AGE STUDY OF SPERM WHALE BASED ON READING OF TOOTH LAMINATIONS

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INTRODUCTION

The size limit for the sperm whales to catch is prescribed as 35 feet in the case of coastal whaling and 38 feet in the case of factory ship whaling by the International Regulation of Whaling. Referring to the body length at the sexual maturity, we suspect that the size limit for the sperm whale might be too severe when compared with that for the other species of whales. There is no doubt about that the keeping the size limit to catch in high level is the best way for the conservation of the whale resources. However, as the whaling operation becomes more intensive and the average body length of the whales to be caught diminish markedly, the whalers must wish to know plainly the indispensable minimum size limit for the conservation of the resources.

So we should obtain at first the exact knowledge on the sexual maturity and revise the size limit basing on them if necessary, then determine the number of catch on each stock of the sperm whales.

From this point of view, we enumerate here the previous studies on the sexual maturity of sperm whales. Matthews (1938) states that the female matures sexually at the former term of the second year after the birth and the male matures at the latter term of the same. Kasahara (1950) claimes that the sperm whale matures sexually at the middle of the third year after the birth. These were brought out not from the age determination of the whale but from only the size constitution. On the other hand, Clarke (1956) discussed in detail on the body length at sexual maturity (see table 20 of his paper). Nishiwaki & Hibiya (1951, 1953) and Nishiwaki, Hibiya & Kimura (1956) have investigated also on this problem, but as the data on the small whales are insufficient, the satisfactory result has not been conclusive.

Now, using the materials of the present series of whales collected during the last several years, we carried out again a deeper investigation on the above-mentioned subject. It has been thought that the teeth are the best age characters for the sperm whale, but the studies on them have never been published. We have studied here on the maxillary and

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mandibular teeth and have got the new information on the age of sperm whale.

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MATERIAL

It has been noticed that in teeth of the sperm whale some year marks appear similarly in some other mammals. So we have collected the mandibular teeth of the whale, and cut longitudinally or transversely in

TABLE 1. SIZE DISTRIBUTION OF SEXUALLY IMMATURE AND MATURE SPERM WHALES USED IN THIS STUDY

Body length (feet)	Males		Females	
	Immature	Mature	Immature	Mature
21	1	—	—	—
22	1	—	1	—
24	1	—	—	—
27	—	1	3	—
28	—	—	1	1
29	—	—	1	2
30	2	—	—	5
31	1	3	—	6
32	—	3	—	12
33	—	4	—	10
34	—	4	—	9
35	—	6	—	13
36	—	2	—	8
37	—	3	—	3
38	—	2	—	1
39	—	4	—	—
40	—	3	—	—
43	—	1	—	—
44	—	1	—	—
45	—	1	—	—
46	—	1	—	—
48	—	1	—	—
50	—	2	—	—
51	—	4	—	—
52	—	1	—	—
53	—	1	—	—
Total	6	48	6	70

order to count the laminations on the cut surface of the tooth. We used teeth from the seventh through the tenth counted from the front in each individual, because they are the biggest of the dental series. But they are not satisfactory for our purpose, for the tips of the teeth began to be defaced following the growth of teeth, and their sections did not show the whole process of their growth, moreover the individual variations of attrition were considerable.

At this juncture, several years ago, we got a chance to get all teeth of a calf whose size was 22 feet long. All teeth were still in gum and not in defacing. Observing the maxillary teeth of this specimen, we found that the number of laminations in them was similar to that of

TABLE 2. COMPOSITION OF NUMBER OF LAMINATIONS IN THE TEETH OF EXAMINED SPERM WHALES

Number of laminations	Males		Females	
	Sexually Immature	Sexually mature	Sexually Immature	Sexually mature
2	1	—	—	—
3	—	—	1	—
4	1	—	—	—
5	1	—	—	—
7	—	—	1	—
8	—	1	4	—
9	1	—	—	1
10	1	3	—	1
11	1	3	—	4
12	—	4	—	6
13	—	3	—	2
14	—	4	—	2
15	—	2	—	2
16	—	2	—	1
17	—	2	—	1
18	—	1	—	5
19	—	—	—	1
21	—	—	—	2
22	—	—	—	3
23	—	—	—	1
24	—	—	—	1
26	—	1	—	1
28	—	1	1	1
29	—	—	—	2
31	—	2	—	3
32	—	—	—	1
33	—	—	—	2
37	—	—	—	1
44	—	1	—	—
49	—	—	—	1
65	—	1	—	—
Total	6	31	6	45

the mandibular teeth. Since then we have collected the maxillary teeth of the sperm whales whose mandibular teeth were defaced. At the same time, we have endeavoured to collect the teeth of small individuals as many as possible.

Tables 1 and 2 show the number of whales which we investigated and from which we collected the teeth. They are composed of the many whales which were netted with the fixed nets or stranded themselves. The biological data of them are shown in the appendix.

METHOD OF LAMINATION READING AND CHARACTERISTIC OF THE TEETH

For the purpose of determining the age of the sperm whale, the transversed section of the teeth is of no practical use. It may be understood by figure 1. Therefore we employed the teeth cut longitudinally through the axis. The tiny teeth were worn down with grinder and then filed and polished with iron rasps, and then polished with rough and fine whetstones. For the big teeth, after cutting off with metallic saw carefully never to cross the axis, we grinded it by the above-mentioned method.

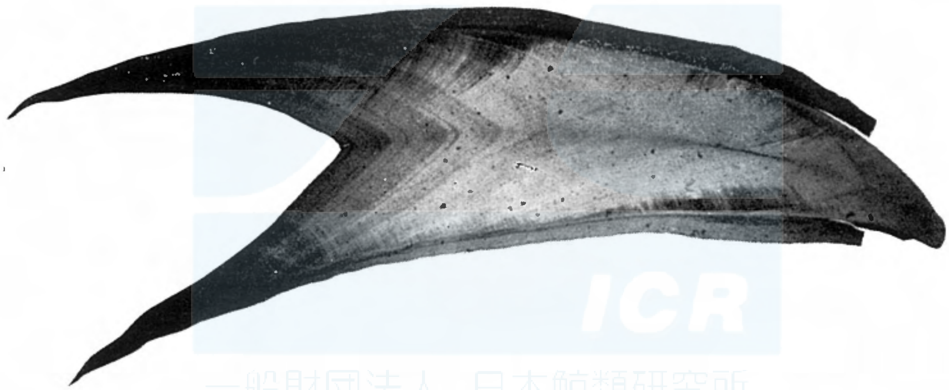

Fig. 1. Longitudinally section of a mandibular tooth of a sperm whale. (No. F 9). $7^1/_4$ laminations ($\times 2^2/_3$).

On counting the number of laminations we used the magnifying-glass ($\times$7) or binocular dissecting microscope ($\times$20). High magnification by the microscope was not only needless, but sometimes it made nuisance for counting, because the lamination which we counted consisted of from two to five fine lamellae in which more fine lamellae were found under the high-powered microscope. The aspect described here are shown obviously in figure 1.

Laminations will be also seen in the cement covering of the dentine. Although this lamination coincides with the same in the dentine, there are many cases of cement with obscure laminations. Outside of the teeth, jagged rings are appeared, as may be seen in the teeth of seals, but they are also rather obscure. So, both of them are not available as age character.

