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CONTENTS OF NUMBER 24


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

AN OSTEOLOGICAL STUDY OF THE CUVIER'S BEAKED WHALE, *ZIPHIUS CAVIROSTRIS*, IN THE NORTHWEST PACIFIC

HIDEO OMURA

ABSTRACT

Skulls and postcranial skeletons of *Ziphius cavirostris* were studied for eleven specimens, mostly stranded on the sandy beach of Japan. Some distinctions between the adult male and female and/or juvenile are noted in the skull measurements. The fusiform tooth and the massive mesorostral bone with posterior truncation in the male will be completed after the attainment of the physical maturity. The total number of the vertebrae is 46–47, and not differs from that of the other oceans. The proportional development of bones of skull as well as the vertebrae according to the growth of whale body is also studied in some extent.

INTRODUCTION

The Cuvier's beaked whale or the goose-beaked whale, *Ziphius cavirostris*, distributes in all temperate and tropical seas (Rice and Scheffer, 1968). In the North Pacific, strandings of this species were reported from the coast of western North America by various authors (for example Hubbs, 1946) and these are well summarized and studied of its seasonality by Mitchell (1968), which contains records of 41 strandings. These strandings range between Alaska and the tip of Baja California. From the Central Pacific also strandings were reported from Hawaii (Richards, 1952) and Midway Islands (Galbreath, 1963).

In the northwest Pacific two large skulls were found on the coast of Kamchatka in 1951 (Tomilin, 1957). The only place where this whale is regularly hunted is on the coast of Japan (Backus and Schevill, 1961), but as yet no comprehensive study has been published (Mitchell and Houck, 1967). Hitherto only two papers were published (Ogawa, 1936–37; Omura *et al.* 1955).

Strandings of *Ziphius cavirostris* are not uncommon also on the coast of Japan. These are reported in local newspaper articles, and when the strandings had occured near to Tokyo the staff of the Whales Research Institute have endeavored to collect samples of these animals. Thus from 10 individuals skulls and sometimes with post-cranial skeletons have been collected. Once someone of the institute made a study of these bones, but he could not finish it before he moved to the other research laboratory where he is not able to continue the study of this kind.

I have investigated the material again, stimulated by the situation mentioned above, and they are now reported in this paper. To my regret the data on the exact time, place, body length, sex, and other particulars of the animals are missing, but if I

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correctly remember most of them had stranded on the sandy beach of Sagami Bay at different times and not in mass. One animal which stranded on the coast of Tokyo Bay is also included. In any case all of them were collected from several places near to Tokyo.

Buckus and Schevill (1961) write "Japanese whalers and cetologists seem not yet to have recorded their observations of the living animal—a thing we may all look forward to." On this problem I am not able to contribute anything in this paper yet.

MATERIAL

The skeletons used in this study are as follows:

ZC2. Very young specimen. Skull, right mandible, vertebrae, scapulae, 12 pairs of chevron bones, a pair of pelvic bones, fragments of ribs, a part of sternum are preserved.

ZC11. Juvenile specimen. All bones except those of the flippers and pelvic bone are preserved.

ZC12. Adult but suspicious of its sex. Nearly all bones are preserved as in the case of ZC11, but each rib was cut into several pieces by saw, possibly just after the stranding by spectators.

ZC6. Only skull and mandibles are preserved.

ZC3. Possively young adult female. Nearly all bones are preserved as in the case of ZC11.

ZC7. Juvenile specimen. Nearly all bones are preserved as in the case of ZC11, but each rib was cut into several pieces by saw.

ZC4. Only skull, mandibles, ribs and stermum are preserved.

ZC8. Possibly adult male. Only skull and mandibles are preserved.

ZC1. Possibly adult female. Nearly all bones are preserved as in the case of ZC11.

ZC10. Possibly adult female. Nearly all bones are preserved as in the case of ZC11.

TWM1. Adult male. Skull and mandibles. This specimen does not belong to our collection. This whale was taken off Taiji on some day and the skull is being kept at the Taiji Whale Museum.

SKULL

Diagnosis. According to Moore (1968) the diagnostic characters of the skull of *Ziphius* are as follows:

1. Where the premaxillary bones ascend posteriorly on either side of the superior nares and terminate, their anterior faces are oriented mesially a small but obvious amount from directly forward.
2. The combined breadth of the nasal bones is greatest anteriorly and where the right nasal is out on contact with the right premaxillary bone.
3. When the skull is upright and the long axis of the beak is horizontal, in

lateral view the nasal bones both project somewhat farther anteriorly from the synvertex of the skull than do the up-curled posterior ends of the premaxillary bones.

Further, in his key to the living genera of the beaked whales by characters of the skull he separates *Ziphius* from *Berardius* in the character that when the posterior aspect of the skull is viewed from a point aligned with the long axis of the rostrum, and from a distance of at least two meters, in the former the synvertex of it is completely occuluded by the supraoccipital, or so little of the synvertex shows that the profiles of both descending sides are not seen to become sheer, whereas in the latter the profile of the synvertex projects above the supraoccipital as a slightly asymmetrical block with sheer sides.

The eleven slulls of *Ziphius* I examined are all in agreement with the above descriptions (Plates I-V).

Adulthood and sex. As already stated the data on sex and body length of the specimens are lacking. But in *Ziphius* the adult male can be distinguished from the adult female and juvenile by the presence of the prenarial basin, prominent mesorostral bone, and by the size and eruption from the gum of the tooth (True, 1910; Fraser, 1942; Moore, 1968). Further, it is common practice among mammalogists to regard a mammal as morphologically adult when the epiphyses have become so fused to the centrum of each of the vertebrae that their sutures are obliterated (Moore, 1968). Using these criteria I have tried to determine the adulthood and sex of the specimens. In the following the specimens are arranged in the order of their skull length.

ZC2. (Pl. I, Fig. 1) The skull length is 590 mm and evidently from a young animal. Bones of the skull articulated each other very loosely and the sutures between them are open. Mesorostral ossification is not developed at all and no prenarial basin present. This specimen has 47 vertebrae and none of the epiphyses has become fused to its centrum. Further, from 7th up to and including 15th vertebra, the bones consisted of the spinous and transverse processes are not united to the bodies of the centra. In 5th, 6th, 16th, and 17th vertebra they are united to their centra, but sutures are still visible. Sex is not known.

ZC11. (Pl. I, Fig. 2; Pl. III, Fig. 1) The skull length is 707 mm and also evidently from a juvenile animal. In this specimen too the mesorostral ossification is undeveloped and no prenarial basin is present. The sutures of the each bone of the skull are visible. It has 46 vertebrae and none of the epiphyses is united to its centrum.

ZC12. (Pl. I, Fig. 3; Pl. III, Fig. 3) The skull length is 811 mm and it looks like to be from an adult male, because there present the prenarial basin distinctly as shown in Pl I, Fig. 3. The mesorostral bone is developed, but it does not rise beyond the level of the premaxillaries. It begins about 10 cm from the tip of the rostrum as a narrow ridge, and it increases its height and width towards the middle of the rostrum, and then depressed gradually, and not abruptly, to the prenarial basin. At the middle part of the beak the width of the ridge is about 18 mm and about 10 mm below the level of the premaxillaries.

Fraser (1942) reports a case that the mesorostral is prominently developed with the skeleton of young animal, and with the widely open pulp cavity of the teeth (young male, Unionhall, 1913. 2. 11. 1.). In the specimen ZC12 the mesorostral is developed in much lesser degree than in this specimen, but it is from an adult animal, because all of the epiphyses of the 47 vertebrae are so entirely fused to their centra that the sutures are obliterated. Further the teeth of this specimen exhibit a typical feature of an adult female. Their roots are completely closed and the shape is cylindrical and not fusiform (Fig. 1). The greatest diameter is only 11 mm in the both teeth, as shown in Table 3.

The above mentioned characters of this specimen suggest that this is an adult female, but a question to this conclusion is the presence of the distinct prenarial basin. True (1910) describes " in those specimens in which the sex is known to be female, or is marked as such, the premaxillae are comparatively narrow ". Further Harmer (1927) notes " in the male the outer border of the expanded parts of each premaxilla is raised far above the inner border, so that the part in question slopes down steeply into the prenarial basin ". The measurements of the skull are shown in Table 1 and in Fig. 3. This specimen has comparatively wider premaxillae than in the other specimens which are thought to be female or juvenile. Harmer's description is thought to be applied also to this specimen. Further, in this specimen the shape of the inner border of the right premaxillary is different from the other specimens. Its width at the position of the premaxillary foramen is narrow, but posterior to that it gains abruptly its width and the inner margin directs transversely, and lies at nearly the posterior margin of the prenarial basin.

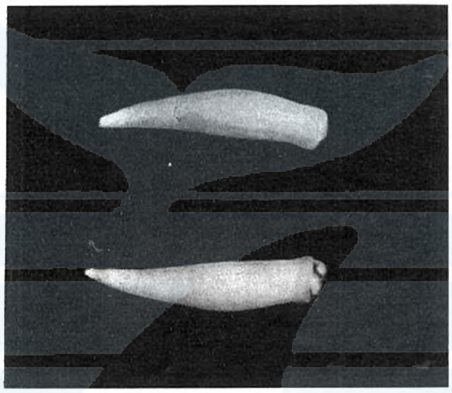


Fig. 1. Teeth of the specimen ZC 12.

As regards to the teeth some more mention is needed. They are slender and cylindrical in shape. Their tips are pointing, but in close observation the tip of the left tooth exibit a very slight wear, and the right tooth has a fractured tip (Fig. 1). According to the working hypotheses adopted by Moore (1968) of the criterion of adulthood and sex of the Hyperoodontidae (Ziphiidae) 1) Teeth with filled or virtually filled pulp cavities provide a criterion of adulthood. 2) Teeth exhibiting natural wear as evidence of having erupted in life a criterion of male sex. 3) Teeth exhibiting no such wear but with pulp cavities completely or virtually filled are a criterion of female sex. A slight wear or fracture of the teeth in the specimen ZC12 are not sure that these are caused by natural or by damage during or after the maceration. If these are caused by natural wear this specimen is possibly from an adult male, notwithstanding of their slender shape. It resembles to the specimen reported by Fraser (" Young adult " male, Garrynamonie, South Uist, 1935. 4. 18.1), in which one of the teeth has a fractured tip but the other is complete, and the greatest diameter of these teeth are 15 and 14 mm respectively. As to the mesorostral he states " The mesorostral is well developed . . . , but in the region where, in the typical old male, the mesorostral is suddenly depressed, that of the South Uist specimen dips down in a gradual slope to the floor of the prenarial basin ". In this respect too the specimen ZC12 resembles to the South Uist specimen, as stated already. I assumed this specimen to be an adult male in the later analysis of the skull proportions.

Another one feature of some interest of this specimen is the unusual development of some of the vertebrae. The posterior part of the 17th vertebra (1st lumbar) and the anterior part of the 18th vertebra (2nd lumbar) are irregularly developed and at center of the vertebral body there present an irregular pit (Fig. 2). Such abnormality is also found between 29th vertebra (2nd caudal) and 30th vertebra (3rd caudal). These are possibly due to some pathological cause, but it is not certain that these abnormality had any effect to the growth of the skull and the teeth.

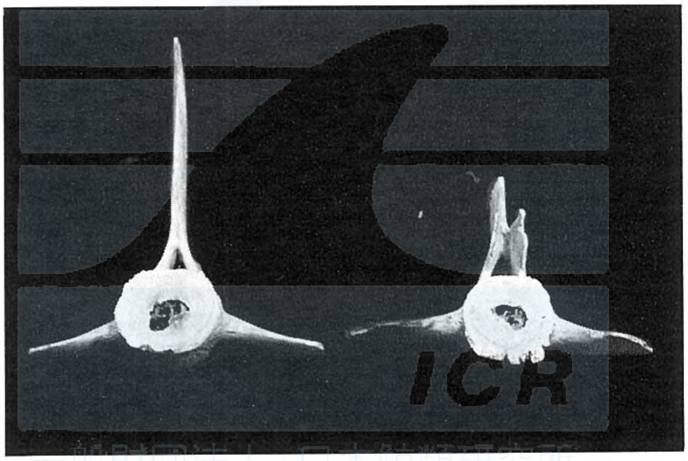


Fig. 2. 17th and 18th vertebrae of the Specimen ZC 12.
Left: Posterior view of the 17th vertebra.
Right: Anterior view of the 18th vertebra (spinous process partly broken).

ZC6. (Pl. I, Fig. 4; Pl. IV, Fig. 1) The skull is larger than the foregoing specimen and measures 819 mm in length, but it seems to be from a younger animal. The sutures between bones of the skull are visible. The mesorostral bone is undeveloped and the canal is empty. The prenarial basin is undeveloped. All of the vertebrae and teeth are lacking, but presumably from a juvenile animal.

ZC3. (Pl. III, Fig. 4; Pl. IV, Fig. 3) The skull length is 823 mm. The mesorostral bone is developed, but its superior face is below the level of premaxillaries by about 5 mm towards the middle part of the rostrum, and then depressed gradually and finally ends just after the region where, in the premaxillaries, the foramina are situated. It is separated from the anterior end of the bony ethmoid, the vertical face of which is tuberculated, and rests on the vomer. The sutures between premaxillaries and the maxillaries are visible in most parts. No prenarial basin is developed.

This specimen has 46 vertebrae and all of the epiphyses are fused to their centra, but in the dorsal vertebrae sutures are still visible, especially in the posterior part of each vertebra. It is possible that this specimen is of an adult, at least semi-adult, female, though the teeth are lacking. The length and the breadth of the mandibular alveoli are 17 and 12 mm in the right and 18 and 12 mm in the left.

ZC7. (Pl. II, Fig. 1; Pl. III, Fig. 2) The skull length is 826 mm. There is a low ridge which runs antero-posteriorly on the superior surface of the vomer, which begins about 4 cm posterior from the tip of the vomer and ends after the level of the premaxillary foramina. The prenarial basin is undeveloped and the premaxillaries, maxillaries, and the vomer articulate loosely. The anterior end of the bony ethmoid rests on the flattened part of the vomer.

This specimen has 47 vertebrae and the epiphyses are not fused to their centra, but separated, except a few vertebrae in the cervical and caudal vertebrae. Accordingly, it is possible that this specimen came from a juvenile animal.

TWM1. (Pl. V, Figs. 1 and 2) The skull is 837 mm in length and evidently from an adult male. The mesorostral bone is developed conspicuously and its superior surface rises over the level of the premaxillaries. It extends from the tip of the beak posteriorly and at a point, 92 mm from the tip, it is truncated abruptly. At this point the bone is 55 mm wide and 50 mm thick. On either sides of the middle part of the mesorostral there are a groove of about 3 cm deep which separates it from the ridge of the premaxillaries. The prenarial basin is also developed conspicuously and the skull itself is well ossified.

The teeth are massive, and fusiform in shape. Their measurements are given in Table 3.

ZC4. (Pl. II, Fig. 2) The skull is 844 mm in length and not well ossified. The mesorostral is undeveloped and the canal is empty. The prenarial basin is undeveloped and the right premaxillary is nearly flat at this region. The beak is slender, and it seems that the specimen is of a female. None of the vertebrae and teeth has been preserved.

ZC8. (Pl. IV, Fig. 2; Pl. VII, Fig. 2) The skull is 886 mm in length and rather heavy. Most of the sutures of the articulating bones are visible, but that of the vomer and premaxillaries is not clear. The mesorostral bone is developed as a ridge of about 5 mm width. It begins at the tip of the vomer or about 10 cm posterior to the tip of the beak and ends at just after the line connecting the premaxillary foramina, and then depressed. The superior face of the mesorostral is about 5 mm below the level of the premaxillaries. The inner part of the right and left premaxillaries are steeply depressed at the prenarial portion and forms the basin, together with the depressed part of the mesorostral. The teeth are lacking, but the alveoli of the both mandibular teeth are large, and measures about 20 mm width and 28 mm

TABLE 1. SKULL MEASUREMENTS OF *ZIPHIUS CAVIROSTRIS* IN NORTHWEST PACIFIC. (in mm)

Measurement no.	ZC 2 juv.	ZC 11 juv.	ZC 12 ad. ♂	ZC 6 juv.	ZC 3 ad. ♀	ZC 7 juv.	TWM 1 ad. ♂	ZC 4 ♀	ZC 8 ad. ♂	ZC 1 ad. ♀	ZC10 ad. ♀
1	590	707	811	819	823	826	837	844	886	891	921
2	313	386	460	472	459	487	475	489	499	503	517
3	413	514	581+	616	630+	637	651	636	659	661	728
4	444	555	611+	667	630+	676	687	675	694	695	764
5	272	345	390	394	415	400	413	399	425	435	470
6	283	368	440	429	427	456	438	467	469	450	458
7	501	603	689	730	701	738	742	747	774	766	769
8	372	465	531	560	550	577	573	591	588	589	609
9	383	458	534	582	546	569	557	585	575	578	587
10	525	626	717	745	743	744	753	767	794	801	821
11	463	566	623	675	645	663	654	680	698	690	701
12	282	369	419	437	435	435	444	454	462	451	490
13	106	105	144	141	154	128	128	135	142	143	138
14	89	120	127	121	131	137	117	129	128	130	149
15	83	98	98	119	123	108	120	100	116	110	130
16	72	87	86	105	111	95	106	94	105	99	124
17	328	378	471	448	477	463	486	448	502+	517	522
18	320	381	468	449	476	454	476	445	451+	507	517
19	300	357	433	439	462	447	456	437	499	486	498
20	215	248	261	258	250	261	300	271	311	322	340
21	130	127	170	139	139	139	141	129	148+	165	161+
22	42	50	66	48	50	51	54	53	—	69	—
23	76	88	102	95	91	96	95	87	—	—	—
24	67	53	55	52	52	50	55	54	—	60+	—
26	52	67	69	77	63	67	87	60	74	75	73
27	48	66	63	73	61	50	69	52	67	66	65
29	135	157	177	183	163	166	210	166	202	181	185
30	120	143	174	164	157	158	207	154	193	176	182
31	119	144	177	168	164	160	212	156	204	178	187
32	47	56	54	48	46	52	68	55	68	71	66
33	188	250	288	305	283	291	285	312	305	310	332
34	140	192	224	233	215	222	244	226	248	246	275
35	79	103	97	109	105	93	98	101	125	110	125
36	41	58	64	62	68	66	104	57	83	74	84
37	61	84	91	90	76	88	119	85	103	99	91
38	81	104	107	112	124	102	118	106	115	111	132
39	290	355	367	402	411	382	430	388	455	427	453
40	64	68	92	91	105	80	65	83	91	96	96
41	75	101	137	106	118	119	155	107	147	126	125
42	29	36	59	45	50	48	—	45	66	51	53
43	118	138	133	150	140	122	116	131	168	158	142
44	172	190	203	234	226	260	313	198	250	255	268
45	0	0	0	20	0	0	0	0	35	0	0
AB—left*	53	50	—	50	—	50	54	54	—	57	53
AB—right*	55	54	55	54	—	55	—	57	—	60	57

* Greatest length of auditory bulla.

length, whereas in the specimen ZC10, which is thought to be an adult female, the corresponding figures are 14 and 20 mm respectively.

All of the vertebrae of this specimen are lacking, but it is probable that this skull was obtained from an adult male.

ZC1. (Pl. II, Fig. 3) The skull is 891 mm in length and well ossified, especially in the region of the beak. A very low and narrow ridge is present on the vomer, even the highest part of which lying over 10 mm below the level of the premaxillaries. No prenarial basin is developed. The mandibles of this specimen is lacking, but both teeth have been secured, of which measurements are given in Table 3. They are slender and resembles in shape to those of the specimen ZC12 and the root is completely closed in the both teeth.

In this specimen the number of the vertebrae is 47 and all of the epiphyses are so completely fused to their centra that the sutures are obliterated.

In conclusion above it may possibly be concluded that this specimen is from an adult female.

ZC10. (Pl. II, Fig. 4; Pl. VII, Figs. 1 and 2) The skull is 921 mm in length and this is the largest skull among my collection. It exhibit characters of an adult female. The mesorostral bone is less developed and there is a low and narrow ridge which runs from the tip of the vomer, about 10 cm from the tip of the rostrum, posteriorly to the prenarial region where the anterior end of the bony ethmoid rests. The height of the ridge is about 5 mm at the highest part and well below the level of the premaxillaries. No prenarial basin is developed. The broadened part of the right premaxillary is nearly flat, except the extreme outer part where a ridge is formed.

This specimen has 47 vertebrae and all of the epiphyses are so entirely fused that the sutures are obliterated. No tooth was left from this specimen, but the size of the mandibular alveoli is small as stated already. Accordingly this specimen is possibly from an adult female.

Skull proportions. The measurements of each skull are shown in Table 1 in actual length in mm. The measurement numbers are those used by Moore (1963) and followed by Mitchell and Houck (1967) and Mitchell (1968). These are as follows:

Descriptions of measurements provided in Table 1.

1. Greatest length of skull.
2. Greatest length of rostrum, tip of beak to line connecting apices of antorbital notches.
3. Tip of rostrum to posterior margin of pterygoid nearest mid-sagittal plane.
4. Tip of rostrum to most posterior extension of wing of pterygoid.
5. Tip of rostrum to most anterior extension of pterygoid.
6. Tip of rostrum to most posterior extension of maxillaries between the pterygoids on the palate.
7. Tip of rostrum to most posterior extension of maxillary plate.
8. Tip of rostrum to anterior margin of superior nares.
9. Tip of rostrum to most anterior point on premaxillary crest (i.e. to anterior tip of nasals).

10. Tip of rostrum to most posterior extension of temporal fossa.
11. Tip of rostrum to most posterior extension of lateral tip of left premaxillary crest.
12. Tip of rostrum to most anterior extension of pterygoid sinus.
13. Greatest length of temporal fossa.
14. Greatest length of orbit.
15. Greatest length of right nasal on vertex of skull.
16. Length of nasal suture.
17. Greatest breadth of skull across postorbital processes of frontals.
18. Greatest breadth of skull across zygomatic processes of squamosals.
19. Greatest breadth of skull across centers of orbits.
20. Least breadth of skull across posterior margins of temporal fossae.
21. Greatest span of occipital condyles.
22. Greatest width of an occipital condyle.
23. Greatest length of an occipital condyle.
24. Greatest breadth of foramen magnum.
26. Greatest breadth of nasals on vertex.
27. Least distance between premaxillary crests.
29. Greatest span of premaxillary crests.
30. Least width (strictly transverse) of premaxillae where they narrow opposite superior nares.
31. Greatest width of premaxillae anterior to place of measurement no. 30.
32. Width of premaxillae at midlength of rostrum.
33. Width of rostrum in apices of antorbital notches.
34. Width of rostrum in apices of prominential notches.
35. Greatest width of rostrum at midlength of rostrum.
36. Greatest depth of rostrum at midlength of rostrum.
37. Greatest transverse width of superior nares.
38. Greatest inside width of inferior nares, at apices of pterygoid notches, on the pterygoids.
39. Height of skull. Distance between vertex of skull and most ventral point on pterygoids.
40. Greatest width of temporal fossa approximately at right angle to greatest length.
41. Least distance between main or anterior maxillary foramina.
42. Least distance between premaxillary foramina.
43. Distance from posterior margin of left maxillary foramen to most anterior extension of left maxillary prominence.
44. Greatest length of vomer visible at surface of palate.
45. Amount added to skull length because of breakage of occipital condyle.

The measurement number 45 of Moore is "Amount added to beak because of breakage ", but it is slightly changed. In the present specimen some skulls were cut open of their supraoccipital bones triangularly by saw in order to extract brain for the anatomical study at the Department of Anatomy, Faculty of Medicine, University of Tokyo. Most of them were so carefully cut that the occipital condyles were not damaged, but in the specimens ZC6 and ZC8 their tips were slightly cut down. Accordingly I have estimated the lost length, comparing them with other specimens.

Mitchell and Houck (1967) have studied some of the differences between the large male and female skulls on the one hand and the juvenile male skull on the other. I have tried to find out the difference in the skull proportion, if any, which separates

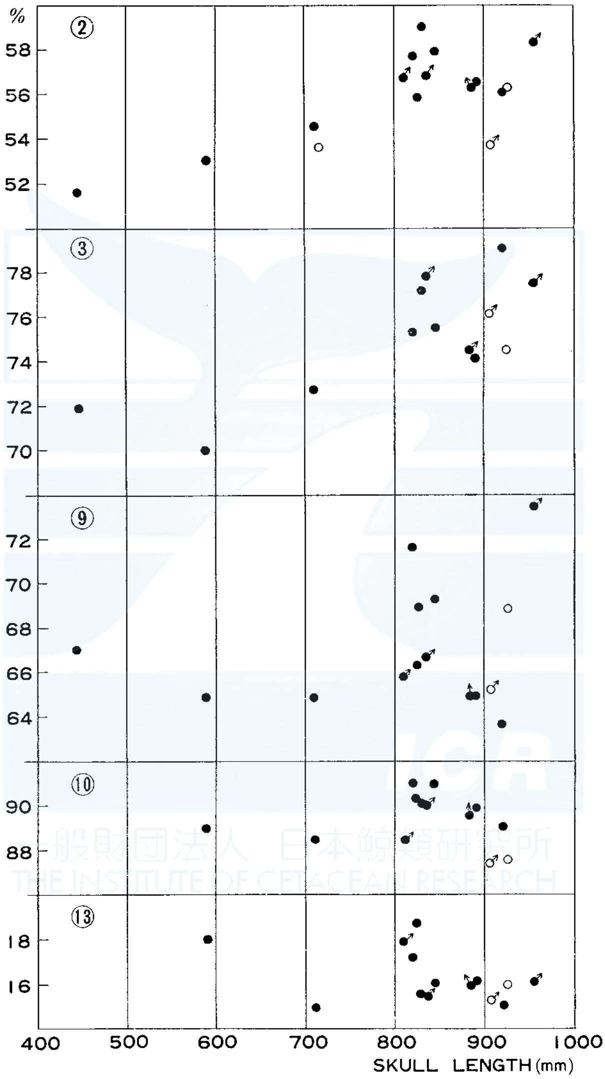
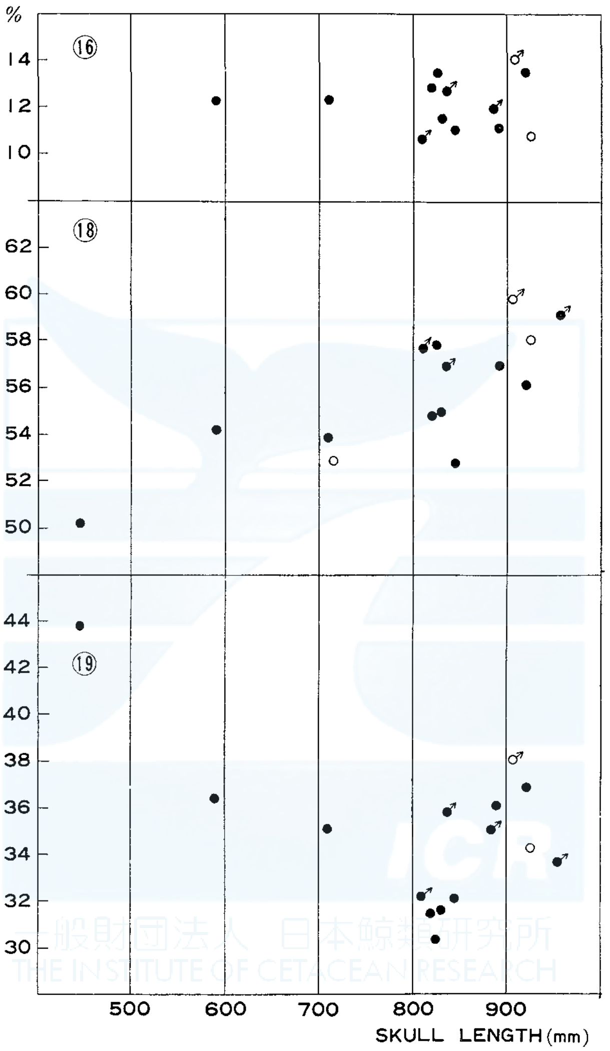


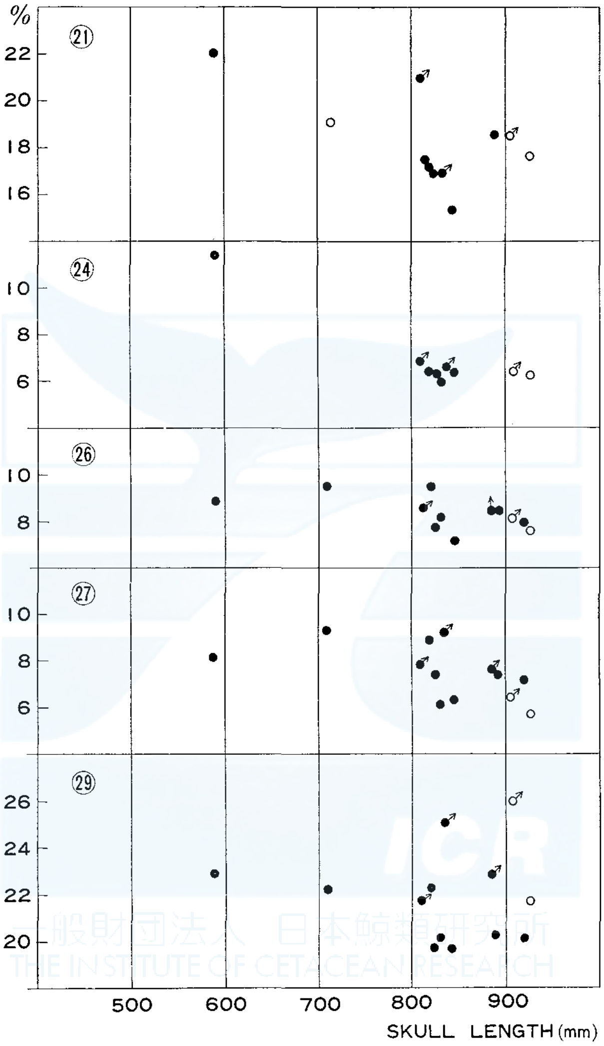
Fig. 3. Skull proportion of *Ziphius cavirostris* in the North Pacific. Closed circle indicates specimens from the northwest Pacific, and open circle those from the northeast Pacific. Presumed adult males are denoted by male symbol. Numeral in circle in each figure indicates measurement number described in the text.

the adult male from the adult female and/or juvenile as well as the proportional change according to growth of the skull. I have calculated the percentage figures against the skull length of the measurements and then plotted them in the order of skull length (Fig. 3). In Fig. 3 I also included two skulls reported by Ogawa (1936–37). One of these skulls is the smallest which measures 445 mm in length, and obtained from a female of 247.6 cm long, taken off Shiogamashi, Miyagi-ken. The other skull is the largest and measures 956 mm in length, obtained from a 590 cm long male at Taiji. I also included, for the sake of comparison between skulls from the northwest and northeast Pacific, a skull reported by Hubbs (1946), of which length is 716 mm and obtained from an immature female, and two skulls reported by



Fig, 3. Continued.

Mitchell and Houck (1967). The skull length of their specimens are 907 mm (HSC 57–1) and 923 mm (HSC 59–3), and the former is from a male and the latter from a female. Both are presumed to be adult in their report. Further, Mitchell (1968) reports measurements of skulls of northeast Pacific, but they are not cited in Fig. 3, mainly due to the unknown sex and maturity.

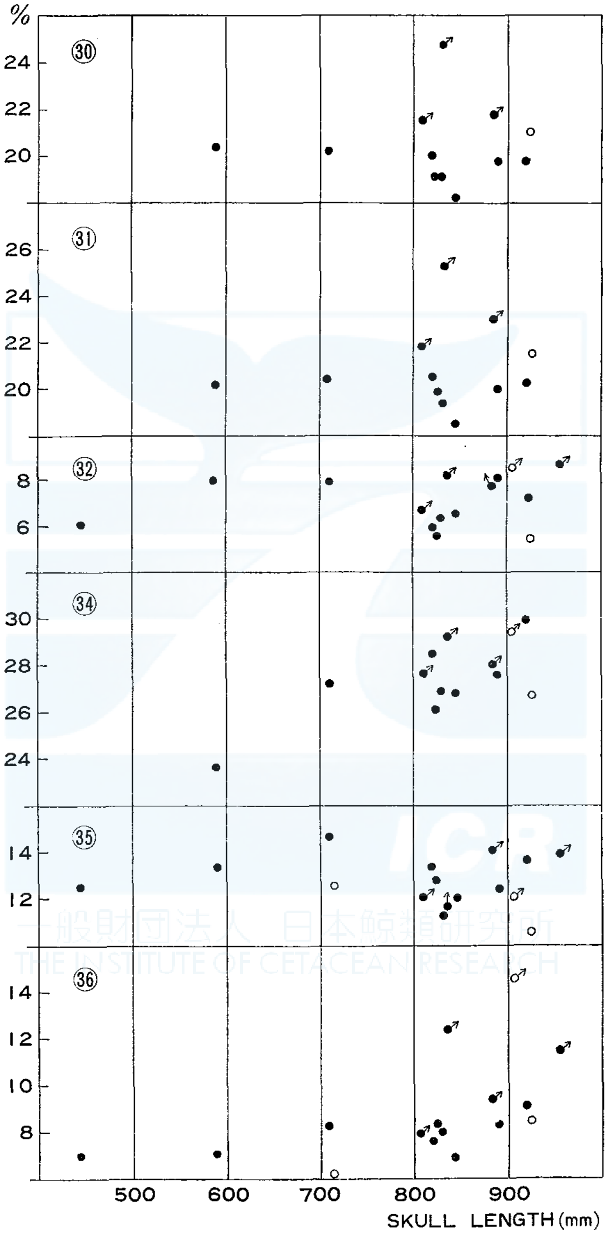


Fig, 3. Continued.

In this figure the skulls of the northwest Pacific are marked by closed circle and those from the northeast Pacific by open circle. The skulls presumed to be adult male are so marked with symbol, and others without symbol. As to the specimens of the other authors I calculated the percentage figures from their measurements.

As seen in this figure there are a wide range of variation and it seems that the individual difference is much greater than the difference by sexes. But in some characters the presumed adult male is separated from the others. These measurements are the following:

30. Least width (strictly transverse) of premaxillae where they narrow opposite superior nares.



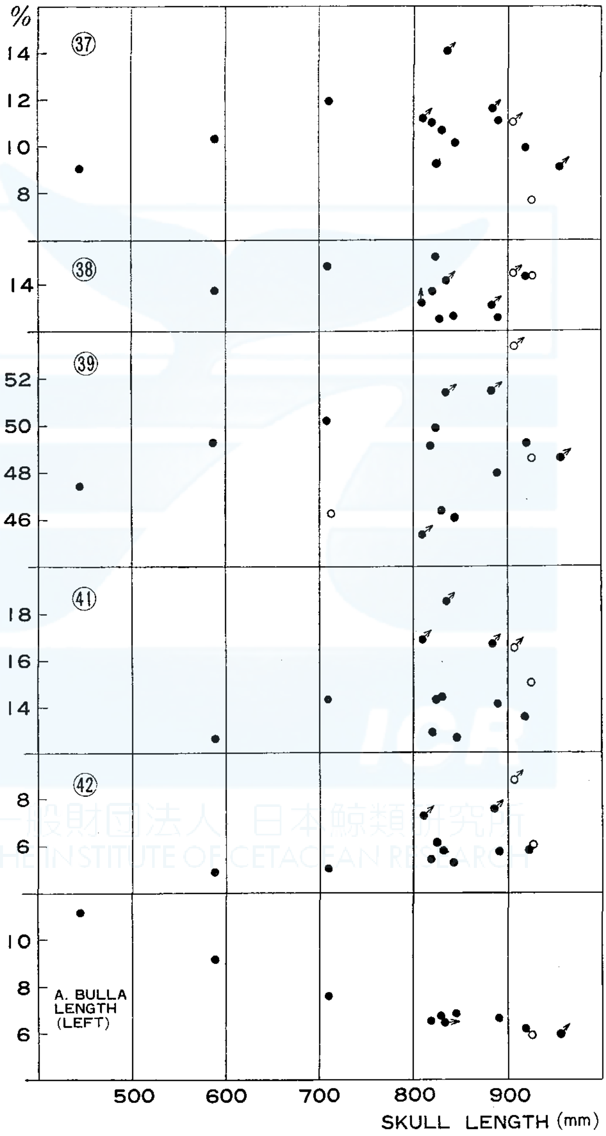
Fig, 3. Continued.

31. Greatest width of premaxillae anterior to place of measurement no. 30.
41. Least distance between main or anterior maxillary foramina.
42. Least distance between premaxillary foramina.

And also in the following measurements the presumed adult male shows greater value than the others with a few exceptions.

29. Greatest span of premaxillary crest.
36. Greatest depth of rostrum at midlength of rostrum.

Most of the above characters concern to the width of the premaxillae and it is



Fig, 3. Continued.

possible that in the adult male the width of the premaxillae posterior to the midlength of the rostrum is greater than in females and juvenile animals. It is also possible that in the adult male the depth of the rostrum increases with age and in the old aged male the greatest depth of rostrum at its midlength is very conspicuous.

The absolute length of the whale body is no good criterion of maturity in *Ziphius cavirostris* (Mitchell and Houck, 1967) and this is also applied to the skull length, as suggested by the present material. But in Fig. 3 there are suggested some general trend of the proportional changes in some of the measurements. They can be grouped in the following three categories:

1) The proportion increases with the growth of the body or age.
   2. Greatest length of rostrum, tip of beak to line connecting apices of antorbital notches.
   3. Tip of rostrum to posterior margin of pterygoid nearest mid-sagittal plane.
   18. Greatest breadth of skull across zygomatic processes of squamosals.
   29. Greatest span of premaxillary crests. Male.
   30. Least width (strictly transverse) of premaxillae where they narrow opposite superior nares. Male.
   31. Greatest width of premaxillae anterior to place of measurement no. 30. Male.
   34. Width of rostrum in apices of prominential notches.
   36. Greatest depth of rostrum at midlength of rostrum. Male.
   41. Least distance between main or anterior maxillary foramina. Male.
   42. Least distance between premaxillary foramina. Male.
2) Practically no proportional change is observed with age.
   10. Tip of rostrum to most posterior extension of temporal fossa.
   13. Greatest length of temporal fossa.
   16. Length of nasal sutures.
   26. Greatest breadth of nasals on vertex.
   27. Least distance between premaxillary crests.
   32. Width of premaxillae at midlength of rostrum.
   35. Greatest width of rostrum at midlength of rostrum.
   37. Greatest transverse width of superior nares.
   38. Greatest inside width of inferior nares, at apices of pterygoid notches, on the pterygoids.
3) The proportion decreases with age.
   21. Greatest span of occipital condyles.
   24. Greatest breadth of foramen magnum.
   Addition. Greatest length of auditory bulla.

The last mentioned measurement, greatest length of auditory bulla, is not included in the Moore's measurements, but I added this measurement in Table 1, following after Mitchell and Houck (1967).

In conclusion above the length of the rostrum becomes larger proportionally with age, and it becomes more wider at the base, but not at its midlength. The proportional breadth of the skull is also becomes wider with age.

TABLE 2. COMPARISON OF SKULL MEASUREMENTS BETWEEN ADULT MALE AND OTHERS, EXPRESSED AS PERCENTAGE OF SKULL LENGTH.

Measurement no.	Presumed adult male			Adult female and/or juvenile*		
	Number	Range	Mean	Number	Range	Mean
2	3	56.32–56.75	56.60	6	55.77–58.96	57.15
3	2	74.38–77.78	76.08	5	74.19–79.04	76.18
4	2	78.33–82.08	80.21	5	78.00–82.95	80.84
5	3	47.97–49.34	48.47	6	47.27–51.03	49.02
6	3	52.33–54.25	53.17	6	49.73–55.33	52.51
7	3	84.96–88.65	86.99	6	83.50–89.35	86.94
8	3	65.47–68.46	66.77	6	66.11–70.02	67.89
9	3	64.90–66.55	65.76	6	63.74–71.06	67.37
10	3	88.41–89.96	89.33	6	89.14–90.96	90.21
11	3	76.82–78.78	77.91	6	76.11–82.42	79.20
12	3	51.66–53.05	52.28	6	50.62–53.79	52.75
13	3	15.35–17.76	16.38	6	14.98–18.71	16.41
14	3	13.92–15.66	14.68	6	14.59–16.59	15.56
15	3	12.08–14.34	13.17	6	11.85–14.95	13.48
16	3	10.60–12.66	11.70	6	11.11–13.49	12.25
17	2	58.06–58.08	58.07	6	53.08–58.02	56.08
18	2	56.87–57.71	57.29	6	52.73–57.84	55.56
19	3	53.39–56.32	54.73	6	51.78–56.14	54.04
20	3	32.18–35.84	34.37	6	30.38–36.92	33.11
21	2	16.85–20.96	18.91	5	15.28–18.52	16.90
22	2	6.45– 8.14	7.30	5	5.86– 7.74	6.43
23	2	11.41–12.58	12.00	4	10.31–11.62	11.15
24	2	6.57– 6.78	6.68	4	6.05– 6.35	6.28
26	3	8.35–10.39	9.08	6	7.11– 9.40	8.10
27	3	7.56– 8.24	7.86	6	6.05– 8.91	7.17
29	3	21.82–25.09	23.24	6	19.67–22.34	20.39
30	3	41.45–24.73	22.65	6	18.25–20.02	19.33
31	3	21.82–25.33	23.39	6	18.48–20.51	19.76
32	3	6.66– 8.12	7.48	6	5.59– 7.97	6.57
33	3	34.05–35.51	34.66	6	34.39–37.24	35.78
34	3	27.62–29.15	28.25	6	26.12–29.86	17.62
35	3	11.71–14.11	12.59	6	11.26–13.57	12.54
36	3	7.89–12.43	9.90	6	6.75– 9.12	8.00
37	3	11.22–14.22	12.36	6	9.23–11.11	10.32
38	3	12.98–14.10	13.41	6	12.35–15.06	13.41
39	3	45.25–51.37	49.32	6	45.97–49.94	48.06
40	3	7.77–11.34	9.79	6	9.69–12.76	10.76
41	3	16.59–18.52	17.33	6	12.68–14.41	13.68
42	2	7.27– 7.45	7.36	6	5.33– 6.08	5.70
43	3	13.86–18.96	16.41	6	14.77–18.32	16.46
44	3	25.03–37.40	30.22	6	23.46–31.48	28.12
AB**–left	1	—	6.45	5	5.75– 6.40	6.14
AB**–right	1	—	6.78	5	6.19– 6.75	6.58

* Exclude smaller skulls than 800 mm in length.

** Greatest length of auditory bulla.

The temporal fossa, nasals, superior and inferior nares retain their size in porportion to their skull length, but the occipital condyles and the tympanic bulla grow very little with age, and hence their proportional sizes decrease with the growth of the skull.

Distinctions of adult male were already mentioned. One interesting feature among the measurements is the difference in the lengths of the right and left auditory bullae. In the seven skulls in which both bullae were retained, the right bulla is always greater than the left (see Table 1). In the skulls reported by Mitchell and Houck (1967) also the right bulla is longer than the left in two skulls with both bullae (HSC 57–2, HSC 59–3). It is not clear, however, whether or not this is related to some physiological matter such as difference in hearing between right and left ears in this species.

In Fig. 3 most of the measurements are shown in proportion to the skull length, but they do not cover all measurements. In Table 2 all measurements are arranged as percentages of skull length, separately by the presumed adult male and adult female and/or juvenile of my specimens. Of course more material, especially for the adult male, is needed for the tabulation of such nature. I present here this table, therefore, only for reference.

Further, I compared the proportions of the skull of the northwest Pacific specimens to those of the northeast Pacific specimens as reported by Mitchell and Houck (1967) and Mitchell (1968). They are partly included in Fig. 3. If all of the material from the northeast Pacific are plotted in Fig. 3 it shows more wide individual variation, and none of the difference between the specimens from the east and west North Pacific. But in the measurement no. 8, tip of rostrum to anterior margin of superior nares, some distinction is noted in which my measurement showing always smaller value, though this is not included in Fig. 3. It may possible, however, this is

TABLE 3. MEASUREMENTS OF MANDIBLES AND TEETH OF *ZIPHIUS CAVIROSTRIS* IN NORTHWEST PACIFIC.

Measurement no.	ZC 2	ZC 11	ZC 12	ZC 6	ZC 3	ZC 7	TWM 1	ZC 4	ZC 8	ZC 1*	ZC 10
a	494	605	710	718	737	730	753	737	777	—	808
b	91	108	134	158	156	162	153	157	171	—	145
c	85	111	130	139	138	170	140	160	186	—	170
d	261	330	341	397	391	393	420	413	417	—	451
e	101	120	150	134	138	136	139	137	160	—	156
f	24	38	45	40	49	35	49	46	50	—	48
g	—	374	423	416	443	403	434	422	474	—	488
h	—	—	49	—	—	—	48**	—	—	52	—
i	—	—	46	—	—	—	36**	—	—	55	—
j	—	—	11	—	—	—	21	—	—	11	—
k	—	—	11	—	—	—	22	—	—	12	—
l	—	—	10	—	—	—	15	—	—	10	—
m	—	—	10	—	—	—	15	—	—	9	—

* Only teeth were saved.

** Tip erased.

due to the difference in the method of measurement, because this is rather difficult to define and in the light of good agreement in the other measurements. I have not placed, therefore, much importance on this measurement.

In Table 3 measurements of mandibles and teeth are shown. It is regrettable that the teeth are lacking in most of the specimens and more mention on mandibles and teeth may not be needed here. The measurement number are as follows:

Descriptions of measurements of mandibles provided in Table 3.

a. Greatest length of right dentary bone.
b. Greatest length of right dentary to posterior end of symphysis.
c. Greatest length of right dentary to posterior border of mental foramen.
d. Greatest length of right dentary to anteromedial margin of mandibular vacuity.
e. Height at coronoid process.
f. Breadth of symphysis at posterior margin of mandibular alveoli.
g. Breadth of jaws across mandibular condyles.
h. Total length of tooth—*left.*
i. Total length of tooth—*right.*
j. Greatest diameter of tooth—*left.*
k. Greatest diameter of tooth—*right.*
l. Diameter at right angle to greatest diameter—*left.*
m. Diameter at right angle to greatest diameter—*right.*

VERTEBRAE (Pl. VI)

Complete sets of the vertebrae of *Ziphius cavirostris* in the northwest Pacific were secured from seven individuals. In some specimens the spinous and transverse processes, and sometimes the vertebral body too, were cut by saw just after the stranding by spectators. But still they are in such condition that they could be restored. Thus there is no difficulty in counting of their number and take measurements.

The vertebral formulae of each specimen are shown in Table 4. As seen from this table the total number of vertebrae is 46–47: cervical 7, dorsal 9–10, lumbar

TABLE 4. VERTEBRAL FORMULA OF *ZIPHIUS CAVIROSTRIS* IN NORTHWEST PACIFIC.

Specimen	Cervical	Dorsal	Lumbar	Caudal	Total
ZC 2	7	10	10	20	47
ZC 11	7	9	10	20	46
ZC 12	7	9	11	20	47
ZC 3	7	9	10	20	46
ZC 7	7	9	10	21	47
ZC 1	7	10	10	20	47
ZC 10	7	10	10	20	47

10–11, and caudal 20–21. True (1910) gives a table in which the vertebral formulae for eight specimens are shown, including those reported by the other authors. In his table the vertebral numbers are: cervical 7, dorsal 9–10, lumbar 9–11, caudal 19–20, and the total 46, excepting the specimens with question and the one which has 49 vertebrae, the Argentine specimen. But he comments " In the figures of the Argentine specimen the last ten caudals are practically without characters, and it is perhaps allowable to question whether the terminal two or three were not added to make an even taper to the end of the column. If such be not the case, this specimen had more vertebrae than any other ". It can be concluded, therefore, that in the vertebral count there is no distinct character which separates *Ziphius cavirostris* of the northwest Pacific from the other oceans.

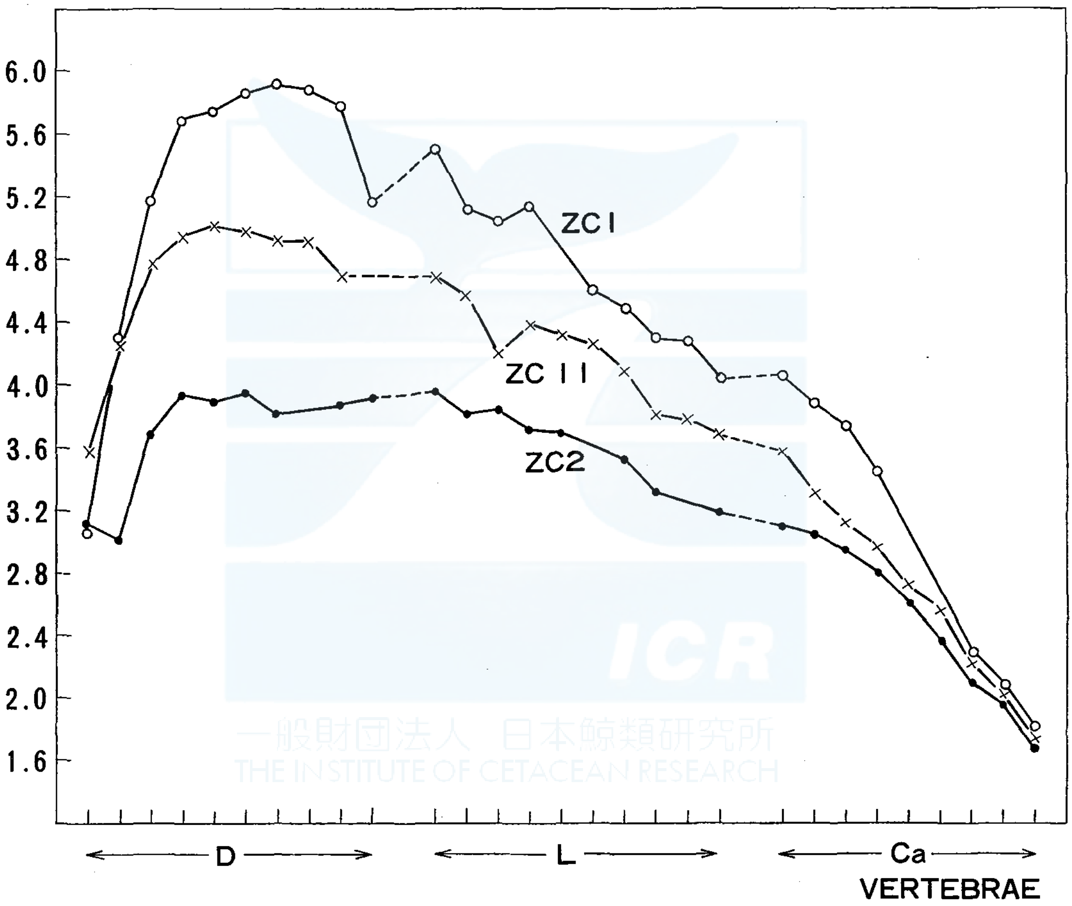


Fig. 4. Ratio of greatest height against height of centrum in each vertebra in dorsal, lumbar, and caudal vertebrae of *Ziphius cavirostris* in the northwest Pacific.

The measurements of vertebrae of the seven specimens are shown in Appendix Table with some notes of observations. Since the vertebrae were secured from the very young, juvenile, and adult animals it is possible to investigate the change in size of vertebrae according to the growth of the whale body.

In Fig. 4 are shown the ratios of the greatest height against the height of the centrum in each vertebra for the specimens ZC2 (very young), ZC11 (juvenile), and ZC1 (adult). This figure may demonstrate the relative height of the spinous process, and its change according to the age. As seen in this figure the relative height of the spinous processes becomes larger with growth, especially in the dorsal vertebrae, except the 1st dorsal.

In Fig. 5 are shown the ratios of the greatest breadth of each vertebra against its centrum breadth separately for the three specimens. This figure shows the relative growth of the transverse processes according to age, at least of those in the lumbar and caudal regions. It is of some interest to note that in the dorsal vertebrae the length of the transverse processes increase gradually, but in the 3rd vertebra anterior to the last it shows practically no relative growth and the value itself is very low, and after that vertebra they grow increasingly until the first lumbar where the value is greatest. This is partly due to the fact that in the dorsal vertebrae the transeverse processes are not situated at the level of the center of the centrum, but at more superior position, and in the 3rd vertebra anterior to the last they present at the highest position among the dorsal vertebrae. As seen in the Appendix Table the greatest breadth of this vertebra is always smaller than in the neighboring vertebrae.

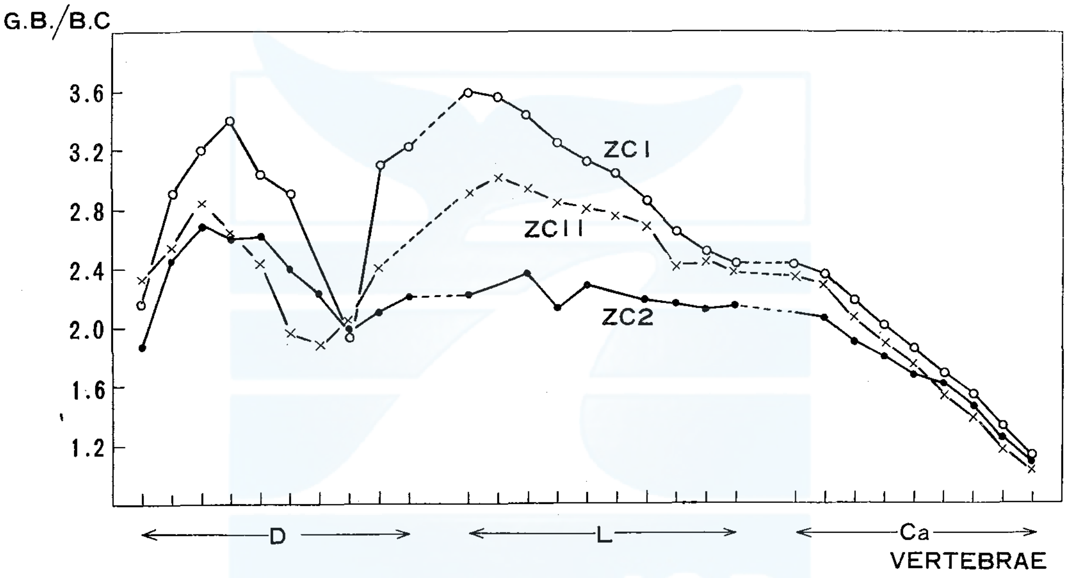


Fig. 5. Ratio of greatest breadth against breadth of centrum in each vertebra in dorsal, lumbar, and caudal vertebrae of *Ziphius cavirostris* in the northwest Pacific.

