisphere. However, as shown in Figs. 2 and 3, breeding will last fairly long time. Basing the growth curve, conception dates and gestation months are calculated in each foetal length of each month as shown in Table 1. And Tables 2 & 3 are the frequency of foetal size distribution in each month for the sperm whales of which data were given from the International Whaling Statistics, 1937–1961.

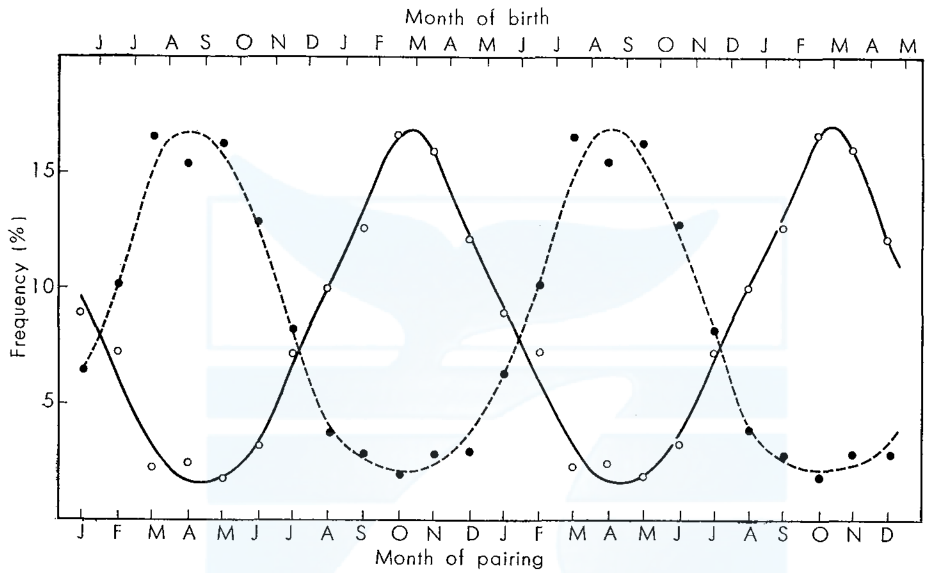

Fig. 4. Pairing and parturition frequencies calculated from foetal lengths for the southern and northern sperm whales.
Open circles and solid line: southern hemisphere, Closed circles and broken line: northern hemispnere.

Frequency of conception dates were calculated from Tables 1, 2, and 3. Pairing extends all seasons of the year as shown in Fig. 4. But the mode of pairing is April and October in the northern and southern hemisphere respectively, and most conception extends between February to June in the northern hemisphere, and between August to December in the southern hemisphere. The months are late winter to late spring in both hemispheres, and during the months, 71 and 67 per cent of total conceptions of the year are considered to take plase in the northern and southern hemisphere respectively. Bimodal frequency distribution of the pairing season is not seen in the sperm whale as reported by Naaktgeboren *et al.* (1960) for the fin whale.

Change of pairing season according to the age of the mother whale

Laws (1961) reports that pairing seasons are different between primiparous and multiparous fin whales, the former is about one month later than the latter, and pairing season becomes earlier with the increase of age of the mother whale.

Body lengths of foetuses were measured and maxillary teeth of the mothers were collected for 110 sperm whales in Japanese coast during 1960 to 1962 seasons. The conception dates were calculated from foetal lengths, and the ages were counted on the growth layers in the dentine of maxillary teeth. Fig. 5 shows the average conception date in the age classes of the whales. Average conception date in under 10 years class which is estimated to be almost primiparous is 6th of June, on the contrary, average conception dates of over 11 years classes which are estimated to be almost multiparous are early decade or middle decade of May. Furthermore, there is a tendency that pairing date becomes gradually earlier accompanying with the increase of age in the sperm whale.

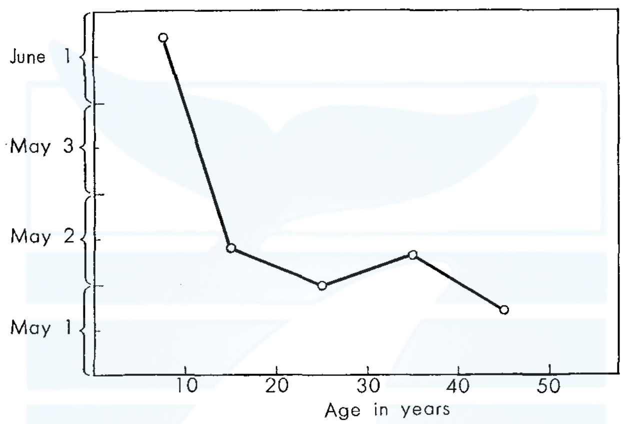

Fig. 5. Change of average conception dates according to the age of sperm whales in the waters adjacent to Japan.

In Japanese coastal whaling, composition of younger female sperm whales in the catch increases gradually from spring to fall. This phenomenon means older group migrates northward ealier. And it is estimated that whales having early pairing season leave their breeding ground earlier than the others. Further investigation will need on the ecology of schools especially " harem " in the sperm whale for the solution of this problem.

Yearly fluctuation of pairing season

Conception dates were calculated from the records of foetal lengths of the sperm whales caught in adjacent waters to Japan during 17 years from 1946 to 1962, and average conception date was calculated in each year. Fig. 6 shows the result. During these years conception took plase earliest in 1947, and average date was 6th of April, and the latest year was 1958. The average date was 20th of May. Range of yearly fluctuations is one month and a half.

Recently pairing season seems to become later from Fig. 6, but we must remember that recently the catch season removes to fall in Japanese coastal whaling. And as described in the previous section, composition of younger whales in the catch increases from spring to fall. The younger females have later pairing season.

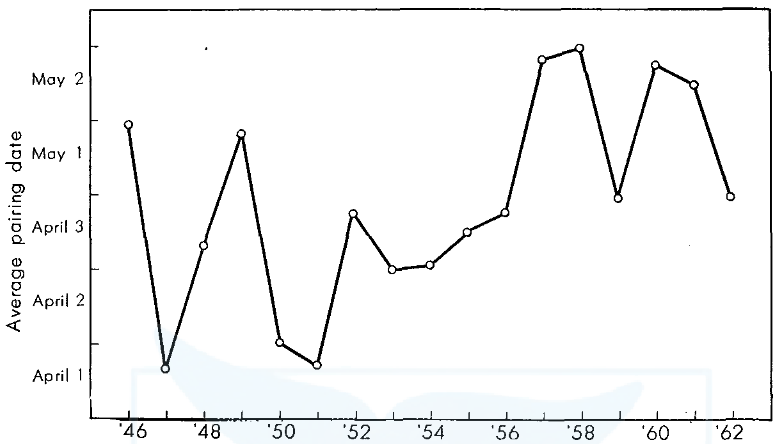

Fig. 6. Yearly fluctuation of conception dates for the sperm whales in adjacent waters to Japan during 1946 to 1962, based on foetal lengths in each month.

GESTATION, PARTURITION AND LACTATION

Monthly foetal length frequency

Using the records on the foetal lengths given in the International Whaling Statistics, 1937–1961, monthly foetal length frequencies are summarized in Tables 2 and 3 for the northern and southern sperm whales respectively. In Figs. 2 and 3 the monthly foetal length frequency distributions are set out. Comparing the two figures, we can find that monthly frequency distributions are different each other between the northern and southern sperm whales. It is clear that they are separated to different stocks. On the contrary, in the northern sperm whales, the monthly frequency distributions do not show significant difference among the whales taken in the waters of Japan, Kuril Islands, Pacific coast of North America and the North Atlantic. In the same way, the monthly length distributions do not show the significant difference among the whales caught in the waters of Chile, Peru and South Africa. That is to say, if there are several stocks in the same hemisphere, they will show the same growth pattern in their gestation periods.

In some months there are two peaks of the length distribution. Bimodal distributions are evidently seen in July, August and September in the northern hemisphere and January, February and March in the southern hemisphere. The monthly peaks move continuously to the peak in the next month. These phenomena suggest that modal period of conception is one a year, and the gestation period lasts over one year.

Growth curve of the foetus

Fig. 7 shows the relation between the mean foetal lengths in each decade for the northern and southern sperm whales. The data are due to the International Whaling Statistics, 1937–1961. In this figure, growth curves of both hemisphere sperm whales fit each other when one of them slide the axis of abscissa to 6 months. This means that the growth rates are almost the same between the both hemisphere sperm whales. Excluding the earlier and later stages, the given figures are recognized as straight lines. In early stage the figures are seemed to be higher than the actual one, for very small embryos are apt to be overlook and are not recorded occasionally. On the contrary, in the late stage of gestation we must consider that the given figures are seemed to be lower than the actual, because in this season there are some individuals which are already born, and they bring down the true figure.

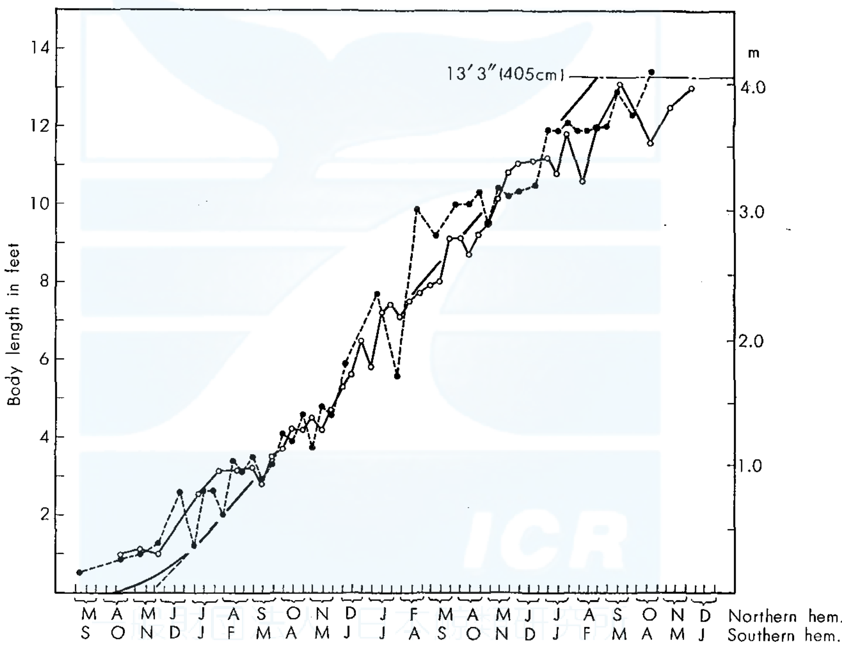

Fig. 7. Mean foetal lengths in each decade and foetal growth in length of both hemisphere sperm whales.
Broken line and closed circles: Northern hemisphere, Solid line and open circles: Southern hemisphere, Broad line: growth curve.

Two regression lines are calculated using the mean foetal lengths in each decade during the months September to June in the northern hemisphere and March to December in the southern hemisphere. Cross point between the regression line and the axis of abscissa is the last decade of May and the last decade of November for the northern and southern hemisphere respectively. And the cross point between the body length at birth (405 cm or 13 feet 3 inches, as shown in the following section) and the regression line is the last decade of August and the last decade of February in the northern and southern hemisphere respectively. Therefore, the period between the two points is 15 months and one decade (468 days) in the both hemisphere.

Laws (1959) showed that the foetal growth in toothed whales could be described by a linear plot of length except non-linear early part of pregnancy. And I agree with his theory for the case of the sperm whale.

The mean conception date was calculated by means of the method of Huggett & Widdas (1951) and Laws (1959):

$$Lt_0 = 468 \text{ days} \times 0.07/0.93$$
$$= 35 \text{ days}$$

Therefore, the conception date is estimated to be middle to last decade of April and middle to last decade of October in the northern and southern hemisphere sperm whales.

Thus, the growth curve of the foetus of the sperm whale is drawn as broad line in Fig. 7, and the both hemisphere sperm whales will show the same growth curve in gestation period.

TABLE 4. FOETAL LENGTHS OF SPERM WHALE IN EACH GESTATION MONTH

Gestation month	Foetal length		Month	Foetal length	
	feet	cm		feet	cm
1	0.2	6	9	6.9	210
2	0.8	24	10	7.7	234
3	1.7	52	11	8.6	262
4	2.5	76	12	9.5	289
5	3.4	103	13	10.3	314
6	4.2	127	14	11.2	341
7	5.1	155	15	12.1	369
8	6.0	183	16	12.9	393

Table 4 shows the average foetal length in each gestation month.

Growth rate of foetus in males seems to be slightly greater than that in females, but the difference will be very small.

Sex ratio in gestation period

Sex ratio in foetal stage is one of the needful factors for the stock assessment of sperm whale.

Summarizing 2677 foetal records in the International Whaling Statistics, 1937–1961, calculated sex ratios of males are shown in Table 5. They are 48.1, 56.2 and 45.6 per cent in the waters of the North Pacific, Chile & Peru and Africa respectively. The average sex ratio of males is calculated as 51.03 per cent. Therefore, it will be concluded that the sex ratios of males and females are almost equal in the sperm whale.

Body length at birth

On the body length birth in the sperm whales, several authors described as shown in Table 6.

TABLE 5. SEX RATIOS OF THE SPERM WHALE IN THE FOETAL STAGE

	North Pacific	Chile & Peru	Africa	Total
Males	514	628	224	1,366
Females	554	490	267	1,311
Both sexes	1,068	1,118	491	2,677
% of males	48.13	56.17	45.62	51.03

After the International Whaling Statistics 1937–1961

TABLE 6. DESCRIPTIONS ON THE BODY LENGTHS AT BIRTH IN THE SPERM WHALE BY SEVERAL AUTHORS

Authors	Body length at the brith	Locality
Bennett (1840)	14 ft	
Melville (1851)	14–15 ft	
Matsuura (1936)	13–14 shiaku	Japan
—— (1940)	14–15 shiaku	Japan
Matthews (1938)	4 m or little more	Southern hemisphere
Mizue & Jimbo (1940)	14–15 ft	Japan
Clarke (1956)	3.92 m	Azores
Laws (1959)	4.15 m	Southern hemisphere

TABLE 7. RECORDS OF NEWLY BORN SPERM WHALES

Body length		Date	Locality	Author
3.71 m	(12′ 8″)	14, VIII	Azores	Clarke (1956)
3.86 „	(12′ 8″)	12, VIII	„	„
3.89 „	(12′ 9″)	12, VIII	„	„
4.04 „	(13′ 3″)	11, VIII	„	„
4.04 „	(13′ 3″)	? IX	Barmuda	Wheeler (1933)
5.00 „	(16′ 5″)	27, VII	Japan	Ohsumi *et al* (1963)
5.2 „	(17′)	19, VIII	„	Matsuura (1940)
5.2 „	(17′)	27, X	„	„
5.5 „	(18′)	?	North Atlantic	Harmer (1933)

Observation of parturition for the cetacea is very rare chanses for us, and so measurement of body length at birth is almost impossible. Neonatal body length must be determined with larger foetal lengths and body length of calves which are estimated as soon after birth. However, whale calves are protected from catch, and we have only few data on the measurements of the calves as shown in Table 7.

The shortest calf was 3.71 m (12′ 2″) in this Table. According to Ohsumi *et al.* (1963), a calf stranded in a Japanese beach on 27th July, 1957. This calf was 5.00 m (16′ 5″) in body length, and had no growth layer in dentine of teeth. Examining the deposition of dentine, the calf was at least 4 months old, then the neonatal length is clearly estimated to be under 5 m.

The maximum foetal length is 19 feet 6 inches in the records on the sperm whale foetuses in International Whaling Statistics. But it is exceptional, and I wonder whether it was foetus actually or not. In the records of 2,695 sperm whale foetuses, there are 6 (0.22%) foetuses of which body lengths are 17 and 16 feet.

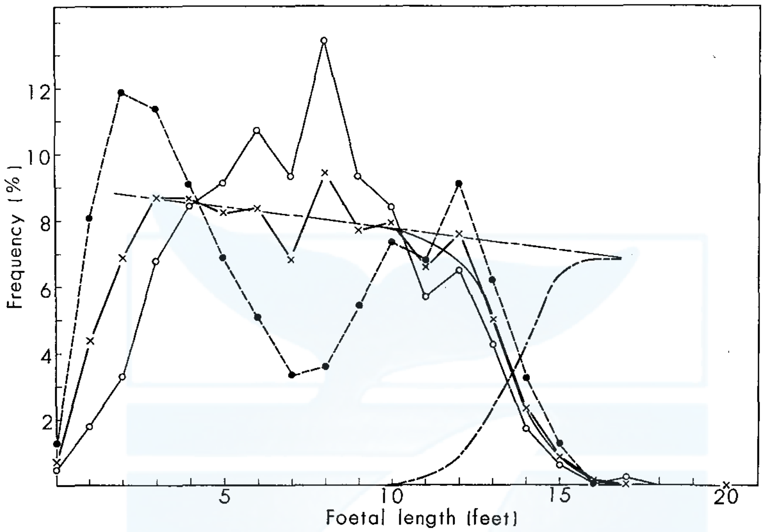

Fig. 8. Size distributions of the sperm whale foetuses, and estimation of the length at birth.

Open circles and solid line: Southern hemisphere, Closed circles and broken line: Northern hemisphere, Crosses and broad line: Both hemisphere, Straight Chain line: Estimated change of frequency from broad line, Broad chain line: Estimated size distribution of calves (Straight line minus broad line).

Fig. 8 shows the size distributions of sperm whale foetuses. Pattern of the distribution in the northern hemisphere is different with that in the southern hemisphere. It is caused with the difference of whaling season between the both hemisphere (foetus data are many in summer-fall seasons in the northern hemisphere, and they are many in spring season in the southern hemisphere). Summing up the data in the both hemisphere, the combined frequency distribution gradually decreases from 3 to 12 feet, after then the frequency decreases suddenly. Comparing size distributions over 8 feet long in the summer season (July-September in northern hemisphere and January-March in southern hemisphere) when is the parturition season of the sperm whale as described in the following section, the distribution patterns of the both hemisphere are nearly the same each other, although modal lengths are 13 and 12 feet in the southern and northern hemisphere respectively as shown in Fig. 9. Average foetal lengths are 11.67 and 11.78 feet in southern and northen hemisphere sperm whales. These results mean that there is no difference of body lengths at birth between the both hemisphere sperm whales. The neonatal length should be larger than the average foetal length at the season, because the individuals which have been born at that season are of course excluded from the size distribution of foetuses, and they drop the really average body length in this season.

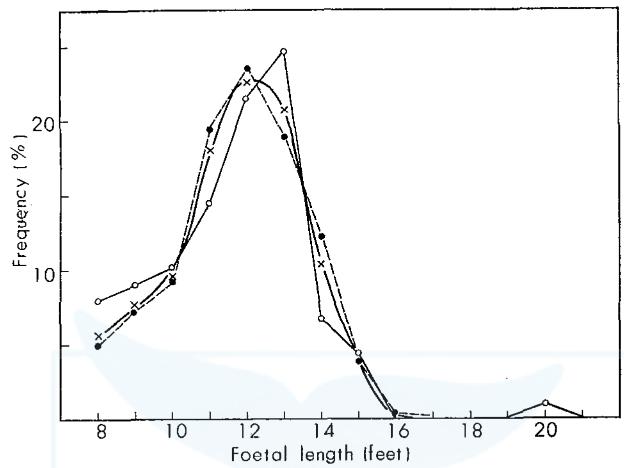

Fig. 9. Foetal size distribution of the sperm whales in parturition months.

Open circles and solid line: Southern hemisphere in January, February and March, Closed circles and broken line: Northern hemisphere in July, August and September, Crosses and broad line: Both hemisphere.

Regression line was drawn in Fig. 8, and estimating that the distance between the line and smoothed broad curve is the frequency of calves, the size distribution of calves are shown as a broad chain line in Fig. 8. Cross point between chain line and smoothed foetal line is 13.6 feet (4.15 m). It is estimated the length is the average body length at birth in the sperm whale. However, considering the records that there are 5 calves of wich body langths are under 4.15 m among the few data in Table 7, the given neonatal length will be little larger than the real one. The body lengths of the 5 calves are between 3.71 and 4.04 m, and the average is 3.98 m. In conclution I estimate that 4.05 m (13 feet 3 inches) is the average body length at birth in the sperm whale of both hemispheres.

Parturition season

Table 8 shows the parturition season in the sperm whales described by several authors.

In the previous section, the average body length at birth was given as 13 feet 3 inches. The mean parturition date will be got from a cross point between the growth curve and the body length of 13 feet 3 inches in Fig. 7. It is last decade of August in the northern hemisphere, and last decade of February in the southern hemisphere. They are both late-summer season. Catch dates of the calves which are considered to be soon after birth are during middle decade of August to September as shown in Table 7. This will support the above result.

Fig. 4 shows periodical change of parturition dates in addition to the periodical change of conception dates calculated by means of growth curve and foetal size frequencies in each month. In the northern sperm whales, 71 per cent of the year's parturition takes plase during June to October, and in the peak month August 20.8 per cent of parturitoion. Parturition lasts through the year, but during January to April the proportion of parturition is only 11 per cent. In the southern hemisphere, 67 per cent of parturition will take plase during December to April, and 9 per cent during July to October.

TABLE 8. DESCRIPTIONS ON THE PARTURITION SEASONS IN THE SPERM WHALE BY SEVERAL AUTHORS

Authors Northern hemisphere	Parturiton season	Location
Beale (1839)	Not limited	
Bennett (1840)	Ditto	Japan
Tago (1922)	Ditto	Japan
Harmer (1933)	June～December	Bormuda Is.
Matsuura (1936)	May～August	Japan
—— (1940)	May～September	Japan
Mizue & Jimbo (1950)	July～October	Japan
Clarke (1956)	May～November (peak: July～August)	Azores Is.
Chuzhakina (1961)	May～October (peak: July～August)	Kuril Is.
Southern hemisphere Matthews (1938)	September～April (peak: February)	Africa

Gestation period

On the gestation period for the sperm whale, Scammon (1874) described as 10 months. Harmer (1933) and Matsuura (1936) estimated to be 12 months. Later authors all reported longer gestation periods. Matthews (1938), Matsuura (1940) and Clarke (1956) got a result of 16 months, Mizue & Jimbo (1950) 17 months, and Chuzhakina (1961) 16–17 months respectively for the gestation period of the sperm whale. Laws (1959) studied foetal growths for several cetaceans, and calculated the gestation period of the sperm whale to be 491 days or 16 months.

As described in the former sections, average conception date is middle decade of April, and the average parturition date is last decade of August in the next year for the northern sperm whale. For the southern sperm whale, they slide just 6 months from those in the northern hemisphere. Therefore, gestation period is calculated to be 16.4 months (about 503 days). Of course we must estimate that there is individual variation in the gestation period in the sperm whale.

Body length at weaning

We have scanty knowledges on the lactation of the sperm whale.

Matsuura (1936) estimated the lactation period to be about 6 months, but he did not describe on the body length at weaning. Matthews (1938) thought lactating period was 7 months, and length at weaning was estimated with growth curve and lactating period to be 6.5 m (21 feet). Clarke (1956) examined the stomach contents of 15 small sperm whales caught in the waters to adjacent Azores Islands. And he found that milk was contained in the stomach of whales under 6.6 m in length, but food animals were found in those of whales over 6.8 m in length. Then he determined weaning length of the sperm whale would be between 6.6 and 6.8 m, probablly 6.7 m (22 feet).

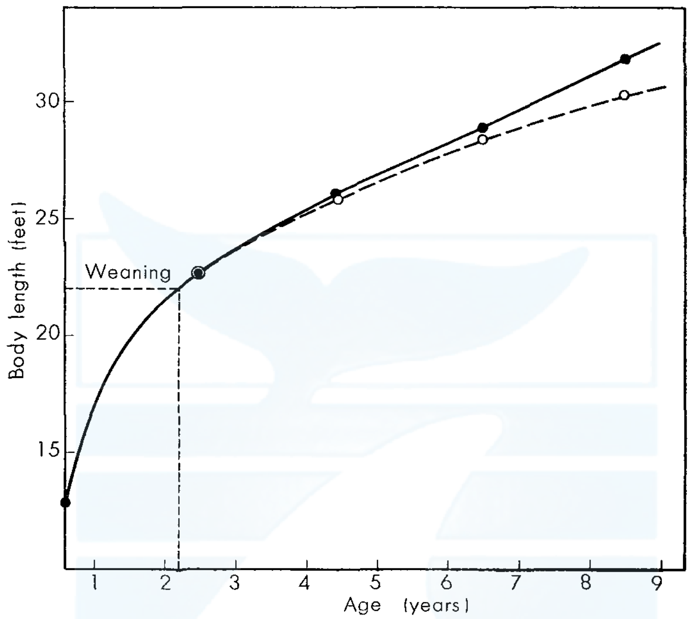

Fig. 10. Growth curves of male and female sperm whales based on the growth layers in dentine of maxillary tooth, and estimation of weaning period from body length at weaning.
Open circle and broken line: Females, Closed circle and solid line: Males.

There was nothing in the stomach of a 5.0 m long sperm whale which stranded on Japanese coast. This whale was estimated to be suckling, although milk was not confirmed in the stomach.

According to some observations on feeding of small sized toothed whales in aquariums, infants begin to eat food simultaneously suck mother's milk after some months from birth (Tavolga & Essapian, 1957; etc.).

At the present time, there is no datum to be added to the information by Clarke (1956) on the problem of body length at weaning for the sperm whale, and so I also employ his theory for the length at weaning in the present paper.

Weaning season and lactation period

Matsuura (1936) estimated lactation period was 6 months, and in his paper parturition season was May-August. Then weaning season is December-February in his theory. Matthews (1936) estimated that weaning season was August for southern sperm whale. Clarke (1956) determined the season was September, for the whales of weaning body length appeared during July-October in Azores. And he also estimated the lactation period to be 13 months after correction with weaning season of the calculated 15 months from the composition of lactating and pregnant whales.

As described in former sections we have few chanses to investigate calves, and so to pursue a growth in length seasonally is impossible for the sperm whale. Another method is to use growth curve as examined by Matthews (1938).

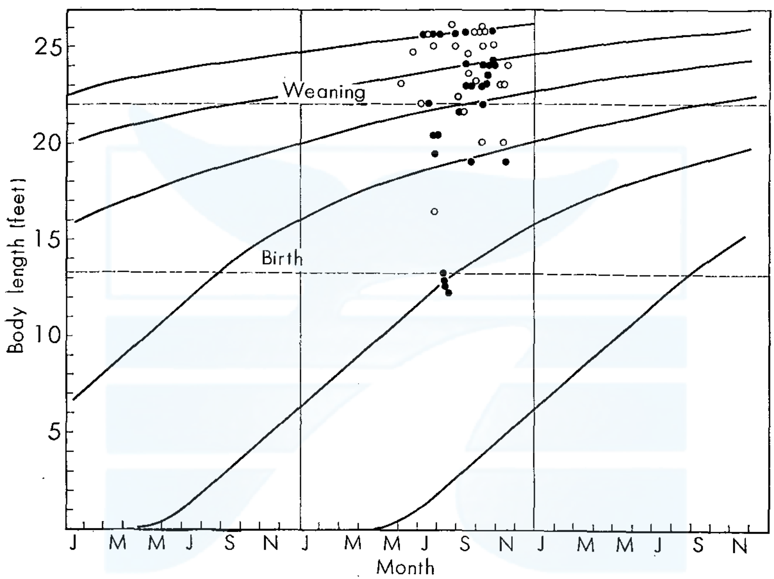

Fig. 11. Growth curve of foetuses and calves for the sperm whales in the northern hemisphere, and the records of date and body length of calves.
Open circle: Female, Closed circle: Male.

Recently age determination of the sperm whale has developed by reading growth layers in the dentine of maxillary teeth (Nishiwaki *et al.*, 1958; Ohsumi *et al.*, 1963). Fig. 10 shows a growth curve based on reading the growth layers in young sperm whales. According to Ohsumi *et al.*, dark band in dentine appears in winter, and mean parturition season is August. Therefore, a time from birth to formation of the first dark band is about 4 months in average. In Fig. 10, graduations on the axis of abssisa show winter (January 1st).

If the weaning length is 22 feet, lactation period is estimated from Fig. 10 as 1.6 years (2.3–0.7=1.6). If lactation period is 1.6 years (=19 months), weaning season becomes March-April in the northern hemisphere. However, Clarke states weaning season is September considering the appearence of weaning whales, and as shown in later chapter, proportion of resting whales increase after August. Therefore, I determine weaning season is August or September in the northern hemisphere. Then the lactation period is more suitable to estimate as 24–25 months than 19 months.

Fig. 11 shows growth curve in gestation and calving ages and some plots of calves by date and length. As there are individual variations in growth rate and conception date, plotted points ride not always on the growth curve.

In the present paper, lactation period becomes much longer than the previous theory. On this problem, bottle-nosed dolphin (*Tursiops truncatus*) which were kept alive in an aquarium suckle for 18 months (Tavolga & Essapian, 1957), and a mother bottle-nosed dolphin (*Tursiops gilli*) which died at 2 years and 6 months after parturition secreted milk still at its death (Nakajima, 1963). According to Sergeant (1962), pilot whale (*Globicephala melaena*) has 22 months of lcatation period. Above reports seem to support my result.

OVULATION

Relation between the number of ovulation and age

Age of the sperm whale is present in the dentine of the maxillary tooth as a growth layer (Nishiwaki *et al.*, 1958). And the annual accumulation rate of the growth layer is studied by Ohsumi *et al.* (1963).

The relation between the age (number of growth layers in the dentine) and the number of corpora lutea and corpora albicantia in the ovaries were given for 892 female sperm whales which were investigated in the coast of Japan during the seasons from 1960 to 1962. Fig. 12 shows the above relation on each individual. Individual variation is relatively remarkable, but correlation coefficient is calculated as +0.76 for the ages more than 6 years old. There is an intensity that the deviation spreads accompanied with the increase of the age. This seems to show that there is individual variation in the ovulation cycle of the sperm whale. On the other hand, the ages at one ovulation distribute from 6 to 18 years. This shows that there is an individual variation in the age at sexual maturity. Then, the variance of the relation between age and number of ovulation is caused by the above two factors.

Fig. 13 shows the mean number of ovulations in each age (solid line) and the mean age in each number of ovulation (broken line). Two lines are both likely straight. This shows that there is close relation between age and number of ovulation, and the ovulation cycle is constant as the avarage. However, examining in detail, the gradient of the line is larger in the young ages than that in the older ages, and in old ages, the deviation between solid line and broken line spread each other. The ovulation is seemed to become gradually to lessen in the relation with the age.

Average annual number of ovulation and average ovulation cycle

Average annual number of ovulation was given calculating the coefficient of regression line from relation table. In above section we found that gradient of the

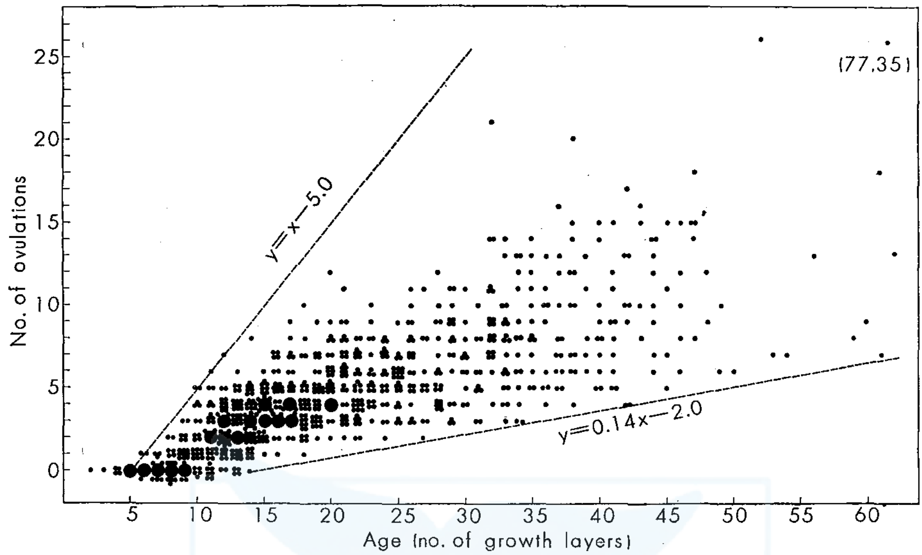

Fig. 12. Relation between age and number of ovulations for the sperm whales caught in the waters adjacent to Japan (1960–1962).

Small circle: One whale, Large circle: Ten whales, Broken lines: Upper and lower limits.

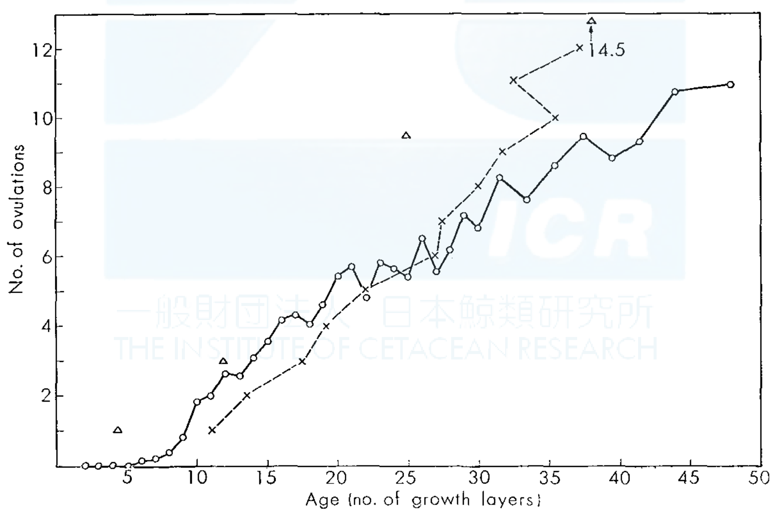

Fig. 13. Mean number of ovulations in each age and mean age in each number of ovulations for the sperm whales in the waters adjacent to Japan (1960–1962).

Open circles and solid line: Mean number of ovulations in each age, Crosses and broken line: mean age in each number of ovulations, Triangle: Result in the paper by Chuzakina (1961).

line in younger ages is different from that in older ages, then two coefficients were given separated at the age of 20 years as shown in the following:

Age	Average annual number of ovulation
6–20	0.308
21–48	0.255
6–48	0.265

In the older ages average annual number of ovulation is low, and 3 factors will be considered on this subject. The first is a possibility that ovulation cycle becomes prolonged as the increment of the age. The second factor is a ploblem whether old corpus albicans is not able to be distinguished or not. On this problem I will examine in the following section. The third factor is a artificial error on the counting of corpora albicantia. As the increase of accumulation of corpora albicantia in the ovaries, we are apt to miss counting the corpora number.

TABLE 9. BIOLOGICAL DATA ON FOUR MARKED SPERM WHALES RECAPTURED IN THE NORTH PACIFIC BY 1962

Mark no.	Elapsed time(A) (Years-Months)	No. of growth layers at recapture(B)	No. of corp lut. & alb. in ovaries(C)	Estimated age at marking(B-A)	Estimated age from sexual mat.(D)	Annual no. of ovulation(C/D)
J2871	10–1 1/3	18	0–2, 0–1	8	9	0.33
J2883, 2984	10–1 1/3	20	1–2, 0–3	10	11	0.54
J3166	9–1	30	0–3, lost	21	21	(0.29)
J3237	8–2 1/2	14	0–0, 0–2	6	5	0.40

As shown in Fig. 12, the deviation of corpora number are relatively large, but the ranges are limitted within two broken lines. Average annual number of ovulalation given from the upper limitted line is 1.00, and this value is considered to show the maximum vulation rate. On the contrary, annual ovulation number given from the lower limitted line is 0.14, and this will show the minimum ovulation rate of the sperm whale. Therefore, annual ovulation number is included within the range from 0.14 to 1.00, and the average annual rate is considered to be 0.27 in the sperm whale caught in the waters adjacent to Japan.

Calculating the ovulation cycle from the annual number of ovulation, it distributes from one year to 7.1 years, and the average ovulation cycle is 3.7 years. Then, the ovulation cycle of the sperm whale is considered to be fairly long, and connecting with the reproductive cycle as shown in the following chapter, the sperm whale is estimated to be mono-oestrous.

Examination of annual number of ovulation by means of whale marking

Amoung the marked sperm whales recaptured in the North Pacific by the end of 1962, there were 4 individuals of which maxillary tooth was collected for the age counting and in the same time the corpora number in the ovaries were counted. The biological data on the 4 individuals are shown in Table 9. We can not know the age at the time of marking of the recaptured whales, but it is able to be estimated by the elapsed time from marking till recapture and the growth layers in the dentine of upper tooth.

Now, the age at sexual maturity was estimated to be 9 years (Ohsumi *et al.*, 1963). In the present paper also shows the similar result, for cross point of solid line at lovulation level in Fig. 12 is 9.2 years. Age at marking of J 2871 whale is estimated to be 8 years, then this individual was near the age at sexual maturity at that time. Using the average age at sexual maturity, it will be estimated to become sexual maturity after 1 year from marking. As elapsed time is 10 years, this individual is estimated to be 9 years from sexual maturity. Finally, average annual number of ovulation is calculated from the number of ovulations devided by the age from sexual maturity, and it is 0.33. In the same way, average annual number of ovulation on other 3 recaptured whales are 0.54, 0.29, and 0.40 respectively for J 2883, J 3166, and J 3237. The average of 4 whales is 0.39. This value is similar to those which calculated in the above section.

Persistence of corpus albicans

It is believed that the involution speed of corpus albicans is very slow in the cetacea, and it does not vanish for the life span. On this problem, Laws (1961) studied thouroughly for the ovaries of the fin whale, and he supported the theory.

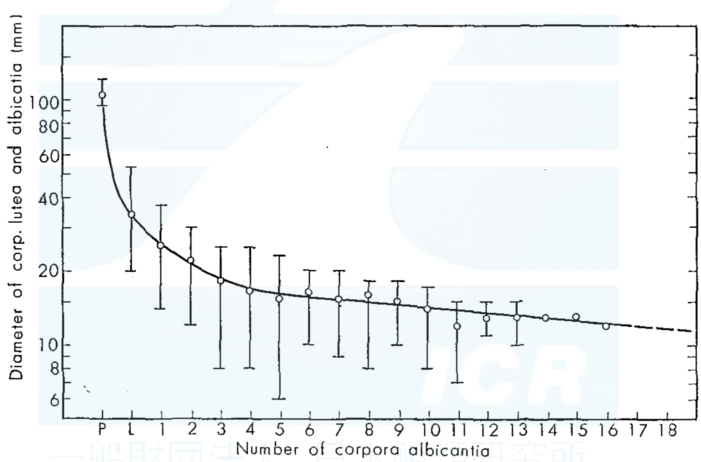

Fig. 14. Regression of mean diametre of corpora lutea and albicantia with increment of corpora numbers.
P: Corpora lutea of pregnancy, L: Corpora albicantia of lactation, Open circle: Mean value, Bar: Range of diametre.

Nishiwaki, Hibiya & Ohsumi (1958) measured the diametre of corpora lutea and corpora albicantia in the ovaries of 18 sperm whales, and reported preliminally that corpus albicans persisted for life span in the sperm whale. Then, Chuzhakina (1961) examined the ovaries of the sperm whale histologically, and got the same result as Nishiwaki *et al.*, because a corpus albicans which was disappearing partly or completely in the ovary was not observed at all.

In the present paper, diametres of corpora lutea and c. albicantia were measured for 29 sperm whales caught in the adjacent waters to Japan, and they were arrenged according to their size for each individual, to get the change of diametre accompanied with the increase in number of corpora albicantia in the ovaries. Corpus albicans of lactation was separated from other corpora albicantia.

As shown in Fig. 14, corpora lutea of pregnancy were 95–120 mm in diametre for 10 individuals, and the mean diametre of them was 105.0 mm. On the change of size in corpus luteum during gestation period, Chuzhakina (1961) reported that diameter of the body did not involute during the period. Laws (1961) describes the same result in the fin whale.

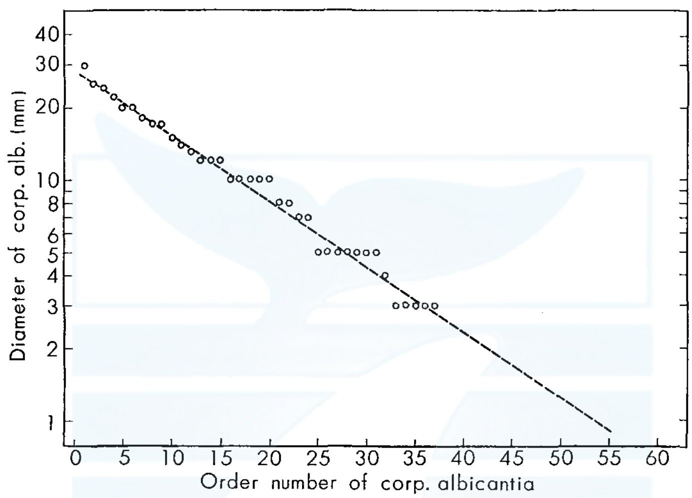

Fig. 15. Arrangement of diametre of 37 corpora albicantia in the ovaries of a sperm whale caught in the coastal waters of Japan.
Open circle: Actual diametre, Broken line: Regression curve.

After parturition corpus luteum reduses suddenly its size into corpus albicans. Corpora albicantia of lactation were 20 to 53 mm in diameter for 18 lactating sperm whales, and the mean diameter was 33.6 mm. The diameters of corpora albicantia except corpora albicantia of lactation were 3–37 mm. Arrenging them according to their size, it is found that the speed of involution gradually decreases, and the mean diameter of the corpora is 12 mm in the corpora number of 16. This size is easily recognized by naked eyes. However, the size of corpora albicantia in old stage is not constant as described by Laws (1961) for the fin whale, and seems to continue to decrease as shown in Fig. 14.

Fig. 15 shows the arrengement of diameters of 37 corpora albicantia in the ovaries of an individual which has the most corpora number in our materials. According to the Figure, the process of involution of corpus albicans is drawn as a hypabola, and the smallest corpus was 3 mm in diameter. If we are difficult to distinguish the size under 2 mm by naked eyes, the number of corpora will be 42 from the Figure. Considering from the frequency distribution of corpora number in the sperm whale, the composition of individuals of which number of corpora are over 20 is very small, and the maximum is 37. The age of the individual in Fig. 15 is 56+ from dentinal growth layers, and it is estimated to be very old.

It will be concluded that corpus albicans in the ovaries of the sperm whale continues to decrease in its size, but persists in ovary through the life.

Multiple-ovulation and multiplets

More than one ovum ovulate in the same time or simultaniously to the previous ovulation in an oestrus and at least one ovum furtilize in the oestrous, all Graafian follicles which have ovulated into oestrous should remain as *corpora lutea* during the gestation period. Then, the number of corpora lutea in the ovaries of a pregnant whale is considered to show the number of ovulations in the same oestrous period, although there are rare cases in which more than one ovum ovulate from one graafian follicle in cetacea (Bannister, 1963).

Of the total of 446 sperm whales which were investigated their both ovaries and had corpora lutea in the ovaries, 442 whales (99.11%) had only one copus luteum, 3 whales (0.67%) had 2 corpora lutea and one whale (0.22%) had 3 corpora lutea in the ovaries. Therefore, the frequency of multiple ovulation is considered to be extreamly low.

A frequency of multiplets is also an indication of multiple ovulations. However, the frequency of multiplets should be lower than that of multiple ovulation, because all ovulations do not always succeed to the furtilization. On the occurrence of twins in the sperm whales, Bennett (1840), Beneden & Gervais (1880), Matsuura (1936) and Matthews (1938) reported. And the frequency of twins is calculated as 0.66% from the data in the papers of the latter two authors. Using the records of foetuses of sperm whale in the International Whaling Statistics, of total 2,664 pregnant whales only 12 whales (0.45%) had twins. There is no record on the multiplets more than twin in the sperm whale. The frequency occurrence of multiplets will be lower than that of baleen whales (Kimura, 1956).

The frequency of the multiplets (0.45%) is lower than that of multiple ovulations (0.8%). But, it is dangerous to connect the figures to the fertilization rate of ovums, because the sperm whales are usually flensed in land stations where equipments are often worse than those in factory ships, and it will be apt to miss the finding of foetuses in the flensing at land stations.

PREGNANCY RATE

Seasonal change of pregnancy rate and the true pregnancy rate

Pregnancy rate is expressed as the rate of pregnant whales in the sexually mature females which have one or more than one corpus luteum or corpus albicans in the ovaries. Matsuura (1936) described that the occurrence of pregnant sperm whales varied with seasons in Japanese coast, but the total pregnancy rate was calculated as 34 per cent through the year. Matthews (1938) reported on the sperm whales in South Africa that of the total of 14 females which had been investigated during the seasons June to September 7 were pregnant and 5 were desided as soon after ovulation or early stage of pregnancy. Then the pregnancy rate is calculated as 86 per cent. Clarke (1956) stated that the pregnancy rate was 27 per cent during the seasons June to December in Azores Islands area, although he suggested the possibility of the phenomenon that some pregnant and lactating sperm whales did not approach to the area.

TABLE 10. MONTHLY CHANGE OF PREGNANCY RATES OF THE SPERM WHALFS CAUGHT IN THE ADJACENT WATERS TO JAPAN, 1960-62, AND THE CORRECTION FOR THE TRUE PREGNANCY RATE

	May & June	July	Aug.	Sept.	Oct.	Nov.	Total
Pregnant whales	26	31	117	280	98	21	573
Total mature whales	41	48	221	658	346	85	1,399
Pregnancy rate (%)	63.5	64.6	53.0	42.6	28.3	24.7	40.9
Exchange ratio 1	0.29	0.38	0.65	0.77	0.91	1.00	
True pregnancy rate 1 (%)	18.4	24.5	34.5	32.8	25.8	24.7	26.8
Exchange ratio 2	0.50	0.50	0.50	0.67	1.00	1.00	
True pregnancy rate 2 (%)	31.8	32.3	26.5	28.4	28.3	24.7	28.7

In the sexually mature females caught in the coastal waters of Japan from May to November during 1960–1962, the number of whales of which both ovaries were examined and number of whales which had corpus luteum in the ovaries among the above whales are shown in Table 10. Cutting the abdorminal part of whales for the purpose of cooling the carcas, foetuses are often lost in Japanese coastal whaling. However, I think that we have no objection to regard the whale which has corpus luteum in ovaries as the pregnant whale. It is because that pregnant whale has always corpus luteum, and when an ovum does not furtilize, corpus luteum involute fastly into corpus albicans. As the peak of pairing season is April in the northern hemisphere, the cases of occurrence of corpus luteum without furtilization will be scarse in the season of our investigation.

As shown in the Table, the pregnancy rate varies remarkably according to season. During the months from May to August, the rates are over 50 per cent, but it becomes to 42 per cent in September, and the rates are under 30 per cent in October and November.

Now, in the former chapter, gestation period of the sperm whale was estimated to be 16.4 months, and two groups exist in some seasons of the year. They are individuals which have been pregnant since the last year, and the other group includes the individuals which conceived in the next year during the seasons April to August, and after then, most pregnant whales were conceived in the year. Therefore, the pregnancy rates which were got according to each month during April to August are pretence ones.

For the purpose of calculation of the true pregnancy rate, the following two methods were employed. The first method is to get the ratios of the pregnant whales conceived in the year to total pregnant whales from size frequency of foetuses in Table 3, and the pretent pregnancy rates are recounted into the true rates by the above ratios. The ratios and the true pregnancy rates are shown in Table 10 as exchange ratio 1 and true pregnancy rate 1. As the result, the calculated pregnancy rates in each month become nearly constant and ranged between 18 and 35 per cent, and the average is 26.8 per cent.

However, in Table 10, small embryos are often difficult to be found and so it is considerable that some of the small embryos are not recorded by fishermen. Then, the second method is employed for calculation of the true pregnancy rate. In the northern hemisphere, the peak of parturition season is about August, and the peak of pairing season is considered to be April. Then, during 5 months from April to August, half of the pregnant whales should be conceived in the last year. In September I considered that 2/3 of the total pregnant whales are conceived in the year, because the large foetuses exist fairly in this month. The pregnant whales which appear in October and November are considered to be conceived in the same year. This method was preliminally emploied in the paper of Ohsumi *et al.* (1963). True pregnancy rate 2 is given in Table 10, using the above exchange ratio 2. The exchanged pregnancy rate 2 are almost constant in each month as similar as the true pregnancy rate 1, and they distribute between 24 and 32 per cent, and the average is calculated to be 28.7 per cent. In conclution, the true pregnancy rate of the sperm whale in the waters adjacent to Japan is estimated to be 26–29 per cent.

Previous reports on the pregnancy rate of the sperm whale did not consider the ratio of the whales which had been conceived in the last year. For instance, Matsuura (1936) reported the pregnancy rate as 34 per cent, but in his paper the average pregnancy rate during the months September to March was 28.6 per cent. This figure is very near to my result.

On this subject, a question is occured whether the materials which had been caught in the coast of Japan represent the total population of mature females in the ocean or not. Clarke (1956) suggested a segregation in the migration of pregnant and lactating females in Azores Islands waters. Ecological study on the schools of the sperm whale has not been developed, and the investigation on this problem should be done in future, but I want to pay attention on the result that the pregnancy rate fairly coincides with the annual number of ovulations which obtained in previous chapter. I consider that this coincidation shows the figures obtained as the true pregnancy rate representing those which in the mother population.