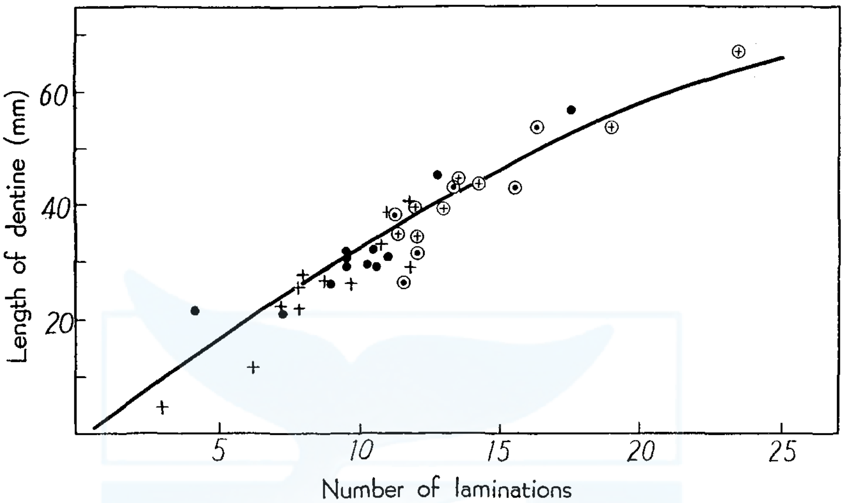

Fig. 2. Growth curve of mandibular teeth in the sperm whales.
Cross: female, closed circle: male, open circle: defaced:

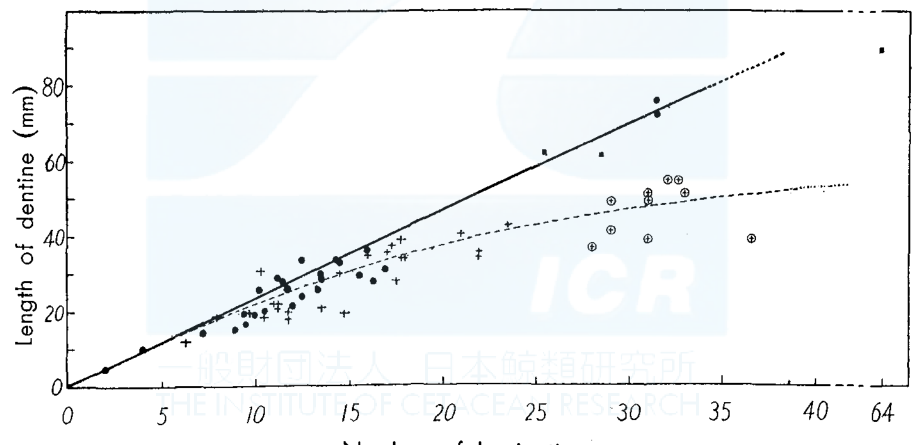

Fig. 3. Growth curve of maxillary teeth in the sperm whales.
Cross: female, closed cirde: male, square: northern male, open circle: radices dentes formed.

Using the teeth of six foetuses, we observed the developmental process of teeth and confirmed the presence of neonatal line in them. Moreover, on seven examples of which the teeth have never been defaced, we found that the number of laminations in each tooth of an similar throughout the dental series. But with the growth of animals mandibular teeth were defaced from their tops. The attrition begines at the stage of 12 laminations as is shown in figure 2. In the sperm whale, it is considered that the eruption of teeth have some relation with sexual maturity. And after the eruption attrition of teeth will begin. On the other hand, some of maxillary teeth are often buried in gum throughout the life. Figure 2 shows the relation between the number of laminations (in the case of the attrition in mandibular teeth we used number of laminations in the maxillary teeth) and the length of dentine. The lengths were measured along the axes. From this figure it is clear that the growth of teeth is faster than the attrition. At almost same age, both the teeth of males and females begin to be defaced.

Fig. 4a. A series of right mandibular teeth of a sperm whale foetus. Male, 400 cm in body length. ($\times 4/5$)

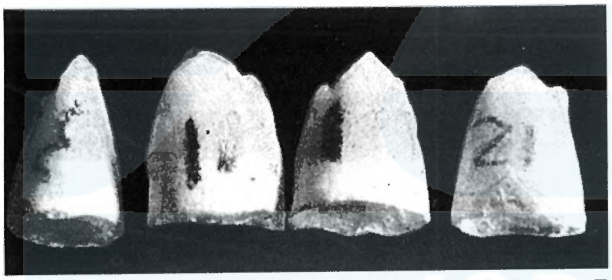

Fig. 4b. Four left mandibular teeth of a sperm whale foetus. Female, 365 cm in body length. ($\times 3$)

In old sperm whales, radices dentes are formed and the the teeth stop growing. The formation of radix dentis progresses both from anterior and posterior ends of the dental series. In maxillary teeth, radices dentes are formed at the stage of about 30 laminations for female whale, but not yet formed at the age of 65 laminations in the male maxillary teeth. As shown in figure 3, this phenomenon may have some relation with the physical maturity of the whale.

Examining the dental series of foetuses, it was found that the teeth other than the anterior four and the posterior four were conical and tridentate. After the birth the head of dentine is covered with cement, but it appears when the latter are uncovered. Figure 4 indicated a set of mandibular teeth of two foetuses. Osteodentines often bury within the dentine in maxillary teeth of females. The first formation of osteodentine may concern with the sexual maturity of female as shown in Plate II.

RELATION AMONG BODY LENGTH, WEIGHT OF TESTIS AND NUMBER OF LAMINATIONS IN THE TEETH

Figure 5 shows the relation between the body length of male whales and the weight of testes. In other species especially in baleen whales, the rapid increase of weight of testis appeared at the period of sexual maturity. Therefore, we can determine with relative ease the relation between the weight of testis and the body length at that stage. In the

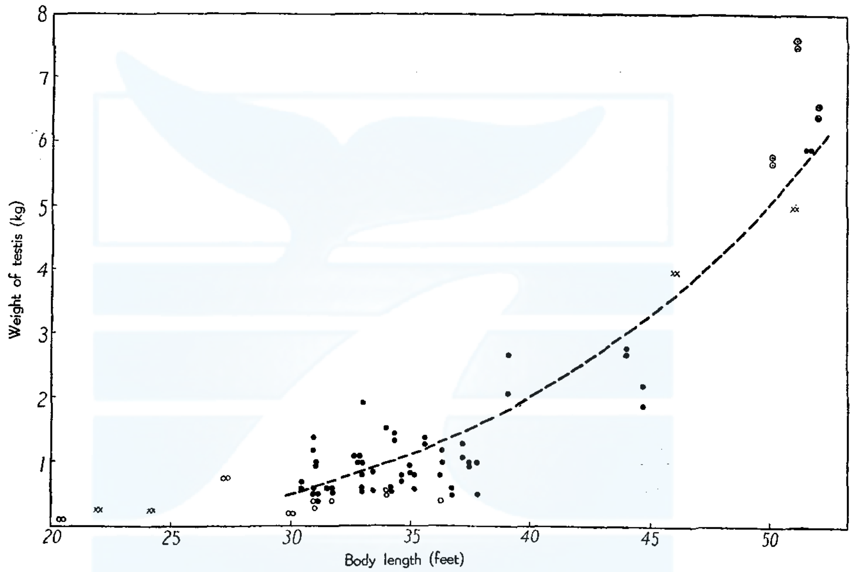

Fig. 5. Relation between the body length and the weight of testis in the sperm whales. Open circle: sexually immature, closed circle: sexually mature, cross: not examined histologically, point in the open circle: mature from the northern Pacific, broken line: mean curve by Nishiwaki, Hibiya & Kimura (1955).

sperm whale, however, testis increases slowly in weight and it is difficult to determine the point of sexual maturity with the weight of testis only. In Figure 5 is also shown the mean curve of the relation between the body length and the weight of testis of the sperm whales caught in adjacent waters to Japan (Nishiwaki & Hibiya, 1951). The present data are shown with signs of circles. White circle represent an immature testis all of which were determined with histological investigation, and the black one is a mature testis.