Omura (1971) reports that in the baleen whales the long distant migrating species and fast swimmers have more developed vertebrae in the posterior portion of the lumbar and in the anterior portion of the caudal regions than in the other species. For the *Ziphius cavirostris* I also calculated the mean length of each centrum, using the same following formula:

Mean length $= \sqrt[3]{a\times b\times c}$

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

The calculated lengths are shown in Fig. 6 for the specimens ZC2, ZC11, ZC7 (larger juvenile than ZC11), and ZC1. This figure denotes that in this species the vertebrae in the posterior portion of the lumbar and in the anterior portion of the caudal regions become larger with the growth of the body. This fact is presumed to be applied to the other species of whales too.

In the *Ziphius cavirostris* the first several cervicals are fused into a mass. Among seven specimens four vertebrae, namely the atlas, axis, the 3rd, and the 4th cervicals are fused in five specimens, and the remainders are three and six, as noted in Appendix Table.

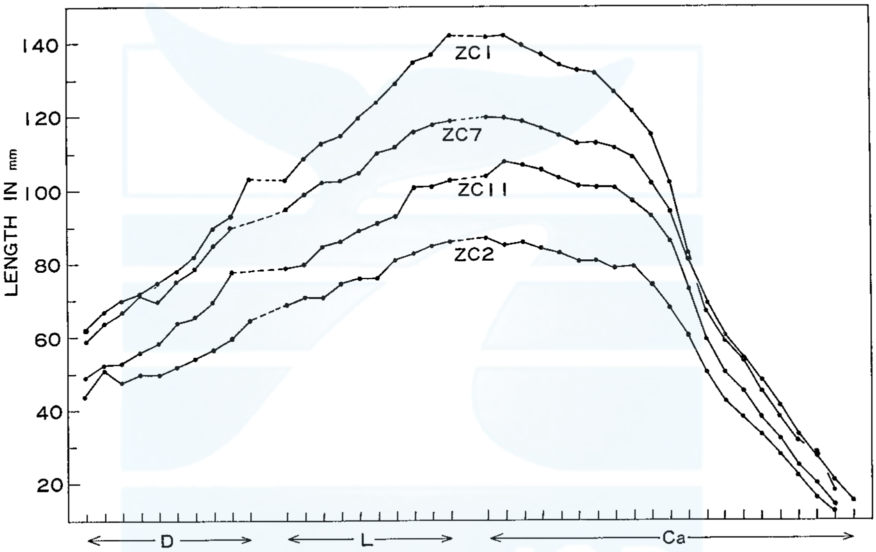


Fig. 6. Comparison of mean length of each vertebra in four specimens of *Ziphius cavirostris* in the northwest Pacific.

OTHER BONES

Rib. A complete set of ribs was obtained only from the specimen ZC3, and even in this specimen the last three (right side) and four (left side) ribs were cut into two or three fragments. The broken parts were restored and the measurements were made of their straight length, and the results are shown in Table 5.

Scapula (Pl. VII, Fig. 3) The scapula is fan shaped and the acromion is well developed with broadened distal end. The coracoid is also developed. From six specimens the scapulae were secured and their measurements are shown in Table 6.

The other bones e.g. sternum, hyoid, chevrons were also secured from some of the specimens, but they are mostly fragmental and have less value to report here, but the

TABLE 5. STRAIGHT LENGTH OF RIBS OF THE SPECIMEN ZC3.
(in mm)

Rib number	Right	Left	Rib number	Right	Left
1	453	435	6	753	745
2	614	595	7	745	740
3	698	693	8	710	710
4	755	753	9	630	635
5	770	763	—	—	—

TABLE 6. MEASUREMENTS OF SCAPULAE OF *ZIPHIUS CAVIROSTRIS* IN NORTHWEST PACIFIC. (in mm)

Specimen	Right		left	
	Breadth	Height	Breadth	Height
ZC 2	195	139	198	141
ZC 11	256	180	256	180
ZC 12	367	246	361	256
ZC 3	384	264	379+*	271
ZC 7	358	237	356	237
ZC 10	412	286	408	283

* Tip broken.

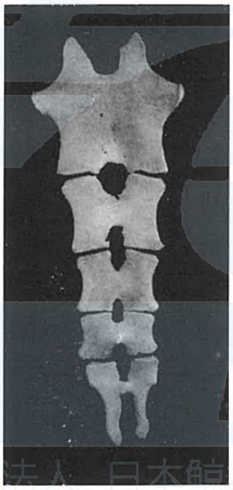


Fig. 7. Sternum of the specimen ZC 3.

sternum of the specimen ZC3 is complete (Fig. 7). It is consisted of five segments and the overall length is 796 mm and the greatest breadth of the first segment is 289 mm.

DISCUSSION

Among eleven skulls I investigated the most interesting one is the specimen ZC12. As I have already discussed this skull is presumed to be an adult male, chiefly due to the presence of the distinct prenarial basin. The skull measurements also suggest this to be the true. This specimen is the smallest among those with male symbols in

Fig. 3. As already mentioned, in the measurement number 29 (Greatest span of premaxillary crests) and 36 (Greatest depth of rostrum at midlength of rostrum) the adult male shows greater value than the others with a few exceptions, and this specimen is included among the exceptions in the both measurements. It is probable that the span of premaxillary crests and the depth of rostrum at midlength of rostrum will increase with age. The oldest male among my specimens is TWM1, next to the smallest in Fig. 3, judged from the well developed mesorostral bone with posterior truncation as well as the presence of the massive and fusiform teeth. This specimen shows far greater value in the both measurements than in the specimen ZC12. The teeth of the specimen ZC12 are slender and cylindrical in shape with closed roots. It is true that this specimen has already attained the physical maturity, but all evidences suggest that this specimen is not an old animal. Fraser (1942) describes " the massive fusiform teeth are indication of a late phase in the animal's life ", and it is possible that the passage from the cylindrical to the fusiform shape in the tooth of the male is brought about after the attainment of the physical maturity, but subject to the individual variation.

It is also suggested from the material used in this study that the development of the mesorostral bone is continued after the attainment of the physical maturity and the massive mesorostral with the posterior truncation in the male is completed with old age.

In seven specimens the mesorostral bone is recognized in varying degree of development, from mere a low ridge on the upper surface of the vomer (ZC7) to a well developed bone with posterior truncation (TWM1). These material confirms the finding by Fraser (1942) that the mesorostral ossification is demonstrably a development of the vomer, and not an ossification of the cartilaginous ethmoid.

On the other points I have already discussed in the foregoing chapters.

ACKNOWLEDGMENTS

My sincere thanks are due to Dr. Edward Mitchell of the Arctic Biological Station, Fisheries Research Board of Canada, who stimulated and encouraged me for the study of this species and kindly sent me a xeroxed copy of the very valuable literature on the skull of this species by Kernan (1918). I also express my gratitude to Dr. Richard G. Van Gelder of the American Museum of Natural History who sent me an original copy of the Kernan's paper, which contains many excellent photographs of bones of the skull, upon request from Dr. Mitchell.

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APPENDIX TABLE. MEASUREMENTS OF VERTEBRAE OF *ZIPHIUS CAVIROSTRIS* IN NORTHWEST PACIFIC. (in mm)

1. Specimen ZC 2

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	168	165	151*	88*	60	* Articulating face.
2	2	136					Very young specimen.
3	3	88					All of the epiphyses are not
4	4	79		64	51	6	fused to their centra.
5	5	72	121	60	50	15	First 4 cervicals united
6	6	75	139	63	50	14	into a mass, but only
7	7	84	142	75	52	17	partly.
8	D 1	124	165	66	53	24	In vertebrae up to and
9	2	150	176	61	50	34	including 8th dorsal
10	3	149	180	55	49	41	the centra are not
11	4	141	185	54	47	49	fused with a mass of
12	5	131	187	50	48	52	processes, but separa-
13	6	122	193	51	49	56	rated. In 9th dorsal
14	7	117	195	52	51	60	these are fused, but
15	8	107	197+	54	53	64	sutures are visible.
16	9	128	205	61	53	67	10th dorsal and there-
17	10	158	216	72	55	70	after completely fused.
18	L 1	171	225	77	57	74	
19	2	164+	233	76	61	76	
20	3	174	241	74	63	78	
21	4	167	245	78	66	82	
22	5	177	248	78	67	85	
23	6	159+	246+	77	69	89	
24	7	172	254	79	72	92	
25	8	174	249	81	75	94	
26	9	181	245+	84	76	97	
27	10	183	245	85	77	98	
28	Ca 1	169+	233	88	75	99	
29	2	175	229	85	75	98	
30	3	163	224	87	76	95	
31	4	153	211	85	75	92	
32	5	143	196	85	75	89	
33	6	131	180	81	76	86	
34	7	118	163	81	78	83	Transverse processes im-
35	8	103	148	82	76	80	perfectly perforated
36	9	87	130	80	78	78	
37	10	—	113	75	77	71	Transverse processes dis-
38	11	—	93	66	74	65	appear.
39	12	—	70	63	65	52	
40	13	—	—	58	54	41	Spinous process disap-
41	14	—	—	51	43	34	pears.
42	15	—	—	48	36	31	
43	16	—	—	42	31	27	

Continued . . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
44	17	—	—	35	25	24	
45	18	—	—	30	19	19	
46	19	—	—	22	13	15	
47	20	—	—	16	9	13	

2. Specimen ZC 11

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	203	176	134*	88*	69	* Articulating face.
2	2	181		—	—		Juvenile. All of the epiphyses are not fused to their centra.
3	3	111		—	—		
4	4	83		73	60		
5	5	79	133	68	58	17	First 4 cervicals united into a mass, but the 4th fused only at the tip of spinous process.
6	6	87	145	68	58	17	
7	7	101	137	91	54	19	
8	D 1	166	199	72	56	29	
9	2	178	226	70	53	39	
10	3	173	243	61	51	49	
11	4	154	252	59	51	59	
12	5	144	256	59	51	64	
13	6	135	269	69	54	69	
14	7	129	270	69	55	75	
15	8	152	275	74	56	82	
16	9	211	285	88	61	87	
17	L 1	253	290	87	62	91	
18	2	254	293	84	64	96	
19	3	250	302	85	72	99	
20	4	248	315	87	72	101	
21	5	248	323	89	75	106	
22	6	245	328	89	77	109	
23	7	243	331	90	81	111	
24	8	236	335	98	88	119	
25	9	231	329	95	87	124	
26	10	231	324	97	88	127	
27	Ca 1	232	319	98	89	129	
28	2	229	317	101	96	129	
29	3	213	295	103	95	124	
30	4	194	281	104	95	121	
31	5	179	254	102	93	114	
32	6	159	236	103	92	110	
33	7	139	209	101	94	108	
34	8	119	190	103	94	105	Transverse processes imperfectly perforated.

Continued . . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
35	9	101	163	98	94	99	Left transverse process perforated.
36	10	—	138	90	94	94	Transverse processes disappear.
37	11	—	112	83	90	84	
38	12	—	82	76	78	65	
39	13	—	—	69	62	48	Spinous process disappears.
40	14	—	—	62	51	40	
41	15	—	—	55	45	37	
42	16	—	—	46	38	32	
43	17	—	—	38	31	29	
44	18	—	—	31	23	21	
45	19	—	—	25	15	20	
46	20	—	—	20	10	15	

3. Specimen ZC 12

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	300	220	163*	94*	135	* Articulating face.
2	2			—	—		Adult. All of the epiphyses are completely fused to their centra.
3	3				—		
4	4		162	—	—		First 6 cervicals are united, but the 6th fused only at the inferior part of the body.
5	5		167	—	—		
6	6		172	81	83		
7	7	131	190	115	69	25	Spinous processes are fused in 1–4th, and others free.
8	D 1	219	293	92	69	41	
9	2	236	351	82	66	56	
10	3	242	363	79	63	70	
11	4	230	351+	75	61	82	
12	5	211	340+	75	64	90	
13	6	204	382	75	67	94	
14	7	200	285	81	68	102	
15	8	265	395	88	69	110	
16	9	345	405	94	75	120	Facets for articulation for ribs present.
17	L 1	389	434	95	78	138	Posterior portion of the 1st and anterior portion of the 2nd lumbar developed extraordinary and a pit present at the center of both centra.
18	2	385+	425+	114	109	133	
19	3	365	455	100	93	137	
20	4	389	453	103	96	143	
21	5	355+	459	105	98	147	
22	6	368	443+	107	104	150	
23	7	282+	470	108	106	157	

Continued. . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
24	8	346+	473	110	109	163	
25	9	260+	477	117	116	157+	
26	10	288+	479	119	118	175	
27	11	300	485	115	123	179	
28	Ca 1	305	467	115	118	180	
29	2	292	472	119	126	175	Centra developed extraordinally as in the case of the 1st and 2nd lumbars.
30	3	262	431	131	121	158+	
31	4	215+	401	125	115	160	
32	5	231	375	128	115	151	
33	6	200	332	127	118	140	
34	7	173	295	123	119	135	Transverse processes imperfectly perforated.
35	8	149	263	118	118	124	
36	9	125	227	117	120	115	T.p. perforated.
37	10	—	192	106	118	106	T.p. disappear.
38	11	—	144	96	105	83	
39	12	—	101	88	91	62	
40	13	—	—	82	79	53	Spinous process disappears.
41	14	—	—	77	67	51	
42	15	—	—	68	58	43	
43	16	—	—	56	47	39	
44	17	—	—	49	37	35	
45	18	—	—	41	29	31	
46	19	—	—	37	28	28	
47	20	—	—	24	13	22	

4. Specimen ZC 3

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	250	197	143*	86*	81	* Articulating face.
2	2	203		—	—		Adult. All of the epiphyses are fused to their centra but linea epiphysialis are visible up to 7th caudal.
3	3	133		—	—		
4	4	111		80	71		
5	5	90	151	78	71	18	First 4 cervicals united, but the 4th fused only at spinous and left transverse processes.
6	6	97	181	78	73	22	
7	7	107	207	106	76	27	
8	D 1	187	283	73	71	44	
9	2	207	346	76	68	57	
10	3	195	353	66	61	67	
11	4	180	359	64	60	78	
12	5	176	364	64	60	85	
13	6	179	367	66	61	91	
14	7	166	374	69	62	98	

Continued . . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum Breadth	Centrum Height	Centrum Length	Notes
15	8	210	384	74	64	104	
16	9	279	392	79	65	112	
17	L 1	353	409	82	73	119	
18	2	360	424	84	78	124	
19	3	355	440	85	82	128	
20	4	360	451	86	85	131	
21	5	357	455	89	86	136	
22	6	352	460	91	91	144	
23	7	340	458	94	97	150	
24	8	320	453	98	99	157	
25	9	318	444	102	101	164	
26	10	313	444	103	103	167	
27	Ca 1	321	433	105	106	168	
28	2	322	416	106	106	168	
29	3	302	410	109	104	164	
30	4	267	379	111	107	157	
31	5	242	347	114	104	149	
32	6	212	318	114	105	146	
33	7	187	287	112	105	141	Transverse processes perforated.
34	8	156	257	111	105	136	
35	9	118	225	108	103	125	
36	10	98	189	96	101	115	
37	11	—	158	90	98	100	Transverse processes disappear.
38	12	—	109	80	87	69	
39	13	—	—	78	75	56	Spinous process disappears.
40	14	—	—	69	58	51	
41	15	—	—	69	52	47	
42	16	—	—	56	46	43	
43	17	—	—	50	36	38	
44	18	—	—	38	27	32	
45	19	—	—	33	18	29	
46	20	—	—	25	11	21	

5. Specimen ZC 7

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum Breadth	Centrum Height	Centrum Length	Notes
1	C 1	220	206	134*	90*	71	* Articulating face.
2	2			—	—		Juvenile. Epiphyses are only fused to their centra in 4–5 cervicals and 11–17 caudals.
3	3			83	70		
4	4	110	135	77	71	20	First 3 cervicals are united into a mass as well as their spinous processes.
5	5	96	162	74	71	20	
6	6	93	155	73	73	22	
7	7	138	181	72	71	28	

Continued . . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
8	D 1	186	263	71	65	45	
9	2	190	316	73	61	58	
10	3	182	328	74	59	69	
11	4	176	333	76	60	79	
12	5	180	331	69	60	84	
13	6	174	349	71	64	91	
14	7	144	347	75	68	96	
15	8	237	356	85	69	106	
16	9	285	358	89	73	111	Articulating facet for rib present.
17	L 1	289	373	91	80	116	
18	2	299	386	93	87	119	
19	3	295	402	96	89	124	
20	4	292+	413	96	90	128	
21	5	298	412	98	93	127	
22	6	290	430	99	99	134	
23	7	281	428	103	99	139	
24	8	267	429	106	102	144	
25	9	268	423	109	99	152	
26	10	265	419	107	102	155	
27	Ca 1	261	409	107	103	157	
28	2	253	384	108	104	155	
29	3	237	381	111	100	150	
30	4	214	359	113	100	143	
31	5	198	327	110	100	137	
32	6	179	304	108	102	131	
33	7	164	274	108	104	128	Transverse processes perforated imperfectly.
34	8	135	244	110	103	123	
35	9	108	240	105	105	119	
36	10	—	181	93	105	108	Transverse processes disappear.
37	11	—	145	86	103	94	
38	12	—	98	84	90	71	
39	13	—	—	77	75	56	Spinous process disappears.
40	14	—	—	70	63	48	
41	15	—	—	65	54	45	
42	16	—	—	58	47	41	
43	17	—	—	48	38	39	
44	18	—	—	39	28	34	
45	19	—	—	32	20	30	
46	20	—	—	26	14	25	
47	21	—	—	20	9	17	

Continued . . .

APPENDIX TABLE. Continued.

6. Specimen ZC 1

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	279	236	164*	—	83	* Articulating face.
2	2	240		—	—		Adult. All of the epiphyses are fused to their centra completely.
3	3	191		—	—		
4	4	124		87	72		
5	5	101	150	81	73	25	First 4 cervicals fused into a mass, including spinous processes.
6	6	99	178	79	73	24	
7	7	170	224	92	76	26	
8	D 1	187	230	87	75	36	
9	2	226	318	78	74	52	
10	3	237	362	74	70	67	
11	4	242	380	71	67	78	
12	5	219	379	72	66	88	
13	6	222	397	76	68	93	
14	7	195+	408	78	69	101	
15	8	174	418	91	71	112	
16	9	282	421	91	73	121	
17	10	328	422	102	82	129	
18	L 1	360	439	100	80	138	
19	2	360	457	101	89	146	
20	3	354	470	103	93	149	
21	4	347	478	107	93	153	
22	5	336	—	108	101	158	
23	6	330	488	109	106	164	
24	7	323	492	113	110	173	
25	8	312	489	118	113	185	
26	9	303	490	121	114	185	
27	10	298	483	125	120	189	
28	Ca 1	300	483	124	119	192	
29	2	298	472	127	122	183	
30	3	285	441	131	118	177	
31	4	261	404	130	117	168	
32	5	239	—	129	114	162	
33	6	220	—	130	118	153	
34	7	195	283	127	123	147	
35	8	161	243	123	117	143	Transverse processes perforated.
36	9	129	213	115	117	134	
37	10	—	177	108	115	121	Transverse processes disappear.
38	11	—	141	100	109	96	
39	12	—	—	92	93	65	Spinous process disappears.
40	13	—	—	80	71	53	
41	14	—	—	72	56	50	
42	15	—	—	65	50	48	
43	16	—	—	47	43	44	

Continued . . .

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
44	17	—	—	42	33	39	
45	18	—	—	37	25	34	
46	19	—	—	31	27	27	
47	20	—	—	27	10	22	

7. Specimen ZC 10

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
1	C 1	257	178	163*	100*	87	* Articulating face.
2	2			—	—		Adult. All of the epiphyses are fused to their centra completely.
3	3			—	—		
4	4			90	79		
5	5	95	147+	87	74	18	
6	6	107	209	85	76	19	First 4 cervicals fused into mass.
7	7	120	195	112	80	25	
8	D 1	203	273	94	79	40	
9	2	236	326	94	72	56	
10	3	239	358	93	67	70	
11	4	230	372	73	69	83	
12	5	218	385	74	66	93	
13	6	201	398	76	68	98	
14	7	183	405	81	70	105	
15	8	189	442	92	68	116	
16	9	283	419	95	71	121	
17	10	345	437	100	74	130	
18	L 1	372	449	102	83	136	
19	2	356	459	104	91	142	
20	3	356	469	105	95	144	
21	4	353	477	106	97	147	
22	5	343	484	108	105	153	
23	6	334	486	108	108	158	
24	7	325	491	111	111	167	
25	8	311	489	114	117	175	
26	9	308	485	119	118	179	
27	10	315	479	122	120	180	
28	Ca 1	310	475	130	127	181	
29	2	288	459	134	132	177	
30	3	265	431	131	126	168	
31	4	253	399	137	123	159	
32	5	240	369	136	123	152	
33	6	217	332	135	126	147	
34	7	193	303	136	121	145	
35	8	155	272	135	122	141	

Continued...

APPENDIX TABLE. Continued.

Serial no.	Vertebral no.	Greatest breadth	Greatest height	Centrum			Notes
				Breadth	Height	Length	
36	9	128	240	123	124	131	Transverse processes perforated.
37	10	—	207	110	124	123	Transverse processes disappear.
38	11	—	159	102	115	102	
39	12	—	106	93	97	67	
40	13	—	—	82	79	54	Spinous process disappears.
41	14	—	—	75	67	50	
42	15	—	—	69	61	45	
43	16	—	—	61	53	44	
44	17	—	—	55	45	42	
45	18	—	—	46	32	35	
46	19	—	—	40	23	28	
47	20	—	—	31	16	21	

EXPLANATION OF PLATES

PLATE I

Superior view of skulls of *Ziphius cavirostris* in the northwest Pacific.
Fig. 1. Specimen ZC 2. Skull length 590 mm. Very young. Sex unknown.
Fig. 2. Specimen ZC 11. Skull length 707 mm. Juvenile. Sex unknown.
Fig. 3. Specimen ZC 12. Skull length 811 mm. Adult male.
Fig. 4. Specimen ZC 6. Skull length 819 mm. Juvenile. Sex unknown.

PLATE II

Superior view of skulls of *Ziphius cavirostris* in the northwest Pacific.
Fig. 1. Specimen ZC 7. Skull length 826 mm. Juvenile. Sex unknown.
Fig. 2. Specimen ZC 4. Skull length 844 mm. Female.
Fig. 3. Specimen ZC 1. Skull length 891 mm. Adult female.
Fig. 4. Specimen ZC 10. Skull length 921 mm. Adult female.

PLATE III

Fig. 1. Inferior view of skull of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 11.
Fig. 2. Inferior view of skull of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 7.
Fig. 3. Posterior view of skull of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 12.
Fig. 4. Posterior view of skull of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 3.

PLATE IV

Lateral view of skull of *Ziphius cavirostris* in the northwest Pacific.
Fig. 1. Specimen ZC 6. Skull length 819 mm. Juvenile. Sex unknown.
Fig. 2. Specimen ZC 8. Skull length 886 mm. Adult male.
Fig. 3. Specimen ZC 3. Skull length 823 mm. Adult female.

PLATE V

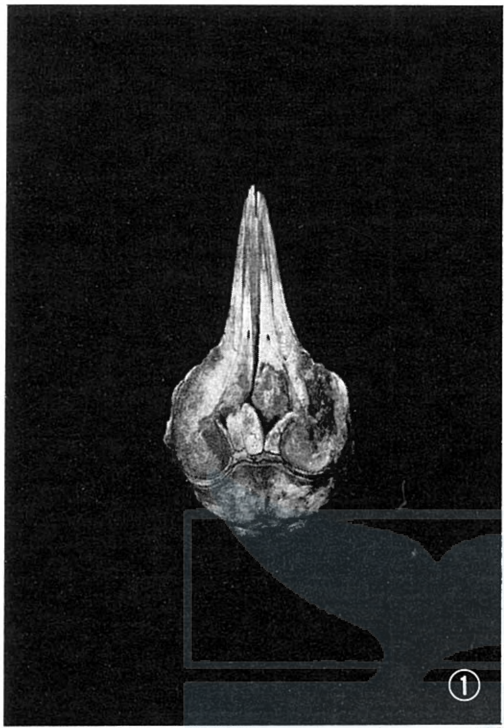
Skull of *Ziphius cavirostris* in the northwest Pacific. Specimen TWM 1. Skull length 837 mm. Old adult male.
Fig. 1. Lateral view.
Fig. 2. Anterior view, showing prenarial basin and a part of mesorostral bone.

PLATE VI

Vertebrae of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 3.
Fig. 1. Cervical and dorsal vertebrae.
Fig. 2. Lumbar vertebrae.
Fig. 3. Caudal vertebrae.

PLATE VII

Fig. 1. Mandible of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 10. Adult female. Lateral view.
Fig. 2. Mandibles of *Ziphius cavirostris* in the northwest Pacific.
Left: Specimen ZC 8. Adult male.
Right: Specimen ZC 10. Adult female.
Fig. 3. Scapulae of *Ziphius cavirostris* in the northwest Pacific. Specimen ZC 3.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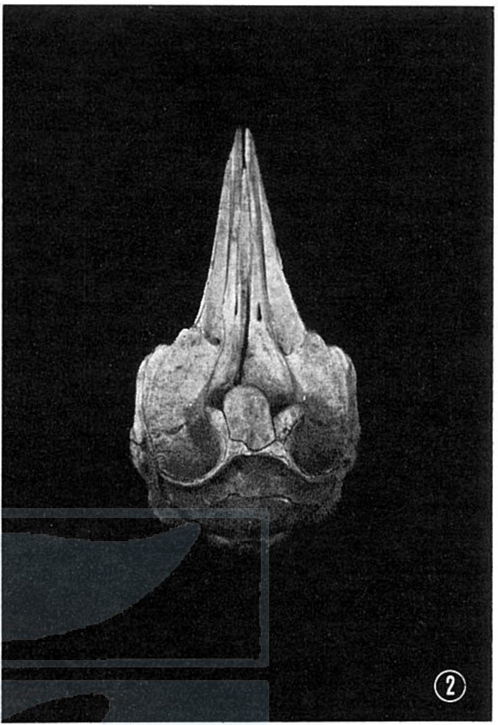
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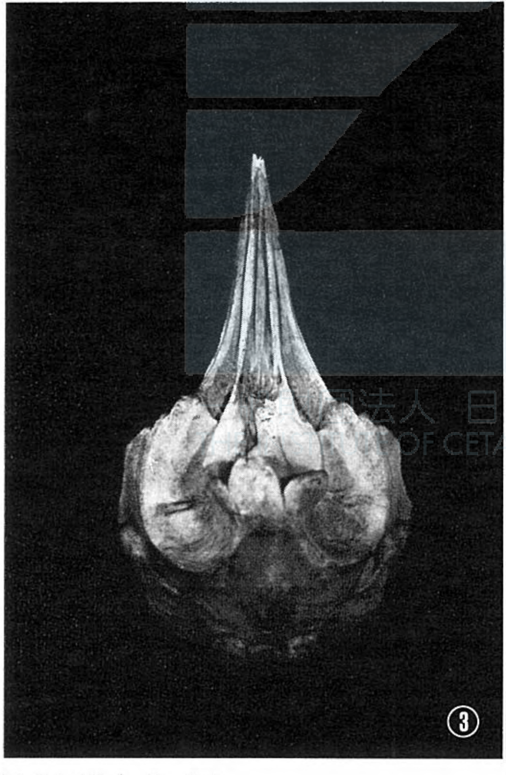
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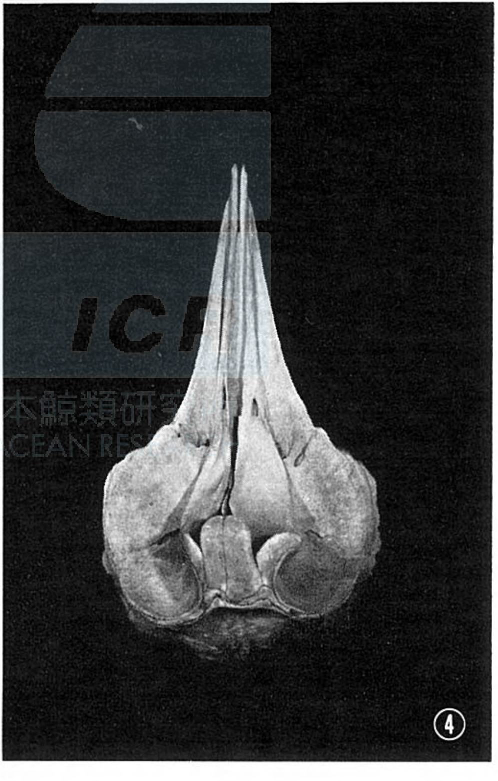
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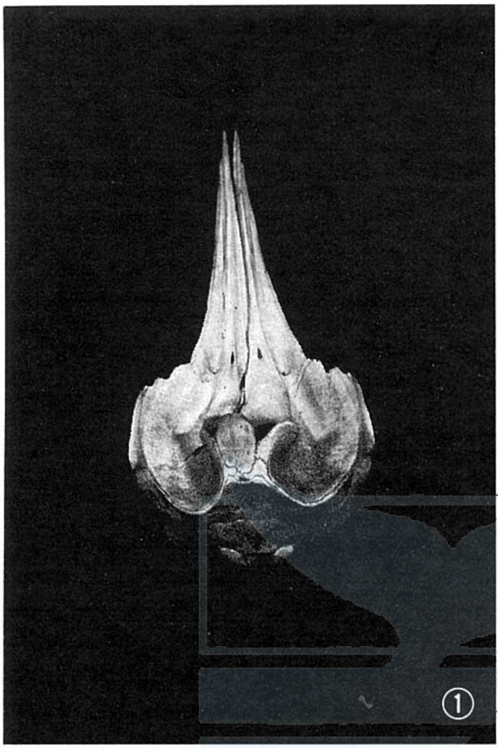
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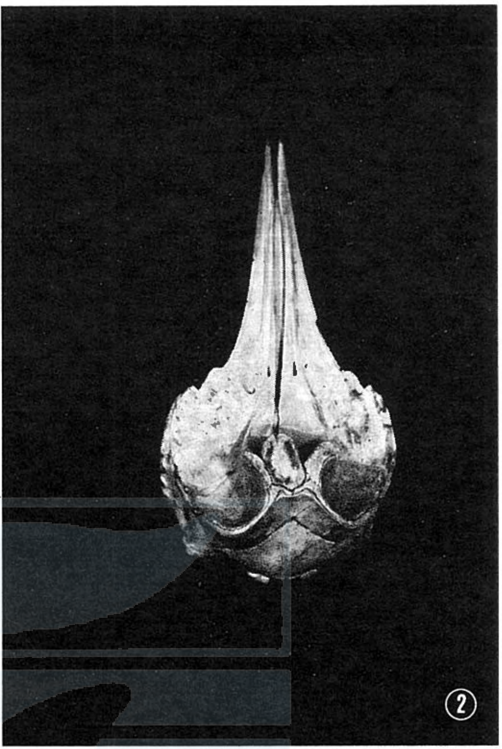
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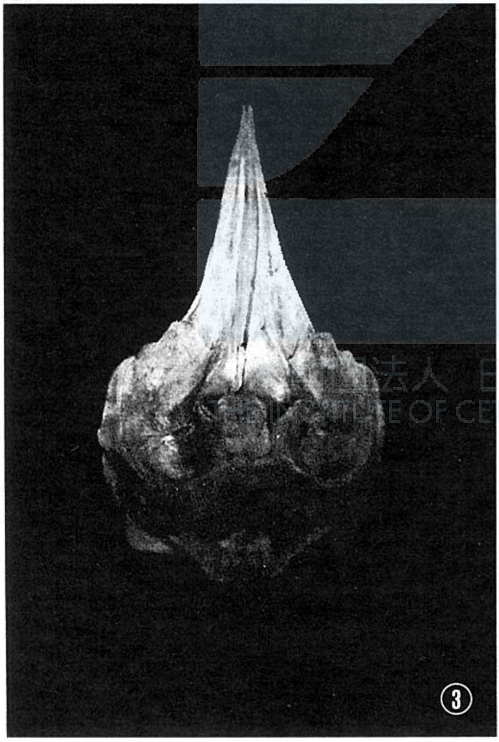
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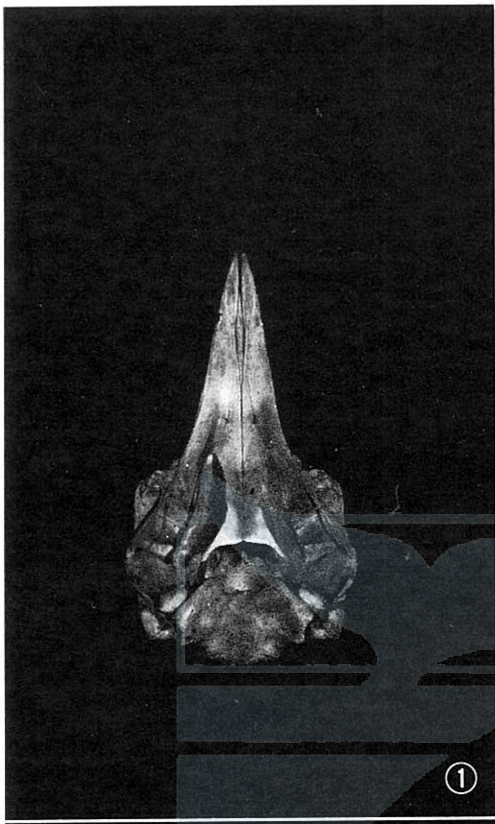
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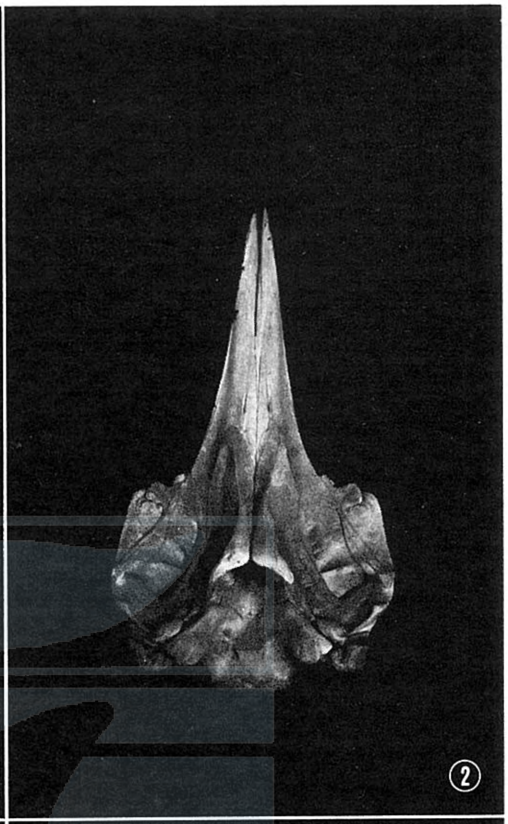
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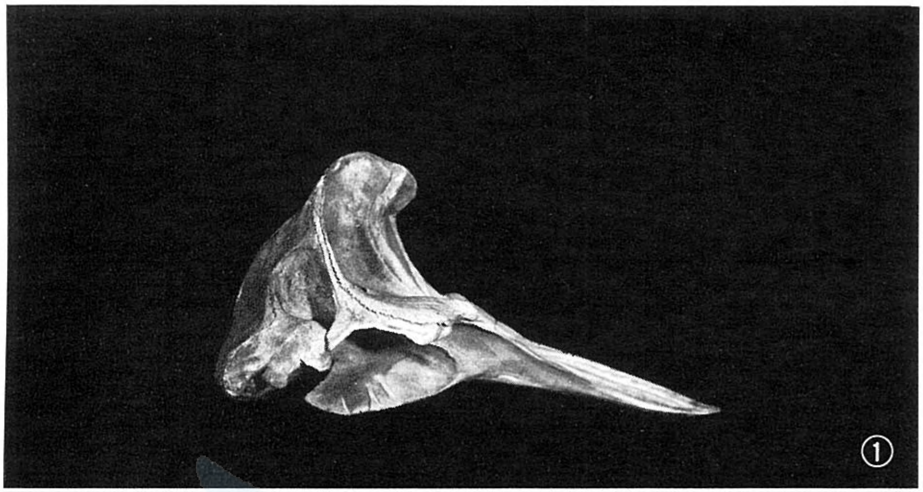

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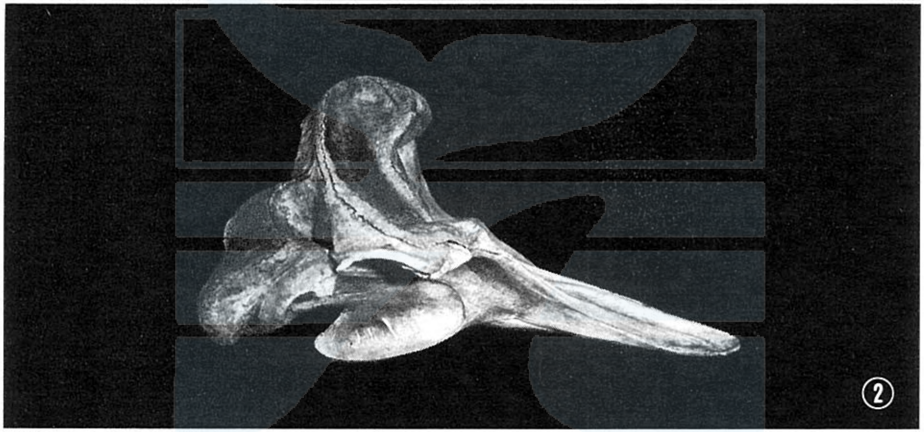

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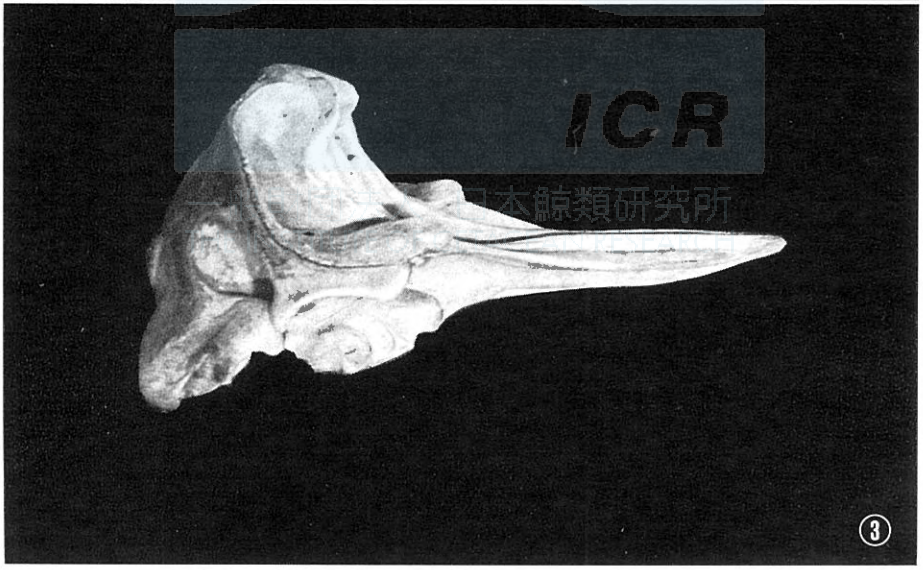

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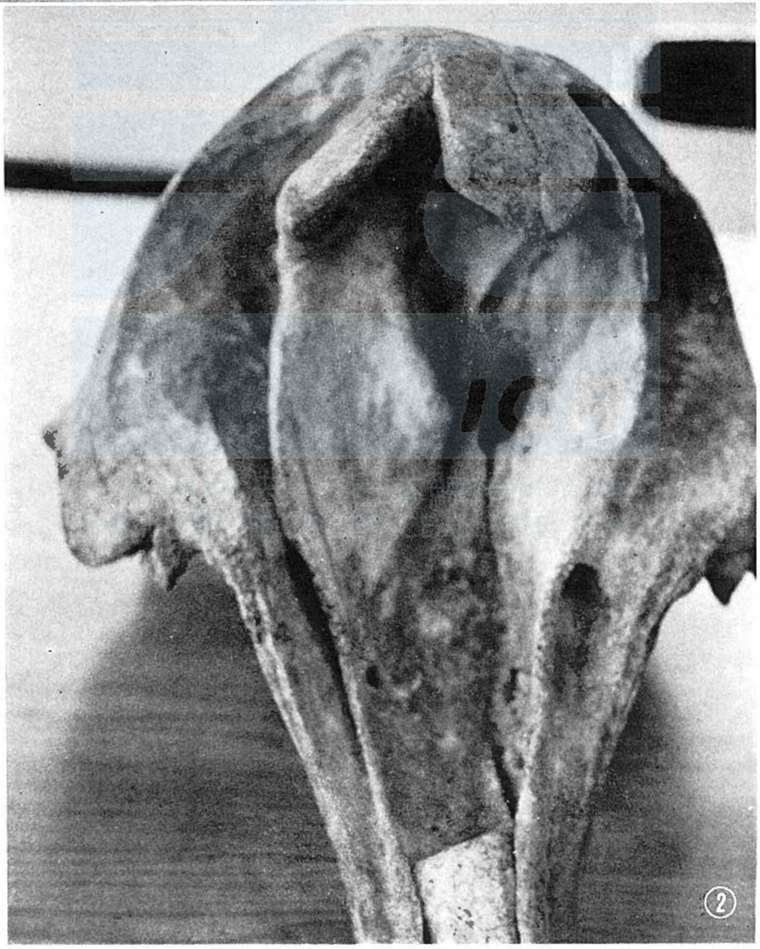

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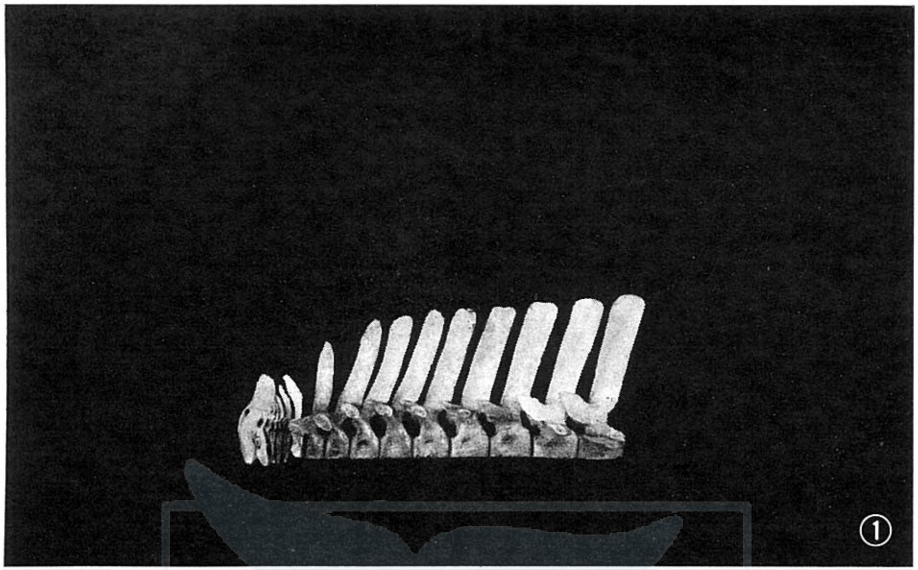

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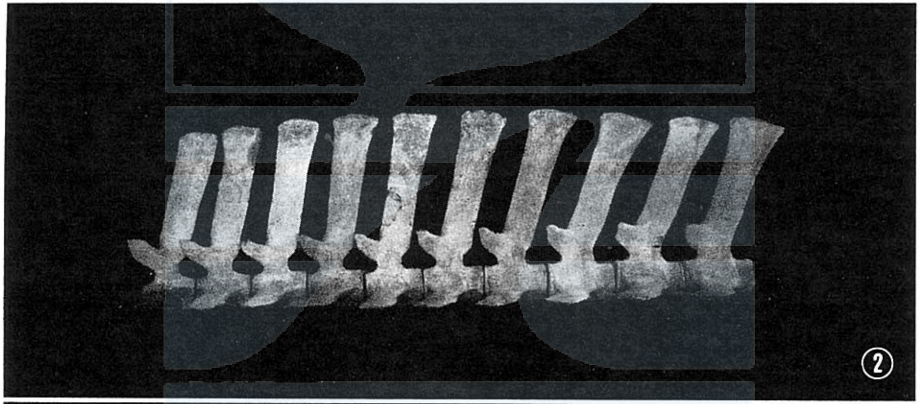

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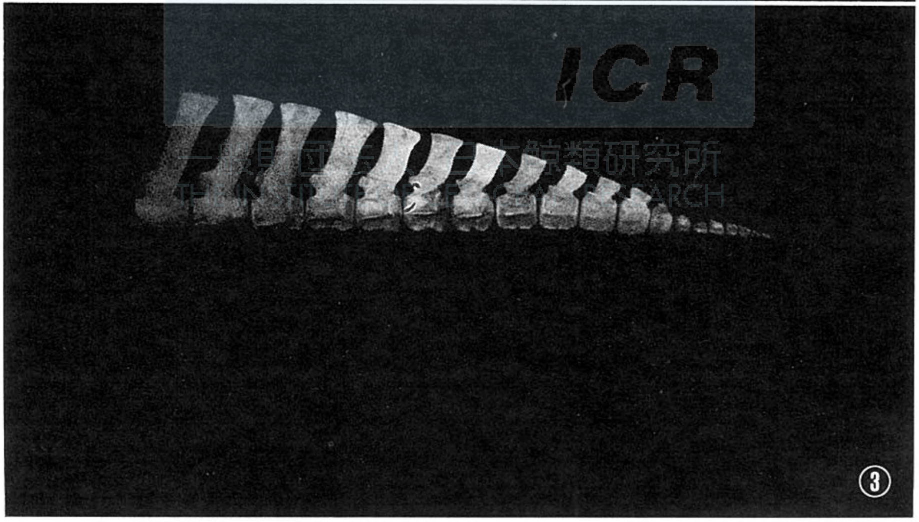

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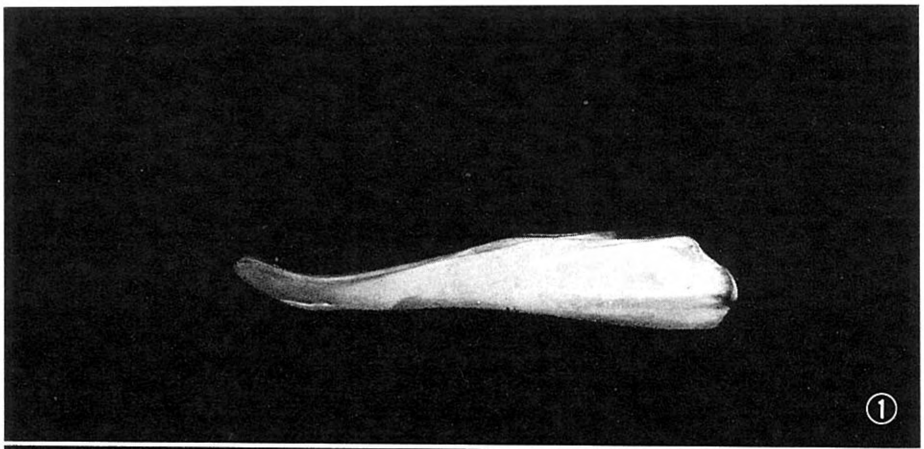
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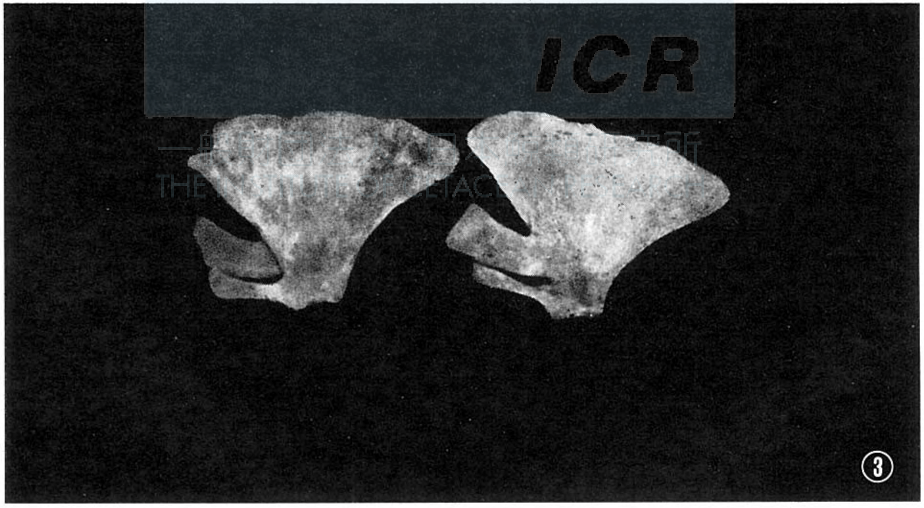
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ICR
一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

CATCH OF THE CUVIER'S BEAKED WHALES OFF JAPAN IN RECENT YEARS

MASAHARU NISHIWAKI* AND NOBUO OGURO*

ABSTRACT

We analysed Cuvier's beaked whales (*Ziphius cavirostris*) caught off the coast of Japan between 1965–70. In most cases they were caught in waters deeper than 1000 m. They eat food abounding in the surrounding waters. 70% of 189 whales were males. This tendency was the same every year, and was also reported by Omura *et al.* (1955). 87% of the whales caught were mature, and the average body length of both sexes was larger than between 1948–52. If an annual quota of 30–50 animals were to be observed, this probably would not endanger the *Ziphius* stock in the western North Pacific.

The 'smaller whale' whaling industry of Japan has been catching a considerable number of Cuvier's beaked whales (*Ziphius cavirostris*) along with Minke whales (*Balaenoptera acutorostrata*) and Baird's beaked whales (*Berardius bairdi*). Omura *et al.* (1955) reported on the Cuvier's beaked whale caught off the coast of Japan between 1948–52. The total catch during that period was 85. *Ziphius* is the least valuable of the three to the whaling industry, and hence there is less pressure on it than on the other two. It is evident that coastal whaling operations have diminished and the number of catcher boats have decreased in recent years. There must, therefore, have been some change in the different relative rates of catch of *Ziphius* and the other two species, while the total catch has been decreasing. Our discussion here concerns *Ziphius* caught between 1965–70. The data was extracted from the report by the Fisheries Agency of the Japanese Government on the harvest of the smaller whales during 1965–70.

ANALYSIS OF CATCH

The areas of the whaling operation and the precise positions of catch are shown in Fig. 1. The coastal waters are divided in the same way as by Omura *et al.* (1955). *Ziphius* whales has been taken in each of the seven areas except for VI, in which, nevertheless, Omura *et al.* has some catch records. The catch positions are mostly on the 1000 m contour or in deeper waters, and are most abundant in areas I and II. The catches are particularly numerous in Area I on account of the indented coastline and the concomitant meandering 1000 m contour.

Table 1 and Fig. 2 show the size distribution of the whales caught. Table 2 indicates the monthly catch in each area. The total catch was 189, of which 132 were males (70%) and 57 were females (30%). This rate is almost the same as re-

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* Ocean Research Institute, University of Tokyo, Tokyo.

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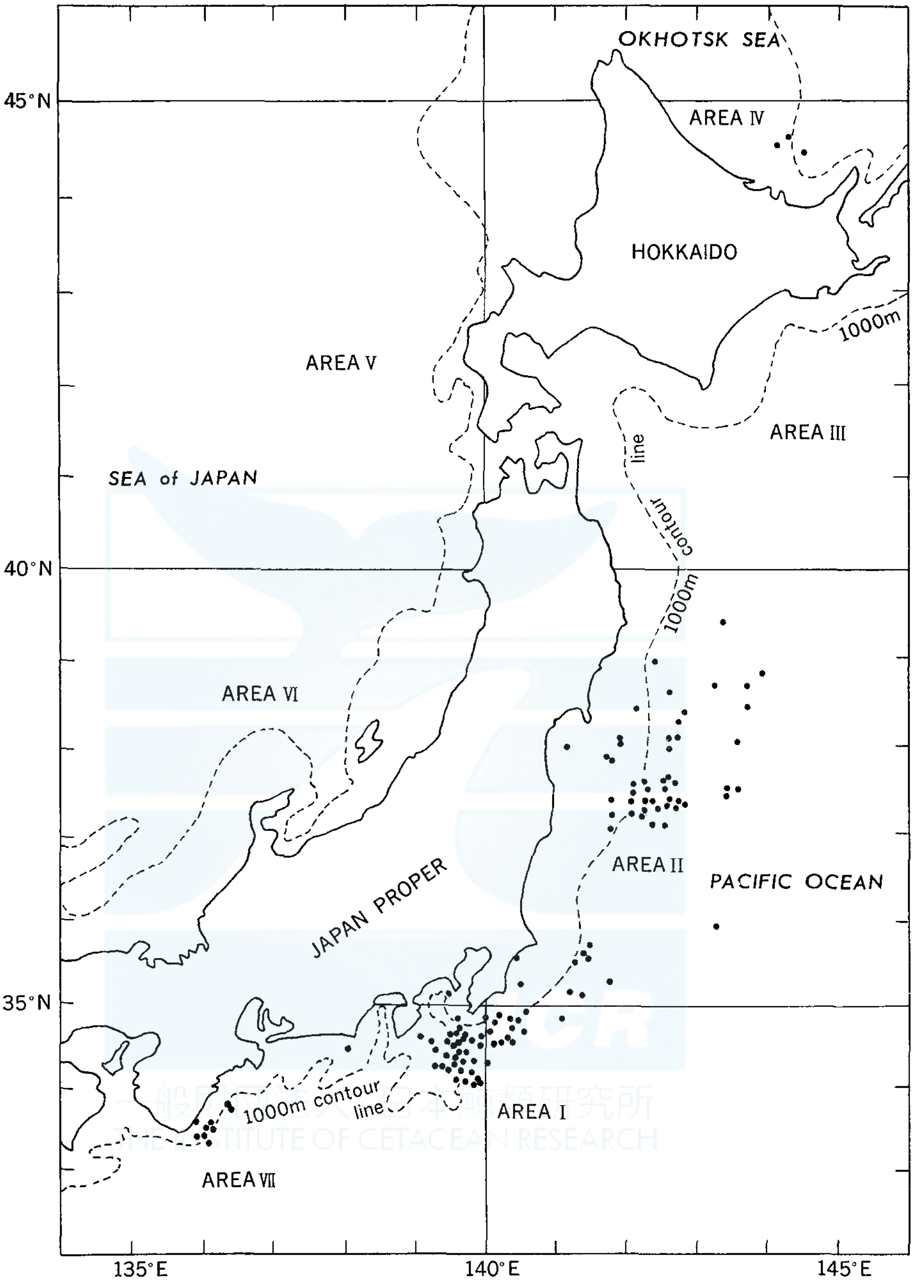

Fig. 1. Position of catch of *Ziphius cavirostris* off Japan, 1965–1970.