Change of pregnancy rate accompanied with age

Change of pregnancy rate accompanied with age is known in general mammals. But there are few reports on this subject for the cetacea.

Table 11 shows the age distribution of the pregnant whales (individuals which have corpus luteum in the ovaries) and the total females (individuals of which both ovaries were examined) caught in the coastal waters of Japan during 1960–1962 seasons. The ages are based on the number of growth layers in the dentine of maxillary tooth. Fig. 16 shows the change of pregnancy rate accompanied with age. These rates are of course pretent as described in previous section. Pregnancy rate increases suddenly after the age at sexual maturity, and it attains to maximum at 15–20 years. After then, the rate begins to decrease gradually with increment of age. However, the rate at 50 years of age is still 75 per cent of the figure at maximum rate. In Table 11, there is no pregnant whale over 61 years old. But the materials are few, and so it is not concluded from this phenomenon that there is menopause in the sperm whale.

TABLE 11. AGE COMPOSITION OF FEMALE SPERM WHALES, PREGNANT SPERM WHALES AND THE PERCENTAGE OF PREGMANT WHALES IN THE TOTAL FEMALES, JAPANESE COAST, 1960-62

Age (year)	Pregnant whales	Total whales	% of pregnant whales	
1- 2	—	1	0.0	
3- 4	—	3	0.0	
5- 6	2	29	6.9	
7- 8	6	52	11.5	
9-10	22	69	31.9	
11-12	46	101	45.5	
13-14	40	119	33.6	
15-16	35	82	42.7	
17-18	32	81	39.5	
19-20	41	76	53.9	
21-22	23	67	34.4	
23-24	16	43	37.2	
25-26	18	54	33.4	
27-28	12	33	36.4	
29-30	14	35	40.0	
31-32	12	35	34.3	
33-34	13	37	35.2	
35-36	12	31	38.8	
37-38	7	29	24.1	31.1
39-40	8	19	42.1	
41-42	7	19	36.8	37.5
43-44	5	13	38.5	
45-46	4	13	30.8	31.6
47-48	2	6	33.3	
49-50	2	4	28.6	
51-52		3		
53-54	2	3	50.0	
55-56	—	1		
57-58	1	4	33.3	
59-60	1	2		
61-62	—	3	0.0	
63-64	—	2	0.0	
Total	383	1,069		

Number of corpora albicantia in the ovaries is also one of age characters in the cetacea, and as shown in Fig. 12, there is close relation between the age based on number of growth layers in the dentine and number of corpora in the ovaries.

Table 12 shows two frequency distributions of corpora numbers. One is the whales with corpus luteum and the other one is the total whales of which both ovaries were examined. And Fig. 17 shows the pregnancy rate in each corpora class calculated from Table 12. The given curve has the same tendency as Fig. 16,

TABLE 12. NUMBER OF PREGNANT SPERM WHALES AND THE PERCENTAGE OF THE PREGNANT WHALES IN EACH NO. OF CORPORA IN THE OVAVIES. COAST OF JAPAN, 1960-62

No. of corpora	Pregnant whales	Total whales	% pregnant
1	36	103	35.0
2	42	108	38.8
3	66	188	35.1
4	78	157	49.1
5	62	156	39.7
6	43	99	43.4
7	39	97	40.2
8	28	68	41.1
9	23	57	40.4
10	15	39	38.5
11	10	29	34.5
12	5	18	27.8
13	4	16	25.0
14	2	12	16.7
15	3	11	} 21.4
16	—	3	
17	1	4	} 16.7
18	—	2	
19	—	—	
20	—	1	
21	—	1	
22	—	—	
23	—	—	
24	1	1	
25	—	1	
30	—	1	
35	—	1	
37	—	1	
Total	458	1,174	

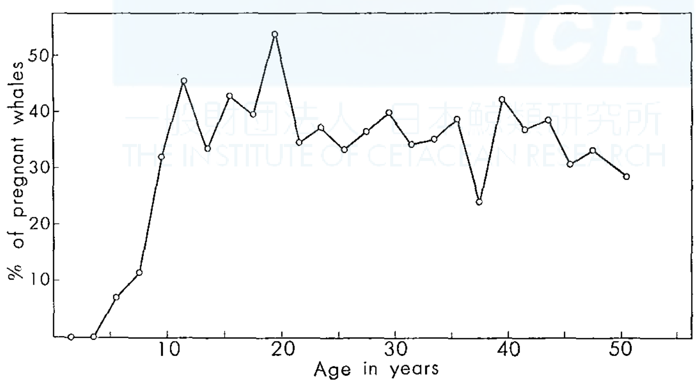

Fig. 16. Change of pregnancy rates according to the age in the female sperm whales.

that is to say, in earlier stage, pregnancy rate increases with increment of corpora number, and the rate attains to maximum value at 4 of corpora numbers. After then the rate decreases gradually, but the tendency of the decrement is more remarkable than the case in Fig. 16. In Table 12, there is no pregnant whale over 25 of corpora numbers. However, an individual with 37 corpora in the ovaries was lactating. This example shows that the sperm whale can conceive in older age.

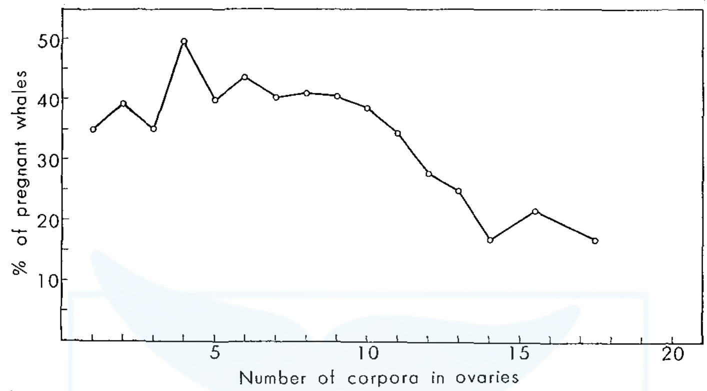

Fig. 17. Change of pregnancy rates according to the number of corpora in the ovaries of the sperm whales.

The difference of the tendency of decrease between Figs. 16 and 17 is able to be explained that annual number of ovulations decreases accompanied with increment of age as shown in the previous chapter, and the older ages based on number of ovulations concentlates the true ages, on the other hand, the individuals of which annual number of ovulations is higher than the normal have a tendency to have Type D of reproductive cycle as examine in the following chapter. The whales which have this type of reproductive cycle have low pregnancy rate.

REPRODUCTIVE CYCLE

Patterns of reproductive cycle and a review on the previous papers

The sperm whale is mono-oestrous as discussed in the previous chapter of the present paper. In general, oestrous period is classified as follows:

1. Post-partum oestrus.
2. Inter-lactation oestrus.
3. Post-lactation oestrus.
4. Post-resting oestrus.

The first case of oestrus is considered to exist in the sperm whale. However, as shown in the following section, the frequency of this case will be low. Clarke (1956) reported on this kind of oestrus for the sperm whale in Azores. Chittleborough (1958) and Laws (1961) also described on this case for the baleen whales.

The second case has a possibility to exist in the sperm whale, for the lactation period is considered to be very long in this kind of whale. The fact that there are some individuals which are simultaniously pregnant and lactating will support the existence of the second case as well as the first case. Chuzhakina (1961) mentioned on the possibility of this case in the sperm whale.

Matthews (1938) described that ovulation occured immediately at the end of lactation for the sperm whale, and resting period was short even if it was existed. However, as Clarke pointed out, the season when Matthews investigated was the former half of the pairing and it is proper that there is no resting whales in this season. Clarke did not recognize the post-lactation oestrus. If the sperm whale ovulate immediately to weaning, the season will be mostly August or September in the northern hemisphere. But, the frequency of conception is the lowest of the year in this season. Laws (1961) showed a theory that most of the female fin whale ovulate at weaning, but they do not conceive in this time because of the decline of sexual activity in the males in the season. Laws's theory will not be applied to the sperm whale. Because, the occurrence of mature ovarian follicles or corpora lutea just after ovulation in the ovaries is not recognized in the sperm whales caught in summer season in Japanese coastal waters. On the contrary, Sergeant (1962) reported that in the pilot whale (*Globicephala melaena*) there is no resting period, and it generally ovlates just after the weaning.

Clarke considers that post-resting oestrus is the most normal case in the sperm whale. I agree with his consideration from the investigation of reproductive cycle for the sperm whale.

Concerning to the reproductive cycle of the sperm whale, Matsuura (1936) first estimated two-years cycle (gestation period: 12 months, lactation period: 6 months, and resting period: 6 months). However, today this theory is not given our approval, for it is clear that his estimation on the gestion period is not true. Matthews (1938) also showed two-years reproductive cycle for the southern sperm whale. He estimated gestation period as 16 months and lactation period as 7 months. But, his theory is contradictory to the real phenomena in two points that lactaing period is too short and there is no resting period in his theory. Clarke (1956) advocated 3 years, reproductive cycle for the sperm whale in Azores. It includes 16 months gestation, 13 months lactation and 7 months resting periods. And Chuzhakina (1961) reported that the reproductive cycle was 2.5 years, that is, gestation was 16–17 months, lactation lasted to 10–11 months, and resting was 3–4 months.

Calculation of reproductive cycle

From the relation between age and number of ovulations, mean number of ovulations per year decrease slightly with the increment of age, and it is 0.31 by 20 years of age, 0.26 between 21 and 48 years, and 0.27 in total ages. From these figures, the ovulation cycle is calculated as 3.2, 3.9, and 3.7 years respectively in above ages. That is to say, the reproductive cycle is considered to be 3–4 years calculated with number of ovulations per year.

In the previous chapter, the true pregnancy rate was given as 26–29 per cent. Then the pregnancy cycle is calculated as follows:

1 year/0.26–0.29 = 3.4–3.8 years

This value coincides fairly with the reproductive cycle calculated from annual rate of ovulations. I consider that pregnancy cycle supports that reproductive cycle is 3–4 years for the sperm whale.

Establishment of several types of reproductive patterns

Pattern of reproductive cycle and the number of ovulations in each pattern are shown in Fig. 18, considering from gestation and lactation periods. Type A is a case that ovulation does not occure after parturition and weaning, and the resting stage lasts for more than one year. In this case mean annual rate of ovulation is less than 0.25. The possibility of existing of such individuals is deemed by the result that the lower limit of annual ovulation is 0.14 in the relation between age and number of ovulations. The longer resting stage is, the smaller annual ovulation becomes. The longest reproductive cycle is calculated as 7.2 years from the lower limit of above relation. Considering the ageal change of pregnancy rate, the frequency occurrence of Type A will increase with age.

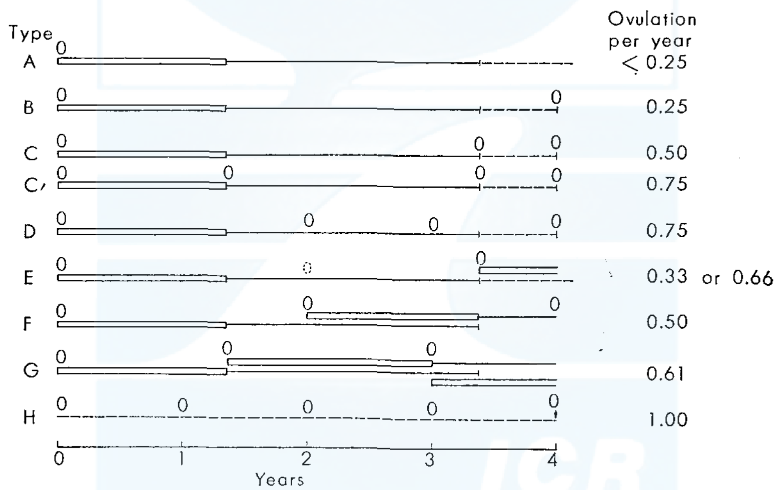

Fig. 18. Types of reproductive cycles in the female sperm whale.
Square: Pregnant period, Solid line: Lactating period, Broken line: Resting period, O: Ovulation.

Type B is a 4 years reproductive cycle which ovulate after 8 months' resting period. Annual rate of ovulation of this type is 0.25, it is the most near the mean number of annual ovulations, and it is regarded as the most normal reproductive cycle for the sperm whale, estimating with other reproductive phenomena. Type C is a reproductive cycle in which an unsuccessful ovulation occures immediately to the weaning, and the whale conceives in the time of the next ovulation after resting period. The mean number of ovulations per year is 0.50. In Type C', the first ovulation takes plase immediately to parturition in addition to Type C. Annual rate of ovulations is 0.75 in this case. However, according to the investigation of the ovaries during August to October when is considered as the season of parturition and weaning in Japanese coastal waters, appearence of corpora lutea of ovulation or mature graafian follicles is rare in this season, and Clarke (1956) got the similar result for the sperm whales in Azores. Therefore, the possibility of existing of Types C and C′ is considered to be small in the sperm whale.

TABLE 13. REPRODUCTIVE STAGES OF FEMALE SPERM WHALES IN EACH MONTH IN THE WATERS OF JAPAN, (1960-62)

Actual figure	May and June	July	Aug.	Sept.	Oct.	Nov.	Total
Pregnant	3	13	54	107	41	7	225
Pregnant and Lactating	1	2	14	26	15	1	59
Lacating	4	11	28	100	72	8	223
Resting	—	3	28	104	78	12	225
Total	8	39	124	337	206	28	732
Percent							
Pregnant	37.5	44.9	43.6	31.7	19.9	25.0	30.7
Pregnant and Lactating	12.5	6.9	11.3	7.7	7.3	3.6	8.1
Lactating	50.0	37.9	22.6	29.7	35.0	28.6	30.4
Resting	0.0	10.3	22.6	30.9	37.9	42.9	30.7

Type D is a 4 years reproductive cycle in which unsuccessful ovulation is taken plase in a pairing season and the next ovulation lead to conception after the resting period. The reproductive cycle of Type D has a possibility to remove into Type E or F explained in the following, and it is considered to exist according to the seasonal change of graafian follicles. Average number of ovulations per year in this type is calculated as 0.75, and it is under the upper limit of the relation between age and number of ovulations. It is considered that there is a possibility to exist such a type of sexual cycle, especially in younger ages. Type E is a 3 years reproductive cycle in which whale does not ovulate or does not conceive if it ovulates at the first breeding season during lactating period, and it conceives at the next breeding season. The possibility of existing of this type will be supported by the fact that there are individuals which are pregnant and lactating. Annual number of ovulations is 0.33 or 0.67. In the reproductive cycle of Type F, whale conceives at the first breeding season, and the next parturition takes plase at weaning. The existence of this type is supported with the same fact as shown in Type E, and a phenomenon that there is a record that a sperm whale with a foetus of 340 cm in length was still lactating is explained more easily by Type F than by Type E. Type F is a 2 years reproductive cycle, and annual ovulation is 0.50. The whales of about 20 years of age have Types E and F of sexual cycle more frequently than other ages judging with ageal change of pregnancy rate. Type G is a 16–17 months sexual cycle which conceives immediately to parturition. This type has the same contradiction as explained in Types C and C', and a whale of this type must continue to suckle the last calf after the next parturition. Therefore, the possibility of existing of this kind of type will be negligible. Type H is a sterile sexual cycle in which whales repeat an nusuccessful ovulation in every breeding season. The annual number of ovulations is 1.00, and this agrees with the upper limit of Fig. 12. This type of reproductive cycle will be more frequently in pubertal or young ages.

Summarizing the above considerations, Type B will be typicl reproductive cycle for the sperm whale, and Type A will be also common in the species. Types D, E, F and H also have possibility to exist, especially Types E and F will be 8 per cent of the reproductive cycle in the sperm whales in adjacent waters to Japan as shown in the following section.

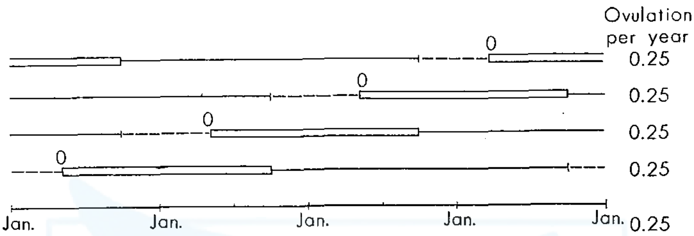

Fig. 19. A pattern of reproductive cycle for the female northern sperm whale (A), based on Type B in Fig. 18. Marks are the same as in Fig. 18.

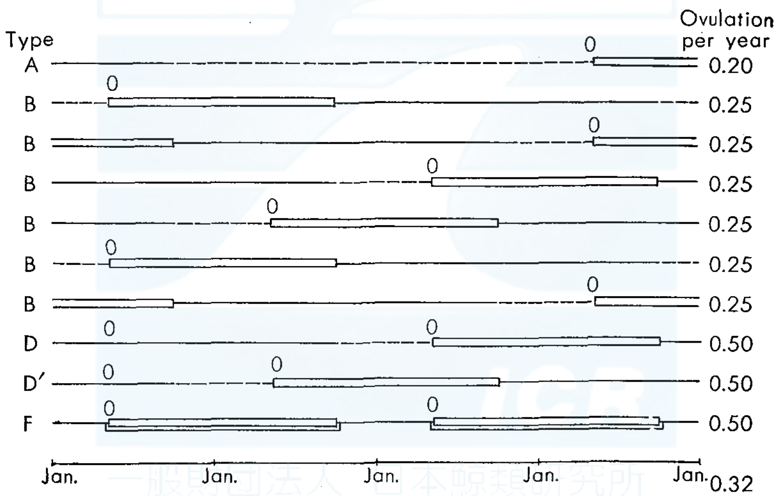

Fig. 20. A combined pattern of reproductive cycles for the female northern sperm whale (B), based on Types A, B, D and F in Fig. 18. Marks are the same as in Fig. 18.

Examination of reproductive cycle by means of seasonal change in reproductive conditions

Reproductive conditions were grouped into pregnant, simultaniously pregnant and lactating, lactating and resting stages for 732 female mature sperm whales of which both ovaries and mammary gland were examined in the coast of Japan. The result is shown in Table 13. And seasonal change of the compositions of the above reproductive conditions is also shown in Fig. 21-C.

The composition of individuals which were simultaniously pregnant and lactating is 3.6–12.5 per cent, and 8.1 per cent in average. The frequency does not vary so remarkably, although there is slight tendency to decrease with season. The ratio of resting individuals is low until August, and then it increases. This phenomenon is concerned with that weaning season is about August in the northern hemisphere sperm whale. It was already studied that the frequency of pregnant individuals decreases after August. Lactating individuals are almost constant in the composition seasonally, and the ratio is about 30 per cent.

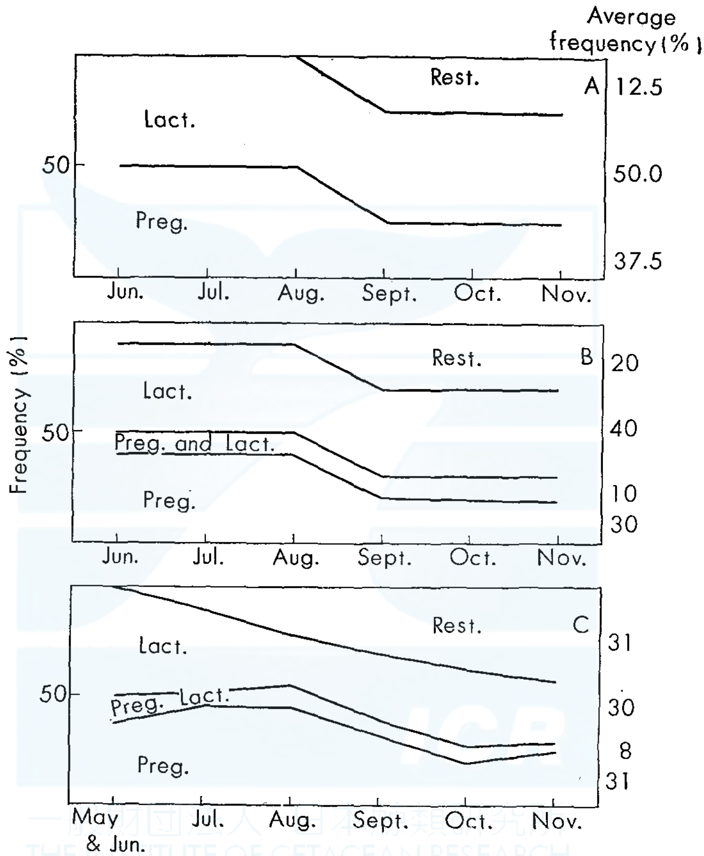

Fig. 21. Seasonal change of estimated and actual composition of reproductive stages for the female sperm whales caught in adjacent waters to Japan.
Data are based on Figs. 19, 20 and Table 12.

Fig. 19 shows a pattern of reproductive cycle for the female northern sperm whale. This pattern is composed with only Type B which is considered as the typical reproductive cycle in the sperm whale. And the seasonal change of ratios of reproductive conditions is shown in Fig. 21–A. Comparing the seasonal change of Pattern A with the actual one (C) in Fig. 21, the ratio of resting stage of the former is smaller than the latter, on the contrary, ratio of lactating stage is larger than the latter. Furthermore, Pattern A can not explain the actual composition, for there is no pregnant whales with lactation in Pattern A. Therefore, the reproductive cycle for the sperm whale is not composed of only single type of Type B, but it will be composed of complex types of reproductive cycles.

Making a combined pattern (B) of reproductive cycle with Types A, B,D, and F as shown in Fig. 20, the seasonal change of composition of reproductive conditions is calculated as shown in Fig. 21–B. This seasonal change fairly agrees with the actual one (Fig. 21–C). The combination of reproductive types in this pattern is 60 per cent of Type B, 20 per cent of Type D (D'), 10 per cent of Type A and 10 per cent of Type F. And the annual rate of ovulations is calculated as 0.32. This rate is near that of young ages.

In practice, the reproductive cycle in the sperm whale will be a complex pattern which is composed more types than the pattern which was shown in Fig. 20. In Type A, there will be Types A', A", . . . in which resting period is longer than that in Type A, and it is estimated that Type E will add in the actual reproductive cycle in the sperm whale. Accompanying with the increment of the age, proportion of Types A, A', A", . . . is considered to increase, on the contrary, the proportion of Types D and F will decrease in the reproductive cycle in the sperm whale.

From the above consideration, it was found that the types of reproductive cycle which were established in the previous section are able to explain the seasonal change of composition of reproductive conditions by a combination of the types. And the estimated pattern is supported to be near the actual eombination of reproductive cycle in the sperm whale in the adjacent waters to Japan.

SUMMARY

1. Some problems concerning to the reproduction of the sperm whale chiefly in the north-west Pacific were studied.

2. Diameter of graafian follicle changes seasonally, and it is estimated to become largest in spring season in average.

3. Pairing season was estimated from monthly frequency of foetal lengths. Pairing extends all season of the year, but the mode of pairing is in April and October in the northern and southern hemisphere respectively. There is a tendency that pairing date becomes gradually earlier accompanying with increase of age.

4. Sex ratio of the males is 51.0 par cent in gestation period.

5. Body lengths at birth is estimated as 4.05 m (13 feet 3 inches). There is no difference of the lengths between the both hemisphere whales.

6. Parturition chiefly takes plase during June to October, and December to April in the northern and southern hemisphere respectively.

7. Gestation period is calculated to be 16.4 months in both hemisphere.

8. Lactation period is suitable to estimate as 24–25 months, and the weaning season is determined to be August or September in the northern hemisphere.

9. Annual rate of ovulation is calculated from the relation between age and number of ovulations. It is 0.27. The rate decreases gradually accompanied with increase of ages.

10. Process of involution of corpus albicans is drawn as like a hypabola, but it persists in ovary through the life.

11. Frequency occurrence of multiple ovulations and multiplets are very low in the sperm whale. It is estimated to be 0.89 and 0.45 per cent for multiple ovulation and multiplets respectively.

12. Pretence pregnancy rate varies remarkably according to season, and the true pregnancy rate is calculated to be 26–29 per cent for the sperm whale in the waters adjacent to Japan.

13. Pregnancy rate changes accompanied with the age, and the age of maximum pregnancy is 15–20 years and 4 corpora.

14. Average duration of reproductive cycle is calculated to be 3–4 years for the sperm whale. Eight types of reproductive cycles were established considering gestation and lactation periods and annual rate of ovulation.

15. Examining the reproductive cycle by means of seasonal change in reproductive conditions, it is found that the actual reproductive cycle is composed of many types of the cycle.

ACKNOWLEDGEMENT

The materials used in the present paper were collected by the efforts of biologists who investigated, collected and examined the material under the leading by Dr. H. Omura, Director of the Whales Research Institute. My sincere thanks are due to them.

I am much indebted to many members of the Japanese whaling companies for the help in investigation and collection of the materials.

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SOME INFORMATIONS ON MINKE WHALES FROM THE ANTARCTIC

TOSHIO KASUYA AND TADAYOSHI ICHIHARA

INTRODUCTION

Williamson (1959, '61) already reported on the specimens of *Balaenoptera bonaerensis* Burmeister (1867) caught in the Antarctic whaling areas II and III. Though he did not made any conclusion on the taxonomical position of *B. bonaerensis* and *B. acutorostrata*, he considered that *B. huttoni* Gray (1874) is a synonim of *B. bonaerensis* and that *B. bonaerensis* will be common in the Antarctic Ocean.

Utrecht & Spoel (1962) reported a male *B. bonaerensis* captured in the area III in the Antarctic whaling season 1959/60. They pointed out a difference of the length of the flipper between *B. acutorostrata* and *B. bonaerensis* and concluded that *B. bonaerensis* is a variation of *B. acutorostrata.*

A Japanese whaling fleet, the Nissin-maru No. 3, captured 96 little piked whales in the area III and IV in the Antarctic whaling season 1963/64. The whalers say that all of the little piked whales caught by the fleet were another type of little piked whale, namely *B. bonaerensis*, and judging from a coloured picture and a collected baleen plate it is sure that some of them, at least 14 whales presented on the picture, were *B. bonaerensis.* So we can give some informations on these whales.

We acknowledge to Mr. Keiji Sasaki of the Taiyo Gyogyo Co., who showed us some data concerning these whales. Mr. Kaoru Yamada and Mr. Fusao Ozawa of the Japanese Fisheries Agencies, kindly presented us photographs and a baleen plate of whales which are included in this paper.

DISTRIBUTION

The captured positions of the little piked whales by the Nissin-maru No. 3 are shown in Table 1. The whales shown in Fig. 3 were captured on Jan. 6, 1964 and the position is 62°–54′S, 115°–19′E. This is the first record for *B. bonaerensis* captured in the Antarctic whaling area IV.

TABLE 1. POSITION OF CAPTURE AND SCHOOL COMPOSITION

Date captured	Position captured	Number			Ratio of male (%)
		Male	Female	Total	
Dec. 13, 1963	61°–55′S, 120°–44′E	1	0	1	100.0
Dec. 28, 1963	62°–42′S, 55°–14′E	0	1	1	0.0
Jan. 6, 1964	62°–54′S, 115°–19′E	15	3	18	83.3
Jan. 7, 1964	63°–00′S, 119°–35′E	50	10	60	83.3
Jan. 8, 1964	62°–56′S, 124°–05′E	12	3	15	80.0
Jan. 10, 1964	62°–21′S, 133°–17′E	1	0	1	100.0
Total		79	17	96	82.3

Fig. 1 shows the position where *B. bonaerensis* were captured including the position reported by Burmeister (1867), Gray (1874), Williamson (1961) and Utrecht & Spoel (1962).

From this figure it is suggested that *B. bonaerensis* distributes in the Atlantic and the Indian part of the Antarctic Ocean, and probably in the Pacific part of the Antarctic Ocean also.

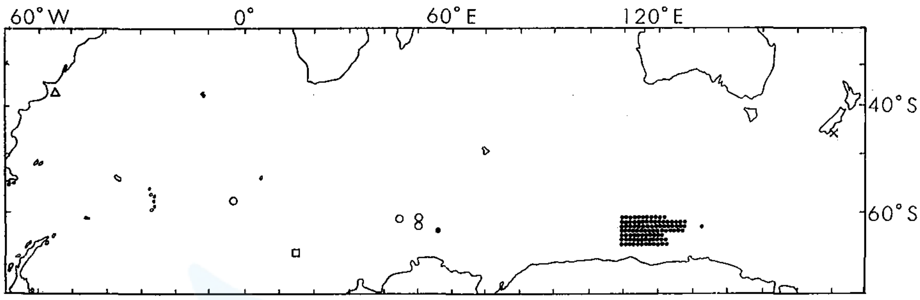

Fig. 1. Captured position of *B. bonaerensis*, each point shows one whale.
●: Nisshin-maru No. 3 □: Utrecht & Spoel (1962)
○: Williamson (1961) △: Burmeister (1867)
×: Gray (1874)

EXTERNAL CHARACTERS

The external characters of our specimens coincides fairly well with those reported by Williamson (1961) and Utrecht & Spoel (1962), particularly in the flipper without white band, baleen plate with darkly coloured external edge.

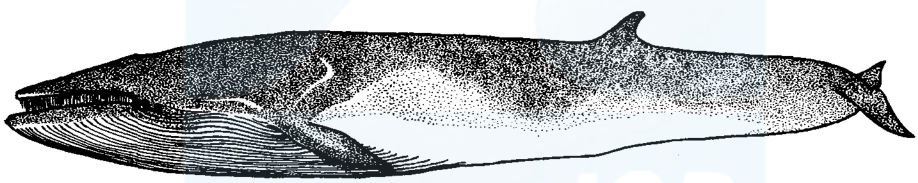

Fig. 2. Schematic figure of the pigmentation of *B. bonaerensis*.

But our photograph shows that the pigmentation of the left side of the head region exceed that of the right side. The darkly pigmented area of the jaw is broader in the left side and the white area on the upper rip is longer in the right. The number of baleen plates without the darkly colourd edge, which distribution seems to correlate to the presence of the white area of the upper rip, is smaller in the left side than in the right. This coincides better with Utrecht and Spoel (1962) rather than Williamson (1961). One of two pale streaks, which begin near the anterior insertion of flipper, extends toward shoulder and the other points to ear in our specimens. But these streaks also have the possibility to occur on *B. acutorostrata*. The dark dorsal pigmentation in *B. bonaerensis* expands toward the flank in front of the dorsal fin (Fig. 2).

The dorsal surface of tail flukes is pigmented darkly and the ventral surface is generally white except darkly pigmented anterior edges.

Fig. 3. *B. bonaerensis* captured by the Nisshin-maru No. 3 on Jan. 6, 1964.

BALEEN PLATE

One baleen plate at nearly mid point of the series was collected. Though it has slight deficit at the side of oral cavity, its assumed breadth is 14.0 cm and its length from the gum line to the tip of plate along the external edge except the fringes, is 23.5 cm. And the breadth / length ratio is 0.60.

Fig. 4 shows the relation between the breadth and the length of baleen plates of *B. bonaerensis* from the Antarctic and *B. acutorostrata* from the coastal waters of Japan. It is difficult to find out any difference of the ratio between *B. bonaerensis* and *B. acutorostrata* from these materials.

It is a plate from the nearly middle of the series, so the longest plate of the whale will be longer than it. Our longest baleen plate from the coastal waters of Japan is 19.9 cm. So the baleen plate of *B. bonaerensis* can be said to be longer than that of *B. acutorostrata* from the northern hemisphere which coincides with Williamson (1961) and Utrecht & Spoel (1962).

Fig. 5 shows a baleen plate of *B. bonaerensis* and those of *B. acutorostrata* which have baleen plates with dark band at the external edge, and they are found more often in the Japan Sea and the Okhotsk Sea coast than in the Pacific coast of Japan. But these dark edges are narrower than that of *B. bonaerensis* and brownish in colour.

The diameter of baleen fringes of one *B. bonaerensis* and five *B. acutorostrata* from the coastal waters of Japan were measured. The latter baleen plates are the longest plates of a series. The baleen plates of suckling calf was not used, for their fringes are more fine than that of the adult. From one third to one forth, from 84 to 114 in number, of fringes in a plate are selected at random and measured their diameter at the base with a micrometer. These measurement are shown in Fig. 6 and Table 2. They suggest the larger diameter in *B. bonaerensis* than *B.*

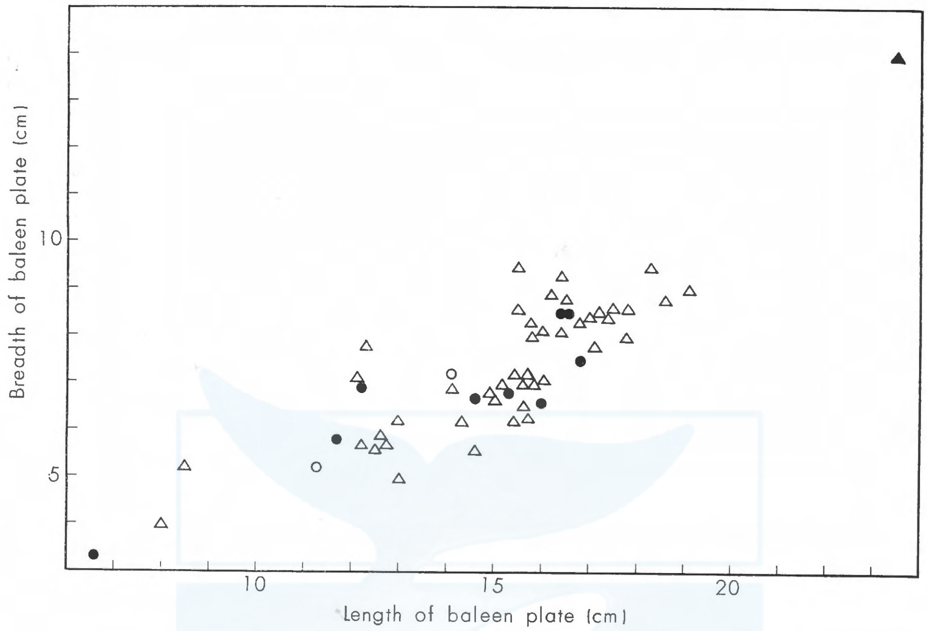

Fig. 4. Relation between the length and the breadth of baleen plate.
B. acutorostrata . . . ● male, ○ female, △ unknown
B. bonaerensis . . . . ▲ sex unkhown

Fig. 5. Baleen plates of *B. acutorostrata* (left three) and *B. bonaerensis* (right), ×0.22.

TABLE 2. DIAMETER OF BALEEN FRINGES (mm)

Specimen	B. bonaerensis	B. acutorostrata 1	2	3	4	5
Length of baleen plate	235	125	166	177	175	182
Number of fringes measured	84	95	86	115	98	93
Range of diameter	0.140–0.728	0.101–0.537	0.134–0.547	0.111–0.486	0.130–0.789	0.141–0.830
Mean diameter	0.354	0.211	0.274	0.225	0.293	0.279
Range of two standard error	±0.033	±0.016	±0.022	±0.016	±0.022	0.028

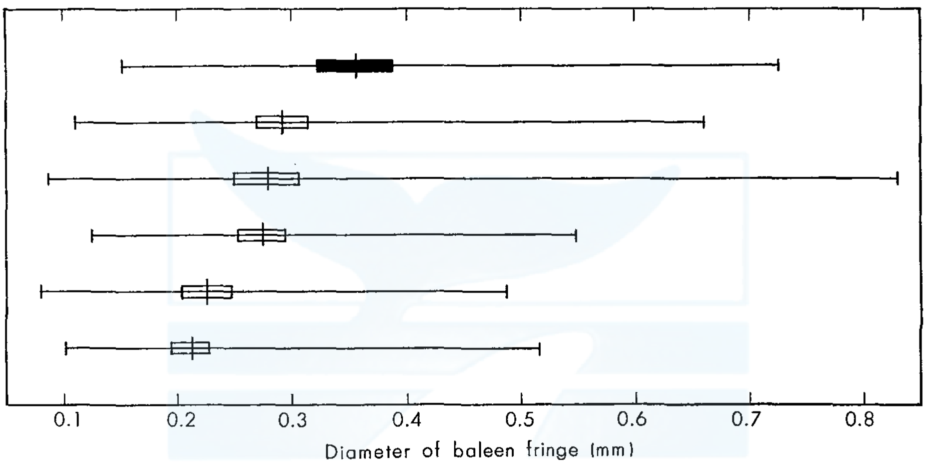

Fig. 6. Diameter of baleen fringes, range, mean and the range of two standard error. Top: *B. bonaerensis*, Bottom five: *B. acutorostrata*.

acutorostrata.

SCHOOL AND BODY LENGTH

Though the whaler says that all of the little piked whales caught by the Nisshi-maru No. 3 seemed to belong to the same type, it was not observed by any biologist. There is an evidence to suggests the occurrence of *B. acutorostrata* in the Antarctic (Taylor, 1957). During the marking voyage in the end of December in 1959, Ichihara observed three little piked whales swim around the catcher boat in area IV in the Antarctic. From the white band on the flipper, these whales were identified as *B. acutorostrata*. Therefore, we cannot conclude definitely that all the whales captured by the Japanese fleet were *B. bonaerensis*. But we present here the body length, sex and the length of foetus for the purpose of reference.

As shown in Table 1 the whales are caught on January 6, 7 and 8, 1964. It is said that the catches of each day belonged to one school respectively and nearly all of the component of each school were caught.

The ratios of male whales in the catches from the three schools show nearly same value 80 percent, which seems to suggest the dominance of male in the schools of *B. bonaerensis* migrating these latitude.

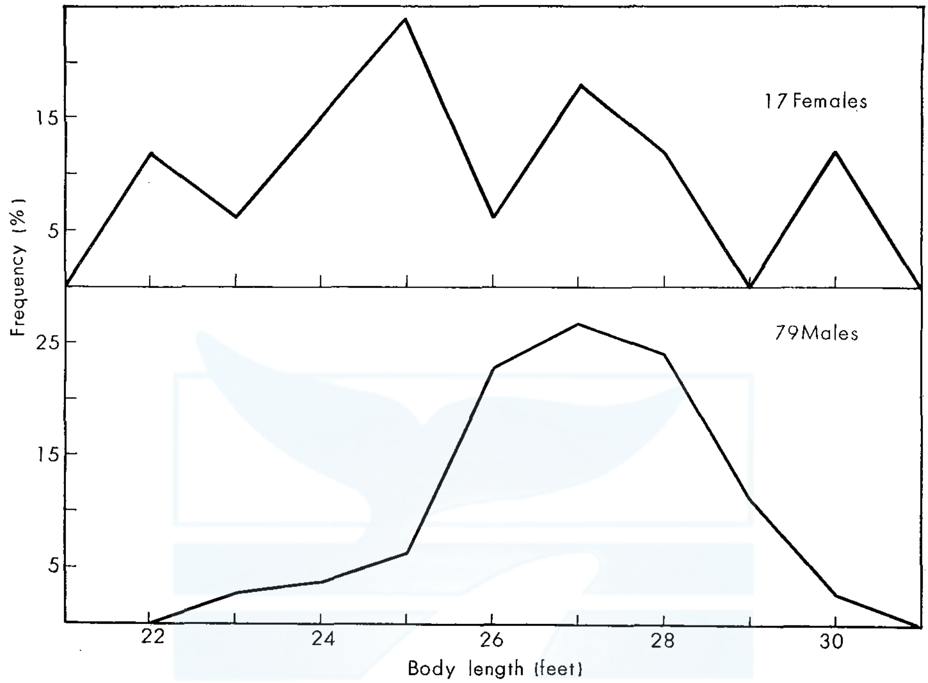

Fig. 7. Body length composition of the little piked whales caught by the Nisshin-maru No. 3.

TABLE 3. BODY LENGTH COMPOSITION

Body length (foot)	Male	Female	Total
22	—	2	2
23	2	1	3
24	3	2	5
25	5	4	9
26	18	1	19
27	22	3[1)]	25
28	18	2[2)]	20
29	9	—	9
30	2	2	4
Total	79	17	96

1) One is pregnant. 2) Two are pregnant.

TABLE 4. BODY LENGTH OF THE FOETUSES (cm)

Date captured	Body length	Sex
Jan. 7, 1964	45	Female
Jan. 8, 1964	19	Male
Jan. 8, 1964	18	Male

Table 3 and Fig. 7 show the body length composition. There is no whale shorter than 21 ft. Although we consider the selection of larger whales by gunners, it is safe to say that larger whales dominently migrate to the higher latitude as in the case of *B. acutorostrata* in the northern hemisphere.

The ovary and testis were not examined. But one and two pregnant whales were found, in the catch on Jan. 7 and 8th, and their body length was 27 and 28 ft. respectively. Willismson (1961) also reported a newly matured female of 27 ft. Our data will provide some information on the body length at the attainment of sexual maturity of female whales.

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FOODS OF BALEEN WHALES IN THE GULF OF ALASKA OF THE NORTH PACIFIC

TAKAHISA NEMOTO AND TOSHIO KASUYA

The foods of baleen whales in the North Pacific have been studied by Banner (1949), Ponomareva (1949) and Nemoto (1957: 1959: 1962). But these are results on the whales caught in the north west part of the North Pacific in general. In recent Japanese whaling, comparatively many baleen whales have been caught in the Gulf of Alaska and the foods of those baleen whales have been collected as the continuance of the works carried out up to these days.

The materials of foods of baleen whales have been collected in 1961, 1962 and 1963 on the factory ships as it has been done. Some materials were also collected on right whales in 1961, which were permitted to catch under the special permission for the scientific research.

The distribution of euphausiids, which is important for whales foods, have been studied by Banner (1949), Nemoto (1959: 1962) and Brinton (1962), and these results are of great help for the general consideration of the distribution of foods of baleen whales.

DISTRIBUTION OF BALEEN WHALES

The Gulf of Alaska waters was famous for the whaling ground for right whales in 19 century (Townsend, 1935). Fin and sei whales, however, mainly constitute the recent catch of baleen whales as illustrated in Fig. 1 and Fig. 2. Both fin and sei whales are common in the mid-gulf where right whales were caught, but the fin whale catch is sometimes restricted in the shore waters in a certain year, for example 1963, as shown in Fig. 1. But fin whales were caught in the off waters in 1962 possibly owing to the foods distributions in the Gulf of Alaska.

The distribution types of baleen whales were discussed in a previous report (Nemoto, 1959). Sei whales are ocean dinizen and they seem not to approach shallow inshore waters and the marginal sea. This is also confirmed in the recent catch as shown in Fig. 2. On the other hand, fin whales feed also in the shallow coastal waters and marginal seas as in the open ocean.
Blue whales, the euphausiids feeder and ocean denizen, are caught in the edge of Alaskan continental shelf where euphausiids are most prosperous through the summer season.

FOODS OF BALEEN WHALES

Collected stomach contents of baleen whales have been examined and plotted in Figs. from 3 to 6. The occurrences of euphausiids and copepods in fin whales are given as the percentage occurrences in each 1 latitude and 2 longitudes square in Fig. 3. As it is clearly shown, copepods are observed in the off waters and euphausiids are mainly distributed in the shore waters as the foods of fin whales in 1963.

Three species of euphausiids, *Euphausia pacifica*, *Thysanoessa inermis* and *T. spinifera* are main euphausiids occurred in the stomachs of baleen whales in the coastal waters.

The distributions of North Pacific euphausiids also have been discussed by Banner (1949), Brinton (1962) and Nemoto (1962). Six northern Pacific euphausiids *Euphausia pacifica*, *Thysanoessa inermis*, *T. longipes*, *T. raschii*, *T. spinifera* and *Tessarabrachion oculatus* are all common in the Alaskan Gulf although the depth and horizontal distributions are somewhat different.

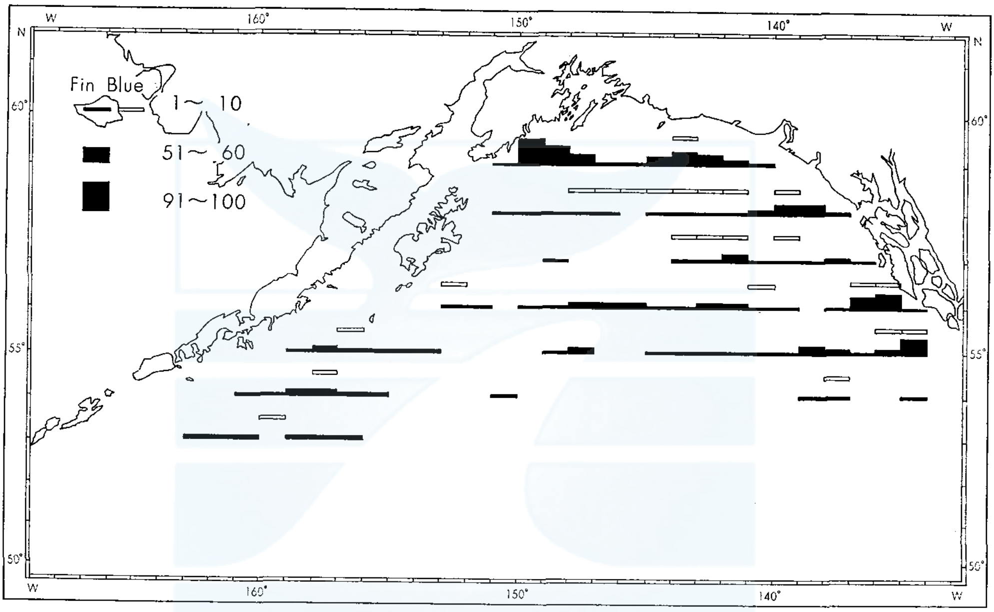

Fig. 1. Catch distribution of blue and fin whales by Japanese whaling expeditions in the Gulf of Alaska in 1963.

Euphausia pacifica is recorded from the most northern Gulf of Alaska by Banner (1949). The geographical distribution of *Euphausia pacifica* established by Brinton (1962) endorces the wide distribution of this species in the subarctic Pacific, and its importance for marine animals may be valid in the southern waters (Nemoto, 1959: Brinton, 1962). *Euphausia pacifica* is found in both oceanic and neritic waters in vast swarms (Banner, 1949), but baleen whales in the Gulf of Alaska took it mainly in the continental shelf edge of the gulf. The size of the collected specimens is larger comparing with specimens in southern waters (Unpublished data in the Whales Research Institute).

Thysanoessa spinifera is one of the most important euphausiids in the Alaskan Gulf as a food of baleen whales. It was found in the shore waters of the Aleutian Islands only in the eastern side (Nemoto 1959: 1962), but it was never found in the west waters of the Bering sea and the North Pacific (Nemoto, 1959: 1962: Brinton, 1962). It distributes from the eastern part of the Aleutian Islands to the southern California along the shelf waters. It is considered to be the most dominant euphausiids species in the neritic waters of the Gulf of Alaska. Baleen whales, blue, fin and humpback whales, which are swallowing type in feeding (Nemoto, 1959) are possibly feed on this *T. spinifera* in those waters. *T. spinifera* appeares to be restricted to depths of less than 100 meters (Brinton, 1962), and it is found also in the daytime in the shallower waters in near-shore waters.

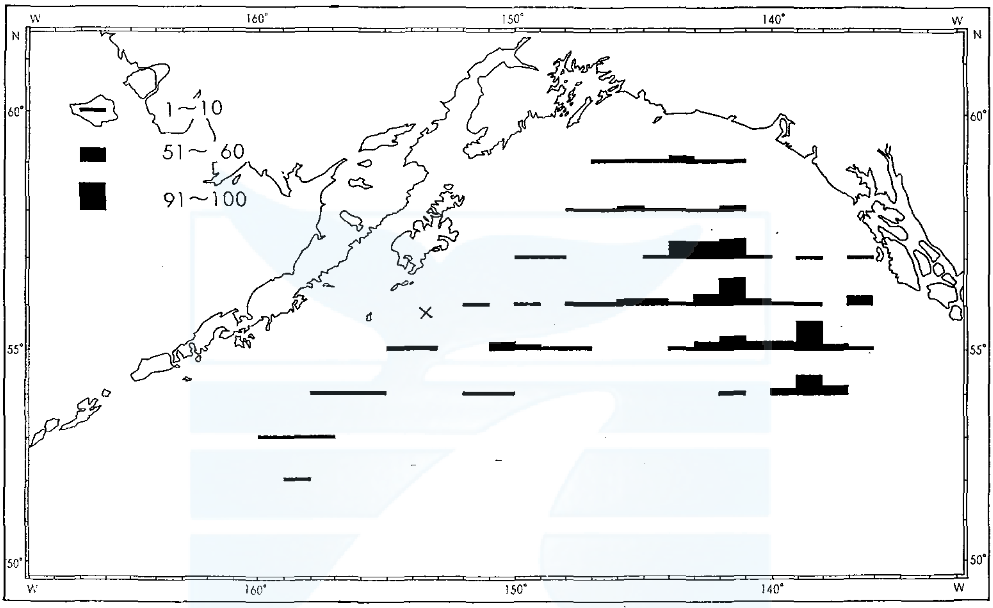

Fig. 2. Catch distribution of sei whales by Japanese whaling expeditions in the Gulf of Alaska in 1963.

The third species, *Thysanoessa inermis* is the most important euphausiids species in the waters of the east Bering Sea and off Kamtchatka waters (Nemoto, 1959), but it is rather scarce as the foods of baleen whales in the Gulf of Alaska. Banner reported it from the Gulf of Alaska and Brinton also noted the main range of *T. inermis* covers arctic boreal regions of the North Pacific north of 52°N in the eastern part. As for the morphorogical types of *T. inermis,* two spines form is dominant in these areas as considered in a previous report (Nemoto, 1959: 1962), and it amounts about 75% or more in the Gulf of Alaska waters, in the east side of the Pacific.

