AGE STUDIES OF FIN WHALE BASED ON EAR PLUG

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INTRODUCTION

An article examining ear plug as the determination of age of baleen whale, mainly concerning fin whale in the Antarctic, was given in the Scientific Reports of the Whales Research Institute No. 12. By that time, ear plugs had been already collected from the northern part of the North Pacific and reached to our Institute intact. The present paper examines ear plugs collected in the Antarctic season 1956–57, and in the northern Pacific season 1956 and 1957.

In preceding paper (Nishiwaki, 1957), the validity of ear plug as the age characteristic of the fin whale was explained in details. The present paper supplies the scanty data in preceding work, examining the laminations essential to the age determination except for baleen plate reading. Besides, it compares southern fin whales with northern fin whales, in their growths. It is considered in our studies that 2 laminations are deposited in one year in the ear plug.

As ear plugs were collected in large numbers as shown in the northern Pacific expedition of 1957, the study on age character may be extended to a clue to researches for whale stocks remaining undecided. However samples are supposed to have necessary but not yet sufficiant numbers for the latter study. When age compositions are considered as a clue to whale stocks, it is remarkable that the ear plug is worth analysing males and females together, but the hard effort and skillfulness are needed in the sampling of ear plug. On the other hand, even if the number of ovulations is related only to the age of female, it is easily counted through training after overies are picked up from the flensed whale. In the Japanese expeditions, the researches for ovaries have been carried out for most of whales killed, by inspectors and biologists on board the floating factory ships. In the present problem therefore the laminations of ear plug are considered chiefly against the numbers of total ovulations and interesting informations are obtained.

Acknowledgements are due to the Japanese government whaling inspectors and the staff of whaling companies who cooperated in the collection of ear plugs. We are also indebted to Mr. K. Nasu of our Institute for his helpful work on board.

MATERIAL AND METHOD

The numbers of ear plugs used in the present work were 288, 149 and 403 for the Antarctic expedition season 1956–57, the northern Pacific expeditions of 1956 and 1957 respectively, as shown in the appendixes.

In the northern Pacific expedition of 1956, the sampling of ear plugs was not carried out mainly for male but for female fin whales to compare the number of laminations with that of total ovulations. In the nothern Pacific expedition of 1957, the sampling of ear plugs was carried out at random for male as well as for female fin whales, so the samples collected may represent the whale stock to a considerable degree. In the Antarctic expendition season 1956–57, ear plugs were collected at random in 5 Japanese fleets but their numbers were not enough to represent the whale stock.

The ear plugs were preserved in 10% formalin solution soon after collections. Cutting down the convex side of ear plug with knife, we smoothed its surface to nearly longitudinal axis with iron rasp, since then we smoothed further its surface with rough and fine whetstones to read apparently the laminations. Then, the number of laminations of core was counted by authors alternately, by their naked eyes and with magnifying glasses or dissecting-microscopes.

COLOUR OF CORE

According to Symons (1956), the colour of ear plug varies from a dull ochre to black and this observation coincides with us. During our counting of laminations, we found the core of ear plug of the younger whale are easily discriminated from that of the older whale through its colour. In the younger stage of whale, especially from the birth to the sexual maturity, the colour of core is whitish yellow and the structure of core is fragile and coarse. When the whale becomes older, the colour of core changes from a dull ochre to blackish brown and the structure of core changes more hardly and densely. Each lamination before the sexual maturity is remarkably thick for male as well as for female fin whales. In this regard three samples of females are shown in Fig. 1.

VARIATION OF CORE LENGTH

It was already shown in the preceding paper (Nishiwaki, 1957) that the wide individual variations were found in the increases of thickness of laminations in the core of ear plugs. We now measure the lengths of cores on the samples caught in the northern Pacific in 1956 to confirm

the above fact and compare with the samples from the Antarctic.

In order to explain the difference of length between the left and right core, five samples are shown in Table 1.