TABLE 1. NUMBER OF CATCH OF *ZIPHIUS AVIROSTRIS* ACCORDING TO THE MONTHS AND AREAS, 1965–1970.

Month	Area I		Area II		Area IV		Area VII		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Jan.	2	0	2	2			1	0	5	2
Feb.	18	10							18	10
Mar.	11	8					2	0	13	8
Apr.	1	0							1	0
May	6	2	1	0			3	0	10	2
June	4	2					3	0	7	2
July			1	0	1	0		*	2	0
Aug.	10	3	3	4	2	0		*	15	7
Sept.	7	6	12	1					19	7
Oct.	4	6	8	2					12	8
Nov.	2	3	20	3					22	6
Dec.	0	1	7	4			1	0	8	5
Total	65	41	54	16	3	0	10	0	132	57

* A sex unidentified individual is excluded.

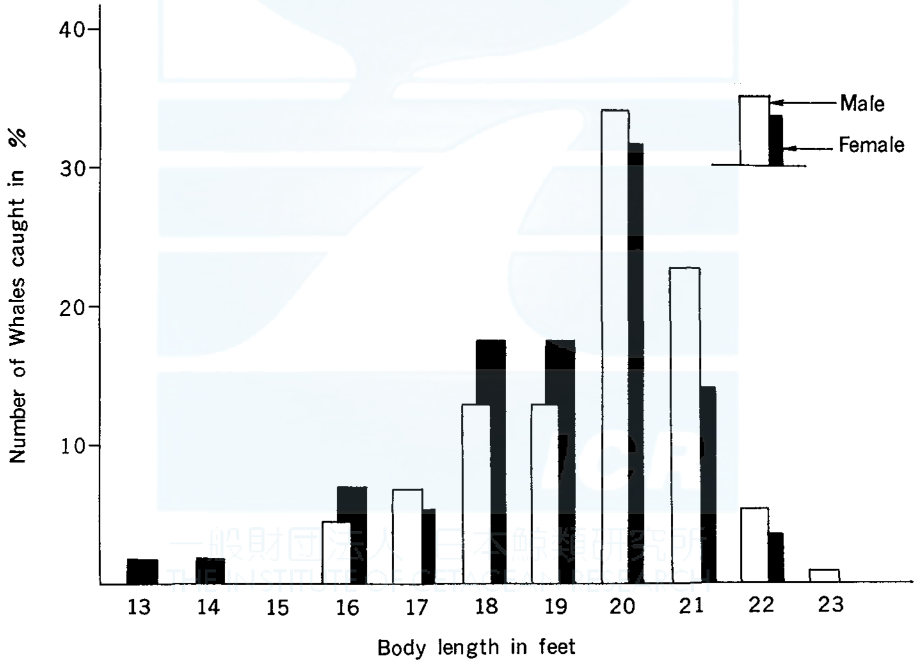

Fig. 2. Size distribution of *Ziphius cavirostris* caught, 1965–1970.

ported by Omura *et al.* The catch in each area was as follows: in area I 106 were caught, 70 in II, 3 in III and 12 (including 2 individuals of unidentified sex) in VII. In Area I, 64 were caught between Jan-June and 42 between Aug-Dec, while area II, 64 of the year's total of 70 were caught between Aug-Dec. In area IV only 3 were caught between May-June, while in area VII records are scattered throughout the

TABLE 2. AVERAGE BODY LENGTH AND SEX RATIO OF *ZIPHIUS CAVIROSTRIS* CAUGHT DIVIDED BY AREAS AND MONTHS, 1965–1970.

	Area I		Area II	
	Male	Female	Male	Female
Jan.–June				
Average length	20.1	19.8	—	—
Sex ratio	65.5	34.4	—	—
Aug.–Dec.				
Average length	18.9	18.1	19.5	19.1
Sex ratio	54.8	45.2	74.1	21.9

first six months of the year.

The whales caught in the above mentioned periods are presented in Table 2 together with the average body length of both sexes and the sex ratio. According to above mentioned data, the abundant catch in Area I between Feb-May may consist of adult males going north to chase after adult females. The whales caught in Area I in the other months may be younger males searching for food. The abundant catch in Area II between Aug-Dec seems to consist of males migrating south, some of them possibly in the company of adult females.

SIZE DISTRIBUTION

As seen in Fig. 2 and Table 3, the greatest body lengths of all the individuals caught were 23 feet for males and 22 feet for females. The most common body length for both sexes was 20 feet, while most of the catch was in the length range 18–21 feet.

There are four species of *Mesoplodon* in the western North Pacific: *M. stejnegeri*, *M. densirostris*, *M. ginkgodens* and *M. carlhubbsi*. We found some suggestions of

TABLE 3. SIZE DISTRIBUTION OF *ZIPHIUS CAVIROSTRIS* CAUGHT, 1965–1970.

Body length in feet	Number			Percentage		
	Male	Number	Total	Male	Female	Total
13		1	1		1.8	0.5
14		1	1		1.8	0.5
15						
16	6	4	*10	4.5	7.0	5.3
17	9	3	12	6.8	5.3	6.4
18	17	10	27	12.9	17.5	14.3
19	17	10	27	12.9	17.5	14.3
20	45	18	*63	34.1	31.6	33.3
21	30	8	38	22.7	14.0	20.1
22	7	2	9	5.3	3.5	4.8
23	1		1	0.8		0.5
Total	132	57	189	100.0	100.0	100.0
Sex ratio	69.8	30.2	100.0			
Maturity				88.6	84.2	87.3

* A sex unidentified individual is excluded.

TABLE 4. ANNUAL CATCH OF *ZIPHIUS CAVIROSTRIS* AND THEIR SEX RATIO ACCORDING TO AREAS, 1965–1970.

Year	Area 1		Area II		Area IV		Area VII		Total		Sex ratio	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1965	14	7	28	6	3	0	2	*0	47	13	78.3	21.7
1966	10	8	6	2			1	0	17	10	63.0	37.0
1967	19	12	7	4			3	0	29	16	64.4	35.6
1968	9	6	10	2			2	0	21	8	72.4	27.6
1969	4	2	3	2			2	0	9	4	69.2	30.8
1970	9	6							9	6	60.0	40.0
Total	65	41	54	16	3	0	10	0	132	57	69.8	30.2

* Two sex unidentified individuals are excluded.

Mesoplodon in the discarded bones around the whaling stations where *Ziphius* are processed, but there has been no report of *Mesoplodon* being caught by these companies. Therefore, the data in Fig. 2 for *Ziphius* may include some *Mesoplodon,* but the percentage of the latter is so small that it could exert no significant effect on the figures.

The catch for each year is indicated in Table 4. Although the total catch of *Ziphius* has been decreasing year by year, this may be partly due to reduced hunting effort rather than to an actual population decrease.

FOOD

The stomach contents varied according to the area in which the animals were caught, as shown in Fig. 3. The food found in the stomachs of the animals from Area I consisted mainly of deep-sea fish, but that from animals in Areas II and VII was exclusively squid. There was no food report from Area V. Therefore, deep-sea fish must have been the main food in waters deeper than 1000 m, while squid must be the main food in the shallower waters. As seen in Fig. 3, deep-sea fish were often found in the animals from Area I all through the year, but squid was sometimes found in Area II from Nov-Jan. This evidence suggests that the whales may eat whatever fish are abundant in the waters where they happen to be.

CONCLUSION

Our analysis suggests that Cuvier's beaked whale (*Ziphius cavirostris*) has been being caught throughout the year, abundant harvests being taken in Feb., Sept. and Nov. The greatest body length in our sample is 23 feet (male) and 22 feet (female). The data also suggest that the majority of *Ziphius* whale were caught in waters deeper than 1000 m. The variety of food in the stomachs examined shows that the *Ziphius* whales, like other smaller whales, eats the food most common in its surrounding waters. Both sexes of *Ziphius* seem to be about 18 feet in body length when they attain sexual maturity. 87% of the whales caught were mature, and the average

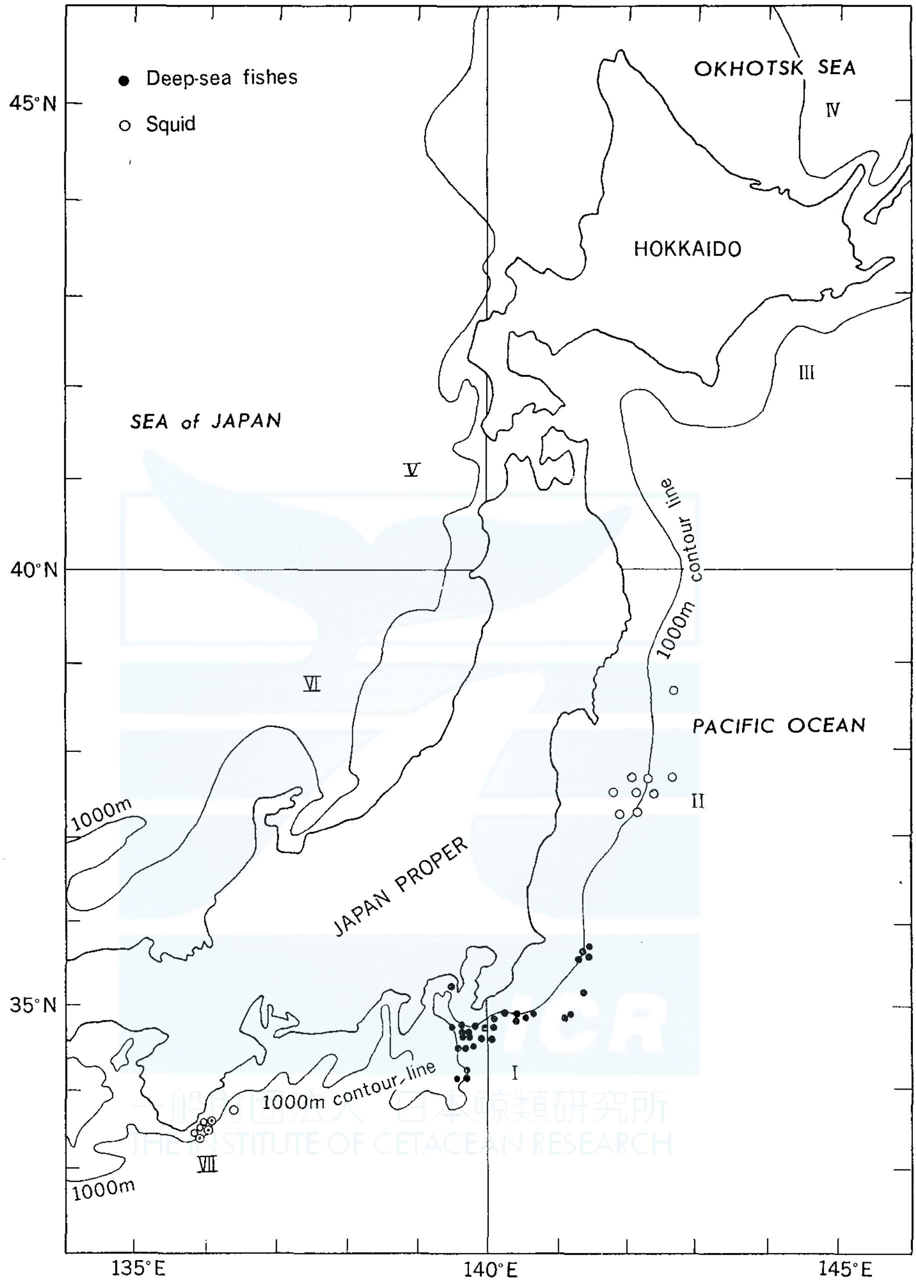

Fig. 3. Position of catch of *Ziphius cavirotris* with stomach contents, 1965–1970.

body length of both sexes from this data are greater than those in the data of Omura *et al.*

Considering that the number of new whaling boats has been decreasing continually, possibly, if the population remains in its apparently stable condition as at present, this industry may not endanger the *Ziphius* stock. Our estimate of a permissable quota, based on Omura's paper and the consistency of the average body length over the years is in the region of 30–50 animals, regardless of age or sex.

ACKNOWLEDGEMENT

We are greateful to the members of the Whaling Administration Section of the Fisheries Agency for allowing their data to be used in this report.

We would also like to thank the stuff members of the Biology of Fisheries Resources Division of the Ocean Research Institute, the University of Tokyo and Mr. T. Kubota of the Fuji Suisan Co. for their helpful advice.

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

FURTHER COMMENTS ON *MESOPLODON GINKGODENS*

MASAHARU NISHIWAKI,* TOSHIO KASUYA*
KAZUO KUREHA* AND NOBUO OGURO*

ABSTRACT

We examined two similar specimens of toothed whale recently stranded in Sagami Bay, near Tokyo, and confirmed them both to be *Mesoplodon ginkgodens*.

A comparison between these and the Oiso (type) specimen showed no distinct differences. The external measurements and osteological studies confirmed our belief in the authenticity of the type specimen.

As a result of examining the Ito specimen, we concluded that even an old male of this species has very few scars on his skin, this must be related to the incompletely erupted teeth in this species, fighting can not remain much scars.

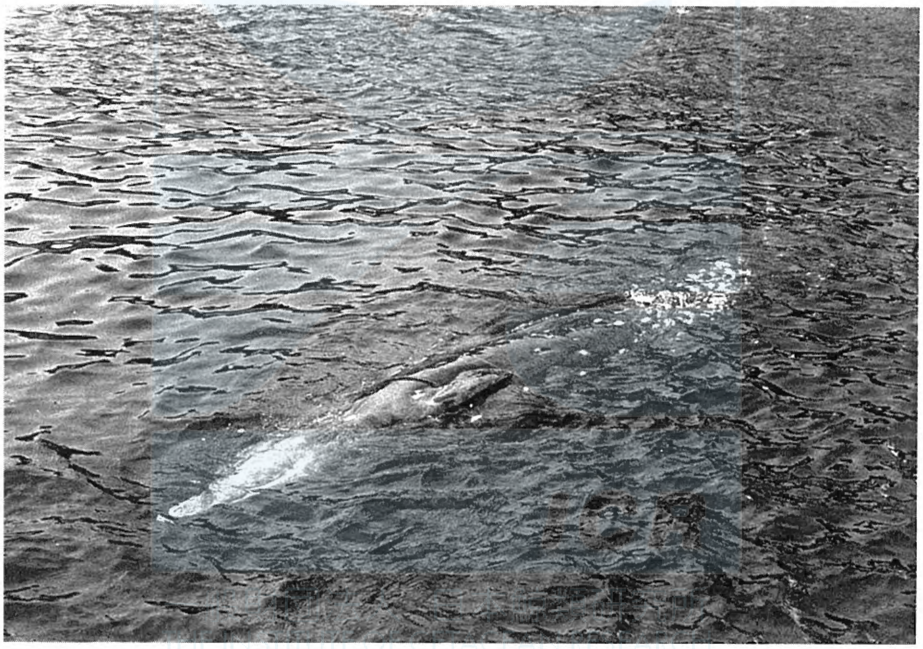

Fig. 1. Ito specimen, *M. ginkgodens* is moored at the Ito fish market. Photo by N. Oguro.

INTRODUCTION

Mesoplodon ginkgodens was first described and named by Nishiwaki and Kamiya in 1958. Some scientists have expressed doubt on the Oiso specimen of being a male *M. ginkgodens*, since most of its teeth were buried in the gum, which recalls the condition

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* Ocean Research Institute, University of Tokyo, Tokyo.

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of female *M. stejnegeri*. Moreover, from the photograph taken by an onlooker at the time of stranding, the animal bore few scars on the body surface. The intact body was only witnessed by local people and fishermen.

We are presenting here the results of our examination of two animals identified to be *M. ginkgodens*, one of which was washed ashore at Kamakura in 1968 and the other near Ito in 1971.

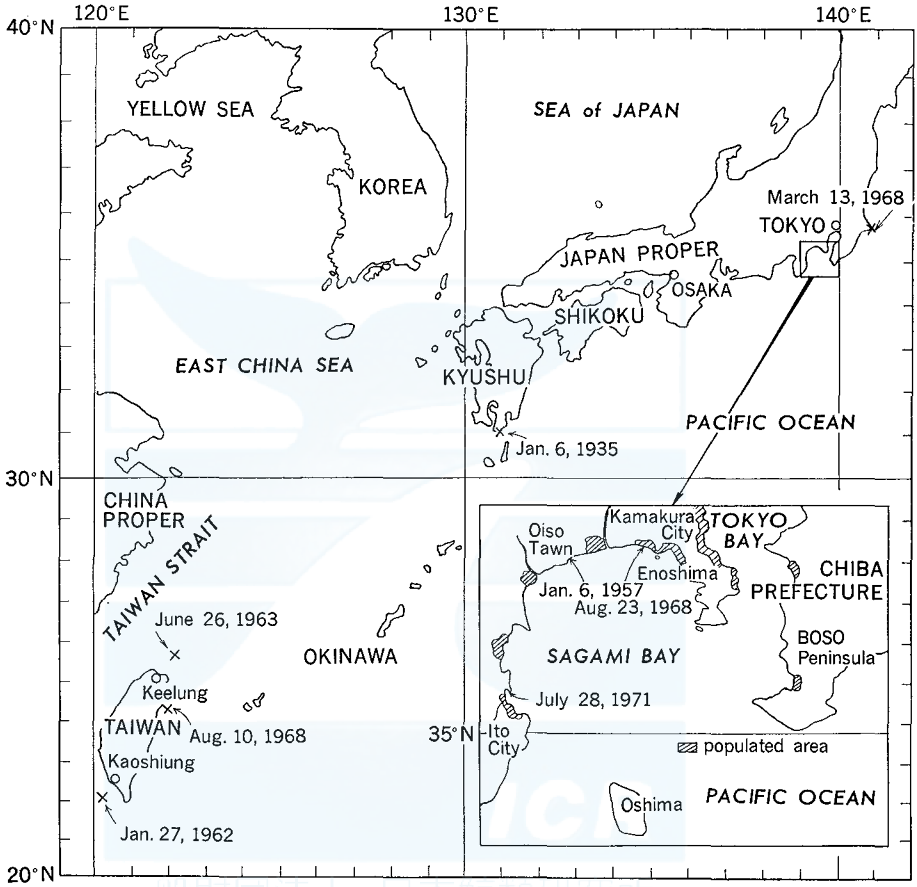

Fig. 2. The stranded or captured positions of *Mesoplodon ginkgodens*.

Besides, there was one more specimen of *M. ginkgodens* occured at Choshi City, Chiba Prefecture. A newspaper reported a strange whale stranded on the beach on March 13, 1968. We rushed at the spot but Mr. Mitsuyoshi Aoki of the Tokai University had collected it already. Two of us were allowed to study on it together and we identified it to be a *M. ginkgodens*. On this specimen, however, will be published in other paper. Therefore we only add in Fig. 2 the location and the date of stranding.

In addition, we have three informations on the specimens of *M. ginkgodens* from Taiwan waters. Mr. Hung-chia Yang of the Taiwan Fisheries Research Institute collected them. One of them appears in " Geiken Tsushin " (Yang, 1964) and other two will be published by him in near future. He kindly communicated to us.

The occurrence of eight isolated individuals of *M. ginkgodens* stranded on the coast of Japan and captured in Taiwan waters, among them, six were found within recent 10 years, suggests that this species may not be so rare in the western part of the North Pacific as has been supposed. Since groups of this animal have not been reported, the social structure of this species is still obscure; possibly they often travel solitarily.

The locality of those eight specimens are shown in the map in Fig. 2.

MATERIALS

One of our specimens (TK 242) was stranded on the beach at Kamakura, Kanagawa Prefecture, in Aug. 23, 1968. Since local people mistook it for a specimen of the commonly eaten *Ziphius cavirostris*, the flesh had been removed, and the skeleton together with the intact head had eventually been discarded on the beach. Quite by chance, Dr. Masayuki Nakajima of the Enoshima Marineland came across the skeleton. He made some external measurements at once and reported it to us. The body length was estimated by reconstructing the vertebrae, and the external measurements of the head were taken. Afterwards we also examined the bones osteologically.

The other specimen (TK 366) was washed ashore near Ito City, Shizuoka Prefecture, in July 28, 1971. It was found by a fisherman, taken to Ito fish market and sold. Mr. Akio Tamura of the Ito Aquarium happened to see it, however, and since he immediately recognised it to be *M. ginkgodens*, he rang one of us up. We measured the external body proportions, dissected it, and weighed its inner organs, and afterwards examined the skeleton osteologically.

EXTERNAL APPEARANCE

Since we received the Ito specimen intact, we were able to examine the external aspect of the body in detail and photographed it. However, as in the case of the Kamakura specimen, the information we could obtain from Dr. M. Nakajima was that the animal was a male.

As we mentioned before, the lack of scarring on the body surface of the Oiso specimen was one of the reasons that there had been some doubt as to its male identity. However, the Ito specimen, which was certainly a male, also bore very few scars. It may be that *M. ginkgodens* males are so little scarred on account of their incompletely erupted teeth. Their fighting can not remain much scars on their skin. On the ventral surface of the Ito specimen there were many scars from parasitic infections, but most of these had healed.

The external body measurements of both specimens are compared with those of the Oiso (type) specimen in Table 1. The comparison indicates no differences of any taxonomic significance among the three specimens. In both the new specimens the dorsal fin shows definite undulations (Fig. 3), and the tail fluke has no notch but

TABLE 1. EXTERNAL MEASUREMENTS OF *MESOPLODON GINKGODENS*

		Oiso specimen		Kamakura specimen		Ito specimen	
		cm	%	cm	%	cm	%
1.	Body length	472.0	100	470	100	477.0	100
2.	Head, occipital condyles to the tip of snout	80.0	16.9	—	—	—	—
3.	—, greatest width (opposite to the eyes)	43.0	9.1	—	—	—	—
4.	Projection of the lower jew beyond the snout	2.5	0.5	1.0	0.2	1.3	0.3
5.	Tip of the lower jaw to the teeth	20.5	4.3	21.5	4.8	23.9	5.0
6.	Tip of the lower jaw to the apex of teeth	40.0	8.5	37.0	7.9	—	—
7.	Tip of the lower jaw to the center of eye	51.0	10.8	51.0	10.9	57.4	12.0
8.	Tip of the lower jaw to the blowhole	49.0	10.4	48.0	10.2	53.8	11.3
9.	Breadth of the blowhole	8.0	1.7	—	—	—	—
10.	Distance between apices of both teeth	11.5	2.4	—	—	11.9	2.5
11.	Flipper, axilla to the tip	33.0	7.0	32.0	6.8	41.2	8.6
12.	Flipper, anterior insertion to the tip	51.0	10.8	50.0	10.6	54.0	11.3
13.	Flipper, greatest width	13.0	2.8	14.0	3.0	15.4	3.2
14.	Tail flukes, total spread	112.0	23.7	—	—	119	24.9
15.	Tail flukes, middle point of the hinder margin to the tip (average)	57.5	12.2	—	—	—	—
16.	Height of dorsal fin	—	—	19.0	4.4	21.4	4.8
17.	Length from tail notch to tip of dorsal fin	—	—	—	—	158	33.1
18.	,, to anus	—	—	—	—	139	29.1
19.	,, to umbilicus	—	—	—	—	218	45.7

Fig, 3. Dorsal fin of *M. ginkgodens*, Ito specimen.

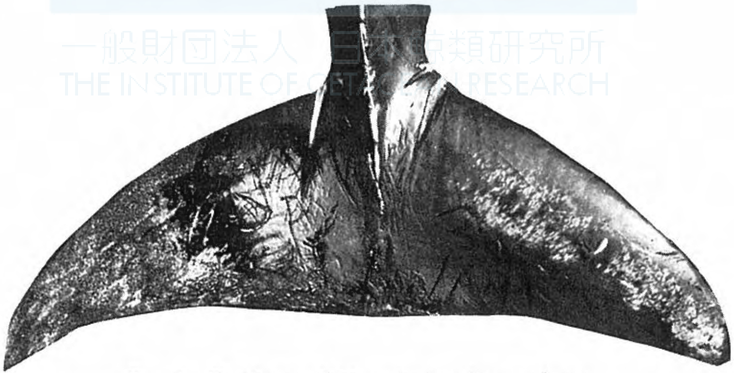

Fig. 4. Tailflukes of *M. ginkgodens*, Ito specimen.

its posterior is a little swollen (Fig. 4). The Oiso specimen also lacked the tail fluke notch. The left flipper of the Ito specimen was photographed and its phalangeal bones are shown in Fig. 5.

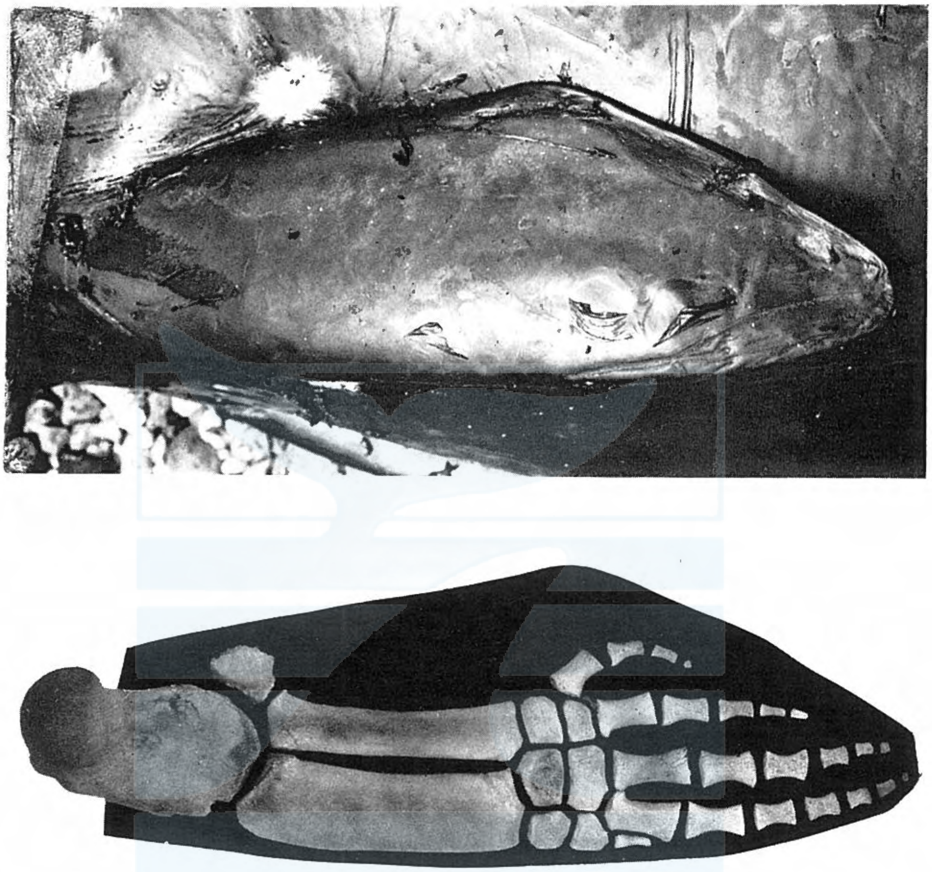

Fig. 5. Left flipper and phalangeal bones of *M. ginkgodens*, Ito specimen.

INNER ORGANS

Fig. 6 is a photograph of the left side view of exposed inner organs in the body cavity of Ito specimen. We found no unusual feature in them, in general, as organs of a toothed whale. But a considerable hypertrophy is seen in the spleen. We can not tell whether it is a normal size or a pathologic phenomenon caused by stranded stress. Although this species is a close relative of *Ziphius cavirostris* which has the stomach with multiple compartments, the stomach seen in this specimen was of dolphin type. The kydney is located comparatively posteriorly and the heart is larger in proportion than to those in other toothed whales.

Weight of each organ is indicated in Table 2.

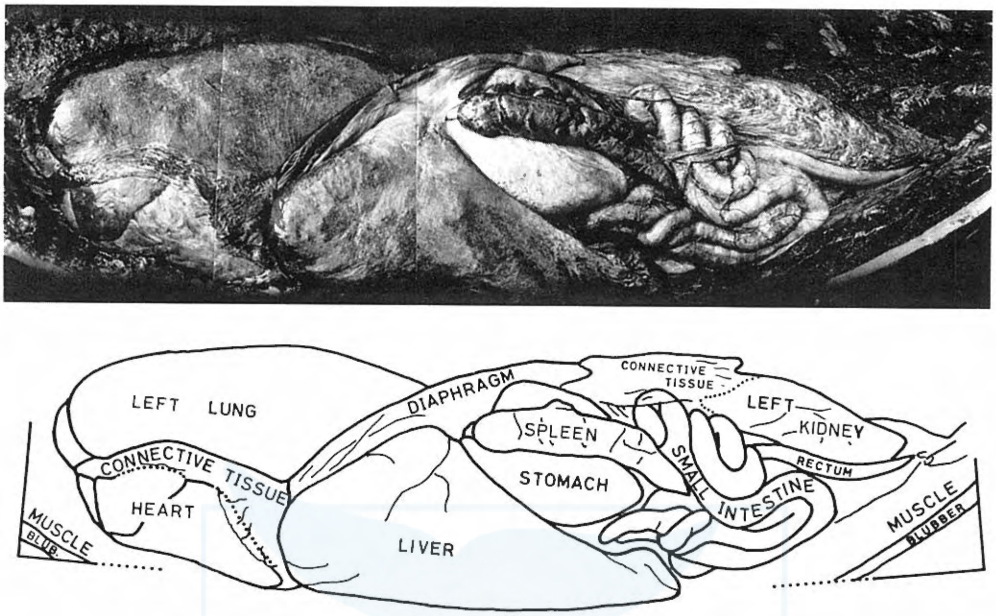

Fig. 6. Inner organs of *M. ginkgodens*, Ito specimen, showing their shape and position.

TABLE 2. WEIGHT OF INTERNAL ORGANS OF *MESOPLODON GINKGODENS*, ITO SPECIMEN (in Kg)

Lung	R.	10.80	Pancreas and Omentum		2.15
	L.	10.70	Corpus suprarenale	L.	0.010
Heart		5.60	Kidney	R.	8.40
Trachea and Esophagus		1.90		L.	7.20
Stomach[1)]		7.40	Urinary bladder		0.130
Intestine[2)]		11.10	Diaphragm		2.40
Mesenterium		1.78	Testis	R.	0.130
Liver		12.20		L.	0.140
Spleen		1.01	Others		2.29

1) Include stomach contents, 2) 16 m in length.

The testis weights of the Ito specimen were 140g (left) and 130g (right). These weights are unusually small compared with those from other whales of similar size. However, we are not yet able to tell if the condition of this animal was typical or pathological. The periferal tissue in the testis was in the puberty stage, mature tissue and sperm being found only around the ampulla of the vas deferens. Unfortunately there have been no previous descriptions of the *Mesoplodon* testis with which to compare our findings.

OSTEOLOGICAL EXAMINATION

Table 3 compares the skull dimensions of the three specimens in order to detect any differences between the Oiso (type) specimen and the other two. However, apart

TABLE 3. SKULL DIMENSIONS OF *MESOPLODON GINKGODENS*

			Oiso specimen		Kamakura specimen		Ito specimen	
			mm	percemtage to the length	mm	percentage to the length	mm	percentage to the length
1.	Total (condylo-basal) length		779	100	716	100	762	100
2.	Length of rostrum (median)		476	61.1*	426	59.6	456	60.2
3.	Breadth of rostrum at base		208	26.7*	201	28.1	215	28.2
4.	Breadth of rostrum at middle		64	8.2	63	8.8	59	7.8
5.	Depth of rostrum at middle		54	6.9	—	—	47	6.2
6.	Breadth of premaxillae at middle of rostrum		47	6.0	—	—	47	6.2
7.	Breadth of premaxillae opposite premaxillary foramina		69	8.9	56	7.8	77	10.2
8.	Length of nasal suture line		48	6.2*	48	6.7	54	7.0
9.	Distance from tip of rostrum to anterior end of vomer visible on palate		160	20.5	140	19.6	207	27.3
10.	*Distance from tip of rostrum to* anterior margin of superior nares		578	74.2	499	69.7	547	72.2
11.	Greatest breadth across zygomatic processes of squamosal		357	45.7*	350	48.9	363	47.9
12.	Breadth across posterior margins of temporal fossae		218	28.0	200	27.9	227	29.8
13.	Length of tympanic bone	L.	41	5.3	41	5.7	45	5.9
		R.	42	5.4	43	6.0	46	6.1
14.	Breadth of occipital condyles		126	16.2	111	15.5	117	15.4
15.	Breadth of foramen magnum		47	6.0	38	5.3	40	5.3
16.	Height, vertex to inferior border of pterygoids		293	37.6	277	38.7	303	40.0
17.	Length of mandible	L.	666	85.5	621	86.7	640	84.5
		R.	672	86.3	621	86.7	642	84.7
18.	Length of symphysis		184	23.6	162	22.6	179	23.6
19.	Distance from anterior end of mandible to anterior end of alveolus	L.	180	23.1	193	27.0	211	27.9
		R.	183	23.5	199	27.8	213	28.1
20.	Distance from anterior end of mandible to posterior end of alveolus	L.	277	35.6	226	31.6	302	39.9
		R.	282	36.2	229	32.0	300	39.6
21.	Depth between angle and coronoid process	L.	121	15.5	110	15.4	114	15.0
		R.	122	15.7	111	15.5	115	15.2
22.	Length of tooth	L.	91	11.2	—	—	81	10.7
		R.	92	11.6	66	9.2	79	10.4
23.	Breadth of tooth at cervix (antero-posterior)	L.	99	12.7	—	—	83	11.0
		R.	99	12.7	56	7.8	77	10.2
24.	Breadth of tooth (transverse)	L.	16	2.1	11	1.5	16	2.1
		R.	16	2.1	11	1.5	16	2.1

* The figures have been changed from formerly published data (Nishiwaki and Kamiya, 1958).

TABLE 4. DIMENSIONS OF THE VERTEBRAE

Number of vertebrae		Kamakura specimen			Ito specimen				
		(1)	(2)	(3)	(1)	(2)	(3)	(4)	(5)
C.	1st						135		
	2nd*	53	131	183	33	124	118	42	52
	3rd						110		
	4th	16	100	82	14	95	92	42	39
	5th	16	104	88	14	106	92	41	42
	6th	17	104	95	15	120	88	43	43
	7th	19	136	128	20	158	124	47	47
D.	1st	25	183	156	26	198	159	48	57
	2nd	38	237	166	32	244	169	51	56
	3rd	50	262	163	49	266	171	53	53
	4th	58	271	158	57	279	164	52	53
	5th	65	281	157	62	280	164	53	51
	6th	71	290	156	67	283	162	54	47
	7th	78	303	154	73	295	156	50	44
	8th	85	313	109	79	299	154	49	40
	9th	89	321	197	85	306	175	48	34
	10th	95	322	266	92	319	233	46	32
L.	1st	101	334	289	97	327	275	45	32
	2nd	104	348	293	102	337	277	43	32
	3rd	108	360	296	107	355	286	42	32
	4th	111	366	296	111	361	291	43	32
	5th	115	375	291	115	367	294	42	31
	6th	118	372	283	119	372	294	43	31
	7th	123	377	276	124	379	294	40	29
	8th	131	379	266	129	390	293	34	23
	9th	134	379	261	134	395	286	30	24
	10th	138	368	261	138	395	277	30	22
	11th	142	354	262	142	386	272	28	21
Ca.	1st	140	346	257	143	381	269	23	18
	2nd	133	325	241	142	362	257	18	15
	3rd	127	307	223	130	341	235	15	14
	4th	122	287	204	123	313	218	14	14
	5th	116	257	181	115	281	196	12	12
	6th	109	232	147	107	247	169	11	10
	7th	106	203	121	100	224	143	10	8
	8th	101	172	98	95	190	117	10	9
	9th	94	148	(83)	90	166	97	7	7
	10th	89	119	(78)	83	141	82	6	6
	11th	75	(86)	(78)	69	113	76	3	4
	12th	54	(75)	(75)	50	78	76	—	—
	13th	44	(60)	(70)	40	61	70	—	—
	14th	39	(50)	(55)	37	51	62	—	—
	15th	37	(45)	(51)	36	48	54	—	—
	16th	36	(37)	(46)	35	43	50	—	—
	17th	32	(30)	(43)	32	33	44	—	—

Continued . . .

TABLE 4. Continued.

Number of vertebrae	Kamakura specimen			Ito specimen				
	(1)	(2)	(3)	(1)	(2)	(3)	(4)	(5)
18th	28	25	37	29	28	36	—	—
19th	24	19	29	24	22	30	—	—
20th	22	16	26		17	26	—	—
*				34				
21th	8	8	11		10	12	—	—

(1)=Length of body at center
(2)=Total height at anterior
(3)=Breadth between ends of transverse processes
(4)=Greatest height of neural canal
(5)=Greatest breadth of neural canal

C7+D10+L11+Ca21=49
* fused

from some minor individual differences, there was no distinct disparity.

There are various controversial criteria for defining the rostrum base. We chose to adopt the method of Moore (1963) who has carried out the most detailed examination of the *Mesoplodon* skull to date. The measurements of the Oiso specimen according to this method are a little different from those we published originally (Nishiwaki and Kamiya, 1958). The figures in Table 3 which have been changed accordingly are indicated by an asterisk.

The vertebral dimensions of two new specimens are shown in Table 4.

The rib collections from the Oiso and Kamakura specimens were not complete, but we presumed the complete number of the thoracic vertebrae to be ten from the shape and condition of the remaining ribs and attached vertebral bones. The rib measurements of Ito specimen are shown in Table 5. The Ito specimen was the first one which we collected with a complete rib cage, and many of its ribs on both sides had been broken and healed, as seen in the Plate VIII.

The number of lumbar vertebrae were 10 in the Oiso skeleton and 11 in the other two. This difference may only be due to difficulties in identifying the chevron bones, which are sometimes very small or not ossified, and then missed when the

TABLE 5. DIMENSIONS OF RIBS OF *MESOPLODON GINKGODENS*, ITO SPECIMEN (in mm).

Number of rib	Straight length		Along visceral border		Breadth at middle	
	Left	Right	Left	Right	Left	Right
1	320	313	435	445	54	54
2	449	453	580	587	44	43
3	518	535	678	682	34	33
4	567	583	732	743	31	31
5	587	592	745	741	29	30
6	589	595	745	746	30	29
7	602	618	742	746	30	30
8	606	614	705	695	28	28
9	559	578	648	638	27	26
10	508	506	568	545	18	18

bones are collected. Distinguishing between the lumbar and caudal vertebrae was therefore difficult.

The vertebral formula was same in the new specimens shown as follows:

$$C\,7+D\,10+L\,11+Ca\,21=49$$

In the vertebral column of Kamakura specimen, between No. 3 thoracic and No. 3 caudal vertebrae, their centrum and epiphyses have not ankylosed. On the other hand, all those in the Ito specimen have ankylosed as well as in the Oiso (type) specimen.

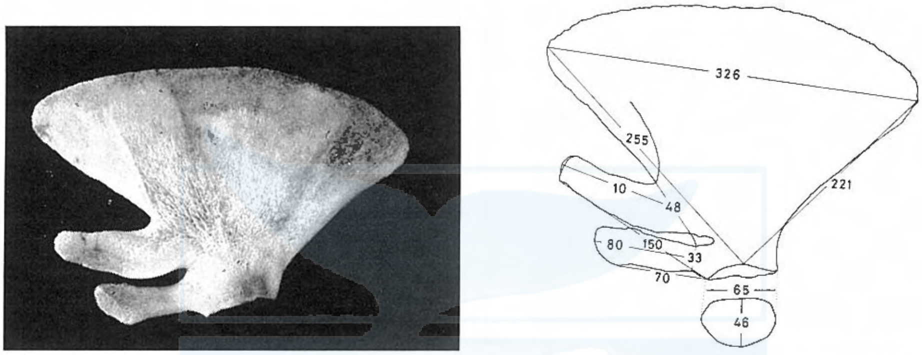

Fig. 7. Scapula of *M. ginkgodens*, Ito specimen and the measurements of Kamakura specimen.

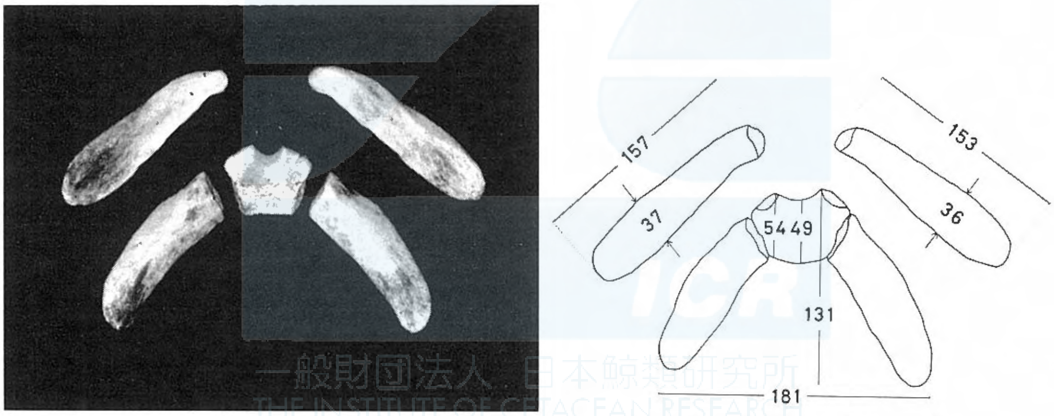

Fig. 8. Hyoid bones of *M. ginkgodens*, photograph of Kamakura specimen and measurements of Ito specimen.

The photographs of scapula, hyoids and pelvic bones of Ito specimen and the drawings and dimensions of scapula, hyoids and sternum bones of Kamakura specimen are shown in Fig. 7 through 10.

The dimensions of the chevron bones (Fig. 11) are indicated in Table 6.

Plate V shows the dorsal view of the mandible and teeth from each specimen, and Plate VI compares the inner-lateral and ventral root views of the right side tooth from each specimen. Although the absolute ages cannot be determined from the teeth alone, the Kamakura specimen was certainly the youngest, but the elder two were indistinguishable. In the three specimens all but the apices of the teeth were buried under the gum.

The number of phalanges in both flippers of Ito specimen is shown by following formula.

I: 1, II: 7, III: 6, IV: 5, V: 4

Because of the partial decomposition, the reliable count was not obtained in Kamakura specimen.

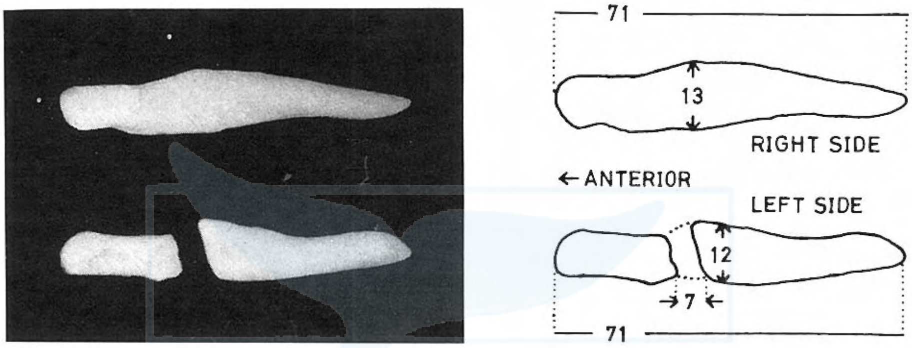

Fig. 9. Pelvic bones of *M. ginkgodens*, Ito specimen.

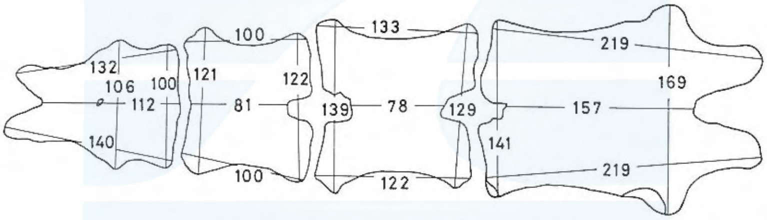

Fig. 10. Dimensions of sternal bones of *M. ginkgodens*, Ito specimen.

Fig. 11. Chevron bones of *M. gingodens*, Kamakura specimen.

We have discussed in an earlier paper (Nishimura and Nishiwaki, 1964) on the confusion over the four species of *Mesoplodon* in the North Pacific, *M. ginkgodens, M. densirostris, M. stejnegeri* and *M. carlhubbsi*. The Ayukawa speciemn (Nishiwaki and

TABLE 6. DIMENSIONS OF CHEVRON BONES OF *MESOPLODON GINKGODENS*, ITO SPECIMEN (in mm).

Number of chevron		Greatest length (antero-posterior)	Greatest breadth	Greatest height (supero-inferior)
1	R	54	—	49
	L	57	—	51
2		79	55	118
3		92	49	132
4		102	49	116
5		89	49	97
6		83	49	80
7		88	51	62
8		74	45	42
9		60	37	29
10	R	24	—	19
	L	24	—	14
11	R	18	—	10

Kamiya, 1969) attributed to *M. stejnegeri* was ascribed to *M. carlhubbsi* by Moore (1963) on the basis of several skull features including the controversial maxillary crest. The Akita speciemn (Nishiwaki, 1962) originally considered to be a *M. bowdoini*, was reidentified to be *M. stejnegeri* by Moore (1963), using similar criteria and viewing from the point of distributed area. While we are in agreement with the result of his identification, we consider that there will still remain some question on the validity of the morphology of maxillary crest as the specific character.

SUMMARY

1. We examined two similar specimen of toothed whale stranded in Sagami Bay, one of which was at Kamakura in 1968 and the other near Ito in 1971.
2. Their external proportions were little different from those of the Oiso (type) specimen.
3. There were no distinct osteological differences between these two and the Oiso (type) specimen.
4. The vertebral formula of the two specimens is as follows:

   C 7+D 10+L 11+Ca 21=49

5. The phalangeal formula for Ito specimen is as follows:

   I: 1, II: 7, III: 6, IV: 5, V: 4

6. We considered the two specimens to be *M. ginkgodens*.
7. The Oiso specimen (NSMT-M8744) is kept in the National Museum, while the Kamakura (TK 242) and Ito specimens (TK 366) are kept in the Taiji whale museum and the Ocean Research Institute of the University of Tokyo respectively.

ACKNOWLEDGEMENT

We wish to express our sincere gratitude to Dr. Masayuki Nakajima of the Enoshima Marineland and Mr. Akio Tamura of the Ito Aquarium who keenly noticed the rarely occurred individuals of *M. ginkgodens* and informed us.

We acknowledge the kindness of Mr. Hung-chia Yang of the Taiwan Fisheries Research Institute who informed us the catch position of the Taiwan specimens of *M. ginkgodens*.

Our sincere thanks are also due to Mr. Mitsuyoshi Aoki of the Tokai University who informed us the data of the Chōshi specimen.

We indebted deeply to Dr. Yoshinori Imaizumi of the National Science Museum for his contribution toward our re-examination on Oiso (type) specimen in the Museum.

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EXPLANATION OF THE PLATES

PLATE I

1. Right lateral aspect of *Mesoplodon ginkgodens,* Ito specimen.
2. Ventral aspect of *Mesoplodon ginkgodens,* Ito specimen.
3. Left side head of *Mesoplodon ginkgodens,* Ito specimen
4. Dorsal view of the snout of *Mesoplodon ginkgodens,* Ito specimen, showing the apices of teeth.

PLATE II

Dorsal view of the skulls of *Mesoplodon ginkgodens,* Oiso (Type), Kamakura and Ito specimens (top to bottom).

PLATE III

Ventral view of the skulls of *Mesoplodon ginkgodens,* Oiso (Type), Kamakura and Ito specimens (top to bottom).

PLATE IV

Lateral view of the skulls of *Mesoplodon ginkgodens,* Oiso (Type), Kamakura and Ito specimens (top to bottom).

PLATE V

Dorsal view of mandibles of *Mesoplodon ginkgodens,* Oiso (Type), Kamakura and Ito specimens (top to bottom).

PLATE VI

Left lateral view of vertebral column of *Mesoplodon ginkgodens,* Kamakura specimen, cervicals and thoracics, lumbars and caudals (top to bottom).

PLATE VII

Left leteral view of vertebral column of *Mesoplodon ginkgodens,* Ito specimen, cervicals and thoracics, lumbars and caudals (top to bottom).

PLATE VIII

Ventral view of rib cage with sternums of *Mesoplodon ginkgodens,* Kamakura specimen.

PLATE IX

Dorsal view of rib cage of *Mesoplodon ginkgodens,* Ito specimen.

PLATE X

Inner-lateral view and ventral view of right side tooth of *Mesoplodon ginkgodens,* Oiso (Type), Kamakura and Ito specimens (top to bottom).