Another neritic species *Thysanoessa raschii* has been recorded in the shore waters of the Alaskan continental shelf by Banner (1949), but it has not been observed as foods of fin and other baleen whales in the Gulf of Alaska. Perhaps it distributes shallower and colder neritic waters along the Alaskan continent throughout winter and summer seasons.

Thysanoessa longipes on the other hand, distributes in the off waters. In 1962, comparatively many fin whales had been caught when they were feeding on *T. longipes* in the mid-gulf. The concentration of *T. longipes* in the mid-gulf is also shown by plankton investigations (McAllister, 1961: Brinton, 1962). It is preliminarily suggested that the relative abundance of off shore species *T. longipes* may affect the migration of fin whales to those areas. The close related species, *T. inspinata* has not been found in the stomachs of baleen whales caught in the Gulf of Alaska. In 1963, *T. longipes* has not been found in the mid-Alaskan Gulf and fin whales had not been observed in the area in swarms. *T. longipes* is also important in the Bering Sea and southern waters of the Aleutian Islands, and annual fluctuations

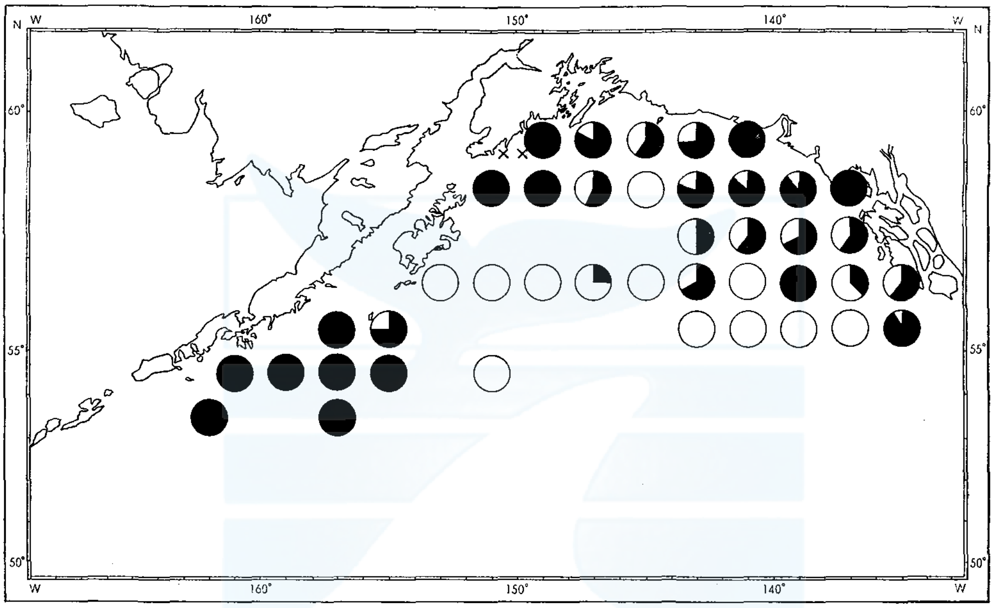

Fig. 3. Percentage occurrences of euphausiids (Black) and copepods (White) in the stomachs of fin whales caught in the Gulf of Alaska in 1963. Cross—Position of right whale capture.

were also observed in comparing with other euphausiids such as *T. inermis* and *T. raschii* (Nemoto, 1959), which form the stable feeding grounds every year. Two species of copepods, *Calanus cristatus* and *C. plumchrus*, are common as the foods of baleen whales in the Gulf of Alaska as in the Bering Sea (Nemoto, 1962). Fin whales prefer *Calanus cristatus* as the swallowing feeding type, but a few fin whales also take *Calanus plumchrus*.

Sei whales are mostly skimming feeder in the North Pacific (Nemoto, 1959), feeding on copepods. As it is illustrated in Fig. 4, they exclusively feed on copepods in the off waters of the Gulf of Alaska. *Calanus cristatus* and *Calanus plumchrus* are observed as the foods of sei whales. *C. cristatus* is more dominant in the off waters, although sei whales have taken *C. plumchrus* in the western waters of Kamtchatka region and southern off waters of the Aleutian Islands.

Two cases of right whales which have taken *Calanus prumchrus* in the coastal

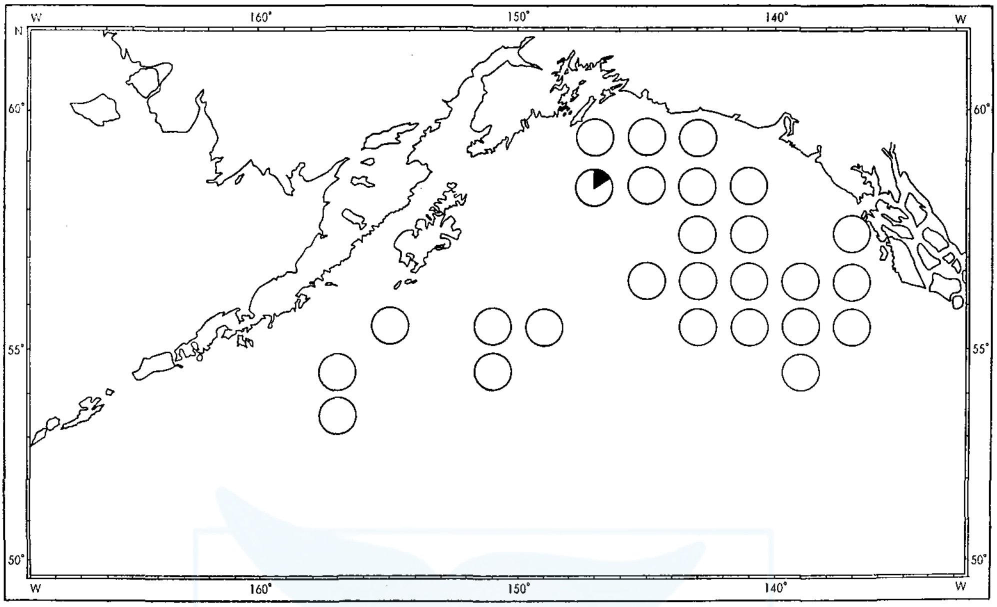

Fig. 4. Percentage occurrences of copepods (White) and euphansiids (Black) in the stomachs of sei whales caught in the Gulf of Alaska in 1963.

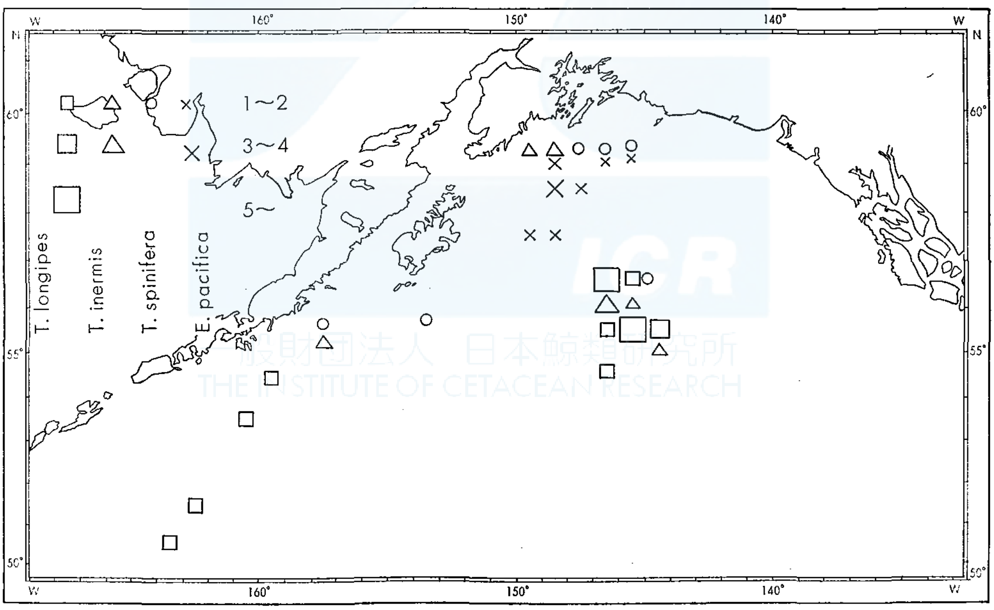

Fig. 5. Euphausiids occurrences in the stomachs of baleen whales in 1962.

waters of Kodiak Islands show that they were skimming feeder, which coincides with the results obtained in the waters off Japan.

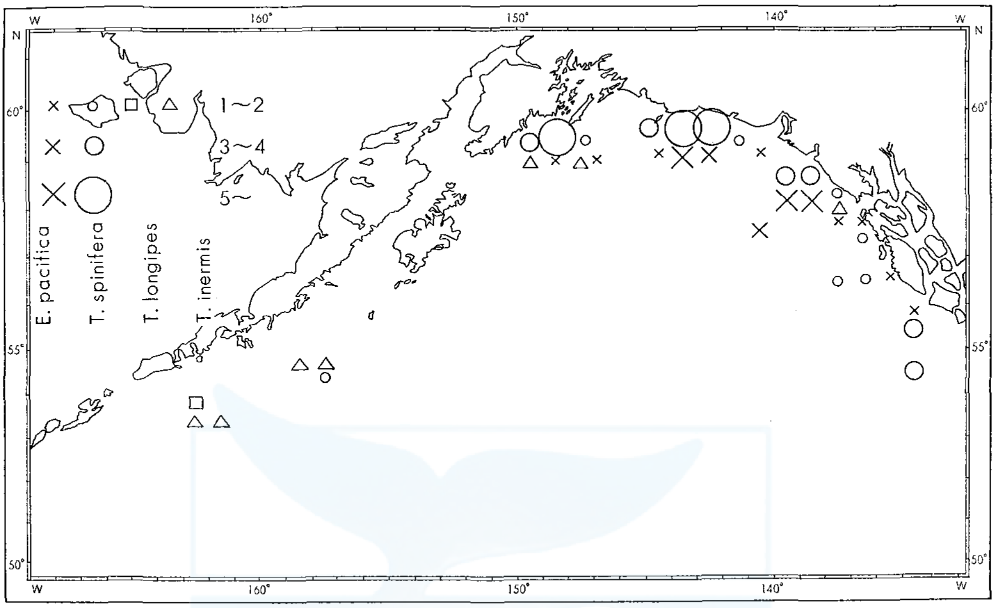

Fig. 6. Euphausiids occurrences in the stomachs of baleen whales in 1963.

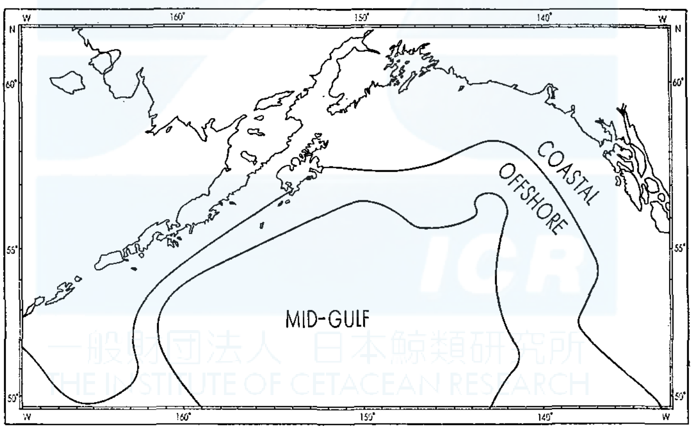

Fig. 7. Water masses in the Gulf of Alaska (After Doe, 1955).

The water mass of the Alaskan Gulf is described by many authors, and one example is given by Doe (1955). It fairly well coincided with the main distributions of the euphausiids species and copepods. *Thysanoessa spinifera*, *T. raschii* and *T. inermis* are coastal species, whereas *T. longipes* is offshore species. The life cycle of the former species may be brought up in the neritic domain, but *T. longipes* has some connections with the west waters where it is found along the boundary of the water masses, between subarctic and Aleutian neritic waters.

SUMMARY

The foods of baleen whales in the Gulf of Alaska have been examined. The main species of euphausiids are *Euphausia pacifica*, *Thysanoessa spinifera*, *T. longipes* and *T. inermis*. *Calanus cristatus* and *C. plumchrus* are also important as foods of baleen whales. The distribution of each species is discussed and possible relations between the natural regions of the Gulf of Alaska waters and euphausiid distributions are stated.

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A RARE SPECIES OF DOLPHIN *(STENELLA ATTENUATA)* FROM ARARI, JAPAN

MASAHARU NISHIWAKI, MASAYUKI NAKAJIMA*
AND TOSHIRO KAMIYA**

INTRODUCTION

Recently, Oceanariums have been developed in several places in Japan. Various species of dolphins and porpoises have been kept in them. Hitherto Arari Bay, a small fishing village, supplying dolphins only for human consumption locally, became a famous place of supplying live dolphins for the Oceanariums.

Fig. 1. The dolphin herd was caught by the " oikomi-drive " method into a round wall of net at ARARI.

The dolphins of the present species which had never been seen previously even by the fishermen in Arari, were caught by the " oikomi drive " method on 7th June, 1964 and were driven into a round wall of net. The number of captured dolphins alive in the herd were about fifty, but when the authors arrived, some of them had already been transported to some of the Oceanariums. The authors therefore, could not observe all individuals in the herd.

At first glance Nishiwaki thought that the shape of the body quite resembled

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Delphinus delphis. Then he touched the palate of a carcass and recognized that the dolphin belonged to the genus *Stenella.* Numerous small spots were observed on the every parts of the skin, so he thought the species name might be *Stenella frontaris.* The tips of the dolphins, however, were apparently white. On this evidence he wavered in choice. When the taxonomical studies were completed, it was clear that these dolphins belonged to the rare species *Stenella attenuata.* We would like to repcrt it as follows.

TABLE 1. FREQUENCY OF BREATHING IN THE TRANSPORTATION

Name of places	Arari	Toi	Funabara	Shuzenji	Mishima	Hakone	Odahara	Katase
Heights from sea leved (m)	2~3	535	130	60	20	850	5~10	2~3
Transit time	07:30	08:30	09:30	10:30	11:30	12:30	13:30	14:30
Air temperature	26.0	24.0	26.5	25.0	25.0	23.0	22.0	23.0
Water temperature	23.0	16.0 use ice	15.5	19.5	20.0	20.5	21.8	21.0
Frequency of breating								
Dolphin No. 1	13	13	11	9	12	6	10	6
〃 2	26	18	17	34	42	43	24	36
〃 3	43	26	21	14	16	8	7	7
〃 4	24	43	36	67	37	24	25	22

Temperatur indicates in centigrade.
Frequency of breathing counted in continued three minutes.

TABLE 2. AMOUNT OF HOOD OF THE DOLPHIN IN CAPTIVITY

Date	Amount	Kind of food	
28 June	3.9 kg	Horse mackerel	×122
29 〃	4.6	〃	×109
30 〃	5.3	〃	×129
1 July	5.3	Horse mackerel, Squid	×170
2 〃	6,0	Squid	×112
3 〃	7.5	〃	× 55
4 〃	7.1	〃	× 44
5 〃	7.0	〃	× 53
6 〃	5.8	〃	× 33
Average	5.8		× 92

TRANSPORTATION AND KEEPING

Though *Stenella caeruleo-alba* hardly eat food due to their fright, these dolphins ate soon after having been driven alive into a wall of net. Following the first one which began to eat, they all gradually ate small mackerels. They were fed 5–6 kg of small mackerels each by the fishermen. For this reason representatives of Oceanariums came to buy them. " Enoshima Marineland " transported them on 27th June.

The dolphins were laid on a stretcher, pulled up by a hand crane and put into track. Then they were carried to Enoshima over the Hakone mountain (about 850 m hights). The dolphins were placed on thick spongeous mats and were covered with dipped blankets. Sea water was pouring continuously on the blankets to keep them from drying. The air and the water temperatures were measured at least once in an hour. Table 1 shows them.

Herzmon-A (Outohormon) for the hart stimulant, Save-amine (Promajine hydrochloride) as the tranxilizer and Bicilin-sol (Dibenthyl ethylene diamine dipenicillin G in aqueous suspension) for antibiotic injected in their dorsal muscles.

These transported individuals were two females of 190 cm body length, a female of 180 cm and a male of 181 cm. When they arrived at Enoshima Marineland, their conditions were very bad. They were put into the big pool. Soon after that they clashed against the separating net or the pool sides, evidently having they lost their directions.

Two females, which were eating (3–7 kg/day) appeared as if they would live long, but died 2 days later. Both had fetuses 80 cm long. Another female which died 10 days later was also dissected. It had no fetus but had a functional corpus luteum in the ovary, so this female must have been caught soon after the parturition. Most of the females were either in the condition of a little before or soon after parturition. So that the shocks of capture and the transportation might have been doubled by the above mentioned conditions. That seemed the cause of death.

BODY LENGTH DISTRIBUTION

The dolphin herds of this species were found in May and August, 1961. All of a herd caught in May 1961, 194 individuals and 34 fetuses, were measured in body length. It is shown in Fig. 2.

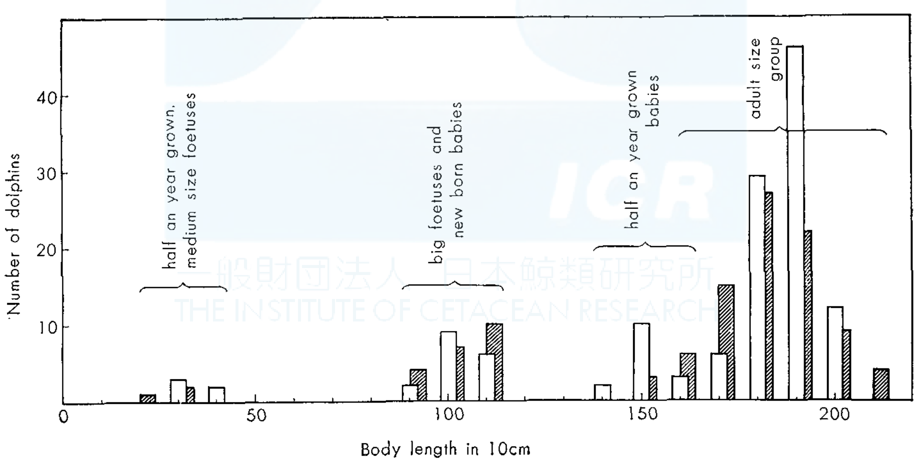

Fig. 2. Body length distribution of a herd of *Stenella attenuata*.

The largest body length of the fetuses was 106 cm and the smallest swimming individual was 104 cm. About 105 cm therefore must be the parturition body length. The largest adult was 201 cm in females and 208 cm in males, but in

Fig. 2 those body lengths were indicated in every 5 cm. In the figure several fetuses that smaller than 50 cm are seen. But we have no data of very small fetuses. One of the reason is that the ovaries and the uteruses were not dissected in detail.

The group at around 100 cm body length consist of some large fetuses and some new born pups. A little distant from this group, a peak at 150 cm, though it consisted mainly the females, can be seen. This group is considered as the half-year old grown young, delivered in the previous autumn. In the adult size groups the peak for females is 180 cm and for males is 190 cm.

From looking at the figure and assuming their period of pregnancy as twelve months, two seasons for mating and partrition can be considered in spring and

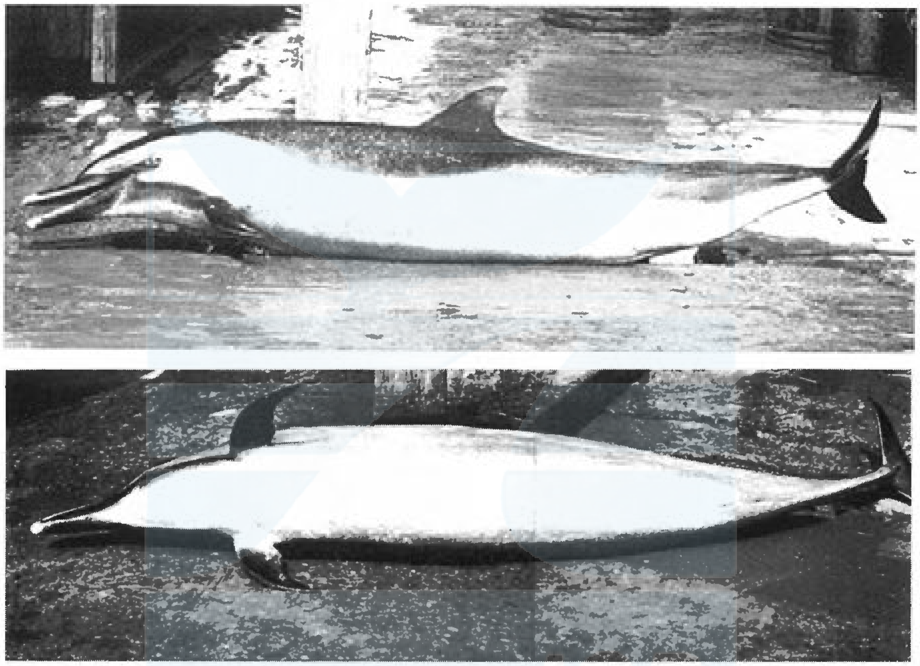

Fig. 3. Lateral and ventral views of the ARARI specimen No. 4.

autumn. The smaller group of the adult size are considered to consist of the one year old individuals. Of cause they were probably not sexually mature. The ovaries and the testes were not observed, so the body length at reaching sexual maturity and the rate of maturity on both sexes could not estimate.

Within the adult size group males are fewer than females. Males might be reduced by fighting.

Since the dolphin herd was captured in 1959, the same species of dolphin has been caught several times around Izu Peninsula until spring of 1964, but after this present observation no special examination could be made. According to the catch reports of the Fishermen's Association, it is estimated that a herd of this dolphin species usually consist about 100～300 individuals.

Tip of the beak in this dolphin species, is white and very easy to distinguish from other dolphin species, when they are swimming or in the market. They are recognized by fishermen easily.

EXTERNAL CHARACTERS

The outer body proportions of this species are shown in Table 3 and 4 comparing the data with that of other species of genus *Stenella* the authors would say that the body form is very similar to *Delphinus delphis* rather than *Stenella caeruleo-alba*, but the shape of the flippers is different.

Fig. 3. Dorsal view of the ARARI specimen No. 4.

Body coloration: the dorasl half of the body is blueish purple black with numerous gray and white spots and the ventral half of the body is gray with numerous tiny white spots. There are no spots on the head, the dorsal fin, the flippers and the tail flukes. Those parts were observed as black. No colored zone was seen on the center of the belly as a white line. The dorsal black coloration was doubled just beneath the dorsal fin. One black colored zone began from the beak and waved to posteriorly, ending just behind the dorsal fin. Another zone, though this area was lighter than the former, began from the anterior end of the dorsal fin and waved to the tailflukes. They crossed just beneath the dorsal fin and made a triangular shaped dark area. This resembles the coloration of the dolphins belong the genus *Delphinus*.

A black band extends from the eyes and ends at the root of the forehead on the beak. Another wide black band proceed from the anterior insertion of the

TABLE 3. EXTERNAL MEASUREMENTS OF THE ARARI SPECIMENS

<table>
<tr><td>Serial number</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>Sex</td><td>M</td><td>F</td><td>M</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>M</td></tr>
<tr><td>Number of teeth</td><td>45 | 44
43 | 43</td><td>43 | 42
42 | 43</td><td>44 | 44
42 | 41</td><td>44 | 44
43 | 43</td><td>41 | 40
40 | 39</td><td>40 | 42
41 | 40</td><td>39 | 38
36 | 37</td><td>34+ | 33+
35+ | 35+</td><td>40 | 40
39 | 37</td></tr>
<tr><td>Skull length in mm</td><td>428</td><td>411</td><td>381</td><td>397</td><td>412</td><td>408</td><td>414</td><td></td><td></td></tr>
<tr><td>Body length in cm</td><td>208.0
100</td><td>201.0
100</td><td>165.0
100</td><td>180.0
100</td><td>192.0
100</td><td>190.0
100</td><td>184.0
100</td><td>190.0
100</td><td>181.0
100</td></tr>
<tr><td>Tip of rostrum to anterior margin of forehead</td><td>11.0
5.3</td><td>12.0
6.0</td><td>—
—</td><td>—
—</td><td>10.5
5.5</td><td>10.6
5.6</td><td>13.5
7.7</td><td>12.0
6.3</td><td>11.5
6.4</td></tr>
<tr><td>Tip of rostrum to angle of gape</td><td>23.0
11.0</td><td>26.0
13.0</td><td>22.0
13.4</td><td>22.0
12.2</td><td>22.5
11.7</td><td>26.5
14.0</td><td>26.5
14.4</td><td>27.5
14.5</td><td>26.0
14.4</td></tr>
<tr><td>Tip of rostrum to center of blow hole</td><td>29.5
14.2</td><td>28.0
14.0</td><td>25.5
15.4</td><td>25.5
14.2</td><td>29.0
15.1</td><td>29.5
15.5</td><td>32.5
17.7</td><td>30.6
16.1</td><td>31.0
17.1</td></tr>
<tr><td>Tip of rostrum to center of eye</td><td>28.0
13.5</td><td>30.5
15.2</td><td>26.5
16.1</td><td>27.0
15.0</td><td>27.0
14.0</td><td>31.0
16.3</td><td>32.5
17.7</td><td>30.3
16.0</td><td>29.5
16.3</td></tr>
<tr><td>Center of eye to ear hole</td><td>6.0
2.9</td><td>6.5
3.2</td><td>—
—</td><td>—
—</td><td>5.5
2.9</td><td>5.0
2.6</td><td>5.5
3.0</td><td>5.4
2.9</td><td>5.5
3.0</td></tr>
<tr><td>Notch of tailflukes to posterior end of dorsal fin</td><td>—
—</td><td>86.0
42.8</td><td>67.0
40.5</td><td>75.0
41.8</td><td>78.0
40.5</td><td>78.0
41.0</td><td>73.0
39.6</td><td>81.0
42.6</td><td>71.0
39.2</td></tr>
<tr><td>Notch of tailflukes to anus</td><td>55.0
26.5</td><td>52.0
26.0</td><td>41.5
25.2</td><td>49.0
27.2</td><td>50.0
26.0</td><td>48.0
25.2</td><td>50.0
27.2</td><td>49.3
26.0</td><td>46.0
25.5</td></tr>
<tr><td>Notch of tailflukes to center of umbilicus</td><td>114.0
54.8</td><td>104.0
51.8</td><td>85.0
51.6</td><td>96.0
53.2</td><td>102.0
53.0</td><td>100.0
52.6</td><td>95.0
51.6</td><td>105.0
55.2</td><td>96.0
53.0</td></tr>
<tr><td>Anus to center of genital opening</td><td>22.0
10.6</td><td>6.0
3.0</td><td>14.0
8.5</td><td>—
—</td><td>6.0
3.1</td><td>6.5
3.4</td><td>7.0
3.8</td><td>7.5
4.0</td><td>15.0
8.3</td></tr>
<tr><td>Base length of dorsal fin</td><td>30.0
14.0</td><td>25.0
12.4</td><td>20.0
12.1</td><td>23.0
12.8</td><td>26.0
13.5</td><td>27.0
14.2</td><td>25.5
13.8</td><td>25.0
13.2</td><td>26.0
14.4</td></tr>
<tr><td>Height of dorsal fin</td><td>17.0
8.2</td><td>17.0
8.5</td><td>—
—</td><td>—
—</td><td>18.0
9.4</td><td>15.0
7.8</td><td>15.0
8.2</td><td>15.0
7.9</td><td>17.5
9.7</td></tr>
<tr><td>Total spread of tailflukes</td><td>47.0
22.5</td><td>43.0
21.4</td><td>—
—</td><td>—
—</td><td>45.0
23.5</td><td>43.0
22.6</td><td>43.0
23.3</td><td>40.5
21.3</td><td>39.0
21.6</td></tr>
<tr><td>Flipper : anterior insertion to tip</td><td>30.0
14.4</td><td>24.0
12.0</td><td>—
—</td><td>—
—</td><td>25.5
13.3</td><td>25.6
13.5</td><td>26.0
14.2</td><td>29.0
15.2</td><td>27.3
15.1</td></tr>
<tr><td>—— : axilla to tip</td><td>21.0
10.1</td><td>17.0
8.5</td><td>—
—</td><td>—
—</td><td>18.5
9.6</td><td>16.7
8.8</td><td>19.0
10.4</td><td>20.5
10.4</td><td>19.3
10.7</td></tr>
<tr><td>—— : greatest breadth</td><td>10.5
5.0</td><td>8.5
4.2</td><td>—
—</td><td>—
—</td><td>9.0
4.7</td><td>8.6
4.5</td><td>9.0
4.9</td><td>10.0
5.3</td><td>9.5
5.3</td></tr>
<tr><td>Remarks</td><td></td><td>Number of corpora in ovaries
pregnant
1 | 0
3 | 0</td><td></td><td></td><td></td><td>pregnant
1 | 0
1 | 0</td><td></td><td>pregnant</td><td></td></tr>
</table>

flippers toward the angle of gape or a little more anterior part of the lower jaw. In *Stenella caeruleo-alba* it goes toward the eye. However the dolphins belonging to the genus *Delphinus* show the same character of this band. On the tip of their snout, a white patch was clearly seen. This is one of the important colorations.

On the body of the fetuses and the new born pups there were no white tips, although tiny white spots were bearly parceptable.

TABLE 4. EXTERNAL MEASUREMENTS OF THE ARARI SPECIMENS COMPARED WITH THOSE OF *STENELLA* SPECIES

Measurements (Data expressed as percentage of body length)	Range of the male Arari Specimens	Range of tqe female Arari Specimens	"Atlantide" Specimen (male)	*Stenella plagiodon* (=p. dovis of True 1884 p. 319)	Type of *Stenella graffmani* (Lönnberg)	*Prodolphinus froenatus* (female) (Ogawa specimen)	Range of *Stenella caeruleo-alba* from Izu, Japan
Body length (cm)	165.0–208.0	180.0–201.0	200.0	215.7	224.5	189.0	197.0–229.0
Tip of rostrum to anterior margin of forehead (snout length)	5.3– 6.4	5.5– 7.7	4.5	5.9	5.0	—	5.3– 5.9
Tip of rostrum to angle of gape	11.0– 14.4	11.7– 14.5	12.0	12.9	12.9	13.0	14.2– 14.8
Tip of rostrum to center of blow hole	14.2– 17.1	14.2– 17.7	14.8	16.1	14.5	15.6	16.0– 16.8
Tip of rostrum to center of eye	13.5– 16.3	14.0– 17.7	14.3	15.6	14.6	15.0	14.5– 16.8
Center of eye to ear hole	2.9– 3.0	2.6– 3.2	2.7	—	—	—	—
Notch of tailflukes to posterior end of dorsal fin	39.2– 40.5	39.6– 42.8	47.5	—	—	47.6	41.5– 43.8
Notch of tailflukes to anus	25.2– 26.5	25.2– 27.2	30.0	28.8	30.7	28.5	27.8
Notch of tailflukes to center of umbilicus	51.6– 54.8	51.6– 55.2	56.5	—	—	—	52.0– 55.0
Anus to center of genital opening	8.3– 10.6	3.0– 4.0	9.0	—	—	2.9	6.8– 7.2
Dorsal fin : basal length	12.1– 14.4	—	16.5	17.0	—	—	9.2– 14.4
: vertical height	8.2– 9.7	7.8– 9.4	8.0	11.2	6.7	7.9	8.3– 8.9
Tailflukes : total spread	21.6– 22.5	21.3– 23.5	22.0	24.4	20.9	21.3	22.3– 25.3
Flipper : anterior insertion to tip	14.4– 15.1	12.0– 15.2	12.0	14.1	10.5	11.0	—
—— : axilla to tip	—	—	8.5	—	—	—	9.2– 10.6
—— : greatest breadth	5.0– 5.3	4.2– 5.3	4.5	5.8	4.8	—	4.6– 5.2

OSTEOLOGY

The dimensions of the skull are shown in Table 3 with the comparable data of the certain other species.

The data of the present specimen quite resembled the " Atlantide " dolphin which was describe by Dr. F. C. Fraser, the snout of which is also white. It was presented as a near relative of *Stenella frontrais* and *S. doris*. The Authors feel however, although most resembling *Stenella attenuata*, it would be a indepentent species. The dental formula is $\frac{38\sim45}{36\sim43}$ in both sides.

The vertebral formula is as follows.

C7+D15～16+L19～18+Ca37=78

The most anterior two in the seven cervical vertebrae are fused. The ribs are 15 or 16 pairs, there are 1 or 2 pairs of free ribs included. The individuals which have 16 pairs of ribs are observed more often than those having 15 pairs. The number of the caudal vertebrae is 37, the added number of the dorsal and the lumbar vertebrae is 34, so the total number is 78. In other words the first

TABLE 5. SKULL DIMENSIONS OF THE ARARI SPECIMENS

Serial number	1	2	3	4	5	6	7
Sex (M=male, F=female)	M	F	M	F	F	F	F
Body length in cm	208	201	165	180	192	190	184
Measurements (Data expressed as mm and percentages of skull length)							
Skull length (condyro-basal length in)	428	411	381	397	412	414	408
Rostrum length	258 60.28	252 61.31	227 59.58	244 61.45	241 58.49	250 60.39	236 57.8
Rostrum width at base	94 21.96	89 21.65	82 21.52	90 22.67	96 23.30	95 22.95	92 22.5
Rostrum width at middle	47 10.98	45 10.95	41 10.76	48 12.09	48 11.65	46 11.11	47 11.5
Rostrum width 60 mm in frount of ant. orb. notches	63 14.72	62 15.09	54 14.17	61 15.37	63 15.29	61 14.73	61 15.0
Rostrum width 3/4 length	33 7.71	31 7.54	29 7.61	30 7.56	33 8.01	31 7.49	33 8.1
Width across preorbitalis	166 38.78	163 42.78	150 39.37	160 40.30	168 40.78	162 39.13	158 38.7
Width across postorbitalis	183 42.76	175 45.93	161 42.26	173 43.58	186 45.14	182 43.96	172 42.2
Width across zygomatics	161 37.62	159 39.66	160 41.99	169 42.57	165 40.05	160 38.65	152 37.3
Width between parietals	152 35.51	145 35.28	137 35.96	150 37.78	161 39.08	149 35.99	155 38.0
Maximun width of pmx. proximally	74 17.29	68 16.55	70 18.37	69 17.38	74 17.96	73 17.63	73 17.9
Tip of rostrum—ant. margin of superior nares	295 68.93	282 68.61	259 67.98	280 70.53	286 69.42	289 69.81	286 70.1
Tip of rostrum—end of pterygoid	307 71.73	294 71.53	271 71.13	286 72.04	289 70.14	302 72.95	286 70.1
Temporal fossa—length	60 14.02	60 14.60	52 13.65	53 13.35	60 14.56	58 14.01	60 14.7
Temporal fossa—height	38 8.88	42 10.22	36 9.45	34 8.56	37 8.98	35 8.45	33 8.1
Hinder end tooth row to tip of pmx. R.	218 50.93	216 52.55	196 51.44	206 51.89	206 50.00	213 51.49	199 48.7
Hinder end tooth row to tip of pmx. L.	219 51.17	215 52.31	195 51.18	206 51.89	207 50.24	212 51.21	196 48.0
Mandible length R.	362 84.58	371 90.27	322 84.51	340 85.64	350 84.95	358 86.47	342 83.8
Mandible length L.	362 84.58	369 89.78	322 84.51	341 85.89	350 84.95	359 86.71	343 84.1
Coronoid height R.	61 14.3	61 14.8	58 15.2	58 14.6	62 15.0	60 14.5	63 15.4
Coronoid height L.	60 14.0	60 14.6	58 15.2	58 14.6	61 14.8	61 14.7	61 15.0
Hinder end tooth row to tip of mandible R.	216 50.47	211 51.34	188 49.34	205 51.64	206 50.00	212 51.21	201 49.3
Hinder end tooth row to tip of mandible L.	216 50.47	210 51.09	189 49.61	206 51.89	206 50.00	211 50.97	202 49.5
Length of symphsis	73 17.06	72 17.52	66 17.32	68 17.13	66 16.02	78 18.84	69 16.9
Teeth	45 | 44 43 | 43	43 | 42 42 | 43	44 | 44 42 | 41	44 | 44 43 | 43	41 | 40 40 | 39	39 | 38 36 | 37	40 | 42 41 | 40

chevron bone appears on the 42nd bone in the vertebral column. The chevron bones are usually 28, the most anterior and the most posterior three bones are usually separated in two parts. The most anterior two chevron bones segments are fused on each side. The individual variations in the vertebral formula are very scarce. The phalangeal formula is as follows. I: 2, II: 9, III: 7, IV: 3, V: 2.

SUMMARY

1. The dolphins which had never been reported scientifically in Japan were caught on 6th July, 1959.
2. After that until spring of 1964, several herds of this species have been caught. A herd of them was measured for the body length distribution. The body length at parturition is about 105 cm, the largest one was 208 cm in males and 201 cm in females.
3. The dolphins ate small mackerel easily from the human hand.
4. The breeding seasons are inferred to be in both spring and autumn, gestation period is about 12 months, growth period to attain the adult length is about a year.
5. External body characters are as follows; white area was observed on the tips of the snout in the adults, numerous tiny spots existed on the skin, the charactersistic of the black band from the eyes and the flippers resembled rather *Delphinus delphis* than *Stenella caeruleo-alba*.
6. The vertebral formula is C7+D15∼16+L19∼18+Ca37=78. The phalangeal formula is I: 2, II: 9, III: 7, IV: 3, V: 2. The dental formula is $\frac{38\sim45}{36\sim43}$
7. The dimensions of the skull quite resembled that of the " Atlantide dolphin."
8. The authors considered the species of this dolphins as *Stenella attenuata*. The authors would like to call this species in Japanese as "ARARI-iruka ".

ACKNOWLEDGEMENT

The authors are indebted to the members of the Fishermen's Union of Arari for their kind cooperation on this study, and thanks are also due to Messrs. of the Keeping Section in the Enoshima Marineland, Miss Kazuko Ogura and Miss Kazuko Akasaka for their collaboration in examination of the specimens.

Dr. Ikusaku Amemiya and Dr. Teizo Ogawa kindly discussed for this species and gave the lead to us. The authors grateful appreciated them.

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TABLE 6. SKULL MEASUREMENTS COMPARED

Measurement (Data expressed as percentages of skull length)	Range of the present specimen	"Atlantide" Specimen	Range of *Prodelphinus attenuata*	Type of *Prodelphinus attenuata*
Skull length (condyro-basal length)	381–428 mm	372 mm	373–423 mm	385 mm
Rostrum length	58.5–61.5%	56.2%	59.5–61.9%	59.5%
Rostrum width at base	21.5–23.3	23.4	19.9–22.3	21.8
Rostrum width at middle	10.8–12.1	12.1	9.0–10.9	9.6
Rostrum width 60 mm in frount of ant. orb. notches	14.2–15.4	15.6	13.0–15.8	13.0
Rostrum width 3/4 length	7.5– 8.0	8.9	6.1– 7.1	6.2
Width across preorbitalis	39.1–42.8	41.1	35.5–38.2	38.2
Width across postorbitalis	42.3–45.1	46.2	39.5–42.9	42.1
Width across zygomatics	37.6–42.6	46.2	39.4–42.1	42.1
Width between parietals	35.3–39.1	39.5	32.1–36.2	35.6
Maximum width of pmx. proximally	16.6–18.4	18.5	15.5–16.6	15.8
Tip of rostrum—ant. margin of superior nares	68.0–70.5	67.2	68.9–72.4	69.3
Tip of rostrum—end of pterygoid	70.1–73.0	69.9	69.7–73.2	—
Temporal fossa—length	13.4–14.6	17.6	14.6–18.2	15.8
Temporal fossa—height	8.6–10.2	15.3	10.2–13.7	11.4
Hinder end tooth row to tip of pmx. R.	50.0–52.6	47.3	51.3–53.4	51.7
Hinder end tooth row to tip of pmx. L.	50.2–52.3	47.3	51.2–53.4	51.4
Mandible length R.	84.5–90.2	84.4	84.0–85.5	85.5
Mandible length L.	84.5–89.8	84.1	84.2–85.1	84.7
Coronoid height	14.3–15.2	16.4	13.5–14.6	13.8
Hinder end tooth row—tip of mandible R.	49.3–51.6	48.7	49.1–52.0	50.4
Hinder end tooth row—tip of mandible L.	49.6–51.9	48.9	49.1–51.7	49.8
Teeth	$\frac{39 \mid 38}{36 \mid 37}-\frac{45 \mid 44}{43 \mid 43}$	$\frac{42 \mid 41}{39 \mid 39}$	$\frac{35 \mid 36}{38 \mid 38}-\frac{44 \mid 43}{43 \mid 43}$	$\frac{43 \mid 43}{43 \mid 42}$

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WITH VARIOUS DATA OF *STENELLA* SPECIES

Type of *Prodelphihus capensis*	Type of *Clymenia doris*	Range of *Clymenia doris* and *Prodelphinus doris*	Type of *Prodelphinus froenatus*	Type of *Prodelphinus frontalis*	Range of *S. frontalis*	*Prodelphinus froenatus*	*Prodelphinus longirostris*
413 mm	399 mm	363–408 mm	377 mm	392 mm	—	380	419
60.5%	59.4%	56.7–60.0%	57.8%	57.6%	56.2–60.0%	56.1	63.5
22.3	22.3	20.3–24.0	23.1	22.7	21.4–24.0	22.4	18.6
9.9	12.5	11.1–13.7	13.8	11.2	11.1–13.8	11.3	11.5
14.6	16.0	14.2–17.0	17.2	14.8	14.2–17.2	—	—
7.0	9.0	7.9– 9.5	10.1	8.4	—	—	—
38.2	40.1	38.4–42.7	42.2	40.0	38.4–42.7	—	35.1
42.9	44.9	43.7–47.7	47.7	44.1	43.7–47.7	41.3	—
42.1	44.6	43.4–47.7	47.2	44.1	—	—	—
32.9	36.8	34.1–39.5	36.6	36.2	36.2–39.5	35.3	31.5
16.0	18.5	17.4–21.0	19.1	19.1	17.4–21.0	18.4	15.3
70.5	67.9	65.8–69.6	68.4	67.6	65.8–69.6	66.1	73.3
70.5	70.7	69.1–70.7	69.8	71.2	67.6–71.2	72.1	76.1
16.5	16.8	15.8–19.3	18.8	17.6	—	18.2	12.9
12.1	14.0	11.6–14.5	13.0	12.0	—	15.8	10.7
51.3	50.1	48.5–52.5	49.9	50.0	46.3–52.5	48.4	55.4
51.8	50.9	48.8–52.0	49.1	50.5			
84.0	83.9	81.1–85.5	—	84.7	81.3–86.3	82.2	86.4
84.3	84.2	81.3–86.3	—	85.2			
14.0	15.3	14.8–16.3	—	15.3	14.7–16.4	16.8	14.3
49.1	48.1	46.7–52.0	—	49.0	46.9–52.0	45.8	55.8
49.1	48.1	46.9–51.2	—	48.7			
39 | 39 / 38 | 38	37 | 34 / 34 | 34	33 | 34 / 33 | 33 – 41 | 40 / 40 | 40	L38 R37	38 | 37 / 37 | 38		34 | 31+ / 30+ | 29+	59 | 60 / 61 | 60

EXPLANATION OF PLATES

(The figure number in the plate is given from top to bottom)

PLATE I

Fig. 1. Left lateral view of skull of the Arari specimen (No. 1).
Fig. 2. Dorsal views of skulls of the Arari specimen. 2, 1 and 4 from the left.
Fig. 3. Ventral views of skulls of the Arari specimens No. 2, 1 and 4 from the left.

PLATE II

Fig. 1. Inner lateral view of the No. 2, dorsal view of the No. 1 and outer lateral of the No. 4 of mandibles of the Arari specimens.
Fig. 2. Dorsal view of skull of the Arari specimen, the mandible is occuluted.

PLATE III

Fig. 1. Lateral view of cervical, dorsal and lumbar vertebrae of the Arari specimen (No. 1). Vertebral formula is C7+D16+L18+Ca37=78
Fig. 2. Lateral view of caudal vertebrae of the Arari specimen (No. 1).
Fig. 3. Lateral view of chevron bones of the Arari specimen (No. 1).

PLATE IV

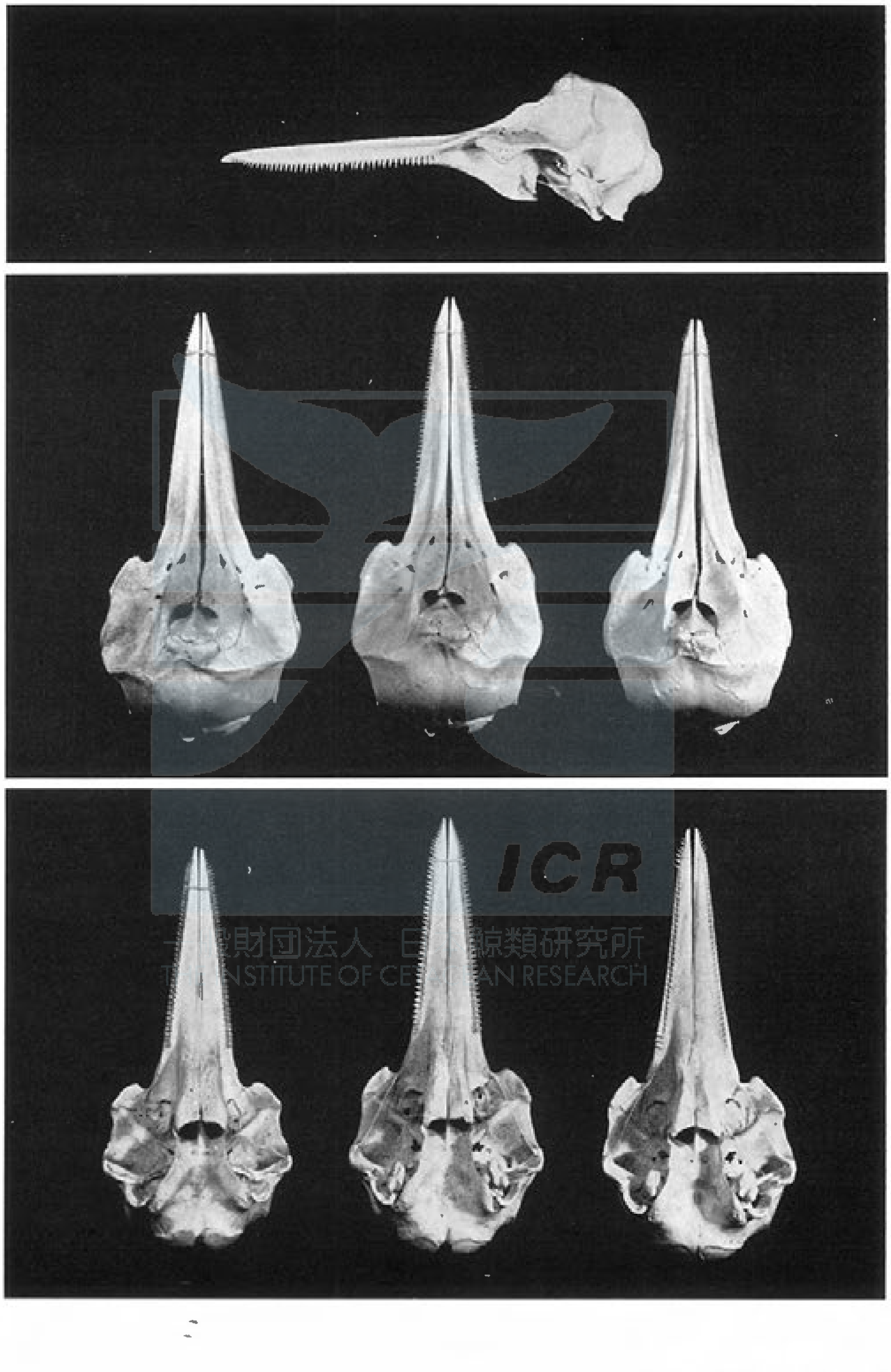
Fig. 1. (left figure in the PLATE) Lateral view of cervical vertebrae of the Arari specimen (No. 3), showing only anterior two vertebrae fused.
Fig. 2. Cranial views of cervicals of the Arari specimen (No. 3).
Fig. 3. Caudal views of cervicals of the Arari specimen (No. 3).