Figure 6 shows the relation between the number of laminations in the teeth and the weight of testis in same manner.

In the previous papers (Nishiwaki & Hibiya, 1951, 1952; Nishiwaki, Hibiya & Kimura, 1956), we could not use enough data determining the sexually mature length in the male. So we did not get the conclusion on the problem and showed the presumptive length at sexual maturity for the male (less than 38 feet). We determined the sexual maturity of the male by the presence of spermatozoa in the seminiferous tubules. Clarke (1956) interposed some objections to our method. He states that since there is evidence that male sperm whales have a sexual cycle, it is doubtful whether the presence or absence of spermatozoa is a very reliable means of discriminating between mature and immature animals. He says that the whale whose seminiferous tubules are large and open should be regarded to be sexually mature. And he pointed out that the sexually

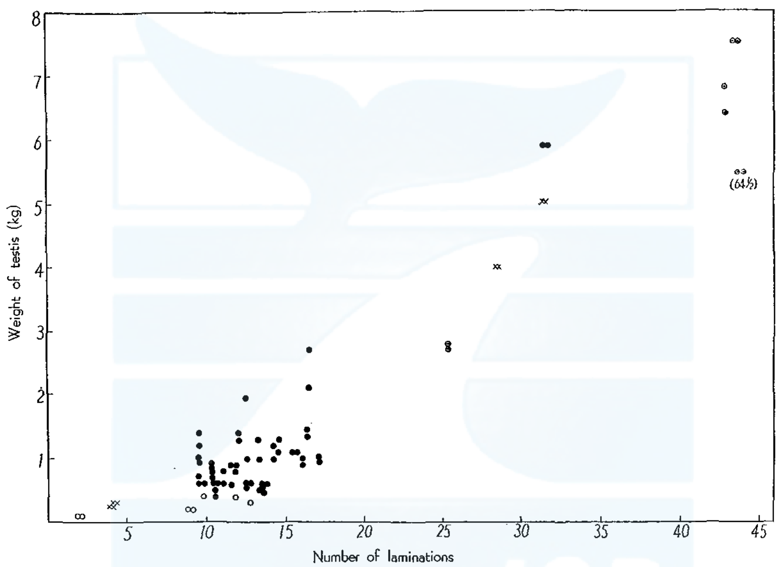

Fig. 6. Relation between the number of laminations and the weight of testis in the sperm whales. Marks are the same as figure 5.

mature length estimated by us in the previous papers would be bigger than that by him.

In the present study, we classify the degree of the maturity of testes in following three stages, that is to say, these are the testes in which spermatozoa exist (+), those in which seminiferous tubules are open but spermatozoa do not exist (±), and those whose tubules are closed and decided as immature (−). And then we regard ± as mature.

Owing to the scanty of samples of the testes under 1.0 kg in weight, we suggested in our previous papers that the male sperm whale attained sexual maturity at 1.1 kg in testis weight. But from figure 4, the weight of testis at maturity is about 0.5 kg. According to Clarke (1956), the combined volume of both testes at maturity is 1.5 *l*. As the density of testes is about 1.0 g/cm^3, the figure of the weight in gram corresponds almost to that of the volumal in cubic centimeter. From our data, the combined weight of testes is calculated to be 1.0 kg. Therefore the value by Clarke is bigger than that by us.

Table 1 shows the body length of sexually mature and immature whales determined by the histological examination of testes in the male. Although number of samples are relatively few, the body length at sexual maturity is supposed to be 31 feet in the male.

Table 2 is a record of the number of laminations for sexually mature and immature whales. The number of laminations at sexual maturity estimated from this datum is about 10.

RELATION BETWEEN NUMBER OF OVULATIONS, BODY LENGTH AND ALSO NUMBER OF LAMINATIONS

Figure 7 shows the relation between the body length and the number of ovulations in the sperm whale. The deviation of the latter at each body length is remarkable. On the other view, the deviation of body length at each number of ovulations is also conspicuously vest. On the contrary, it is found that the frequency of ovulations correspond relatively close to the number of laminations (fig. 8).

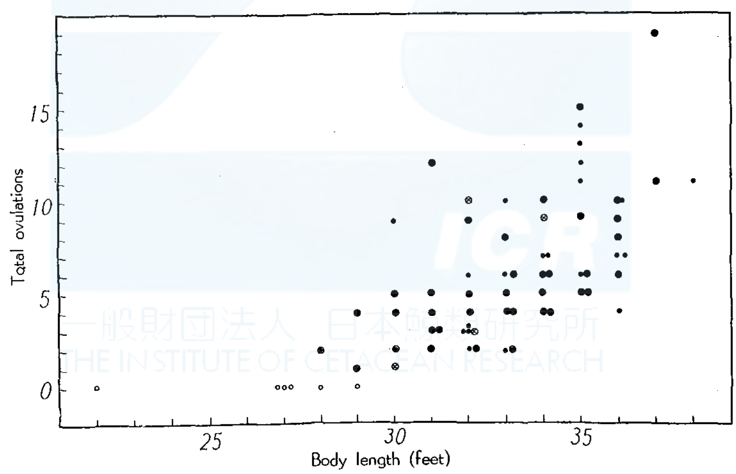

Fig. 7. Relation between the body length and the total ovulations in sperm whales. Open circles: sexually immature, cross in the open circle: ovulating, point in the open circle: resting, closed circles: pregnant.

The same phenomenon was observed on the laminations in the ear plug of fin whales (Nishiwaki, 1957), and the numbers of those laminations are regarded as the most reliable age characters for the baleen whales.

Similarly, the number of laminations in the teeth can be appreciated as the most reliable age character for the sperm whale. The lamination may be formed periodically in the teeth.