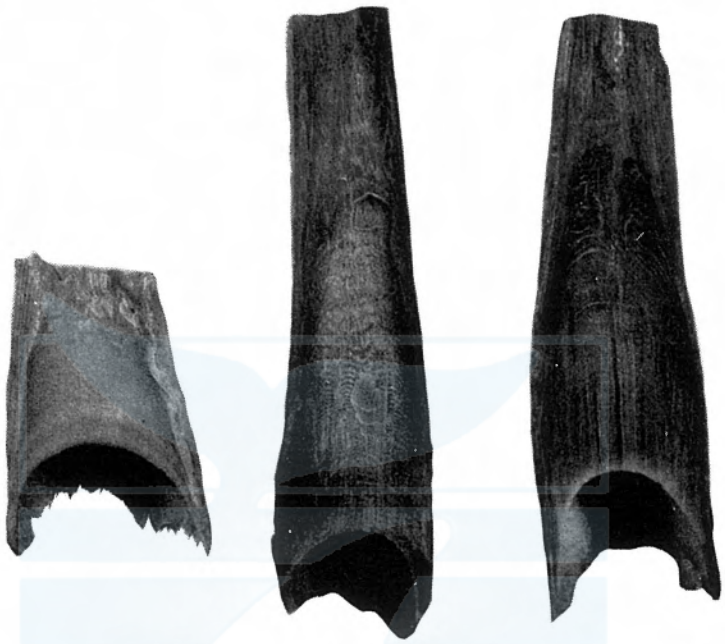

Fig. 1. Bisected specimens of ear plugs from fin whales. (×2/3)
Left specimen: from the Antarctic, sexually immature female, body length 58 feet, 7 laminations.
Middle specimen: from the Antarctic, sexually mature female, body length 70 feet, 36 laminations.
Right specimen: from the northern Pacific, sexually mature female, body length 64 feet, 100 laminations.

TABLE 1. THE DIFFERENCE OF THE CORE LENGTH AND THE NUMBER OF LAMINATIONS BETWEEN THE LEFT AND RIGHT EAR PLUG OF THE SAME FIN WHALE. THE SPECIMENS ARE CAUGHT IN THE NORTHERN PACIFIC IN 1956.

Body length in feet	Sex	Left core		Right core	
		Length in mm	No. of laminations	Length in mm	No. of laminations
56	Female	19	6	16	6
58	Female	27	9	26	9
63	Female	48	14	48	15
64	Female	67	100	51	100

The length between the two cores of an individaul differs to some extent but the lamination is the same in numbers. A little difference may depend upon the cutting technique of the core. The difference

of 16 mm. shown in a female of 64 feet in length in Table 1 may come from the growing process of each ear plug. In Fig. 2, the lengths of cores of individuals are plotted against the number of laminations.

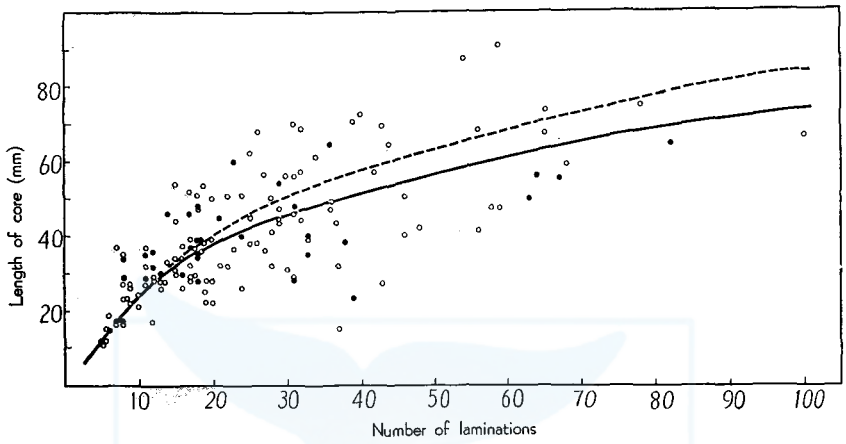

Fig. 2. Variation of core length in different ear plug of the fin whales caught in 1956 in the Northen Pacific.
Sold line: Northern Pacific. Broken line: Antarctic (Nishiwaki 1957).
Open circles: Females. Solid circles: Males.

There are also wide individual variations in the ear plugs of fin whales in the northern Pacific. It may be concluded that the length of core is useless for an age character of the fin whale. There is seen no variation of core length between males and females in Fig. 2. This fact supports that the sex of whale can not be discriminated with the morphological character of the ear plug. Moreover, the mean length of core of fin whale seems to be shorter in the northern Pacific than in the Antarctic ; the core lengths of older whales are shorter in the former than in the latter by about 10 mm. This finding maybe depends upon the difference of skull width between two whale populations.

LAMINATION AND WEIGHT OF TESTIS

In Fig. 3, the weight of testis is plotted against number of laminations, indicating the heavier one of two testes. As shown in this figure, the weights of testis scatter wider in the older whales. In the northern Pacific, as all testes of whales killed were weighed, numbers of samples are much in the figure more than those in the Antarctic. In the Antarctic expeditions, the testes were not weighed usually, if they seem to be sexually mature from their volumes. Therefore, though actual numbers of ear plugs in the Antarctic are fairly much as shown in the ap-

pendix, all of them are not used for the present purpose and testes of rather younger individuals are plotted in Fig. 3.