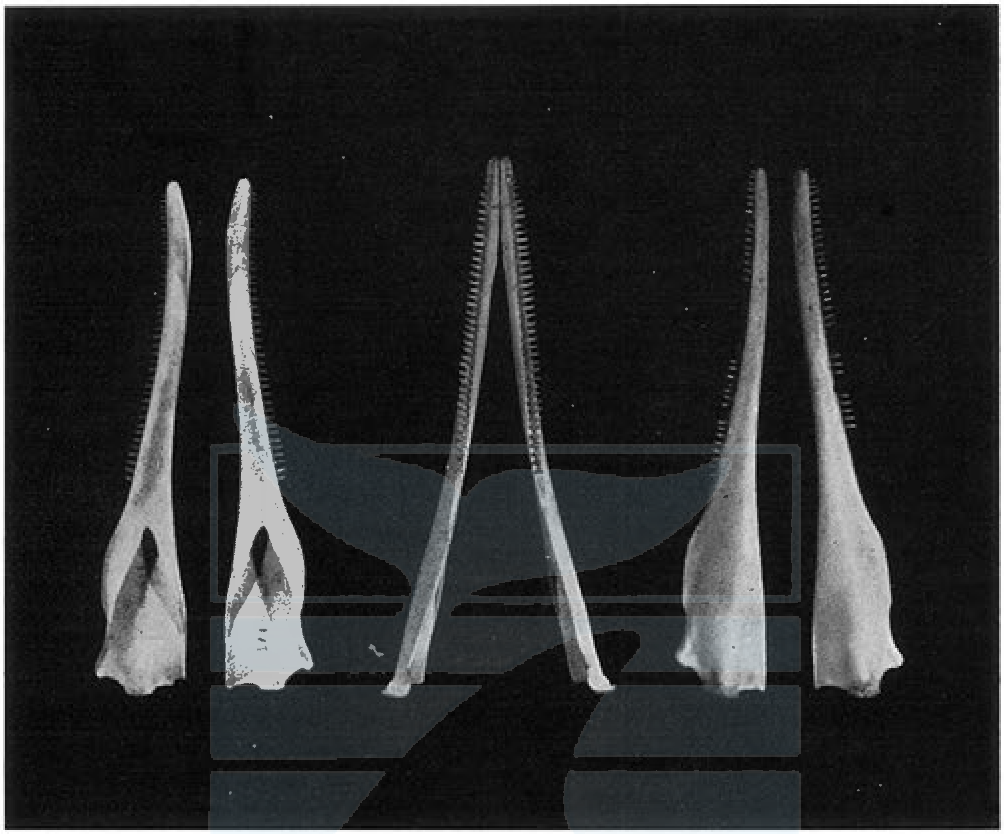
PLATE V

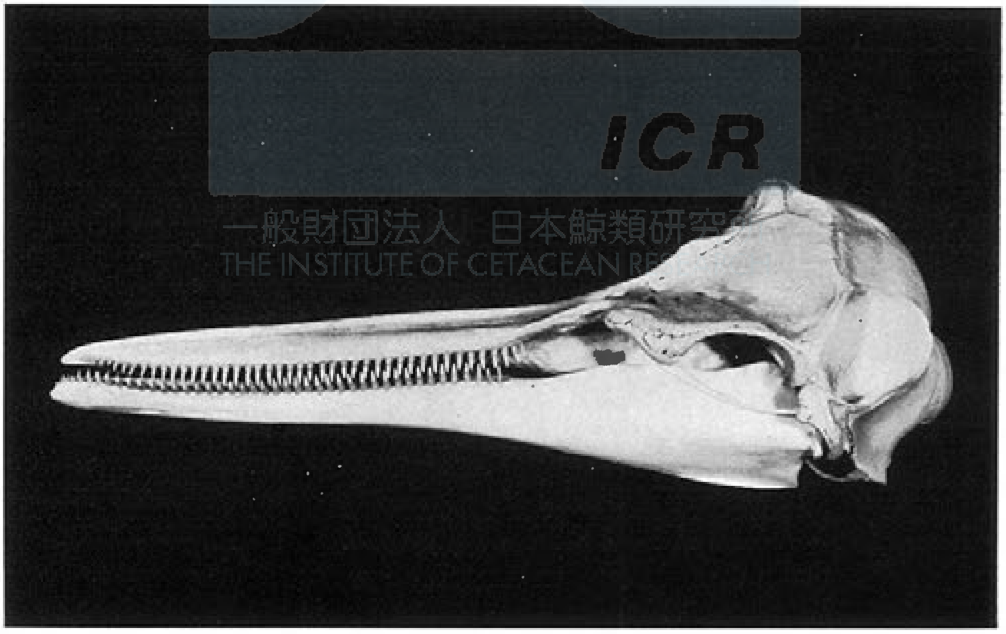
Fig. 1. Dorsal views of sternum, sternal ribs, vertebral ribs, hyoid bones and pelvic bones of the Arari specimen (No, 1).
Fig. 2. (lower left) Detailed figure of pelvic bones of the Arari specinen (No. 1).
Fig. 3. (lower right) Detailed figure of hyoid bones of the Arari specimen (No. 1).

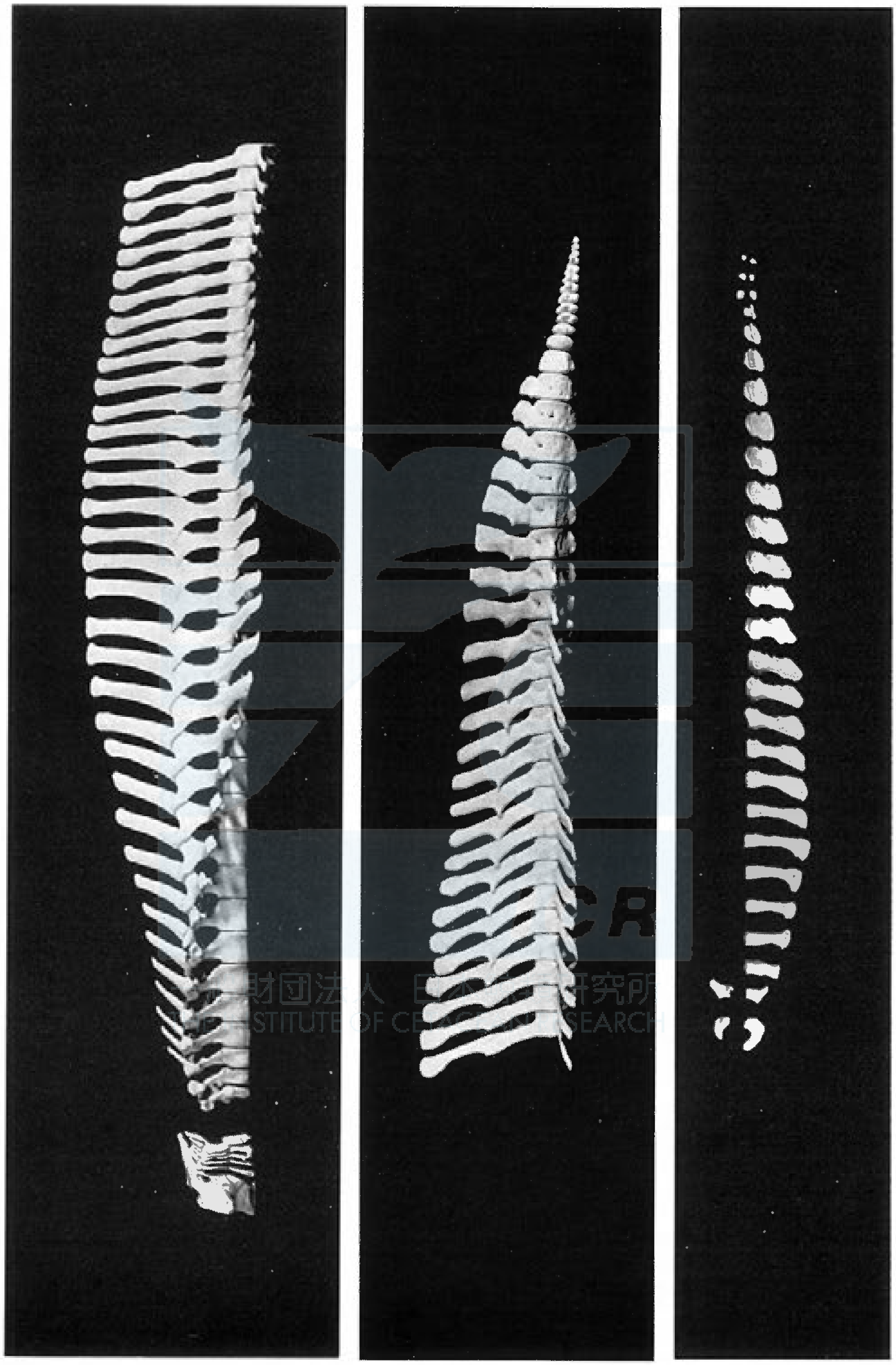
PLATE VI

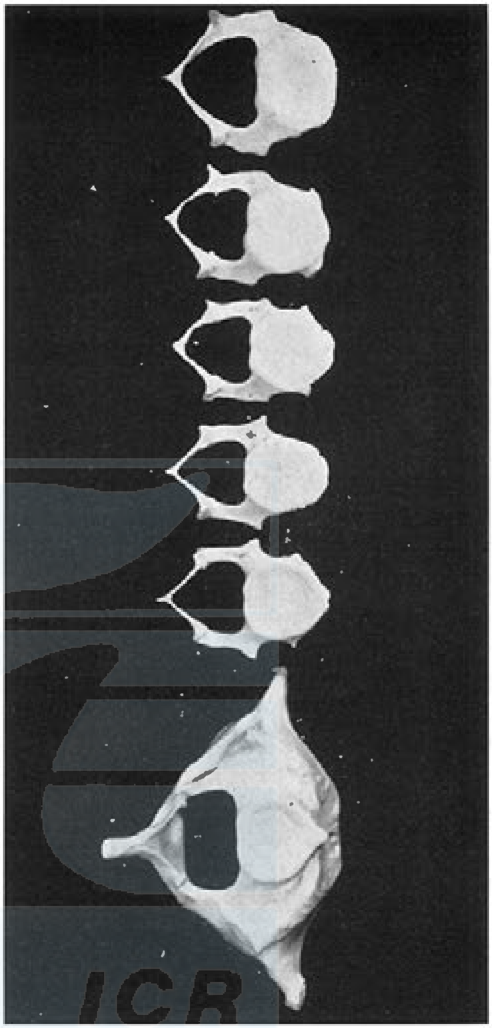
Fig. 1. Dorsal views of the bones of flipper with scapula of the Arari specimen (No. 1). Phalangeal formula is I : 2, II : 9, III : 7, IV : 3, V : 2.
Fig. 2. Tympanic bulla of the Arari specimen (No. 4).

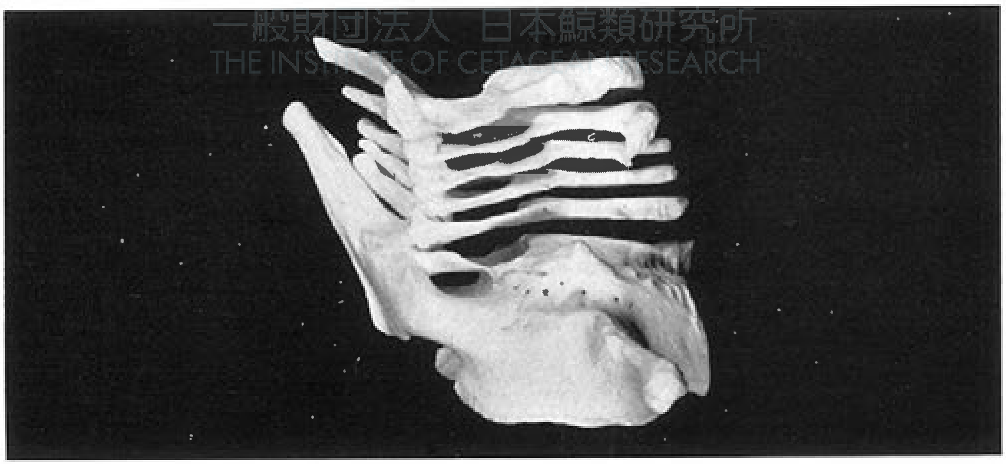


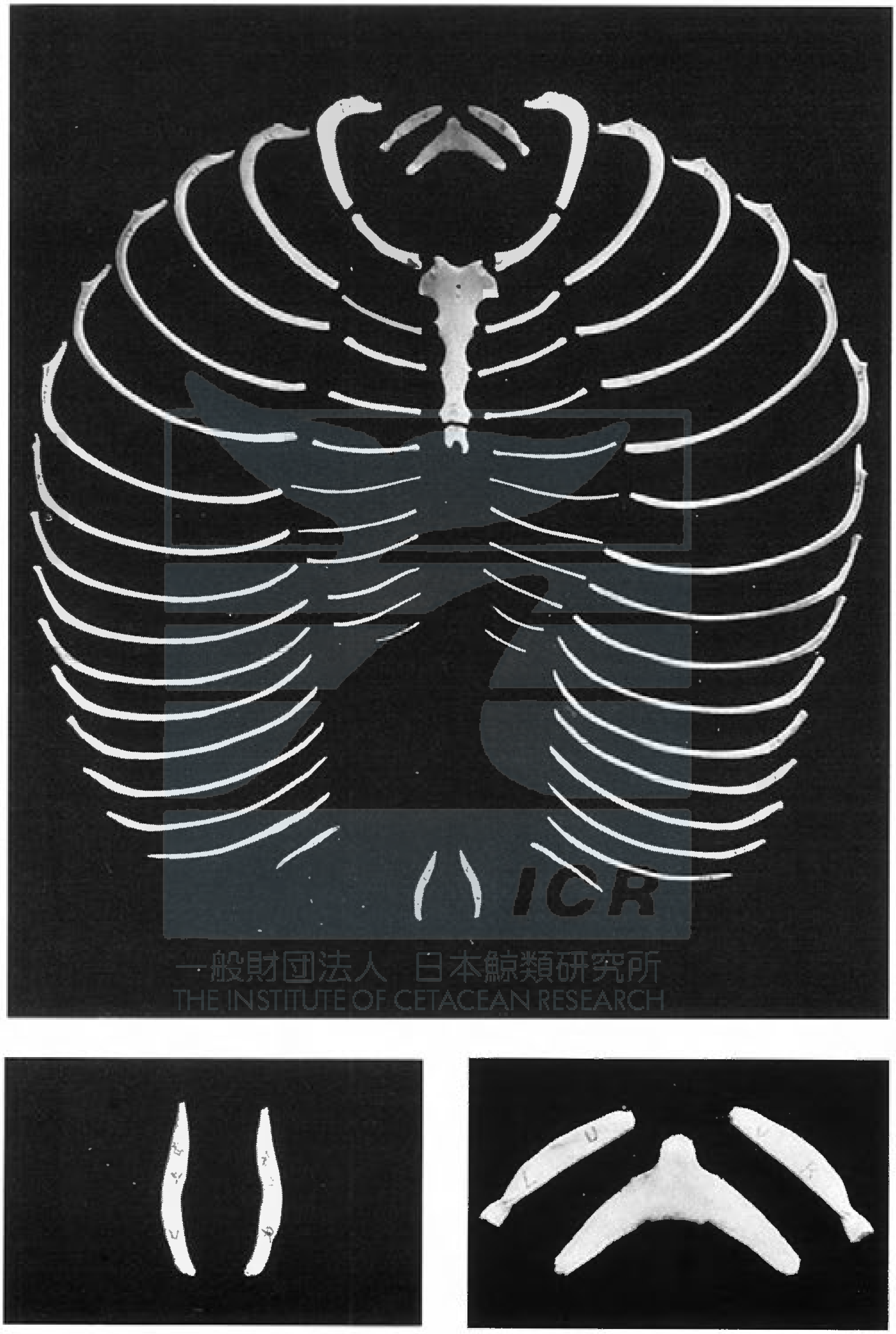


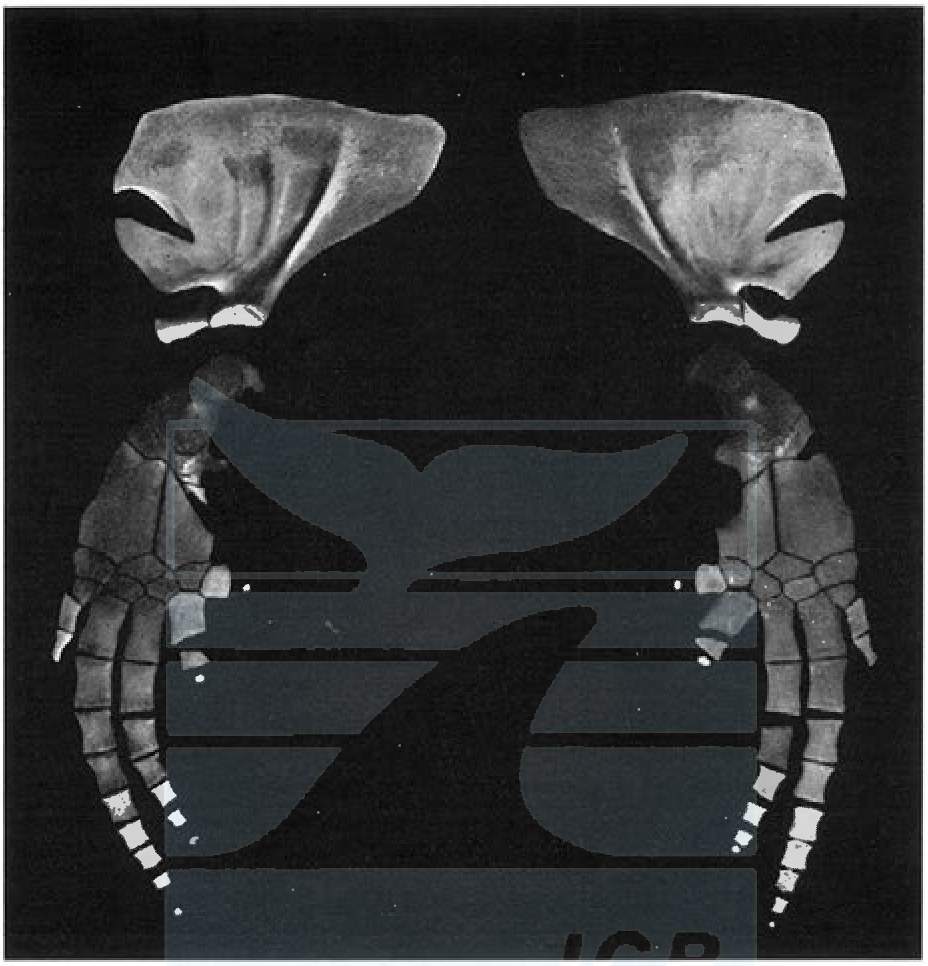


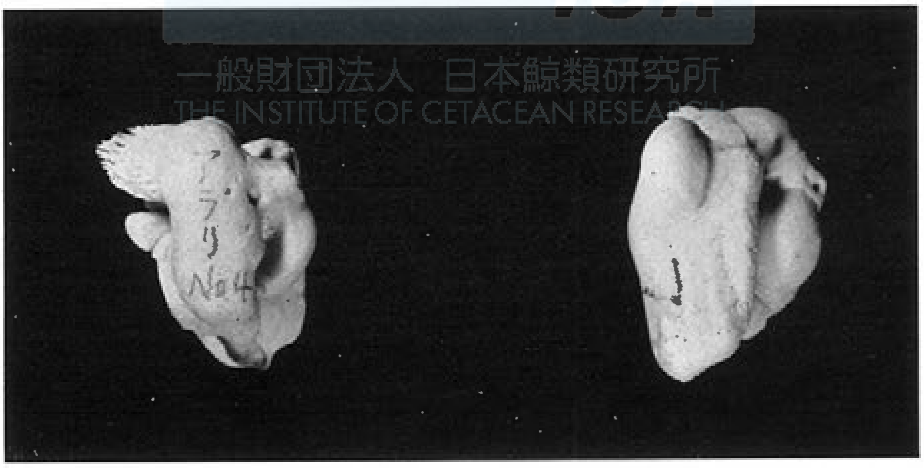












FERESA ATTENUATA CAPTURED AT THE PACIFIC COAST OF JAPAN IN 1963

MASAHARU NISHIWAKI, TOSHIO KASUYA, TOSHIRO KAMIYA*, TERUO TOBAYAMA**, AND MASAYUKI NAKAJIMA***

INTRODUCTION

The fishermen at some fishing villeges of the Izu Peninsula, Shizuoka Prefecture, engage in fishing for small cetaceans. Their method of fishing is a unique one. When some small fishing vessels find a school of dolphins, cooperating with other ships, they drive it toward the inlet near the villege. The school is driven in and enclosed in the inlet with a net. Then usually they are pulled up and killed.

On January 28, 1963 a school of *Feresa attenuata* composed of 14 porpoises were discovered near the entrance of Sagami Bay and captured at Futo, on the east coast of the Izu Peninsula. All of them were kept alive for some days in a pool of the Ito Aquarium together with other dolphins. Though during this period effort to tame them was made, all of them died within 22 days after the capture, and they were examined.

Feresa Gray is one of the genera about which very little is known. The first specimen was reported in 1827 as *Delphinus intermedius* by Gray but the location of the collection is not known. Gray also reported a second specimen, a type of *Feresa attenuata*, in 1875, the collection location of which is known only as " the South Sea ". These specimens are known only from the skulls, and other skeletal and external characters remained unknown until recently. Then Yamada (1954) reported a whole skeleton and some fragments of the blubber collected at Taiji, Japan. This specimen gave us the first knowledge on the whole skeleton and a glimpse of external characteristics. The fourth specimen was captured in 1958 at Yenn, Senegal and a report on its skull was made by Cadenat (1958).

So we think it valuable to report the data on this poorly known genera obtained from the examination of the Futo specimens.

CAPTURE AND KEEPING

On January 28, 1963 a school of *Feresa* Gray composed of 14 porpoises was found by a fishing vessel at a point about 2 km off the north shore of Oshima Is. which is situated at the entrance of Sagami Bay. Their direction of swimming was southerly. Near the area where the school was found, no school of the same species had previously been observed.

After about two and a half hours they were driven by a number of fishing vessels into the Futo harbour, which is situated about 30 km north west from O-

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shima Is. It required about twice the amount of time as compared with other small cetaceans, for example *Stenella caeruleoalba*, to make the drive. During the driving they seemed obedient and sounded shallowly only three times, each of which was for about 3 minutes. Other small cetaceans usually sound deeply many times in order to escape.

In the enclosure of the harbour, they acted in the same manner as in the pool of the Ito Aquarium, some kept themselves perpendicular and others swam slowly in the horizontal postur around the former. They observed the men on the shore with both eyes when they were perpendicular.

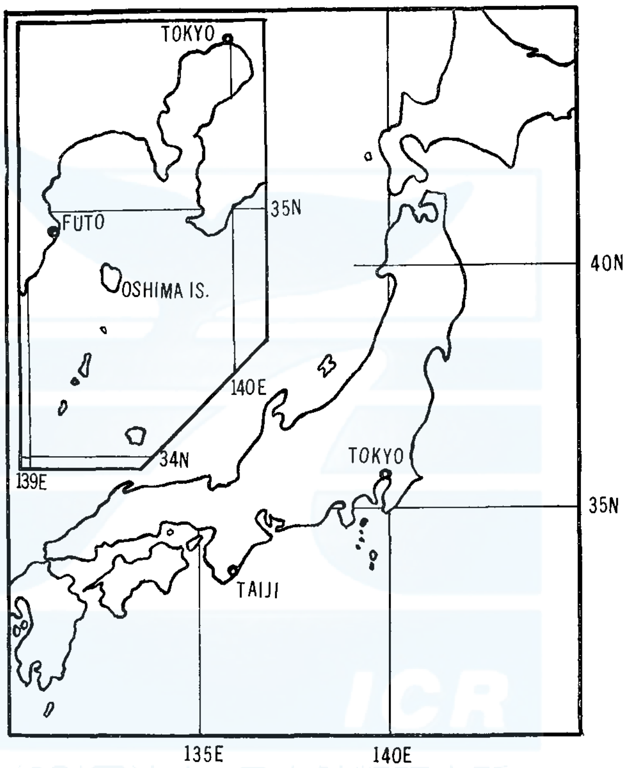


Fig. 1. Chart showing the coastal area of Japan.

The porpoises were separated into five groups and transported from the harbour to the Ito Aquarium by truck during the next two days following capture. About a half hour was spent for each transportation, and the condition of the whales seemed fairly well with no vomiting except for one which died in transit during the fourth trip. During the transportation the respiration rate and the pulse rate of all porpoises was counted every five minutes. The average respiration rate fell between 8.4 and 5.1 times per minute, and it showed the tendency to decrease with the elapse of time on the truck. The total average rate of respiration during the transport was 7.1 times per minute. The average pulse rate was 66 times per minute. The body temperature was not observed. The average air and water temperature at the time of the transportation were 8.2°C and 13.5°C respectively.

Except for one male which began to take food all Porpoises died within a week from capture. Of the 12 whales which died in the pool within the week, five could not be observed the condition when dying but the other seven had convulsive fits and sank with their mouths half open after abnormal swimming for 20 minutes to 3 hours. The cause of the death could not be determined.

The one male which lived in the aquarium for 22 days, seems to have died from pneumonia judging from the swelling of limphonodi bronchopulmonales and purulence in the lungs.

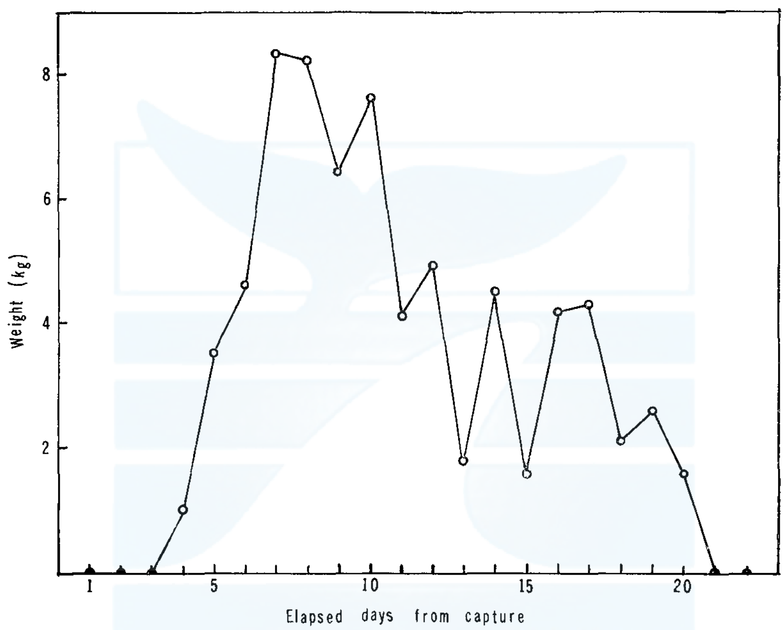


Fig. 2. Food consumption of a male *Feresa* Gray kept alive for 22 days in a pool.

This male first begun to take living sardines 4 days after capture, having rejected squid, saurel and mackerel-pike. From this success we gave food by throwing, mainly in daytime, aiming the standard weight 8 kg of food a day, or five per cent of the presumed body weight of 160 kg. But the standard was attained only for 2 days. Though the animal kept high activity at night, the throwing of food at night did not increase consumption.

Seven days after capture, giving food from hand directly was tried and succeeded easily, but it was stopped on the ninth day due to the decrease of food intake. The food consumption of the specimen is shown in Fig. 4.

The respiration rate in the aquarium is shown in Fig. 3. Each one is the mean number of the per minute rates counted over a five minute period at 10: 00 and 14: 00. The average rate of respiration of the male porpoise in the aquarium is 3.9 times per minute and average time spent submerged in the water is 25.6 seconds.

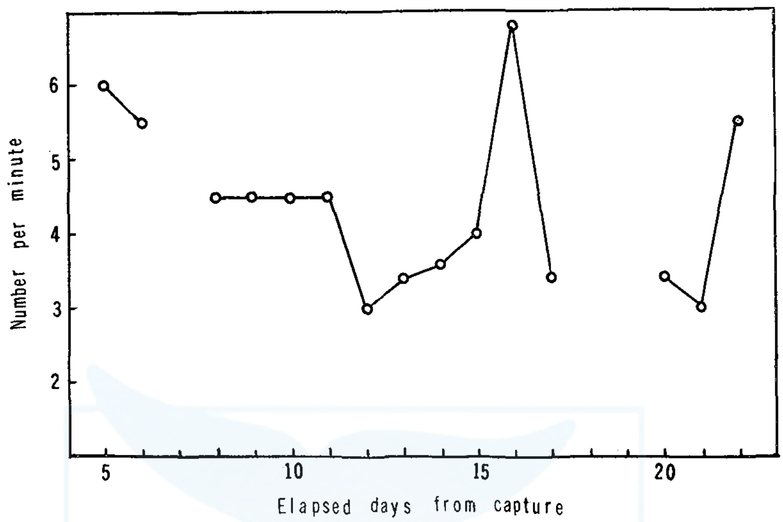


Fig. 3. Respiration rate of the same whale shown in Fig. 2.

TABLE 1. DATES TRANSPORTED AND DEATH OF FUTO SPECIMENS

Specimen No.	Date transported	Date of death	Days kept alive	Sex	Body length (cm)
1	29 I ’63	30 I ’63	2	M	240
2	30 I ’63	30 I ’63	2	M	217
3	30 I ’63	31 I ’63	3	M	215
4	30 I ’63	31 I ’63	3	F	215
5	29 I ’63	1 II ’63	4	F	225
6	29 I ’63	2 II ’63	5	F	225
7	29 I ’63	2 II ’63	5	F	221
8	29 I ’63	2 II ’63	5	M	229
9	29 I ’63	3 II ’63	6	M	223
10	30 I ’63	3 II ’63	6	M	244
11	29 I ’63	4 II ’63	7	F	227
12	29 I ’63	4 II ’63	7	F	221
13	30 I ’63	4 II ’63	7	F	208
14	29 I ’63	19 II ’63	22	M	214

Note: No. 4 is still frozen at Enoshima Marineland.
Skeleton of No. 6 is kept at the Zool. Museum, Herbart University by the wishes of Dr. W. E. Schevill.
No. 10 is used to show the internal organs at Ito Aquarium.

EXTERNAL CHARACTERS

The external measurements of the Futo specimens are shown in Table 2 and Appendix I. The ranges of body length in 7 males and 7 females are 214–244 cm and

208–227 cm respectively, and some of both sexes were full grown, which shows that the male grows larger than the female. All of the measurements of tail flukes, flippers dorsal fin and head region made on Taiji specimen by Yamada (1954) fall within the range of the Futo specimens.

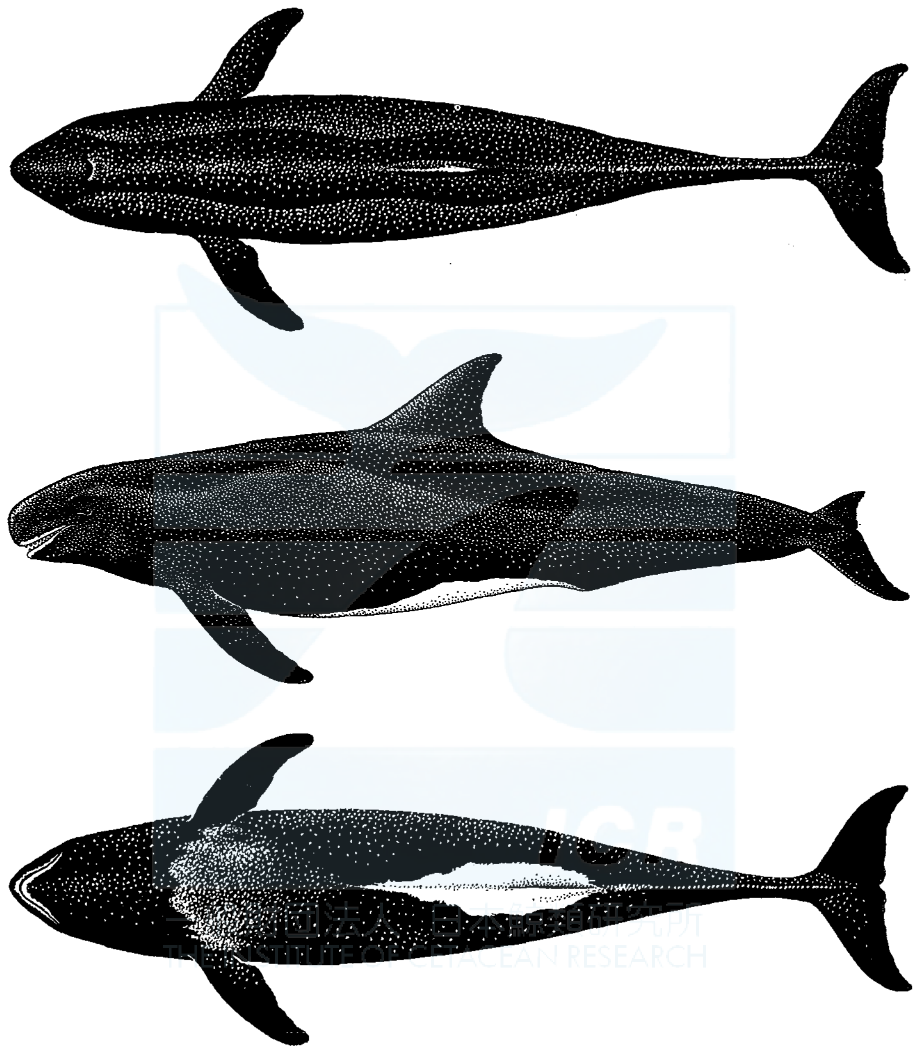


Fig. 4. Dorsal, lateral and ventral views of *Feresa attenuata*.

The sexual difference of the external measurements is found in the length between the tip of upper jaw and middle of reproductive aperture, this measurement is larger in the female than in the male.

TABLE 2. EXTERNAL MEASURMENT OF FUTO SPECIMENS SHOWN IN THE PERCENTAGE OF TOTAL LENGTH

		Range in 7 males	Range in 7 females
1.	Length, total	214 - 244 cm	208 - 227 cm
2.	Length, tip of upper jaw to center of eye	8.7 - 11.4 %	8.1 - 10.8 %
3.	Length of gape	5.4 - 7.2	6.0 - 8.4
4.	Center of eye to external auditory meatus (direct)	3.0 - 4.0	3.2 - 3.8
5.	Length, center of eye to angle of gape	2.4 - 5.8	1.4 - 3.8
6.	Length, tip of upper jaw to blow-hole	6.7 - 11.9	7.2 - 11.1
7.	Anteriormost point of gape to blowhole along the melon	15.2 - 18.1	16.3 - 17.1
8.	Length, tip of upper jaw to anterior insertion of flipper	16.8 - 21.6	18.6 - 21.3
9.	Length, anterior insertion of flipper to axilla	6.1 - 6.7	4.0 - 7.0
10.	Length, tip of upper jaw to tip of dorsal fin	54.8 - 61.8	54.3 - 60.6
11.	Length, tip of upper jaw to mid-point of umbilicus	38.6 - 45.1	40.3 - 44.9
12.	Length, tip of upper jaw to mid-point of genital aperture	56.2 - 51.3	57.8 - 61.1
13.	Length, tip of upper jaw to center of anus	62.8 - 66.8	61.4 - 65.8
14.	Projection of upper jaw beyond the lower	0.9 - 2.5	0.9 - 1.9
15.	Girth, at anterior insertion of flipper	45.5 - 49.6	45.6 - 53.8
16.	Girth, at anterior insertion of dorsal fin (maximum)	52.6 - 64.7	59.0 - 63.3
17.	Maximum height of body, including dorsal fin	25.2 - 31.7	27.2 - 32.4
18.	Length of eye	1.0 - 1.4	0.9 - 1.3
19.	Width of blowhole	1.4 - 2.1	1.3 - 2.3
20.	Length of flipper, anterior insertion to tip	18.3 - 22.1	14.7 - 22.2
21.	Length of flipper, along anterior edge	20.3 - 24.0	20.5 - 24.4
22.	Length of flipper, axilla to tip	13.8 - 16.4	14.7 - 19.0
23.	Width of flipper, maximum	6.1 - 7.0	5.8 - 7.0
24.	Dorsal fin, height	9.4 - 11.6	9.6 - 10.9
25.	Dorsal fin, length of base	14.0 - 19.4	15.8 - 19.1
26.	Dorsal fin, anterior insertion to tip along anterior edge	17.5 - 21.4	18.3 - 21.3
27.	Dorsal fin, posterior insertion to tip along posterior edge	11.3 - 13.7	9.3 - 13.3
28.	Dorsal fin, anterior insertion to posterior edge (minimum)	12.6 - 15.3	13.9 - 16.3
29.	Width of tail flukes, tip to tip	23.8 - 28.1	23.0 - 28.4
30.	Anterior insertion of tail fluke to notch	6.8 - 8.3	6.9 - 8.8
31.	Anterior insertion of tail fluke to tip	15.0 - 18.2	14.2 - 18.2
32.	Distance, tip of tail fluke to notch	10.7 - 14.5	12.7 - 15.1

Two females were pregnant and the body length of their fetuses, both female, were 205 mm and 530 mm. Their external measurments are listed on Appendix I.

The shape of dorsal fin and tail flukes coincides with that drawn by Yamada (1954). But the flipper is more concaved at the posterior edge and convex at the anterior than the figure of Yamada (1954), so it somewhat resembles with that of *Globicephala* but its length is definitely much shorter. This configuration of the flipper is seen not only in the adult but also in the fetus. The posterior edges of the dorsal fin, flipper and tail flukes of all specimens except the fetuses are indented irregularly. So we think that this shape is formed after birth.

The shape of the head region of our specimens differs from the figure drawn by Yamada (1954), which is a figure reconstructed from the flensed specimen. On his figure the head is too slender. Our specimens show a more globular head with well developed melon.

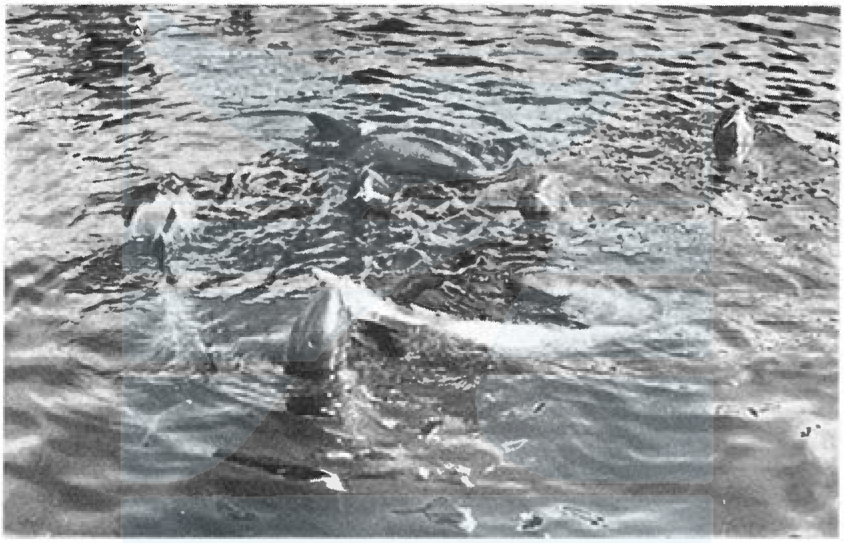


Fig. 5. *Feresa* Gray swimming perpendicularly in the pool of a aquarium.

The true position of the flipper seems to be some what anterior than that on his figure. As the position on his figure is an assumed one, it must be incorrect.

A ventral groove was found on the Futo specimens, which starts at the middle point between the flippers and extend in increasing depth to the urinogenital groove. A external beak was not present on our Futo specimens.

The better part of the dorsal surface, head, throat and both side of flipper and tail flukes are coloured bluish black. The inguinal area is covered with a oval white area in which anus and reproductive aperture open. The breast, the area between the two flippers is gray, its boundary area is indistinct and changes gradually into the surrounding bluish black.

The upper and lower lips have irregular white area which seems to be formed after birth.

Above mentioned white or gray areas are easily observed on a carcass, and there is another pale area which is very indistinct on a carcass. It covers most of the flank, from the insertion of tail flukes to the area around the eye, and most of the ventral surface. Its upper margin starts in front of the eye and, increasing its height, attains its maximum height at nearly the middle point of axilla and the anterior insertion of dorsal fin, and then decreases its height till the lowest point near the dorsal fin, then it extend obliquely upward and finally reaches the anterior insertion of flipper. The lower border begins at the same point as the upper and reaches the axilla, and the two pale areas of the left and the right sides untie at the ventral surface immediately posterior to the oval reproductive area.

Fig. 6. *Feresa* Gray swimming horizontally in the same pool as Fig. 5, notice the pale area on the flank.

CLASSIFICATION INTO SPECIES

Table 3 shows the skull measurements shown in per cent of total skull length of the specimens of the genus *Feresa* already reported, and the ranges of the Futo specimens. Each measurement of the already reported 4 specimens fits fairly well into the range of the Futo specimens. In our specimen the breadth of rostrum at base seems to increase with the body length. B.M. 362 A has a large value on this measurement, which would be due to the advanced age of the specimen. Though the length of the maxillary tooth row is longer in B.M. 362 A and in B.M. 1672 A than in our specimens, this could be due to the difference of the measured points.

In the Futo specimens the depth of temporal fossa is larger in the right side than the left, and the measurements of B.M. 362 A and B.M. 1672 A fall within the range of right side in our specimens. The length of mandibular symphysis is very short in Taiji specimen comparing with other specimens, it may be due to the difference of point measured.

As mentioned above the breadth of rostrum at base seems to increase with age, other difference of the shape of skull due to age or sex can not be found.

When their small body length (shorter than 250 cm), number of teeth and the shape of skull are considered, our Futo specimens cannot be classified out of the genus *Feresa* Gray. And all of them are classified into *Feresa attenuata* Gray (1875).

TABLE 3. SKULL MEASURMENTS SHOWN IN PER CENT OF TOTAL SKULL LENGTH

		B.M. 362A	B.M. 1672A	Taiji specimen	Yenn specimen	Range in 6 male Futo specimens	Range in 6 female Futo specimens
1. Total (condylo-basal) length		362 mm	350 mm	385 mm	347 mm	356–380 mm	365–390 mm
2. Length of rostrum (medium)		47.4%	48.0%	47.8%	47.5%	44.7–49.2%	47.2–48.4%
3. Breadth of rostrum at base		33.2	30.3	30.2	31.1	27.7–31.7	28.9–31.8
4. Breadth of rostrum at middle		24.6	21.4	23.1	24.3	23.4–25.1	22.9–24.7
5. Breadth of premaxillae at middle of rostrum		16.9	14.9	14.8	15.5	16.1–17.4	15.0–17.7
6. Greatest breadth of premaxillae		25.1	26.0	22.6	25.4	23.4–26.2	23.7–25.0
7. Distance from tip of rostrum to anterior margin of superior nares		62.4	63.2	59.2	61.3	60.7–63.2	56.9–62.6
8. Breadth across orbits		58.3	57.4	56.1	56.4?	56.5–60.7	53.7–58.6
9. Breadth across posterior margins of temporal fossae		42.3	49.4	40.3	42.3	38.4–44.0	40.3–42.7
10. Length of temporal fossa		25.4	24.0	24.2	24.7	24.0–27.9	22.0–27.1
11. Depth of temporal fossa	L.	20.2	21.1	17.4	—	17.2–19.2	16.9–19.4
	R.			19.8	21.0	18.3–22.3	17.6–23.7
12. Length of maxillary tooth row	L.	35.6	36.3	30.7	31.7	29.5–31.8	27.6–32.0
	R.			31.4	31.7	29.5–32.1	26.1–33.3
13. Length of mandibular ramus	L.	79.8	80.0	73.7	78.3?	72.2–79.4	75.8–79.2
	R.					72.2–79.9	76.3–79.5
14. Length of mandibular symphysis		8.3	9.7	7.8	9.0	8.9–10.0	8.7–10.1
15. Length of mandibular tooth row	L.	37.3	38.0	36.4	36.3	33.9–37.0	31.5–37.5
	R.			36.9	36.3	35.0–37.6	33.1–38.4
16. Depth between angle and coronoid process	L.	21.8	20.9	21.3		22.0–22.8	20.8–23.8
	R.			21.3		22.6–23.6	20.8–24.1
17. Number of alveoli		11 | 11 / 11 | 10	11 | 12 / 12 | 13	11 | 10 / 13 | 13	10 | 10 / 13 | 13	10–11 | 9–10 / 12 | 12–13	10–11 | 8–10 / 11–13 | 11–13

The length/breadth ratios of skull and rostrum of the Futo specimens fall between 1.50 and 1.78 and between 1.42 and 1.73 respectively, which, as mentioned by Nishiwaki (1963), shows, in conjunction with the number of teeth, that the genus *Feresa* comes within the range of Globicephalidae advocated by Nishiwaki (1963) and is especially akin to the genus *Pseudorca*.

OSTEOLOGICAL NOTES

The vertebral formulae and the number of the vertebrae, ribs and chevron bones are shown in Table 4. The uncinate transverse process on 7th dorsal vertebra pointed out by Yamada (1954) exist on the Futo specimens (Fig. 7). Distance be-

TABLE 4. NUMBER OF VERTEBRAE, RIBS AND CHEVRON BONES OF FUTO SPECIMENS

Specimen No.		1	2	3	5	6
Number of vertebrae	C. (fused)	7 (1-3)	7 (1-3)	7 (1-4)	7 (1-3)	7 (1-6)
	D.	12	12	12	13	13
	L.	17	17	16	16	15
	Ca	34	32	34	33	34
	Sum	70	68	69	69	69
Number of ribs	L. (two headed)	12 (6)	12 (6)	12 (5)	12 (7*)	12 (6)
	R. („)	12 (6)	12 (6)	12 (5)	12 (6)	12 (6)
Number of sternal ribs	L.	8	8	8	8	8
	R.	9	8	8	8	8
Number of cervical ribs	L.	1	—	—	—	—
	R.	—	—	—	—	—
Number of chevron bones		25	26	26	25	25
Centrum of vertebra ankylosed with epiphyses		Completed	Completed	Completed	Completed	Completed

Specimen No.		7	8	9	10	11	12	13	14
Number of vertebrae	C. (fused)	7 (1-3)	7 (1-3)	7 (1-3, 4-5)	7	7 (1-3)	7 (1-3)	7 (1-4)	7 (1-3)
	D.	12	12	13	13	13	12	13	12
	L.	16	16	16	16	15	17	16	16
	Ca	31+	34	33	33	34+ (1)	33	34	32+ (1)
	Sum	66+	69	69	69	69+ (1)	69	70	67+ (1)
Number of ribs	L. (two headed)	12 (5)	12 (6*)	13 (6*)		12 (6)	12 (5)	12 (6)	12 (5)
	R. („)	12 (5)	12 (6)	12 (6*)	13 (6)	12 (7*)	12 (5)	12 (7*)	12 (5)
Number of sternal ribs	L.	9	8	8		9	8	9	5+
	R.	9	8	8	9	9	8	9	5+
Number of cervical ribs	L.	—	—	—		—	—	—	1
	R.	—	—	—	—	—	—	—	—
Number of chevron bones		21	26	27		22	22	27	23
Centrum of vertebra ankylosed with epiphyses		Completed	Completed	C 1-7		Completed	C 1-D 2 Ca 12-33	C 1-5 Ca 25-34	C 1-5 Ca 24-32

* Head of the last two headed rib is separated from the rib.

TABLE 5. PHALANGEAL FORMULAE OF FUTO SPECIMENS

Specimen	1		2		3		5		7		8		9		10		11		12		14	
No.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
I	3	3	3	3	3	3	2	2	2	2	2	2	3	3		3	2	2	2	2	2	2
II	8	8	9	9	9	9	10	10	8	8	8	8	9	9		9	8	8	8	8	9	8
III	7	7	8	8	8	8	8	8	7	7	7	7	7	7		8	7	7	7	7	7	7
IV	4	4	4	4	5	5	4	4	4	4	4	5	3	4		5	4	4	4	4	4	4
V	2	3	2	3	3	3	—	2	2	2	2	2	2	2		2	2	2	2	2	2	2

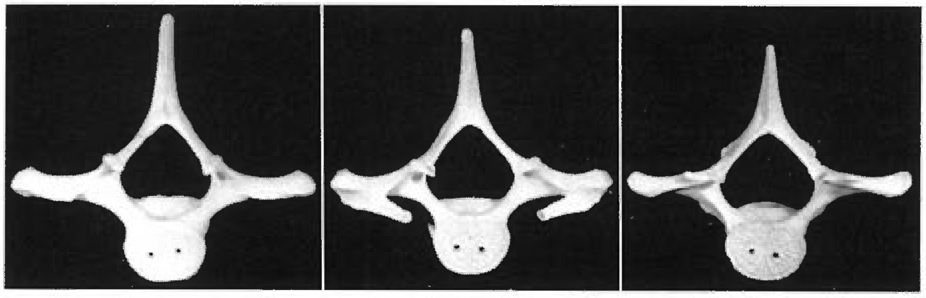


Fig. 7. Cranial views of dorsal vertebrae, showing the uncinate transverse process on the 7th, left to right: 6th, 7th and 8th. (specimen No. 12).