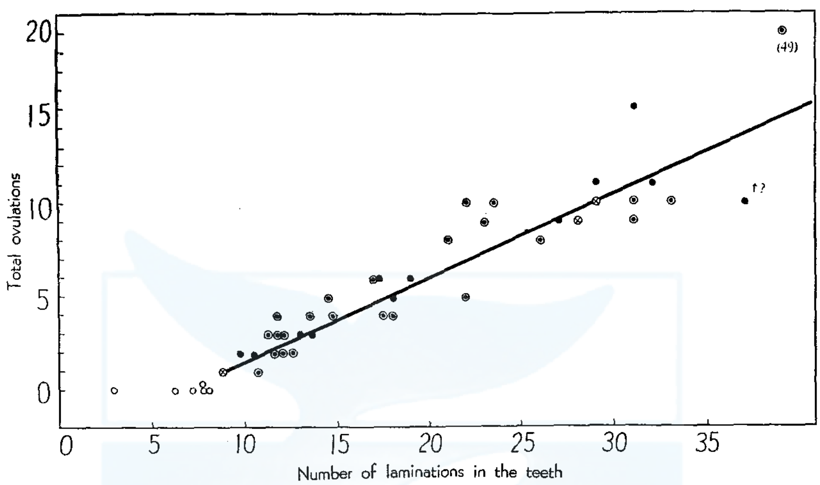

Fig. 8. Relation between the number of laminations and the total ovulations. Marks are the same as figure 7.

The experimental formula derived from our present data is as follows.

$Y=0.44X-3.00$ Y: Number of ovulations

X: Number of laminations in the tooth

From table 1, it is decided that the sexually mature length of the female sperm whale is about 29 feet. And the number of laminations at sexual maturity is about 9 according to table 2.

RELATION BETWEEN NUMBER OF LAMINATIONS IN THE TEETH AND BODY LENGTH

The frequency of ovulations has been regarded as a good age character for the whales. Figure 9 shows the relation between body length and the frequency of ovulations, and the curve will show the growth of the animal. But the growth during immature stage cannot be shown by this method. Furthermore, the number of ovulations in a breeding season varies with the individual and the year.

From this figure it will bee seen that the body length at sexual maturity (namely at the point of the first ovulation) is 29 feet long, and the length at physical maturity is 35-36 feet long as for the female sperm whale.

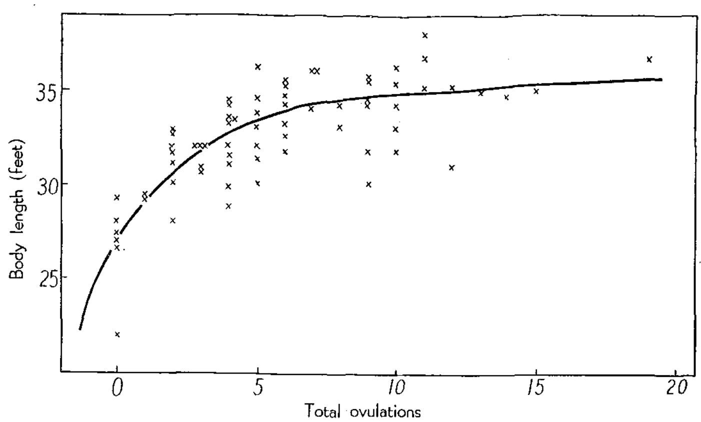

Fig. 9. Growth curve of the female sperm whales based on the total ovulations.

Figure 10 shows the relation between the number of laminations in the teeth and the body length. In this manner can be indicated the growth in both sexes, and also in foetus. Using the data by Matthews (1938), Matsuura (1936), and Mizue (1950) we adopted 16 months as the pregnant period and 13 feet as the body length at birth.

The mark × in figure 10 is the length and time at weaning by Clarke (1956). On our smallest male specimen which was 20 feet 6 inches in body length and with two laminations in its teeth, we had no chance examining its stomach content. Therefore it is not certain whether it was nursing or not. It was observed, however, that a male individual which is 22 feet long in body length and has three laminations in its

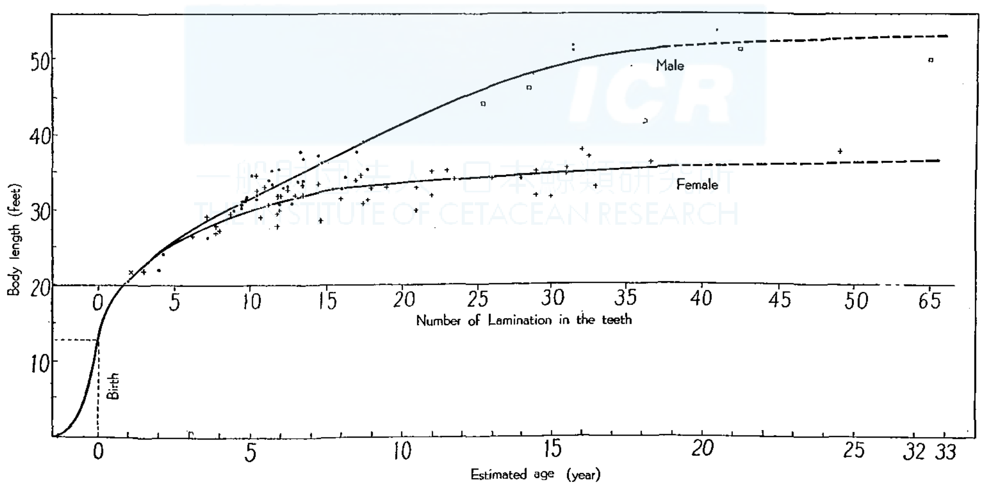

Fig. 10. Growth curve of the sperm whale according to number of laminations. Point: male, cross: female, square: male from the northern Pacific.

teeth and a female which was 22 feet long with four laminations had eaten squids. It was supposed that these had been already weaned. The lactating period is about 13 months by Clarke (1956). We consider that it is from 8 to 12 months, though continuance of lactation for 13 months are rather seldom case. From this point of view we consider that the whale which is 20 feet 6 inches in body length and with two laminations in teeth is one year old. According to the information about the teeth of the blue-white dolphin (Nishiwaki & Yagi, 1953) and the ear plugs of the fin whale (Laws & Purves, 1957), it is estimated that two laminations are formed in the teeth of sperm whales every year. If two laminations in the teeth of the sperm whale correspond to one year, the age at sexual maturity is four and a half or five years old, as the numbers of laminations are nine or ten in both sexes at that time. From figure 10, the body length at physical matuaity is 36 feet for the female. On the other hand, male grows rapidly after sexual maturity and continues to grow over 50 feet long. It was observed that the whale which was 51 feet 6 inches long in body length and has $31\frac{1}{2}$ laminations in the teeth was not physically mature (Plate 2). According to the investigation on the physical maturity of the male sperm whale in the northern Pacific by one of us (Kimura, 1957), the body length at physical maturity was over 52 feet.

INVOLUTION OF CORPUS LUTEUM

We have very scanty informations about the involution of corpus lateum in the ovaries of whales. And it is an important problem whether corpus luteum becomes to disappear or not. As we can estimate the age of the female sperm whale by the teeth, we arrange in order the corpora lutea and albicantia by means of their diameters. On the whale whose teeth were not sampled, we estimate its age from figure 8 by the number of ovulations.

Table 3 shows the diameter of corpora lutea and albicantia. By the classification of the diameter of the corpora albicantia we will estimate the number of ovulation in each breeding season. As for the relation between the number of laminations in the teeth and number of times of ovulations we obtained the empirical formula as shown above chapter. It means that two corpora albicantia formed every two years. We used this value as the standard of arrangement.