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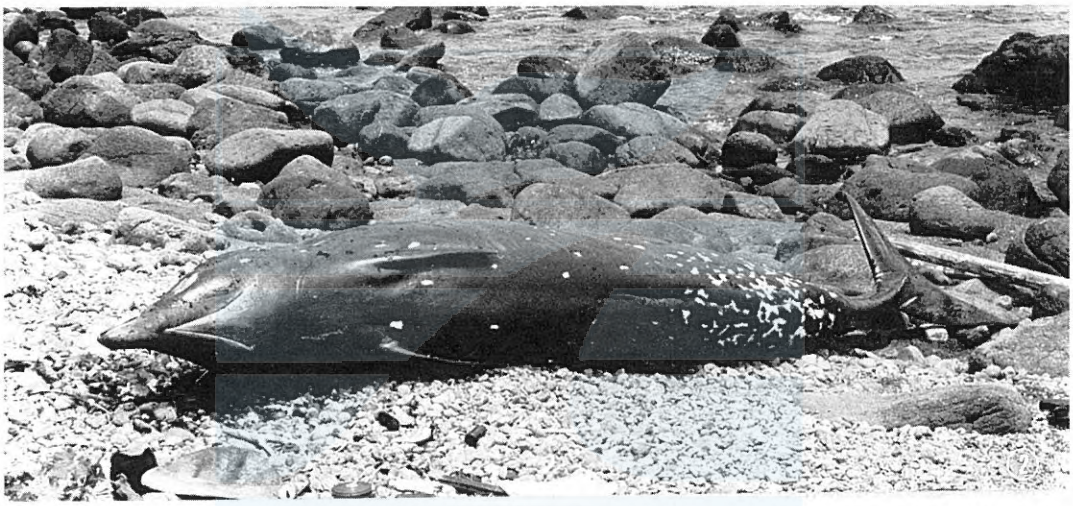
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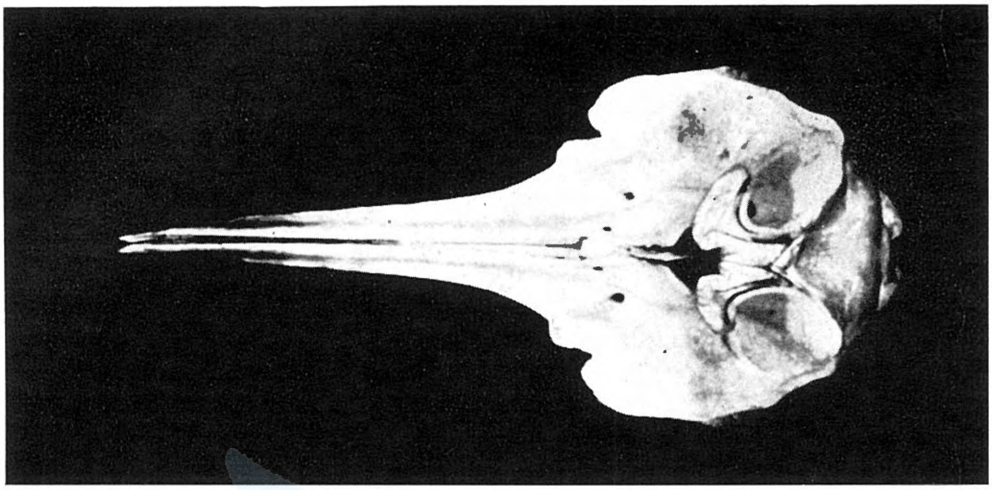

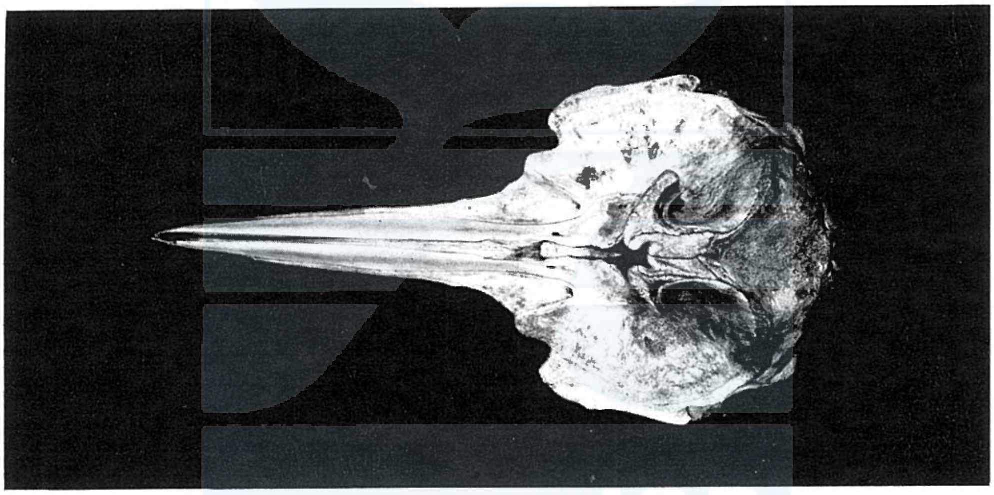

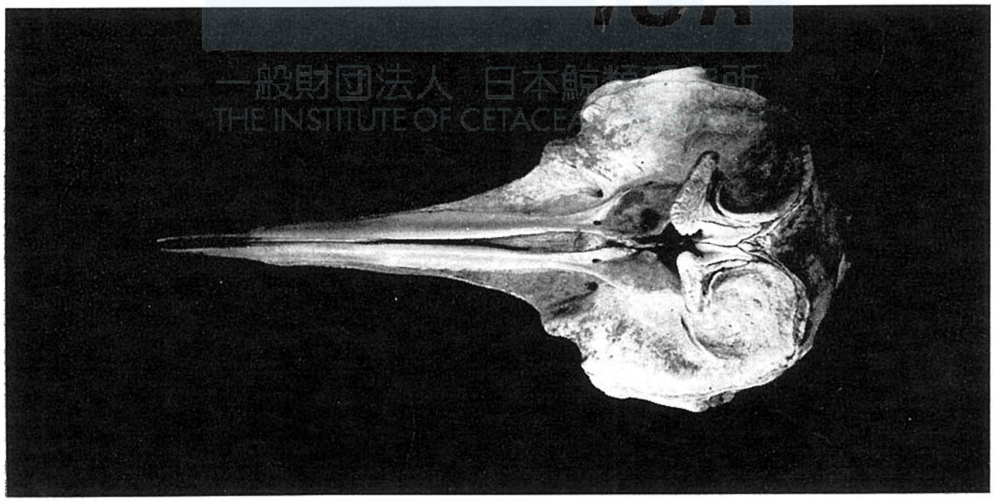

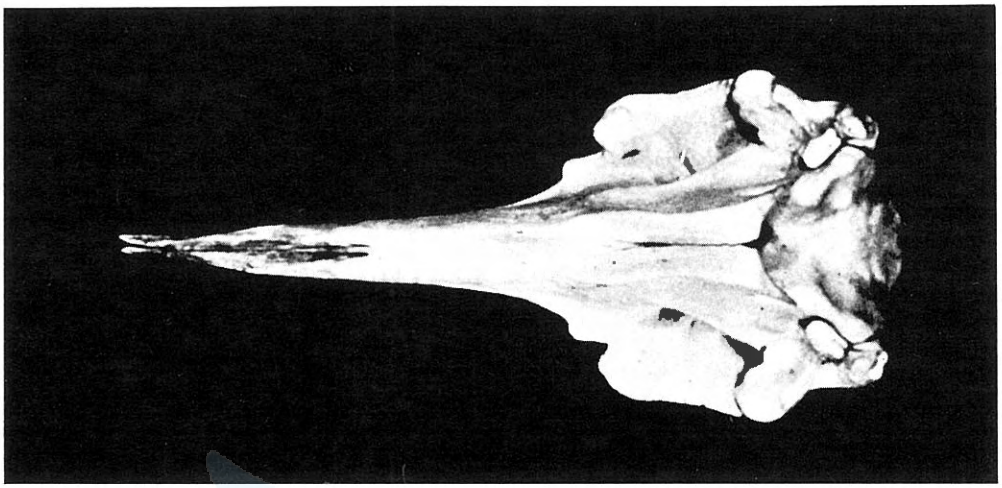

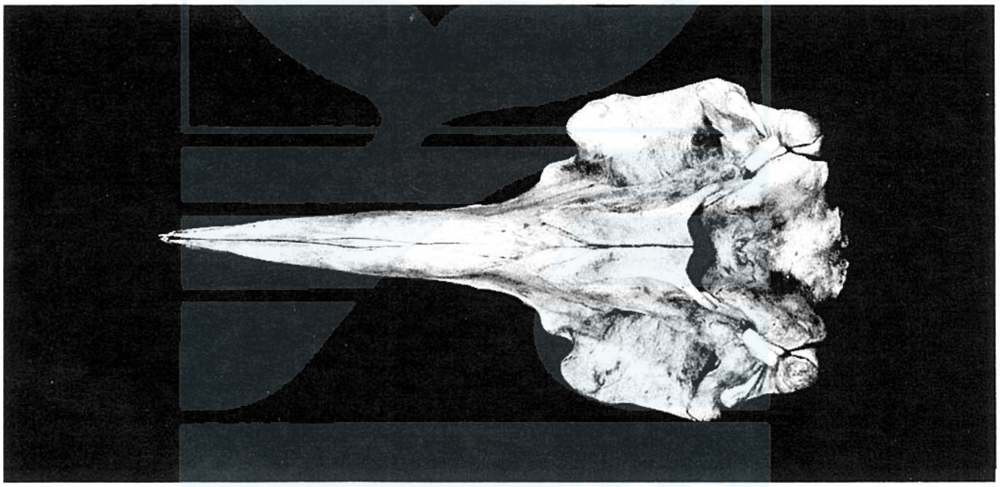

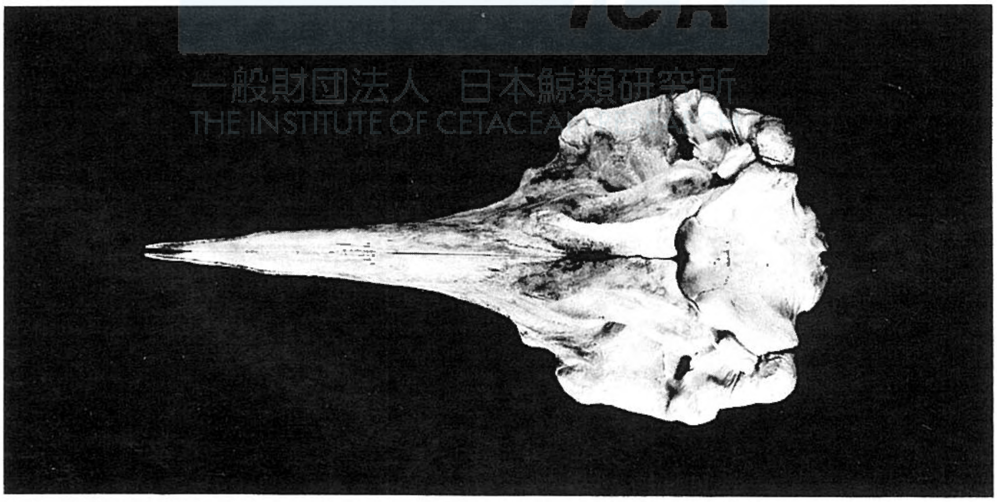

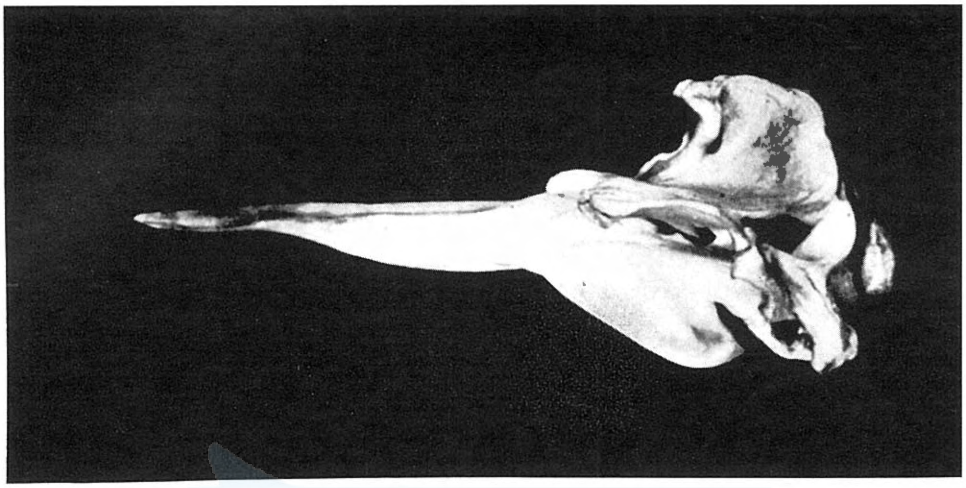

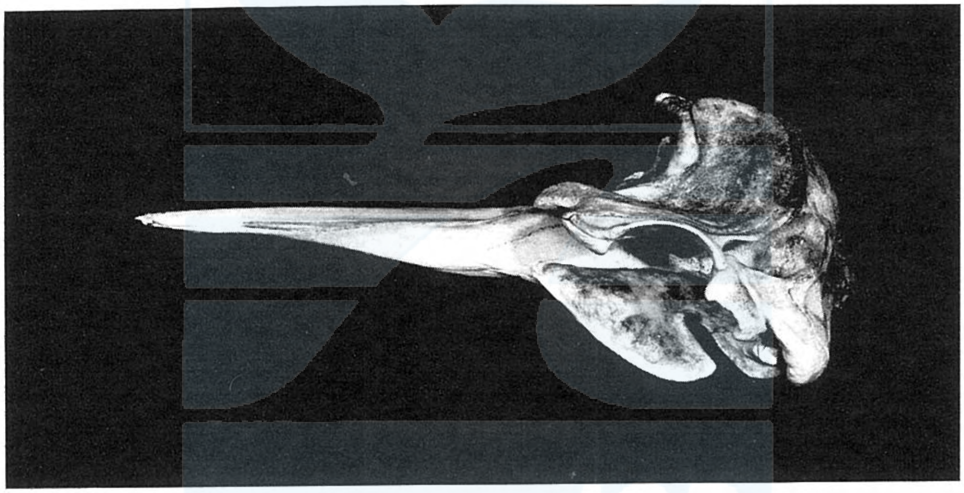

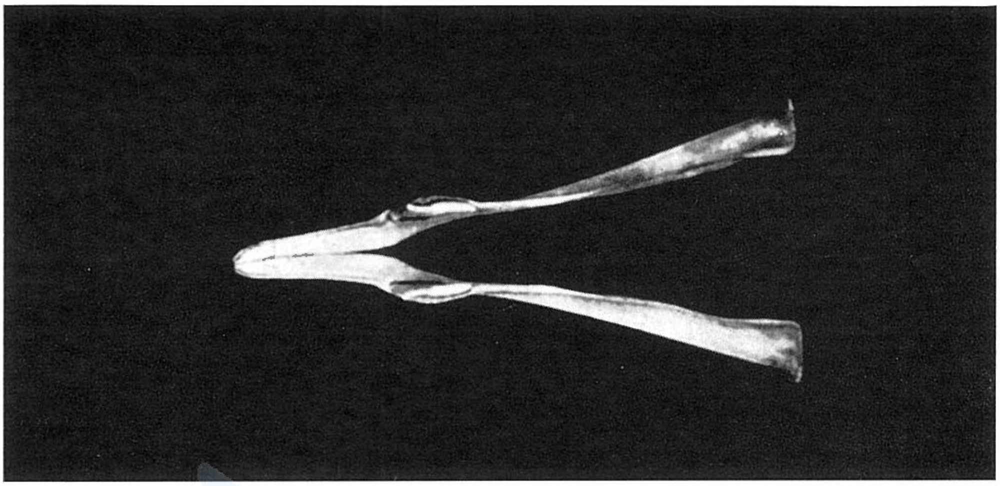

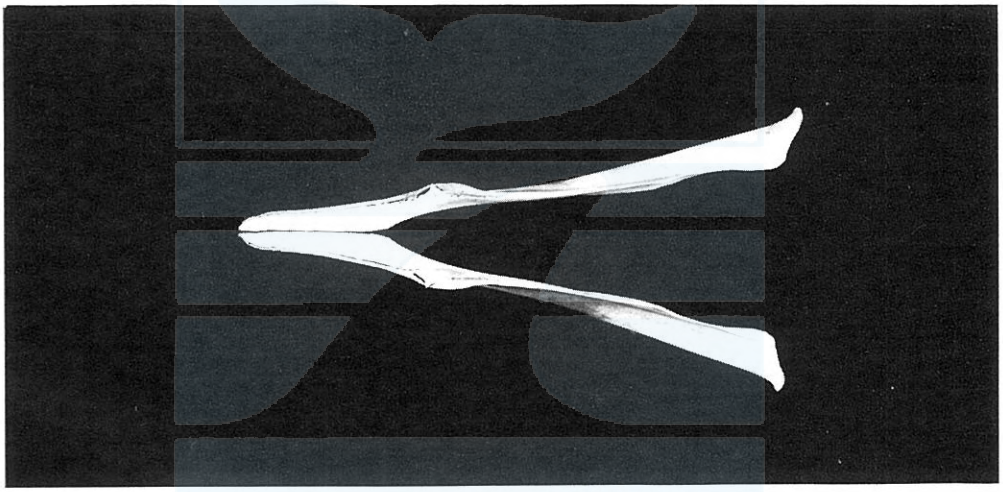

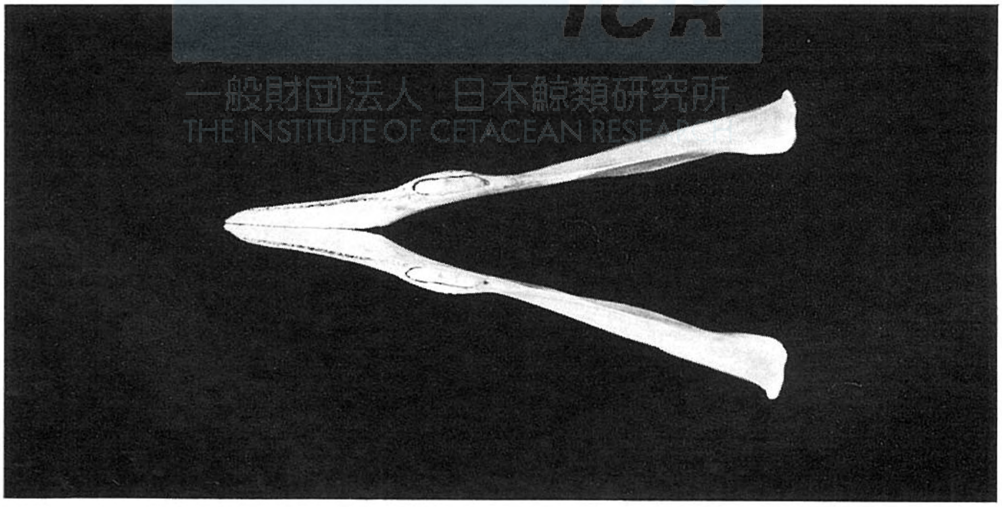

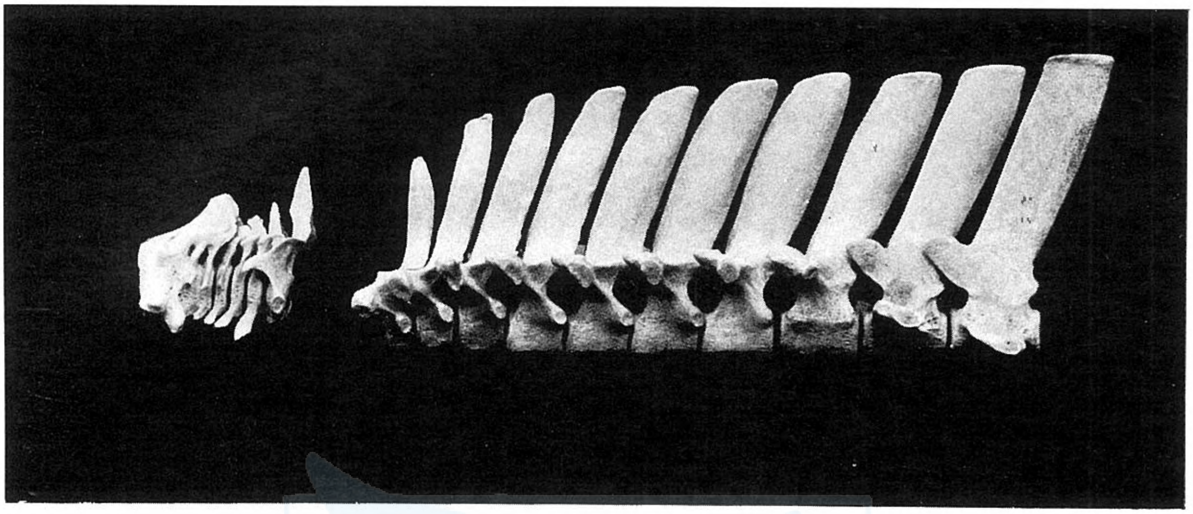

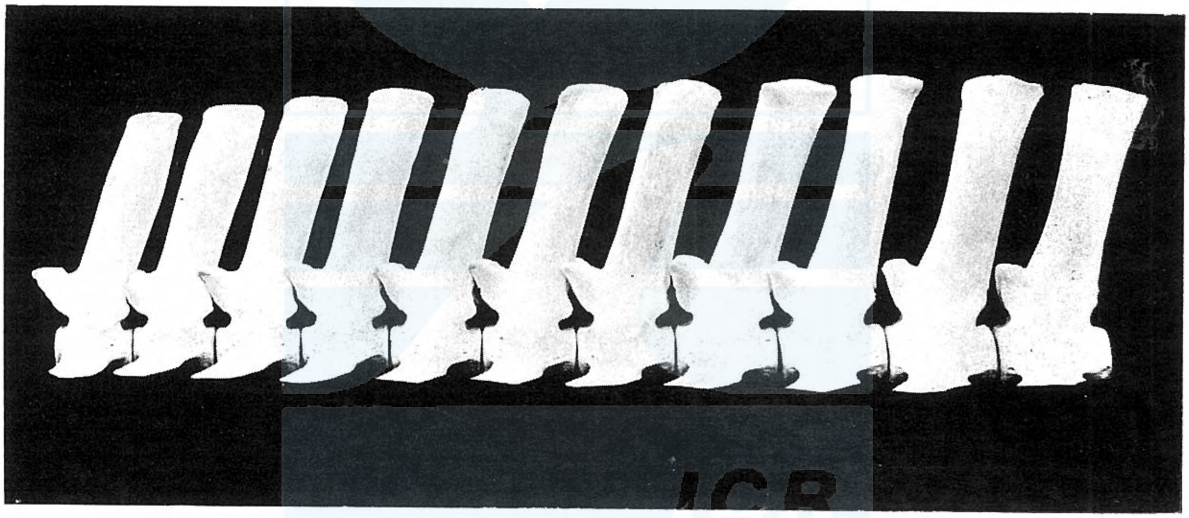

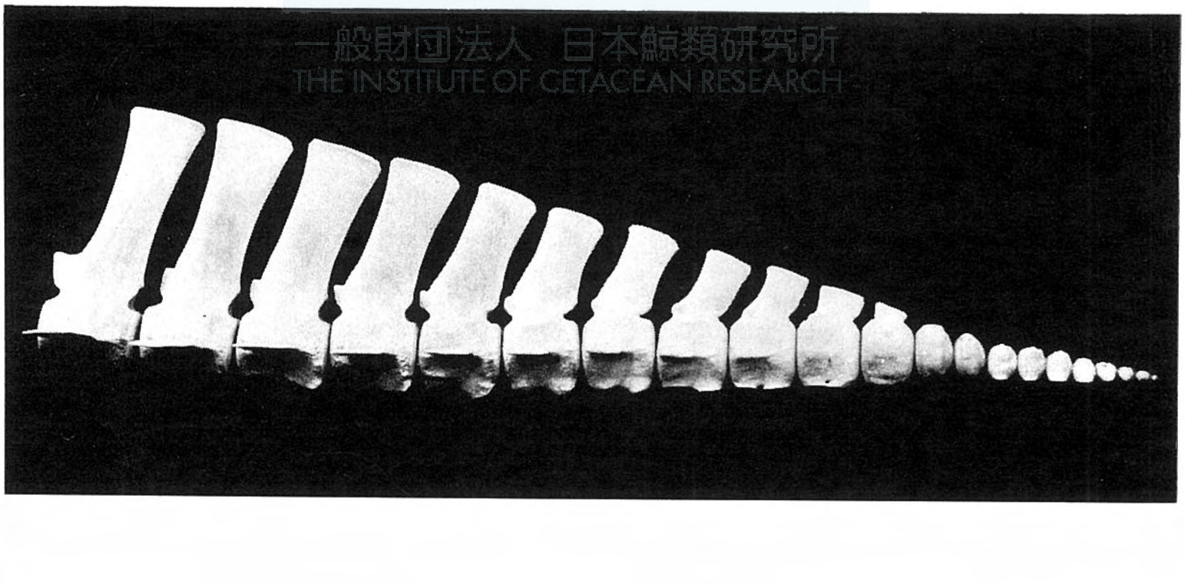

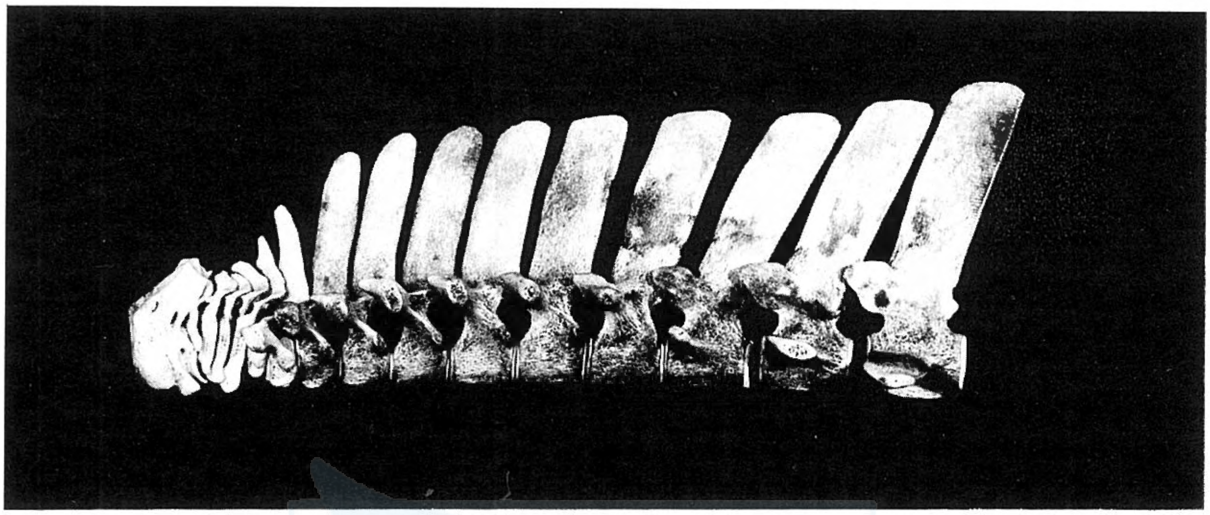

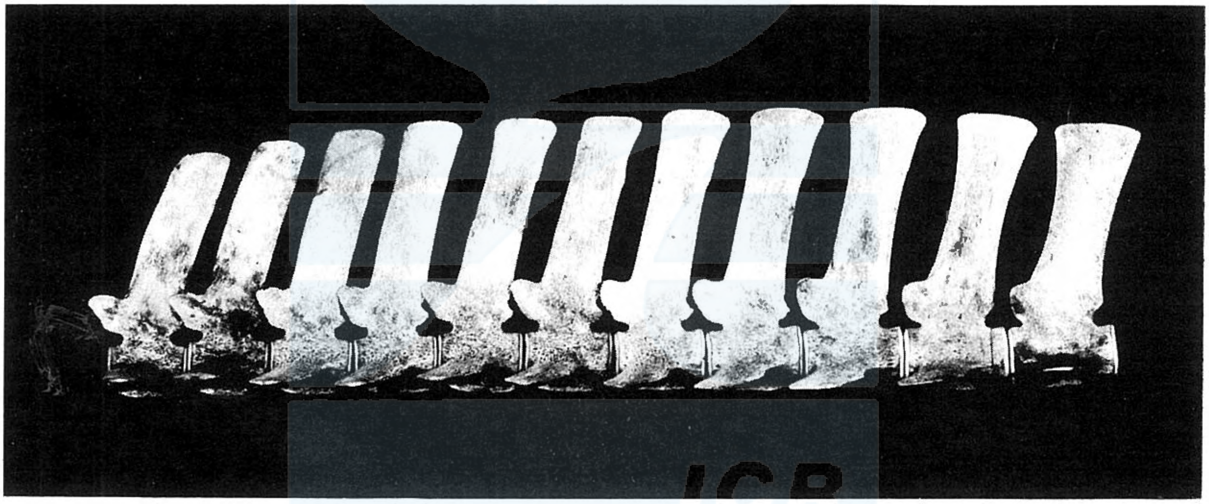

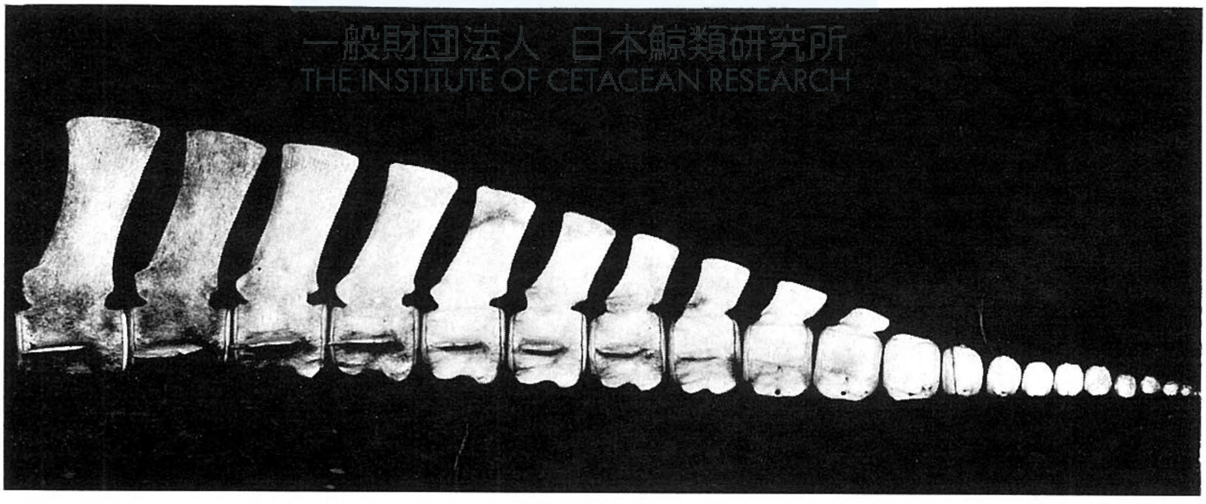

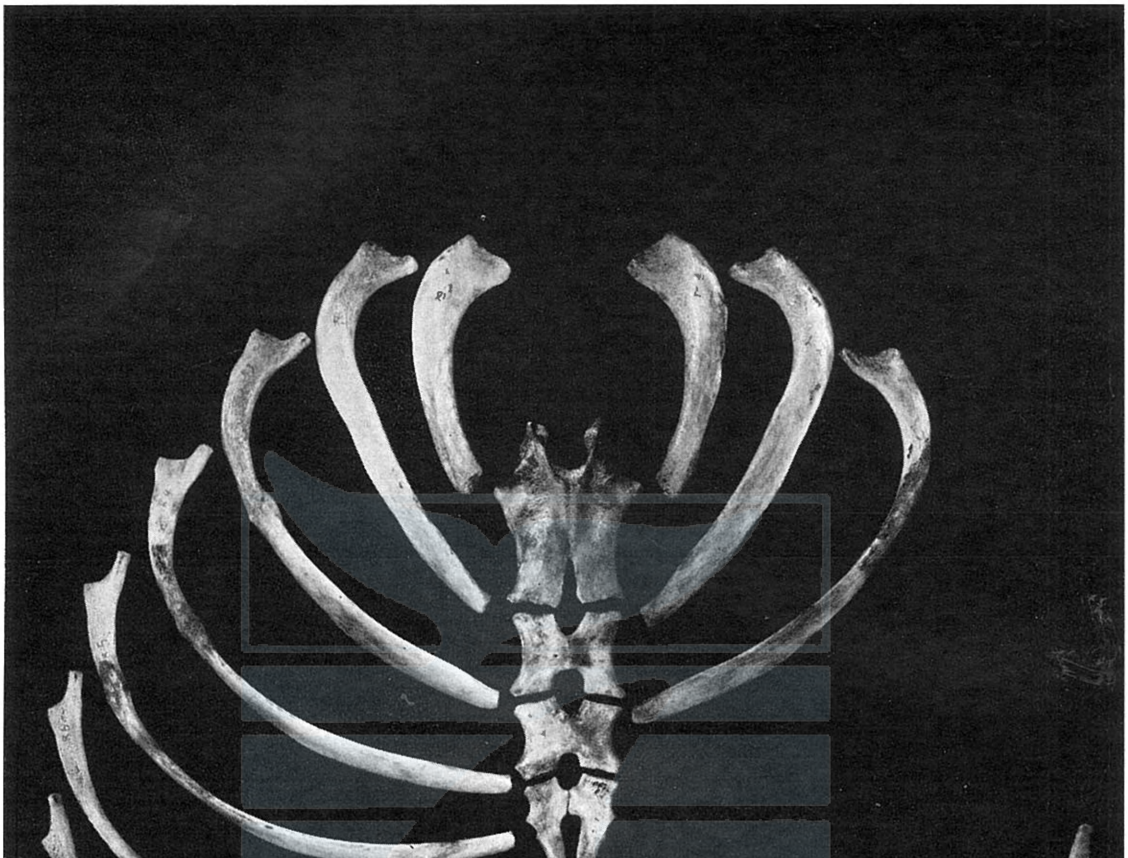

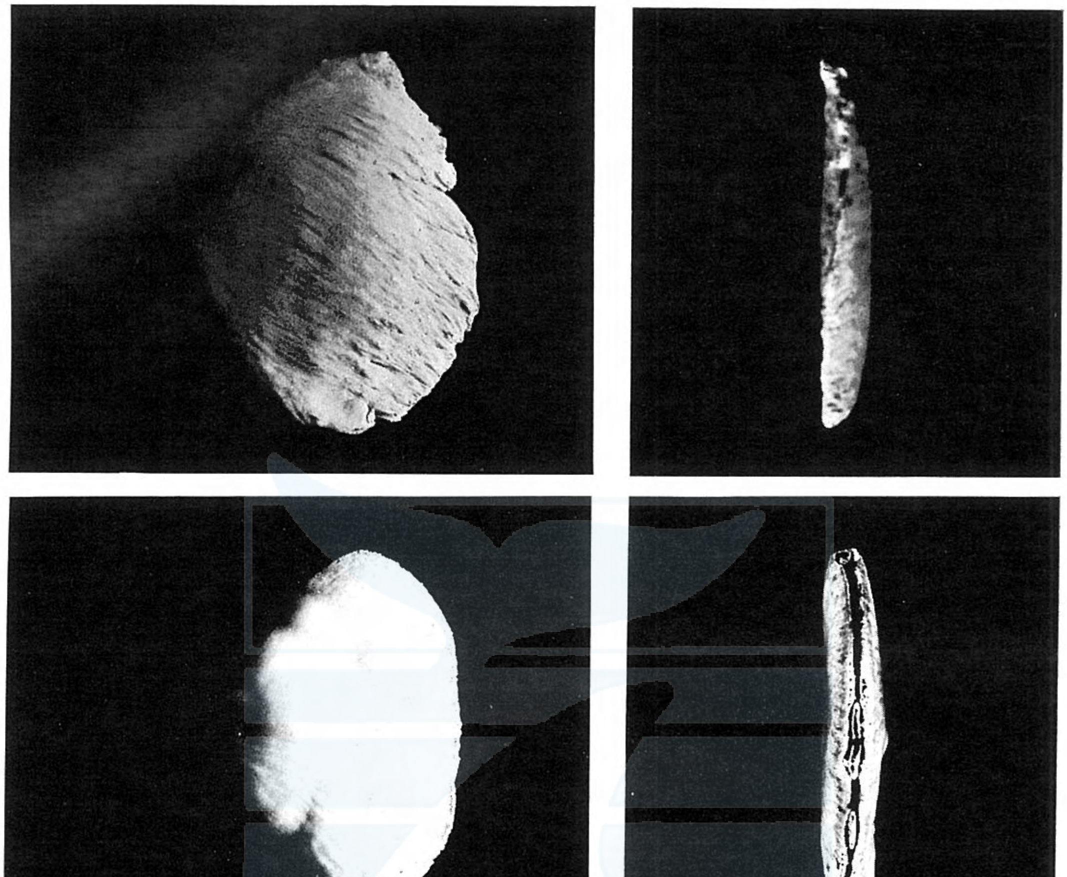

GROWTH AND REPRODUCTION OF *STENELLA CAERULEOALBA* BASED ON THE AGE DETERMINATION BY MEANS OF DENTINAL GROWTH LAYERS

TOSHIO KASUYA*

ABSTRACT

Growth and reproduction of *Stenella caeruleoalba* caught on the Pacific coast of Japan in October to January were studied based on the annual growth layers in dentine. The mating seasons are in May and June, and in November and December. Calves are born after 12 months gestation at 100 cm in body length. They attain sexual maturity at 9 years at the lengths 212 cm in females and 220 cm in males, and physical maturity at 14 to 15 years at the lengths 222 cm in females and 236 cm in males. Lactation lasts about 1.5 years. Mean reproductive cycle is about 3 years or slightly less. Oestrous females assemble to form a school, which is retained at least for one reproductive cycle but can join with the schools in other growth and reproductive stages of both sexes.

INTRODUCTION

The dolphin fishing was formerly operated in the several villages along the coast of the Izu Peninsula, which situates in the Pacific coast of Japan (Japanese Fisheries Bureau 1900). But in most of these places this fishing was abolished before the world war II.

Though, until few years ago Arari on the west coast of the Izu Peninsula operated this fishing for *Stenella caeruleoalba* (Meyen, 1833) and other delphinids in spring season (Nishiwaki and Yagi 1953, Nishiwaki *et al.* 1965), the operation have recently ceased. At present, only Futo and Kawana on the east coast are cooperatively operating this fishing with several speed boats.

The fishing season for these two villages usually starts in the middle of October and closes in December, but few catches have been made in January and early October. The catches are mostly *Stenella caeruleoalba* with occasional catch of *Stenella attenuata* and other delphinids (Tobayama 1969). According to the private communication of Mr. N. Miyazaki, the mean annual catch of *Stenella caeruleoalba* in the both villages is about 4980 individuals in recent 3 seasons from 1968–'69 to 1970–'71, when the catch was regulated by the fishermen to control the market price.

The schools of *Stenella caeruleoalba* are found mostly in the waters off the south east to north coast of Oshima Island, and then chased into the Kawana harbor or the Futo harbor (Tobayama 1969). There are few catches in the west coast of the

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* Ocean Research Institute, University of Tokyo, Tokyo.

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island. As shown in Fig. 1, there is a strong inflow of warm water in the south east entrance of the Sagami Bay. The migration of this species in the Sagami Bay and its south east entrance seems to be related with this current.

This study was intended to obtain some informations on the growth and reproduction of *Stenella caeruleoalba* as a base of the population study.

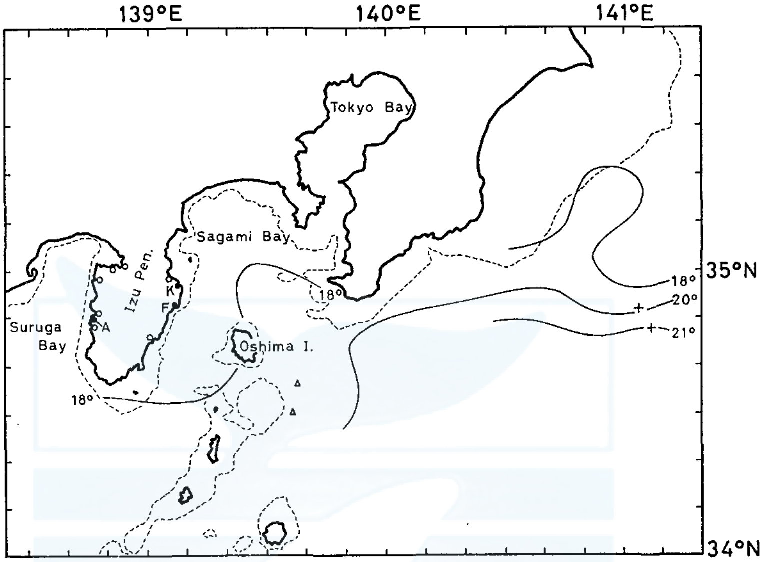

Fig. 1. Map showing the geography around Sagami Bay with the position of sighting of this species in Nov. 1971 (cross) and in Nov. 1970 (triangle). The surface isothermal line is based on the observation in November 1971. Dotted line indicates 200 m line of the depth. A indicates Arari, F Futo, K Kawana, and other white circles the position where dolphin fishing was formerly operated.

MATERIALS AND METHOD

Most of the materials used in this report were obtained from the 4 schools, schools A, B, F, and G in Table 1, processed at Kawana or Futo in 1967, '68, and '70.

School A, captured on 15 Nov. 1968 and processed at Futo, contained 1680 individuals, and 406 individuals were studied randomly. They were composed of newborn calves, juvenile, and mature individuals of both sexes, but lacking in the calves from 110 cm to 140 cm in body length. Fetuses from 5 cm to 105 cm in body length were observed.

School B was caught on 16 Nov. 1968 and processed at Kawana. Among 319 dolphins constituted this school, 318 were studied. This school was composed of juvenile and mature individuals of both sexes ranging from 160 cm to 255 cm in body length, with an exception of a calf of 100 cm. No pregnant female was observed.

School F, caught on 26 Nov. 1967 and processed on 28 Nov. at Kawana, was composed of about 3,300 individuals, among which only 146 were studied randomly. They were composed of newborn calves, juvenile and adult individuals ranging in

TABLE 1. SOME INFORMATIONS ON THE SCHOOL COMPOSITION OF *STENELLA CAERULEOALBA*

School no.	No. caught	No.[1] studied	Sex ratio (male, %)	Ratio in mature female (%)				Immaturity in females (%)	Date killed
				p	l	p&l	r		
A	1,680	406	31.3	41.1[2]	47.7	0.5	10.7	18.1	16, 18, 22 Nov. '68
B	319	318	56.0	0	89.5	0	10.5	86.2	17 Nov. '68
C	330	38	—	—	—	—	—	—	21 Oct. '70
D	256	256	—	—	—	—	—	—	2 Dec. '70
E	2,000	125	—	—	—	—	—	—	22 Nov. '70
F	3,300	150	34.0	2.0	80.4	0	17.6	47.4	28 Nov. '67
G	330	84	41.7	23.3	63.3	0	13.3	31.3	14 Oct. '70
H	101	58	—	—	—	—	—	—	4 Oct. '71
I	—	22	—	—	—	—	—	—	19 Nov. '69

[1] Fetus not included. [2] 3 recently ovulated nonpregnant females included. P pregnant. L lactating. R resting. P&L pregnant and simultaneously lactating.

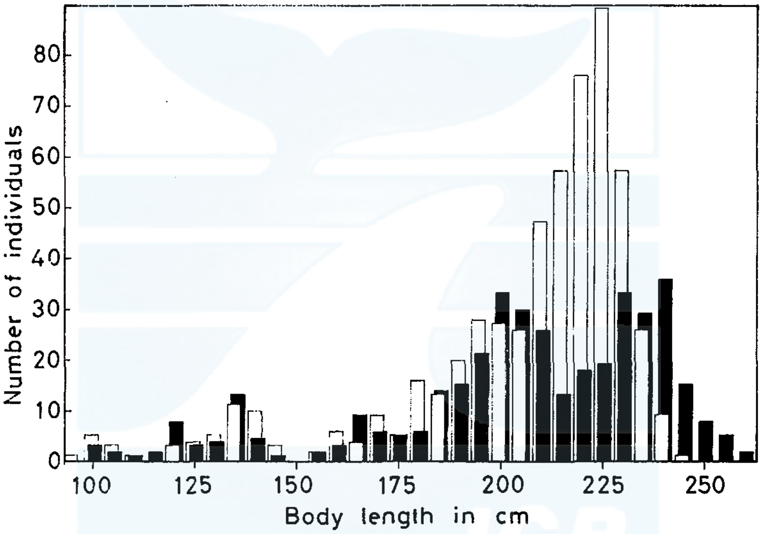

Fig. 2. Body length frequency of the materials used in this study, schools A, B, F and G are combined. Black indicates male and white female.

body length from 95 cm to 255 cm. But the dolphins of 150 cm to 195 cm were scarce. Only three fetuses were observed.

School G was captured on 12 Oct. 1970, and processed and studied on 14 Oct. Among 330 individuals constituted this school 84 individuals were studied randomly. They were composed of juvenile calves ranging from 100 cm to 130 cm and from 165 cm to 200 cm, and adult individuals of both sexes ranging from 210 cm to 260 cm in body length. Few fetuses were observed.

The body length was measured in each 1 cm interval in a straight line from the tip of upper jaw to the bottom of the notch of the tail flukes by two persons with a tape measure. When the length was analized, each body lengths were grouped into the nearest 5 cm.

The mammary gland was observed in the field and classified into lactating and non-lactating. Ovaries were collected from all the adult females and from most of the immature females, and fixed with 10% formalin solution. The number of corpora albicantia and lutea was counted in the laboratory slicing the ovary into about 1 to 2 mm thickness. The both testis were collected from all the males and preserved with same manner as used for ovaries. The weight was measured in the laboratory. When a corpus luteum was observed in the ovary, the uterus was carefully searched for small embryo.

Several teeth were collected with a hammer and a chisel usually from the central part of the upper tooth row, and fixed with 10% formalin solution.

For preparing the tooth for age determination, at first the connective tissue was removed with nife, then its half side was ground off perpendiculary with stones of various granule. The polished surface was glued on a plastic board with synthetic resin, then the other side was polished with the same manner to a thickness from 50 to 70 μ. The growth layers in dentine were observed under transmitted light with binocular microscope (×20—×50).

Other than the materials obtained from the schools A, B, F, and G, some tooth samples and biological data collected at Kawana, Futo, and Taiji (33°35′N, 135°55′E) were presented by Dr. S. Ohsumi and Dr. K. Hirose. They are used in analizing the growth curve. The informations on the body lengths of the fetuses and juvenile calves of the schools C, D, E, and H were offered by Mr. N. Miyazaki, and those of school I by Dr. K. Hirose. These body length frequencies are used in analizing the reproduction of this species.

AGE DETERMINATION

The dentinal growth layers are used in this study as the age characteristics of *Stenella caeruleoalba*. In the dentine of this species, as shown in Pls. I and II, there are observed the layers of opaque and translucent dentine arranged alternately. Though, the thickness of the layer varies at the positions on a tooth, the thickest is the layer formed in the fetal stage. This fetal layer is usually composed of a opaque dentine. But sometimes there are observed one or two faint laminated structure, on which no study was conducted. Probably this will be a reflection of the physiological conditions of the mother which have affected the formation of the laminated dentine of the mother. Though there is a neonatal line between the fetal dentine and the postnatal dentine, this structure is inconspicuous in this species than in the sperm whale (Ohsumi *et al* 1963).

The structure, the thickness and translucency, of the postnatal dentine bounded on the neonatal line is variable between the animals. This will be related with the date of birth and the season when the alternation of the opaque and translucent layers occurs. There are usually observed one or two faint translucent layers in the thick opaque layer accumulated just after the birth. But this fine structure was not used for age determination, because it was not expected to show the annual accumulation cycle.

The thickness of the postnatal layers decreases with the age of accumulation, especially the 7th or 8th and the latter layers are thinner. The dentine of about 15th or latter layers is composed of poorly calcified secondary dentine as in the case of *Globicephala melaena* (Sergeant 1962). It is possible to read the laminations in this secondary dentine with slight difficulty.

Though the boundary of opaque and translucent layers is usually not clear, there is no indication to consider that there is significant difference of the thickness between two layers.

Fig. 3 shows the seasonal change of the conditions of the newest dentinal growth layer in the tooth with 13 or less layers, in which the layer is not too thin to make the accurate observation. It is expected, from Fig. 3, that the alternation of dentinal layer from the opaque to the translucent occurs in from November to December.

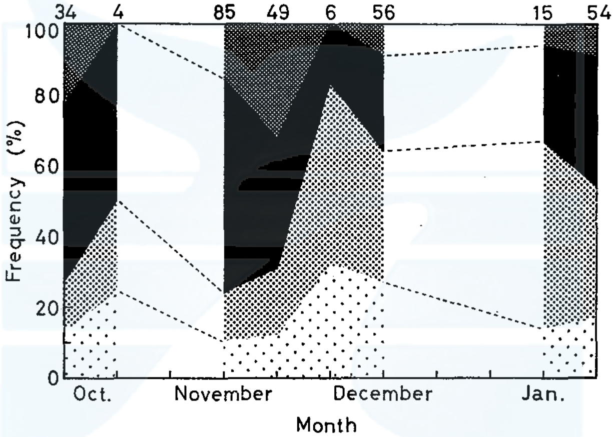

Fig. 3. The condition of the newest dentinal layers. The marks indicate thin opaque layer, thick opaque layer, thin translucent layer, and thick translucent layer (from top to bottom). The numbers at the top indicate the sample size. The dates of the kill are grouped into the 1st, 2nd, and 3rd decade of month.

In this study it is presumed that the opaque layer is accumulated in summer and the translucent in winter as in the case of *Physeter catodon* (Ohsumi *et al* 1963), *Tursiops truncatus* (Sergeant 1959), and *Globicephala melaena* (Sergeant 1962).

For determining the age of the dolphins, it was tentatively assumed that the opaque and translucent layers indicate the growth in 6 months respectively. And in the animals with the number of opaque layers 5 or less, the age was determined to each nearest 1/4 years considering the conditions and thickness of the oldest (formed just after birth) and the newest layer, in the animals with between 6 and 10 layers to nearest 1/2 years, and in the animals with more than 10 layers the number of the opaque layers was used as the approximate age of the animal.

GROWTH

Lengths and length frequencies

The length frequencies show characteristic features in each schools. This is considered to be resulted from the schooling behavior related with the maturity and reproductive cycle. Descriptions of the length frequencies of each schools are roughly made in the chapter of Materials and Method, and some discussions in the chapter of Reproduction.

When schools A, B, F, and G are combined, the smallest individual is found in the length group of 95 cm, the largest female in 245, and the largest male in 260 (Fig. 2). The highest frequency of the adult female is in the length group of 225 cm, and that of male probably in 240 cm. The length of the adult male seems to exceeds that of the female about 15 cm (see *Growth curve*).

No significant difference of length frequency between both sexes is observed in the animal smaller than 175 cm.

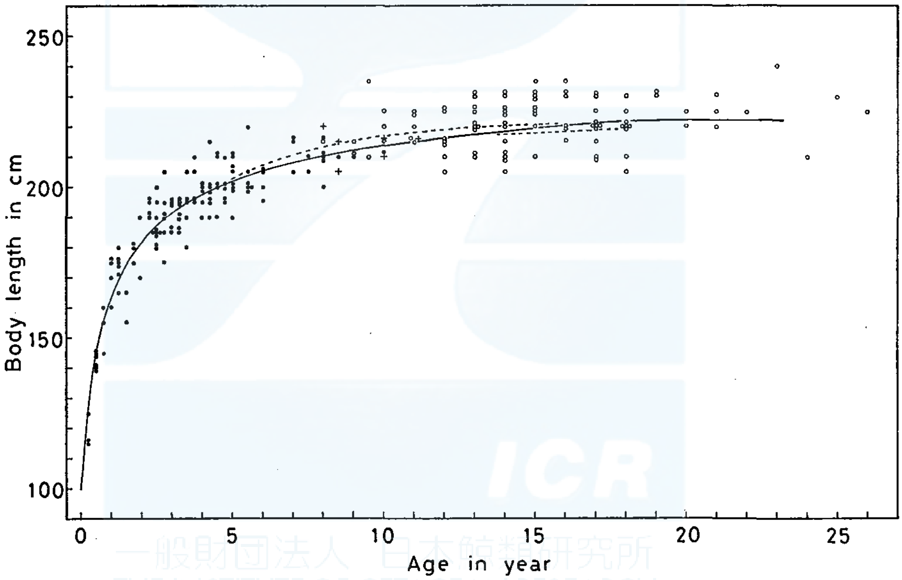

Fig. 4. The mean growth curve of the female. One dentinal layer corresponds to one year. Closed circle indicates immature female, open circle mature, and cross unknown. For explanation see text.

Growth curve

The relation between body length and the age in 218 females is shown in Fig. 4. The growth is characteristic in the rapid increase of the length in the first 2 years. The increase of the body length seems to stop at the age of 14 or 15 years. This age is considered to mean the time when most of the female individuals attain the physical maturity. As the mean body length of the 36 females at the age of 16 years or more is

222.4 cm, it is considered that the mean maximum body length attained by the female is approximately 222 cm. The age of oldest female was 26 years.

The mean growth curve shown by a solid line in Fig. 4 was drawn by eye, considering the mean body lengths in each ages. Based on this growth curve and the mean body length at birth obtained separately, it was tried to adapt the Bertalanffy's growth formula, $L(t)=a(1-e^{\alpha-\beta t})$, using Walford's finite differences diagram. But it was impossible to adapt single growth formula for the mean growth curve of the female. For the growth of the first 2.5 years, the formula with the constances $a=192.2$, $\alpha=-0.7350$, and $\beta=1.1384$ fits perfectly. The growth curve at the age of 2.5 years or more can be calculated from the above diagram, the mean final length 222.4 cm, and $L(2.5)=186.8$ of the former formula. This gives the constances $a=222.4$, $\alpha=-1.1813$, and $\beta=0.2601$, which is shown by the dotted line at the top in Fig. 4. These two formulae can be considered to represent approximately the mean growth curve of the female *Stenella caeruleoalba.* But the fitness of the latter formula is not good for the ages between 6 and 12 years. Another formula which fits better only to those ages is shown by the constances $a=219.1$, $\alpha=-1.3026$, $\beta=0.2445$, and shown by the dotted line at the bottom in Fig. 4.

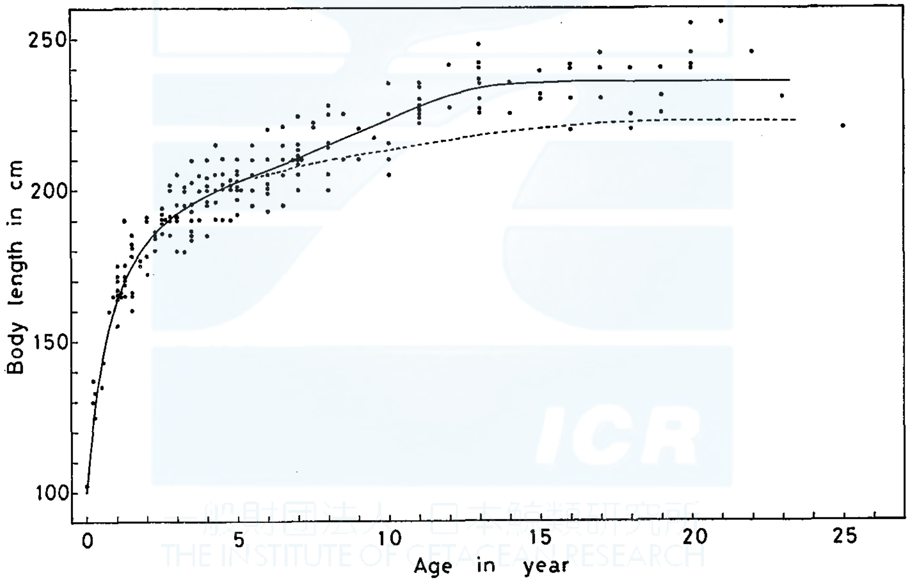

Fig. 5. The mean growth curve of the male. Solid line is drawn for male by eye. Dotted line is the female growth curve shown by the solid line in Fig. 4.

The relation between body length and age in 191 males is shown in Fig. 5. The line was drawn by eye. In the younger individuals the growth of the male is same with that of the female. The difference of the body length between both sexes appears at about 6th year. After this age the growth is rapid and attaines the approximale length 230 cm at the age of 13 years. This rapid growth will probably related with the attainment of the sexual maturity, and resembles with that of the male *Physeter catodon* (Nishiwaki *et al* 1958). But the growth does not continue so long period as the sperm whale. The physical maturity is considered from the growth curve to be attained at 14 or 15th year as in the case of the female. The mean body length of the males of 16 or more years old is 235.9 cm or approximately 236 cm, which is considered to be the mean maximum body length attained by the male. This length is 14 cm larger than that of the female, which coincides with the value expected from the body length frequency.

The age of the oldest male was 25 years.

Mean body length at birth

Because of the scarecity of the samples, the body length at birth was obtained combining the both sexes. This will not give erroneous result because there is observed no sexual dimorphism in the body length of the younger individuals.

The mean body length at birth was calculated from the body length frequencies of the large fetus and newborn calf. The data from the 4 schools, A, B, F and G were used for this purpose. The body lengths were grouped into each nearest 5 cm units. The largest fetus and the smallest calf were found in the length groups of 105 cm and 95 cm respectively. So the length frequencies in the length groups between 90 cm and 110 cm are considered here.

The numbers of calves and fetuses in the above range are 17 and 73 respectively, and the frequencies of both categories are equal in the length group 105 cm (Table 2). But there is a wide discrepancy between the total numbers of fetus and calf. As the cause of this phemomenon, it is possible to expect two reasons. One is related with the method of fishing in which a school of dolphins is chased for several hours to be driven into the harbor, during this chase some of newborn calves may be lost. The other less probable cause is the difference of the schooling behavior or segregation of the newborn calf and the mother.

TABLE 2. BODY LENGTH FREQUENCIES OF FETUSES AND CALVES

Body length (cm)	Futus (no.)	Calf (no.)	Fetus (%)	Calf (%)	% of calf (corrected)
90	15	0	20.50	0	0
95	27	1	36.99	5.88	13.72
100	27	8	36.99	47.06	55.99
105	4	5	5.48	29.41	84.29
110	0	3	0	17.65	100
Total	73	17	100	100	50.00

Though the correctness of these possible presumptions are not proved in this study, the length frequencies were corrected to equalize the total numbers of fetus and calf. Then the ratios of the calf and the fetus were calculated in each length groups (Table 2). From this corrected percentage of the calf, the regression line $y = 5.411x - 490.3$ is obtained by the method of least squares, where y is the frequency of the calf in percentage and x is the body length in cm. The mean body length at birth, 99.8 cm, is obtained from this formula as the body length corresponding to the frequency of 50% (Fig. 6). But when the accuracy of the measurement is considered, it is better to say that the mean body length at birth is 100 cm.