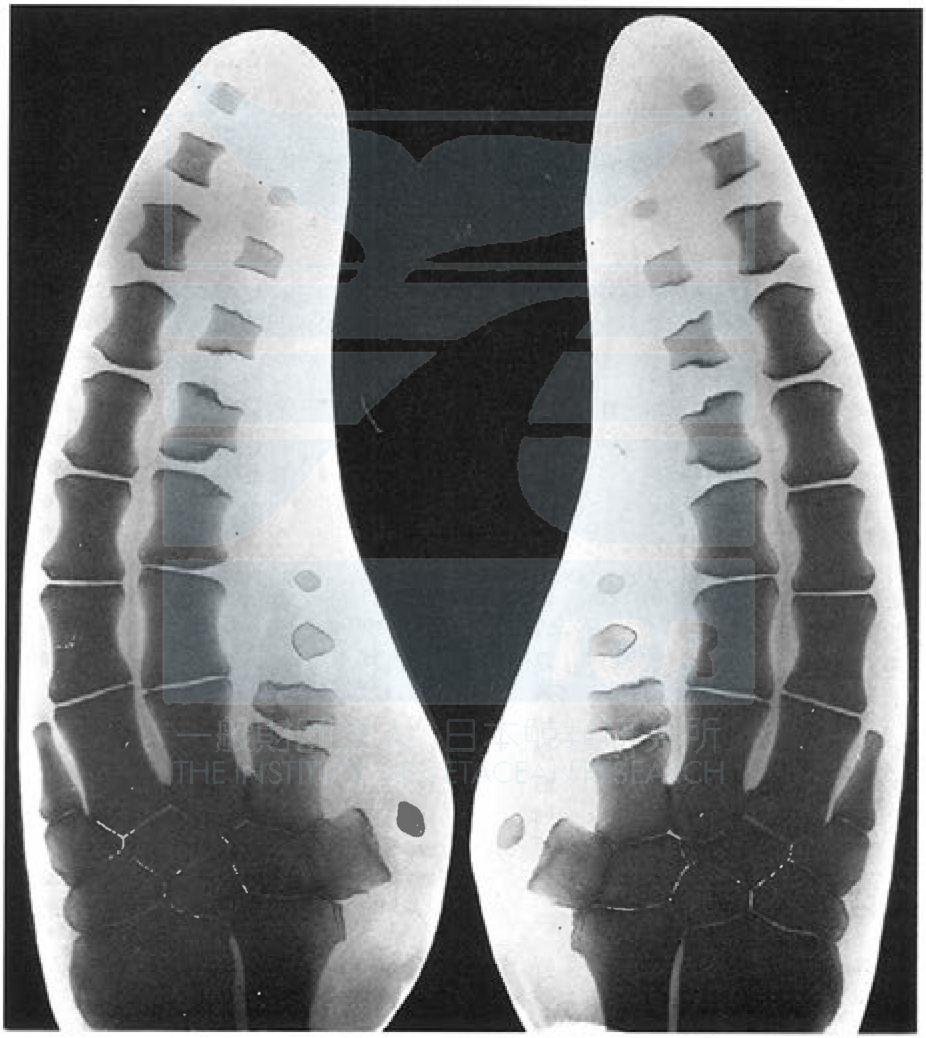


Fig. 8. Xray photograph of left (left) and right (right) flippers. (specimen No. 11).

TABLE 6. DIMENSIONS OF VERTEBRAE (mm)

Specimen No. / Vertebra No.	6							8							12						
	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G
C 1		94	136										25	44	25[2]			99	140	28	43
2								21[2]			87	140						—	105		
3	42[1]														6			—	66		
4								6			64	52			6			69	53		
5								5			61	48			6			70	50		
6				65	48			6			60	54			9			73	52		
7	8	33	41	70	76	30	37	9	30	46	60	80	28	40	10	33	45	72	79	26	33
D 1	12	31	42	71	109	29	40	12	29	39	62	107	29	44	14	31	40	94	106	31	38
2	19			92	116			16			68	109			20			96	116		
3	23			95	119			22			74	112			25			96	118		
4	27			111	120			26			87	113			28			98	116		
5	29			117	119			28			89	116			30			100	118		
6	30			111	121			30			97	118			31	28	33	105	122	35	38
7	32	29	32	137	121	42	39	31	30	32	102	123	38	37	32	29	33	108	126	35	38
8	32			120	130			32			107	128			34			113	129		
9	33			122	135			32			107	131			35			117	140		
10	33			128	148			32			105	147			35			120	157		
11	34			132	178			32			105	182			35			123	182		
12	33			135	208			32			93	181			33			129	194		
13	32			145	219			—	—	—	—	—	—	—	—	—	—	—	—	—	—
L 1	32	33	36	153	216	31	21	31	32	36	117	183	27	19	33	32	35	135	196	30	21
2	30			158	214			31			130	183			33			141	197		
3	30			164	221			30			137	185			32			147	198		
4	29			168	218			29			144	191			32			149	198		
5	29			171	215			28			149	186			32			153	199		
6	28			175	210			28			148	188			30			155	198[4]		
7	27	35	39	173	205	34	17	28			153	182			30	34	38	155	196[4]	32	15
8	27			175	203			27	35	38	156	179	28	14	30			156	188		
9	27			173	195			27			157	175			29			154	188		
10	28			173	190			26			157	173			29			154	185		
11	27			170	184			26			157	166			28			151	183		
12	28			168	180			26			155	157			28			151	176		
13	27			164	177			26			148	149			30			149	170		
14	27			159	173			26			147	145			30			147	164		
15	28			146	171			26			145	141			30			145	160		
16	—	—	—	—	—	—	—	27			137	135			31			139	154+		
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	31	40	41	129	150	15	9
Ca 1	28	41	41	149	167	26	11	27	41	41	136	131	16	10	31	41	42	131	148	23	8
2	28			144	161			27			131	129			29			127	143		
3	27			136	159			26			125	126			29			122	136		
4	27			130	150			26			123	123			29			115	131		

Table 6. Dimensions of vertebrae (continued)

Specimen No. / Vertebra No.	6							8							12						
	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G
Ca 5	27			128	141+			27			120	122			28			112	129		
6	27			122	144[4]			26			117	115			28			108	123		
7	26			116	136[4]			25			114	110			29			104	113		
8	26			112	128[4]			25			110	107			28			100	107		
9	26			108	120[4]			26			106	100			30			96	103		
10	26			101	113			26			102	95			30			91	98		
11	27	41	44	99	105	9	5	26	41	42	98	86	15	5	32	41	40	88	90	10	4
12	27			92	96			26			94	88			31			86	83		
13	28			91	83			27			91	72			31			78	74		
14	29			83	61			28			92	72			32			78	66		
15	29			85	71+			29			86	65			32			77	58		
16	31			79	56			30			84	60			33			71	52		
17	31			75	51			31			79	53			33			70	47		
18	32			73	48			32			74	49			33			67	42		
19	31			66	43			32			71	44			34			64	38		
20	32			60	39			33	41	38	62	36	4	4	34	41	33	59	35	1	1
21	32			60	37			34			57	34			33			52	33		
22	32	43	36	55	34	1	2	33			52	32			28			45	31		
23	30			51	32			31			45	32			21			39	34		
24	26			40	32			27			38	35			16			30	35		
25	19			34	35			20			32	38			14			24	36		
26	16			28	34			16			25	38			12			20	35		
27	14			22	32			15			21	38			12			18	33		
28	12			20	32			14			18	34			11			18	30		
29	12			19	30			12			18	29			10			14	27		
30	11			17	27			10			11	27			9			12	23		
31	10			14	22			8			13	23			8			8	19		
32	9			11	19			7			10	19			7			7	14		
33	10			8	16			} 14[3] (33–34)			7	14			—	—	—	—	—	—	—
34	11			6	12						5	11			—	—	—	—	—	—	—

A = Length of body at center
B = Height of body at front end
C = Breadth of body at front end
D = Total height from anterior bottom
E = Bilateral breadth of transverse processes
F = Greatest height of neural canal
G = Greatest breadth of neural canal

1): Six are united.
2): Three are united.
3): Two are united.
4): doubled the left half

TABLE 7. DIMENSIONS OF TEETH OF FUTO SPECIMENS (mm)

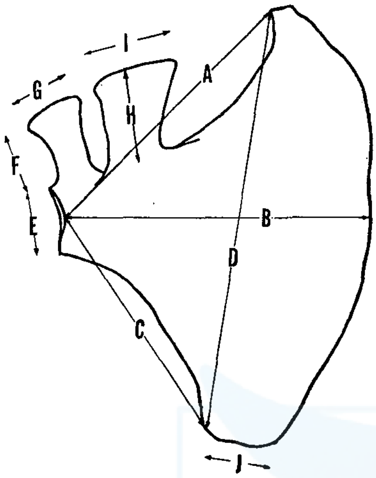
	Specimen No.	6				8				12	
		Length		Diameter		Length		Diameter		Diameter	
	No. of teeth	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
Maxillaly teeth	1	19	18	5	5	17	7	7	3	7	6
	2	20	21	6	6	20	16	6	5	7	7
	3	21	22	7	6	18	15	8	5	8	7
	4	21	21	7	7	19	19	7	6	8	8
	5	20	21	7	7	19	+	6	6	8	8
	6	19	20	7	7	17	19	8	7	8	8
	7	19	19	7	6	17	18	7	7	7	8
	8	17	17	6	6	16	18	7	7	7	7
	9	15	16	6	5	16	16	7	7	7	7
	10	10	—	4	—	14	15	6	6	6	7
Mandibular teeth	1	16	16	7	6	20	+	7	6	6	6
	2	19	19	7	7	20	+	8	7	6	6
	3	21	21	8	7	20	19	8	8	6	6
	4	22	21	8	7	21	20	8	8	6	6
	5	22	23	8	8	21	22	8	8	7	6
	6	24	23	8	7	21	22	8	8	7	6
	7	23	23	7	7	21	22	8	8	5	6
	8	23	23	7	8	21	22	8	8	4	5
	9	21	22	7	7	21	21	8	8	4	6
	10	22	19	7	6	22	21	8	8	4	5
	11	20	21	6	6	19	20	7	7	—	4
	12	8	18	4	6	3	—	2	—	—	—
	13	—	16	—	5	—	—	—	—	—	—

TABLE 8. DIMENSIONS OF RIBS OF FUTO SPECIMENS (mm)

	Specimen No.	6						8						12					
		A		B		C		A		B		C		A		B		C	
	No. of ribs	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
Vertebral ribs	1	178	172	25	24	21	22	170	170	22	25	19	20	189	192	21	22	20	20
	2	312	320	16	16	25	24	297	298	16	26	20	20	326	324	18	19	23	21
	3	381	379	12	12	28	29	350	348	13	14	26	25	390	393	17	12	24	29
	4	413	412	10	10	28	29	382	383	12	12	26	27	420	413	9	9	27	29
	5	420	420	11	11	25	26	397	408	11	12	25	26	427	427	9	9	26	25
	6	420	418	11	11	26	26	380	405	11	11	25[2]	24	398	392	8	9	29[1]	29[1]
	7	388	384	11	11	28[1]	27[1]	360	377	11	10	—	—	390	380	8	9	—	—
	8	382	382	9	10	—	—	Ca374[3]	365	11	10	—	—	380	372	8	8	—	—
	9	373	376	8	8	—	—	358	350	10	10	—	—	354	348	7	8	—	—
	10	347	351	8	8	—	—	326	338	9	9	—	—	327	323	7	7	—	—
	11	330	332	8	8	—	—	290	292	9	9	—	—	298	294	6	6	—	—
	12	291	283	6	7	—	—	241	237	7	7	—	—	231	223	5	4	—	—
	13	—	136	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sternal ribs	1	100	96	17	12			95	96	16	16			98	94	16	18		
	2	105	103	17	12			98	97	12	12			97	96	9	9		
	3	113	110	11	10			118	112	9	9			107	108	7	8		
	4	114	116	9	9			117	117	10	9			106	116	7	7		
	5	122	128	7	6			133	129	8	7			123	124	5	5		
	6	137	139	5	6			142	136	7	7			138	132	6	4		
	7	158	156	7	7			141	143	6	6			124	128	6	6		
	8	118	118	6	6			120	103	5	5			95	84	4	4		

A : Length along visceral border
B : Breadth at middle
C : Distance between two heads
1) Length of the process on uncinate transverse process
2) Head is separated from the rib
3) Broken

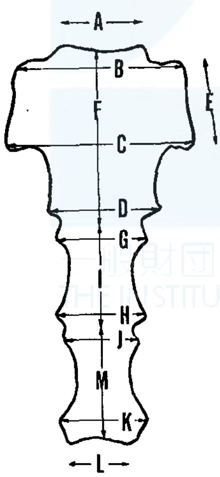
TABLE 9. DIMENSIONS OF SCUPULAE OF FUTO SPECIMENS (mm)



Specimen No.	6 L.	6 R.	8 L.	8 R.	12 L.	12 R.
A	—	—	142	143	147	148
B	165	165	143	142	152	150
C	—	—	123	127	120	122
D	—	—	225	229	210	210
D′	227	232	—	—	258	251
E	37	35	35	35	35	35
E′	28	28	28	29	29	29
F	42	43	40	42	45	40
G	34	37	25	32	36	37
H	45	43	50	47	45	58
I	60	57	48	48	41	46
J	57	56	57	46	34	31

D′ : Length along vertebral border
E′ : Breadth of grenoid cavity

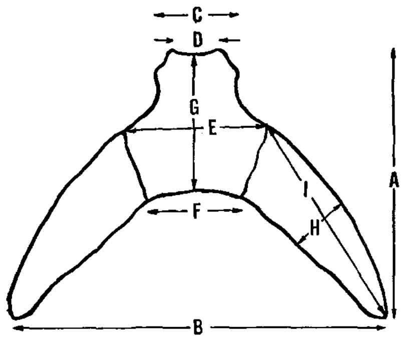
TABLE 10. DIMENSIONS OF STERNUMS OF FUTO SPECIMENS (mm)



Specimen No.	6	8[1]	12
A	47	36	38
B	80	75	84
C	97	88	89
D	60	58	57
E L.	47	32	35
R.	47	30	36
F	92	93	93
G	48	43	43
H	48	38	40
I	57	67	61
J	37	32	31
K	45	32	26
L	35	20	7
M	60	48	45
Total length	—	157 (1–II)	192

1) 2nd and 3rd segments are separated, and their length of facets are measured 22 and 24 respectively.

TABLE 11. DIMENSIONS OF HYOID BONES OF FUTO SPECIMENS (mm)



Specimen No.		6	8	12
A		103	86	101
B		136	113	131
C		30	28	33
D		15	12	18
E		69	63	65
F		46	36	37
G		54	55	50
H	L.	25	27	25
	R.	26	27	25
I	L.	80	64	75
	R.	78	67	70
Stylohyals straight length	L.	41	82	98
	R.	90	83	100
„ breadth at middle	L.	13	15	15
	R.	14	15	16

TABLE 12. DIMENSIONS OF CHEVRON BONES OF FUTO SPECIMENS

Specimen No.	6		8		12	
No. of chevron	A	B	A	B	A	B
1	L. 22		L. 19		L. 30	
	R. 24[1]		R. 18		—	
2	L. 18		L. 24[2]		29	18
	R. 28[1]		R. 23			
3	27	20	L. 26[2]		31	19
			R. 25			
4	27	21	27	21	39	20
5	36	22	27	22	45	20
6	49	24	34	23	48	21
7	52	23	40	24	49	21
8	54	23	41	24	47	21
9	54	23	39	23	46	20
10	53	24	39	23	46	20
11	50	23	45	25	43	21
12	49	24	45	26	43	21
13	47	25	45	27	41	21
14	45	25	40	27	37	21
15	41	25	40	26	30+	21
16	39	25	37	26	35	21
17	37	24	34	26	30	21
18	34	23	32	25	27	21
19	32	23	30	25	25	20
20	28	22	27	24	19	18
21	24	20	23	22	14	16
22	18	18	19	19	12	16
23	11	16	15	19	R. 7	—
24	10	13	12	18	—	—
25	L. 7	—	L. 9	—	—	—
	R. 7	—	R. 9	—	—	—
26	—	—	L. 5	—	—	—
	—	—	R. 4	—	—	—

A: Total height, B: Maximum breadth across the laminae
1), 2) fused together

tween the tips of the processes of specimen Nos. 6, 8 and 12 are 54 (D 7),77 (D 7) and 57 mm (D 6) respectivery.

Table 5 and Fig. 8 show the pharangeal formulae and the X ray photograph of the flippers.

The dimensions of skeleton except skull are shown in Tables 6–13.

TABLE 13. DIMENSIONS OF PELVIC BONES OF FUTO SPECIMENS (mm)

Specimen No.	Straight lengt		Breadth at middle	
	L.	R.	L.	R.
6	105	105	12	12
8	118	115	14	10
12	122	121	11	11

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APPENDIX I EXTERNAL MEASURMENTS

Point of measurment	Specimen No. 1 (Sex M) cm	%	2 (M) cm	%	3 (M) cm	%	8 (M) cm	%
1. Length, total	240	100.0	217	100.0	215	100.0	229	100.0
2. Length, tip of upper jaw to center of eye	21.0	8.7	22.0	10.1	24.5	11.4	20.0	8.7
3. Length of gape	13.0	5.4	13.0	6.0	12.0	5.6	14.5	6.3
4. Center of eye to external auditory meatus (direct)	L. 9.5	4.0	R. 7.5	3.5	L. 7.0	3.3	L. 7.0	3.1
5. Length, center of eye to angle of gape	L. 8.0	3.3	9.0	4.1	12.5	5.8	5.5	2.4
6. Length, tip of upper jaw to blowhole	16.0	6.7	21.0	9.7	25.5	11.9	22.0	9.6
7. Anteriormost point of gape to blowhole along the melon	40.0	16.7	37.5	17.3	39.0	18.1	39.0	17.0
8. Length, tip of upper jaw to anterior insertion of flipper	L. 41.5	17.3	—	—	46.5	21.6	38.5	16.8
	R. —	—	—	—				
9. Length, anterior insertion of flipper to axilla	L. —	—	—	—	14.5	6.7	15.0	6.6
	R. —	—	—	—	—	—	—	—
10. Length, tip of upper jaw to tip of dorsal fin	—	—	134.0	61.8	131.0	60.9	125.5	54.8
11. Length, tip of upper jaw to midpoint of umbilicus	100.0	41.7	93.0	42.9	83.0	38.6	100.5	43.9
12. Length, tip of upper jaw to midpoint of genifal aperture	131.0	54.6	122.0	56.2	113.5	52.8	124.5	54.4
13. Length, tip of upper jaw to center of anus	158.0	65.8	145.0	66.8	135.5	63.0	149.5	65.3
14. Projection of upper jaw beyond the lower	6.0	2.5	4.0	1.8	2.0	0.9	3.7	1.6
15. Girth, at anterior insertion of flipper	119.0	49.6	—	—	—	—	109.0	47.6
16. Girth, at anterior insertion of dorsal fin (maximum)	143.0	59.6	—	—	139.0	64.7	143.0	62.4
17. Maximum height of body, including dorsal fin	76.0	31.7	—	—	68.0	31.6	70.0	30.6
18. Length of eye	3.0	1.2	2.5	1.2	3.0	1.4	2.4	1.0
19. Width of blowhole	—	—	4.0	1.8	3.0	1.4	4.8	2.1
20. Length of flipper, anterior insertion to tip	L. 48.0	20.0	—	—	47.5	22.1	43.5	19.0
	R. 49.0	20.4	43.0	19.8	—	—	42.0	18.3
21. Length of flipper, along anterior edge	L. 53.5	22.3	—	—	50.5	23.5	46.5	20.3
	R. 53.5	22.3	47.0	21.7	—	—	—	—
22. Length of flipper, axilla to tip	L. 36.0	15.0	—	—	35.0	16.3	32.0	14.0
	R. 37.0	15.4	33.5	15.4	—	—	31.5	13.8
23. Width of flipper, maximum	L. 15.5	6.5	—	—	15.0	7.0	14.5	6.3
	R. 15.5	6.5	15.0	6.9	—	—	14.0	6.1
24. Dorsal fin, height	24.0	10.0	22.0	10.1	25.0	11.6	22.5	9.8
25. Dorsal fin, length of base	40.0	16.7	42.0	19.4	39.0	18.1	32.0	14.0
26. Dorsal fin, anterior insertion to tip along anterior edge	—	—	—	—	46.0	21.4	40.0	17.5
27. Dorsal fin, posterior insertion to tip along posterior edge	—	—	—	—	29.5	13.7	26.5	11.6
28. Dorsal fin, anterior insertion to posterior edge (minimum)	—	—	—	—	33.0	15.3	30.0	13.1
29. Width of tail flukes, tip to tip	59.0	24.6	61.0	28.1	54.5	25.3	62.5	27.3
30. Anterior insertion of tail fluke to notch	L. 18.0	7.5	18.0	8.3	15.5	7.2	17.0	7.4
	R. 18.0	7.5	18.0	8.3	—	—		
31. Anterior insertion of tail fluke to tip	L. 36.0	15.0	37.5	17.3	35.5	16.5	38.5	16.8
	R. 36.0	15.0	37.5	17.3	—	—	—	—
32. Distance, tip of tail fluke to notch	L. 30.0	12.5	31.0	14.3	28.5	13.3	32.5	14.2
	R. 30.5	12.7	31.5	14.5	—	—	—	—

1) fetus of No. 11 2) fetus of No. 12

9 M		10 M		14 M		4 F		5 F		6 F	
cm	%	cm	%	cm	%	cm	%	cm	%	cm	%
223	100.0	244	100.0	214	100.0	215	100.0	225	100.0	225	100.0
21.0	9.4	22.5	9.4	22.5	10.5	21.0	9.8	22.0	9.8	22.5	10.0
15.0	6.7	15.0	6.1	15.5	7.2	14.5	6.7	13.5	6.0	16.0	7.1
6.7	3.0	L. 7.7	3.2	7.0	3.3	R. 7.0	3.3	R. 8.5	3.8	L. 7.5	3.3
6.0	2.7	8.0	3.3	7.0	3.3	6.5	3.0	8.5	3.8	6.5	2.9
23.5	10.5	24.5	10.0	23.0	10.7	18.5	8.6	20.0	8.8	23.5	10.4
38.0	17.0	39.0	16.0	32.5	15.2	36.0	16.7	38.0	16.9	38.5	17.1
46.0	20.6	46.0	18.9 —	40.0 41.0	18.7 19.2	44.0	20.5	48.0	21.3	44.0	19.6
15.0	6.7	16.0 —	6.6 —	13.5 13.0	6.3 6.1	— 10.0	— 4.7	15.0	6.7	9.0 —	4.0 —
131.0	58.7	138.0	56.6	122.0	57.0	128.5	59.8	130.0	57.8	125.0	55.6
100.5	45.1	96.5	39.5	94.0	43.9	90.0	41.9	101.0	44.9	100.0	44.4
114.5	51.3	127.0	52.0	117.0	54.7	126.0	58.6	130.0	57.8	133.5	59.3
140.0	62.8	156.0	63.9	139.0	65.0	132.0	61.4	148.0	65.8	145.5	64.7
3.0	1.3	3.0	1.2	5.0	2.3	3.0	1.4	3.5	1.6	3.5	1.6
108.0	48.4	111.0	45.5	105.0	49.1	109.5	50.9	110.0	48.9	102.5	45.6
132.0	59.2	141.0	57.8	112.5	52.6	130.0	60.5	135.0	60.0	136.5	60.7
66.0	29.6	73.0	29.9	54.0	25.2	65.0	30.2	64.0	28.4	70.5	31.3
3.0	1.3	2.5	1.0	3.0	1.4	2.0	0.9	2.5	1.1	2.0	0.9
3.5	1.6	4.0	1.6	3.5	1.6	3.5	1.6	3.0	1.3	3.5	1.6
47.0	21.1	50.0 —	20.5 —	40.0 41.0	18.7 19.2	— 40.0	— 18.6	— 50.0	— 22.2	44.5 —	19.8 —
53.5	24.0	54.0 —	22.1 —	43.5	20.3	— 44.0	— 20.5	— 55.0	— 24.4	48.5 —	21.6 —
36.5	16.4	38.0 —	15.6 —	31.0 30.5	14.5 14.3	— 32.0	— 14.9	— 37.0	— 16.4	33.0 —	14.7 —
14.0	6.3	15.0 —	6.1 —	13.0 13.0	6.1 6.1	— 12.5	— 5.8	— 15.0	— 6.7	13.0 —	5.8 —
21.0	9.4	26.0	10.7	23.0	10.7	22.0	10.2	24.5	10.9	23.0	10.2
32.0	14.3	38.0	15.6	34.0	15.9	34.0	15.8	38.0	16.9	43.0	19.1
42.5	19.1	47.5	19.5	37.5	17.5	40.0	18.6	48.0	21.3	46·0	20.4
28.0	12.6	27.5	11.3	24.5	11.4	24.0	11.2	21.0	9.3	30.0	13.3
28.0	12.6	34.0	13.9	27.5	12.9	32.5	15.1	33.0	14.7	34.0	15.1
56.0	25.1	58.0	23.8	53.0	24.8	49.5	23.0	64.0	28.4	60.5	26.9
17.0	7.6	16.5	6.8	15.0 15.0	7.0 7.0	— 15.0	— 7.0	— 15.5	— 6.9	— 19.0	— 8.4
40.5	18.2	42.0 —	17.2 —	34.0 34.5	15.9 16.1	— 38.0	— 17.7	— 41.0	— 18.2	— 32.0	— 14.2
30.5	13.7	34.0 —	13.9 —	23.5 23.0	11.0 10.7	— 30.0	— 14.0	— 34.0	— 15.1	— 31.5	— 14.0

	7 F		11 F		12 F		13 F		15[1] F		16[2] F	
	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%
1.	221	100.0	227	100.0	221	100.0	208	100.0	20.5	100.0	53.0	100.0
2.	18.0	8.1	24.5	10.8	22.5	10.2	21.5	10.3	2.4	11.7	7.2	13.6
3.	15.0	6.8	17.0	7.5	18.5	8.4	13.5	6.5	1.6	7.8	5.5	10.4
4.	L. 7.0	3.2	L. 7.5	3.3	8.0	3.6	R. 7.0	3.4	L. 1.2	5.9	L. 2.5	4.7
5.	L. 3.0	1.4	L. 7.5	3.3	4.0	1.8	R. 8.0	3.8	L. 0.8	3.9	L. 1.5	2.8
6.	20.0	9.0	23.0	10.1	24.5	11.1	15.0	7.2	1.9	9.3	6.9	13.0
7.	36.0	16.3	38.0	16.7	37.5	17.0	34.0	16.3	3.4	16.6	10.0	18.9
8,	41.0 —	18.6 —	46.0 —	20.3 —	44.5	20.1	— 41.3	— 19.9	5.1 —	24.9 —	13.2 —	24.9 —
9.	15.0	6.8	14.5 —	6.4 —	15.5	7.0	— 13.5	— 6.5	1.4 —	6.8 —	4.2 —	7.9 —
10.	120.0	54.3	137.0	60.0	134.0	60.6	120.0	57.7	11.6	56.6	33.9	64.0
11.	98.5	44.6	96.0	42.3	89.0	40.3	91.0	43.7	10.7	52.2	27.6	52.1
12.	135.0	61.1	134.0	59.0	132.0	59.7	127.0	61.1	13.5	65.9	35.0	66.0
13.	142.0	64.3	142.0	62.6	140.0	63.3	133.0	63.9	14.1	68.8	36.6	69.1
14.	4.0	1.8	4.0	1.8	2.0	0.9	4.0	1.9	0.4	2.0	0.2	0.4
15.	119.0	53.8	105.5	46.5	112.0	50.7	101.0	48.6	13.8	67.3	28.5	53.8
16.	140.0	63·3	134.0	59.0	140.0	63.3	117.0	56.2	14.3	69.8	29.8	56.2
17.	71.5	32.4	65.0	28.6	64.0	29.0	56.5	27.2	5.7	27.8	11.5	21.7
18.	2.5	1.1	2.5	1.1	2.5	1.1	2.8	1.3	0.4	2.0	0.8	15.1
19.	4.0	1.8	3.5	1.5	5.0	2.3	3.5	1.7	0.9	4.4	1.1	2.8
20.	— 32.5	— 14.7	45.0 —	19.8 —	46.0	20.8	— 41.0	— 19.7	3.6 —	17.6 —	10.8 —	20.4 —
21.	— 49.5	— 22.4	49.5 —	21.8 —	50.5	22.9	— 45.0	— 21.6	3.9 —	19.0 —	12.5 —	23.6 —
22.	— 42.0	— 19.0	34.0 —	15.0 —	34.5	15.6	— 32.5	— 15.6	2.4 —	11.7 —	7.5 —	14.2 —
23.	— 15.0	— 6.8	15.0 —	6.6 —	14.5	6.6	— 14.7	— 7.0	1.2 —	5.9 —	3.3 —	6.2 —
24.	22.3	10.1	22.5	9.9	22.5	10.2	20.0	9.6	1.0	4.9	3.6	6.8
25.	35.0	15.8	41.0	18.1	40.0	18.1	33.0	15.9	2.8	13.7	7.7	14.5
26.	41.5	18.8	47.0	20.7	43.0	19.5	38.0	18.3	2.3	11.2	9.1	17.2
27.	25.5	11.5	24.5	10.8	22.0	10.0	23.0	11.1	1.0	4.9	5.0	9.4
28.	31.0	14.0	33.0	14.5	36.0	16.3	29.0	13.9	2.3	11.2	6.5	12.3
29.	60.0	27.1	61.0	26.9	54.5	24.7	51.0	24.5	4.2	20.5	10.3	19.4
30.	— 19.5	— 8.8	16.5 —	7.3 —	16.0	7.2	— 17.0	— 8.2	1.9 —	9.3 —	4.0 —	7.5 —
31.	— 39.5	— 17.9	38.5 —	17.0 —	37.0	16.7	— 33.0	— 15.9	3.0 —	14.6 —	8.4 —	15.8 —
32.	— 31.0	— 14.0	32.5 —	14.3 —	31.0	14.0	— 26.5	— 12.7	2.2 —	10.7 —	6.2 —	11.7 —

APPENDIX II SKULL MEASURMENTS (mm)

Point of measurment	Specimen No.	1		2		3		8		9	
	Sex	M		M		M		M		M	
	Body Length(cm)	240		217		215		229		223	
			%		%		%		%		%
1. Total (condylo-basal) length		380	100.0	359	100.0	372	100.0	356	100.0	378	100.0
2. Length of rostrum (median)		170	44.7	166	46.2	168	45.2	168	47.2	186	49.2
3. Breadth of rostrum at base		120	31.6	99	27.7	118	31.7	110	30.9	112	29.6
4. Breadth of rostrum at middle		94	24.7	90	25.1	93	25.0	88	24.7	91	24.1
5. Breadth of premaxillae at middle of rostrum		66	17.4	58	16.2	64	17.2	58	16.3	61	16.1
6. Greatest breadth of premaxillae		89	23.4	94	26.2	91	24.5	91	25.6	90	23.8
7. Minimum breadth of premaxillae near the base of rostrum		58	15.3	50	13·9	56	15.1	55	15.4	53	14.0
8. Length of premaxilla	L.	277+	72.9+	263	70.5	273	73.4	257	72.2	291	77.0
	R.	294	77.4	283	78.8	290	78.0	282	79.2	312	82.5
9. Breadth of superior nares		55	14.5	50	13.9	48	12.9	46	12.9	48	12.7
10. Distance from tip of rostrum to bottom of maxillary notch	L.	186	48.9	175	48.7	184	49.5	175	49.2	192	50.8
	R.	186	48.9	175	48.7	183+	49.2+	176	49.4	195	51.6
11. Distance from tip of rostrum to anterior end of vomer		41	10.8	28	7.8	31	8.3	45	12.6	40	10.6
12. Distance from tip of rostrum to anterior margin of superior nares		236	62.1	223	62.1	233	62.6	216	60.7	239	63.2
13. Distance from tip of rostrum to posterior median end of maxillae on palate		182	47.9	172	47.9	171	46.0	163	45.8	187	49.5
14. Distance from tip of rostrum to posterior end of vomer on cranial base (median)		288	75.8	268	74.7	279	75.0	268	75.3	282	74.6
15. Breadth across middle of orbits		215	56.6	218	60.7	212	57.0	206	57.9	221	58.5
16. Breadth across zygomatic processes		235	61.8	240	66.9	232	62.4	229	64.3	239	63.2
17. Breadth across post-orbital processes		230	60.5	238	66.3	230	61.8	224	62.9	237	62.7
18. Height of skull including nasals		190	50.0	188	52.4	183	49.2	180	50.6	191	50.5
19. Breadth across posterior margins of temporal fossae		162	42.6	158	44.0	143	38.4	155	43.5	151	40.0
20. Length of temporal fossa	L.	92	24.2	96	26.7	100	26.9	91	25.6	99	26.2
	R.	99	26.1	100	27.9	99	26.6	86	24.2	100	26.5
21. Depth of temporal fossa	L.	67	17.6	69	19.2	68	18.3	68	19.1	65	17.2
	R.	74	19.5	77	21.4	73	19.6	72	20.2	69	18.3
22. Length of maxillary teeth row	L.	121	31.8	111	30.9	115	30.9	105	29.5	114	30.2
	R.	115	30.3	106	29.5	117	31.5	107	30.1	113	29.9
23. Distance from first tooth to bottom of maxillary notch	L.	176	46.3	175	48.7	179	48.1	168	47.2	182	48.1
	R.	175	46.0	170	47.4	179	48.1	169	47.5	185	48.9
24. Breadth of occipital foramen		43	11.3	39	10.9	38	10.2	40	11.2	39	10.3
25. Height of occipital foramen		39	10.3	38	10.6	36	9.8	37	10.4	41	10.8

10		14		5		6		7		11		12		13	
M		M		F		F		F		F		F		F	
244		214		225		225		221		227		221		208	
	%		%		%		%		%		%		%		%
395	100.0	368	100.0	365	100.0	372	100.0	372	100.0	380	100.0	390	100.0	375	100.0
193	48.9	175	47.6	175	47.9	180	48.4	179	48.1	181	47.6	184	47.2	183	47.6
		108	29.3	116	31.8	114	30.6	112	30.1	110	28.9	118	30.3	106	29.3
		86	23.4	90	24.7	90	24.2	87	23.4	87	22.9	91	23.3	80	23.4
		60	16.3	62	17.0	60	16.1	62	16.7	62	16.3	69	17.7	56	15.0
		89	24.2	90	24.7	90	24.2	93	25.0	90	23.7	95	24.4	89	24.2
		57	15.5	58	15.9	—	—	58	15.6	57	15.0	58	14.9	49	15.5
		281	76.4	273	74.8	272	73.1	270	72.6	273	71.8	276	70.8	267	76.4
		292	79.3	296	81.1	298	80.1	294	79.0	299	78.7	307	78.7	296	79.3
		47	12.8	51	14.0	51	13.7	46	12.4	48	12.6	49	12.6	47	12.8
		185	50.3	185	50.7	192	51.6	187	50.3	189	49.7	194	49.7	188	50.3
		188	51.1	186	51.0	194	52.2	189	50.8	191	50.3	196	50.3	189	51.1
		37	10.1	29	7.9	39	10.5	33	8.9	33	8.7	46	11.8	45	10.1
		228	62.0	227	62.3	231	62.1	226	56.9	238	62.6	240	61.5	235	62.0
		183	49.7	183	50.1	183	49.2	185	49.8	185	48.7	187	47.9	181	49.7
		277	75.3	270	74.0	284	76.3	278	74.8	285	75.0	298	76.4	281	75.3
		208	56.5	214	58.6	218	58.6	212	56.5	204	53.7	218	55.9	199	56.5
		230	62.5	239	65.5	—	—	235	63.2	229	60.3	242	62.1	219	58.4
		227	61.7	235	64.4	236	63.4	231	62.3	225	59.2	239	61.3	218	61.7
		177	48.1	195	53.4	—	—	179	48.1	184	48.4	—	—	177	47.2
		153	41.6	156	42.7	158	42.5	157	42.2	155	40.8	157	40.3	155	41.6
		96	26.1	95	26.0	87	23.4	83	22.3	90	23.7	94	24.1	92	26.1
		88	24.0	99	27.1	93	25.0	82	22.0	91	23.9	99	25.4	89	24.0
		66	17.9	68	18.6	63	16.9	72	19.4	66	17.4	70	17.9	67	17.9
		82	22.3	74	20.3	70	18.8	88	23.7	67	17.6	74	19.0	77	22.3
		117	31.8	106	29.0	119	32.0	113 (122)	30.4	105	27.6	120	30.8	119	31.8
127	32.2	118	32.1	106	29.0	120	33.3	118	31.7	99 (109)	26.1 (28.7)	120	30.8	112	29.9
		176	47.8	176	48.2	—	—	178	47.8	179	47.1	184	47.2	180	48.0
		181	49.2	176	48.2	—	—	180	48.4	182	47.9	185	47.4	180	48.0
		43	11.7	43	11.8	44	11.8	47	12.6	40	10.5	39	10.0	44	11.7
		40	10.9	43	11.8	35	9.4	42	11.3	36	9.5	36	9.2	37	9.9

26. Breadth across occipital condyles		107	28.2	92	25.6	88	23.7	99	27.8	87	23.0
27. Length of occipital condyle	L.	65	17.1	56	15.6	50	13.4	57	16.0	55	14.6
	R.	65	17.1	56	15.6	52	14.0	57	16.0	55	14.6
28. Length of mandibular ramus	L.	283	74.5	280	78.0	286	76.9	275	72.2	300	79.4
	R.	285	75.0	282	78.6	288	77.4	275	72.2	302	79.9
29. Length of symphysis		38	10.0	34	9.5	33	8.9	34	9.6	36	9.5
30. Length of mandibular teeth row	L.	129	33.9	128	35.7	129	34.7	124	34.8	140	37.0
	R.	133	35.0	131	36.5	134	36.0	125	35.1	142	37.6
31. Length of mandibular hiatus	L.	112	29.5	115	32.0	123	33.1	120	33.7	136	35.8
	R.	110	28.9	115	32.0	124	33.3	118	33.1	134	35.4
32. Depth between angle and coronoid process	L.	85	22.4	81	22.6	82	22.0	79	22.2	86	22.8
	R.	87	22.9	81	22.6	85	22.8	82	23.0	89	23.6
33. Breapth across mandibular condyles		202	53.2	215	59.9	210	56.5	203	57.0	220	58.2
34. Length of tympanic bulla	L.	41	10.8	40	11.1	39	10.5	38	10.7	41	10.8
	R.	41	10.8	41	11.4	38	10.2	38	10.7	41	10.8
35. Greatest breadth of tympanic bulla	L.	26	6.8	24	6.7	24	6.5	23	6.5	24	6.3
	R.	25	6.6	24	6.7	24	6.5	23	6.5	24	6.3
36. Number of alveoli		$\frac{11 \mid 10}{12 \mid 13}$		$\frac{10 \mid 9}{12 \mid 12}$		$\frac{10 \mid 10}{12 \mid 12}$		$\frac{10 \mid 10}{12 \mid 12}$		$\frac{10 \mid 9}{12 \mid 12}$	

		96	26.1	89	24.4	94	25.3	93	25.0	97	25.5	90	23.1	93	24.8
		51	13.9	55	15.1	54	14.5	56	15.1	58	15.3	58	14.9	53	14.1
		52	14.1	57	15.6	56	15.1	58	15.6	60	15.8	61	15.6	55	14.7
		285	77.4	289	79.2	285	76.6	282	75.8	289	76.1	302	77.4	287	76.5
304	77.0	285	77.4	290	79.5	286	76.9	284	76.3	290	76.3	303	77.7	288	76.8
		35	9.5	36	9.9	33	8.9	37	9.9	33	8.7	37	8.7	38	10.1
		131	35.6	137	37.5	134	36.0	138	37.1	131	34.5	123	31.5	139	37.1
146	37.0	135	36.7	135	37.0	137	36.8	135	36.3	130	34.2	129	33.1	144	38.4
		121	32.9	122	33.4	—	—	110	29.6	120	31.6	130	33.3	120	32.0
		121	32.9	124	34.0	—	—	112	30.1	121	31.8	133	34.1	117	31.2
		81	22.0	87	23.8	85	22.4	82	22.0	81	21.3	86	22.1	78	20.8
		82	22.3	88	24.1	88	23.7	82	22.0	83	21.8	86	22.1	78	20.8
		203	55.2	218	59.7	202	54.3	208	55.9	208	54.7	196	50.3	209	55.7
		40	10.9	40	11.0	41	11.1	38	10.2	40	10.5	42	10.8	39	10.4
		39	10.6	40	11.0	40	10.8	38	10.2	40	10.5	42	10.8	39	10.4
		24	6.5	23	6.3	23	6.2	23	6.3	24	6.3	35	9.0	24	6.4
		24	6.5	23	6.3	23	6.2	23	6.2	24	6.3	35	9.0	24	6.4
		10	10	9	9	10	10	10(11)	10	9	8(9)	10	10	10	9
		12	12	12	12	12	13	13	12	12	11	11	12	12	13

APPENDIX III ORGAN WEIGHTS IN PROPORTION TO THE BODY WEIGHT

The absolute and relative weights of visceral organs are tabulated in the following. The numbers in parentheses show the percentage of each organ weight to the body weight.

	No. 6[2] 225 cm. ♀	No. 11[1] 227 cm. ♀		No. 12[2] 221 cm. ♀		No. 13[1] 208 cm. ♀	
Body weight	—	155.8 kg.		145.5 kg		110 kg.	
Brain	—	1060 g.	(0.68)	1100 g.	(0.76)	940 g.	(0.85)
Heart	840 g.	1080	(0.69)	770	(0.53)	570	(0.52)
Lung L	1880	2470	(1.59)	1855	(1.27)	1650	(1.50)
Lung R	2280	2350	(1.51)	1640	(1.13)	1980	(1.80)
Stomach	1800	2600	(1.67)	1715	(1.18)	940	(0.86)
Spleen	42	85	(0.053)	65	(0.045)	98	(0.089)
Liver	2050	2740	(1.76)	1960	(1.35)	2200	(2.00)
Pancreas	67	90	(0.058)	89	(0.061)	100	(0.091)
Kidney L	295	670	(0.43)	276	(0.019)	340	(0.31)
Kidney R	321	670	(0.43)	246	(0.017)	290	(0.26)
Adrenals L	5	11	(0.0071)	5	(0.0034)	8	(0.0073)
Adrenals R	5	10	(0.0064)	—		8	(0.0073)
Thyroid	11	—		—		9	(0.0082)
Thymus	—	—		—		32	(0.029)
Hypophysis	—	0.8	(0.0051)	—		0.65	(0.0059)
Intestine	4000	4000	(2.56)	3100	(2.13)	3270	(2.97)
„ length	15.2 m.	17.2 m.		14.7 m.		16.4 m.	

1) Each organ was weighed at the autopsy of the fresh cadaver.

2) Each organ was calculated from the value after preservation in formalin.

EXPLANATION OF PLATES

PLATE I

External features of *Feresa attenuata*

Top to bottom:

Lateral view of female fetus, body length 205 mm.

Lateral view of female fetus, body length 530 mm.

Lateral view of adult female.

Dorsal view of adult male.

Ventral view of the same porpoise.

PLATE II

Skulls of *Feresa attenuata*

Top to bottom: dorsal, lateral and ventral view.

Left: male, body length 240 cm (Specimen No. 1).

Right: female, body length 227 cm (Specimen No. 11).

PLATE III

Mandible of *Feresa attenuata*

Top: male, body length 240 cm (Specimen No. 1).

Bottom: female, body length 227 cm (Specimen No. 11).

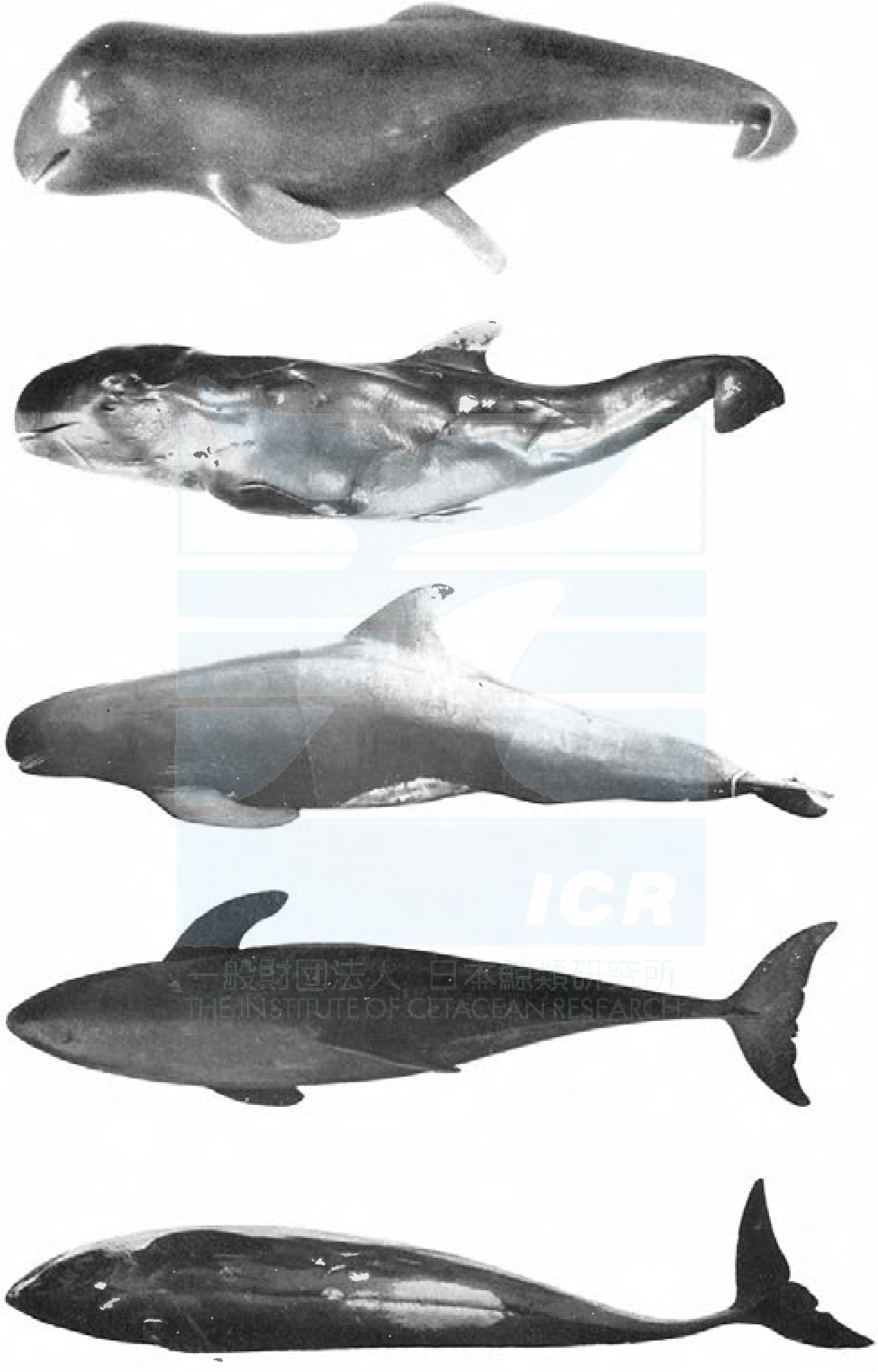
PLATE IV

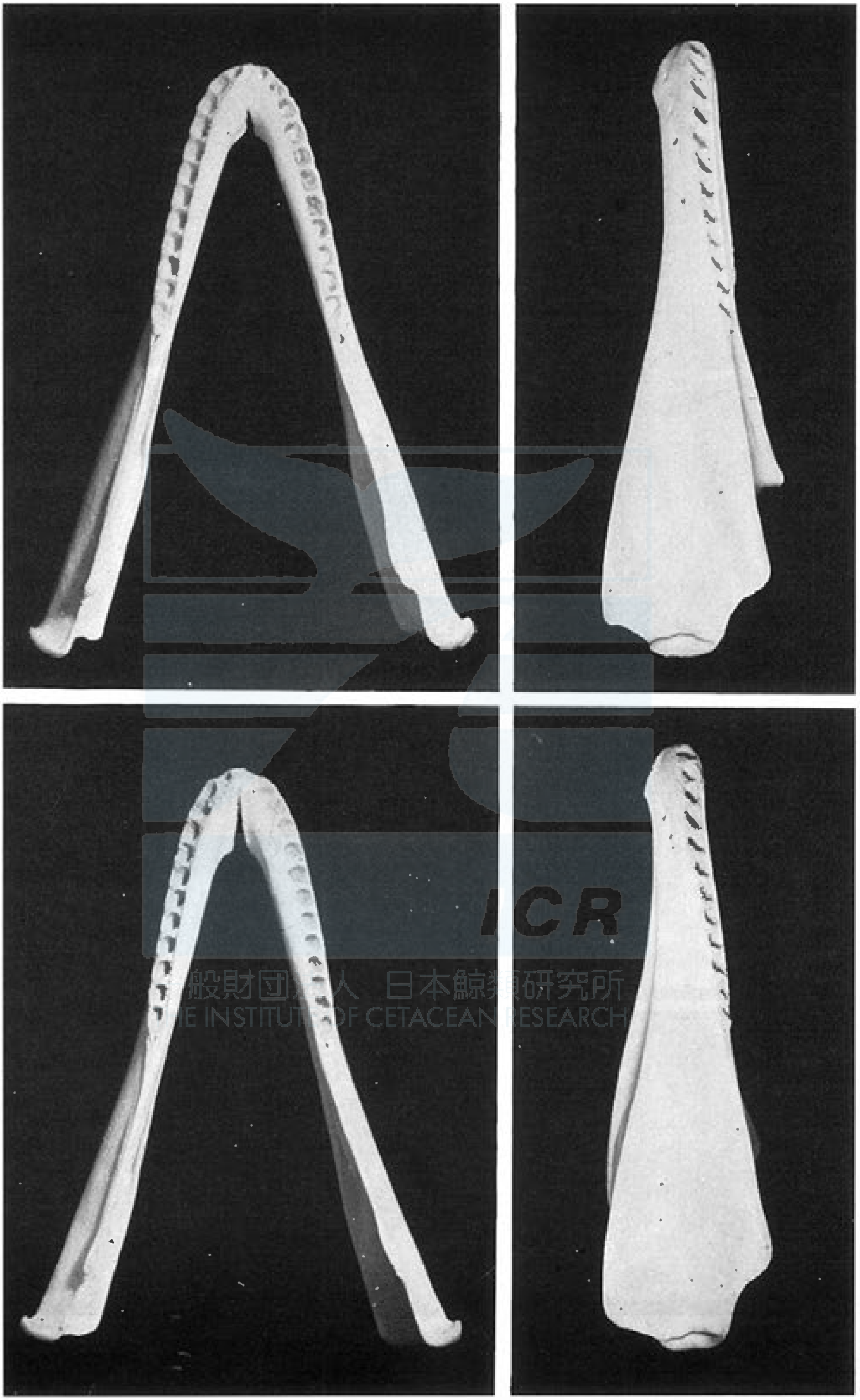
Vertebrae of *Feresa attenuata*, female body length 225 cm (Specimen No. 6).