Figure 10 shows the relation between the diameters of corpora lutea or albicantia and the estimated duration after the ovulation corresponding respectively to them. The duration after the last ovulation were estimated basing on the sexual conditions of the whales. For instance, a

TABLE 3. DIAMETER OF CORPORA LUTEA AND ALBICANTIA OF SPERM WHALES

Serial number	Body length	Number of lamination in the teeth	Estimated age after Sexual maturity	Number of corpora lutea / albicantia left	Number of corpora lutea / albicantia right	Diameter of corpora lutea or albicantia in mm.	Sexual condition
F— 6	28′— 0″	$11^3/_4$	$1^7/_8$	0/1	0/1	34,14	lactating
F—11	29′—10″	$11^3/_4$	$1^7/_8$	0/2	0/2	37,22,17,14	resting
F—13	30′— 0″	12+	2+	0/1	0/1	35,20	lactating
F—17	31′— 8″	$9^3/_4$	$^7/_8$	1/0	0/1	105,33	pregnant, foetus: M, 5′—4″
F—18	31′— 9″	31+	$11^1/_2$+	0/5	0/4	30,20,19,17,14,14,13,12	lactating
F—24	32′— 0″	$11^2/_3$	$1^5/_6$	1/1	0/1	95,40,28	pregnant, foetus: M, 84 cm
F—25	32′— 0″	22	7	0/3	0/2	28,20,13,10,6	just finished lactation
F—28	33′— 0″	18	5	0/2	0/5	32,29,27,24,18	lactating, thickness of mammary gland: 17 cm
F—39	34′— 3″	29	$10^1/_2$	2/5	0/4	100,70, hereafter unknown	pregnant, foetus: 17 cm
F—42	34′— 9″	31+	$11^1/_2$+	1/5	0/8	100,30,24,22,20,17,17,16,15,14, 14,12,11,11	pregnant, foetus: 3′—2″
F—52	31′— 0″	—	$11^1/_4$	0/6	0/6	25,22,20,18,18,15,12,12,10,10,8, 7	lactating, thickness of mammary gland: 20 cm
F—53	31′— 1″	—	$1^3/_4$	0/1	0/1	37,25	lactating
F—54	31′— 4″	—	$4^1/_3$	0/2	0/3	32,15,15,11,8	lactating
F—55	32′— 6″	—	$5^1/_3$	0/4	0/2	30,25,18,15,15,8	lactating
F—56	33′— 6″	—	3	0/1	0/3	28,25,18,11	lactating, slightly
F—57	34′— 6″	—	$4^3/_8$	0/3	0/2	26,17,16,15,12	lactating
F—58	34′— 6″	—	$8^1/_4$	0/6	0/3	20,14,12,12,10,10,10,9,8	lactating, slightly
F—59	35′— 6″	—	$5^1/_3$	0/2	0/4	50,20,20,15,15,12	lactating, uterus was not involuted yet

whale which had one corpus luteum and was pregnant with 17 cm. long foetus was estimated to had ovulated three months ago. And about the lactating corpus albicans the time of the last ovulation is estimated by the thickness of mammary gland, the width of uterus, or density and quantity of the milk.

It is known from figure 11 that diameter of the corpus lateum graviditatis is about 100 mm., but it involutes rapidly after parturition, in the lactation its diameter is 30–50 mm. and in the end of the period it decreases to about 25 mm. then after 3 or 4 years it involutes to about 10 mm. After that time the corpus albicans continues to involute but does

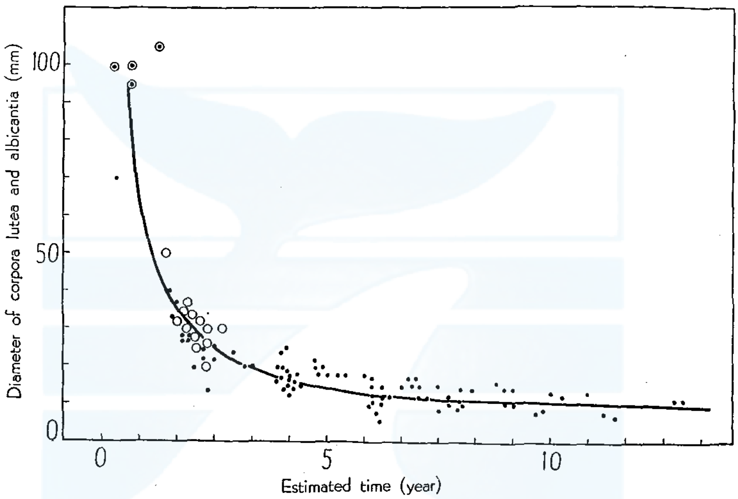

Fig. 11. Involuting course of corpora lutea of the sperm whales. Point in the open circle: corpus luteum, open circle: corpus albicans in lactating, point: corpus albicans.

not disappear throughout the life. The most numerous number of ovulation was 19 in our samples, and its number of laminations in the teeth was 49, whereupon the estimated age was $24\frac{1}{2}$ years old. We could not decide whether the corpora albicantia disappear or not in the older age than that of this specimen.

DISCUSSION

The body length of male sperm whale at sexual maturity in our present study agrees well with the result by Clarke (1956). The fact is one of the reasons why this paper we adopted the condition of seminiferous tubule as the standard of sexual maturity according to Clarke. At the same time, it must be the most probable reason that we obtained the specimens of small whales. In our previous investigation, the whales under 34 feet long was very scanty because of the size regulation on the whaling. The most point becoming an issue in the present study was the finding of the practical method of estimating age by counting the laminations in the teeth in other words, the making clear whether two laminations correspond to the duration of one year or not.

On the aetiology of the laminated structure, there are many explanations (for instance Purves (1955) on the ear plug of the fin whale, and Laws (1953) on the teeth of the elephant seal), although there is some need for further studies. On the other hand we could get the result that two laminations in the teeth were formed annually by the experiment upon the blue-white dolphins, actually kept alive under observation. (loc. cit.)

This problem should be solved by further investigations. Marking expedition will be one of the methods of it. Omura & Kawakami (1956) reported basing on the marking investigation in the North Pacific, and stated that the growth in the sperm whales may be much slower than that is generally believed. One male, killed in the 4th year after the marking measured only 35 feet. Of the other three males, killed in 4th year and after the two are both 37 feet and another 39 feet. The length of two females, killed in the 5th and 6th year, were both 36 feet. And it will be better if possible that the method injecting lead-compound with the marking harpoon to deposit lead in teeth are employed.

SUMMARY

1. In the present study were available the sperm whales which had been caught in the northern Pacific or stranded in Japanese coasts in the last several years.

2. The number of laminations in the teeth is available as the criteria for the age estimation. Buried maxillary teeth are suitable for this purpose.

3. The top of dentine of the sperm whale are tridentate in the very young stage.

4. Mandibular teeth begin to be defaced several years after birth, and the pulp cavity of the maxillary teeth is closed at over ten years old. The phenomena may be related to the sexual and physical maturity respectively.

5. The weaning period is estimated to be one year after birth. The body length at this stage is about 21 feet.

6. The male sperm whale attains sexual maturity at the age of four or five (nine or ten laminations) and the body length at that stage is about 31 feet long and its heavier testis is 0.5 kg in weight.