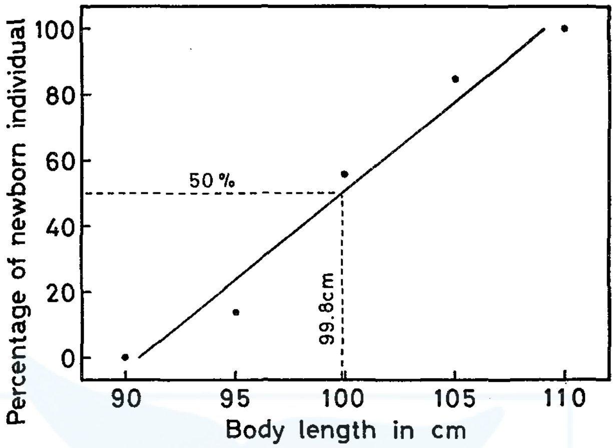

Fig. 6. Mean body length at birth, for explanation see text.

Age at the attainment of sexual maturity

In Table 3 the females with corpus luteum or albicans were identified as attained sexual maturity, and the animals of the age of 6.5, 7.5, 8.5, and 9.5 years were included into the age groups of 6, 7, 8, and 9 years respectively (see Materials and Method). The oldest immature female and the youngest mature female were found in the age groups of 10 years and 8 years respectively. As the materials are very few, and the ratio of the mature individual fluctuates too wide to obtain the regression line, another method was used to estimate the mean age at the attainment of sexual maturity.

At first step, the percentages of mature and immature animals were calculated in each age groups, then those of the immature animals were added from the older age groups to the younger, and those of the mature from the younger to the older. These accumulated percentages are shown in Fig. 7. The mean age of the female at the

TABLE 3. AGE FREQUENCIES OF IMMATURE AND MATURE ANIMALS OF BOTH SEXES

Age	No. of females		No. of males	
	immature	mature	immature	mature
6	2	0	8	0
7	2	0	8	1
8	8	1	4	0
9	1	4	1	2
10	1	2	1	2
11	0	3	2	5
12	0	7	0	1
Total	14	17	24	11

attainment of the sexual maturity is obtained in the figure as the point where two lines cross. This gives the age 8.8 years.

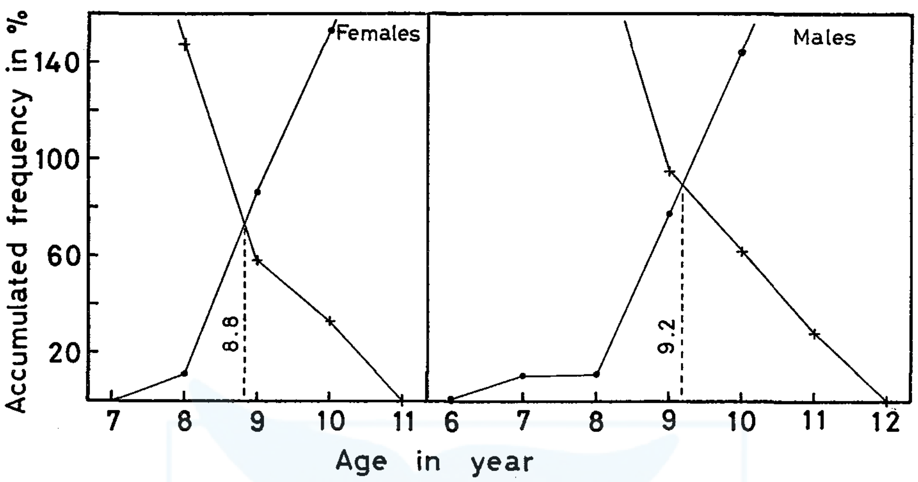

Fig. 7. Mean age at the attainment of sexual maturity. Circle indicates the frequency of mature individual, and cross the immature.

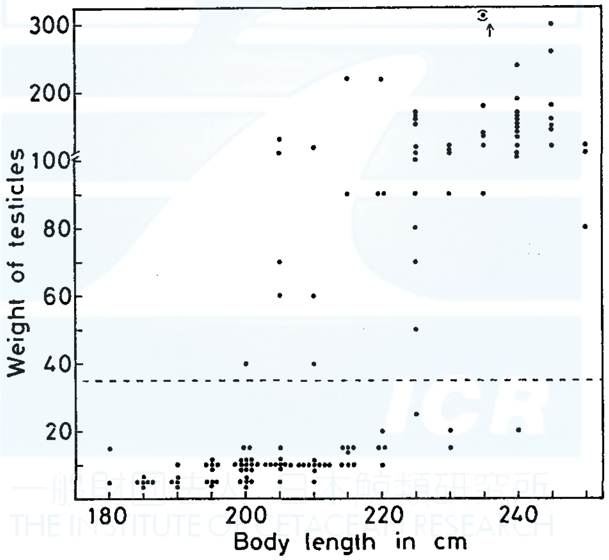

Fig. 8. Relation between body length and the weight of both testis. Dotted line indicates the mean weight at the attainment of sexual maturity used in this study.

Another estimation can be obtained from the relation between age and number of ovulations (Fig. 14), as the age when the number of ovulation is 1.0. The mean age of the female at the attainment of sexual maturity obtained by this method is 8.9 years. These two figures coincide well.

Fig. 8 shows the relation between body length and the combined weight of both testes. Hirose and Nishiwaki (1971) showed with similar materials used in this study that the testes of more than 40g are mature. Though they did not give the mean weight of testis at the attainment of sexual maturity, it is considered to be between 30 g and 40 g. In the present study the testis with 35 g or more in combined weight were considered to be sexually mature.

In the males, the oldest immature animal and the youngest mature were found in the age of 11 and 7 years respectively. The mean age of the male at the attainment of sexual maturity, obtained by the same procedure used in the female, is 9.2 years (Fig. 7).

At present there is no reason to consider that the difference of the ages of the both sexes at the attainment of sexual maturity is significant. And the best estimation for both sexes seems to be the age of 9 years.

The mean body lengths at the age of 9 years obtained on the mean growth curve are 212 cm for female, and 219 cm for male.

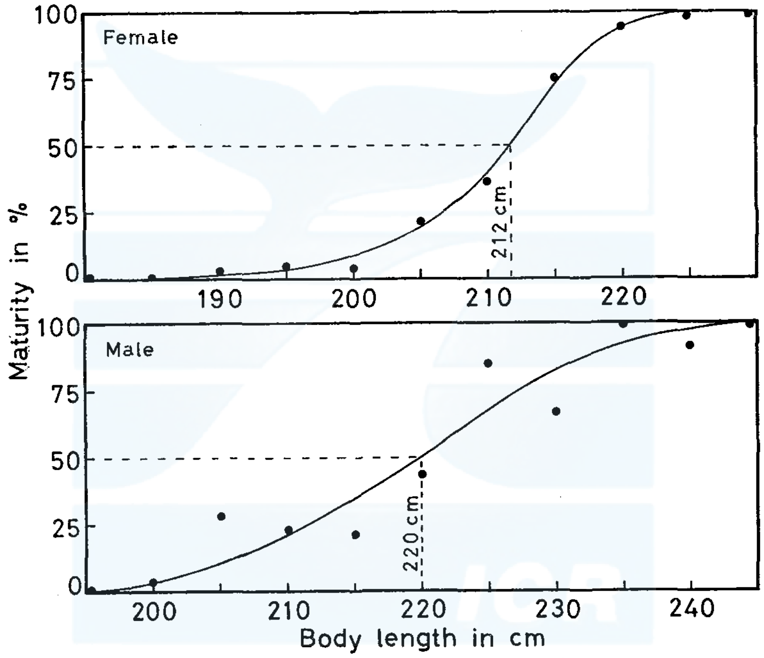

Fig. 9. The body lengths where 50% of individuals are sexually mature. Lines are drawn by eye.

Body length at the attainment of sexual maturity

The ranges between the largest immature individual and the smallest mature are from 190 cm to 220 cm for females, and from 200 cm to 240 cm for males.

The mean body length at the attainment of the sexual maturity was obtained directly from the ratio of the matured individuals in each length groups.

Fig. 9 is based on the 640 immature females and 604 mature females, and 53 immature males and 46 mature males. On the regression lines in Fig. 9, the length where 50% of individuals are sexually mature is 212 cm for females, and 220 cm for males. These figures coincide well with those obtained from the mean age at the attainment of sexual maturity and the mean growth curve.

REPRODUCTION

Sex ratio

Table 4 shows the sex ratios in 4 schools caught at Kawana or Futo, and that of

TABLE 4. SEX RATIO IN PRENATAL AND POSTNATAL INDIVIDUALS, SHOWN BY THE NUMBER OF FEMALES PER 100 MALES

School	Prenatal		Postnatal			
	male	female	male	female	total	sex ratio
A	53	53	127	279	406	219.6
B	0	0	178	140	319	78.6
F	1	1	51	99	150	194.1
G	4	3	35	48	83	172.9
Taiji specimens	0	0	51	40	91	78.4
Total no.	58	57	442	606	1,048	137.1
Sex ratio	100	98.2	100	137.1	—	—

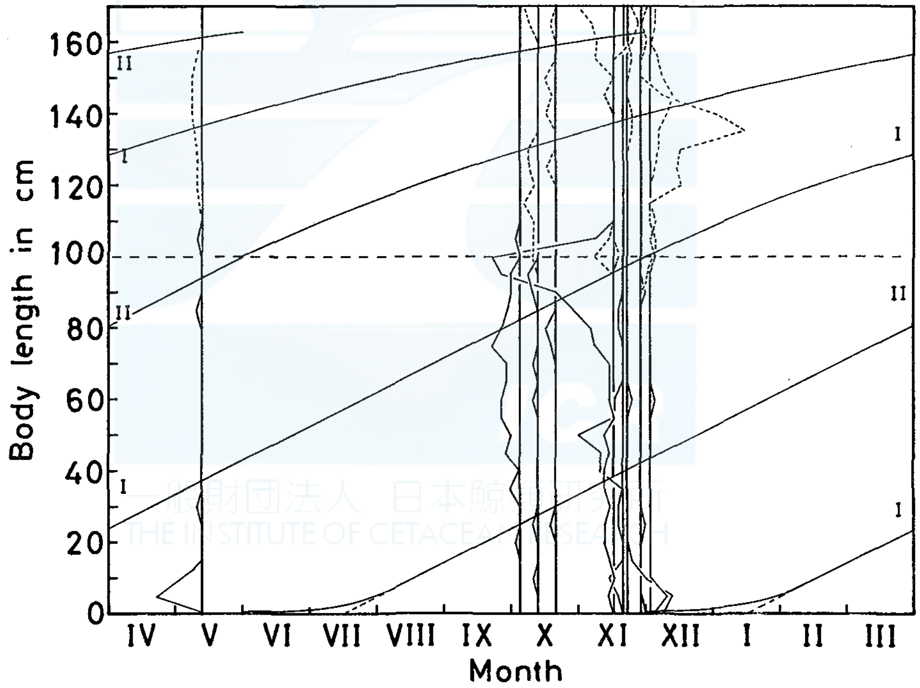

Fig. 10. Body length frequency of the fetus (solid line) and juvenile calf (dotted line). One month interval means 15 individuals. The growth curve of the fetus was drawn presuming 12 month of gestation, and that of calf is based on the growth formula. I is started on the 1st of June and II on the 1st of December. The school D, F, E, I, B (right side, no fetus) and A (left side), C, G, and H are plotted against the date of the catch (from right to left). A school in May is cited from Nishiwaki and Yagi (1953).

the catch off Taiji in January 1969. The ratio is shown by the number of females per 100 males. The Taiji specimens were caught with hand harpoons from various schools and studied by Dr. K. Hirose.

These data show that the sex ratio of the postnatal individuals varies in each schools. This will probably be related with the characteristic schooling behavior concerning the sexual conditions of the animal, and will not show the real sex ratio in the population. The number of both sexes in fetuses is considered to be nearly equal, and no uneven sex ratio is suggested.

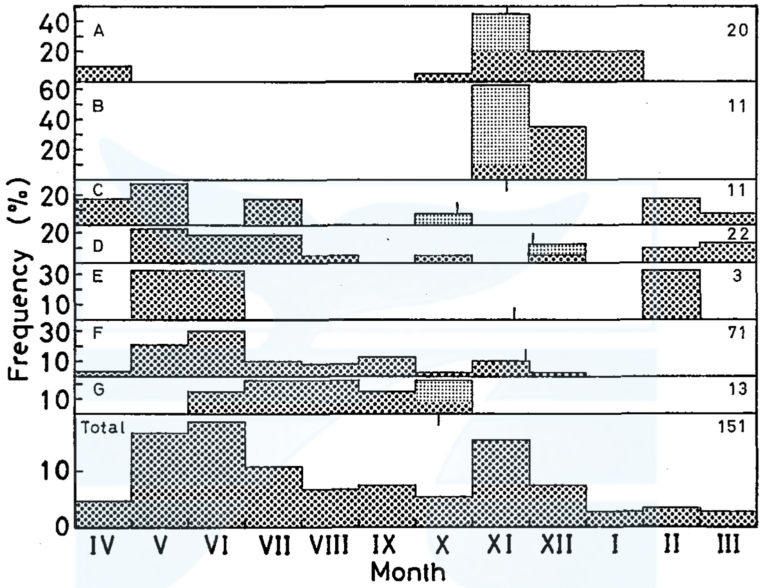

Fig. 11. Frequency of the date of birth of the one year or younger individuals of both sexes calculated with the growth formula. Square with smaller dots indicates the individuals born 12 months prior to the date of catch. The numbers in the right indicate the sample size, and the vertical rod the date of catch.

Parturition season

As there are observed many full termed fetuses and newborn calves in the schools caught in November and December (Fig. 10), this season seems to be at least a part of one of the parturition seasons of *Stenella caeruleoalba.*

Fig. 11 shows the frequency of the parturition infered with the growth formula, the date of catch, and the body length of juvenile calf of 165 cm or less which is considered to contain one year old calves and all the younger individuals. It is seen in this figure that, though some parturitions may occur in any season of the year, this species have two peaks of parturition one in May and June, and the other in November and December. In this figure, the autumn peaks is smaller than the spring peak. But it will not be necessary to think that the autumn peak is smaller than the other, because the frequency of the date of birth infered from the length and date of kill with fetal growth curve shows the reversal pattern (Fig. 12).

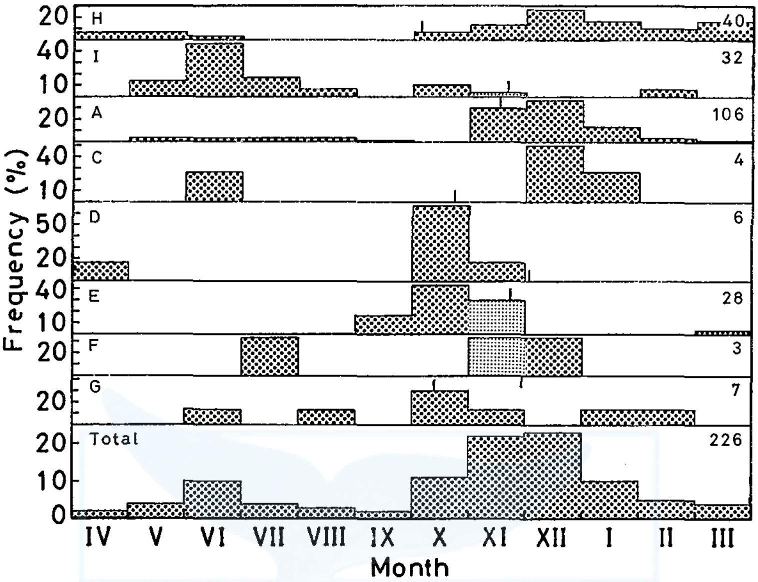

Fig. 12. Frequency of the expected date of birth calculated with the growth curve of fetus. Square with smaller dots indicates the fetuses expected to have been born 12 month after the date of catch. The numbers at the right indicate the sample size, and the vertical rod date of catch.

Mating season

Many small embryos are observed in the females caught in November and December (Figs. 10 and 13). In these figures the smallest length group includes the embryos smaller than 2.5 cm, which range is a half of the width of the length range of 5 cm applied to larger fetuses. Accordingly the height of the frequency of the smallest group must be doubled to compare the relative abundance with that of the larger length groups. Then it reveals that the relative abundance of the fetuses of 2.5 cm or less in body length is higher than that of the next length group.

This will indicate that the beginning of the mating season is at slightly prior to November, and the newly impregnated females are still increasing in November and December. Accordingly it is reasonable to consider that one of the mating seasons is in November and December. As this season coincides with the autumn parturition season, another mating season in May and June is expected. This is supported by the existance of small embryos, 10 fetuses under 10 cm, in a school caught in May at Arari (Nishiwaki and Yagi 1953, reffered in Fig. 10 of this report).

Length of gestation

As the sampling period is restricted to October, November, and early December, it is impossible to follow the seasonal increase of the body length of the fetuses to presume the gestation period and the growth of fetus.

But it can be presumed from the seasons of mating and parturition, and body length frequency of the fetus. As mentioned above, both peaks of mating and parturition are in spring and autumn with the interval of 6 months, then the approximate length of gestation must be a multiple of 6 months. On the other hand, there are observed three peaks in the fetal length frequency in autumn season (Fig. 13).

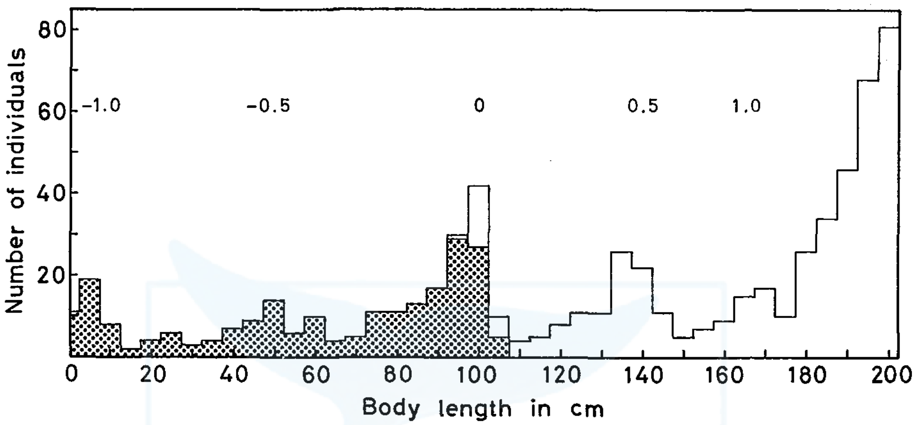

Fig. 13. Body length frequency of the fetus (dotted area) and juvenile calf (white area) in the catch of October to December. Figures at the top indicate approximate age shown by the year from the birth. Schools A to I are combined.

The smallest peak is composed of the newly impregnated fetuses, the largest of the full termed fetuses, and the median of the fetuses impregnated in the preceding season. If the length of gestation period is 18 months or more, there must be observed 4 or more peaks, which is inconsistent with the above observation. Accordingly the gestation period of *Stenella caeruleoalba* is presumed to be about 12 months.

The mean fetal growth curve in Fig. 10 is drawn based on the above gestation period using the method of Laws (1959). 0.13 × Gestation period is tentatively used here for Lt_0 of Laws (1959), which is the time when the extended straight line of the fetal growth cuts the axis of time. The starts of gestation are put at the 1st of December (growth curve I) and at the 1st of June (growth curve II). The growth curve of the calf is based on the growth formula.

Fig. 12 shows the frequency of the date of birth infered with the fetal growth curve, from the length frequency of the fetus and the date of kill. There are two parturition seasons one in June and the other in November and December. This result coincides well with the parturition frequency obtained independently (Fig. 11). It is interesting that the shapes of the autumn parturition peak in Fig. 12 and that of spring parturition peak in Fig. 11 are similar and the highest peaks are in December and June respectively. This will indicate that the frequency of parturition is slightly higher in December and June than in the preceding months, and will support the correctness of the presumed gestation period of 12 months.

For the comparison, the frequency of parturition was calculated on the assumption of the gestation of 11 months and that of 13 months. When 11 months gestation and 0.18 × Gestation period for Lt_0 are assumed, the spring parturition peak is in April. And when gestation of 13 months and 0.13 × Gestation period for Lt_0 are assumed, the spring peak is in the range from April to June with the highest in May. These results do not fit to that obtained from the length frequencies of the juvenile calves.

Length of lactation

In this study the direct information indicating the length of suckling period was not obtained, because no stomach content was studied. But it is expected that the calf starts feeding on food before the age of 0.5 year, because most of the teeth except those in the anterior and posterior regions of the tooth row have erupted in all the individuals of that age.

The length of lactation was estimated from the number of lactating females and that of juvenile individuals caught together. There are observed several peaks in the body length frequencies of each schools. The peaks of the younger individuals are considered to represent the individuals born in some particular parturition seasons, and their approximate age can be presumed from the body length at the mode of frequency. The peak at 100 cm (schools A, B, and F) is considered to be composed of individuals born in the autumn season when they were caught, and that at 165 cm (schools A and B) is of the dolphins about 1 year old. The peaks at 120 cm (school F) and at 115 cm (school G) will have been born about 1/4 year before the catch, and that at 140 cm about 1/2 year before, and that at 170 cm about 1 1/4 years before the catch.

TABLE 5. LENGTH FREQUENCIES OF THE JUVENILE INDIVIDUALS, THEIR APPROXIMATE AGE, AND NUMBER OF LACTATING FEMALES.

School	Length frequency (cm)				Number of lactating females
	Range	Mode	Age	Number	
A	100–105	100	0	5	94
	145–170	165	1	23	
	175–190	185	2	7	
	200–		7+	244	
B	100	100	0	1	17
	160–170	165	1	14	
	175–215	200	2, 2+	245	
	220–			60	
F	95–110	105	0	9	41
	115–125	120	1/4	15	
	130–145	140	1/2	46	
	160–175	170	1 1/4	3	
	185–		4+	77	
G	100–130	115	1/4	11	19
	165–180	170	1 1/4	7	
	195–		4+	54	

The number of the lactating females nearly coincides with that of calves younger than 1 1/4 years old (schools B and G). The number of 2 years and older calves caught together with the lactating females is very few comparing with that of the younger individuals.

The school A was caught on 15 Nov. 1968, and the members were killed on 16, 18, and 22 Nov. when I had a chance to study some of them, but I had no chance to study many dead individuals picked up daily from the harbor and sold. The ratio of the suckling calf may have been higher in these dead individuals which I missed to study. This will be the reason of the low frequency of the juvenile calves in the sample compared with the lactating females. The quite reverse case is found in the school F. This school was caught on 26 Nov. 1967, and I studied on 28 Nov. only the carcases of the dolphins which had died in the water and picked up. In this school, the number of juvenile calves is higher than that of the lactating females. But even in these schools, A and F, it can be suggested that the 2 years old calves are rarely accompanied by the lactating mother.

The lactating females are devided into two groups by the size of the largest corpus albicans (Hirose *et al* 1970). The Futo school and Kawana school in Hirose *et al* (1970) correspond to the school A and B of Table 1 respectively. Probably the lactating females with larger corpus albicans, which is few in number, will be the mothers of newborn calves, and those with the smaller the mothers of the calves of the ages from 1.0 to 1 1/4 years old.

As the conclusion of above discussions, it can be said that lactation lasts at least for 1 1/4 years, and probably for about 1.5 years as in the case of *Tursiops truncatus* (Tabolga and Essapian 1957, Nakajima *et al* 1963), but rarely for 2.0 years. The calves which have started feeding on food by the age of about 0.5 year, will continue to take both food and milk until the age of about 1.5 years.

Female reproductive cycle

As the females lactating and simultaneously pregnant are very rare in the catch and the recently ovulated nonpregnant 3 females were not lactating (Table 1), most of the female seems not to ovulate in the period of lactation.

Between schools, there is wide variation of the ratio of the resting females, in which all the mature females other than the pregnant or lactating are included. But it may be approximately between 10.5 and 17.6% of the total number of the mature females (Table 1). If this ratio is compared with the total of the length of gestation (1 year) and length of lactation (about 1.5 years and surely more than $1^1/_4$ years), the average resting period of between 0.29 and 0.53 year (in case of 1.5 years lactation), or between 0.26 and 0.48 years (in case of less probable $1^1/_4$ years lactation) is obtained.

Accordingly the probable mean reproductive cycle of the female is presumed to be about 3 years or slightly less (gestation 1, lactation 1.5, resting from 0.3 to 0.5 year). This means that some females are impregnated in the same mating season when they have weaned the calves, and most of the females in the next mating season.

In this species the corpus albicans probably remain in the ovary all through its life (Fig. 14). The mean annual accumulation rate of the corpus albicans and luteum is 0.69, and the lowest and the highest accumulation rates are 0.25 and 1.6 respectively. To explain the mean accumulation rate and the mean reproductive cycle, there must be expected about two ovulations in one reproductive cycle (Table 6). But as indicated by the lowest accumulation rate, there must be few females which stay anoestrus for 3 years after giving birth to the calves and show the reproductive cycle of 4 years.

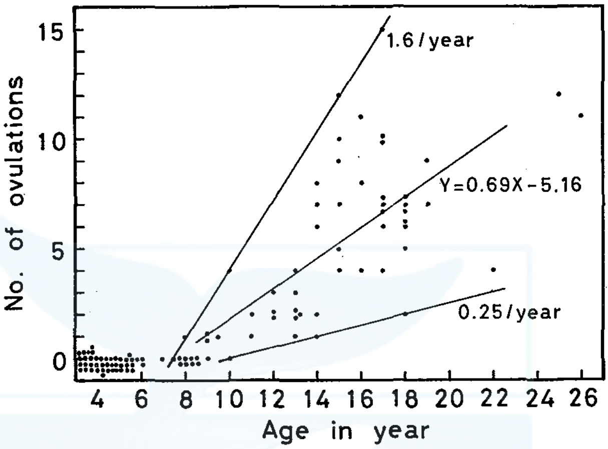

Fig. 14. Relation between age and the number of corpora albicantia and luteum. The regression line is calculated by the method of least squares, and the highest and lowest ranges are drawn by eye.

TABLE 6. MEAN ANNUAL OVULATION RATE CALCULATED FROM THE ASSUMED REPRODUCTIVE CYCLE AND NUMBER OF OVULATIONS IN A CYCLE.

Preg-nant (year)	Lactat-ing (year)	Rest-ing (year)	Repreductive cycle (year)	Number of ovulations					
				1	2	3	4	5	6
1	1.25	0	2.25	0.44	0.89	1.33	—	—	—
1	1.25	0.26	2.51	0.40	0.80	1.20	1.59	—	—
1	1.25	0.48	2.73	0.37	0.73	1.10	1.47	—	—
1	1.25	1.75	4.00	0.25	0.50	0.75	1.00	1.25	1.50
1	1.50	0	2.50	0.40	0.80	1.20	1.60	—	—
1	1.50	0.29	2.79	0.36	0.72	1.08	1.43	—	—
1	1.50	0.53	3.03	0.33	0.66	0.99	1.32	—	—
1	1.50	1.50	4.00	0.25	0.50	0.75	1.00	1.25	1.50

Reproductive cycle and school

Fig. 15 shows the frequencies of the date of conception infered with the mean growth curves of fetus and juvenile individual. The materials include all the fetus and the calves smaller than 165 cm in body length. It is sure in the preceeding discussion that these calves are still accompanied by the mother. The frequencies of conception calculated from the calves are shown by white area, and those calculated from the fetuses are shown by dotted area. The height of the highest peaks of the both frequencies in each schools are modified to be equal.

When schools are seen from the date of the conception of the fetus, the schools are grouped into two patterns. One includes the schools in which the fetuses are mostly composed of the autumn fetus (fertilized in autumn mating season), and the other the schools in which the fetuses are mostly composed of the spring fetus. The schools A, C, D, E, G, and H belong to the former, and school I to the latter. Because of the scarecity of materials it is impossible to classify the school F. The school B did not contain the pregnant female.

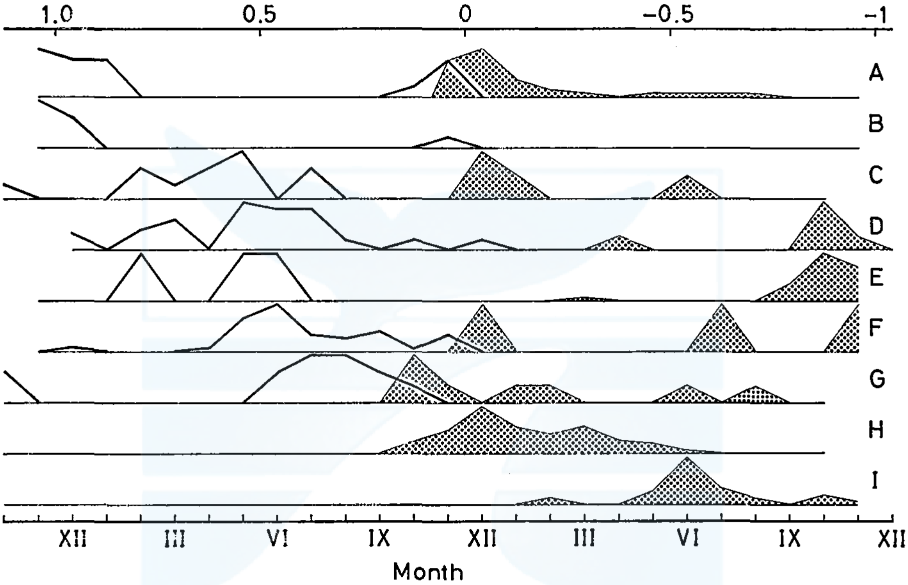

Fig. 15. Frequency of the date of conception of the fetus and calf smaller than 165 cm in body length, calculated by the growth curve. Figures at the top indicate the approximate age of samples at the time of catch. Dotted area indicates the fetuses and the white area calves. For further explanation see text.

Similar classification is possible by the date of conception of the juvenile calves. The calves in schools A and B are mostly composed of the autumn calf (fertilized and born in the autumn season), and those of the schools C, D, E, and F are mostly composed of spring calf. The school G shows the intermediate pattern.

There is observed various combinations between the fertilized date of calves and that of fetuses in the same school. In the school B only calves are observed, in the school A autumn calves and autumn fetuses are observed in one year interval, in the school C mostly spring calves and autumn fetuses in half year interval, in the schools D and E spring calves and autumn fetuses with about 1.5 year interval. In the school F the sample of fetus is too few to conclude, but probably it belongs to the same type with the school D. In the school G the larger fetuses and smaller calves seems to belong to one continuous mating season which slightly deviates from the typical mating season, and there is also observed few fertilizations in half year intervals at both sides of the main peak. In the schools H and I, there is observed no calves smaller than 190 cm and 205 cm respectively. These observation lead me to the following hypothesis on the behavior of the mature female.

The oestrous females may assemble together in a mating season, and will be impregnated. This stage is observed in the schools H and I. The school thus formed is expected to be the base of other complicated schools, when seen only from the side of mature females. This connection of the females will be retained through the period of lactation and at least untill the next oestrous cycle. This stage is seen in the school B. Then the females will reconstruct the school in accordance with the stage of the reproductive cycle. This is the reason why there is observed a peculiarity of the season of the conception of calf or fetus in each schools. All the other schools may have been formed as the result of sporadic annexation of the schools of pregnant females and that of lactating females in various stage of reproductive cycle. No special affinity between the original schools related with the size of calf and that of fetus is expected. The annexation between the lactating schools, or between the pregnant schools is not denied.

The schooling behaviors of the immature individuals of both sexes and of mature males are not well studied. If the males of 220 cm or more in body length are tentatively classified into mature, the numbers of mature males in the schools A, B, F, and G are 93, 41, 11, and 18, or 64.1 %, 242 %, 21.6 %, and 54.6 % of mature females (212 cm or more in length) respectively. It is considered that numerous mature males are found together with the mature females. There is an example of the school composed of immature individuals. This school, composed of about 600 individuals, was caught on 14 Dec. 1971, and random investigation was made on 303 animals by me and Mr. N. Miyazaki. Among these dolphins, all the 66 females were sexually immature and only 6 males in 237 males had testes weighed more than mean testes weight at the attainment of sexual maturity applied in this study.

Though there are observed many spring calves and autumn fetuses, the number of spring fetus is scarce in the present materials (Fig. 13). This may suggest the presence of the segregation of females related with the reproductive cycle. But further confirmation is needed on this problem.

DISCUSSION

There have been published two contrary opinions on the accumulation rate of the dentinal growth layers. Sergeant (1959, 1962) showed on *Tursiops truncatus* and *Globicephala melaena* that one opaque and one clear (translucent) layer are accumulated annually, and that the former in summer and the latter in winter. Similar conclusion was obtained on *Physeter catodon* by Ohsumi *et al* (1963), But Gambell and Grzegorzewska (1967) on *Physeter catodon*, Brodie (1969, 1971) on *Delphinapterus leucas*, and Kleinenberg and Klevezal (1962, cited in Brodie 1969) on *Delphinus delphis* considered that two layers are accumulated annually.

However, as indicated by Sergeant (1962), Ohsumi *et al* (1963), and Brodie

(1969) there are observed several fine layers in one dentinal growth layer. Especially in case of the young sperm whale, one growth layer of Ohsumi *et al* (1963) is usually composed of two parallel layers. Similar one or two vague layers are also observed in the 1st layer of *Stenella caeruleoalba*.

I consider that the above mentioned contravention on the accumulation rate of dentinal layers may be mostly caused by the different interpretation of the fine structure of the layer. It will be most necessary, at present, to establish the standards suited for each species, and then define the accumulation rates in each species.

According to the observation on the several western Pacific *Tursiops truncatus* born in an aquarium, the body lengths at the ages of 0.5, 1.0, and 2.0 years are 133 %, 155 %, and 185 % of the length at birth respectively (Nakajima *et al* 1963). In the Atlantic *T. truncatus*, the similar figure at the age of 7 or 8 months is 160 % (Essapian 1953). These figures coincide well with the growth of *Stenella caeruleoalba* presumed in this study, and suggest the correctness of my interpretation of the dentinal growth layers.

In *Stenella caeruleoalba*, the sexual maturity is attained in the 9th year in both sexes as in the case of *Physeter catodon* (Nishiwaki *et al* 1958, Ohsumi *et al* 1963). But in *Globicephala melaena* (Sergeant 1962) and *Delphinapterus leucas* (Brodie 1971), the mean age of the female at the attainment of sexual maturity is from 4 to 6 years, which is about half of that of the male. Further study is desired to have a conclusion if this result reflects the real growth of these species, or simply resulted from the different interpretation of the dentinal layers.

The mating season of *Stenella caeruleoalba* is peculiar in the possession of bimodal peaks. In the northern species, *Physeter catodon* has a mating season in April (Ohsumi 1965), *Delphinapterus leucas* in April and May (Laws 1959, Brodie 1971), *Globicephala melaena* in April and May (Sergeant 1962), *Phocoena phocoena* in from July to August (Laws 1959, Fisher 1970, Møhl-Hansen 1954). The mating seasons of the former 3 species nearly coincides with the spring peak of *Stenella caeruleoalba*, but the mating season of *Phocoena phocoena* situates in the summer, or at the intermediate season of the spring and autumn peaks of *Stenella caeruleoalba*.

With the relation of the various lengths of gestation period, the parturition seasons are in August in northern *Physeter catodon* (Ohsumi 1965), in June (Laws 1959) or in July and August (Brodie 1971) in *Delphinapterus leucas*, in August in *Globicephala melaena* (Sergeant 1962), and in July (Laws 1959) or in June and July (Fisher 1970) in *Phocoena phocoena*.

These informations are obtained, with one exception of *Physeter catodon*, from the species in colder waters. In these species the mating season and the length of gestation will have been adapted to put the parturition season in the northern summer or late spring, when the environment is better for newborn calves. However, *Stenella caeruleoalba* is considered to distribute, in the western Pacific, in warmer waters (Kasuya 1971, Kasuya and Oguro 1972), and not to migrate north of the northern boundary of the Japan current. Therefore it will not be an important factor for this species to give birth to the calves in summer season. This will have a relation with the existance of the two parturition season in *Stenella caeruleoalba*.

Tursiops truncatus in captivity had the gestation period of about 12 months and nursing period of 18 months (Tavolga and Essapian 1957), or nursing period of 16 months (Nakajima *et al* 1963). These figures show good coincidence with that obtained in *Stenella caeruleoalba.*

Ohsumi (1971) reported a hypothesis on the structure of the school of *Physeter catodon.* There are several structural differences between the school of *Stenella caeruleoalba* and that of *P. catodon.* One is the continuity of the members in the school of mature female of *Physeter catodon.* If this exists in the school of *Stenella caeruleoalba*, it is reasonable to expect the spring fetus and autumn fetus in same frequency in one school. This was not observed in the present study and the continuity, in the strict sense, of the members in nursing school can not be expected in *Stenella caeruleoalba.* Other characteristic features of the school of *Stenella caeruleoalba* are the larger size of the school and the larger number of the mature males found together with the mature females. The juvenile school is observed in *Stenella caeruleoalba* as in the cases of *Physeter catodon* (Ohsumi 1971) and *Globicephala melaena* (Sergeant 1962).

Perrin (1969) considered the between-school differences in coloration detected in *Stenella graffmani* to suggest the generic entities of the school of this species. This is inconsistent with the informations on the schooling behavior of *Stenella caeruleoalba* obtained in this study.

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EXPLANATION OF PLATES

In all the figures the contrast is reversed, or translucent layer is seen dark and opaque layer light.

PLATE I

Fig. 1. Thin ground section of tooth of 92 cm fetus.
Fig. 2. Thin ground section of tooth of a female, 116 cm, 1/4 year.
Fig. 3. Thin ground section of tooth of a female, 173 cm, 1 year.

PLATE II

Fig. 1. Thin ground section of tooth of a female, 193 cm, 4 1/4 year.
Fig. 2. Thin ground section of tooth of a male, 216 cm, 13 year.
Fig. 3. Thin ground section of tooth of a male, 221 cm, 25 year.

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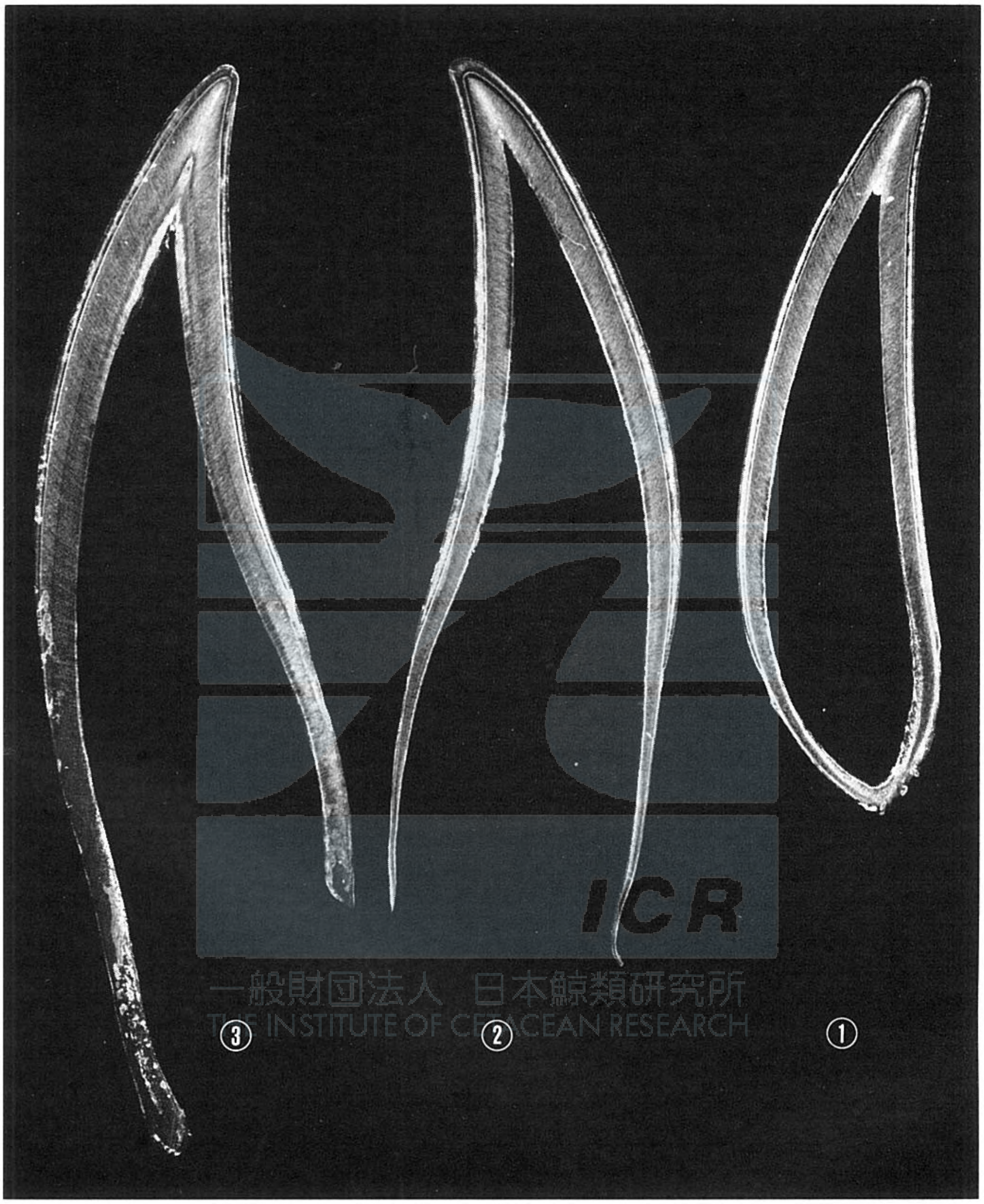
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A NEW TAGGING METHOD OF DOLPHINS

TOSHIO KASUYA* AND NOBUO OGURO*

ABSTRACT

In order to establish a technique to tag the dolphins without disturbing or destroying the school, tagging with bow and arrow was tried for dolphins which come to the bow of the ship. This method requires less skill in shooting and no special handling of the ship. Though, in this method, more than half of the tags are wasted and the length of the time when the tag remains on the dolphin is unknown, this method can be applied in the study of the short period movement of the schools.

INTRODUCTION

Dolphin fishing is operated at the several places on the Pacific coast of Japan. In the northern area *Phocoenoides* and few other boreal species are caught with hand harpoons. And in other area *Stenella caeruleoalba*, *S. attenuata*, and other several delphind species are caught both with hand harpoons and by driving a whole dolphin school into a harbor.

The establishment of the tagging technique is desired to obtain the informations on the migration and the schooling behavior of these species. Especially for the latter purpose, tagging must be performed without destroying the school.

This experiment was intended to establish the method of tagging the dolphins from a cruising vessel.

MATERIALS AND METHOD

The tags are of a type FH-69A (Floy Tag &Manufacturing, Inc., Seattle, Washington), and of the similar type used by Sergeant and Brodie (1969) for *Delphinapterus leucas*, except for a clear vinyl tube which covers, in the present tags, the printed return address and the number. The size of the stainless steel head is 35 mm in length and 7 mm in width. The length of nylon string is 15 cm. The weight of tag is about 3 g.

The arrow, applicator of the tag, is composed of three parts. The shaft is a tube made of glass fiber, 36 cm in length and 7.4 mm in diameter, and furnished with no feather. The head is made of brass. Its anterior part is shaped of a flat disc (15 mm in diameter, and 4 mm in thickness) to protect the dolphin from heavy injury, and the posterior part is shaped of a rod (6 mm in diameter and 17 mm in length) which is inserted into the shaft. A steel rod (70 mm in length and 3 mm in diameter) is inserted into a hole at the center of the brass disc. This rod protrudes about 45 mm from the disc, to leave about 1.5 cm between the disc and head of the tag.

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* Ocean Research Institute, University of Tokyo, Tokyo.

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At the tip of this steel rod, there is a small notch to set the metal head of the tag. The weight of arrow head is about 13 g, and that of the shaft 8 g.

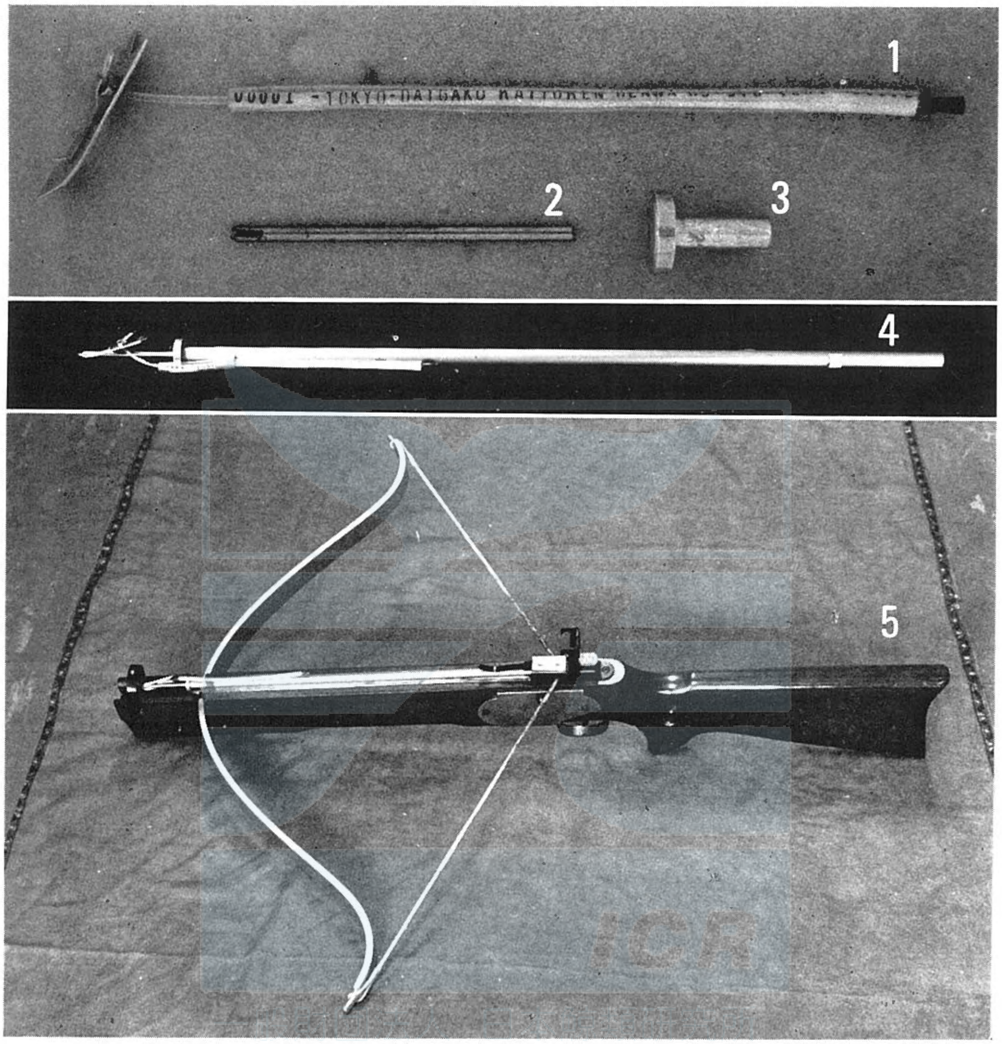

Fig. 1. Tag and tagging instruments. 1 : Tag, 2 : Steel rod of the head of arrow, 3 : Brass disc of the head of arrow, 4 : Tag mounted on the arrow, a small square protuberance is to fix the arrow on the spring of bow. 5 : Cross bow charged with arrow and tag.

In case of shooting the tag, the three parts of the arrow are inserted each other. And the tag head is set in a notch of steel rod and the plastic part is fixed on the shaft with a piece of medical paper adhesive tape. The arrow with tag is shot at the bow of the ship with a crossbow of 80 pound (36 kg) power.

RESULT

Preliminary experiment

As the first step of preliminary experiment, three diameters of disc of the arrow head, 15 mm, 20 mm, and 25 mm, were tried on a carcass of *Stenella caeruleoalba* laid in the air. The 15 mm disc was considered to be of enough size to protect the dolphin, and other experiments were made with 15 mm disc. This tag could efficiently penetrate into the dead dolphin sunk in a tank about 15 cm beneath the surface of the water, when shot at the distance of 5 m and at the angle of about 45°.

Other preliminary experiments were made on a school of *Stenella caeruleoalba* kept alive in Kawana harbor, and on an alive *Phocoenoides truei* tied to a ship. In the former case, two dolphins which had been swimming together were tagged and this accompaniment was observed for 7 hours until one tag, which hit on the hard tissue just behind the blowhole and did not penetrate enough, dropped. Another individual was tagged on the throat and penetrated sufficient depth.

In the case of *Phocoenoides*, when the three parts of the arrow were not fixed but loosely inserted each other, the tag penetrated under the blubber of dorsal region.

Practical experiment

The result of tagging is shown in Table 3. Two tags, nos. 3 and 4, were shot at the bow of the research vessel Tanseimaru (257 gross ton). Her height at bow and speed at the time of tagging were 4.5 m and 10 knot respectively. 8 tags, from no. 31 to no. 45, were shot on the whale catcher Ryuhomaru no. 3 (429 gross ton), and the height and speed were about 6 m and 4 knot respectively. 3 tags, nos. 54, 62 and 67, were shot on the research vessel Hayachinemaru (54 gross ton), and the height and speed were 3 m and 8 knot respectively.

TABLE 1. SOME INFORMATIONS ON TAGGED DOLPHINS

Tag no.	Date	Position	Species	School size	Water temperature	Remarks
3	20 Nov. ’71	35°23′N, 141°11′E	*Tursiosp* sp.	13	17.5	Other schools in short distance
4	21 Nov. ’71	34°52′N, 141°05′E	*S. caeruleoalba*	2	20.0	„
31	19 Jan. ’72	29°35′N, 140°38′E	„	100	19.8	School of small dolphins, no mother and calf
34	„	„	„			
35	„	„	„			
40	„	29°31′N, 140°42′E	„	20	19.8	Mother and calf observed
41	„	20°07′N, 141°11′E	„	100	21.4	Mother and calf observed
42	„	„	„			
43	„	„	„			
45	„	„	„			
62	10 Feb. ,72	39°45′N, 142°17′E	*Phocoenoides truei*	13	9.4	
?67	„	„	„			
54	14 Mar. ’72	39°01′N, 142°17′E	„	6	6.3	

21 tags were wasted to tag the 13 dolphins. The number of tags hit is 38% of the total number of tags shot.

At present (31 March 1972) no recovery is reported.

DISCUSSION

This method of tagging is aplicable for the dolphins which come to the bow of the ship without any special technics both in shooting the arrow and in handling the ship, even on the ship with high bow. But it is difficult to tag the dolphins which do not come to the bow, and requires special technics in the shooting and in handling the ship.

Even in the former species, the difficulty differs between species. *Phocoenoides* swims zigzag very actively at the bow, and considered to be one of the difficult species to tag.

According to the experiment on the Ryuhomaru no. 3, tagging was easier at the speed of 4 knot than the cruising speed 14 knot, because the dolphin stays longer on the surface, But the suitable speed may vary between species, because too slow speed does not usually attract the dolphin.

The two types of arrow head were tried. In one type, the three parts of the arrow were not fixed but loosely inserted into the holes each other. This type was tried on *Phocoenoides*. In other type the three parts were fixed each other, and tried on other species. There is no difference between two types in the shooting. The tagged dolphins went out of sight, in both cases, with the arrow shaft on its body. But we suppose that the shaft will have dropped within short period. Probably, the former type will be better to expect earlier drop of the shaft.

The efficiency of the similar tag on *Delphinapterus leucas* was reported by Sergeant and Brodie (1969). And it is reported that similar tag had stayed on some delphinids for several months (Evans *et al* 1972).

We consider that the present tagging method will be applicable in the study of short period movement of the dolphins.

ACKNOWLEDGEMENTS

This experiment was possible with the cooperation of the crews of the Hayachinemaru, the Ryuhomaru no. 3, and the Tanseimaru, and with that of Kawana Fishermen's Cooperative Union. Mr. T. Masaki of The Far Seas Fisheries Research Laboratory cooperated in tagging on the Ryuhomaru no. 3. Mr. S. Fujino of The Ocean Research Institute, University of Tokyo, kindly prepared the applicators of the tags. Prof. M. Nishiwaki gave us valuable informations on the tag. These persons are acknowledged.

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

SOME INFORMATIONS ON THE GROWTH OF THE GANGES DOLPHIN WITH A COMMENT ON THE INDUS DOLPHIN

TOSHIO KASUYA*

ABSTRACT

Following result was obtained in the study based on the 22 Ganges dolphins obtained in East Pakistan. Though the parturition season lasts long period, there might be two peaks in early winter and in early summer. Calf is born at small size compared with that of oceanic dolphins. The female grows larger, but the weight is slightly smaller than the male of same body length, which will be related with the larger length of the female snout. The sexual and physical maturity seems to be attained at the age of about 10 or less, and more than 20 years respectively. The growth pattern of this species shows peculiarities.

From some morphological differences, it is proposed to deal the Ganges and Indus dolphins as two separate subspecies.

INTRODUCTION

When seen from the evolutional point of view, the freshwater dolphins or Platanistidae is a interesting group of toothed whales in the morphological primitiveness found together with some specialization, and the restricted habitat.

Various authers have conducted the morphological and anatomical studies on *Platanista*, especially Pilleri and his colleagues are conducting the study on *Platanista* in various field of the biological science. They will throw light on the evolution of Platanistidae.

Present study deals with the problems related with the growth and reproduction of *Platanista*, which will afford some of the fundamantal informations on the adaptation and specialization of the toothed whales.

MATERIALS

This study is based on the 22 individuals of the Ganges dolphin obtained or studied by the Cetacean Research Expedition, University of Tokyo, directed by Prof. M. Nishiwaki. These materials are shown in Table 1 together with some biological informations. As shown in Fig. 1, all the present specimens were caught in East Pakistan, present Bangladesh. Among these specimens, no. 14 is a fetus obtained at the lower Meghna and preserved at East Pakistan Fish. Res. Inst. in Chandpur, which external measurements were made by M. Nishiwaki, 5 were caught at the Kola River a tributary of the Jamuna River in the north of Tistamukhghat, 11 at the

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* Ocean Research Institute, University of Tokyo, Tokyo.