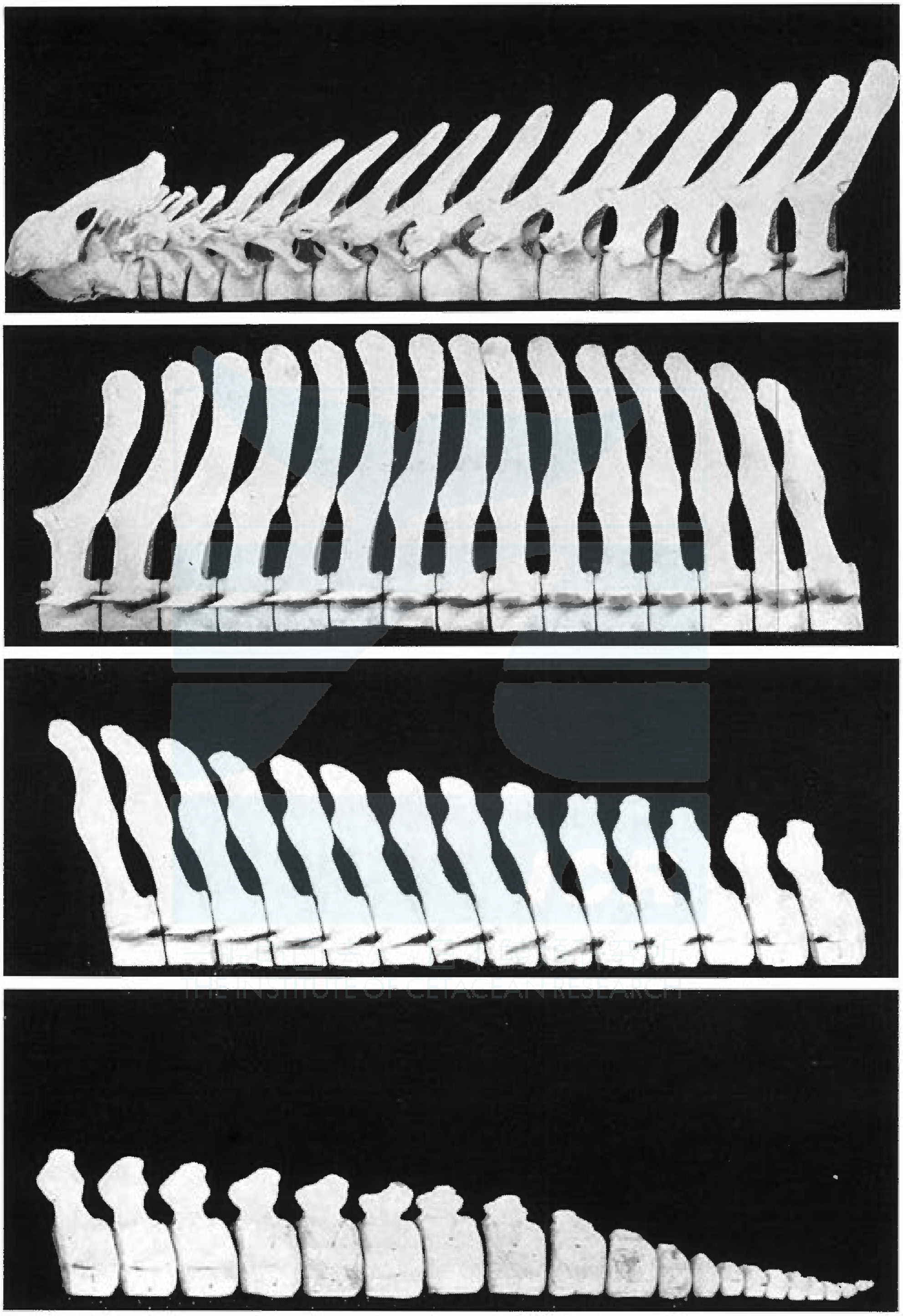
Top to bottom: cervical and dorsal, lumbar, caudal and caudal vertebrae.

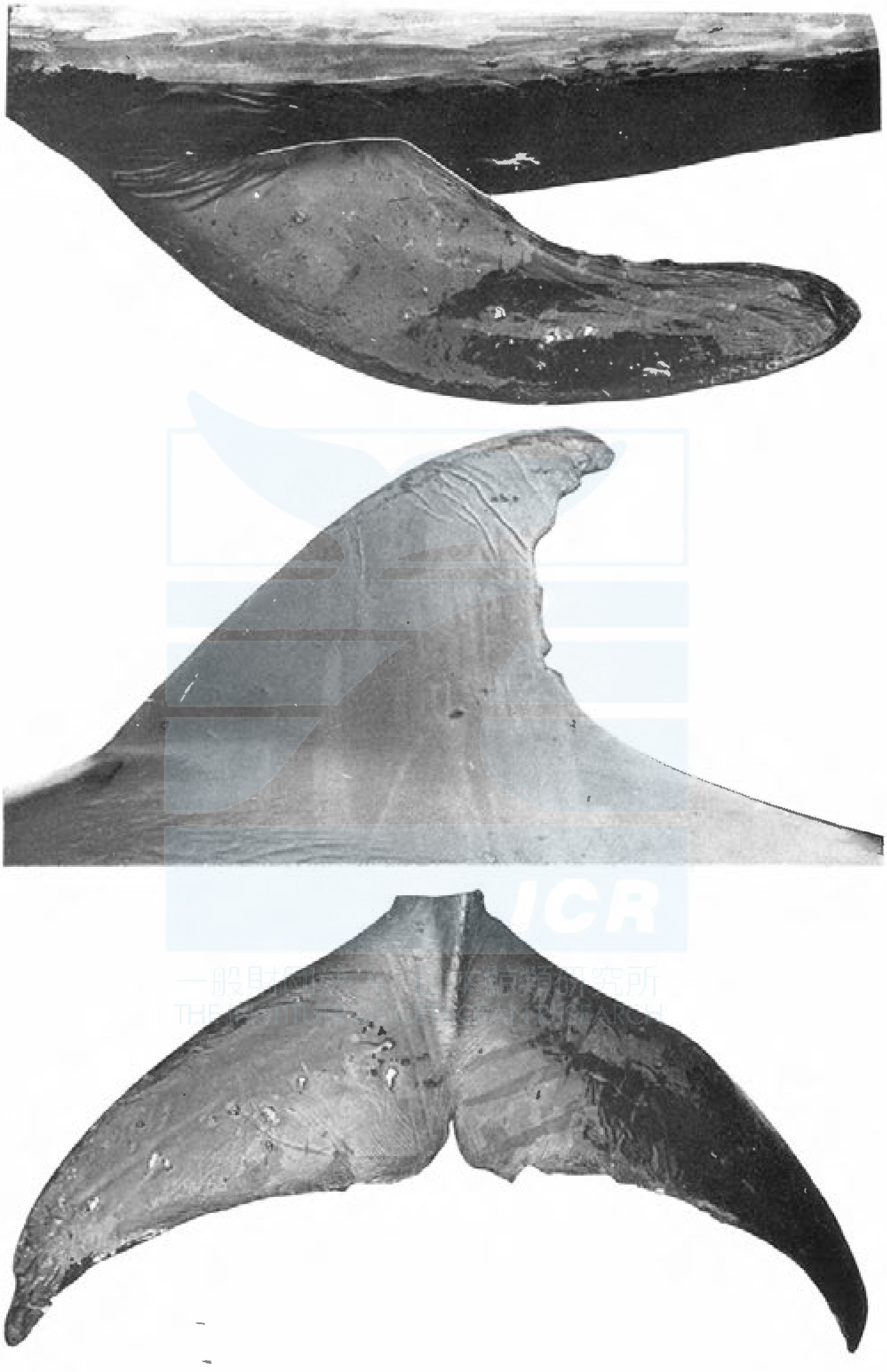
PLATE V

Flipper, dorsal fin and tail flukes (top to bottom) of *Feresa attenuata*.









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THE FIRST OCCURRENCE OF A PORPOISE *(ELECTRA ELECTRA)* IN JAPAN

MASAYUKI NAKAJIMA* AND MASAHARU NISHIWAKI

INTRODUCTION

A small toothed whale was found by a fisherman in the shallows of Hiratsuka Beach, Sagami Bay on 12th Aug. 1963 (Fig. 1). It was still alive and some strength was

Fig. 1. The animal was caught, lay dawn on the HIRATSUKA Beach.

still left in it's body. Fishermen took nearly an hour to catch it. When Nakajima hurried to arrive the Hiratsuka Fish Market, the porpoise had already been dismembered. The head, the fins and the bones were little short of complete and

* Enoshima Marineland, Fujisawa.

were obtainable. The author also observed the skin, meat and internal organs. At first glance he recognized the shape of the head and the white lips were similler to *Feresa attenuata*. Based on the above characteristics the porpoise was considered to be of the *Feresa* species, but continuously comparative differences were found in the shape of the flippers and moreover an evident difference was found in the teeth in that they were smaller and more in number than with *Feresa attenuata*. As these points were unusual, the porpoise was examined eagerly in detail.

EXTERNAL CHARACTERS

The authors could not see the whole shape of the porpoise body, but connected each part of the body, vertebrae and other portions available to rebuild the full length and make measurement. It was 260 cm. The porpoise was a male, the reproductive aperture is shown in Fig. 2.

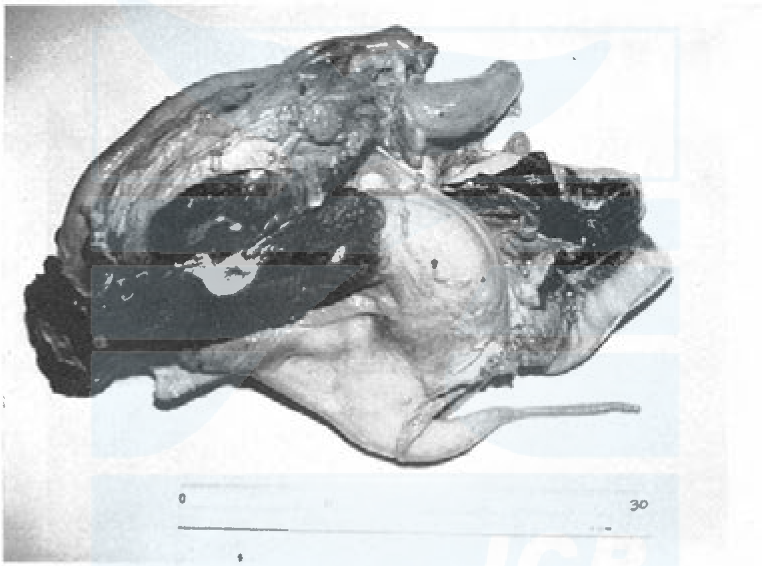


Fig. 2. Genital aparture: the glans penis was markedly slender, long and cylindrical.

The body color was mostly dark grey and a slightly lightened toward the belly. The skin of both lips and the skin around the anus and the genital areas was unpigmented and other such patches were scattered just anterior to the navel. Scars that are usually left by parasite infection or biting, were not found on the skin.

Shape of the forehead was round and beakless in profile like the false killer whale (*Pseudorca crassidens*), but in the front view both cheeks were pressed from the side, so the shape of the snout in dorsal view was fairly sharpened. Observed in profile, the eyes were positioned nearly on the center. The mouth-line extended from the front to below the eyes. The skin of both upper and lower lips was white as is the condition with *Feresa attenuata*.

TABLE 1. EXTERNAL MEASUREMENT OF THE HIRATSUKA SPECIMEN

	mm	%
Total length, from snout to notch of flukes	260	100.0
Head		
From tip of snout to tip of lower jaw	10	0.4
Lower jaw, from tip to angle of gape	270	10.4
From tip of snout to blowhole	345	13.3
From tip of snout to eye	335	12.9
From center of eye to earhole	75	2.9
From tip of snout to blowhole, along upper curve of head	465	17.9
Flipper		
Radial length*	53.0	20.4
Ulnar length*	41.0	15.8
Greatest width*	16.0	6.2
Width at base*	17.0	6.5
Dorsal fin		
Length at base	40.0	15.4
Height	25.0	9.6
Tail flukes		
From tip to frontal incertion*	44.5	17.1
Breadth at base*	20.0	7.7
From tip to notch*	36.0	13.8
Total spread	65.5	25.6

* All measurements are made in straight line.

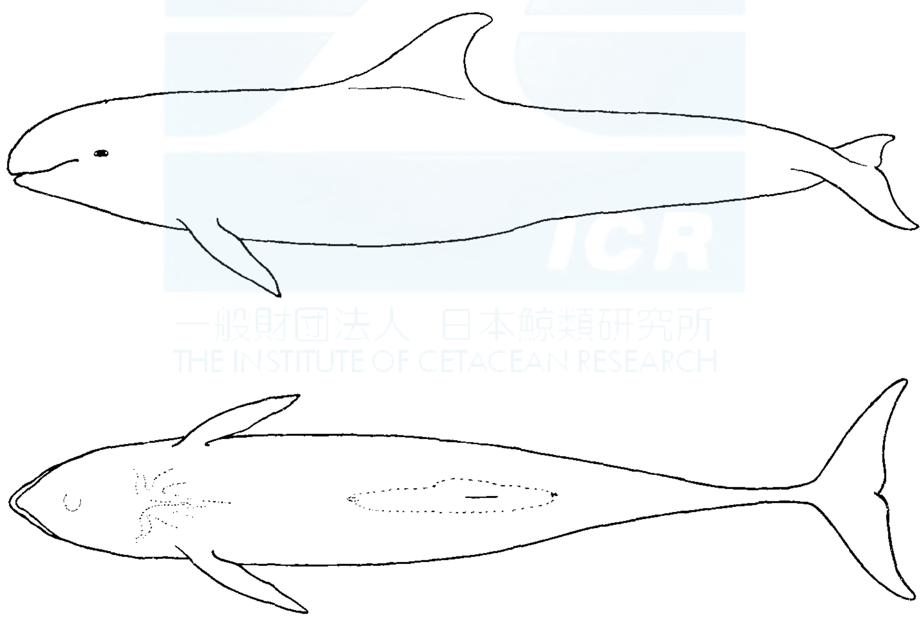


Fig. 3. A restoration picture of HIRATSUKA Specimen.

As shown in Fig. 4, the dorsal fin was trianglar, bend backward and sharp at the tip. The flippers were rather long, and were fairly similar in shape to the false killer whale (*Pseudorca crassidens*). The flippers are shown in Plate III. The tail-flukes were pretty large, almost 1/4 the body length (Fig. 5).

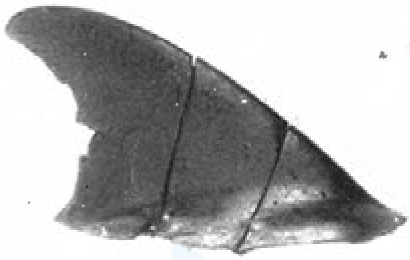


Fig. 4. Dorsal fin, right side.

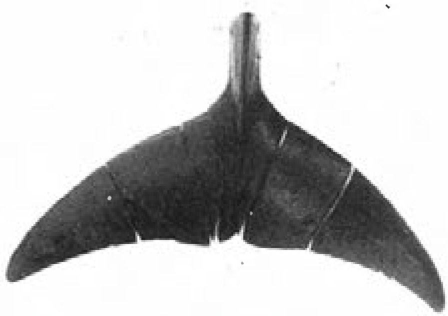


Fig. 5. Tail flukes, dorsal view.

There was no wedge shaped cut nor grooves on the throat. Between both flippers an anchor shape pale in color was seen. *Feresa attenuata* has a groove on the center of the belly which runs from the anus through navel and reaches to the chest, but no groove was found on the porpoise belly. Also with *Feresa attenuata*, a little posterior of the anus, there is a swelling on the tail, but no swelling existed on this porpoise. As Plate II shows, the dental formula was $\frac{24 \mid 25}{24 \mid 24}$. The upper right tooth row was the most numerous in number and the tip tooth of the upper left tooth row was left in the gum. The second to the nineth tooth of both upper tooth row and also the teeth of both lower tooth rows were worn out, especially the posterior part of the each tooth row were extremely worn.

The penis was rather slender from the tip to the middle and then became beg toward the root.

Fig. 3 is a restoration picture which was drawn from the above mentioned photographs and the measurement data. In this figure, the position of the dorsal fin and the flipper were presumed, therefore, it can not be said to be quite the exact position.

OSTEOLOGY

Dimensions of the skull are shown in Table 2. Compared with the data on *Feresa*, the two of them resembled each other quite well in shape, but the snout of the present specimen was longer the dental formula of greater number. The dental formula might be important. The authors, considering this point, made comparison with the dimensions of other skulls which had about the same dental formula. Those skulls were of the genus *Trusiops* and *Lagenorhynchus*. There were some differences among *Trusiops* and the present specimen. But the skull dimensions of *Lagenorhynchus electra* were quite alike.

The length breadth ratio of the rostrum was 1.8 on the present specimen. This value is bigger than *Feresa attenuata*, smaller than *Trusiops* species and *Lagenorhynchus* species except *L. electra*.

The length breadth ratio of the skull was 1.75 on the present specimen. This is bigger than *Feresa attenuata*, smaller than *Trusiops* species and very similar to *Lagenorhynchus* species.

The mandibular symphysis was ankylosed.

Vertebral formula of the present specimen is as follows.

C 7+D 14+L 17+Ca 44 = 82. The total number of vertebrae were 67—70 on *Feresa attenuata*, 61—66 on *Trusiops* species. These were less than the present psecimen. *Lagenorhynchus electra* has 80—84 vertebrae and this characteristic fits the present specimen. All of the epiphyses of vertebrae were ankylosed to their centrum. The present specimen therefore had already reached physical maturity and was a respectably old animal.

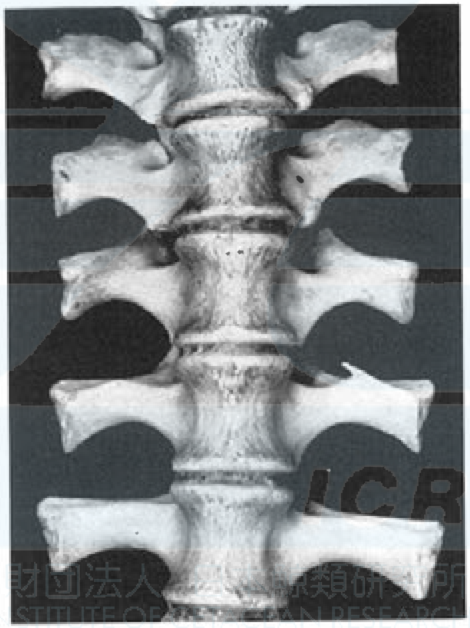


Fig. 6. Ventral view of the dorsal vertebral column, showing the spinal branch on the transvers processes.

The anterior three cervical vertebrae were fused. Number of ribs was 14 on both side, the anterior six were double headed ribs. The seventh dorsal vertebra had a spinal branch on both tips of the transvers processes. The one on the left side was 15 mm long and projected toward the centrum of the sixth dorsal vertebra like a hook. The one on the right side was only 3 mm long and was connected by the cartilage to a small piece of bone. This small bone also pointed toward

TABLE 2. SKULL DIMENSIONS OF THE HIRATSUKA SPECIMEN COMPARED WITH DATA OF *LAGENORHYNCHUS ELECTRA* AND *FERESA ATTENUATA*

		Hiratsuka mm	Specimen %	Range of *L. electra* from True (1889)	Rame of *Feresa attenuata* Ito specimen
1	Total length (condylo-basal)	477	100.0	425–472 mm	356–390 mm
2	Length of rostrum (median)	265	55.6	53.3–54.8%	44.7–49.2%
3	Breadth of rostrum at base	145	30.4	27.5–34.8	27.7–31.8
4	Breadth of rostrum at middle	120	25.2	17.4–23.0	21.3–25.1
5	Thickness of rostrum at middle	28	5.9		
6	Premaxillary breadth at middle of rostrum	61	12.8	12.1–13.3	15.0–17.7
7	Greatest breadth of premaxilla	101	21.2	17.9–22.8	23.4–26.2
8	Greatest breadth of superior nares	65	13.6		
9	*Distances from tip of rostrum to* bottom of maxillary notches	260	54.5		
10	. . . anterior end of vomer	55	11.5		
11	. . . anterior margin of superior nares	331	69.4	66.1–69.0	56.9–63.2
12	. . . posterior end of vomer on cranial basis (median)	383	80.3		
13	Breadth across middle ef orbits	257	53.9		53.7–60.7
14	Greatest breadth across supra-orbital plates of maxillae	254	53.3		
15	Greatest breadth across post-orbital processes	273	57.2	51.5–58.0	58.4–66.9
16	Breadth across posterior margins of temporal fossae	180	37.7	35.5–41.1	38.4–55.0
17	Length of temporal fossae	*94	19.7	17.6–21.6	L22.2–26.9 R22.0–27.9
18	Depth of temporal fossae	*60	12.6	11.4–14.9	L17.2–19.4 R17.6–23.7
19	Length of maxillary tooth row	L188 R182	39.4 38.2	37.3–40.0	L27.6–39.4 R28.7–33.3
20	Breadth of foramen magnum	43	9.0		
21	Height of foramen magnum	40	8.4		
22	Breadth of occipital condyles	108	22.6		
23	Length of mandibular rami	*385	80.9	81.2–81.7	L72.2–79.4 R72.2–79.9
24	Length of mandible (median)	370	77.6		
25	Distance from tip of mandible to coronoid process	*358	75.1		
26	Length of symphysis	32	6.7	7.1– 9.4	8.7–10.1
27	Length of mandibular tooth row	L184 R182	38.6 38.2	36.0–38.6	L31.5–37.5 R33.1–38.4
28	Depth between angle of mandible and coronoid process	*98	20.5	13.3–19.5	L20.8–23.8 R20.8–24.1
29	Breadth across mandibular condyles	245	51.4		
30	Height of skull	193	40.4		47.2–53.4
31	Diameter of largest tooth and Number of alveoli	6	1.2 24 | 25 24 | 24	0.9– 1.1 21–25 | 22–25 19–23 | 19–24	 9–10 | 8–10 11–13 | 11–13
32	Length of bulla tympano-perioticum	*34			
33	Greatest breadth of bulla across proximal volucral end and sigmoid process	*28			
34	Total depth of tympano-prioticum at middle	*26			

* . . . equal on both sides

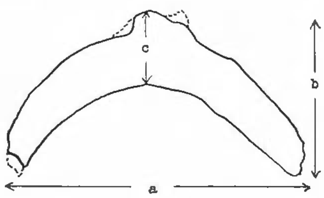
TABLE 3. DIMENTIONS OF VERTEBRAE (mm)

No.		a	b	c	d	e	f	g
Cervical	1.	43	—	103	91	144	—	48
	4.	6	35	41	64	54	26	37
	7.	9	35	45	64	77	25	47
Thoracic	1.	14	32	38	77	105	26	46
	7.	34	37	35	107	121	38	35
	14.	37	39	38	127	200	31	24
Lumbar	1.	35	39	40	131	200	29	24
	9.	30	43	43	158	185	29	17
	17.	22	45	45	128	145	26	12
Caudal	1.	22	45	45	122	140	24	11
	22.	22	42	44	83	56	6	6
	44.	6	5	9	5	—	—	—

a—Length of body at frontal end
b—Height of body at frontal end
c—Breadth of body at frontal end
d—Total height from anterior bottom
e—Bilateral breadth of transvers processes
f—Greatest height of neural canal
g—Greatest breadth of neural canal

Fig. 7. Dorsal view of the hyoid bones, thickness of sytlohyal are very thin.

TABLE 4. DIMENSIONS OF BASIHYAL, THYROHYALES AND STYLOHALS (mm)



a—160
b—110
c— 50

The greatest length, breadth and depth of stylohyals

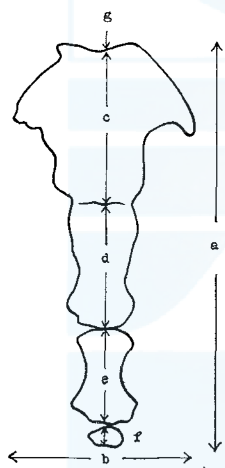
Left : ?, 22, 13
Right: 96, 22, 13

TABLE 5. DIMENSIONS OF RIBS (mm)

No	Length Left c	Length Left s	Length Right c	Length Right s	Breadth at middle Left	Breadth at middle Right
Vertebral ribs (No. 1–14)						
1.	270	181	270	181	26	26
5.*	484	373	475	364	11	12
14.	179	174	266	246	6	8
Sternal ribs (No. 1–9)**						
1.	108		108		19	19
8.*	162		164		7	6
9.	46		100		4	6

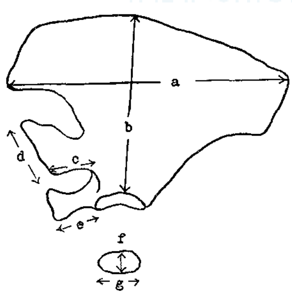
c—curvilinear length along the outer bordar
s—streight length
*—max. size
**—almost streight

TABLE 6. DIMENSIONS OF STERNUM (mm)



a—Total length	244
b—Greatest breadth of manubrinum	109
c—Length of manubrinum	94
d—Lengtho f 2nd sternbra	75
e—Length of 3rd sternbra	57
f—Length of 4th sternbra	18
g—Depth of median (anterior) notch of manubrium	6

TABLE 7. DIMENSIONS OF SCAPULAE (mm)



		Left	Right
a.	Length along vertebral border	227	230
b.	Length of glenoid cavity	39	39
c.	Breadth of glenoid cavity	30	30
d.	Length of acromion, along medial border	43	43
e.	Length of coracoid, from supraglenoid edge to tip	41	42
f.	Greatest breadth of acromion	58	55
g.	Breadth of articular surface	32	31
h.	Height of articular surface	40	40

the centrum of the sixth dorsal vertebra. The function of these structures might be due to the differences of the single headed and the double headed rib junctions. This vertebra characteristic could also be seen on *Feresa attenuata.*

The number of the sternal ribs were nine pairs and five pairs were connected to the sternum. The sternum consisted of four pieces. The first piece of the sternum ankylosed with the second, on the third one there is a vallecula and in center of it a hole was opened.

TABLE 8. DIMENSIONS OF HUMERUS, RADIUS AND ULNA (mm)

		Left	Right
Humerus,	Greatest length	87	87
	Breadth at distal end	55	55
Radius,	Length at middle	120	120
	Breadth at distal end	62	62
Ulna,	Length at middle	95	97
	Breadth at distal end	38	38

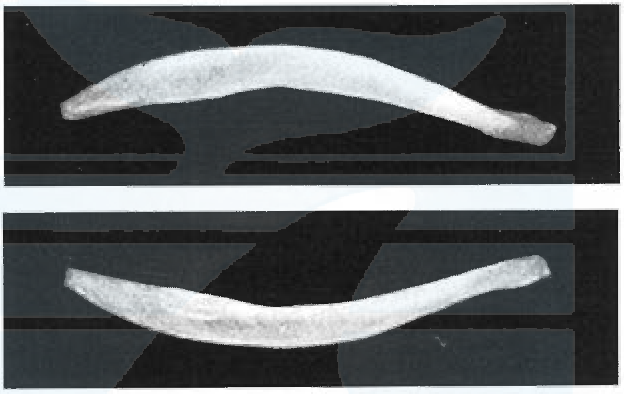
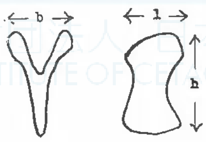


Fig. 8. Left pelvic bone.
upper ... dorsal view
lower ... ventra view
head is right side

TABLE 9 DIMENSIONS OF CHEVRONS
(Range in mm)



Length	8–23
Breadth	15–25
Height	9–47

The posterior ends of the thylohyals were very thin. There were no important characteristics on the scapulae except their posterior edges were a little straighter than with *Feresa attenuata.*

The phalangeal formula in the flippers was I: 3, II: 9, III: 7, IV: 4, V: 3. This formula resembles the formula of *Feresa attenuata.*

The right side pelvic bone was lost due to dismemberment and only the left

TABLE 10. COMPARISON OF OSTEOGICAL CHARACTERISTICS

	Hiratsuka specimen	*Lagenorhynchus*	*Tursiops*	*Ferəsa*
Body length in feet	9	9	12	8
Vertebral formula	C7(3)+D14(6)+ L17+Ca44=82	C7(2)+D14∼15(6)+ L18∼22+Ca38∼41=73∼92	C7(2)+D12∼14(5)+ L17∼19+Ca26∼29=61∼66	C7(3)+D12∼13(5∼7)+ L15∼17+Ca32∼34=68∼70
Dental formula	24 | 25 24 | 24	22∼45 22∼45	18∼26 18∼26	8∼12 10∼13
Phalangeal formula	I, II, III, IV, V 3 9 7 4 3	I, II, III, IV, V 1∼2, 10, 6, 2∼3, 2	I, II, III, VI, V, 1∼2, 7∼9, 5∼8, 2∼3, 1∼2	I, II, III, IV, V 2∼3, 8∼10, 7∼8, 3∼5, 2∼3
Length / breadth: skull	1.75	1.74	2.04	1.59
Length / breadth: rostrum	1.83	2.02	2.32	1.57

side was collected. It's length was 169 mm, the length along the side of it was 175 mm and the greatest breadth was 17 mm.

The number of the chevron bones were thirty, the anterior three and the last one in the column were separated in two parts.

OTHER OBSERVATIONS

1. Internal organs

Internal organs had already been boiled for feed before Nakajima arrived. He was obliged to observe the boiled organ and found no special differences from other small cetaceans.

2. Parasites

In the stomach some nematodes were found. Near the vesical region there were some cysts 20—25 mm diameter. In one cyst a nematode was found, which was 150 mm long and 1 mm in section. In the air sinus of the skull, many nematodes were found. Those were about 30 mm long and 0.5 mm thick. 70 of them were in the left side and 120 were in the right side.

These nematodes were the same type (species) of that had been collected from *Feresa attenuata* which had caught in Futo, 1963.

They were different type of parasite from *Grampus griseus* that are fat, long and with screwed root into the tissue of the air sinus. Once in a certain specimen of *Feresa attenuata*, both type of them were found together.

3. Rete mirabile

Shape and conditions of the right side of the rete mirabile were not so different from other species of small cetaceans, and it's area of spread was 380 mm × 1000 mm on each side.

TAXONOMICAL POSITION OF THE PRESENT SPECIMEN

At first sight Nakajima thought this porpoise might be a *Feresa attenuata*, but he wondered soon after the counting the teeth. The number of teeth was almost twice as many as in *Feresa attenuata.* So he thought that the porpoise might be a new species or even a new genus.

On the suggestion of Dr. T. Ogawa, the authors examined the data of *Lagenorhynchus electra* in detail as mentioned above. Finally the authors decided that the present specimen belonged to *Lagenorhynchus electra* as published by Gray.

In the external characteristics, the porpoises that belong to *Lagenorhynchus* species have a beak though it is very short. Usually a vallecula can be seen between the beak and the forehead. There has been in the past only a little data presented regarding the external appearances of the species of *Lagenorhynchus.*

The classification has generally been decided on the basis of bones, especially the skulls. It is felt that the external characteristics, the size of the bodies, the external appearance and the colorations, are also important for the study of the classification.

L. electra and *L. albirostris* have especially large sized skulls among the species of *Lagenorhynchus*.

The authors considered the above mentioned matters, are reluctant to include this species *electra* in the genus *Lagenorhynchus*.

Dr. Kennes S. Norris of the University of California, Los Angeles found a stranded newborn porpoise on August 1964 at Oahu beach, Hawaii. Photographs of the living animal and skull were sent to Dr. Norris at the Oceanic Institute in Hawaii, and he compared them with a stranded newborn specimen. He concluded that our specimen and his were certainly in the same genus and probably conspecific, and that both seem to represent what Gray (1846) called *Lagenorhynchus electra*. We both concur that the animal is not a member of the genus *Lagenorhynchus*, but is a presently unrecognized genus. The rules of priority, therefore, require that Gray's (1868) name *Electra electra* be applied to the form.

SUMMARY

1. A small toothed whale was caught on 12th August 1963 at Hiratsuka Beach, Sagami Bay, Japan. The porpoise was a male 260 cm long.
2. It had no external beak and quite resembled *Feresa attenuata* in external appearance.
3. Vertebral formula: C 7+D 14+L 17+Ca 44 = 82
   Phalangeal formula: I: 3, II: 9, III: 7, IV: 4, V: 3.
   Dental formula: $\frac{24 \mid 25}{24 \mid 24}$ (alveolar number)
   Length breadth ratio of the skull: 1.75
   Length breadth ratio of the beak: 1.80
4. According to the discussion the present specimen was determined as *Lagenorhynchus electra*.
5. Based on the external characteristics, this species *electra* should not be assigned to the genus *Lagenorhynchus*, but it might belong to the genus *Electra* which was presented by Gray (1868).
6. This is the first occurrence of *Electra electra* Gray (1846) in Japan.

ACKNOWLEDGEMENT

The authors are indebted to the members of the Hiratsuka Fish Market for their kind presenting of the specimen, and thanks are also due to Messrs. of the members of the Enoshima Marineland for their collaboration in examination of the specimen.

Dr. T. Ogawa gave a very important suggestion on this study. The authors would like to express their sincere thanks to him and should be shown their respects to his comprehensive knowledge in the taxonomic field of cetaceans.

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EXPLANATION OF PLATES

PLATE I

Dorsal, lateral and ventral views (top to bottom) of head of the Hiratsuka specimen.

PLATE II

Upper and lower tooth rows are shown in dissected mouth. Teeth are shown in the lowest figure, middle of upper and lower line is the center of the mouth, upper line of teeth is upper tooth row.

PLATE III

Dorsal views of the flippers and their X-ray photographs.

PLATE IV

Dorsal, ventral and lateral views of skull.

PLATE V

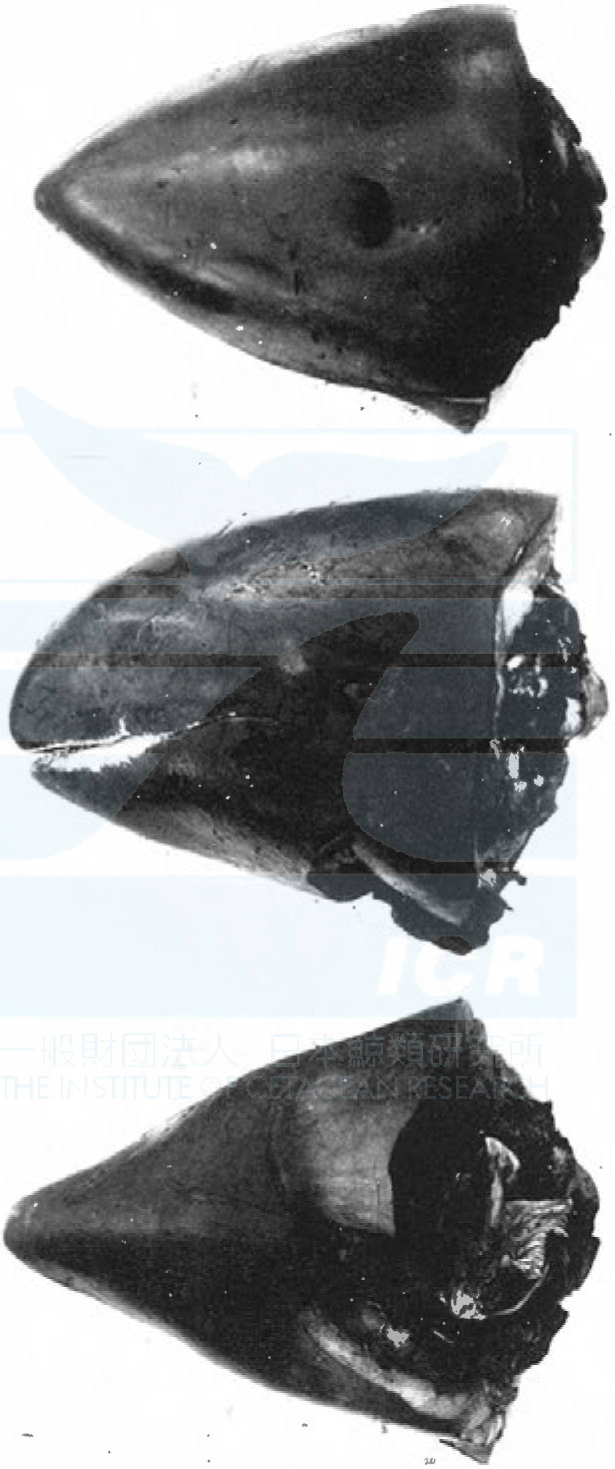
Upper figure is posterior view of skull. Left one of middle figures is dorsal view and right one is ventral view of mandible. Lower figure is lateral view of mandible.

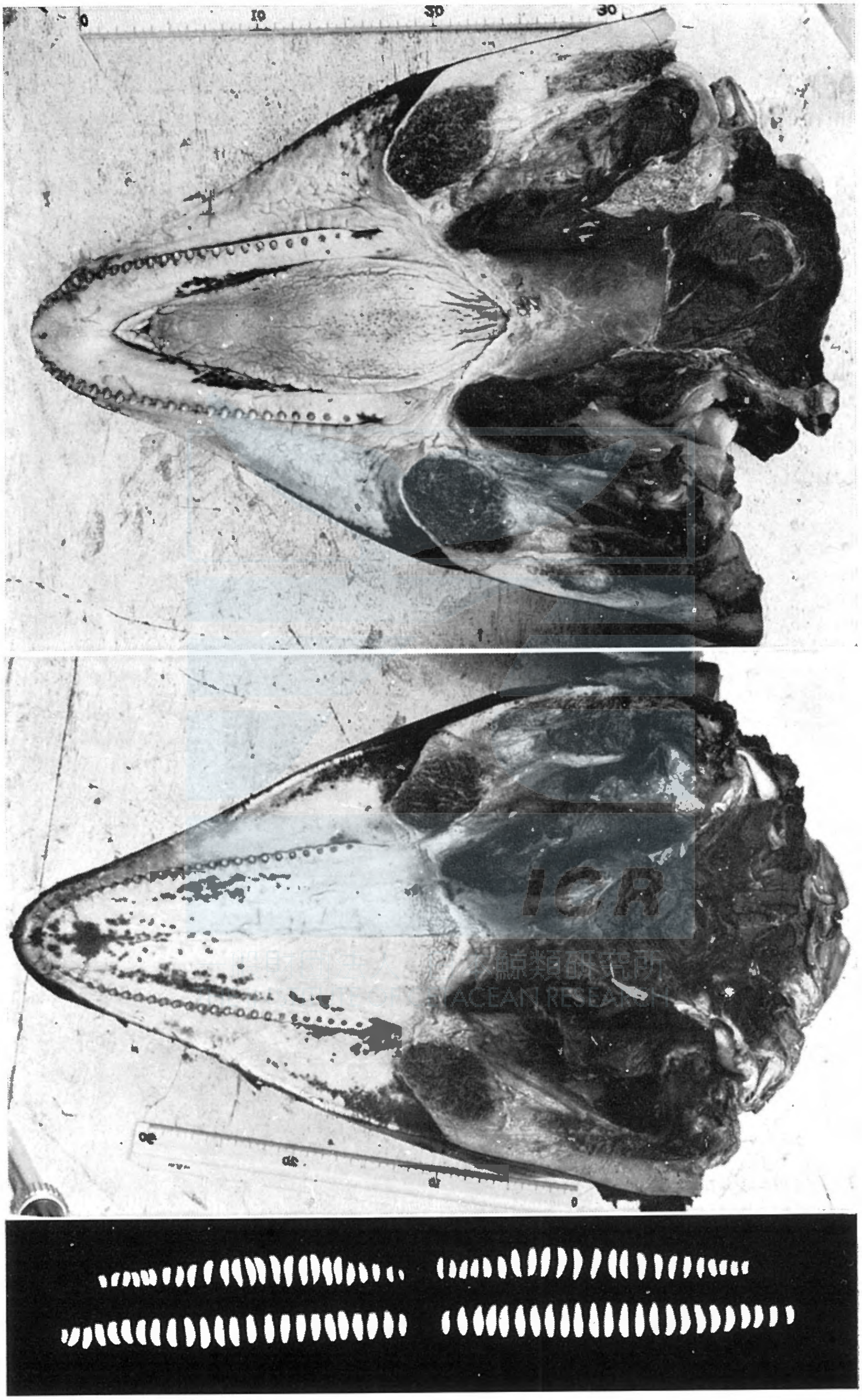
PLATE VI

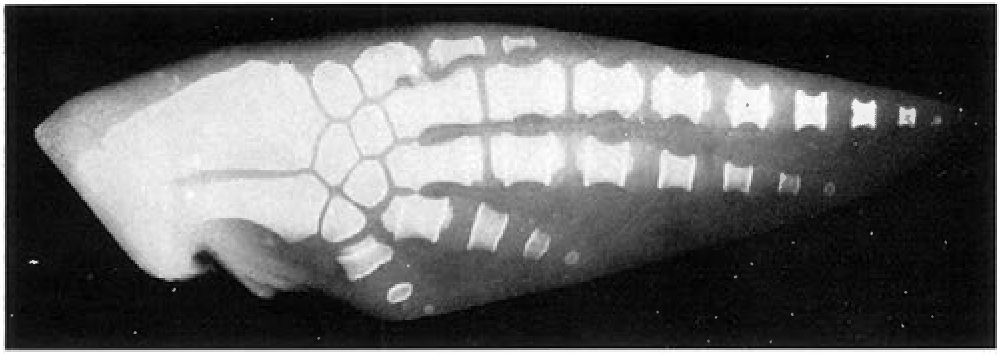
Lateral view of vertebral column : cervicals and dorsals, lumbars, caudals 1–24, caudals 24–44 and chevron bones (top to bottom).

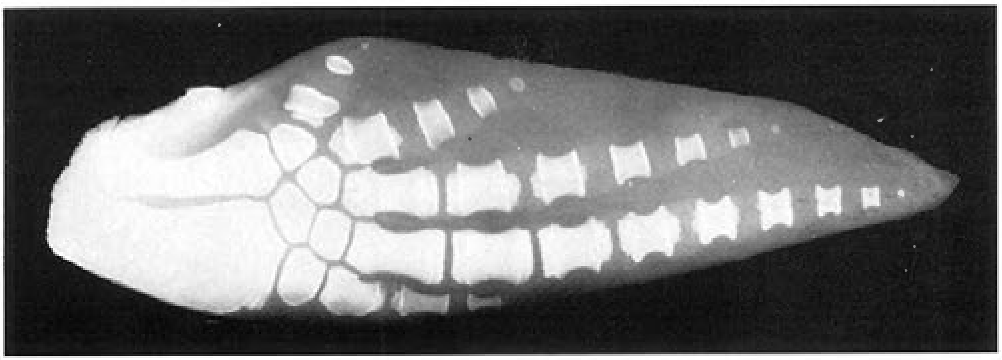
PLATE VII

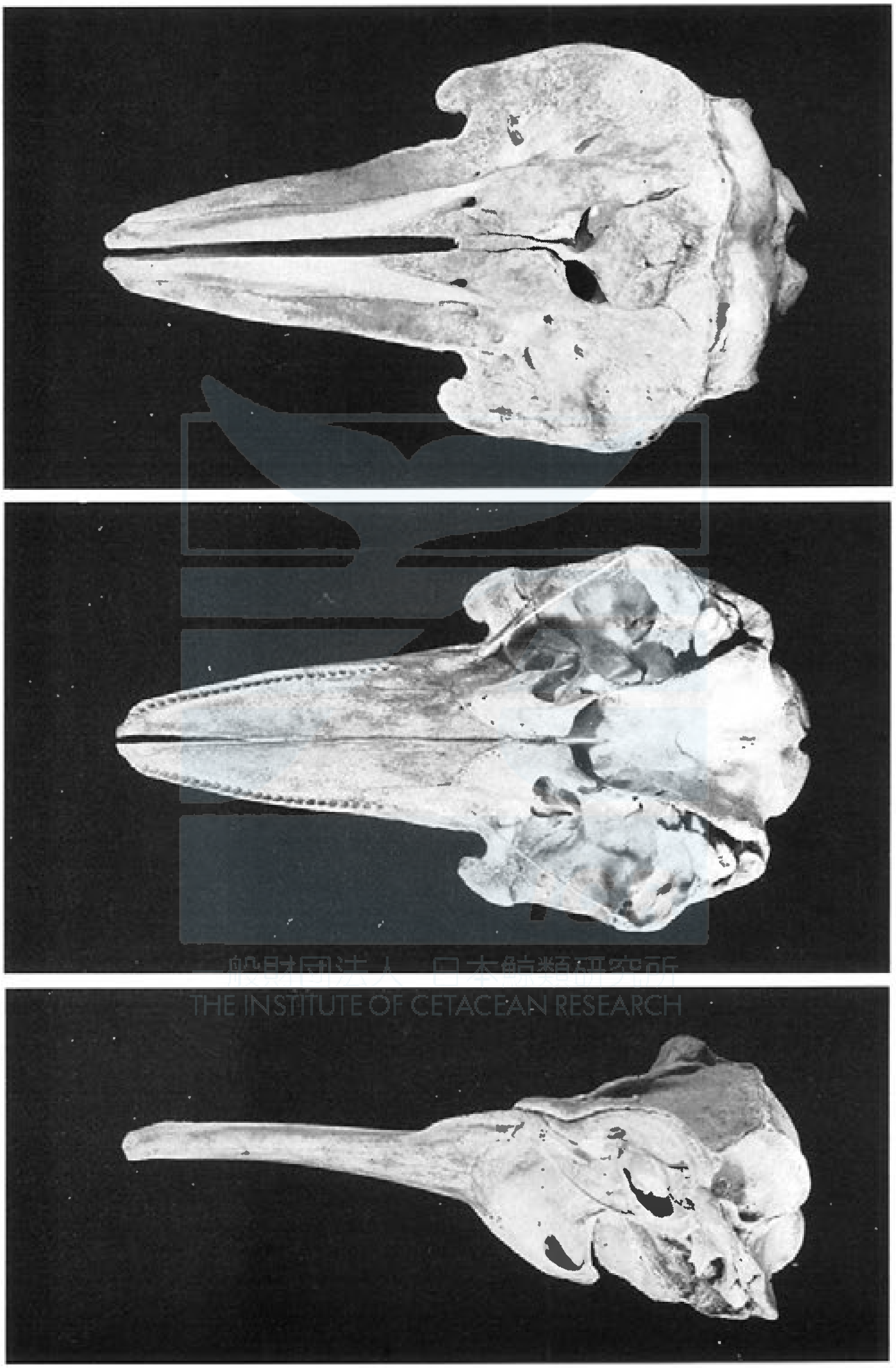
Ventral views of sternum, sternal ribs and vertebral ribs are shown in center figure. Side figures are lateral views of scapulae, right scapula is shown in left figure.