7. The female sperm whale attains sexual maturity at the next breeding season of the age of four, and the body length at that stage

is about 29 feet long.

8. The eruption of teeth have some relation with sexual maturity.

9. Over the age of eighteen the whale attains physical maturity, and the body length is 52 feet long in male and 36 feet in female.

10. The number of ovulation in one breeding season is two in an average. That corpus luteum involutes repidly after parturition but it may not disappear throughout the life.

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EXPLANATION OF APPENDIX

Biological measurement of sperm whales of which teeth are sampled.

Remarks.

1) + : Buried teeth are exist but they are not counted.
2) ? : It is not clear whether teeth are exist or not.
3) ( ): Number of teeth buried.
   Left: anterior
   Right: posterior
4) U : Upper (Maxillary) teeth examined.
5) L : Lower Mandibular tooth examined.

EXPLANATION OF PLATES

PLATE I

Fig. 1. Maxillary and mandibular teeth of three female specimens. ($\times \frac{2}{3}$)
Upper: maxillary teeth. Lower: mandibular teeth.
- a: 26′6″, $6\frac{1}{4}$ laminations (F—2)
- b: 29′4″, $7\frac{1}{4}$ laminations (F—9)
- c: 28′0″, $11\frac{3}{4}$ laminations (F-6)

Fig. 2. Mandibular teeth of four specimens. ($\times \frac{2}{3}$)
- a: Female, 22′, 3 laminations (F—1)
- b: Female, 27′10″, $7\frac{3}{4}$ laminations (F—3)
- c: Male, 30′5″, $9\frac{1}{2}$ laminations (M—6)
- d: Male, 34′, $13\frac{1}{4}$ laminations Defacing begins (M—18)

Fig. 3. Mandibular tooth of a male which is 49 feet long. (MN—3). ($\times \frac{4}{7}$)
Tip of tooth has been relatively defaced.
Number of lamination is over 39.

PLATE II

Fig. 1. Maxillary teeth of four specimens. ($\times 1$)
- a: Male, 20′6″, 2 laminations (M—1)
- b: Female, 32′0″, $11\frac{2}{3}$ laminations (F—24)
- c: Female, 33′0″, 22 lamination (F—25)
- d: Female, 33′0″, over 33 laminations, roof formed (F—30)

Fig. 2. Maxillary teeth of two male specimens. ($\times \frac{5}{8}$)
Upper: 51′0″, $43\frac{1}{2}$ laminations (MN—5).
Lower: 51′6″, $31\frac{1}{2}$ laminations (M—34).

Fig. 3. Maxillary tooth of the oldest specimen.
Male, 50′0″, $64\frac{1}{2}$ laminations (MN—4)

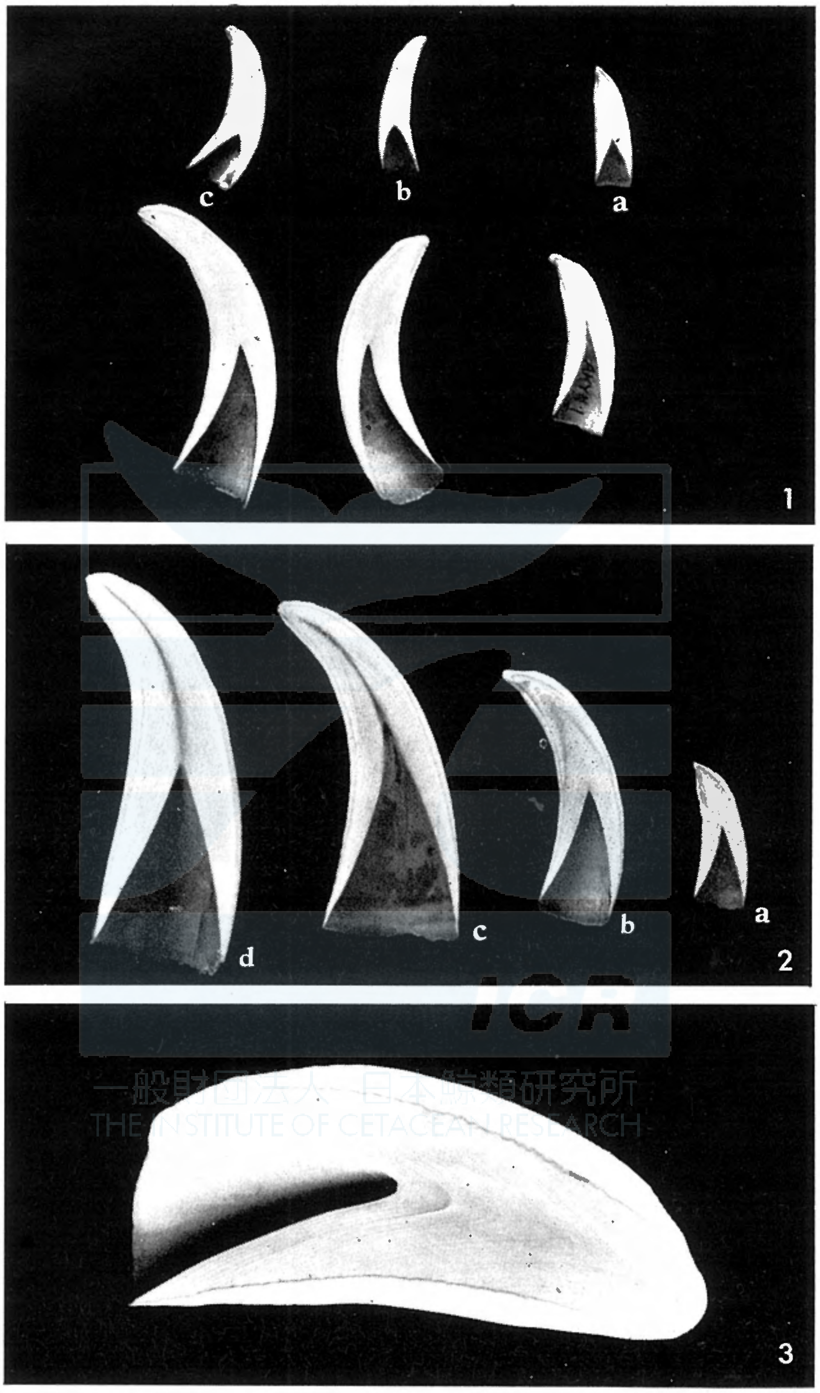
Fig. 4. Defaced Maxillary tooth of a male 52 feet over 42 laminations. (MN—6) ($\times \frac{6}{7}$)
Laminations in cement are seen clearly.