TABLE 1. LIST OF MATERIALS USED IN THIS REPORT

No.	Date of catch	Date of death	Sex	Body length (cm)	Body weight (kg)	Position of capture
1	12, X, 1969	12, X, 1969	♂	105.0	—	Sutiakhali, Brahmaputra
2	—, VI, 1969	—, VI, 1969	♂	100.5	—	,, ,,
3	23, VIII, 1969	23, VIII, 1969	♂	115.0	18.8	,, ,,
4	30, XI, 1969	30, XI, 1969	♂	171.5	—	Kalir Bazar, ,,
5	20, X, 1969	20, X, 1969	♀	110.0	—	Begunbari, ,,
6	20, XII, 1969	28, XII, 1969	♂	117.0	—	Kewatkhali, ,,
7	6, I, 1970	6, I, 1970	♂	113.0	14.5	Khagdahar, ,,
8	12, I, 1970	12, I, 1970	♂	121.5	—	Jamalpur, ,,
9	12, I, 1970	12, I, 1970	♂	117.5	—	,, ,,
10	19, I, 1970	19, I, 1970	♂	200.0	—	Lalpur, Maghna
11	26, I, 1970	27, I, 1970	♀	113.0	—	Kola river
12	26, I, 1970	26, I, 1970	♂	115.0	16.8	Bhairab Bazar, Meghna
13	1, II, 1970	1, II, 1970	♂	115.0	—	,, ,, ,,
14	27, VIII, 1967	27, VIII, 1967	♀	27.0	—	Chandpur ,,
15	26, I, 1970	9, IV, 1970	♀	114.0*	—	Kola river
				118.0	16.4	
16	26, I, 1970	13, IV, 1970	♀	120.0*	—	Kola river
				120.5	17.0	
17	26, I, 1970	2, VII, 1970	♀	120.0*	—	Kola river
				127.0	23.0	
18	28, IV, 1970	28, IV, 1970	♀	126.0	17.0	Dighirpur, Meghna
19	—, V, 1970	—, V, 1970	♂	122.0	22.5	Bhairab Bazar, Meghna
20	7, V, 1970	7, V, 1970	♂	199.0	84.0	E.P.A.U., Brahmaputra
21	8, VI, 1970	8, VII, 1970	♀	67.4*	?7.3*	Bhabakhali, Brahmaputra
				76.0	3.4	
22	26, I, 1970	30, VII, 1970	♂	122.0*	—	Kola river
				126.0	24.0	

* Measured at the time of capture.

Brahmaputra River, and 5 at the Meghna River near Bhairab Bazar.

One of the method used in catching these animals is the "Jagatber" usually operated in dry season (Kasuya and Haque 1972). Specimens nos. 8, 9, 11, 15, 16, 17 and 22 were obtained by this method. Some of other specimens were caught with drag net which instruments are shown in Pl. I, Fig. 2 in Kasuya and Haque (1972).

Specimens nos. 15, 16, 17, and 22 were transported to Japan and kept alive in an aquarium, The Kamogawa Sea World, for several months. No. 21 was kept alive in a pond at Mymensingh for one month, then the carcass, together with nos. 18, 19, and 20, was transported to Japan by Prof. A. K. M. Aminul Haque.

AGE DETERMINATION AND GROWTH

Age characteristics

In this species, the growth layers are observed on both tooth and scapula. On the scapula, there are observed several narrow translucent bands arranged parallel with the contour of the dorsal edge. In the younger individuals less than 2

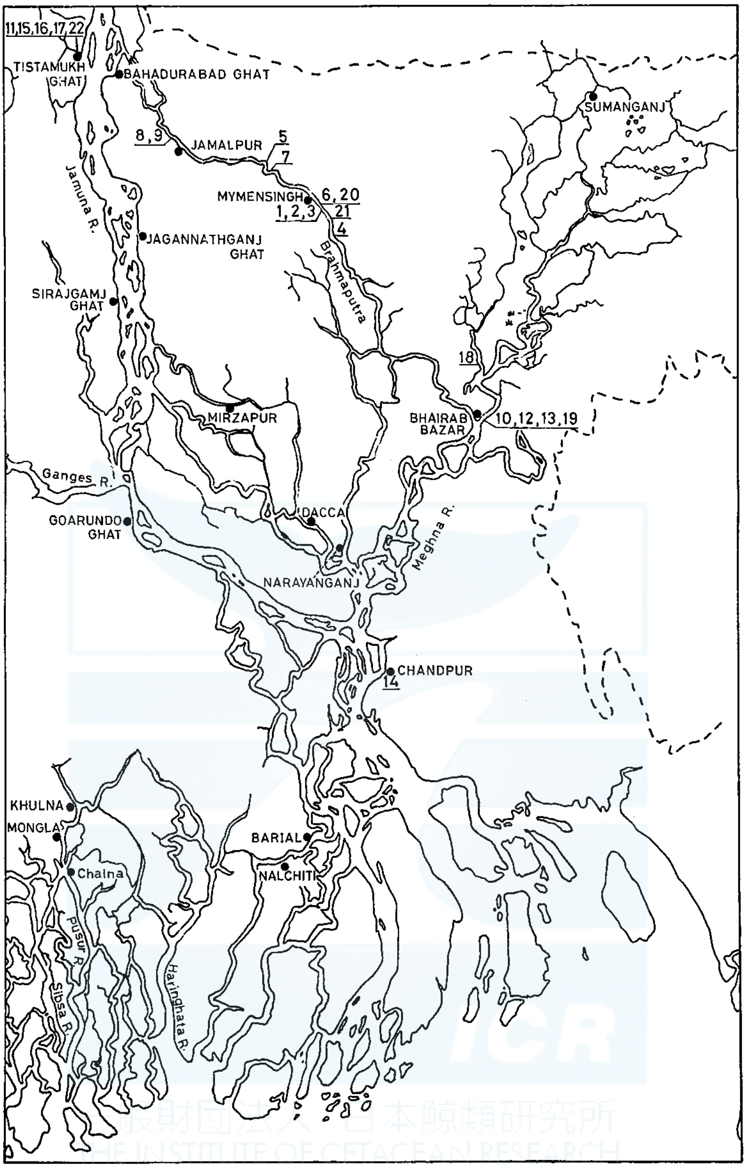

Fig. 1. Map of the Ganges and Brahmaputra River system showing the positions of the catch of present specimens. Numbers in the map indicates the specimen number in Table 1. (For Barial read Barisal.)

years old, the band is clear and the number coincides with that of growth layers in dentine and in cement. But, in the older individuals, the bands formed in the younger stage become vague or disappear, because they are covered by the bone tissue as the thickness of scapula increases.

In the cross section of the tooth, both in dentine and cement, there are observed wider opaque layer and narrower translucent layer accumulated alternately (Pl. I). As the number of layers in dentine and cement nearly coincides, it is considered that they are formed in a same cycle. However, as the growth layers in dentine is more regular in thickness and easily counted than the layers in cement, I concluded that the best age characteristics of *Platanista* is the dentinal growth layers, which is used in the present study.

For preparing the tooth for age determination, a larger tooth removed from the anterior part of maxilary or mandibular tooth row was ground perpendicularly from both sides to the thickness of about 50 to 70 μ (Kasuya 1972).

For determining the age, the number of the opaque layers in dentine was counted under the microscope. In the younger individuals, the age was determined into the approximate 1/4 year intervals considering the thickness of the first and last opaque or translucent layers. The dentine formed in fetal stage, an opaque layer, was not included. Several thin darker dentinal layers often observed in the layer of late fetal stage or in the first postnatal opaque layer are not discussed here. In this study, though the accumlation rate of the growth layers is not concluded, it is presumed from the consideration of the last layer (Table 2) that the translucent layer

TABLE 2. CONDITION OF THE NEWEST LAYERS IN DENTINE OF THE GANGES DOLPHIN, SHOWING THE SEASONAL ALTERNATION OF THE OPAQUE AND TRANSLUCENT LAYERS

Month	Opaque		Translucent
	Thin	Thick	
January	—	3	3
April	—	—	1
May	—	—	1
June	1	—	—
July	1	—	—
August	1	—	—
October	1	3	1
November	—	—	2
December	—	—	1

TABLE 3. AGE OF THE GANGES DOLPHIN PRESUMED FROM THE GROWTH LAYERS IN DENTINE

Age	No. of samples	Range of body length, Sex	Mean body length (cm)
0.25	1	76.0, ♀	—
0.50	1	100.5, ♂	—
0.75	2	105.0–110.0, ♀ ♂	107.5
1.00	9	113.0–117.5, ♀ ♂	116.2
1.25	1	122.0, ♂	122.7
1.50	1	120.0, ♀	
1.75	1	126.0, ♀	
10	1	171.5, ♂	—
16	1	200.0, ♂	—
28	1	199.0, ♂	—

(clear band) will be formed in winter and the opaque in summer as in the case of the oceanic dolphins (Sergeant 1959, '62, Kasuya 1972). The result of the age determination based on the growth layers in dentine is shown in Table 3.

The growth of the tooth of the Ganges dolphin has a peculiarity. Namely, the increase of the length of tooth after the formation of the root, which is considered to be finished at the 4th year after birth, is carried on by the accumulation of the thick cement layer (Pl. I). This type of growth is quite different from that observed in the tusk like tooth of the sperm whale, but can be explained as a result of specialization of the tooth of delphinidae, where the accumulation of cement layer is thinner. The accumulation of the dentinal layers continues after the formation of the root. And even in the oldest individual, in which 28 dentinal layers are counted, there is observed the space for more accumulation of dentine in the dental cavity.

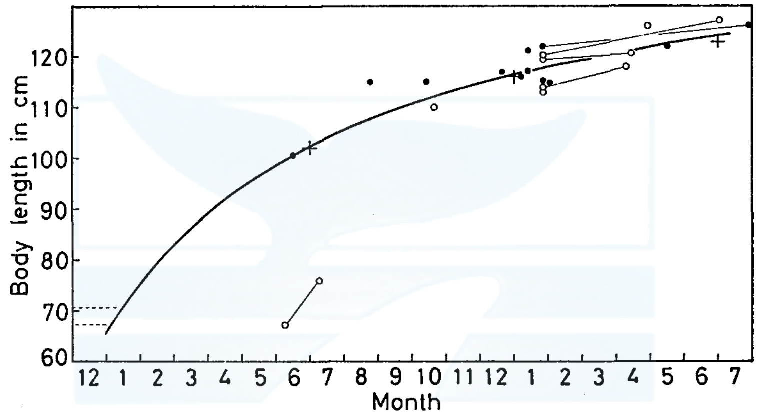

Fig. 2. Presumed mean growth curve of the Ganges dolphin. Closed circle indicates male, open circle female, and cross marks the mean body length at the age of 0.5, 1 and 1.5 year based on the growth layers in dentine. Circles connected with a straight line indicate the body length at the time of capture and that at death. The dotted lines indicate the range of known largest fetus and smallest calf.

Growth in young stage

Among the present specimens, the youngest individual was 67.4 cm (No. 21) at the time of capture. This individual is considered to be just after the birth. Anderson (1878) reported a fetus of 70.5 cm in body length. Therefore, at present, body length of the Ganges dolphin at the time of birth is presumed to be about 70 cm.

Besides the age determination data based on the dentinal layers, following informations on the growth of the Ganges dolphin were obtained. The specimen no. 21 showed the growth of 8.6 cm in body length while it was kept alive in a pond for one month. And the 3 specimens in the 4 animals kept alive in an aquarium, excluding one which had no increase of the length, showed the average growth of 1.1 cm per a month (Table 1). Furthermore, the body length of the juvenile individuals shows a slight increase with the elapse of date of catch.

The growth curve of the Ganges dolphin, shown in Fig. 2, was drawn based on the above informations. According to this curve the animal attains the body length

116 cm at one year after birth, or the increment of 65.7% of the length at the birth.

As shown in Pl. II, only the anterior teeth of upper and lower jaws had slightly erupted in the specimen no. 21. This will indicate that this animal was suckling at the time of capture. Within a month when this animal was kept alive, however, anterior 16 pairs of tooth of the both jaws erupted. And the observation of the stomach of this animal showed that it had started the feeding on fish. All the other juvenile individuals ranging from 110 cm to 120 cm in body length, caught in the river, had the food in the stomach and most of their teeth had already erupted. And these individuals were considered not to be accompanied by the mother. From these informations it is presumed that the calves born in the early winter start feeding at 1 or 2 months after birth, and weaning will be accomplished by the beginning of the dry season, or within one year after birth.

Sexual maturity

As shown in Table 4, all the individuals smaller than 130 cm in body length are sexually immature.

TABLE 4. SEXUAL CONDITIONS OF THE GANGES DOLPHIN

Body length (cm)	Sex	Sample size	Age	Gonads weight (g)	Maturity
110.0–126.0	♀	3	<2	0.4–1.6	immature
115.0–121.5	♂	4	<2	6.7–7.5	immature
171.5	♂	1	10	—	probably mature
199.0	♂	1	28	250	mature
200.0	♂	1	16	1110	mature

A male specimen no. 20, 199 cm in body length, was identified sexually mature by the histological observation of the testis. Though the testes were too decomposed for the histological observation, no. 20, 200 cm in body length, was considered from the weight of testes to have attained the sexual maturity. In the specimen no. 4, the testes had decomposed too bad to weigh, but the size of the original testis was presumed from the size of tunica to be a half or a third of that of no. 10. Then, the weight of the testes of this individual might have been from 40 to 140 g, which is far heavier than those of immature animals, and suggests that this individual had probably attained the sexual maturity or puberty.

This presumption lead to the conclusion that the male Ganges dolphin may attain the sexual maturity at about 10 or slightly less years as in the case of other toothed whales (Kasuya 1972, Ohsumi *et al* 1963, Sergeant 1962), and at the body length about 170 cm or less.

There are 6 records of sexually mature females known to me (Anderson 1878, Pilleri 1970), among which the smallest individual is 200 cm in body length. And the largest immature female is 150 cm (Anderson *loc. cit.*). These informations suggest that the sexual maturity will be attained between 150 cm and 200 cm. But as the female seems to attain larger size, it will be better to consider that the female attains the sexual maturity between 170 and 200 cm in body length.

Physical maturity

None of the present specimens had attained physical maturity. Table 5 shows the relation between body length and the ankylose of vertebral epiphysis to the centrum observed after cleaning the skeleton. The anterior epiphysis ankyloses earlier than the posterior one on the same vertebra. The epiphyses of the posterior thoracic vertebrae seems to be the last which ankyloses to the centrum.

TABLE 5. ANKYLOSE OF VERTEBRAL EPIPHYSES TO THE CENTRUM IN THE MALE GANGES DOLPHIN[1),2)]

Specimen no.	Body length	Age	1 C1	2	3	4	5	6	7	8 D1	9	10	11	12	13	14	15	16	17	18 L1	19	20	21	22	23	24	25
10	200.0	16	+	+	+	+	+	+	+	+	+	−	±	−	±	+	+	+	−	+	+	+	+	+	+	+	+
			+	+	+	+	+	+	+	+	±	+	±	+	±	±	−	−	−	−	−	−	−	−	±	+	+
20	199.0	28	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	±	+
			+	+	+	+	+	+	+	±	−	−	−	−	−	−	−	−	−	−	−	±	−	−	−	+	+
4	171.5	10	+	+	+	±	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
			+	−	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
13	126.0	1.75	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
			+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

1) The upper lines indicate the anterior epiphyses, and the lower the posterior.

2) + indicates the ankylosed epiphysis, ± that ankylosed at small parts, and − free epiphysis.

The male specimens nos. 10 and 20 are physically immature in spite of the age of 16 and 28 years old respectivily, which suggests that the growth of this species continues longer period than *Stenella caeruleoalba* (Kasuya 1972) and probably than *Globicephala melaena* (Sergeant 1962), as in the case of *Physeter catodon* (Nishiwaki *et al* 1958, Ohsumi *et al* 1965).

Anderson (1878) reported a physically mature 211 cm male, and the present specimen no. 10 is supposed to may have attained the physical maturity within a short period. These informations suggest that the body length of male at the attainment of physical maturity is between 200 and 210 cm.

In the present study, no physically mature female was obtained. The largest male known to me is 211 cm in body length (Anderson *loc. cit.*), but there are several records of female larger than this male, or 226, 238, 240 and 252 cm in body length (Anderson *loc. cit.*, Pilleri 1970). Among these records the 238 cm female is physically immature but the 252 cm female is physically mature. Then the best estimation of the body length of the female at the attainment of physical maturity may, at present, be probably about 250 cm, which is larger than that of the male.

BREEDING SEASON

In the present study sufficient number of fetus was not obtained to analize the breeding season. However, the dates of birth of the juvenile individuals were presumed from the body length and date of catch, using the mean growth curve in Fig. 2. This

TABLE 6. DATE OF BIRTH OF JUVENILE INDIVIDUALS PRESUMED FROM THE BODY LENGTH AND GROWTH CURVE, AND RECORDS OF LARGE FETUS OF GANGES DOLPHIN.

Month	IX	X	XI	XII	I	II	III	IV	V	VI
No. of birth[1)]	1	3	2	2	3	2	3	1	0	1
Large fetus[2)]	—	—	—	—	—	—	—	2	—	—

[1)] Calculated from present specimens.

[2)] Cited from Anderson (1878).

resut shows that most of the juvenile individuals were born from October to March with a center in December and January (Table 6). So, it is considered that this season is, at least, one of the parturition seasons of the Ganges dolphin, which coincides with the beginning of the dry season and with the winter season when most of the dolphins in the small rivers move to the main streams (Kasuya and Haque 1972). However, as indicated by specimen no. 21 of present study and four 25 cm fetuses in December reported by Pilleri (1970), another peak of parturition in the beginning of summer season (Anderson 1878) can not be denied. Anyway it seems to be sure that the parturition of this species can occur at any season of the year, and the presumed two peaks are not conspicuous.

If there are two peaks in the parturition season, one in the early winter and the other in the early summer, as in the case of *Stenella coeruleoalba* (Kasuya 1972), the gestation period may probably be about one year. And the 27 cm fetus in August (no. 14) might have been born in the former season and those reported by Pilleri (*loc. cit.*) in the latter. In this case, it must be presumed that the calves born in the early summer would have left, accompanied by the mother, the small streams in September when the water starts to decrease, and that some of the calves born about a year before and newly weaned had failed to leave the small streams where most of the juvenile specimens were obtained in the present expedition.

BODY WEIGHT

Fig. 3 shows the relation between body length and weight in the Ganges dolphin (circles) and the Indus dolphin (Cross marks), including 12 data cited from Pilleri (1970). As seen in Fig. 3, the body weight of the adult female is slightly smaller than that of the male of same body length, but there is no sexual difference in juvenile individuals. This will be related with the sexual dimorphism mentioned in the next chapter.

The regression line, calculated by the method of least squares for all the females of the Ganges dolphin except the smallest specimen (no. 21) is shown by the formula $W=0.0003025\ L^{2.290}$, where L means body length in cm and W body weight in kg. The formula for the Ganges dolphin of adult males and the juveniles of both sexes except no. 21 is shown by $W=0.00002456\ L^{2.826}$.

The body weight of the smallest female is smaller than the value expected from the formula, this will probably due to the unfavorable condition of the animal in the

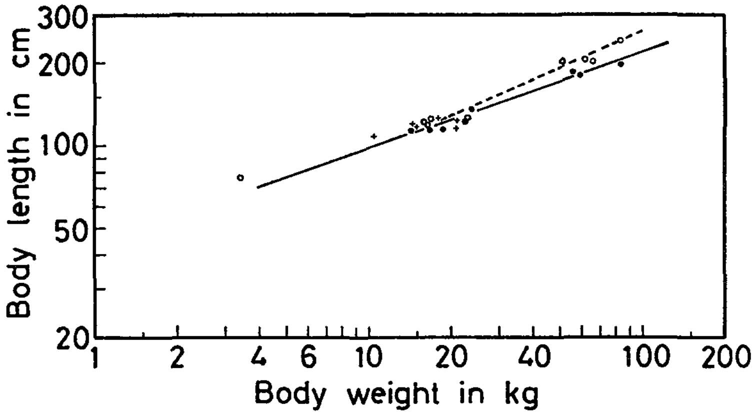

Fig. 3. Relation between body length and body weight in the Ganges dolphin. Closed circle and solid line indicate male, and open circle and dotted line female. Cross mark indicate the Indus dolphin reffered from Pilleri (1970). For explanation see text.

TABLE 7. WEIGHT OF THE GANGES DOLPHIN

Specimen no.	21		19		18		20	
Body length (cm)	76.0		122.0		126.0		199.0	
Sex	♀		♂		♂		♂	
Body weight (kg)	3.42		22.5		17.0		84.0	
Weight of parts	g	%	g	%	g	%	g	%
Blubber	970	30.0	10,600	48.5	5,280	33.7	30,990	35.9
blubber	—	—	10,220	46.7	4,880	31.1	29,140	33.7
tail flukes	—	—	380	1.7	400	2.6	1,850	2.1
Skeleton	1,175	36.3	3,670	16.8	3,723	23.8	16,050	18.6
skull	558	17.3	1,210	5.5	1,640	10.5	5,630	6.5
vertebrae	365	11.3	1,430	6.5	1,150	7.3	5,170	6.0
ribs	130	4.0	560	2.6	503	3.2	2,230	2.6
scapulae	32	1.0	120	0.5	100	0.6	540	0.6
flippers[1]	90	2.8	350	1.6	330	2.1	2,480	2.9
Skeletal muscle	418	12.9	5,881	27.3	5,255	53.6	29,790	34.5
vertebral, dorsal	192	5.9	2,720	12.4	1,800	11.5	11,440	13.2
vertebral, ventral	80	2.5	1,620	7.4	850	5.4	6,190	7.2
masseter	—	—	410	1.9	205	1.3	R. 710	0.8
others	146	4.5	1,131	5.2	2,400	15.3	11,450	13.2
Internal organs	670	20.7	1,724	7.9	1,390	8.9	9,578	11.0
Total	3,233	100.0	21,875	100.0	15,648	100.0	86,408	100.0

[1] Including the blubber.

pond where this animal was kept alive to die.

Table 7 shows the proportional weight of organs of 4 Ganges dolphins. In this species the weight of blubber occupies high percentage of from 30 to 48 % of body weight, and the internal organs do only from 8 to 20 %. The ratio of skeletal muscle, which increases with the growth of the animal, is from 12 to 35 % of the body weight.

In the specimens nos. 18, 19 and 21, the total weight calculated by summing up

TABLE 8. THICKNESS OF BLUBBER MEASURED ON THE LATERAL LINE, LOWER COLUMN INDICATES THE SOFT FATTY TISSUE BENEATH THE DERMIS.

Specimen	21		7		6		9		8		19		20		10	
Body length (cm)	76.0		113.0		117.0		117.5		121.5		122.0		199.0		200.0	
Sex	♀		♂		♂		♂		♂		♂		♂		♂	
	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%
Level of neck	0.5	0.7	1.2	1.1	1.0	0.9	—	—	—	—	—	—	—	—	1.5	0.8
	0.6	0.8	2.0	1.8	3.0	2.6	—	—	—	—	—	—	—	—	3.3	1.7
Level of flipper	0.5	0.7	—	—	1.1	0.9	—	—	—	—	—	—	2.0	1.0	—	—
	0.0	0.0	—	—	1.7	1.5	—	—	—	—	—	—	0.5	0.3	—	—
Level of dorsal fin	0.4	0.5	2.5	2.2	—	—	—	—	—	—	1.3	1.1	2.5	1.3	3.2	1.6
	0.2	0.3	0.0	0.0	—	—	—	—	—	—	1.1	0.9	1.5	0.8	0.0	0.0
Level of umbilicus	0.5	0.7	1.5	1.3	1.5	1.3	1.2	1.0	1.1	0.9	—	—	1.8	0.9	1.8	0.9
	0.3	0.4	1.0	0.9	2.7	2.3	0.9	0.8	1.9	1.6	—	—	0.8	0.4	2.0	1.0
Level of anus	0.3	0.4	1.0	0.9	1.5	1.3	1.6	1.4	1.9	1.6	—	—	2.2	1.1	2.5	1.3
	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	—	0.8	0.4	0.0	0.0

the weight of each parts shows the decrease of from 2.7 to 8.2 % of the original weight weighed before dissection. However, in case of no. 20 which was dissected watering to defrost, the summed weight showed the increase of 2.4 %.

Table 8 shows the thickness of blubber measured on the lateral line. The blubber of this species is characterized by the thick soft fatty layer beneath the harder connective tissue which will probably correspond to the blubber observed in the oceanic cetacea.

RELATIVE GROWTH

All the measurements, except those of appendages and distances between ear, eye and angle of gape, and the length of nasal slit, were made on a tape set in parallel with the carcass. These measurements of the present specimens are tabulated in Appendix. The relative growth of the anterior region of the Ganges dolphin is shown in Figs. 4 and 5, and that of posterior region and appendages in Figs. 6–8 and Table 9. Some important measurements are summarized in Fig. 9.

The length of head region is larger in adult females than in the males of corresponding body length. This is due to the larger length of the female rostrum as suggested by Anderson (1878), and will mean that after the growth of rostrum finished in the male the growth of this region continues in the female to attain about 20 cm larger length. This sexual dimorphism is presumed to come out at about 150 cm in body length. As the position of the anterior insertion of flipper does not show the sexual difference, the length from center of eye to anterior insertion of flipper is considered to be slightly larger in adult males than in the females (Fig. 4, top). Though the rostrum and mandible of juvenile Ganges dolphin is nearly straight, those tips of older individuals of both sexes are bended obliquely upward. This feature is well shown in Pls. 39 and 40 of Anderson (1878).

The relations between body length and the dimensions of the posterior region, and those of appendages are shown by straight lines. The regression lines in Figs. 6–8 and " mean " in Table 9 are calculated for the Ganges dolphin by the method of least squares. Among these measurements, those concerning the positions of umbilicus and genital aperture show the sexual dimorphism. In the male, umbilicus situates slightly anteriorly than it does in the females. This will be related with the extremely anterior situation of the male reproductive aperture, which situates very close to the umbilicus as in the case of *Pontoporia blainvillei* (Table 10). Though the measurement is not recorded, it is clear that the male gential aperture of *Inia* opens near to the umbilicus same as *Pontoporia* and *Platanista* (Pilleri 1969, Fig. 3). So, it is presumed that this character may be general in Platanistidae. But similar character is observed also in *Physeter* and *Kogia*.

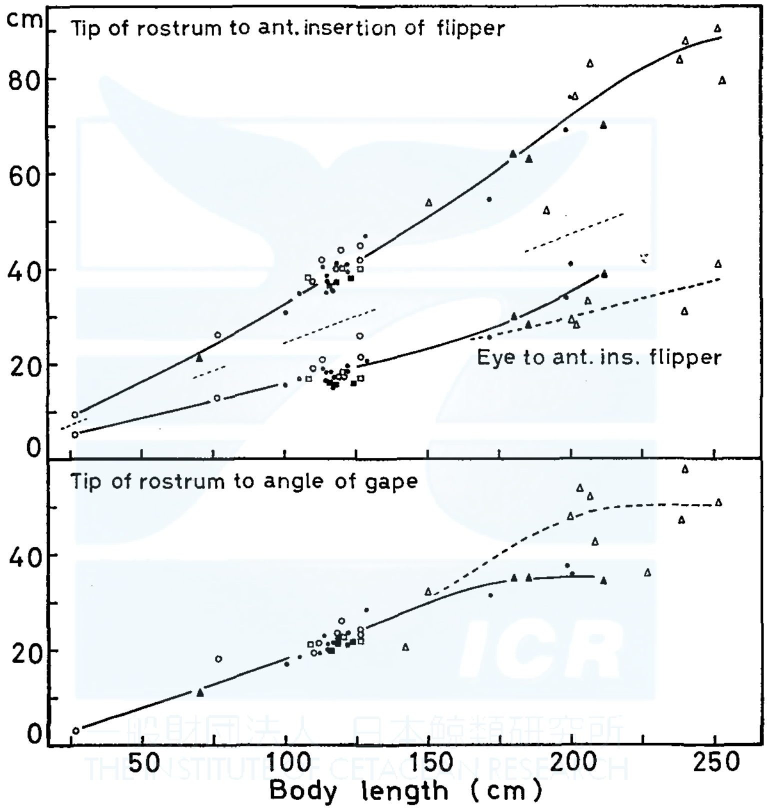

Fig. 4. Relative growth of the anterior region in *Platanista*. Circle indicates present specimen of the Ganges dolphin, triangle the Ganges dolphin reffered from Anderson (1878) and Pilleri (1970), square the Indus dolphin reffered from Pilleri (1970). The closed marks and solid line indicate male, and open marks and dotted line female. Lines are drawn by eye for the Ganges dolphin.

DISCUSSION ON THE GROWTH

Though, in the present study, no definite conclusion on the parturition season was obtained, the possibility was suggested to consider that *Platanista* has two parturition seasons one in early winter and the other probably in early summer. Then, the breeding season of this species seems to retain the same pattern as that of *Stenella caeruleoalba* which is different from that of *Physeter*, *Phocoena*, or *Delphinapterus* (Kasuya 1972).

Ohsumi (1966) showed an allometric relationship, $B=0.532\ M^{0.916}$, between mean body length at birth (B in m) and that of female at the attainment of sexual maturity (M in m) for *Physeter*, *Beradius* and several species of Delphinidae. If this formula is applied for *Platanista* assuming B=0.70 (m), 135 cm is obtained as the female body length at the attainment of sexual maturity. However, this figure is too smaller than the length obtanied in this study, even if it is compared with the smaller sex or the male.

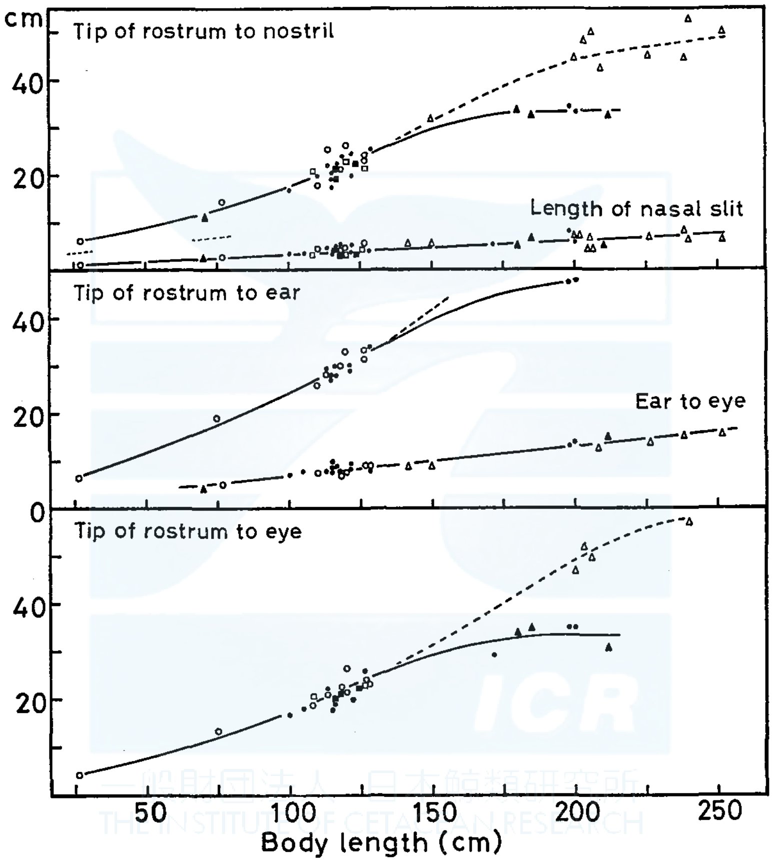

Fig. 5. Relative growth of the anterior region in *Platanista*. For marks see Fig. 4.

The increment of body length of *Platanista* in the first one year after the birth is 65.7 % of the body length at birth. This is nearly same with the value seen in some Delphinidae species (Kasuya 1972), and it is considered that the growth pattern of *Platanista* in the early stage of life retains presumable primitiveness as in the case of some Delphinidae species. Then it is considered that the augmentation of body size may have happened in the later part of the growth as one of the specialization of *Platanista.*

Accompanied with the augmentation of body length, the elongation of the growth period may have brought on as in the case of *Physeter.* But these specialization of growth is considered to have been accomplished as a result of evolution occured independently of that of oceanic odontoceti. Though in the oceanic species the secondary sexual characters as the tooth, or size or proportion of body develops usually in the male with an exception of body length of some Ziphiids, in *Platanista* the body length and the length of rostrum which are the prominent secondary sexual characters develop in the female. In Ziphiidae, at least in *Berardius bairdi* and *Ziphius cavirostris*, the male is smaller than the female (Omura *et al* 1955).

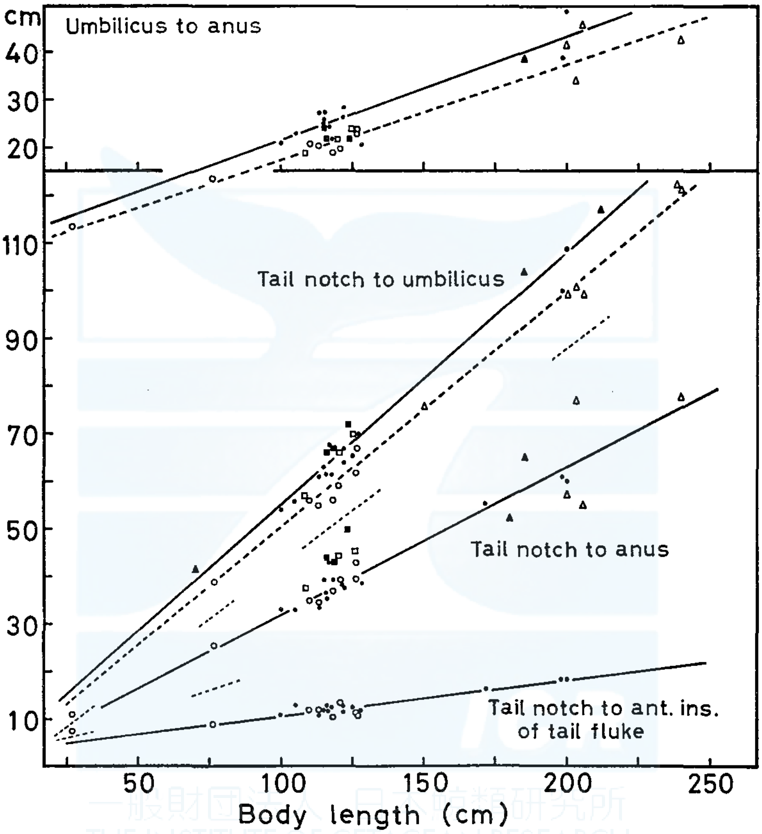

Fig. 6. Relative growth of the posterior region in *Platanista.* Lines are calculated for the Ganges dolphin by the method of least squares. For other marks see Fig. 4.

Though *Platanista* resembles with *Physeter* and *Kogia* in the anterior situation of genital aperture, *Platanista* may have developed this character independently of the other two species.

It is concluded, from the above discussions, that the pattern of the growth ob-

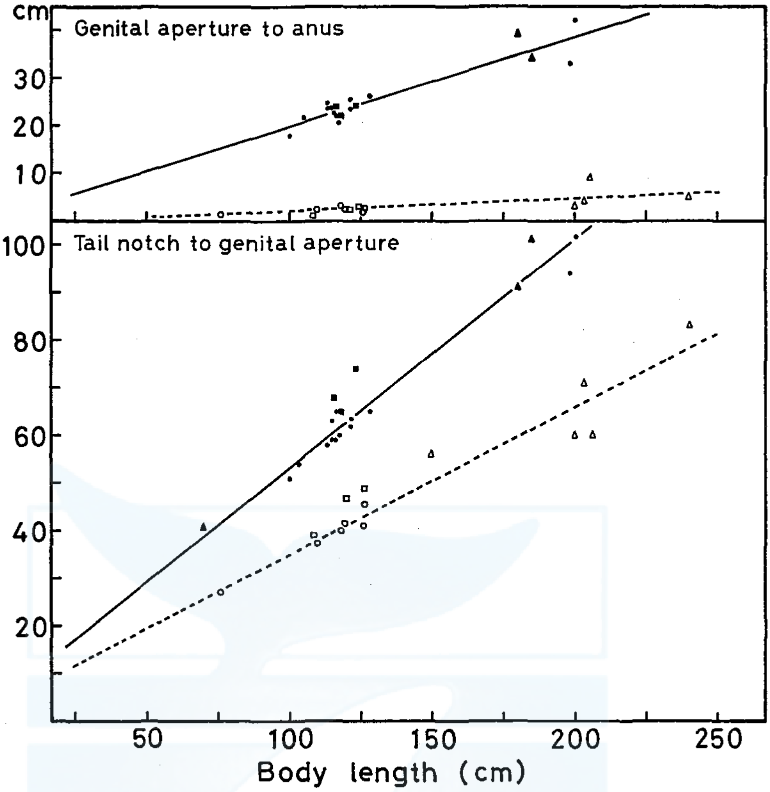

Fig. 7. Relative growth of the posterior region in *Platanista*. For marks see Fig. 6.

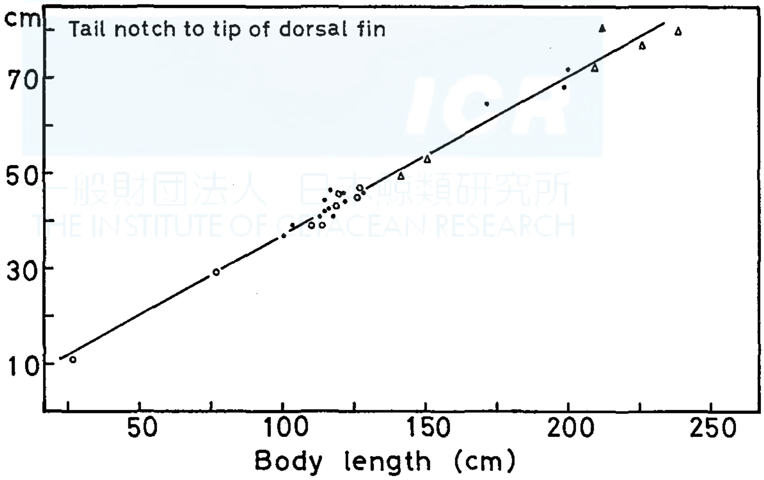

Fig. 8. Relation between body length and length from tail notch to tip of dolsal fin. For marks see Fig. 6.

TABLE 9. COEFFICIENT OF THE REGRESSION LINES[3] OF THE PROPORTIONAL LENGTH OF THE GANGES DOLPHIN

Measurements	Sex	Upper limit		Mean		Lower limit	
		a	b	a	b	a	b
Length from tail notch to tip of dorsal fin[2]	♀, ♂	0.357	4.5	0.335	3.68	0.328	1.9
,, to anus[1]	♀, ♂	0.395	−0.3	0.310	1.06	0.266	−0.3
,, to genital aperture[1],[2]	♀	0.391	−2.7	0.309	4.10	0.254	7.7
,, ,,	♂	0.527	3.5	0.479	5.05	0.437	7.1
,, to umbilicus[1],[2]	♀	0.561	−4.2	0.508	−1.49	0.492	−2.4
,, ,,	♂	0.563	1.6	0.530	1.93	0.472	6.0
,, to anterior insertion of tail fluke	♀, ♂	—	—	0.075	3.22	—	—
Length from anus to genital aperture[1]	♀	0.058	2.9	0.028	0.74	0.014	−0.3
,, ,,	♂	0.216	−0.1	0.187	1.31	0.152	2.7
,, to umbilicus[1]	♀	0.227	−2.7	0.202	−2.59	0.177	−1.8
,, ,,	♂	0.247	−0.4	0.217	0.23	0.254	−11.4
Distance from anterior insertion of flipper to anterior distal tip[2]	♀, ♂	0.179	−0.1	0.166	0.83	0.145	−0.7
Distance from axilla to posterior distal tip of flipper	♀, ♂	0.155	−2.2	0.121	−0.85	0.122	−3.4
Width of flipper[1],[2]	♀, ♂	0.134	−1.6	0.107	−1.51	0.098	−2.5
Total spread of tail flukes[1],[2]	♀, ♂	0.309	−4.6	0.235	−1.47	0.181	−1.1
Distance from tip of to tail flike to tail notch[2]	♀, ♂	0.170	−2.8	0.155	−3.77	0.121	−2.3
,, to anterior insertion	♀, ♂	0.222	−2.6	0.215	−3.50	0.160	−0.8

[1] Include Pilleri (1970), [2] Include Anderson (1878), [3] $Y = aX + b$, where Y and X indicate proportional and body length shown in cm respectively.

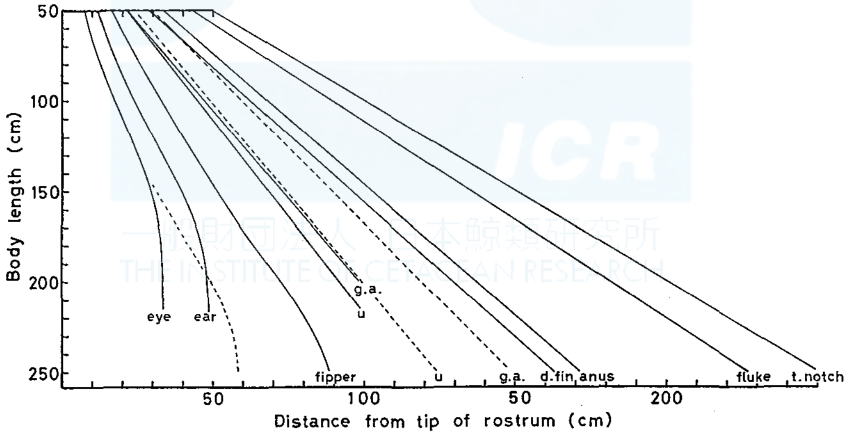

Fig. 9. Summary of Figs. 4–8, showing change of the relative positions of the external organs in the Ganges dolphin. Eye indicates center of eye, ear opening of ear, flipper anterior insertion of flipper, u umbilicus, g.a. genital aperture, d. fin dorsal fin, anus center of anus, fluke anterior insertion of tail fluke, and t. notch tail notch (left to right). Dotted line is for female and solid line for male.

TABLE 10. DISTANCE BETWEEN THE CENTERS OF GENITAL APERTURE AND UMBILICUS, MEASURED ALONG THE BODY AXIS AND SHOWN IN % OF BODY LENGTH

Sex	Male			Female		
Species	N	Range	Mean	N	Range	Mean
Platanista g. gangetica	12	0.8– 4.1	2.5	6	14.4–22.0	17.1
Pontoporia blainvillei (Pilleri 1971)	3	5.1– 7.7	6.0	4	13.0–14.8	13.8
Stenella attenuata (Nishiwaki *et al* 1965)	3	17.7–19.2	18.3	4	20.6–25.2	23.4
Feresa attenuata (Nishiwaki *et al* 1965)	6	10.5–14.3	12.4	7	12.9–19.4	16.4
Berardius bairdi (Omura *et al* 1955)	20	—	21.3	5	—	24.8
Physeter catodon (Matthews 1938)	60	—	7.6	8	—	20.8
Kogia simus (Kasuya *et al* unpbl.)	1	—	7.0	—	—	—

served in *Platanista gangetica* might have originated from that which had scarcely showed sexual dimorphism or augmentation of body size. From this hypothetical primitive growth pattern, that of recent delphinids and other oceanic toothed whales may have derived. But, among recent toothed whales, the delphinids seems to have attained the least modification in the growth pattern. This presumption is compatible with the morphological information on the growth of tooth (see *Age determination*).

TAXONOMICAL CONSIDERATION OF *PLATANISTA*

In Figs. 4–8, the proportional measurements of the Indus dolphin cited from Pilleri (1970) are also plotted. Though most of measurements are within the range of individual variation of the Ganges dolphin, the measurements concerning the length of tail show a significant difference between the dolphins from two river systems (Fig. 10, Table 11). Namely, when compared between the dolphins of nearly same body length, 118 cm, obtained from the two river systems, the length of tail is 6.7 cm shorter in the Ganges dolphin than the Indus dolphin. This difference is too large to concider as individual variation or personal deviation of the measurement. There is also observed a slight difference of the position of the anterior insertion of flipper between the dolphins from two river systems, which seems to come from the difference of the length from center of eye to anterior insertion of flipper (Fig. 4). But it can not be concluded, at present, if the difference is significont or not.

Pilleri (1971) reported the osteological difference observed on the height of nasal crest as a character to distinguish *Platanista gangetica* (Lebeck, 1801) and *P. indi* Blyth, 1859.

According to Yamashita (1971), the strong Himalayan orogenic movement started in the middle of Pleistocene, and is still continuing. He also indicated the

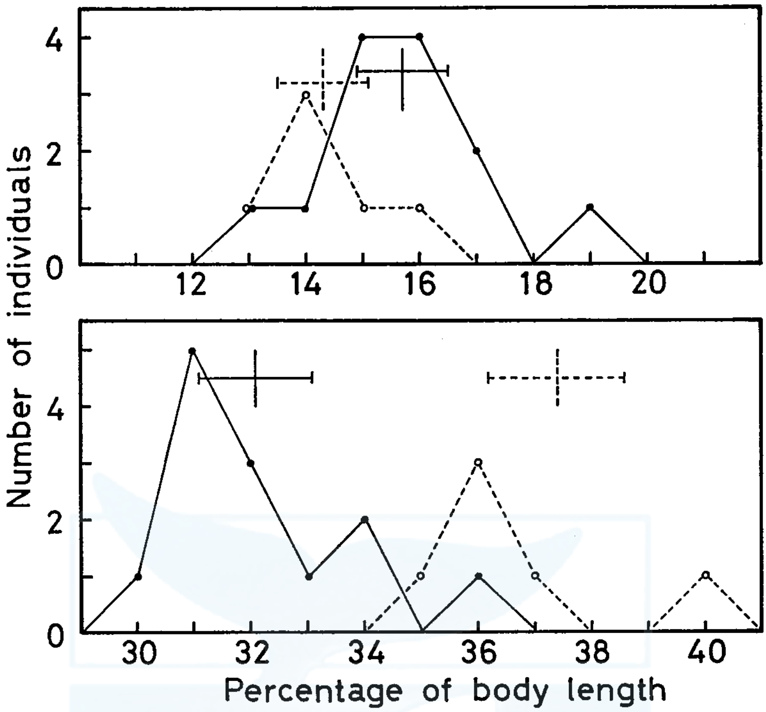

Fig. 10. Frequency distributions of relative length from eye to anterior insertion of flipper (top), and that from tail notch to anus (bottom) in *Platanista*, showing the morphological differences between *Platanista gangetica gangetica* (closed circle and solid line) and *Platanista g. indi* (open circle and dotted line). Vertical and horizontal lines indicate the mean and the ranges of two standard errors in both sides of the mean.

TABLE 11. SOME MEASUREMENTS SHOWING THE MORPHOLOGICAL DIFFERENCE BETWEEN THE GANGES AND INDUS DOLPHINS

Species	Ganges dolphin		Indus dolphin[1]	
No. of samples compared	13		6	
Range and mean of body length (cm)	110.0–126.0	117.2	108.0–126.0	118.3
Length from anus to tail notch				
range and mean in cm	33.5– 43.0	37.6	38.0– 46.0	44.3
range and mean in percentage	29.6– 36.8	32.1	35.2– 40.7	37.4
Length from eye to flipper				
range and mean in cm	15.0– 21.0	18.3	16.0– 18.5	16.9
range and mean in percentage	12.8– 18.6	15.7	13.0– 15.7	14.3

[1] Pilleri, 1970

possibility that the upper streams of some river had shifted, during this period, to have a connection with another river. This kind of exchange of the drainage area may have occurred between the Indus and the Ganges-Brahmaputra, which will have offered the chance for the *Platanista* to expand its habitat to another river, or to exchange the animal between connected two rivers. Anyway there will be no doubt that *Platanista* in the two river systems had originated from the same origin, and gained some morphological differences as the result of the separate evolution.

In some species of Mysticeti (Nishiwaki and Kasuya 1970, Omura 1957, Omura *et al* 1970), the characters of nasal or tail region seems to be the character where the differentiation occurs rapidly. Probably same presumption will be possible on *Platanista*. And, in my opinion, the evidence is still insufficient to consider *Platanista gangetica* and *P. indi* as two distinct species. The best way, at present, will be to deal them as two subspecies, or *Platanista gangetica gangetica* and *Platanista gangetica indi*.

SUMMARY

By the consideration of the growth of the Ganges dolphin based on the 22 individuals obtained in East Pakistan, the following results were obtained.

1. As the age characteristics, the growth layers in dentine is the best among the three characteristics compared in this study.
2. The opaque layers in dentine is suggested to be formed in summer, and the translucent in winter.
3. One of the peak of parturition season is in December and January, and the other, probably in early summer.
4. The calf seems to be born at about 70 cm in body length, and attain the body length of 116 cm in one year, and 123 cm in 1.5 years.
5. The calf probably start feeding at 1 or 2 month after birth, and weaning is accomplished within one year.
6. The sexual maturity is supposed to be attained at the age of 10 or slightly less, and the physical maturity, in the males, at the age more than 20 years.
7. The body weight of the adult female is slightly smaller than that of the male of the same body length.
8. Sexual dimorphism is observed in the body length, length of rostrum, positions of genital aperture and umbilicus, and perhaps in the position of flipper.
9. The growth pattern of *Platanista* seems to have originated from that probably had observed in primitive delphinids.
10. There is a clear difference of the length of tail between the Ganges dolphin and the Indus dolphin. And it is proposed to deal them as separate subspecies.

ACKNOWLEDGEMENT

Greatest thanks are due to Prof. A. K. M. Aminul Haque of the Bangladesh Agricultural University, without his cooperation present study would not have been accomplished. The Kamogawa Sea World and all the members of the Cetacean Research Expedition are also acknowledged for their help offered in East Pakistan and in Japan.

APPENDIX I. EXTERNAL MEASUREMENTS

Specimen no.	14	21	5	11	15	16	18
Sex	♀	♀	♀	♀	♀	♀	♀
From tip of upper jaw to:							
1. tail notch (total length)	27.0	76.0	110.0	113.0	118.0	120.5	126.0
2. anterior end of nasal slit	6.0	14.5	18.0	25.0	21.0	26.2	23.0
3. angle of gape	3.5	13.5	19.5	21.0	23.5	26.2	24.0
4. center of eye	4.2	13.5	18.5	21.0	22.5	26.6	23.0
5. ear	6.5	19.0	26.0	28.2	30.0	33.0	31.5
6. anterior insertion of flipper	9.5	26.5	37.5	42.0	40.0	44.0	42.0
From tail notch to:							
7. tip of dorsal fin	11.0	29.0	39.0	39.0	43.0	45.9	45.0
8. anterior insertion of tail fluke	—	9.0	12.0	12.0	10.5	13.6	11.5
9. center of anus	7.5	25.5	35.0	34.5	37.0	39.2	39.0
10. center of genital aperture	—	27.0	37.5	—	40.0	41.7	41.0
11. center of umbilicus	10.9	39.0	56.0	55.0	56.0	59.0	62.0
From angle of gape to:							
12. center of eye	—	2.3	3.2	—	—	—	3.0
13. ear	—	6.5	8.3	—	—	—	9.5
From ear to:							
14. eye	—	5.5	7.8	—	7.5	8.0	9.0
Flipper:							
15. anterior insertion to anterior distal tip, straight	3.2	13.5	18.5	18.0	18.0	19.1	18.0
16. anterior insertion to anterior distal tip, along curvature	—	14.5	20.5	20.0	20.0	21.0	19.5
17. axilla to posterior distal tip	2.0	9.5	13.0	12.5	13.0	13.5	13.5
18. greatest width	2.0	6.5	11.0	11.5	11.0	12.6	11.0
19. width at base	—	2.5	4.0	—	—	—	4.0
Dorsal fin:							
20. length of base	3.3	9.0	12.0	7.0	—	25.5	10.0
21. height	0.4	1.5	2.0	2.0	2.5	3.1	1.3
Tail fluke:							
22. tip to tip (total spread)	3.8	15.0	24.0	27.0	26.5	24.3	25.0
23. tip to notch	1.8	8.0	12.5	15.0	14.0	12.4	15.0
24. tip to anterior insertion	3.5	14.0	18.5	—	19.0	19.0	22.5
Nasal slit:							
25. length	1.1	2.5	4.5	4.0	4.0	4.5	5.8

In nos. 1 to 11, length was measured in parallel with body axis.

OF THE GANGES POLPHIN (cm).