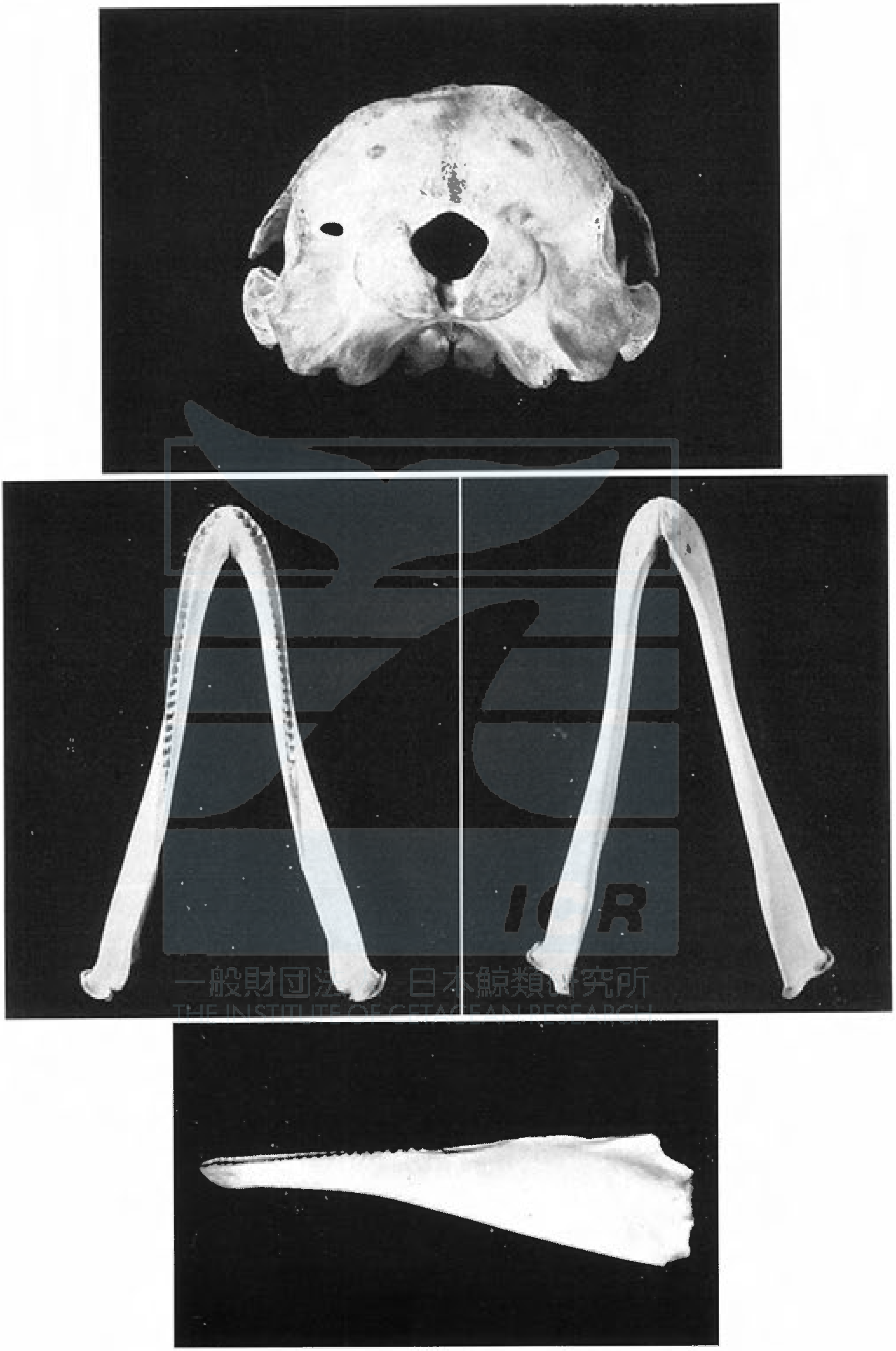


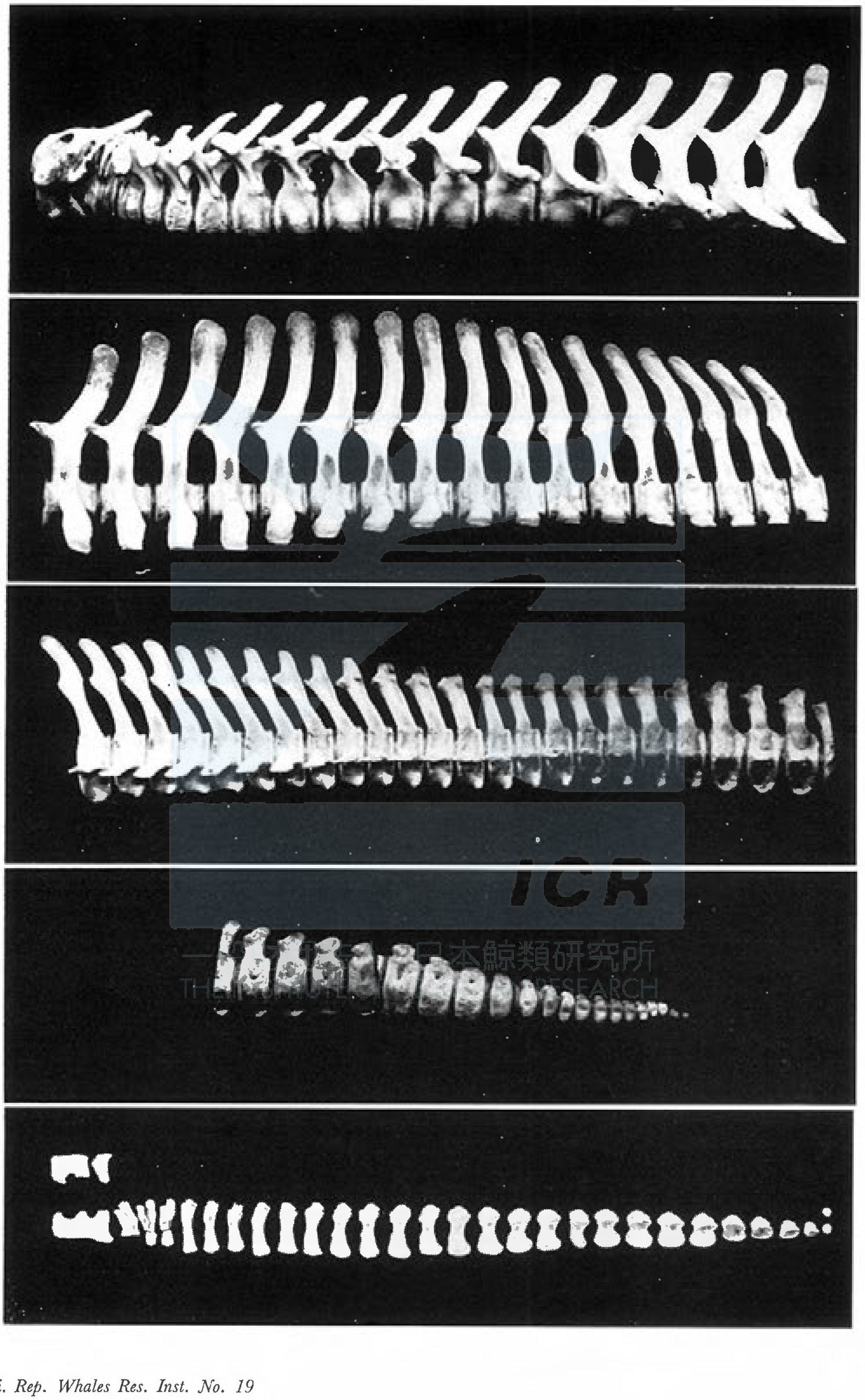


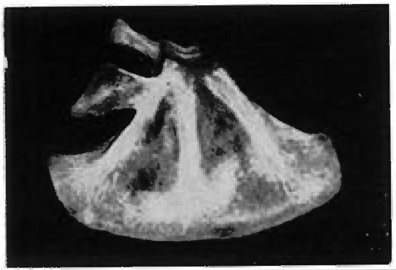


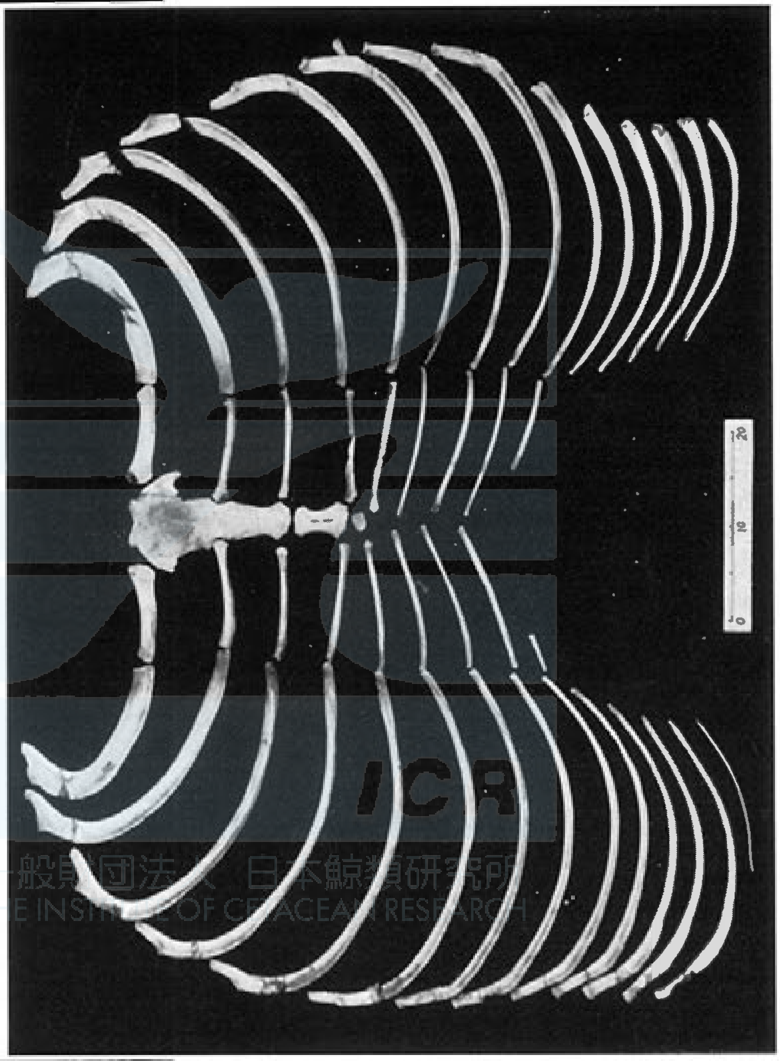


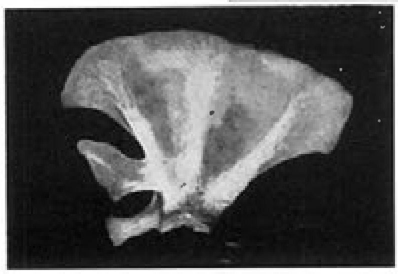












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SECTIONS OF THE DOLPHIN'S HEAD (*STENELLA CAERULEOALBA*)*

HIROSHI HOSOKAWA** AND TOSHIRO KAMIYA**

For the past years one of the authors, Hosokawa, has dissected several specimens of the *Stenella* (*Prodelphinus*) *caeruleoalba* (Meyen), paying speciel attention to the peripheral distribution of cranial nerves. In order to supplement the ordinary anatomical observations, a couple of heads of this animal were sectioned transversely or lengthwise with the hand-saw. Anatomical features of each section surface were very interesting and instructive for understanding the three-dimentional structures of the dolphin's head. Such cross-sectional observation was adopted partially by Slijper (1936) in his comparative-anatomical study of the cetacean blood vessels, by Lawrence and Schevill (1956) in their functional anatomical study of the delphinid nose as well as by Nakajima (1961) in his work on the cetacean rete mirabile, although they did not give detailed explanation of each structure on the section surfaces.

Materials used in the present study comprise two heads of adult *Stenella caeruleoalba* from Kawana, Shizuoka Prefecture, which had been soaked and fixed thoroughly in 10% solution of formalin. One of the specimens was sectioned transversely into six slices (Fig. 1), and each section surface was photographed and sketched from rostral direction. The total length of the head was 45 cm, and each slice was successively some 16, 5, 6, 4.5, 4.5 and 9 cm in thickness. The second specimen, 46 cm in length, was sectioned at first in the median plane. Then the right half was cut lengthwise 5 cm apart from the median surface. In the following pages each section surface will be shown with brief explanations. Since the cross-sections are seen from rostral, the right side of the head is on the left side of the figures.

CROSS-SECTIONS

Section I (Fig. 2-a, b)

The section passes through the root of the *snout* or *rostrum*. The upper and lower jaws are separated from each other by the gap of the *oral cavity*. The skeleton of the upper jaw is represented by the *maxilla*, *premaxilla*, *vomer* and *mesethmoid cartilage*. The last one lies on the median line, enclosed in the canal formed by the premaxillae of both sides and the vomer. The dorsal part of the premaxilla is composed of particularly compact bony substance. Inside the maxilla and premaxilla we see small canals for conducting the *superior alveolar arteries* and *nerves*, which supply small branches to the alveolar plexus around the root of the teeth. For reference, the peripheral distribution of the *trigeminal nerve* is shown in Fig. 13.

* To the memory of late Prof. emeritus Tsunetaro Fujita.

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Needless to say, the Stenella is, like all the other odontocetes, furnished with *homodont teeth*, of which the number amounting to some forty or fifty pairs in both upper and lower jaws. On the left side of the figure the whole contour of one tooth is shown. Approximately half of the total length is inside the maxilla (radix dentis), while the other half, conical in shape and somewhat curved mediad, is out of the gingiva.

Dorsal to the premaxilla and maxilla is a white area occupied by adipose connective tissue. This is the anterior extremity of the so-called " melon ". This peculiar structure, characteristic of most dolphins, lies on the snout and forms the prominence in front of the nostrils. Although there have been proposed many hypotheses about the function of this unique structure, we do not know yet anything definite. Probably the *spermaceti organ*, characteristic of the sperm whale, represents the highly differentiated " melon " of other odontocetes. The " melon " and spermaceti organ have been very often thought in relation to the respiration of the cetacea (Raven & Gregory, 1933; Slijper, 1962, etc.).

Under the melon we see the anterior end of the *m. rostralis* or the *pars labialis* of *m. maxillonasolabialis* (Huber, 1934). These muscle bundles arise from the upper surface of maxilla and run up- and forwards, so as to insert to the thin fibrous capsule of the melon. Some of the muscle bundles, which arise from the lateral border of the maxilla, are directed up- and backwards, so as to border the anterior end of the narial muscle group, pars nasalis of m. maxillonasolabialis (see Fig. 10).

The *mandibula* is cut on both sides in the lower jaw. This bone is furnished with a wide internal space filled with spongy, adipose tissue (*mandibular canal* or *fossa*), and the *inferior alveolar vessels* and *nerves* are seen to pass through this fatty substance (confer Fig. 13).

In the middle of the lower jaw is the cut surface of the *tongue*, representing a peculiar quadrangular shape. Inside the tongue we see the inverted V letter of the *genioglossus* muscle, as well as many *internal lingual muscle bundles* arranged irregularly. Beneath the tongue are sections of the *mylohyoid* muscle and of the *panniculus carnosus*, which covers the ventral surface of the lower jaw.

Section II (Fig. 3-a, b)

It represents a section through the middle of the " melon ". Anatomical features of this section do not show significant differences from those of the preceding one, while the melon and the rostral muscle have considerably increased in size.

In the lower jaw the tongue is cut at about the middle of the *corpus linguae*. In addition to *mm. genioglossus* and *mylohyoideus*, which were already observed in Section I, the *geniohyoideus* and *hyoglossus* are seen in the floor of the oral cavity. The arrangements of these muscles are shown in Figures 11 and 12. As seen in Fig. 11, the *panniculus carnosus* is considerably well-developed on the ventral surface of the lower jaw. Systematic description of the cetacean muscles is to be referred to Stannius (1849), Schulte (1916, 1918), Howell (1930), Slijper (1936), etc.

Section III (Fig. 4-a, b)

This is a section at the *oral angle* or the posterior end of the oral cleft. The bony framework of this section, shaped like a flying bird with extended wings, is composed of *premaxilla*, *maxilla*, *vomer*, *os malare* or *jugale*, *os palatinum*, *os pterygoideum* as well as of the *mesethmoidal cartilage*. The maxilla and os malare form a double-layered bony plate (confer Fig. 9). On the left side of the figure the malar bone shows on its lower surface a pointed prominence representing the root of the *zygomatic process*.

Noteworthily there are peculiar cavernous sinuses inside or in close apposition to the skeleton. The largest one is inside the pterygoid fossa surrounded by os palatinum and pterygoideum (postpalatine air sinus of Flower, 1876). Hence it is called *sinus pterygoideus*. Other sinuses on the section are secondary expansions of the pterygoid sinus.

All the sinuses are traversed by fibrous trabeculae and give spongy appearances. These sinuses belong to the *pneumatic sinus system*, which characterizes especially the odontocetes. All the sinuses such as *pterygoid*, *epitympanic*, *peripetrosal*, etc. are continuous with the tympanic cavity. The pneumatic sinus system was described by Boenninghaus (1904), Gruhl (1911), Yamada (1953) etc., who did not however explain the physiological significance of this peculiar structure. Nerve bundles belonging to V_2 (*n. maxillaris*) are seen in the trabeculae of the *frontal* and *maxillary sinus expansions* (confer Fig. 13).

Above the bony frame the " melon " is seen in the middle of the section, being abutted on by the *m. narialis* on both sides (Fig. 10). The narial muscle of blowhole muscle, *pars nasalis* of *m. maxillonasolabialis* of Huber (1934), is formed by many layers and subdivisions, of which the direction of muscle bundles is somewhat different from one another. Lawrence and Schevill (1956) recognized six layers and called them posteroexternus (pe), intermedius (i), anteroexternus (ae), posterointernus (pi), anterointernus (ai), and profundus (pr).

At the center of the lower half of the section is a transverse slit which is lined with the thick wall of mucous membrane. This is the posterior part of the *oral cavity*, of which the floor is represented by the *radix linguae* (see Section VI). Ventral to the oral cavity we see *m. hyoglossus*, *genioglossus*, *geniohyoideus*, *monogaster*, etc. *M. mylohyoideus* is cut obliquely on each side of the oral cavity.

The *pterygoideus medialis* muscle is seen to occupy the space between the ptergoid process and mandibula, showing close relationship to the frontal sinus expansion. The *n. facialis* is cut under the bony shelter formed by the maxilla and os malare. This nerve trunk can be traced to the rostral until the antorbital notch, where it turns upwards, returns backward on the dorsal surface of the maxilla, so as to supply the whole musculature of the nostril (see Fig. 13).

Section IV (Fig. 5-a, b)

The section passes through the *bony nasal canal*, which courses along the anterior wall of the cranial case. The nasal canals of both sides are separated by the oval-shaped *mesethmoid bone*. Above the *bony naris* the nasal canal continues to the *pre-*

maxillray sac and still further to the *vestibular sac* just under the thick blubber layer.

The complicated structure of the dolphin's *nasal passages* has been subjected to investigations of many scholars such as Rawitz (1900), Gruhl (1911), Burne (1952), Lawrence and Schevill (1958), etc. So the present authors do not intend to go into its details. A somewhat schematic illustration will outline this labyrinthous nasal passage (Fig. 14).

On both sides of the nasal ways we see massively developed *narial muscle, pars nasalis* of *m. maxillonasolabialis*. The intimate topographical relations between this muscle and nasal passage imply their close functional correlations.

The bony frame of the section is composed of *premaxilla, maxilla, os frontale* and *os pterygoideum*. The plate-like lateral projection is formed by the maxilla and os frontale. This peculiar modification and dislocation of the cranial bones are associated with the famous phenomenon called " telescoping " of the cetacean skull (Kernan, 1918; Kellog, 1928, etc.). Branches of *nn. alveolares superiores* are seen between these two bony laminae (see Fig. 13). Lateral to the pterygoid process is seen the *sinus pterygoideus* of the pneumatic sinus system. Upwards it is elongated and continuous to the maxillary and frontal expansions.

On the left side of the section we see the cut surface of the *eye ball* as well as of *extrinsic eye muscles*. The eye ball is characterized by the extraordinarily thick scleral wall, an adaptation to the hydrodynamic environment of the cetacea. The floor of the orbit is formed by a tough fibrous membrane, and the facial nerve runs just under this orbital floor. The *zygomatic arc* is also cut near the tip of the orbital cone.

It is noteworthy that the eye muscles are covered by a thick cavernous layer composed of spongy substance. This is nothing but the *rete mirabile*, or the peculiar network of arterial blood vessels. As well known, the extraordinary development of the rete mirabile is one of the most remarkable characteristics of the cetacean anatomy (Stannius, 1841; Wilson, 1879; Ommanney, 1932; Slijper, 1936; Kock, 1959; Nakajima, 1961; Slijper, 1962, etc.). The rete is distributed mainly in the trunk and neck. In the cranial region it is found in the orbit (*rete orbitale*) and in the floor of the cranial cavity (*rete basis cranii*) (see Section V).

In the lower part of the section we see the oral cavity, which is cut at its posterior end.

Section V (Fig. 6-a, b)

The cranial cavity is cut open and the brain, which is poorly fixed, is exposed. The brain lies on the cushion of the *rete basis cranii*. Meningeal coverings of the brain are quite same as those of man and other mammals.

The bony frame of the section is formed by the *maxilla, os frontale, os parietale, os ethmoidale* and *vomer*. The lateral dislocation of os parietale is a part phenomenon of the " telescoping " of dolphin's skull. The zygomatic process of the *squamosal* is cut on the left side, while the zygomatic arc is still seen on the right.

The *mandibula* is cut near its posterior extremity. As seen already in the preceding section, the medial wall of the mandibula is lost and the *mandibular fossa* is filled with massive fatty substance, which extends forward into the wide mandibular canal (Sections I-III). Medially the mandibular adipose substance is abutted on by the *pterygoid muscles* and *pterygoid sinus*. Because of these intimate topographical relationships, Yamada (1953) guessed that the movements of the lower jaw might effect strongly upon the distension of the pterygoid sinus.

The *pharynx* and *larynx* are shown on the median line. This peculiar situation that the pharynx is cut in front of the larynx can be understood by checking the guide line in Fig. 6-a. The pharnyx is surrounded by muscle groups such as *m. monogaster*, *mylohyoideus*, *styloglossus*, *hyoideus*, *sternothyroideus*, etc. *Os hyoideum* is cut at the basihyal as well as at the stylohyal.

The larynx is cut at the tip of the *arytenoepiglottideal tube*, which protrudes uniquely into the choana. This peculiar tube, characteristically well-developed in the odontocetes, was described by Hosokawa (1950) in the sperm whale (see Fig. 7).

LONGITUDINAL SECTIONS

Section VI (Fig. 7-a, b)

This is the median section of the Stenella's head. Because of the slight asymmetry of dolphin's skull, the right *nasal passage* is cut through, showing the strange disposition of the *nostril* (*blowhole*), *vestibular sac*, *tubular sac*, *nasal plug*, *premaxillary sac*, etc. The *m. narialis* is seen in close topographical relationship to the nasal passage, especially to the nasal plug. In front of the nasal passage we see the " melon ", a peculiar mass of adipose tissue on the dolphin's rostrum.

The skull is represented by the brain case and the long rostrum. The former is cut through *os frontale* fused with *mesethmoidale*, *os supraoccipitale*, *basisphenoidale* and *basioccipitale*, while in the elongated snout we see *os mesethmoidale*, *mesethmoid cartilage*, *premaxilla*, *maxilla*, *os palatinum*, *os pterygoideum*, etc.

The *brain* shows a remarkable dorsal flexion in the pontine region, representing a noteworthy characteristic of the cetacean brain. As seen in this section the brain stem is relatively well developed. The *cerebral hemisphere* shows a very complicated pattern of convolutions and sulci. As well known, the cetacean brain stands highest in the mammalian kingdom, so far as the complexity of the cerebral fissural configuration is concerned. The *corpus callosum* is relatively small.

The *tongue* is very long and its greater part is attached to the floor of the oral cavity. Intrinsic and extrinsic *lingual muscles* are fairly well developed, implying the considerable motility of the tongue. The *arytenoepiglottideal tube* of the larynx is clearly shown at the left and lower end of the figure. As explained in Section V, this tubular structure formed by modified arytenoid and epiglottic cartilages protrudes into the *choana*. Probably the dolphin can breathe and swallow foods simultaneously.

Section VII (Fig. 8-a, b)

This section shows a sagittal plane 5 cm to the right side from the median plane. The medial wall of the section is seen from outside. The section passes through the *foramen jugulare* (*foramen lacerum posterius*), which is represented by a wide gap between the basi-exoccipital and alisphenoidal bones. The gap is filled with vascular plexus, *rete mirabile*, and nn. IX—XI are cut along the posterior bony wall, while the n. XII is seen inside the *hypoglossal canal* within the exoccipital bone.

The *os tympanicum* is seen under the jugular foramen, surrounded by remarkable spongy cavernae of the *peripetrosal pneumatic sinus*. The latter continues forward into the larger pterygoid sinus.

The *mandibula* is cut at the mandibular fossa, which is filled with adipose mass containing branches of the *n. mandibularis*. In the hyoid region we see *os basihyale* and *stylohyale*, surrounded by muscle groups such as *m. monogaster*, *m. mylohyoideus*, etc.

IN CONCLUSION

For the purpose of supplementing the ordinary anatomical dissections and observations of the dolphin's body, heads of the *Stenella caeruleoalba* (Meyen) were sectioned transversely or lengthwise. Then each section surface was photographed, sketched and described. Anatomical features of these sections are very interesting and instructive for understanding the three-dimensional structures of the dolphin's head.

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Addendum

After this paper went to press, we had the opportunity to see the following article which gave brief outline of cross-sections of the *Stenella graffmani.*

Boice, R. C., Swift, M. L., & Roberts, J. C. (1964). Cross-sectional anatomy of the dolphin. *Norwegian Whaling Gazette*, 53 : 177–93.

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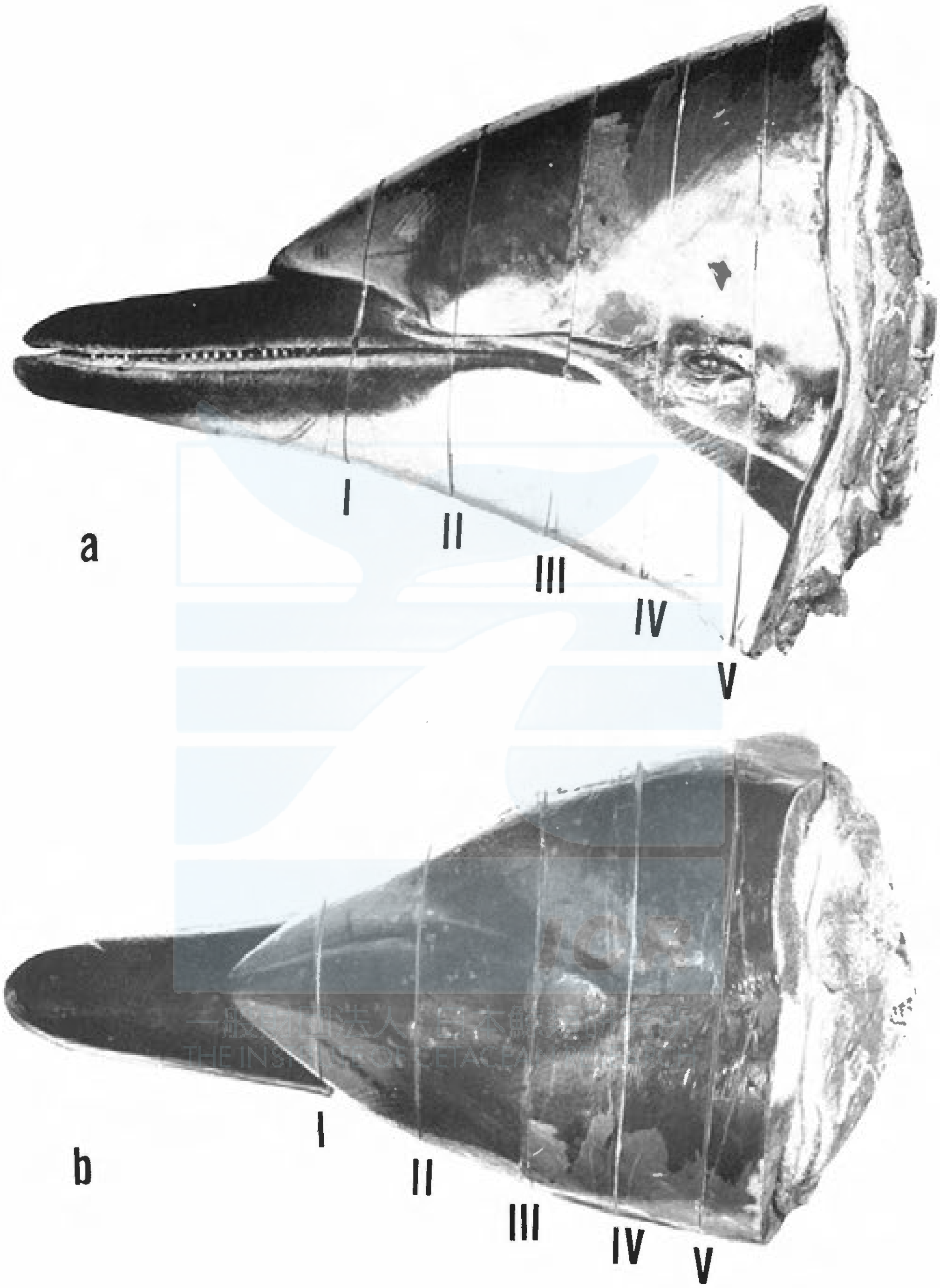

Fig. 1. Guide lines to show the sites of sections. a—lateral view, b—dorsal view.

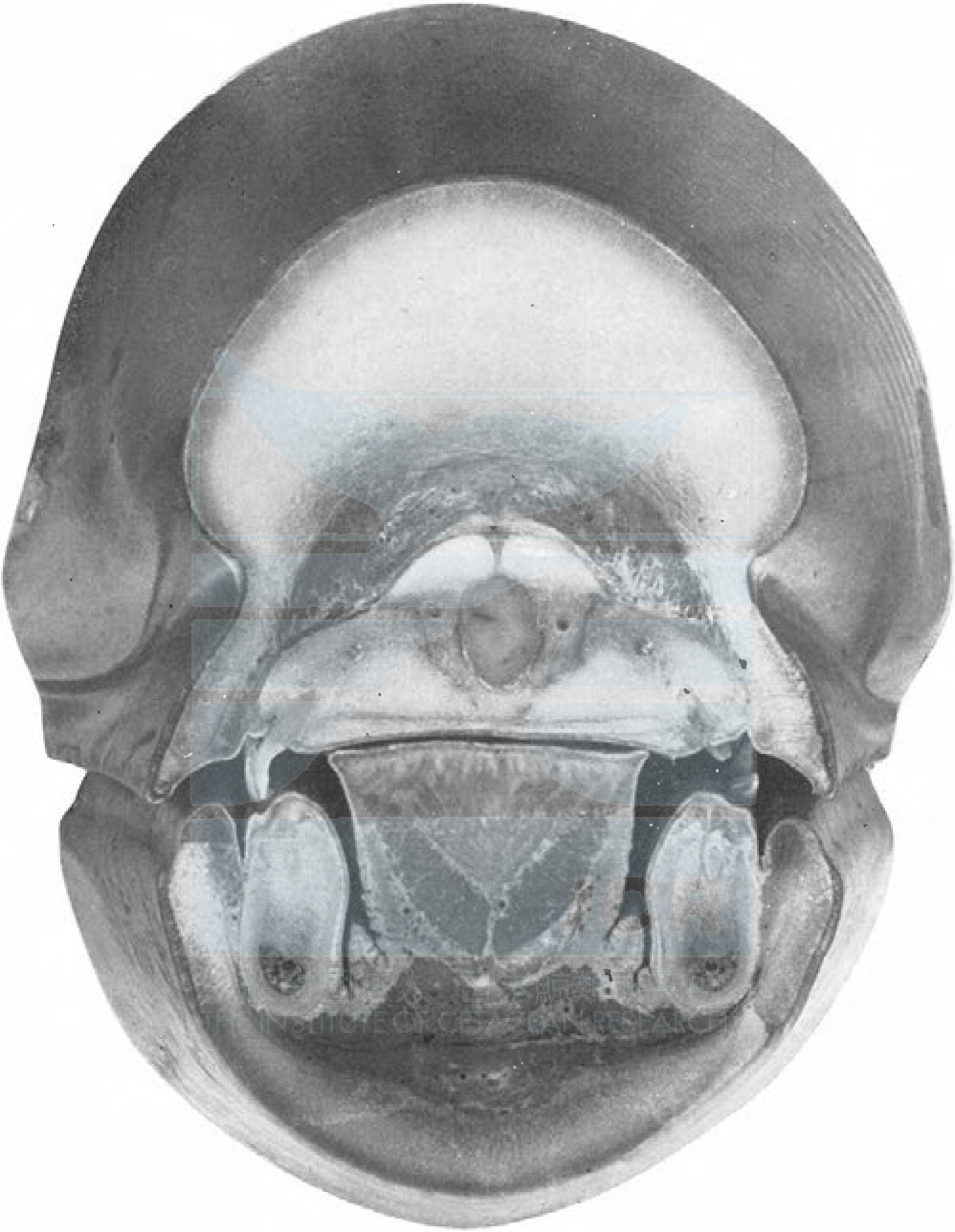

Fig. 2-a. Section I.

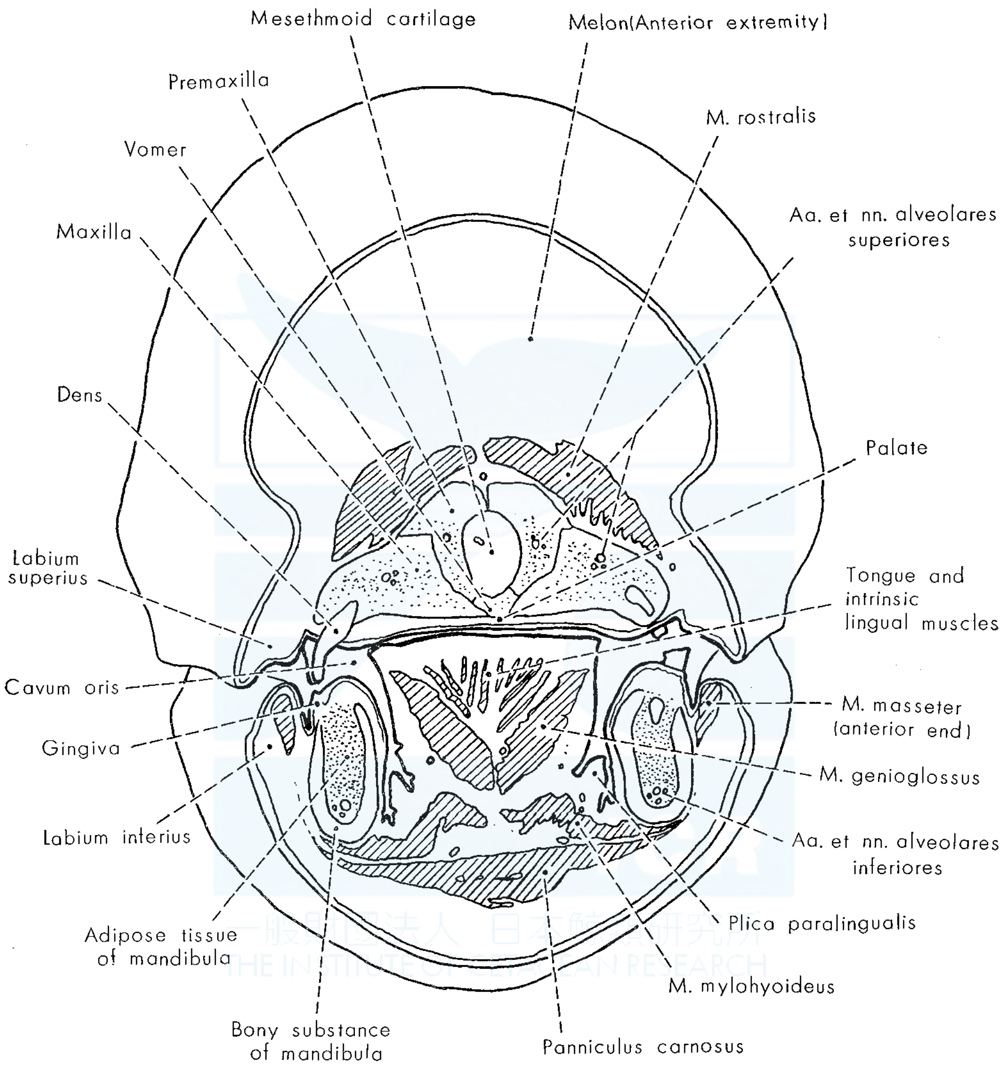

Fig. 2-b. Section I.

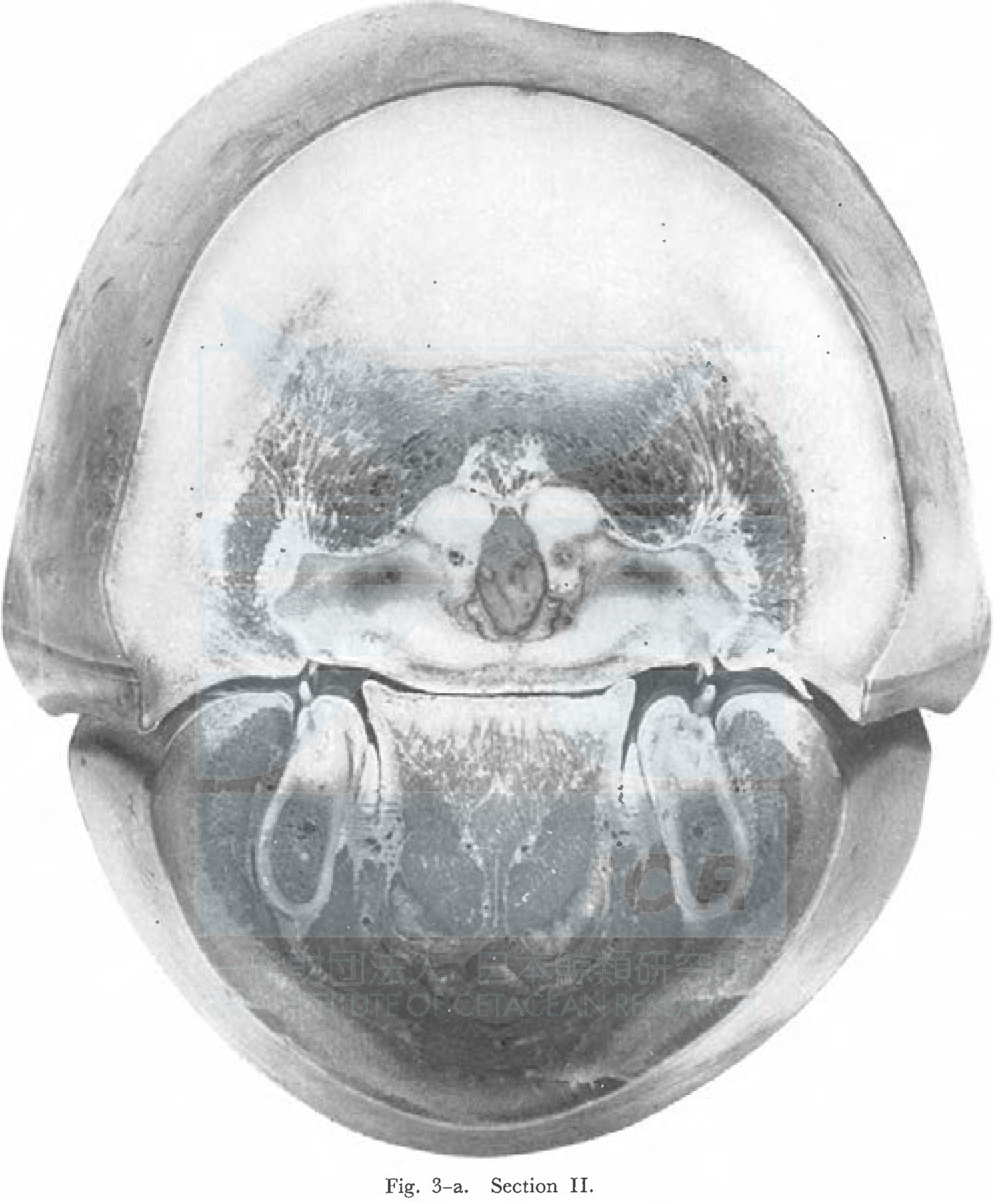

Fig. 3-a. Section II.

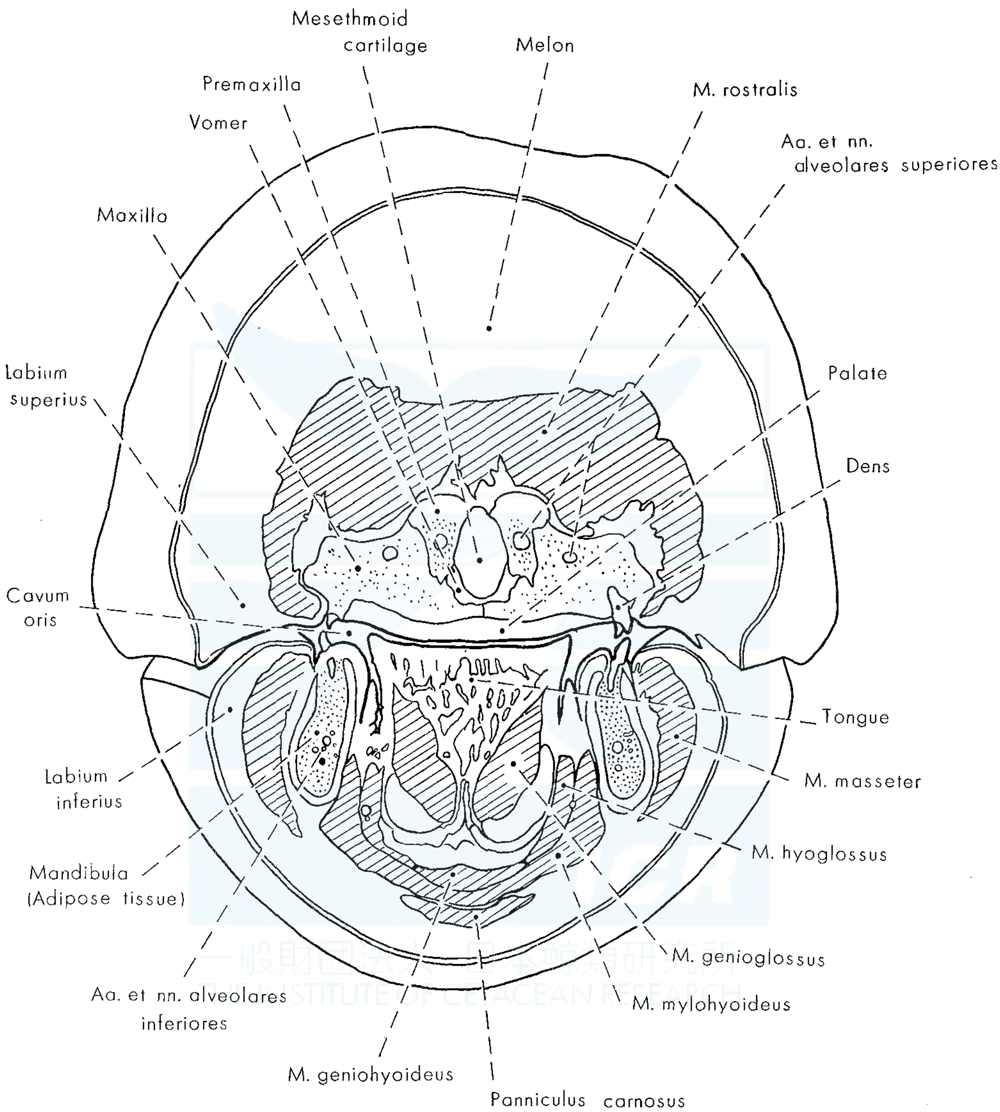

Fig. 3-b. Section II.

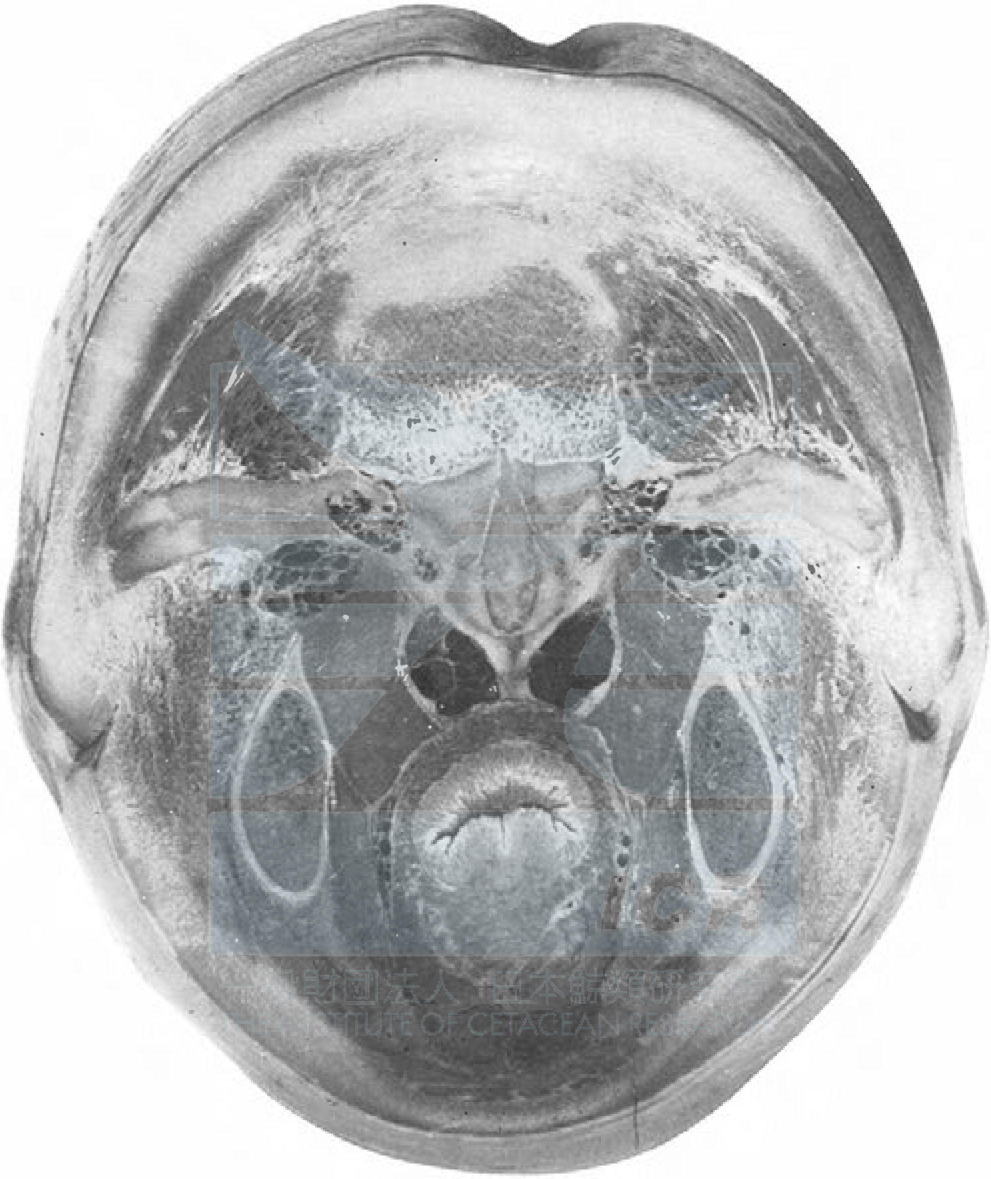

Fig. 4-a. Section III.

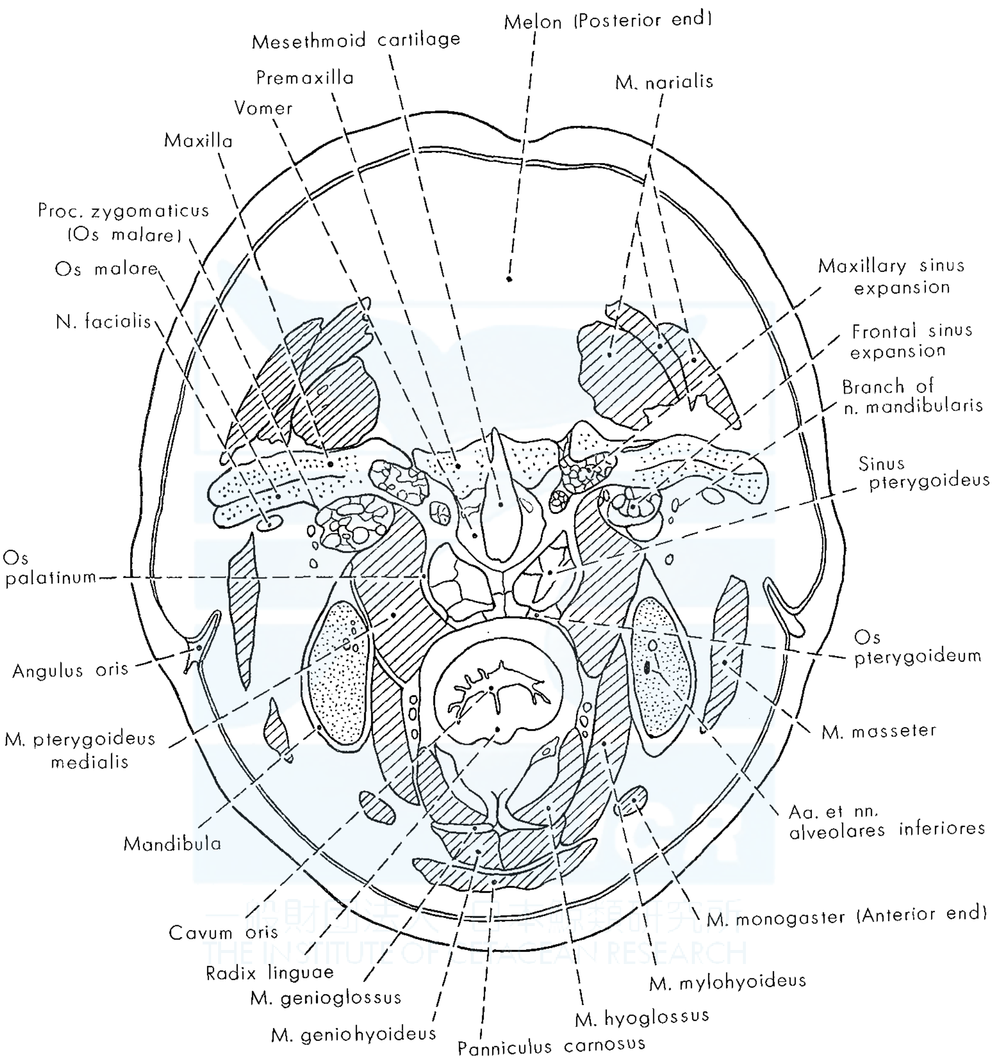

Fig. 4-b. Section III.