APPENDIX

Number of samples	Body length (feet / inch)	Dental formula				Teeth examined	Length of dentine	Number of lamination in the teeth	Testis			
		Left upper	Left lower	Right lower	Right upper				Left weight	Maturity	Right weight	Maturity
M— 1	20— 6	+	(22)	(22)	+	U	5.0	2	0.1 kg	—	0.1 kg	—
M— 2	22	?	?	?	?	L	10.4	4				
M— 3	24— 3	?	?	?	?	L	21.7	4 1/4				
M— 4	27— 4	+	(24)	(24)	+	L, U	21.5, 15.3	7 1/4	0.75		0.75	
M— 5	30— 0	+	(23)	(24)	+	L, U	26.4, 15.7	9	0.2	—	0.2	—
M— 6	30— 5	+	(25)	(24)	+	L	30.8	9 1/2	0.7	+	0.6	+
M— 7	30—10	+	21	25	+	L, U	31.4, 17.3	9 1/3	1.4	+	1.2	+
M— 8	30—11	+	(1) 24 (6)	(1) 25 (7)	+	L, U	32.6, 20.0	10 1/2	0.5	+	0.4	+
M— 9	31— 0	+	(1) 25 (8)	(1) 26 (9)	+	L	45.6	12 3/4	0.3	—	0.6	+
M—10	31— 2	+	(2) 22 (6)	(3) 23 (7)	+	L, U	29.5, 19.7	9 1/2	1.0	+	0.95	+
M—11	31— 8	+	(2) 23 (9)	(3) 24	+	L, U	33.6, 19.4	9 3/4	0.4	—	0.6	+
M—12	31— 9		(9) 21 (6)	(8) 22 (7)		L	29.6	10 1/2+	0.55	+	0.6	+
M—13	32—10	+	(1) 22 (4)	(3) 24 (6)	+	L, U	43.5+, 30.2	15 1/3	1.1	+	1.1	+
M—14	33— 0	+	(3) 26 (8)	(2) 25 (6)	+	U	33.6	12 1/2	0.6	+	0.55	+
M—15	33— 0	+	(1) 24 (6)	(1) 25 (4)	+	U	24.2	12 1/2	1.95	+	1.0	+
M—16	33— 0	+	23 (1)	21	+	U	35.8	16	0.8	+	1.0	+
M—17	33— 5	+	(1) 25	(1) 24	+	L, U	26.4+, 27.4	11 1/2	0.55	+	0.9	+
M—18	34		23	23		L	43.5+	13 1/4+	1.3	+	Lost	
M—19	34— 0	2	(1) 22 (3)	(1) 21 (4)	+	L, U	38.7+, 28.8	11 1/4	0.5		0.55	
M—20	34— 0	+	(1) 22 (4)	(1) 23 (3)	+	U	29.8	13 1/2	0.55	+	0.6	+
M—21	34— 5	+	(1) 23	22	+	L, U	53.8+, 27.7	16 1/3	1.45	+	0.35	+
M—22	34— 8	+	(2) 24 (7)	(3) 24 (6)	+	L, U	30.1, 25.6	10 1/3	0.7	+	0.8	+
M—23	35		25 (8)	25 (8)		L	30.3	10 1/3	0.85	+	0.90	+
M—24	35— 2	+	(3) 24 (5)	(2) 24 (5)	+	L	31.0+	11+	0.6	+	0.8	+
M—25	35— 7	+	(1) 24 (5)	(1) 25 (3)	+	L, U	32.0+, 21.7	12	1.3	+	1.4	+
M—26	36— 4	+	(2) 25	(1) 25	+	U	26.0	11 3/4	0.4	—	0.8	+
M—27	36— 5	+	(1) 23 (5)	(1) 24 (4)	+	U	33.6	14 1/3	1.2	+	1.0	+
M—28	36— 8	+	(1) 23 (1)	(1) 23 (1)	+	U	29.0	13 1/3	0.6	+	0.5	+
M—29	37— 3	+	25 (7)	24 (7)	+	U	32.8	14 1/2	1.1	+	1.3	+
M—30	37— 6	+	(1) 27 (3)	(1) 25 (3)	+	U	30.8	17	1.0	+	0.95	+
M—31	37—10	+	(1) 23 (2)	(1) 22 (2)	+	U	27.4	13 1/3	0.5	+	1.0	+
M—32	39	+	?	?	?	L	57.0	17 1/2	2.7	+	2.1	+
M—33	51	?	?	?	?	U	72.5	31 1/2				
M—34	51— 6	+	(1) 22 (1)	21	+	U	76.0	31 1/2	5.9	+	5.9	+
MN— 1	44	+	?	?	+	U	62.6	25 1/3	2.7		2.8	
MN— 2	46	5	27 (1)	28 (1)	+	U	61.8	28 1/2	—		—	
MN —3	49	?	?	?	?	L	82+	39+	—		—	
MN —4	50	+	21	20	6	U	105.2	64 1/2	5.4		5.8	
MN —5	51	7	21	22	6	U	89.8	43 1/2	7.5		7.6	
MN —6	52	5	22	22	6	U	74.6+	43+	6.4		6.8	

APPENDIX (Cont.)