17	2	1	7	3	13	12	6	9	8	19	22	4	20	10
♀	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂
127.0	100.5	105.0	113.0	115.0	115.0	115.5	117.0	117.5	121.5	122.0	128.0	171.5	199.0	200.0
24.0	(16.3)	19.5	21.5	(17.0)	19.0	20.0	22.0	23.5	24.0	19.5	25.0	34.0	33.0	—
24.5	17.0	18.5	23.0	20.0	21.3	19.5	21.5	23.0	23.5	21.0	28.5	31.6	37.5	36.0
23.5	16.5	18.2	21.5	18.0	20.0	19.0	21.0	22.5	22.0	20.0	26.0	29.2	35.0	35.0
33.5	—	—	29.0	—	27.8	27.0	28.0	30.0	30.0	29.0	34.0	—	47.5	48.0
45.0	31.0	35.0	40.5	35.0	38.5	37.5	36.0	40.5	41.0	39.5	47.0	54.6	69.0	76.0
47.0	37.0	39.0	41.0	44.5	42.0	42.5	46.5	41.0	44.0	46.0	47.0	64.8	68.0	72.0
11.0	11.0	13.0	11.0	12.8	12.0	12.0	12.5	12.0	13.0	11.5	11.5	16.5	18.5	18.5
43.0	33.0	33.0	33.5	39.5	35.5	36.5	43.0	39.5	38.0	38.5	39.0	55.3	61.0	60.0
45.5	51.0	54.5	58.0	63.0	59.0	59.0	65.0	60.0	63.5	62.0	65.0	—	94.0	102.0
67.0	54.0	56.0	61.0	65.5	63.0	61.5	67.5	61.5	64.5	67.0	70.0	—	100.0	109.0
—	—	—	4.2	—	3.4	3.5	2.7	3.0	3.5	3.0	3.5	—	4.5	6.0
—	—	—	9.0	—	9.4	9.5	9.5	9.3	9.5	9.5	9.0	—	14.0	16.0
9.0	7.5	8.0	8.0	8.0	8.8	8.7	9.0	8.0	8.8	9.5	8.0	—	13.5	14.0
20.5	15.5	17.5	19.0	17.0	19.0	19.0	19.0	18.5	18.0	17.0	21.0	—	35.5	29.0
23.0	17.5	19.0	21.0	19.5	21.3	21.0	21.5	20.5	20.0	19.5	22.5	—	39.5	33.0
14.0	11.5	12.0	13.0	13.0	13.2	13.5	14.0	12.5	13.0	11.5	15.5	24.4	23.0	21.0
15.0	8.0	10.0	9.5	8.5	11.5	11.5	9.0	11.5	12.5	11.0	14.0	17.8	25.0	22.5
—	3.5	4.0	3.5	3.0	—	4.0	3.0	4.0	4.0	4.5	5.0	5.7	7.0	7.0
16.0	—	—	21.0	—	8.0	—	19.0	17.0	18.0	11.0	12.5	—	36.0	—
2.5	—	—	4.5	—	2.8	1.5	2.0	3.0	3.0	1.5	3.1	—	5.5	—
28.0	23.0	22.5	26.5	26.5	26.5	25.0	28.5	27.0	28.5	29.0	29.0	38.7	57.0	42.5
16.0	13.0	11.0	15.5	14.5	15.3	13.5	15.0	15.0	—	16.0	15.5	—	30.0	23.0
23.0	—	—	22.5	—	22.5	20.5	22.0	21.5	22.5	21.0	24.0	—	38.5	33.0
4.5	4.3	4.3	4.3	3.3	2.8	3.5	4.8	4.8	3.5	5.0	4.0	5.6	8.0	6.0

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EXPLANATION OF PLATES

PLATE I

Ground thin section of the teeth of Ganges dolphin, translucent layers are shown black and opaque layers white.

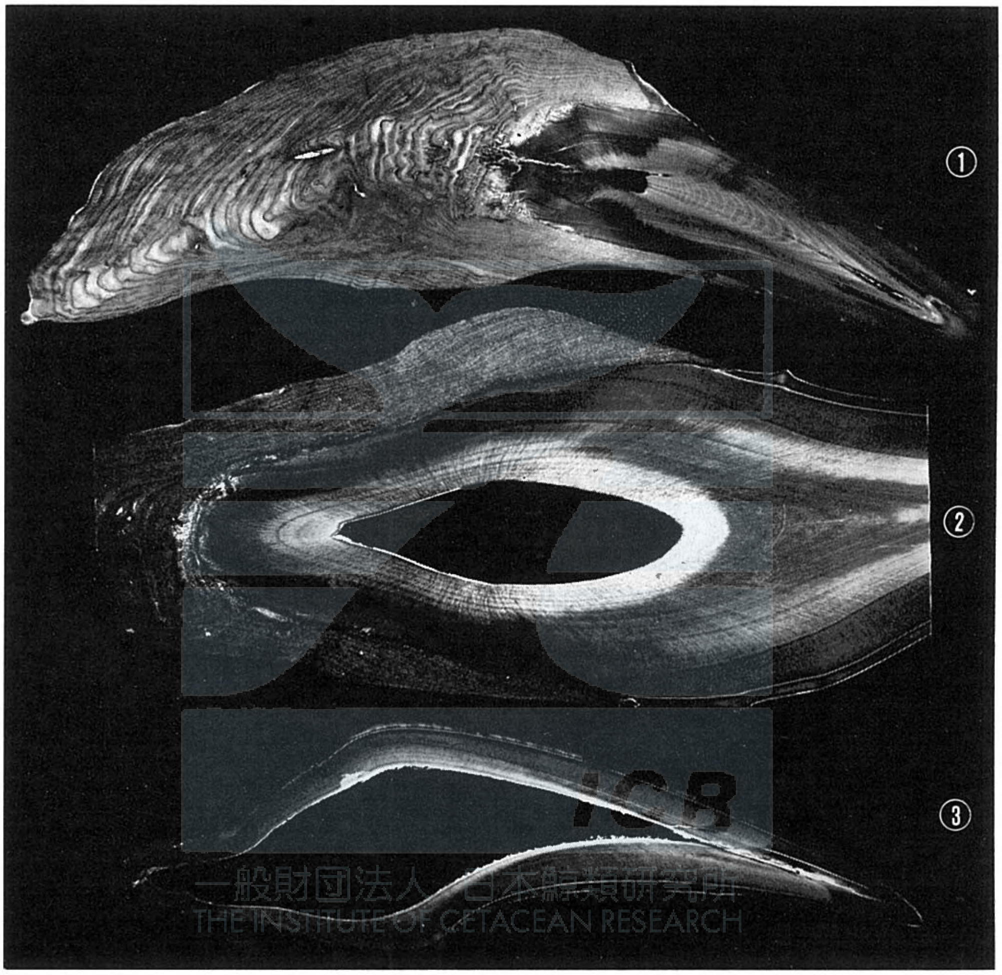
Fig. 1. Specimen no. 20, male, body length 199 cm, number of growth layers 28.
Fig. 2. Specimen no. 4, male, body length 171.5 cm, number of growth layers 10.
Fig. 3. Specimen no. 18, female, body length 126.0 cm, number of growth layers 1 3/4.

PLATE II

Ganges dolphin, no. 21, female, body length 67.4 cm. Photographed at the time of capture. Anterior most one or two pairs of teeth started to erupt, and hairs are observed on the both jaws.

PLATE III

Ganges dolphin, no. 7, male, body length 113 cm. In fresh condition the colouration is pale brown with a tinge of gray. The colour of throat and chest region is paler.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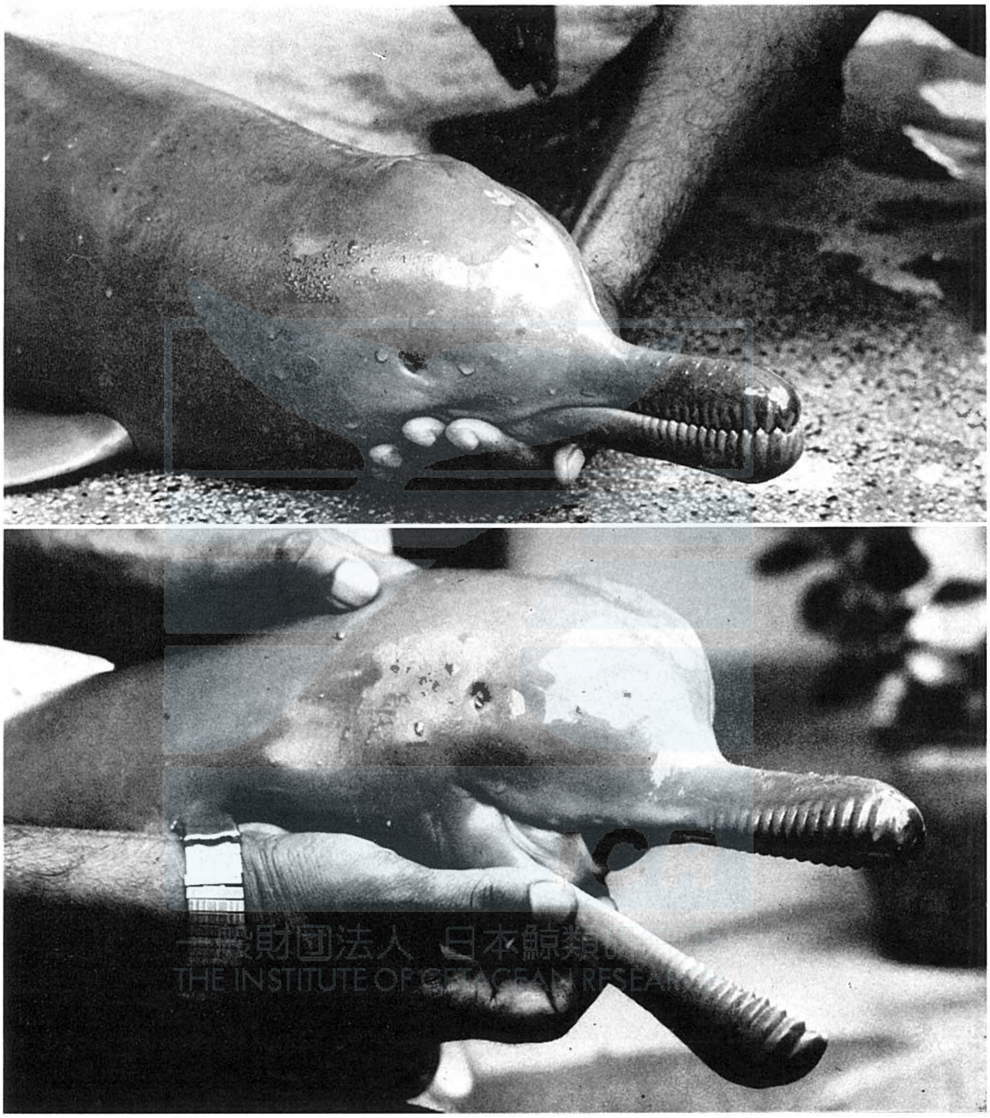

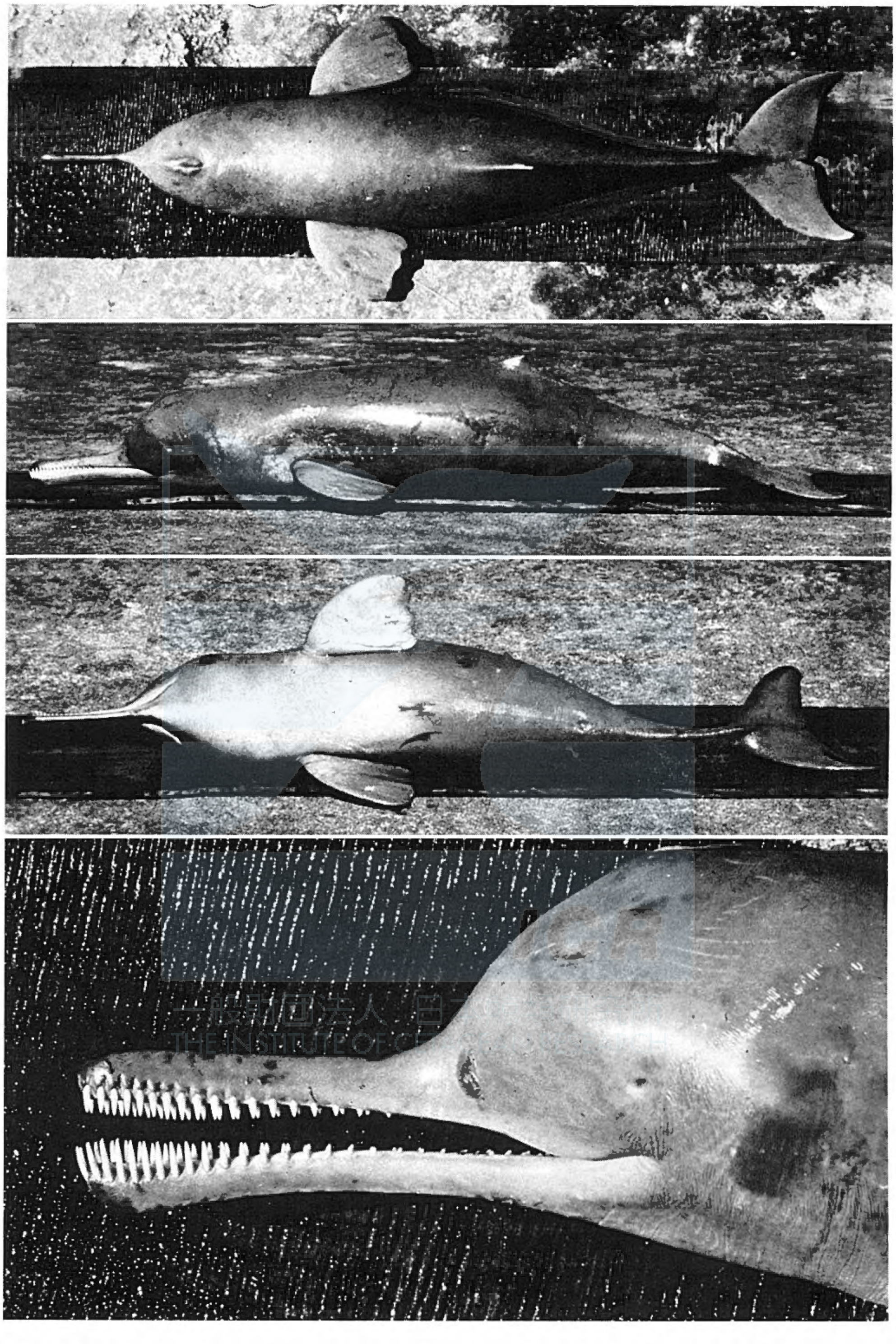


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SOME INFORMATIONS ON DISTRIBUTION AND SEASONAL MOVEMENT OF THE GANGES DOLPHIN

TOSHIO KASUYA* AND A. K. M. AMINUL HAQUE**

ABSTRACT

By analizing the data on the distribution of *Platanista gangetica* obtained in Nepal and East Pakistan in 1969 and 1970, following conclusion was obtained.

The upper range of the distribution in the Narayani River is at Dio Ghat, about 100 km north of the range reported before. In monsoon season, they extend the distribution to smaller streams, and go down to larger streams in dry season. The density is lower in the estuary. They were observed swimming mostly single or in couple in dry season. But they often assemble to special narrow area of waters, which is probably affected by the distribution of food.

INTRODUCTION

Though Anderson (1878) and Pilleri (1970) accomplished a intensive study on the distribution of the Indus and Ganges dolphins, their upper limit of the distribution in the Himalayan piedmont area, and the seasonal movements are not still clear.

Here, we report some informations on the distribution of the Ganges dolphin, *Platanista gangetica*, obtained by the Cetacean Research Expedition, University of Tokyo, directed by Prof. M. Nishiwaki.

The observation in Nepal was made in Feb. 1970, and that in East Pakistan, present Bangladesh, in the period from Oct. 1969 to May 1970.

DISTRIBUTION IN NEPAL

It is reported that the Ganges dolphin distributes in India up to near the boundary of Nepal along the Gandak (Anderson 1878). Present investigation was made at the Narayani River and its tributary, the Rapti River. They form one of the three large river systems in Nepal, and the lower stream of the Narayani River is called the Gandak which meet with the Ganges River at Patna, India.

On the Rapti River, the observation was made from Hitaura (85°02′E, 27°26′N) down to Jhawani in dry season on Feb. 2, 1970. The stream of this river was too shallow to expect the dolphin, and according to the informations obtained from the people in Jhawani and other several villages, the dolphin, which is called *Suongsu*, distributes not in the Rapti River but in the Narayani River.

Along the Narayani River, observation was made on the next 2 days with a small country boat from Dio Ghat to Bhwasara Ghat. The former situates at the confluence of the Kaligandaki and the Burigandaki. The water depth of this river was

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* Ocean Research Institute, University of Tokyo, Tokyo.
** Bangladesh Agricultural University, Mymensingh, Bangladesh.

measured with a weight and a line, and the width of the stream was presumed by eye, which are shown in Fig. 1. Though we could not find the dolphin, following informations were obtained from the people who live in the valley.

1. Dio Ghat: The dolphin is seen at this spot both in dry and rainy seasons, but none in the upper streams.
2. Narayani Bazar: Dolphins are seen sometimes in summer season, usually 1 or 2 individuals, recently (winter) no sighting.
3. Pitonj Ghat: Dolphins are seen sometimes (from Nepalese people). A dolphin was observed once between Dec., 1963 and Jan., 1964 by Mr. T. Shimada a Japanese proprietor of a farm.
4. Bhwasara Ghat: No dolphin is seen in the dry season, but have been seen in August to October (rainy season).
5. Gola Ghat: No dolphin was seen by us.
6. Gola Ghat to Tribeni Ghat: A Japanese doctor Iwashita sighted the dolphins on several occasions in March, 1969.

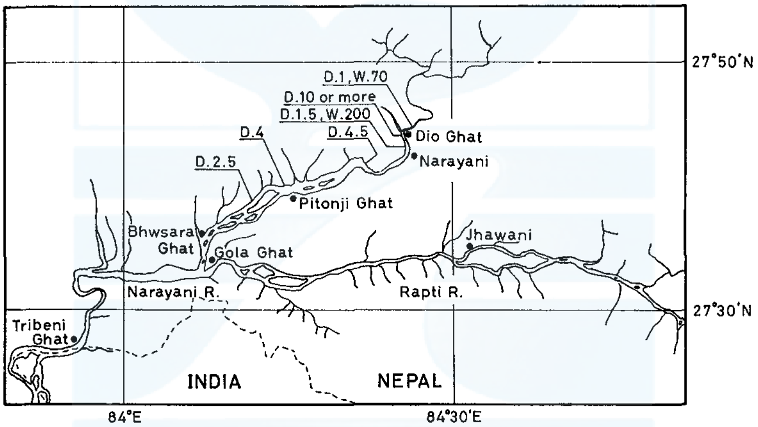

Fig. 1. Map showing the Narayani valley, Nepal. D indicates the depth of the water, and W width in m.

Among these informations, those obtained from Mr. Shimada and Dr. Iwashita are most reliable. Considering all of these informations it is concluded that the Ganges dolphin distributes in the Narayani River both in winter and summer seasons but the density between Gola Ghat and Dio Ghat will be lower in the winter season than in the summer season. Probably, most of the dolphins in the upper stream will move to the downstream in the winter. Though the stream with 10 m or more depth was found at Dio Ghat, most of the part of the stream between Dio Ghat and Gola Ghat was shallow and rapid. This environment will not be suitable for this species. But in the summer season, considering from the water mark on the rock, the water level at Dio Ghat seems to be about 3 m higher than in the winter.

The streams upper than Dio Ghat, or the Kaligandaki and Burigandaki are shallow and run in the rocky mountaineous area. So the migration of the dolphin is not expected. It will be safe to say that the upper limit of distribution along the

TABLE 1. WATER AND AIR TEMPERATURE AT NARAYANI VALLEY AND MYMENSINGH (BRAHMAPUTRA RIVER)

	Narayani valley	Mymensingh
Water	14.9°C (Dio Ghat, 09.00)	19.0–20.7°C (Morning)
	15.8°C (Pitonj Ghat, 10.55	—
Air	7.9°C (06.00)	10.5–13.3°C (06.00)
	21.3°C (13.30)	21 –23°C (14.00)

Narayani River will be at around Dio Ghat, which situates about 250 m above the sea level and about 100 km north from the uppermost range of the distribution confirmed by Anderson (1878).

The air and water temperature in the Narayani valley is shown in Table 1. The air temperature is nearly same with that at Mymensingh and Assam (Pilleri 1970), but the water temperature seems slightly lower than that at the Brahmaputra.

SEASONAL MOVEMENT

The seasonal movement of the Ganges dolphin was studied in East Pakistan, present Bangladesh. The observation was made at fixed stations on the Brahmaputra and the Meghna, or from the cruising ships in the Meghna and the Jamuna. In the case of the fixed stations, a half hour or one hour observation was repeated with the several days intervals. All the stations on the Brahmaputra River were placed around Mymensingh, and the distance from the uppermost station at Khagdahar to the lower station at Kalir Bazar is about 25 km along the river. All of these 8 stations are situated at the depths or at the confluence of a small river (Kewatkhali), where the dolphins are observed more numerously than the other places.

The Brahmaputra was once a main stream of the Brahmaputra river system, but in the present days it is only a branch of the main stream connecting the two big streams, or the Jamuna River and the Megha River. So in the winter season, its water depth is usually less than several meters except some deep spots. In January, the water depth near the station at Kalir Bazar was only about 1 m. The station at Sandarghat in Dacca is also on the relatively small branch of the Meghna River. Other observations were made at the main stream of the Meghna and the Jamuna.

Table 2 shows the seasonal fluctuation of the density of the dolphin considered from the frequency of the surfacing individuals. The density was classified into 4 categories of many, several, few, and none. In case when the number of individuals was estimated, it was also recorded. As seen in this table, the population of the dolphin in the Brahmaputra starts to decrease at the beginning of November. And in December and January, only few individuals seem to have remained in the observed area of the Brahmaputra near Mymensingh. Same tendency was also observed at the station at Sandarghat. Other information on the population density in the Brahmaputra was obtained from the result of " Jagatber " fishing, in which one net is set across the river and another net which is set in the upper stream is moved slowly day by day toward the down stream, finally to catch all the fish between the

TABLE 2. SEASONAL FLUCTUATION OF THE DENSITY OF THE GANGES DOLPHIN SIGHTED AT THE STATION OR ON THE SHIP

Month	Oct.		Nov.			Dec.			Jan.	
Decade	2	3	1	2	3	1	2	3	1	2
Brahmaputra										
Khagdahar		╫	+	+	1	0	0	0	0, 1	
Govindapur	╫	╫	0	0			0	0	0	
Shambhuganj	╫	╫	╫			0	0	0, 1, 2	0	
Kewatkhali	╫	0		+	0, 1–2	0	0, 1	0		
Sutiakhali	╫	+	+	1	0	0, 1	0	0	0	
Phulpur	╫			1		0	0	0	0	
Bhabakhali	╫	╫	╫			0	0	0	0	
Kalir Bazar		╫	╫			1–2	0	0		
Meghna										
Bhairab Bazar			⧻	⧻					⧻	
Sandarghat, Dacca		⧻						0		
Chandpur—Dacca										⧻
Jamuna										
Tistamukhghat —Goalundoghat									⧻	⧻

two nets. The Jagatber operated in January at the Brahmaputra River near Jamalpur (see the map in Kasuya 1972) showed that there was 3 dolphins in the stream of 5 km length.

In Assam the rainy season lasts from May to September and there is very few rainfall in the remaining months (Pilleri 1970), as the result the water level of the Ganges-Brahmaputra river system is considered to decrease from October to April. So we consider that the most of the Ganges dolphin in the tributaries may have retreated to the main streams and will come back again in the rainy season. However, some individuals seem to be left in the tributaries in the dry season. They are mostly juvenile animals of about one year old (Kasuya 1972).

In the large stream of the Meghna and the Jamuna the dolphin is observed in both rainy and dry seasons.

The geographical variation of the density of the Ganges dolphin in dry season was observed from the cruising ship by one or two persons in 1970 in the following area (for the name of the place, see Kasuya 1972).

Jamuna River

2, Jan.; 2 persons, Jagannathganj Ghat—Sirajganj Ghat, Steamer.
14, Jan.; 2 persons, Bahadurabad Ghat—Tistamukh Ghat—Jagannathganj Ghat, Launch.
19, Jan.; 2 persons, Jagannathganj Ghat—Sirajganj Ghat—Goalundo Ghat, Launch.
20, Jan.; 2 persons, Chandpur—Narayanganj, Steamer.
27, Jan.; 1 person, Narayanganj—Chandpur—Barisal (to Sundarbans, continue to 28th), Steamer.

Sundarbans
28, Jan.; 1 person, (Barisal)—Tharacatti—Nalchiti—Mouth of Haringata R.—Chalna—Khulna, Steamer.
30, Jan.; 1 person, Khulna—Mouth of Pusur R.—Khulna, Launch.
Meghna river
30, Apr.–3, May; 1 person, Streams from Bhairab Bazar to Sunamganj, Several launches.

TABLE 3. GEOGRAPHICAL VARIATION OF THE DENSITY OF GANGES DOLPHIN BASED ON THE OBSERVATION ON THE SHIP

Distance from estuary[1]	Locality	Number of sightings individuals	Number of individuals per 100 miles[1]	Month
0– 30	lower Sundarbans	29	29	January
30– 60	up to Khulna (upper Sundarbans)	32	67	,,
	up to Chandpur (lower Meghna)	34	35	,,
60– 90	up to Dacca	95	191	,,
90–120	up of Goalundo Ghat	15	182	,,
120–150	up to Sirajganj Ghat	37	57	,,
150–180		37	69	,,
180–210	up to Tistamukh Ghat	4	16	,,
130<	Meghna, upper stream of Bhairab Bazar	540	229	April and May

[1] in nautical miles.

Table 3 shows the total number of individuals sighted, and the relative density of the dolphin shown by the calculated number of sighted individuals per 100 nautical miles (186 km) of observation. In case of the Meghna, calculation was made assuming the speed of launch as 8 knot (15 km/hour).

According to this result the dolphin seems to distribute densely in the lower and upper Meghna, and lower Jamuna. But the density in the estuary is slightly low.

Other than the Ganges dolphin, 6 *Orcaella brevirostris*, which were identified by the dark colour and the pointed dorsal fin, were observed in 5 occasions at Mongla and Sundarbans.

SCHOOLING BEHAVIOR

Because of the turbidity of the water, the behavior of the dolphin under the water is not observable. In this study, dolphin or dolphins surfacing at close distance and swimming toward nearly same direction were considered to belong to one school.

Table 4 shows frequency distribution of the number of individuals constituting a school. This observation was made in the dry season in the same cruise mentioned in the preceding chapter. It is shown in the table that most of the schools, 90.0% of the total number of schools sighted or 80.4% of the dolphin of this species are single individual. The schools formed by 2 individuals are found in only 8.4% of all the schools, and the number of animals constituting these schools is 15.0%. So, it is con-

TABLE 4. SCHOOL SIZE OF THE GANGES DOLPHIN

Locality	Month	1 no.	1 %	2 no.	2 %	3 no.	3 %	4 no.	4 %	total no.	total %
Tistamukh Ghat to Golundo Ghat	Jan.	73	90.1	5	6.2	2	2.5	1	1.2	81	100.0
Lower Meghna and Sundarbans	Jan.	189	85.9	28	12.7	3	1.4	0	0.0	220	100.0
Upper Meghna	Apr., May	550	91.5	39	7.0	7	1.3	1	0.2	557	100.0
Total no. of schools	—	772	90.0	72	8.4	12	1.4	2	0.2	858	100.0
Total no. of individuals	—	772	80.4	144	15.0	36	3.8	8	0.8	960	100.0

(Column groups 1–4 and total: No. of individuals in a school)

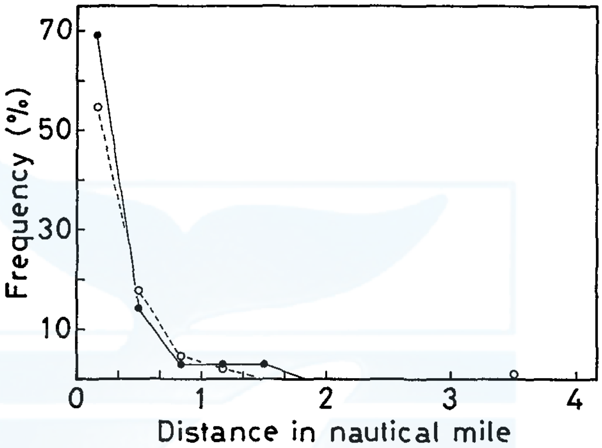

Fig. 2. Frequency distribution of the length of the course where the Ganges dolphin was sighted with the interval less than 1/3 nautical mile. Closed circle and solid line indicate the Jamuna River, and open circle and dotted line the lower Meghna and Sundarvans.

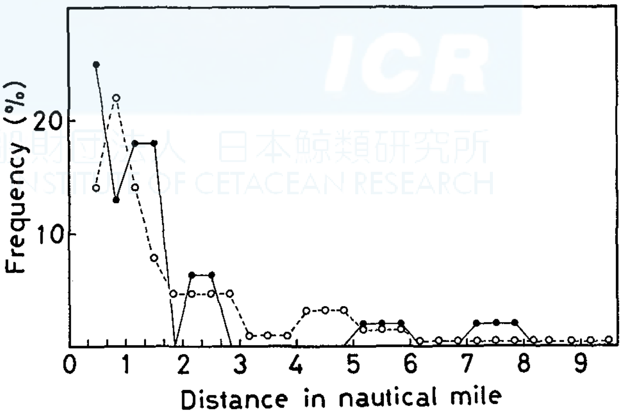

Fig. 3. Frequency distribution of the length of the course where the Ganges dolphin was not sighted. In case where the dolphin was sighted with the interval less than 1/3 miles, it is dealt as continuous. For other marks see Fig. 2.

sidered that the Ganges dolphin is not a gregarious species, at least in dry season, quite different from the other oceanic dolphins.

Fig. 2 shows the frequency distribution of the length of the course of the ship where the dolphins were observed with the intervals less than 1/3 nautical mile (620 m). This indicates that the dolphin assembles to some narrow placess in the river. We think that this will be related with the distribution of the food of the dolphin, because the dolphins were often observed at the confluence of a river or down streams of a shallow place. As seen in Fig. 3, the places where dolphin assembles are usually scattered with the distance less than 3 nautical miles (5.6 km), but sometimes with 4 miles or more distance.

The Ganges dolphin never comes to the bow of the ship, which is different from the usual oceanic dolphins.

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We acknowledge all the members of the Catacean Research Expedition, University of Tokyo, who helped us in collecting the data on distribution of the Ganges dolphin.

Mr. Hamada and Dr. Shimada of the Rapti Agricultural Experimental and Model Farm helped us in having a small trip to the Narayani River, and Dr. Iwashita informed us of his observation on the dolphin in Nepal. These persons are greatly acknowledged.

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EXPLANATION OF PLATE

Fig. 1. Gola Ghat, the upper limit of distribution of *Platanista gangetica* on the Narayani River in Nepal. The stream of this side is the Burigandaki River, the other the Kali gandaki River, and the lower stream at the left.

Fig. 2. Fishing boats in the Brahmaputra River, at Samoganj near Mymensingh, Jan. 1970.

Fig. 3. The Meghna River at Bhairab Bazar, Jan. 1970.

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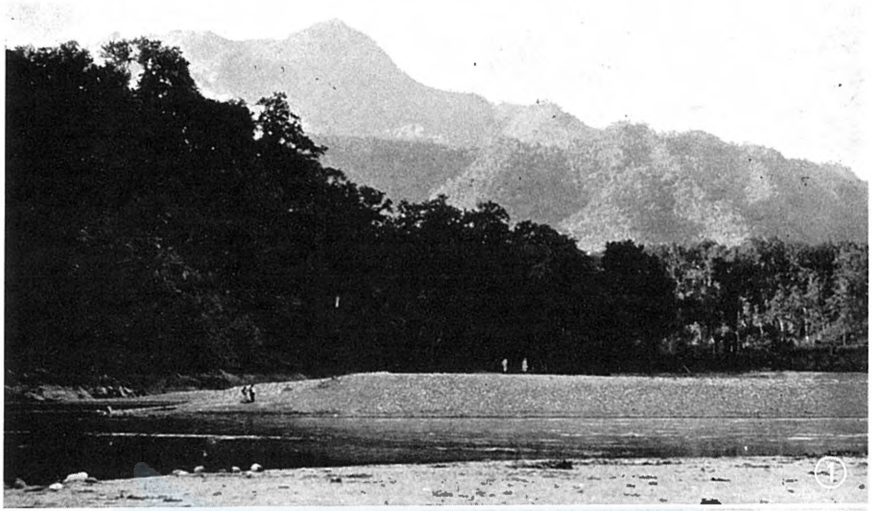
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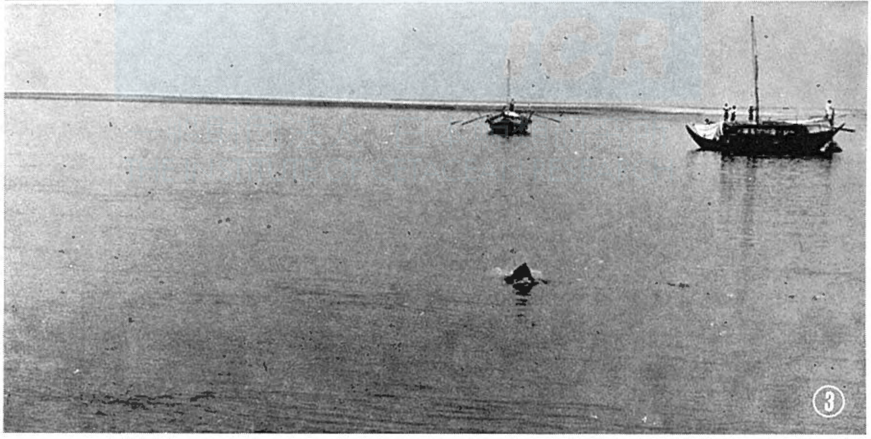
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FATTY ACID COMPONENT OF VARIOUS BLUBBER OIL OF GANGES RIVER DOLPHIN*

HIDEO TSUYUKI** AND SHINGO ITOH**

ABSTRACT

The oil contained in various blubbers of Ganges river dolphin, *Platanista gangetica*, has been investigated in the present work.

The fatty acid component of sample oil has been analyzed by GLC. Thirty-seven fatty acids with chain lengths from 5 to 24 carbon atoms and zero to six double bonds were tentatively identified in Ganges river dolphin oil. Three fatty acids of C_{16} saturated, C_{16} monoenoic and C_{18} monoenoic acids constituted an average of more than 66.45% of total acids. The fatty acid component of each sample oil was found to be relatively rich in unsaturated fatty acids (62.35–77.62%), and saturated fatty acids were contained in small amounts (22.38–37.65%).

INTRODUCTION

In the previous paper (Tsuyuki and Itoh, 1971), we reported that Ganges river dolphin oil comprized more than 24 kinds of fatty acids with 12–22 carbon atoms, including mostly hexadecanoic, hexadecamonoenoic and octadecamonoenoic acids. Further, Pilleri has studied the chemical properties on the lipid of the blubber of *Platanista indi* and *gangetica* (1971).

In the present investigation, the fatty acid component of various blubber oils of two Ganges river dolphins was studied by gas liquid chromatography using a hydrogen ionization detector.

This study is reported as a part of the examination of *Platanistidae* which had been continuing to date by organized Japanese Scientists.

It was a pleasure for us to join in this study.

MATERIALS AND METHODS

The materials used in this study were two Ganges river dolphins (body length 126.0 cm, body weight 17.0 kg, immature female as sample A and 199.0 cm, 84.0 kg, mature male as sample B).

Oils were extracted by boiling various blubbers of Ganges river dolphins with water. The chemical properties of these oils were examined by ordinary methods (Tables 1 and 2).

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

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TABLE 1. PROPERTIES OF OILS CONTAINED IN VARIOUS BLUBBERS OF GANGES RIVER DOLPHIN (A).

Parts of blubbers	Oil content (%)	Acid value	Iodine value	Sapon. value	Unsapon. matter (%)
Thoracic blubber	38.4	1.40	115.5	193.1	1.36
Umbilicus blubber	49.1	1.26	125.6	197.5	1.02
Abdominal hind blubber	40.4	0.62	114.2	189.3	1.26
Frontal back blubber	40.1	1.01	102.9	194.6	1.16
Middle back blubber	50.7	1.46	113.3	190.4	1.72
Posterior back blubber	33.2	1.07	96.1	189.3	1.10

TABLE 2. PROPERTIES OF OILS CONTAINED IN VARIOUS BLUBBERS OF GANGES RIVER DOLPHIN (B).

Part of blubbers	Oil content (%)	Acid value	Iodine value	Sapon. value	Unsapon. matter (%)
Thoracic blubber	48.3	1.10	113.9	198.1	1.70
Umbilicus blubber	48.9	0.90	117.4	207.0	1.65
Frontal back blubber	52.5	1.04	121.9	208.2	1.46
Middle back blubber	50.1	1.41	99.3	195.3	1.03
Tail blubber	34.2	1.05	101.2	128.0	31.80
Melon	51.8	1.00	70.9	218.3	0.92

The fatty acid methyl esters of various blubber oils were prepared with BF_3-methanol reagent according to Metcalfe *et al* (1966). Approximately 200 mg sample of each blubber oil was added to 10 ml of 0.5 N potassium hydroxide-methanol and heated on a steam bath for several minutes. Next, 10 ml of BF_3-methanol (125 g BF_3 per liter of methanol) was added to the above sample and boiled for a few minutes under an atmosphere of nitrogen gas. Then, enough of half saturated sodium chloride solution was added to the sample to float up the methyl esters. About 30 ml of ethyl ether was added to the sample to extract the methyl esters, and the same extraction was repeated for 5 times. The ethyl ether solution was dehydrated with anhydrous sodium sulfate, and evaporated under an atmosphere of nitrogen gas on a water bath. The methyl esters obtained were refined by thin layer chromatography on silica gel (petroleum ether: ethyl ether: glacial acetic acid, 90: 10: 1).

The fatty acid component of each blubber oil was determined quantitatively by GLC of methyl esters in a Shimadzu Gas Chromatograph Model GC–1C apparatus equipped with a flame ionization detector. The columns were 1.80 m × 3 mm diameter stainless-steel tubing packed with 25% DEGS on 60/80 mesh Chromosorb W, and also 2.68 m × 3 mm diameter glass coil packed with 5% PEG on 60/80 mesh Chromosorb W. The carrier gas was nitrogen at a flow rate of 70 ml per minute for stainless-steel column and 35 ml per minute for glass coil column. The stainless-steel column was operated isothermally at 205°C, and the glass coil column was programmed from 70°C–150°C at 4°C per minute and 150°C–190°C at 8°C per minute. The injector block was at 275°C for stainless-steel column and glass coil column was injected by on-column.

The fatty acid components were identified by comparing their retention times to those of purified standards and estimated by comparing the semilog plots of retention times *vs* carbon numbers of the blubber oil methyl esters with those of known mixtures of methyl esters run on the same columns under the same conditions, according to Nelson and Freeman (1960). Also, the identification of fatty acids of odd-carbon chain lengths was checked by hydrogenation over platinum black as a catalyst.

The fatty acid component of sample oil was expressed as percentage of area to total area of all methyl esters, according to Ettre and Kabot (1963).

RESULTS AND DISCUSSION

The fatty acid component of various blubber oils of two Ganges river dolphins are listed in Tables 3 and 4. A detailed analysis of the fatty acid component of various blubber oils revealed the presence of fatty acids 5–24 carbon atoms with zero to six double bonds.

With a few exception, the fatty acid distribution in each blubber oil is nearly seemed to be the same pattern. The three main fatty acids which represented an average of more than 64.18 %(A)–68.72 %(B) of total fatty acids in each blubber oil of Ganges river dolphins are as follows; hexadecanoic acid, hexadecamonoenoic acid and octadecamonoenoic acid.

In the case of Ganges river dolphin A, oils in abdominal hind and middle back blubbers were found the presence of 37 kinds of fatty acids, but it was not find to be presence of eicosatrienoic acid in thoracic, frontal back and posterior back blubber oils, and docosatetraenoic acid in umbilicus blubber oil. The total of hexadecanoic, hexadecamonoenoic and octadecamonoenoic acids had an average of more than 64.18 % of total fatty acids in all blubber oils of Ganges river dolphin A. Also, various blubber oils of Ganges river dolphin A had the large portion of total unsaturated acids (63.93–77.62 %) which contained almost twice the amount of total saturated acids (22.38–36.07 %). Finally, the fatty acid distribution of each blubber oil from Ganges river dolphin A was found relatively the same trend.

In the case of Ganges river dolphin B, the fatty acid component of blubber oils contained mainly hexadecanoic, hexadecamonoenoic and octadecamonoenoic acids which represented an average of more than 68.72 % of total fatty acids. An amount of total saturated acids (25.46–37.65 %) was almostly half of total unsaturated acids (62.35–74.54 %). The oils of thoracic and umbilicus blubbers were found the presence of 36 kinds of fatty acids, and were not identified docosatetraenoic acid. Frontal back blubber oil was found the presence of 37 kinds of fatty acids. Middle back blubber oil contained 33 kinds of fatty acids and did not contain eicosapentaenoic, docosatetraenoic, docosapentaenoic and tetracosamonoenoic acids. Moreover, middle back blubber oil had very small amount of tetradecanoic acid (0.40 %) compared with other blubber oils (average 6.61 %) and conversely the higher amount of octadecamonoenoic acid (35.28 %) more than that of other blubber oils (average 25.41 %). Tail blubber oil contained 32 kinds of fatty acids with absence of eicosadienoic, eicosatrienoic, eicosapentaenoic, docosatetraenoic and tetracosamonoenoic

TABLE 3. FATTY ACID COMPONENT OF OILS CONTAINED IN VARIOUS BLUBBERS OF GANGES RIVER DOLPHIN (A).

Blubbers Fatty acid	Thoracic blubber (%)	Umbilicus blubber (%)	Abdominal hind blubber (%)	Frontal back blubber (%)	Middle back blubber (%)	Posterior back blubber (%)
iso–5–0	0.22	tr	0.23	0.13	0.34	0.16
n–5–0	0.06	tr	0.11	0.05	0.21	tr
6–0	tr	tr	0.07	0.03	0.07	tr
8–0	0.75	0.25	0.79	0.81	0.87	0.46
10–0	0.13	tr	0.12	tr	0.22	tr
12–br*	tr	tr	tr	tr	tr	tr
12–0	1.02	0.37	1.06	0.20	0.57	0.48
12–1	0.04	tr	0.07	tr	0.13	0.10
13–0	tr	tr	0.03	tr	0.06	tr
14–br*	0.21	0.17	0.19	tr	tr	tr
14–0	5.48	5.39	7.56	6.62	4.13	4.50
14–1	2.94	1.72	1.30	1.33	1.85	3.12
14–2	1.07	0.24	0.79	1.61	1.64	1.08
15–0	0.44	0.26	0.58	0.82	0.69	0.75
16–br*	0.31	0.43	0.60	0.32	0.38	0.44
16–0	12.76	12.66	20.34	11.59	13.61	12.72
16–1	23.22	22.29	16.78	23.89	23.72	21.87
16–2	1.46	2.30	0.84	2.32	0.92	2.65
16–3	1.47	1.43	1.55	2.64	1.48	2.26
17–0	0.91	0.89	0.62	1.15	1.14	1.82
18–0	1.55	0.95	2.43	2.14	1.01	3.61
18–1	27.71	30.68	24.83	29.09	29.12	28.17
18–2	3.84	3.47	2.33	3.95	4.36	3.96
18–3	1.52	0.82	1.65	1.54	1.43	0.82
19–0	0.25	0.19	0.32	0.28	0.35	0.20
20–0	0.76	0.36	0.82	0.76	0.71	0.31
20–1	0.71	0.49	1.13	0.88	1.07	0.23
20–2	0.95	0.60	0.95	0.49	0.96	0.44
20–3	—	0.52	1.04	—	0.67	—
20–4	1.38	3.25	2.53	1.36	1.05	1.90
20–5	0.54	1.10	0.45	0.32	0.74	0.66
21–0	0.42	0.46	0.20	0.35	0.68	0.39
22–1	0.69	1.16	0.48	1.32	0.41	1.30
22–4	0.60	—	0.43	0.29	0.48	0.27
22–5	2.75	2.83	3.11	1.48	1.91	2.17
22–6	2.91	3.94	3.21	1.85	2.38	2.54
24–1	0.93	0.78	0.46	0.39	0.64	0.62
Saturated	25.27	22.38	36.07	25.25	25.04	25.84
Unsaturated	74.73	77.62	63.93	74.75	74.96	74.16

* Branched fatty acids.

TABLE 4. FATTY ACID COMPONENT OF OILS CONTAINED IN VARIOUS BLUBBERS OF GANGES RIVER DOLPHIN (B).

Blubbers Fatty acids	thoracic blubber (%)	Umbilicus blubber (%)	Abdominal hind blubber (%)	Frontal back blubber (%)	Middle back blubber (%)	Posterior back blubber (%)
iso–5–0	0.15	0.35	0.17	tr	0.26	0.55
n–5–0	tr	0.27	0.10	tr	0.19	0.27
6–0	tr	tr	tr	tr	0.08	0.10
8–0	0.53	0.99	0.94	0.47	1.32	1.93
10–0	tr	tr	0.21	tr	0.41	0.36
12–br*	tr	tr	tr	tr	tr	tr
12–0	0.29	0.38	0.32	0.23	0.81	0.97
12–1	tr	tr	0.16	tr	0.23	0.18
13–0	tr	tr	tr	tr	0.10	0.09
14–br*	tr	0.19	0.22	tr	0.27	0.12
14–0	5.84	6.33	6.65	0.40	7.15	7.08
14–1	0.92	2.92	2.09	0.81	3.24	3.76
14–2	0.19	0.35	1.10	0.34	1.16	1.17
15–0	tr	0.31	0.53	0.15	0.43	0.41
16–br*	0.66	0.37	0.40	0.83	1.13	0.75
16–0	16.20	14.13	15.48	18.20	22.47	17.09
16–1	22.05	17.24	25.99	26.84	23.94	38.97
16–2	0.99	0.40	0.90	1.22	1.06	0.40
16–3	2.43	1.92	2.52	1.76	2.09	1.86
17–0	1.01	0.94	1.28	1.49	0.83	0.38
18–0	1.17	3.82	3.04	2.89	1.29	1.02
18–1	27.32	29.30	24.31	35.28	24.83	21.31
18–2	2.89	1.68	2.02	2.37	1.56	0.45
18–3	1.69	1.12	0.64	0.95	0.53	0.39
19–0	0.35	0.23	0.14	0.37	0.20	0.14
20–0	0.84	0.51	0.32	0.24	0.71	—
20–1	1.34	0.77	0.78	0.55	0.30	0.25
20–2	1.30	1.17	0.69	0.67	—	—
20–3	0.62	0.48	0.24	0.30	—	—
20–4	1.54	2.23	1.47	0.56	1.02	—
20–5	1.13	1.04	0.98	—	—	—
21–0	0.37	0.55	0.27	0.19	tr	—
22–1	0.85	1.29	0.73	1.28	0.52	—
22–4	—	—	0.38	—	—	—
22–5	3.13	3.61	1.56	—	0.83	—
22–6	3.44	3.90	2.45	1.61	1.04	—
24–1	0.76	1.21	0.92	—	—	—
Saturated	27.41	29.37	30.07	25.46	37.65	31.26
Unsaturated	72.59	70.63	69.93	74.55	62.35	68.74

* Branched fatty acids.

acids. Although the fatty acid component deviated from other blubber oils, there were a few exception. For example, the ratio of total unsaturated acids (62.35%) to total saturated acids (37.65%) was found to be the lower amount than that of other blubber oils, also there was a few presence of fatty acids with 20 or more carbon atoms. Finally, with the exception of melon oil, the fatty acid distribution pattern of thoracic, umbilicus, frontal back, middle back and tail blubber oils from Ganges river dolphin B was relatively followed the same trend as those from Ganges river dolphin A.

In the fatty acid component, melon oil was radically different with other blubber oils, and the levels of individual and groups of fatty acids were unique to this sample. The fatty acid component of melon oil was only 26 kinds of fatty acids. In melon oil, the most notable deviation was the high level of hexadecamonoenoic acid (38.97%), and other main fatty acids were 21.31% of octadecamonoenoic acid and 17.09% of hexadecanoic acid. On the other hand, the short chain acids (less than 17 carbon atoms) were present at high levels (76.44%) while the concentrations (23.56%) of fatty acids with more than 18 carbon atoms were considerably lower than that of other blubber oils. It was probably seemed because melon was not a blubber and was an adipose tissue on an upper jaw.

As concerned with the chemical properties, most of deviation in tail blubber oil of Ganges river dolphin B can be attributed to the high level of unsaponifiable matter (shown in Table 2) and characterized by the low level of saponification value. It was seemed that tail blubber oil had notably some unsaponifiable matters.

In comparison with oils of Ganges river dolphins in fresh water and oils of other dolphins in sea water (Table 5), they have no definite analogy on the fatty acid component. The major acids of Many toothed pilot whale and Common dolphin oils are hexadecanoic and octadecamonoenoic acids and have a low amount of hexadecamonoenoic acid which is contained as one of the main fatty acids of Ganges river dolphin oil. Moreover, Finless porpoise oil has the high amount of hexadecamonoenoic and octadecamonoenoic acids, but it has a few presence of hexadecanoic acid which is one of the main fatty acids of Ganges river dolphin oil. Viewing in comparison of saturated and unsaturated fatty acids, it is found that all dolphin oils have approximately the same distribution of ratio of total saturated and unsaturated fatty acids. The long chain acids with 20 or more carbon atoms which represented 12.50%(A) or 9.30%(B) of the total acids in Ganges river dolphin oil, are only the minor presence or are not present at all in Finless porpoise oil and Many toothed pilot whale oil. 3 kinds of short chain acids with 6 less carbon atoms are contained in Ganges river dolphin oil, however, it is not reported in Many toothed pilot whale, Finless porpoise and Common dolphin oils. It is seemed to be caused by that the analytical method was different in each experiment. The docosahexaenoic acid (10.4%) of highly unsaturated acid which is contained in Common dolphin oil, are only 2.81%(A) or 1.24%(B) of total acids in Ganges river dolphin oil.

Finally, it was seemed that Ganges river dolphin, Finless porpoise, Many toothed pilot whale and Common dolphin oils had not a completely analogical distribution pattern of fatty acid component in this study.

TABLE 5. A COMPARISON OF FATTY ACID COMPONENT OF DOLPHINS OIL.

Dolphins	Ganges river dolphins		Many toothed pilot whale3)	Finless porpoise4)	Common dolphin5)
Fatty acids	A1)	B2)			
iso-5-0	0.18%	0.19%	—%	—%	—%
n-5-0	0.07	0.11	—	—	—
6-0	0.03	0.02	—	—	—
8-0	0.66	0.85	0.1	0.1	—
10-0	0.08	0.12	0.3	0.2	—
12-br	tr	tr	—	0.3	—
12-0	0.62	0.41	1.3	0.9	—
12-1	0.06	0.08	2.0	0.7	—
13-0	0.02	0.02	0.3	0.2	—
14-br	0.10	0.14	—	0.4	—
14-0	5.61	5.27	7.3	8.4	2.0
14-1	2.04	2.00	13.8	4.1	—
14-2	1.07	0.63	4.9	0.7	—
15-0	0.59	0.28	0.5	1.1	—
16-br	0.41	0.68	—	—	—
16-0	13.95	17.30	11.4	7.2	21.2
16-1	21.96	23.21	5.3	2.6	6.0
16-2	1.13	0.91	6.9	1.9	—
16-3	1.81	2.14	0.9	1.2	—
17-0	1.09	1.11	—	—	—
18-0	1.95	2.44	0.8	0.9	2.7
18-1	28.27	28.21	28.1	20.4	27.5
18-2	3.65	2.10	3.7	2.1	1.3
18-3	1.30	0.99	0.8	2.0	0.6
19-0	0.27	0.26	1.4	1.6	—
20-0	0.62	0.52	1.7	1.8	0.7
20-1	0.75	0.75	0.6	1.4	5.8
10-2	0.73	0.77	1.5	—	—
20-3	0.37	0.33	—	1.7	—
20-4	1.91	1.36	2.3	4.6	2.5
20-5	0.64	0.63	—	—	7.9
21-0	0.42	0.28	—	—	—
22-1	0.89	0.93	—	—	4.1
22-4	0.35	0.08	—	—	—
22-5	2.37	1.83	—	3.9	2.3
22-6	2.81	1.24	—	5.3	10.4
24-1	0.64	0.58	—	—	—
Saturated	26.64	29.99	25.1	23.1	26.6
Unsaturated	73.36	70.01	70.8	76.9	68.4

1) Average of all blubbers.

2) Average of blubbers without melon.

3) Tsuyuki and Itoh (1969a).

4) Tsuyuki and Itoh (1969b).

5) Japan Oil Chemists' Society (1971).

SUMMARY

1. The properties of oils contained in various blubbers of two Ganges river dolphins (A and B), *Platanista gangetica*, were studied.
2. The fatty acid component of Ganges river dolphin oil was analyzed by GLC on DEGS and PEG columns.
3. The fatty acid component is as follow:

total saturated fatty acids 26.64% (average of A), 29.99% (average of B);

	A (ave.)	B (ave.)
iso-C_5	0.18%,	0.19%,
n-C_5	0.07%,	0.11%,
C_6	0.03%,	0.02%,
C_8	0.66%,	0.85%,
C_{10}	0.08%,	0.12%,
C_{12} br	tr.	tr.
C_{12}	0.62%,	0.41%,
C_{13}	0.02%,	0.02%,
C_{14} br	0.10%,	0.14%,
C_{14}	5.61%,	5.27%,
C_{15}	0.59%,	0.28%,
C_{16} br	0.41%,	0.68%,
C_{16}	13.95%,	17.30%,
C_{17}	1.09%,	1.11%,
C_{18}	1.95%,	2.44%,
C_{19}	0.27%,	0.26%,
C_{20}	0.62%,	0.52%,

total unsaturated fatty acids 73.36%(A), 70.01%(B);

	A (av.)	B (av.)
C_{12} monoenoic	0.06%,	0.08%,
C_{14} monoenoic	2.04%,	2.00%,
C_{14} dienoic	1.07%,	0.63%,
C_{16} monoenoic	21.95%,	23.21%,
C_{16} dienoic	1.13%,	0.91%,
C_{16} trienoic	1.81%,	2.14%,
C_{18} monoenoic	28.27%,	28.21%,
C_{18} dienoic	3.65%,	2.10%,
C_{18} trienoic	1.30%,	0.99%,
C_{20} monoenoic	0.75%,	0.75%,
C_{20} dienoic	0.73%,	0.77%,
C_{20} trienoic	0.37%,	0.33%,
C_{20} tetraenoic	1.91%,	1.36%,

C_{20} pentaenoic	0.64%,	0.63%,
C_{22} monoenoic	0.89%,	0.93%,
C_{22} tetraenoic	0.35%,	0.08%,
C_{22} pentaenoic	2.37%,	1.83%,
C_{22} hexaenoic	2.81%,	1.24%,
C_{24} monoenoic	0.61%,	0.58%.

4. The fatty acid component of various blubber oils was appeared relatively at the same distribution pattern.

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

THE GROWTH OF TWO SPECIES OF THE HARBOUR SEAL IN THE ADJACENT WATERS OF HOKKAIDO

YASUHIKO NAITO* AND MASAHARU NISHIWAKI*

ABSTRACT

We studied the growth of *P. v. largha*, pagophilic seal, and *P. kurilensis*, pagophobic seal, in the southern Sea of Okhotsk and in the waters around Hokkaido from 1968 to 1971.