Fig. 5–a. Section IV.

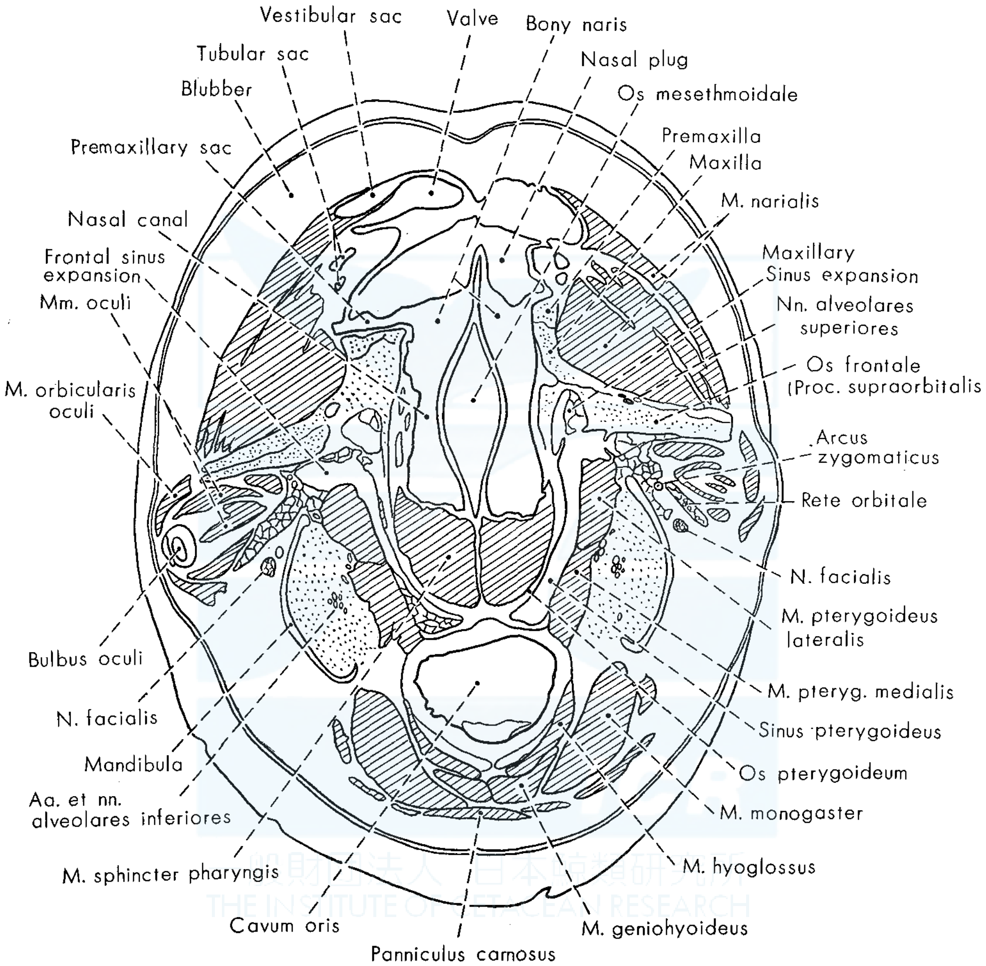

Fig. 5-b. Section IV.

Fig. 6-a. Section V.

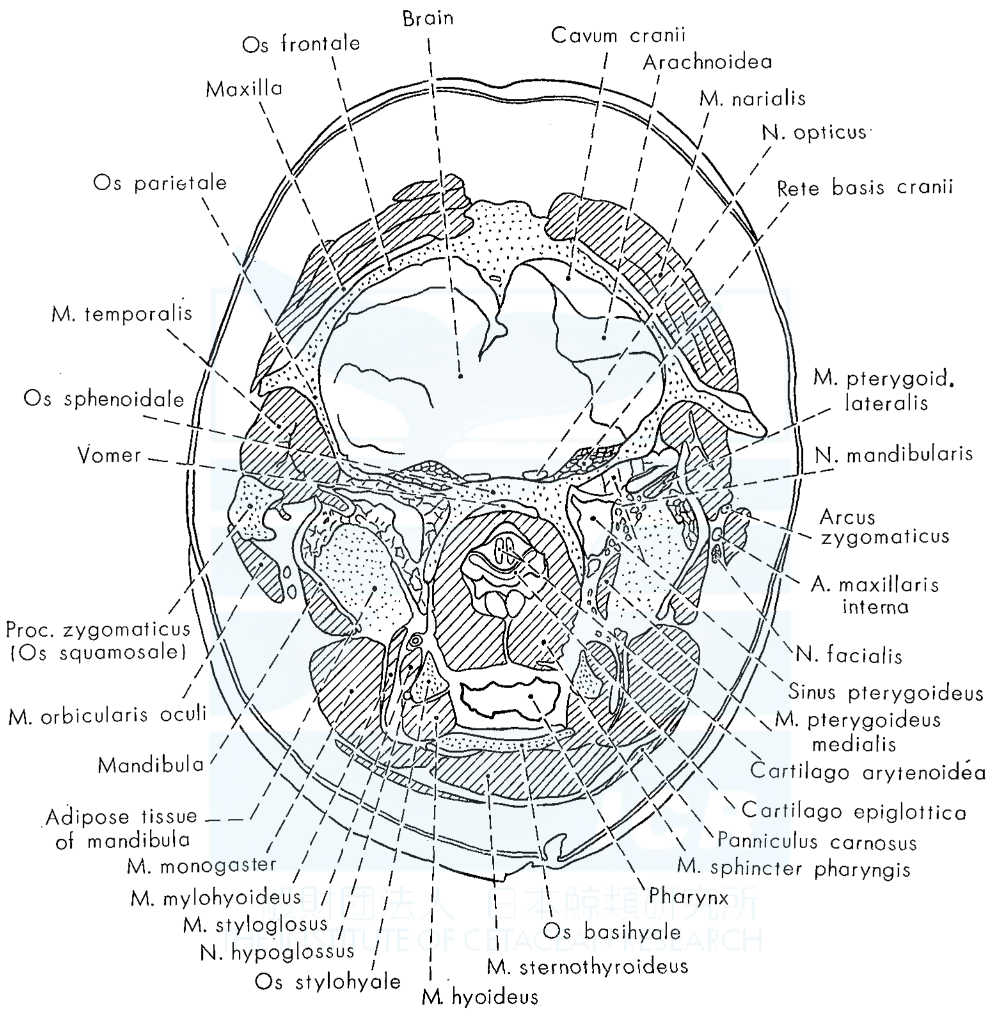

Fig. 6-b. Section V.

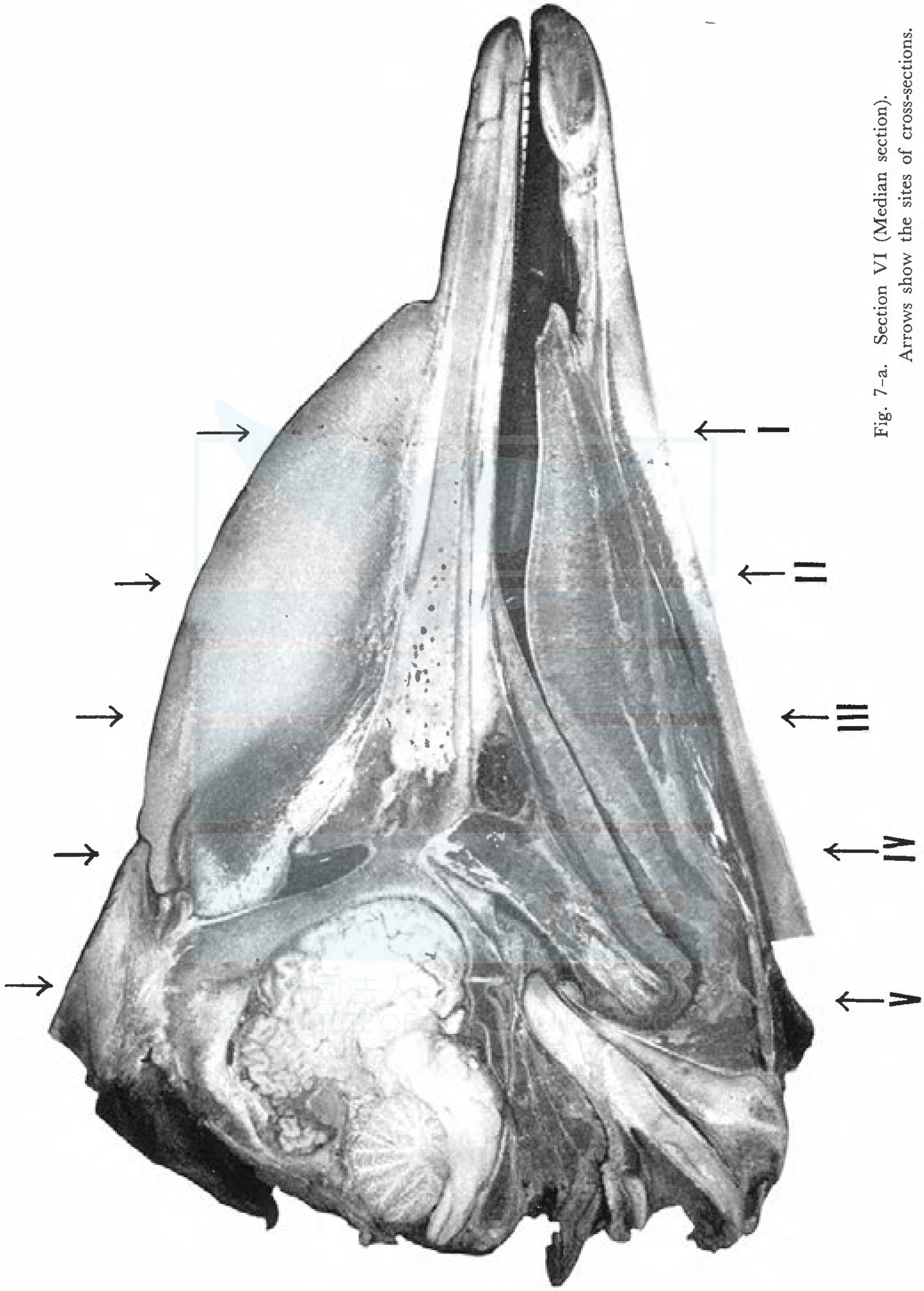

Fig. 7-a. Section VI (Median section).
Arrows show the sites of cross-sections.

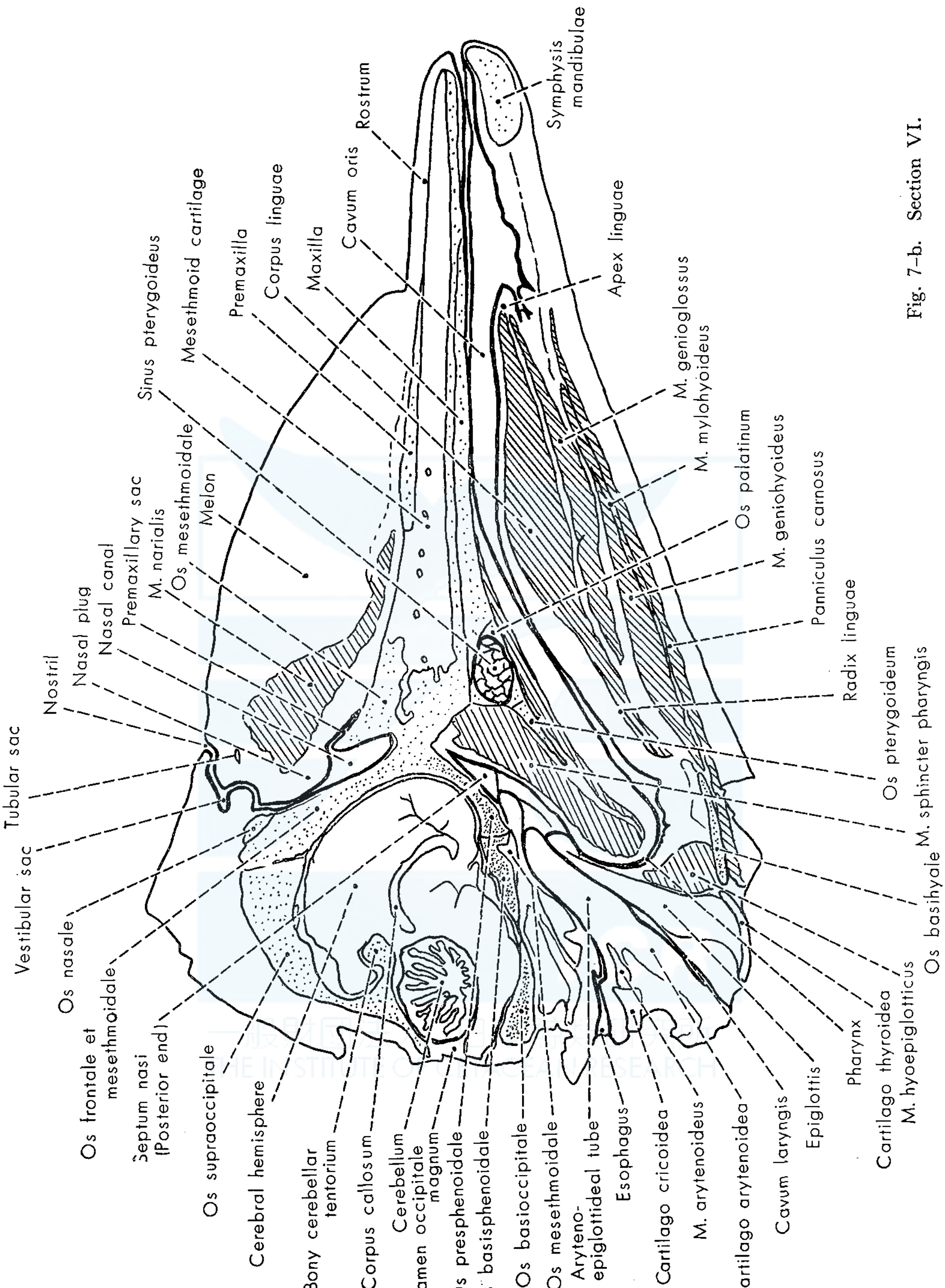

Fig. 7–b. Section VI.

Fig. 8–a. Section VII (Paramedian section).

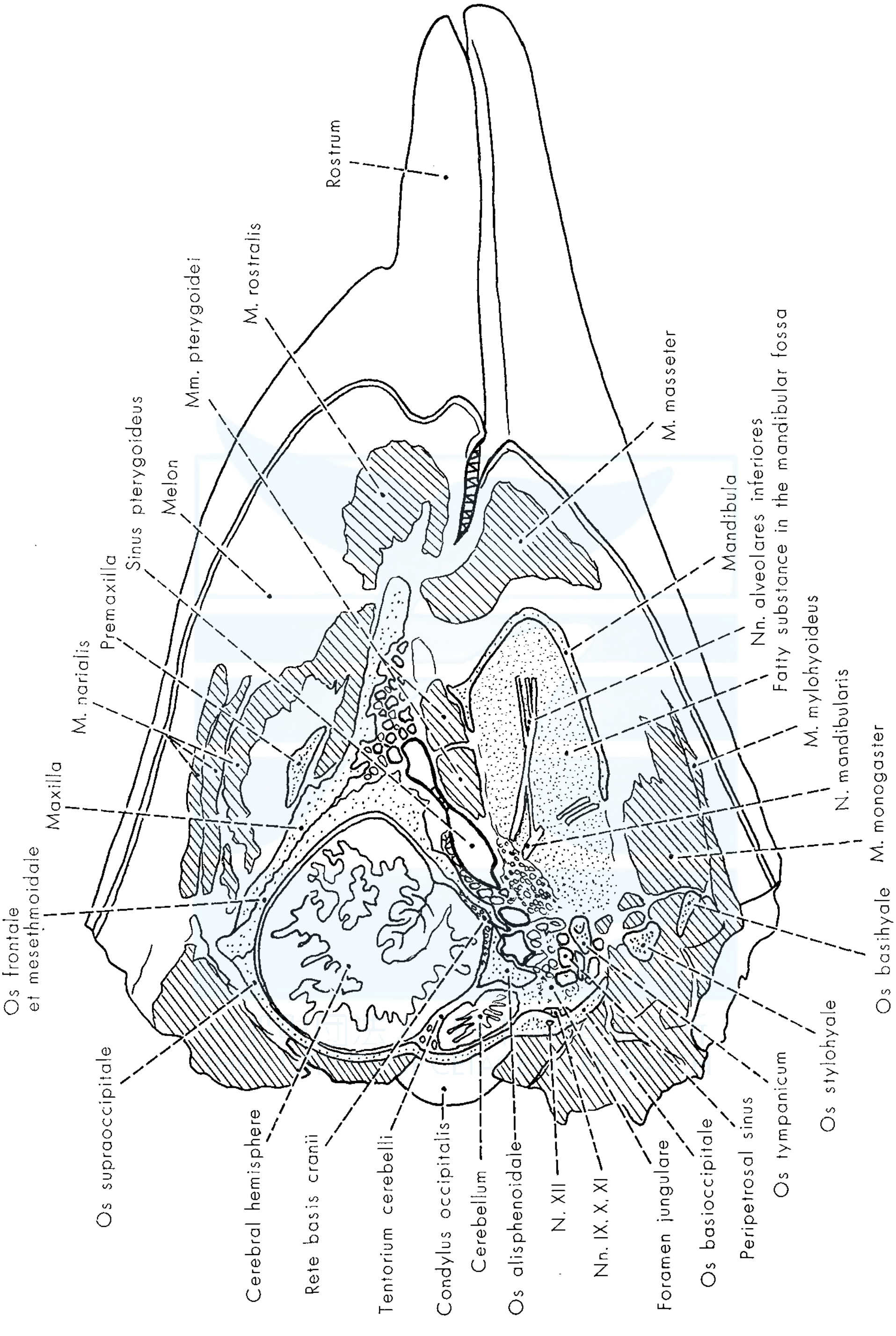

Fig. 8-b. Section VII.

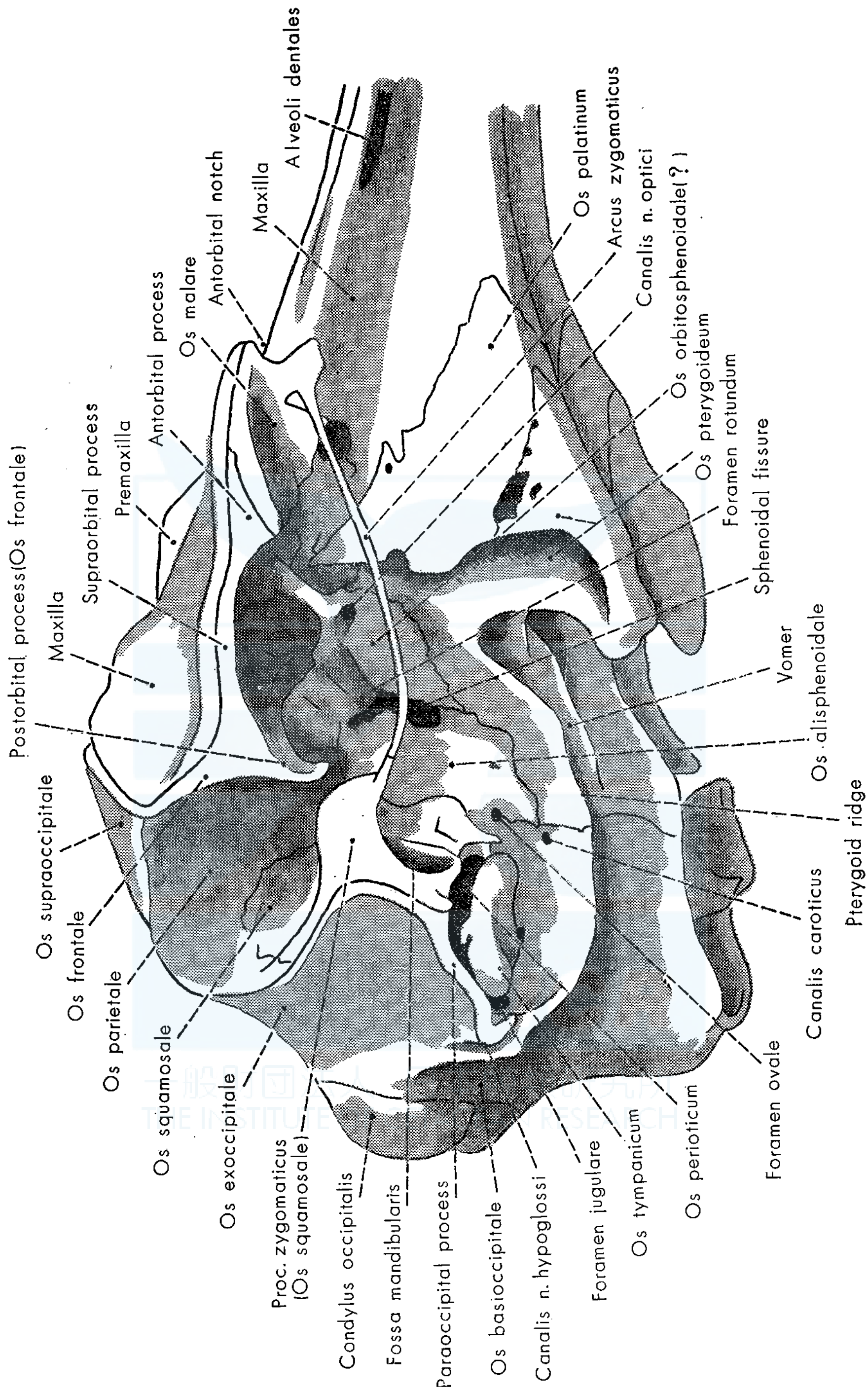

Fig. 9. Skull of the Stenella. Seen from right and below.

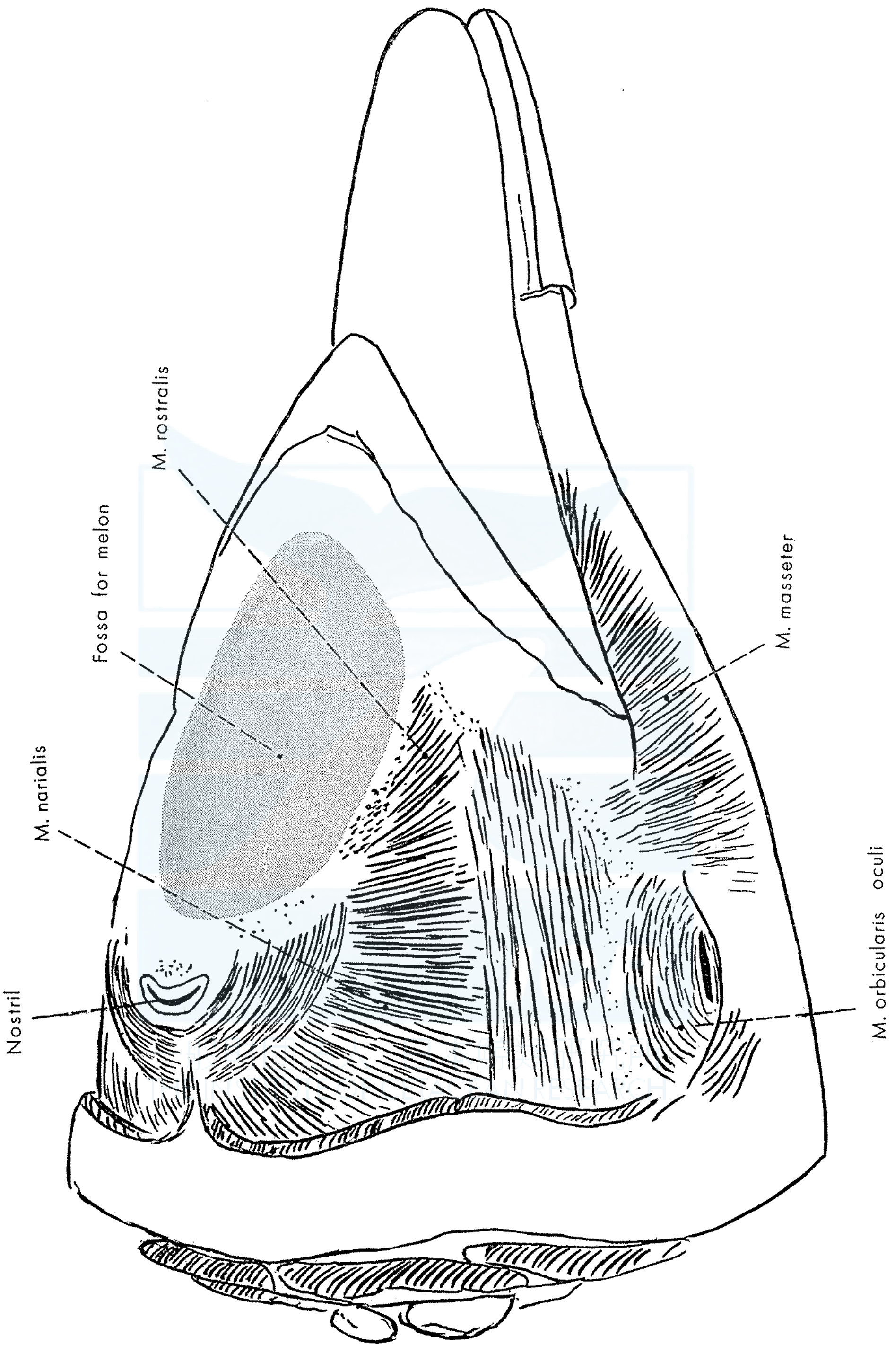

Fig. 10. Muscles (1).

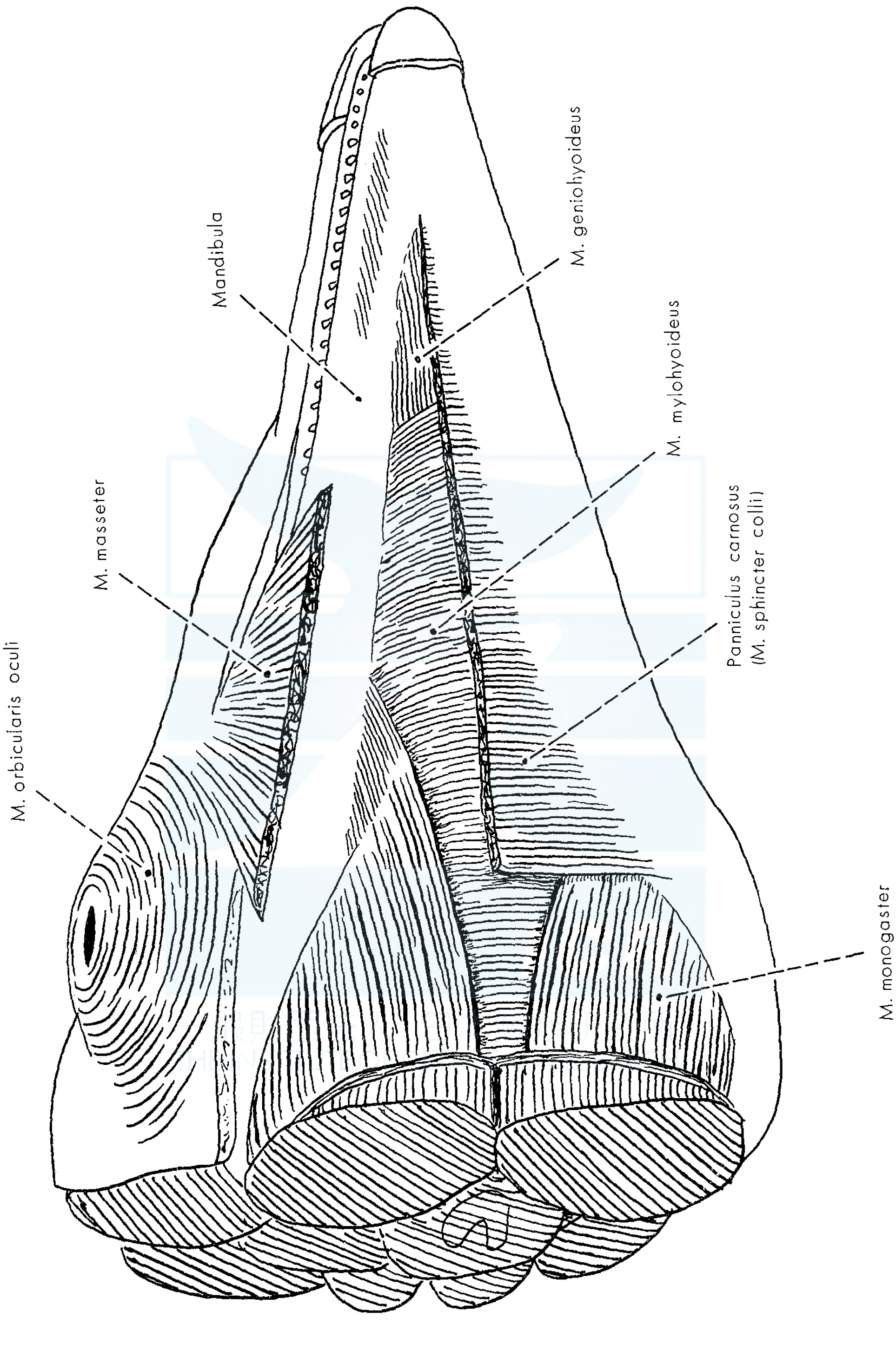

Fig. 11. Muscles (2).

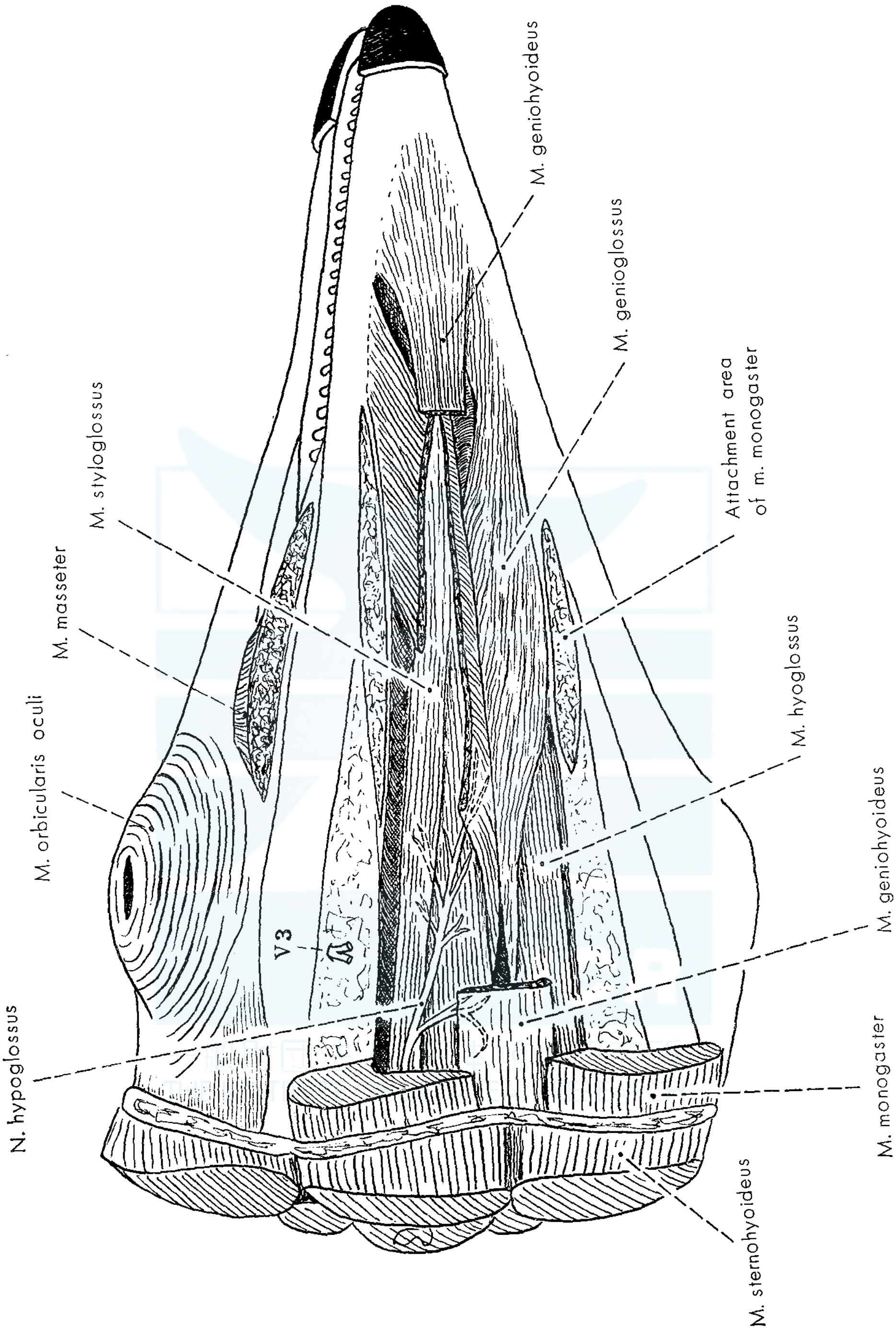

Fig. 12. Muscles (3).

Fig. 13. Peripheral distribution of n. maxillaris (V_2), n. mandibularis (V_3) and n. facialis (VII).

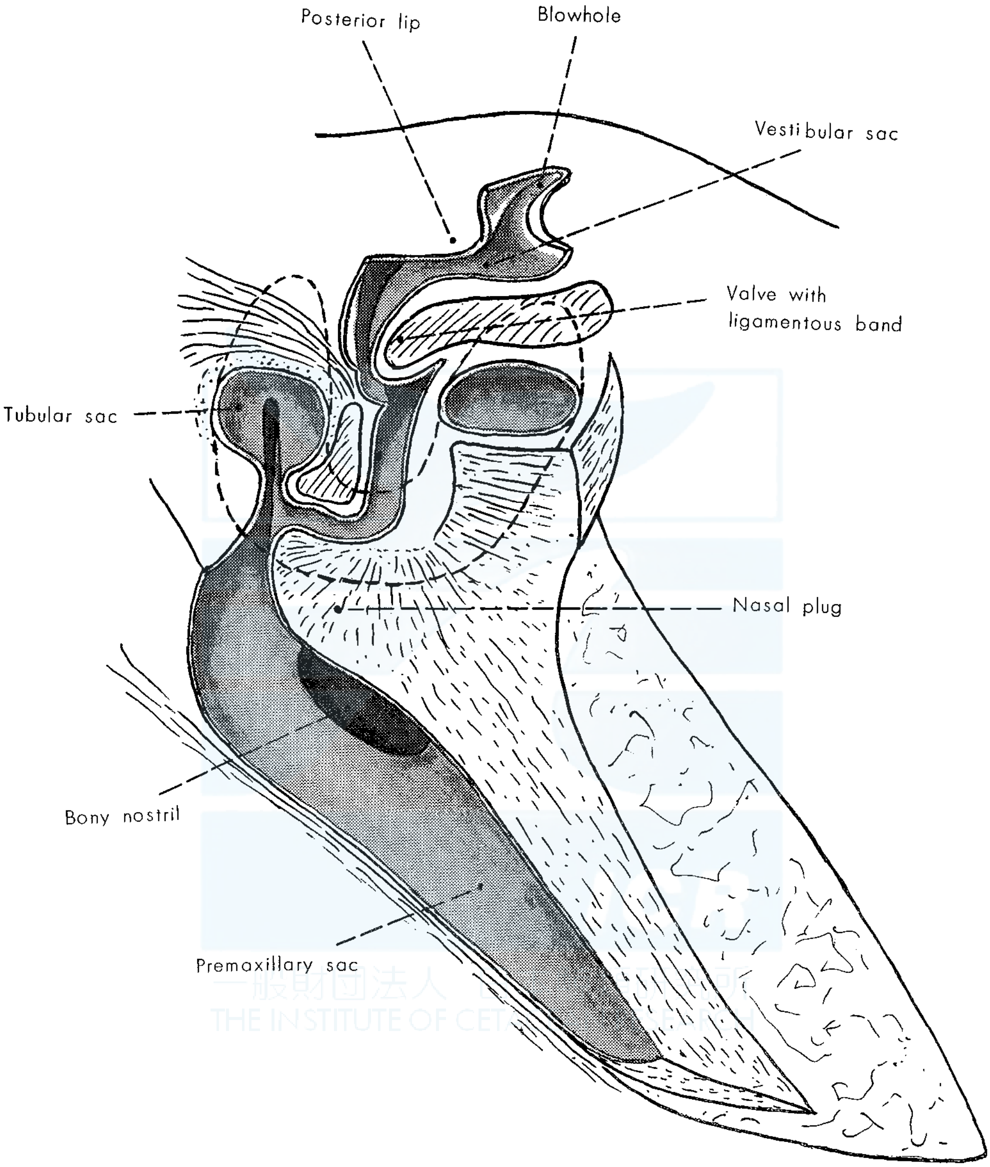

Fig. 14. Nasal passage.

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A DOLPHIN *(STENELLA CAERULEOALBA)* WITH PROTRUDED RUDIMENTARY HIND LIMBS

SEIJI OHSUMI

On December 16 in 1963, a herd of about 450 blue white dolphins (*Stenella caeruleoalba*) was caught by fishermen at Kawana Beach in the eastern coast of Izu Peninsula, Japan. In the course of biological investigation on the herd, I found an individual with protruded rudimentary hind limbs.

Dr. Nishiwaki and his group have investigated this species of dolphin on about ten thousand individuals, but it is the first time for us to find such an individual.

On the protruded rudimentary hind limbs in the postnatal cetacea, there have been reported for one humpback whale (*Megaptera novaeangliae;* Andrews, 1921) and sperm whales (*Physeter catodon;* Ogawa & Kamiya, 1957; Nemoto, 1963). Slijper (1958) reviewed two similar records on a dolphin and a pilot whale.

Ogawa (1953) reported on the presence of the hind limbs in the embryos of the blue white dolphin. And he described that 14 mm long embryo had easily observable hind limbs, keeping pace with becoming smaller of hind limbs protrusion, in 25 mm long embryo the elevation of the flukes made appearance and in larger embryos, there remained no trace of hind limbs elevation at all.

Present individual is a male, and is 230 cm long. Body proportions are shown in Table 1. The proportions are not so different from the normal ones except only one part. The distance between anus and reproductive opening in this dolphin is shorter than the usual. Body colour and pattern of the individual is not different from normal individuals except the haunch portion. As shown in Plates I and II, the margin of pigmentation at anus is different with the normal. The margin of the insertion of the protruded hind limbs is white, and the hind limbs are black. Furthermore, one clear black line is seen along the margin of pigmentation in the ventral portion of each side. In general, there is abnormality in the haunch portion.

Weight of testes is 31.0 gr. in the left side and 29.8 gr. in the right side. In vas deferens fluid were observed many mature sperms. Then this individual is desided to be sexually mature.

Rudimentary hind limbs are protruded on either side of just the mammary slit. Distance between the both tops of limbs is 101 mm. The distance between both anterior margins is shorter than that between the posterior margins. Protruded limbs are ellipsoid. Base of the limbs are oval. The minor axis of the left and right limbs is 22 and 23 mm respectively, and the major axis of the left and right limbs is 28 and 33 mm respectively. The height is 10 and 13 mm in the left and right limbs respectively.

This specimen was preserved in the Department of Anatomy, School of Medicine, University of Tokyo, and anatomical study will be made on the internal structure of the rudimental limbs in the University.

I am much indepted to Dr. T. Kamiya of the Department of Anatomy, Univer-

TABLE 1. MEASUREMENT OF BODY PROPORTIONS FOR THE PRESENT SPECIMEN AND THE NORMAL SPECIMENS IN THE BLUE WHITE DOLPHIN

Items	Present (cm)	Normal (cm)*
Total length	230.0	221–239
Length of snout	12.0	10.5–12.0
Tip of snout to blow hole	32.0	29.0–36.5
,, angle of gape	27.5	25.0–27.5
,, center of eye	34.5	28.0–36.0
,, anterior margin of flipper	49.0	44.0–51.0
Notch of flukes to posterior margin of fin	106.0	96.0–106.5
Length of insertion of flukes	17.0	14.5–17.0
Notch of flukes to anus	70.0	61.0–69.0
,, to umbilicus	129.0	113.0–130.0
Anus to reproductive opening	13.5	15.0–21.0
Flipper, anterior margin to tip	32.0	29.0–31.5
,, broadest width	11.0	9.5–11.0
Fin, length of base	32.0	27.0–35.0
,, height	19.5	19.0–23.0
Flukes, total width	56.5	48.0–59.0

* from 6 specimens (males), body lengths ranged between 221 and 239 cm.

sity of Tokyo, who kindly took photographs of the specimen and gave me some measurements. And I also due to Dr. M. Nishiwaki of the Whales Research Institute to give me the chance to find the present specimen.

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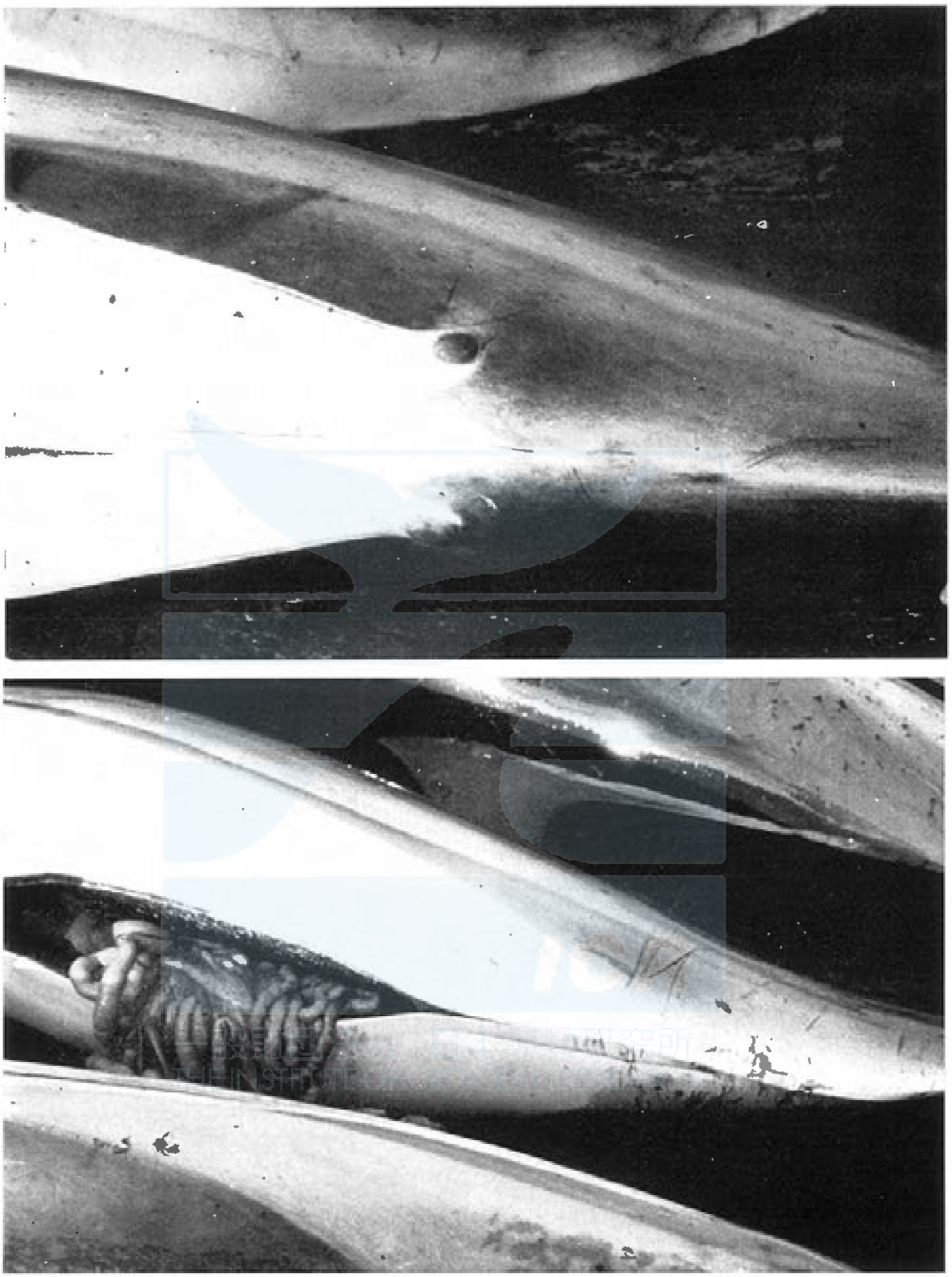
PLATE I

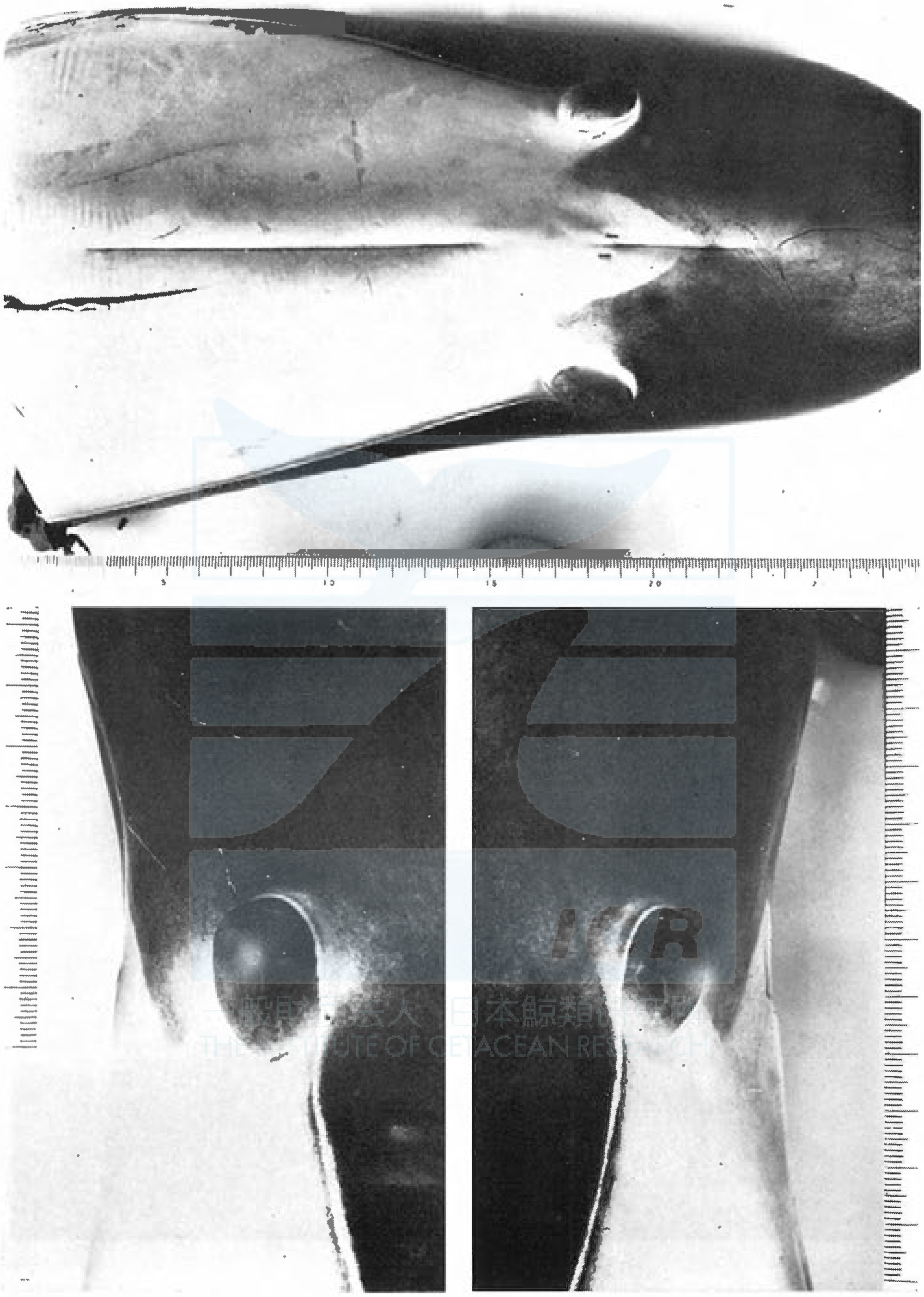
Upper: A blue white dolphin with protruded rudimentary hind limbs. Ventral view.
Lower: A normal male blue white dolpin. Ventral view.

PLATE II

(Photographed by Dr. T. Kamiya)

Upper: Ventral view of the protruded rudimentary hind limbs.
Lower, left: Sidal view of the left hind limb.
Lower, right: Sidal view of the right hind limb.





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