Number of samples	Body length (feet inch)	Dental formula: Left upper	Left lower	Right lower	Right upper	Teeth examined	Length of dentine	Number of lamination in the teeth	Number of corpora: Lutea	/albicantia	Remarks
F—1	22	?	(22)	(22)	?	L	4.8 mm	3	0/0	0/0	
F—2	26—6	+	(22)	(23)	+	L, U	11.7, 12.0	6 1/4	0/0	0/0	
F—3	27—0	+	(23)	(23)	+	L	25.8	7 3/4	0/0	0/0	
F—4	27—5	+	(25)	(24)	+	L, U	28.0, 18.5	8	0/0	0/0	
F—5	28—0	+	(21)	(22)	+	L	22.0	7 3/4	0/0	0/0	
F—6	28—0	+	(2) 20 (13)	(1) 22 (11)	+	L, U	35.0, 20.7	11 3/4	0/1	0/1	
F—7	28—10	+?	(2) 22 (5)	(2) 22 (4)	+?	L, U	41.0, 19.2	11 2/3	0/2	—	
F—8	29—3	+	(3) 21 (9)	(3) 22 (11)	+	L	33.4	10 2/3	1/0	0/0	Lactating
F—9	29—4	+	(22)	(22)	+	L, U	22.4, 16.0	7 1/4	0/0	0/0	
F—10	29—6	+	(23)	(23)	+	L	27.0	8 2/3	1/0	0/0	
F—11	29—10	+	(5) 23 (7)	(7) 23 (1)	+	L, U	29.5, 18.2	11 3/4	0/2	0/2	
F—12	30—0	+	(1) 22	(1) 22	+	L	40.0+	12+	0/1	0/1	Lactating
F—13	30—0	+	25	25	+	U	48.9	21	1/4	0/4	pregnant
F—14	30—10	1	(2) 22 (7)	(2) 21 (5)	+	L, U	35.5+, 21.8	11 1/3	0/1	0/2	
F—15	31	+	25 (2)	23 (2)	+	U	28.0	17 1/2	0/3	0/1	Lactating
F—16	31—6	+	(1) 26 (3)	(1) 25 (6)	+	U	38.9	17 2/3	1/2	0/1	pregnant M 5—4
F—17	31—8	+	(2) 24 (5)	(2) 23 (3)	+	L, U	26.6, 29.8	9 3/4	1/0	0/1	pregnant F 11—5
F—18	21—9	3	25 (1)	25 (1)	4	U	39.3 almost close	31+	0/5	0/4	Lactating
F—19	31—10	+	(1) 26 (2)	(1) 25 (1)	+	U	35.4	16	—	—	
F—20	31—10	+	26	25	+	U	49.4 almost close	29	1/3	0/6	
F—21	32	?	27	26	?	L	35.2+	12+	1/1		
F—22	32	?	22	22	?	L	40.1+	13+	1/0	0/2	pregnant
F—23	32	?	21 (6)	23 (5)	?	L	45.0+	13 1/2	1/1	0/1	pregnant
F—24	32—0	+	24	22	+	U	19.7	11 2/3	1/1	0/1	pregnant M 256 cm
F—25	32—0	+	(1) 23	22	+	U	34.5	22	0/3	0/2	
F—26	32—7	+	(1) 26 (1)	(1) 26	+	U	18.6	10 1/2	1/0	—	pregnant F 1—5
F—27	32—10	+	(5) 27 (10)	(10) 26 (10)	+	U	26.0	12 1/2	0/1	—	
F—28	33—0	4	21	21	4	U	33.9	18	0/2	0/3	Lactating
F—29	33—0	+	24	23	+	U	40.5	21	0/6	0/2	
F—30	33—0	3	26	27	4	U closed	51.5	33+	0/6	0/4	
F—31	33—2	+	(1) 24	(1) 23	+	U	21.3	13 1/2	0/3	0/1	
F—32	33—3	+	(3) 23 (5)	(2) 21 (5)	+	L, U	39.0, 21.8	11	—	—	
F—33	33—3	+	(1) 23 (3)	(1) 22 (2)	+	L	54.0+	19	1/2	0/3	pregnant (foetus, large, lost)
F—34	33—9	+	(1) 22	(1) 23	+	L, U	44.0+, 30.0	14	0/8	0/1+	
F—35	34—2	+	21	21	+	U	35.7	17	0/3	0/3	
F—36	34—2	6	27	26	6	U	36.6	28	1/4	0/4	
F—37	34—3	+		21+	+	L, U	67.0+, 43.0	23 1/2	0/5	—	
F—38	34—3	+	24	24	+	U	24.4 almost close	26	0/6	0/0	
F—39	34—8	+	(7) 23 (10)	(8) 24 (11)	+	U	31.3	10 1/2	—	—	
F—40	34—8	2+	24	24 (1)	+	U	37.5	17 1/3	1/1	0/4	pregnant 17 cm
F—41	34—9	3	23	26	1	U closed	50.0	31+	1/5	0/8	pregnant 3—2″
F—42	35—2	+	24	23	+	U closed	41.3	29	2/5	0/4	pregnant M—0—9
F—43	35—5	2	24	23	3	U	36.0	22	0/8	0/2	
F—44	35—6	1	21	25	2	U	33.8	17 3/4	—	—	
F—45	35—6	+	(1) 24 (2)	(1) 23 (1)	+	U	41.4	23	0/3	0/6	
F—46	35—8	1	25	23	+	U	50.8 close	31	0/4	—	Lactating
F—47	36	+	25 (1)	25	1	L	47.4+	21 1/3+	1/2	0/4	pregnant M 252 cm
F—48	36—3	+	(2) 23 (6)	(1) 21 (6)	+	L, U	39.34, 40.7	36 1/2	1/4		pregnant
F—49	36—10	4	23	22	1	U	64.6	49	0/9	0/10	
F—50	37—7	5	25	22 (5)	3	U	55.3 almost close	32 1/2	—	—	pregnant
F—51	38—0	16	21	22	3	U	55.2 almost close	32	0/5	1/5	pregnant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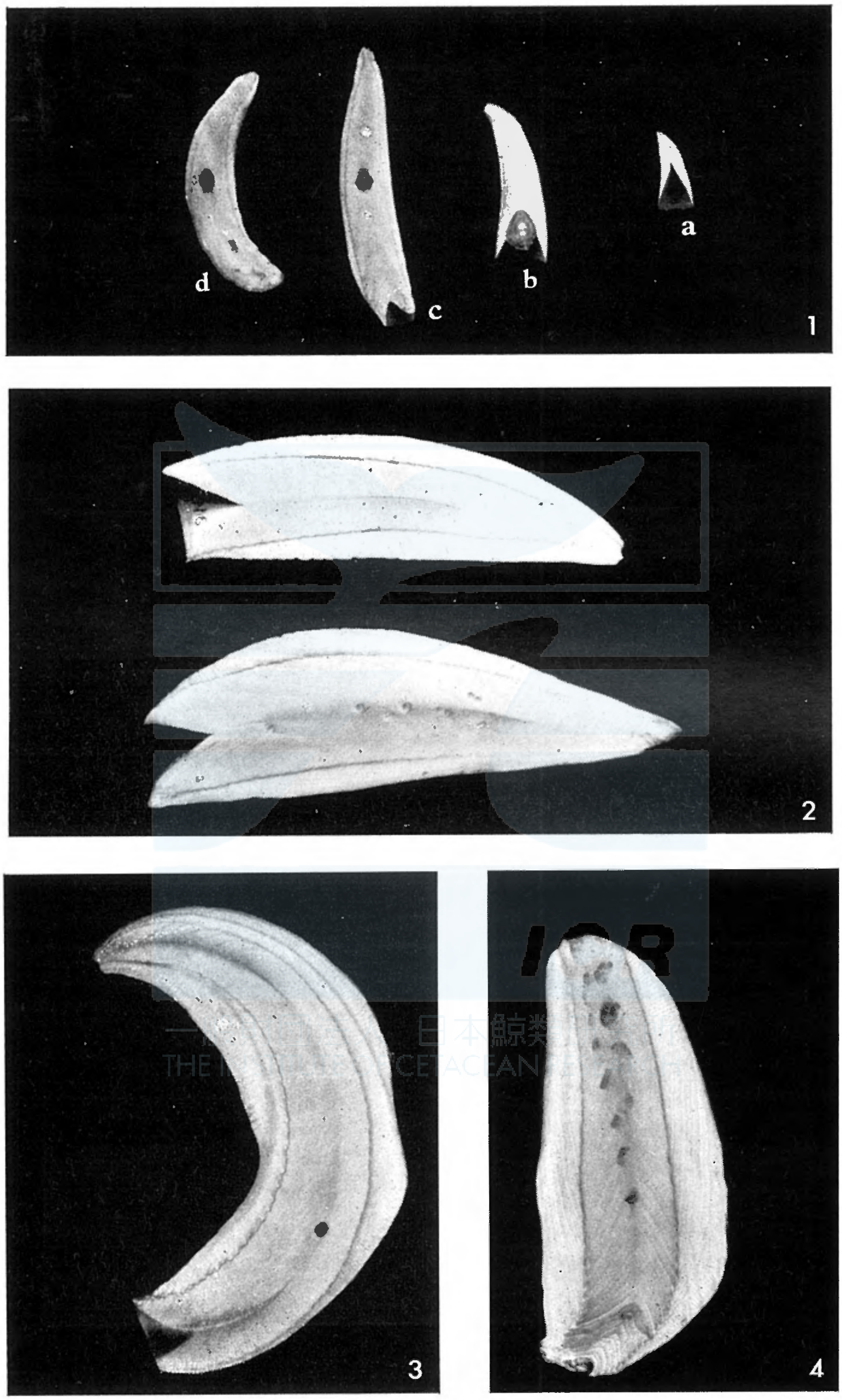
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