P. v. largha: Adult type coat and white coat were observed in the fetus stage. Parturition occurred from mid March and the end of March. Moulting of the white coat and weaning occurred 2–3 weeks after birth. The thickness of blubber was 4.5–5.1 cm in pups on the ice floe and decreased to 2.6 cm after the ice melted. The fully grown body length was 170 and 161 cm in males and females respectively.

P. kurilensis: Parturition occurred in the later half of May, and birth length was 98.2 cm. Weaning occurred 4 weeks after birth. The thickness of blubber was thinner than that of *P. v. largha*. The fully grown body length was 186 and 169 cm in males and females respectively.

INTRODUCTION

It is today noted that there are 5 subspecies of the harbour seal (*Phoca vitulina*) in the northern hemisphere; *P. v. vitulina* in the eastern Atlantic, *P. v. concolar* in the western Atlantic, *P. v. mellonae* in the Seal Lake, Canada, *P. v. richardi* in the eastern Pacific, *P. v. largha* in the western North Pacific.

In the western North Pacific, more than 10 specific or subspecific names were reported for the harbour seal, but they were reduced to only one *P. v. largha* by Scheffer (1958). However, recently by morphological and ecological studies, Belkin (1964) reported new species of *Phoca* named *P. insularis*, which is the same seal reported previously as *P. ochotensis kurilensis* by Inukai (1942a). Concerning the specific name of the new seal, McLaren (1966) used *P. kurilensis* instead of *P. insularis*, recognizing the priority of the name *kurilensis*. Therefore, there exist two species of *Phoca*, *P. v. largha* and *P. kurilensis*, in the western North Pacific.

In Hokkaido, it is noted that both of the above mentioned two species are caught annually by commercial sealing or by fishing net (Naito, 1971). Biological studies of these seals in the waters around Hokkaido and in the southern Sea of Okhotsk were made fragmentarily by Inukai (1942 a, b), Wilke (1954), Nishiwaki and Nagasaki (1960), Belkin (1964) and Belkin *et al.* (1969). Nevertheless, there are still many general biological problems not yet solved.

It is noted that *P. v. largha* is a pagophilic seal and *P. kurilensis* is a pagophobic seal (Belkin, 1964; Belkin *et al.*, 1969). The present study was focussed to reveal

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* Ocean Research Institute, University of Tokyo, Tokyo.

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unknown aspects of the growth of the seals, some of which may be related to such ecological difference between two species.

In the present study, we follow McLaren (1966), and use the name *P. kurilensis*.

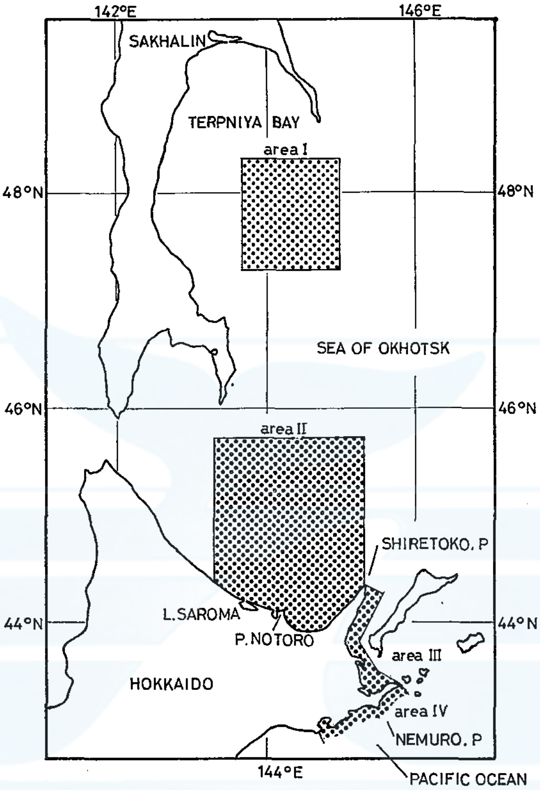

Fig. 1. Sampling areas for *P. v. largha* and *P. kurilensis* in the southern Sea of Okhotsk and the Pacific coast of Nemuro Peninsula.

MATERIALS AND METHODS

In the southern Sea of Okhotsk and the north east coast of Hokkaido, field surveys were made between 1968 and 1971. In the present study, the area surveyed was divided into the following 4 areas according to the sealing area (Fig. 1): I) the mouth of Terpeniya Bay of Sakhalin, II) the Kitami-Yamato bank, Lake Saroma, and Point Notoro, III) the area between Shiretoko Peninsula and Nemuro Peninsula, IV) the Pacific coast of Nemuro Peninsula. Studies of *P. v. largha* were made mainly in areas I, II, III, and studies of *P. kurilensis* were made in area IV. In area I, studies were performed on a sealing boat from the end of April to the beginning of May in 1971. In area II, studies were made from December in 1968 to March in 1969 at Lake Saroma and Point Notoro, and also made on a sealing boat in Kitami-Yamato bank from mid April to the beginning of May in 1969 and 1970. In area III, studies were made from December in 1968 to March in 1969. In area IV, studies were made in May and June in 1969, 1970 and 1971, and in October in 1969. In this area, field observations of *P. kurilensis* were also made at Moyururi Island and other places in 1969 and 1971. *P. kurilensis* was chiefly caught in area IV in May and June. However, some of this species appeared in area III and were caught by fishing net occasionally (Salmon set net). *P. v. largha* seemed not to appear in area IV in May and June except for pups or very young seals, but some appeared in area IV and were caught by the fishing net in Autumn.

Through these studies, body length was measured from the tip of the snout to the end of the tail in a straight line along the body axis in cm. Concerning the seals collected on board, measurements were mostly made before rigor mortis occurred. Some were measured in the condition of rigor mortis, and yet they were not so much curved that we could not measure in a straight line along the body axis. In small embryos (under 100 mm) the length was measured along the curved body axis from the tip of the snout to the end of the tail in mm by using the universal projector, and the length of middle sized embryos (100–400 mm) was measured by using the divider. Large embryos (over 400 mm) were measured same as postnatal seals. Reproductive organs were preserved in 10% formalin. In some cases, they were preserved in 10% formalin after preservation in a freezer.

For age determination, canine teeth were taken from the skulls or lower jaws after connective tissues rotted in the laboratory, and then they were cut longitudinally by grinder and their surface was polished by wetstone. After they were glued to the transparent plastic plate, the half of the remaining tooth was ground again to become about 0.1 mm in thickness. The growth layers were observed by the binocular microscope in reflected and transmitted light. In the present study, age determination was made following the method of McLaren (1958), Mansfield and Fisher (1960), and Bigg (1969). In the seal under 7–8 years of age, both cementum and dentine growth layers were examined, but only cementum growth layers were examined after 7–8 years of age. Ages were calculated from number of growth layers, assuming that every collected *P. v. largha* was born at the end of March and *P. kurilensis* was born in mid May respectively.

PRENATAL GROWTH AND PURTURITION

The prenatal growth of *P. v. largha* and *P. kurilensis* is almost unknown. Tikhomirov (1971) reported the length of near-term fetuses of *P. v. largha* from the Bering Sea. There are no record of fetus of *P. kurilensis*. However, Scheffer and Slipp (1944) and Bigg (1969) reported the prenatal growth of *P. v. richardi* from Washington State and the southern Vancouver Island.

Concerning the parturition Tikhomirov (1971) in the Bering Sea, Wilke (1954) in the southern Sea of Okhotsk, Belkin (1964) and Belkin *et al.* (1969) in the southern Kurile Islands reported on *P. v. largha*, and Inukai (1942a), Belkin (1964) and Belkin *et al.* (1969) stated on *P. kurliensis* from the southern Kurile Islands. In the present study, mating season, growth of fetus in body length, parturition season and birth length were investigated.

Phoca vitulina largha

In area II from the 12th to the 16th of April in 1969, we collected 9 paired females which were on ice floes with males and pups together. Couples of ovaries were collected from 5 out of 9 paired females. The condition of these ovaries was compared with that of single females which were alone on ice floes and were captured from the 17th of April to the 2nd of May. As seen in Table 1, paired females were classified into three groups according to the condition of ovaries. 1) two paired females had large follicles and no corpus luteum in their ovaries, which indicated that fertilization had not occurred yet. 2) one paired female had the large follicle which was partly changing to the tan-color corpus luteum, and partly contained the opaque gelatin like structure. This follicle indicated that the ovary was just after the fertilization. 3) two paired females had the newly formed corpus luteum in their ovaries, and this indicated that fertilization had already occurred. The mean diameter of maximum sized follicles of 5 paired females was 12.5 mm. On the other hand, in the single females only newly formed corpus luteum was found in the ovaries, and this indicated that fertilization was over. The mean diameter of maximum sized follicles was 5.0 mm and was less than half of that of paired females. From these facts, it is indicated that the paired females were in the mating season, and in the single females mating season was over. In the present study, it was difficult to know exactly when the beginning of the mating season occurred, however, it may be supposed that mating occurred from early April to mid April.

TABLE 1. CONDITION OF OVARIES IN THE SINGLE FEMALE AND THE PAIRED FEMALE OF *P. V. LARGHA*.

	Single	Pair
Period of catch	April 17th—May 2nd	April 12th–17th
Number of specimens	23	5
Specimens with large follicles and no newly formed corpus luteum in ovaries	6	2
Specimens with follicle changing to corpus luteum in ovaries	0	1
Specimens with newly formed corpus luteum in ovaries	23	2
Mean diameter of maximum-sized follicle (length+width/2; mm)	5.0	12.7

Concerning the growth of fetus, we examined 20 fetuses of *P. v. largha* collected from survey area II and III. Figure 2 shows that body length of fetuses increased in accordance with time. In this study, the time of implantation is unclear, so the gestation period is also unclear. The fetuses collected in mid October, about 5 months before parturition season, were 175–268 mm in body length and the final stage fetuses collected in later half of March, just before birth, was 780–925 mm. The growth rate seemed to be same in both sexes.

Pups having an umbilical cord may indicate that they were born within the past few days, and from such pups parturition season and birth length would be estimated. In this study we could not collect pups with an umbilical cord, but 4 final stage fetuses were caught which were estimated that they would be born within a few days. These fetuses appeared from the 16th to the 27th of March and did not appear after the 27th of March. Therefore, it seemed that parturition occurred from the mid to the end of March. According to other studies, Wilke (1954) reported from the same area as our area II that parturition may occur in the early half of March, the earliest record of parturition was in late January and the latest was on the 15th of April. Belkin (1964) suggested that pups were born on ice floes from the end of March to mid April in the southern Kurile Islands. However, Belkin *et al.* (1969) suggested that new born pups were observed from early March to the end of March in the same area.

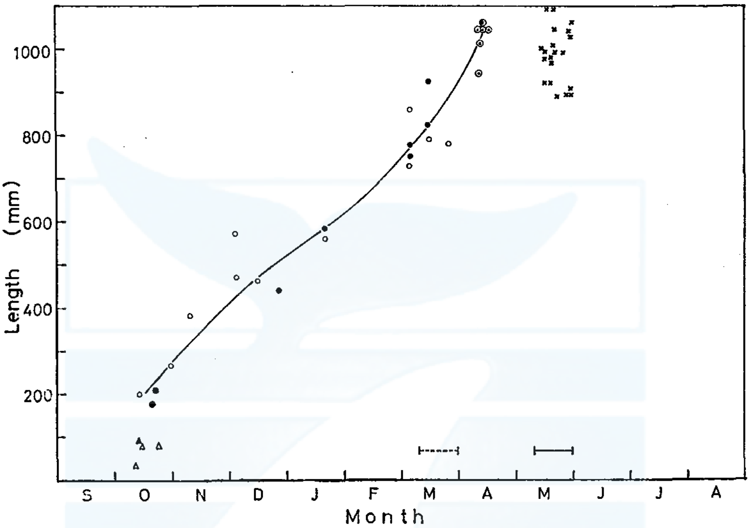

Fig. 2. Prenatal growth of *P. v. largha* and *P. kurilensis* in standard length. ●, ○, males and females of *P. v. largha* ; ⊙, new born pups with white coat ; ▲, △, males and females of *P. kurilensis* ; ×, new born pups with umbilical cord ; ——, time of parturition of *P. v. largha* ; - - -, time of parturition of *P. kurilensis*.

In the present study, birth length was estimated from following considerations. 1) the largest fetus and the smallest new born pup may indicate the birth length. 2) growth curve and parturition season also indicate the birth length. According to 1), birth length was assumed to be 933 mm, since the largest fetus was 925 mm and the smallest new born pup was 940 mm. According to 2), birth length was estimated to be about 850 mm. Since the new born pup was not captured just after birth, the result of the first was relatively large. Therefore, we employed the second result.

Phoca kurilensis

Concerning the mating season, 4 couples out of 67 population were observed to copulate at hauling ground area of Moyururi Island from the 9th to 13th of June in 1969. While copulations were rarely observed in 75 population from 22nd to 27th of June in 1971 at the same hauling ground area. From these data, it is concluded that mating occurs in June, but is difficult to estimate the mating period exactly.

There was no report previously on the prenatal growth of this seal. In the present study, the length of 4 fetuses collected in October from Nemuro Peninsula was 95 mm in males, and 85, 84 and 39 mm in females (Fig. 2). In these fetuses no pigmentation was observed (Plate I).

To estimate the parturition season and the birth length, the appearance of pups with umbilical cords was investigated. Figure 3 shows that parturition of this seal may occur from the middle to the end of May in the Pacific coast of Nemuro Peninsula and the mean body length at birth is 98.2±3.2 cm. The birth length of this species is much larger than that of *P. v. largha* indicated in the present study and that of *P. v. richardi* shown by Bigg (1969). Inukai (1942b) and Belkin (1964) and Belkin *et al.* (1969) suggested that parturition of this seal occurs in mid May and copulation occurs in July in the southern Kurile Islands.

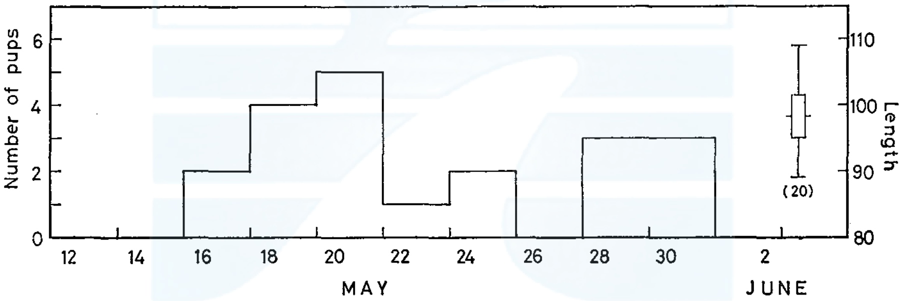

Fig. 3. Frequency of new born pups with umbilical cord, at two days intervals, and birth length(total 20 pups). Vertical line, range ; box, standard error ; horizontal line in box, mean.

POSTNATAL GROWTH

I. Moulting of white coat and weaning

It is generally believed that only *P. v. largha* of all 5 subspecies bears the creamy white coat in its early pup stage for several weeks after birth, and also weaning seems to occur subsequently with moulting of this coat. However, the moulting and weaning season are still unknown. As for *P. v. largha*, Wilke (1954) suggested the time of moulting in the southern Sea of Okhotsk, but the weaning seasons are not obvious. Concerning weaning of *P. kurilensis*, Belkin (1964) and Bilkin *et al.* (1969) suggested from his finding in the southern Sea of Okhotsk.

Phoca vitulina largha

In the fetuses collected in October, clear pigmentation was observed (Plate I). Scheffer and Slipp (1944) traced three progressive changes in type of pelage in *P. v. richardi*: 1) an early, sparse fetal coat, perhaps the forerunner of the third coat, 2) a long, silky white lanugo coat, and 3) a short varigated coat. The first fetus on which appeared fetus pelage according to Scheffer's 1), was caught in early November. From early December, about 3.5 months before parturition season, the fetus began to show the white lanugo coat, which corresponded with Scheffer's 2) change (Plate I). There are no records of pups which have the fetus coat corresponding to Scheffer's 3) change. The near-term fetus of *P. v. largha* do not shed the white lanugo coat, but continue to bear after birth. Stutz (1966) reported the changes of lanugo coat in the fetus of *P. v. richardi*. Firm and dirty white or pale yellowish-grey hair corresponding to Scheffer's 2) change, which resist tugging, appeared characteristic of fetus at about half term. As the fetus neared parturition, this hair become looser enough to be scraped from the skin, and almost near-term fetus lost their lanugo coat. This near-term fetus seemed to exhibit the same pelage as Scheffer's 1) change.

From the catch record of pups captured in area I from the 27th of April to the 4th of May in 1971, and in area II from the 13th of April to the 12th of May in 1969, the time of moulting of the white coat and the time of weaning were considered (Table 2). In order to know the moulting season of the white coat, three pups stages were considered from the condition of white coat: 1) stage of complete white coat, 2) stage of a partial white coat, 3) stage of moulting the white coat.

In area II, as shown in Table 2, pups were considered in the moulting season of their white coat in mid April, and it seemed that the moulting season was over at the

TABLE 2. FREQUENCY OF PUPS OF *P. V. LARGHA* IN THE THREE MOULTING STAGES. PARENTHESIS SHOWS PERCENTAGE.

	Number of pups in white-coat stage		Number of pups in second stage of moulting		Number of pups in final stage of moulting	
Area II						
1969 Apr. 12	1	(45.4)	0	(27.3)	0	(27.3)
Apr. 13	2		1		1	
Apr. 14	3		4		1	
Apr. 15	2		1		4	
Apr. 16	2		0		0	
Apr. 23	0	(0)	0	(20)	2	(80)
May 2	0		1		2	
Area I						
1971 Apr. 27	0		1		6	
Apr. 28	0		0		5	
Apr. 29	0		0		6	
Apr. 30	0		0		2	
May 1	0		0		1	
May 2	0		0		4	
May 3	0		0		3	
May 4	0		0		7	

end of April. In area I, there were no catch records of pups bearing completely white coat from the 27th of April to the 4th of May in 1971. Almost all pups captured in this area had shed their white coat. Therefore, we can suggest that the moulting season was already over at the end of April and the beginning of May in area I in this year. According to Wilke (1954), pups of this subspecies landed by hunters at Abashiri in late April were in the moulting stage, and three stages classified above have been reported. As it is possible to think that Wilke also treated the pups from the same area as area II, the time difference in the moulting season may be related to the ice conditions in each year.

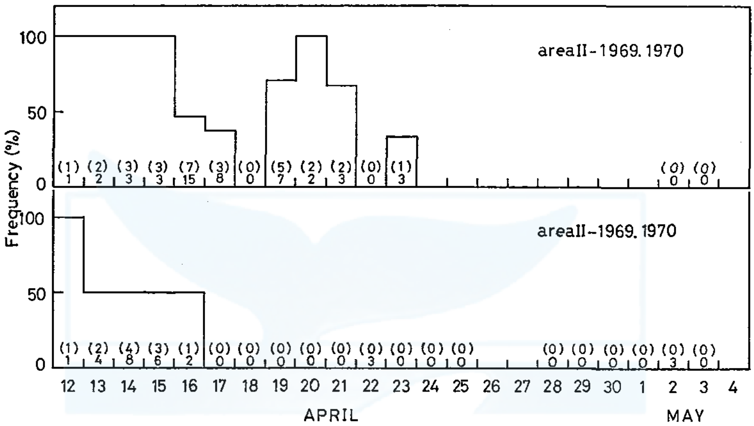

Fig. 4. Frequency of appearance of lactating females (above) and pups cared by its mother (below) in *P. v. largha*. Number in the parenthesis shows the number of lactating females out of total number of sexual mature females, and the number of pups cared by its mother out of total number of pups.

TABLE 3. FREQUENCY OF PUPS OF *P. v. largha* WITH MOTHER IN RELATION TO THREE MOULTING STAGES.

	complete white coat stage	partly moulted stage	completely moulted stage
No. of pups with mother	9	1	0
Total No of pups	10	7	10
Percentage (%)	90	14.3	0

Since the parturition season in area II was considered from mid March to the end of March in 1969, it is considered that moulting of the white coat occurred two or three weeks after birth in this year. This period from birth to moulting is the same as that of King's suggestion (1964).

Time of weaning was estimated by the appearance of pups that were caught with their mothers and the appearance of the lactating females in area II (Fig. 4). In this study, a lactating female was determined when milk secretion was found in the mammary glands. This figure shows that pups with their mothers appeared by mid April, and may indicate that frequency of appearance of lactating females is decreasing from mid April to the end of April in 1969 and 1970. Therefore, it could be suggested that weaning occurs in mid April in area II. We also studied weaning in relation to moulting of the white coat. As shown in Table 3, weaning occurs simultaneously with moulting of the white coat. Since the parturition season in area II was considered to be from mid March to the end of March in 1969, as described above, it is considered that weaning occurred after two or three weeks from birth.

Phoca kurilensis

Inukai (1942b) reported that new born *P. kurilensis* in the southern Kurile Islands had the white coat, yet Belkin (1964) and Belkin *et al.* (1969) opposing Inukai, said that pups of the same seal do not have the white coat. In this study, 20 pups with umbilical cords were observed and the same result as Belkin was obtained.

In some cases, however, pups with lanugo coats were observed. One pup captured in the 20th of May 1969 had a grey long lanugo coat except for the head and flippers (Plate I), and also a pup captured the 25th of May in 1970 had such a coat a little on its back. These facts may indicate that near-term fetuses have lanugo coats. Although we have no record of a lanugo coat fetus, we obtained the information from a fisherman that near-term fetuses which have such a coat were removed from their mother seals caught in mid March by fishing net. This may suggest that pups normally shed their coat in the uterus before birth. The same occurrance was found in *P. v. richardi* in the Alaska Peninsula by Stutz (1966) and Burns (1970). The pups born in early parturition season in late May, retain all or most of their lanugo coat for a short period after birth. Fisher (1952) has reported the yellowish coat pup of *P. v. richardi* born in the peak of parturition on June 8, 1946 from the Skeena River. In the present study, pups with lanugo coats were born not in early but in mid parturition season.

The weaning season of this seal was estimated from the following three investigations: 1) existence of milk in the stomach of pup, 2) appearance of lactating females, 3) appearance of pups together with their mothers in the hauling ground area (Table 4 and 5). Table 4 seems to show that pups of which the stomachs had contained some amount of milk, appeared in May and the beginning of June, and disappeared at the end of June. Table 5 may show that lactating females appeared

TABLE 4. FREQUENCY OF SUCKLING PUPS OF *P. KURILENSIS.*

Date	Number of pups of which stomach contains milk	Number of pups of which stomach contains no milk	Total
May 16	2	0	8
May 20	1	0	1
May 21	1	0	1
May 22	1	0	0
May 24	1	0	1
May 31	0	1	1
Jun. 1	3	0	9
Jun. 2	3	0	3
Jun. 21	0	1	1
Jun. 27	1	3	4
Jun. 28	0	1	1

TABLE 5. FREQUENCY OF LACTATING FEMALES OF *P. KURILENSIS*.

Date	Number of lactating females	Number of nonlactating females	Total
May 13	1	0	1
May 16	2	0	2
May 18	1	0	1
May 22	1	0	1
May 25	1	0	1
May 29	2	0	2
May 30	1	0	1
Jun. 7	1	0	1
Jun. 16	1	0	1
Jun. 27	0	1	1

till mid of June.

The appearance of suckling pups in the hauling ground area was observed at Moyururi Island. From the 9th to the 13th of June in 1969, all 4 pups were observed in suckling and being cared for by their mothers. From the 22nd to the 26th of June in 1971, 4 pups out of 7 rarely suckled, but they were observed to swim with their mothers, and the other remaining three pups were observed in groups without their mothers. From these three investigations, we conclude that weaning of this seal begins to occur at the end of June. Belkin *et al.* (1969) suggested that the pups caught at mid May and the 8th of August in 1963 had milk (100–450 g) in their stomachs and their suckling continue till August, however, his result may be too long compared with this result.

II. Thickness of blubber in early stage of pups

Bigg (1969) and Tikhomirov (1971) suggested that the body weight of pups become double their birth weight during the suckling period. This remarkable increase in their body weight is mostly due to the increase in thickness of blubber. In this study, comparison of the blubber thickness between ice breeding *P. v. largha* and land breeding *P. kurilensis* was made. The thickness of blubber was measured at the middle point between the mammae and the umbilicus where the blubber seems to be the thickest.

Phoca vitulina largha

Measurement of blubber thickness was made on pups caught in area I, II and III (Fig. 5). In area I, 21 pups were caught on ice floes from the 27th of April to the 2nd of May in 1971. Most pups captured here had already lost their white coats except one which still partly had its white coat, and it was estimated that weaning had already occurred but not so long time before. Their mean blubber thickness was 5.1 cm, and seemed to be still in maximum condition. In area II, 9 pups were caught on ice floes from the 12th of April to the 2nd of May in 1969. Seven of these 9 pups were on the point of weaning and moulting the white coat, but 2 pups had already shed their coats. The mean blubber thickness was 4.5 cm and estimated to be in the thickest condition. Seven pups were caught in area III from the 22nd of May to the 27th of June in 1970 and 1971. The mean blubber thickness was 2.6 cm. All pups were caught not on the ice floe, but in water by fishing net.

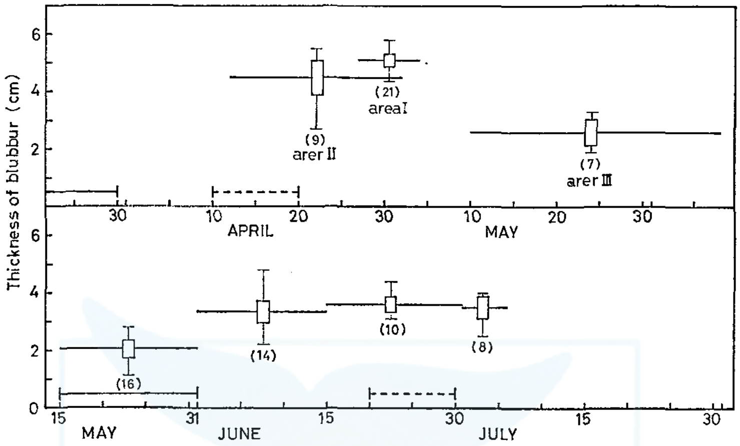

Fig. 5. Change of blubber thickness in pups of *P. v. largha* (above) and *P. kurilensis* (below). Vertical line, range ; box, standard error ; horizontal line in box, mean and sampling period ; foot horizontal line, time of parturition ; foot brocken line, time of weaning.

As seen in figure 5, pups on the ice floe (area I and II) had the pretty thicker blubber than pups in swimming life stage (area III). However, it is not clear as to what is reason why blubber thickness seen in pups of area III is much thinner than in pups of area I and II. The following reasons should be considered: Pups consume their blubber by swimming in the cold water (−1 to 0°C) after weaning. Concerning the difference of blubber thickness of pups found between area I and II, we could not discuss for the sake of short data. Tikhomirov (1971) reported that the mean value of 8–12 day-old pups caught on the 15-20th of April was 26.3 kg and of 1.2–2 month-old pups caught at the end of May and June was 23.9 kg. In addition, the rapid growth in body length during the first month from birth were reported (Tikhomirov, 1971). These facts suggest that decrease in weight is due to decrease in blubber thickness.

Phoca kurilensis

Sixty-five pups were caught on the Pacific coast of Nemuro Peninsula from the 16th of May to the 6th of July in 1969, 1970 and 1971. Figure 5 shows the blubber thickness of 48 pups out of 65 pups that were measured. As shown in figure 5, the mean blubber thickness of pups with umbilical cord caught in later half of May was 2.1 cm, and it was increased rapidly until 3.4 cm in early half of June. The maximum condition of the blubber thickness may occur in the end of June simultaneously with the beginning of weaning. The difference of maximum thickness of blubber between two species is related to the difference in breeding environment. As described above, pups of *P. kurilensis* are born on narrow rocky shores and they begin to swim with their mothers just after birth differing from pups of *P. v. largha* which do not swim before weaning. Therefore, pups of *P. kurilensis* may regularly consume their blubber by swimming, and therefore remarkable accumulation may not occur.

III. Growth of ovaries and testes

As the index of sexual maturity, weight of ovaries and testes, and existence of the newly formed corpus luteum in ovaries and sperm in testes and epididymis were examined in relation to age. Data collected from area I, II, III during April and May, were examined not in each but altogether. The testes were weighed together with the epididymis. Concerning *P. kurilensis*, it was difficult to describe the sexual maturity owing to scanty of data.

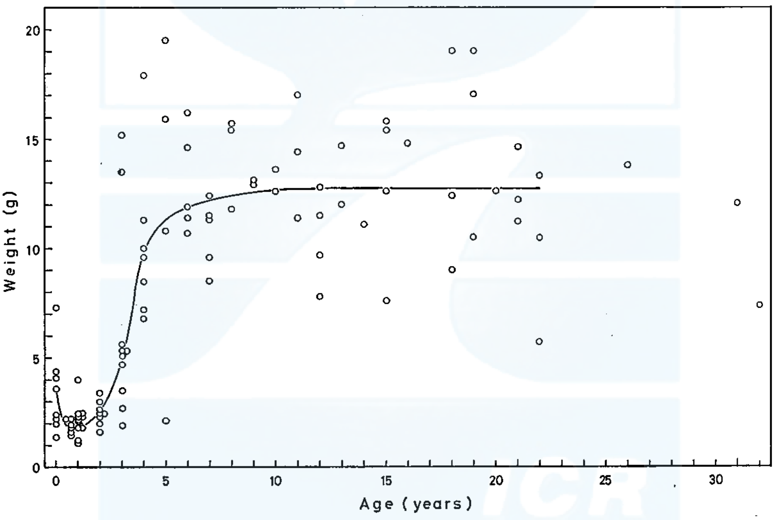

Fig. 6. Growth in the weight of the ovaries of *P. v. largha*. Total number is 102.

In growth of weight of ovaries and testes, 102 specimens from females and 61 specimens from males were used in figure 6 and figure 7 respectively. As shown in these figures, decrease in weight was observed in both ovaries and testes during the first year. Actually, however, these decreases of weight seemed to have occurred within short period after birth. The same occurrence was reported by Tikhomirov (1971). After that, sharp increase in weight was shown in both ovaries and testes from 1–2 years of age to 4–5 years of age. Then, weight of these organs increase gradually until 10 years of age.

Existence of the newly formed corpus luteum was examined in 26 females out of 102 females described above. As seen in Table 6, females from 2–7 years of age were used, and the corpus luteum was observed in 20% of females at 3 years of age. All of 6 females at 4 years of age had the corpus luteum in their ovaries. Similary, existence of sperm in testes and epididymises was examined in 15 males from 1–8 years of age. Table 6 shows that 20% males of 3 years of age and 50% males of 4 years of age were matured, and all of males matured from 5 years of age.

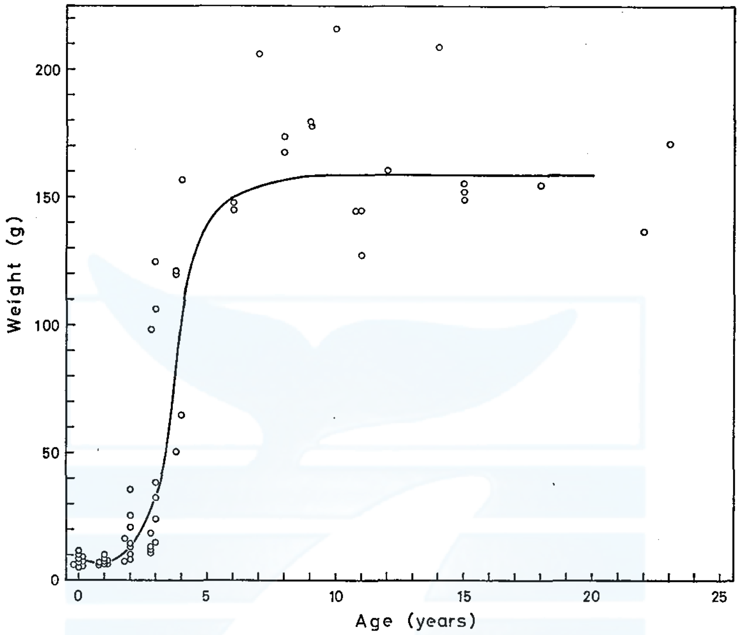

Fig. 7. Growth in the weight of the testes of *P. v. largha.* Total number is 61.

TABLE 6. AGES AT SEXUAL MATURITY IN BOTH SEXES OF *P. V. LARGHA.*

Age	Females: Number of specimens	Females: Number of mature females	Males: Number of specimens	Males: Number of mature males
1			1	0
2	6	0	1	0
3	5	1	5	1
4	6	6	4	2
5	2	2	1	1
6	4	4	1	1
7	3	3	1	1
8			1	1

From these data, it is difficult to estimate the age of sexual maturity in both sexes exactly, but it is approximately considered that females and males of this species reach sexual maturity from 3 years of age and mostly mature at 5–6 years of age.

IV. Growth of body length

Postnatal growth was well shown by Tikhomirov (1971) in *P. v. largha* from the Bering Sea and Bigg (1969) in *P. v. richardi* from the southern coast of Vancouver Island and Alaska. In addition, Belkin (1964) and Belkin *et al.* (1969) reported about *P. kurilensis*, in the Kurile Islands.

Phoca vitulina largha

In this chapter, data collected from areas I, II, III were summed up to describe the postnatal growth of body length. The number of specimens used here was 150 in males and 176 in females. The growth curves are shown in figure 8, which were drawn by eye, but as for the growth curve of females, the following growth formula was approximately applied by using Walford's graphic methods:

$$O<t<2 \qquad l_t=132(1-e^{-0.88(t+0.50)}),$$

$$t\geqq 2 \qquad l_t=161(1-e^{-0.26(t+4.0)}) \qquad (t,\ \text{ages};\ l_t,\ \text{length}).$$

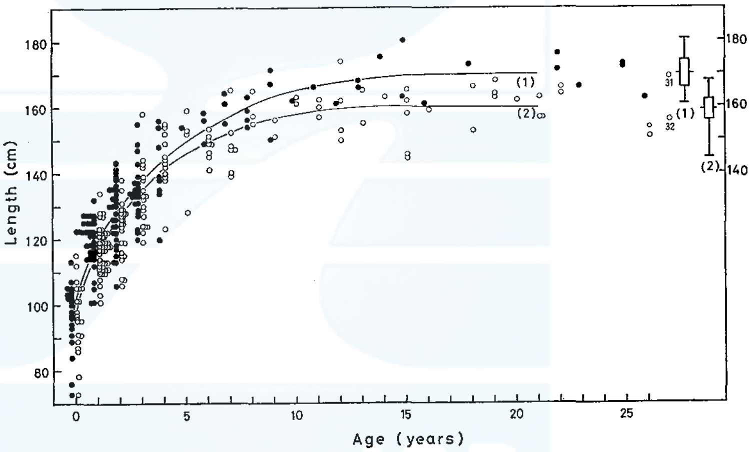

Fig. 8. Postnatal growth in body length of *P. v. largha*, males (1) and females (2). Total number is 150 in males and 176 in females. Vertical line, range– box, standard error ; horizontal line in box, mean.

Concerning the final growth length, mean body length was obtained from the seals over 15 years of age, since the formula did not fit accurately with plots from about 15 years of age. In this figure, the mean length at 0 years age was 97 cm in males and 96 cm in females, which were calculated from the length of pups collected about one month after birth during April and May. Since birth length was presumed to be about 85 cm in former chapter, it was assumed that pups grow more than 10 cm during the first month after birth. The mean length at 1 years of age was 119 cm in males and 117 cm in females, and pups grow 34 cm for males and about 32 cm for females during the first year. About 35 % of the body length growth during the first year seemed to be attained in the first month after birth. The growth rate in the first year observed in the present study is the same as Bigg (1969) showed in *P. v. richardi*, but little lower than *P. v. largha* shown by Tikhomirov (1971).

From birth to 5 years of age, both sexes grow at about similar rate. The growth continue until 14–15 years of age in males and 10–11 years of age in females. Finally attained body length of the seals over 15 years of age was 169.9±4.0 cm for males and 159.0±3.1 cm for females, and the finally attained body length of females was 94.1 % of males.

According to Tikhomirov (1971), *P. v. largha* continues growing until 9 years of age in males and 8 years of age in females, and physically matured body length was 168 cm in males and 162 cm in females. Sexual mature body length of females is 96.4 % of males. Bigg (1969) suggested that *P. v. richardi* continued growing until 9–10 years of age in males and 5 years of age in females. He also reported that fully grown body length was 161.1 cm and 147.7 cm in males and females respectively, and sexual mature body length of females is 92.3 % of males.

Concerning the longevity, the oldest seal was 26 years of age in males and 32 years of age in females, and it seemed that females live longer than males. In another study, it was found 29 years of age and 35 years of age in male and female respectively for *P. v. largha* (Tikhomirov, 1971).

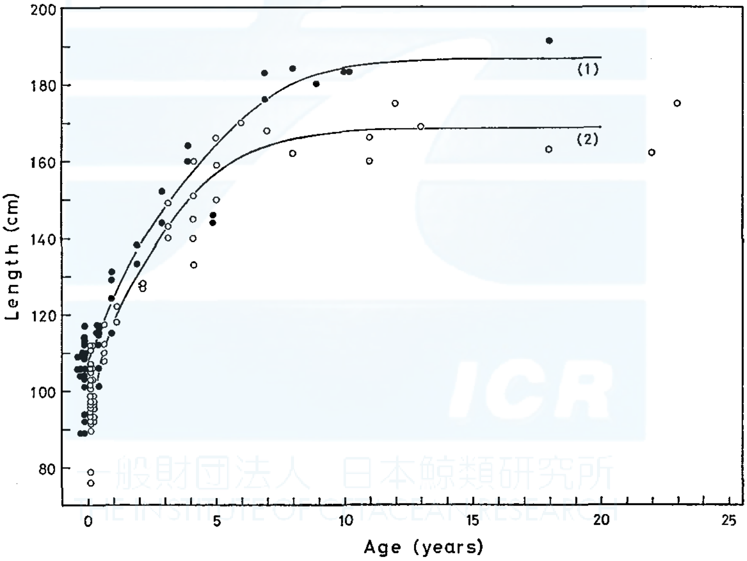

Fig. 9. Postnatal growth in body length of *P. kurilensis*, males (1) and females (2). Total number is 49 in males and 57 in females.

Phoca kurilensis

Most of these data were collected from area IV, and a few from the southern part of area III. The number of specimens used here was 49 males and 57 females, which were collected from area IV. The extent of growth is shown in figure 9, which was drawn by eye. In this figure, the mean length at 0 years of age was 109.7 cm in males and 108.7 cm in females, which was based on the pups collected about a month after birth during May and June. Since the birth length of this species was 98.2 cm as shown former chapter, new born pups grow about 10–11 cm in length during the first month. Concerning specimens over 2 years of age, we are short of data to describe precisely the growth aspect, but we can discuss the general tendency. Males and females grow at about the same rate until 5–6 years of age, and from this age onward dimorphism in body length seems to become clear. By 9–10 years of age, males attain nearly the final growth length, and females attain such length by 7–8 years of age. The maximum body length observed was 191 cm in males and 175 cm in females. Final growth length is assumed to be about 186 cm in males and 169 cm in females, and the final growth length of females was 90.9% of males. This ratio was smaller than that of *P. v. largha*, and *P. v. richardi* according to calculation based on Bigg (1969). Belkin *et al* (1969) suggested that the mean length of sexual mature males was 174 cm and 160 cm in females, and the maximum was 181 cm and 180 cm in males and females respectively. They (1969) also recognized the clear dimorphism in body length in immature seals, describing the mean length of 3 males and 7 females as 139.6 cm and 126.4 cm respectively.

Concerning longevity, it is difficult to discuss with these scanty data.

DISCUSSION

In the present study, we obtained some new facts on prenatal and postnatal growth in *P. v. largha* and *P. kurilensis.*

It was appeared that mating season and parturition season of *P. kurilensis* occurred 2 months later than that of *P. v. largha*, and the birth length of *P. kurilensis* is larger than that of *P. v. largha.* After the parturition, pups of pagophilic *P. v. largha* bears white coat for 2–3 weeks and live on ice floes without swimming. Weaning occurs simultaneously with moulting of white coat 2–3 weeks after birth. Concerning the weaning, it is exactly unknown whether weaning occurs suddenly or gradually. If weaning occurred suddenly, pups would suddenly have the completely independent life and would not have the swimming life with their mothers, furthermore they would not learn the feeding from their mothers. Table 3 may show that departure from the mother occurs quickly as moulting begins to occur. So that, pups may be left alone on ice floes and have the completely independent life. It is also unknown whether pups have swimming life soon after weaning or some time after weaning. If they remained on ice floes, they would be carried by ice floes and their distribution would spread. On the other hand, pups of pagophobic *P. kurilensis* do not have the white coat when they were born. They have the swimming life with their mothers soon after birth, and their suckling is chiefly performed in the water. Weaning occurs about 4 weeks after birth. This period is longer than that of *P. v. largha.* It is also exactly unknown whether weaning occurs suddenly or gradually. However, observation that pups were found with their mothers without showing the suckling behavior may indicate that weaning occurs gradually in this species, and pups may learn the feeding from their mothers.

Concerning the early stage of life, we also studied the thickness of blubber. In *P. v. largha*, pups on ice floes have the thicker blubber and pups in the water have the thinner blubber. This result seems to indicate that change in blubber thickness is due to change in nutritional condition of pups during suckling and weaning period. the other hand, pups of *P. kurilensis* had the thinner blubber as compared with *P. v. largha*. The difference in blubber thickness between two species seems to be related with the difference in nutritional condition of life in early stage described above.

Concerning the growth of body length, sexual dimorphism in body length was observed clearly in *P. kurilensis* as Belkin *et al.* (1969) reported.

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EXPLANATION OF PLATE I

Fig. 1. A female embryo of *P. v. largha*, 20 cm in length, about 5 months before birth (collected on 14th of October).

Fig. 2. A male embryo of *P. kurilensis*, 9.5 cm in length, about 7 months before birth (collected on 14th of October).

Fig. 3. A male white coat embryo of *P. v. largha*, 58.5 cm in length, about 2 months before birth (collected on 19th of January).

Fig. 4. A new born male pup of *P. kurilensis* with umbilical cord which beared grey lanugo coat, 89 cm in length (collected on 20th of May).

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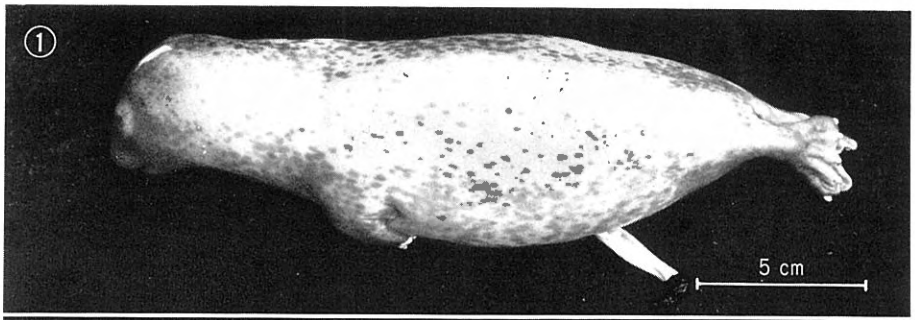

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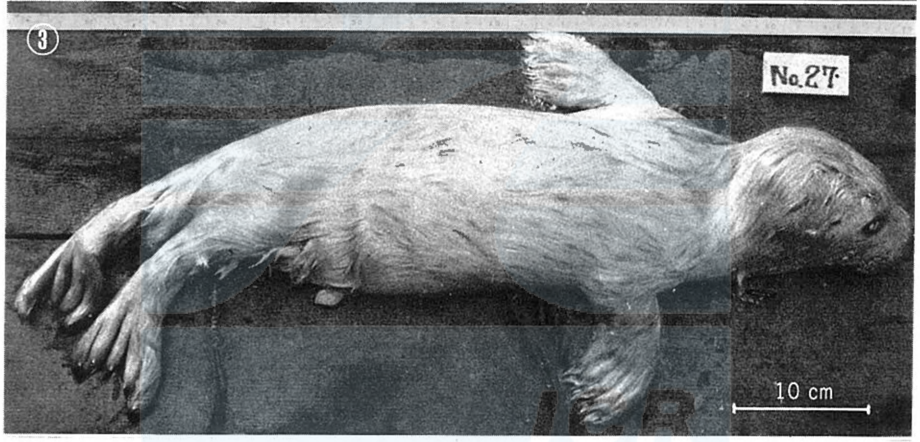

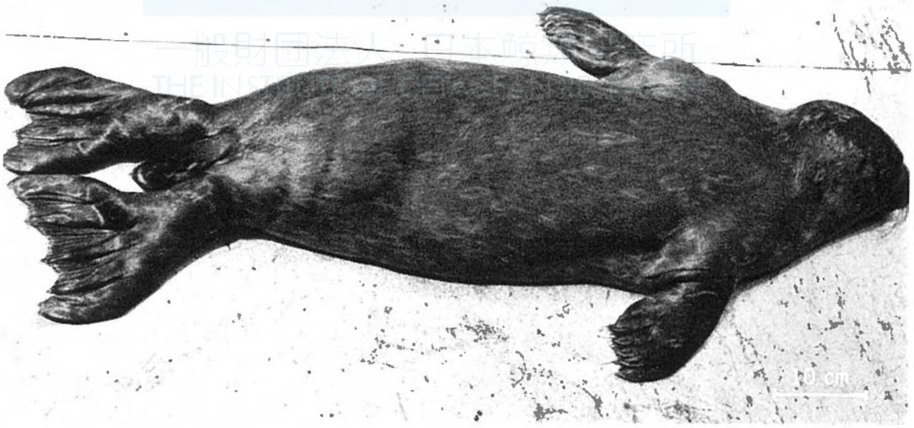

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

DIVING DEPTH OF NORTHERN FUR SEALS IN THE FEEDING TIME

TADAYOSHI ICHIHARA* AND KAZUMOTO YOSHIDA*

Northern fur seals (*Callorhinus ursinus*) are sometimes taken by fishing gears in the open waters. Scheffer (1946) reports seven cases of fur seals taken accidentally by the floating drift net along the Oregon coast of the eastern Pacific and he estimates that fur seals can dive 24 feet (7 meters) to 240 feet (73 meters) below the sea surface. Kenyon (1952) states that fur seals off Sitka, Alaska, have no evidence which they descend much deeper than 30 fathoms (55 meters). He estimates the diving depth of fur seals from the depth of fishing lines on which fur seals sometimes get hooked. In these two reports, there is no description on the time when fur seals were taken by nets or lines.

Generally, fur seals at sea show the inactive behaviors in the day time, except for the migrating period from the breeding islands to wintering areas or from the latter to the former. In the wintering area off the Pacific coast of the northern Japan, sleeping fur seals often are observed in the day time. Japanese research vessels for fur seals have observed and recorded the behavior of seals before these seals are taken at sea. Provided that swimming or moving to some directions indicates the active behavior and sleeping or resting at a location does the inactive behavior of seals, we can examine from the observation records when fur seals move about at sea. The activity index (M) of seals at sea, therefore, will be expressed by the following formula.

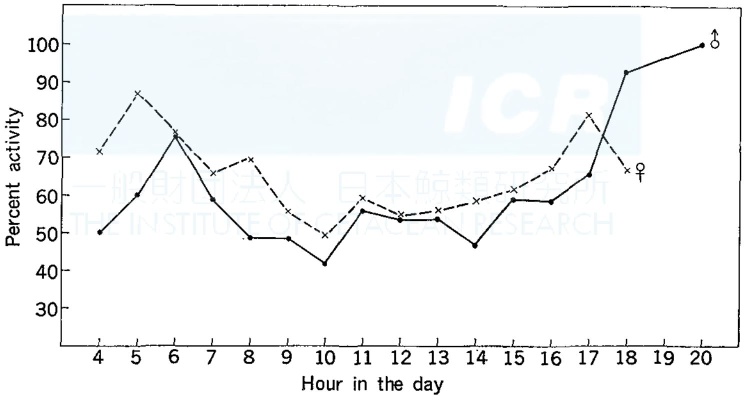

Fig. 1. Activity of fur seals at sea in each hour of the day, in the Pacific coast of the northern Japan from March through June.

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* Far Seas Fisheries Research Laboratory, Fisheries Agency.

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$$M = a / a + i \times 100$$

Where, a is the number of active seals and i is the number of inactive seals at the time of observation. Fig. 1 is given when the value of M is arranged by each hour in a day on the basis of observation records from March through June, when is the latter half of the wintering season of fur seals. Number of seals observed comprised 1483 males and 1677 females from 1958 to 1967. In both sexes, while seals are the most inactive at 1000 in the morning, they are active before 0600 in the morning and after 1800 in the afternoon. Hence, 5 of 10 seals are in the state of sleeping or resting at 1000. This pattern of activity is maintained in spite of the progress of month. Although females are relatively more active than males, it is clear that fur seals are the nocturnal animal. According to several records, fur seals unexpectedly observed at night always were quick in action. Such a nocturnal behavior relates directly to feeding activity of fur seals. Most of seal stomaches collected in the day time has no food or food under digestion. According to the report of the Japanese pelagic research in 1958 off the coast of the northern Japan, about 90% of seals taken at 0500 has food in their stomachs. With the progress of hour in the day time, the occurrence of empty stomach increases and reaches 80% of the total samples collected at 1800 in the afternoon.

Fig. 2. Images of diving fur seals recorded by the echo-sounder of 28 KHz, in the Japan Sea.

After examining the digestive stages of food in the stomach by each hour, this report suggests that fur seals generally take food before sunrise. When the feeding activity of fur seals reaches the maximum is not known because the hunting of seals at night is difficult. Probably the searching activity for food at night determines the nocturnal behavior of fur seals.

In the pelagic research in the Japan Sea, we fortunately took the records of diving fur seals with eco-sounder of 28 KHz. At 1900 on May 3 in 1970, the research vessel Tokai University II, 702.61 ton, stopped to sail as it became dark at the location of 39–47 N, 132–47 E in the western Japan Sea. It was foggy in the evening and the visibility was about 150 meters. In the afternoon of that day, no seal was observed along the sailing course of the vessel. Induced by the light from the deck, however, 5 seals began to swim about the vessel and sometimes passed beneath the bottom of vessel. The sonar which operated continuously through the voyage to examine the vertical distribution of marine organisms, took the swimming images of fur seals on the recording paper. As the vessel was equipped with the sonar at the bottom of the bridge, from the bridge we could confirm seals coming to surface to respire. The other mammals than fur seals were not observed in the waters near the research vessel. The click of dolphins recorded through 28 KHz echo-sounder by Shibata and Nishimura (1969) was not observed in our recording paper. Fig. 2 shows the diving images of seals within the beam of 28 KHz sound. Such clear images were recorded from 1937 through 2245 at night and afterwards 1 or 2 seals repeated to enter the beam of sonar.

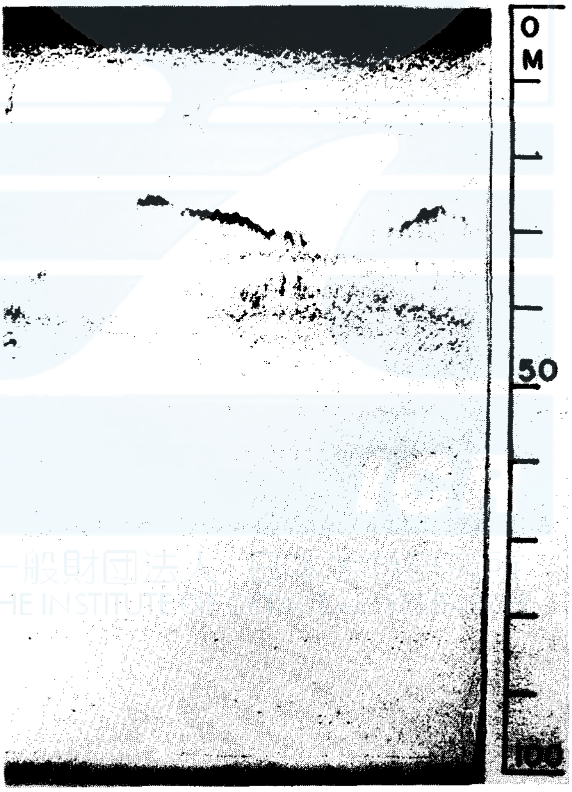

Fig. 3. Experimental image of a killed fur seal recorded by the echo- sounder of 28 KHz.

In order to confirm the image of animal observed on the record of sonar, we tried a test by using a killed fur seal. On May 19, we took a female seal of age 5 in the Pacific coast of the northern Japan. The body weight and the body length of the animal was 34 Kg and 128 cm respectively. Two small boats were prepared for the test in both sides of the research vessel. The weighted seal tied up with a long rope was pulled rapidly in the water along the center of beam of sound. When the seal passed through the bottom of the research vessel, an image was recorded as shown in Fig. 3. We can find the similarlity in images between Fig. 2 and Fig. 3, although the recorded depths are different between them.

In Fig. 2, fur seals swim in the depth of 100 meters and over from 40 meters under the drifting vessel. The record of sonar shows that deeply diving seals do not move horizontally but move rapidly to the deeper waters. As fur seals pursued after schools of squids which were induced by the light of vessel, it is reasonable to suppose that these records indicate the diving depth in the feeding period of fur seals. The species of squids was not determined. The water temperature was 10.1°C in 0 meter, 9.7°C in 10 meters, 8.6°C in 25 meters, 5.3°C in 50 meters and 2.8°C in 100 meters deep at the position of recording, and no remarkable thermocline was observed within 100 meters in depth. These fur seals were not bull at the naked eye observation on their sizes in the sea surface. This record indicates that fur seals descend the depth over 100 meters in the feeding and that they can dive deeper than in the previous records.

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	5↑	whale	whales
ix	4↓	Aninul	Aminul
		the distribution	distribution and seasonal movement
	6↓	oils	oil
	7↓	kinds of harbour seals in the waters arround	species of harbour seal in the adjacent waters of
	9↓	feeding hours. 145-000.	the feeding time. 145-148.