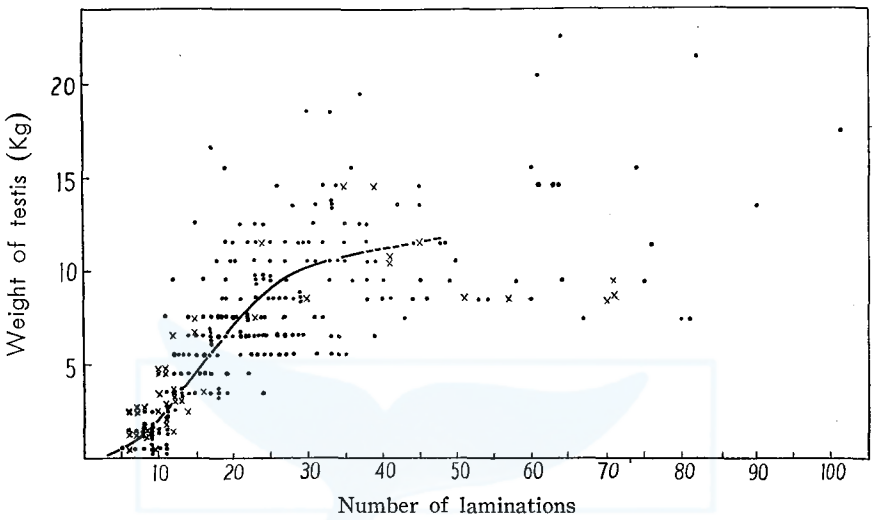

Fig. 3. Growth curve of weight of testis based on the number of laminations. The heavier testis in each individual is used as the symbol of the weight of the testis. black circle: Northern Pacific fin whales cross: Antarctic fin whales

With regard to the growth of testis, the difference between the southern and the northern fin whale is negligible and so the average growth is presumed in a curve as given in Fig. 3. The weight of 5.0 kg. in the sum of both testes has been used for the determination of mature male whale until now but recent histological studies testify this weight is rather heavier. For the present purpose, the male fin whale is considered to mature over 2.5 kg. in the weight of heavier testis. According to the growth curve, the weight of 2.5 kg. in the testis corresponds to the lamination of 11, that is, in the southern and northern hemispheres, male fin whales mature at the breeding season following 5 years after birth. It is interesting that the same fact is obtained for female fin whales. In the appendix, male fin whales, whose ear plugs have been collected, are divided into two groups; one group includes sexually immature whales and the other group involves sexually mature whales.

LAMINATION AND TOTAL OVULATIONS

For the present purpose, number of samples are 128, 108 and 201 in the Antarctic season 1956–57, in the northern Pacific seasons 1956 and 1957 respectively. In the northern Pacific, as the ear plugs in 1956 were collected with some schemes the frequency distribution of lamina-

tions for the saxually immature whale does not resemble that in 1957. However, the laminations of immature whales killed ranges similarly in both years; 11 from 5 laminations in 1956 and 12 from 6 laminations in 1957, that is, the ages of immature whales killed cover 6 from 2.5 years after birth. As tabulated in the appendix, it seems that some female whales mature early at 4.5 years and all females mature by 6 years after birth. When all samples of mature females are considered, an average number of laminations at the sexual maturity is about 11

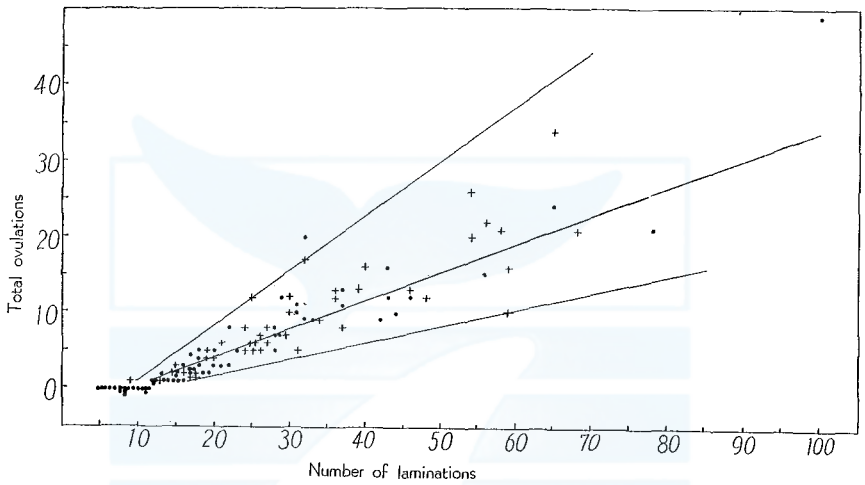

Fig. 4. Relation between the number of laminations and the total ovulations for the northern Pacific fin whale in 1956. cross: Pregnant.

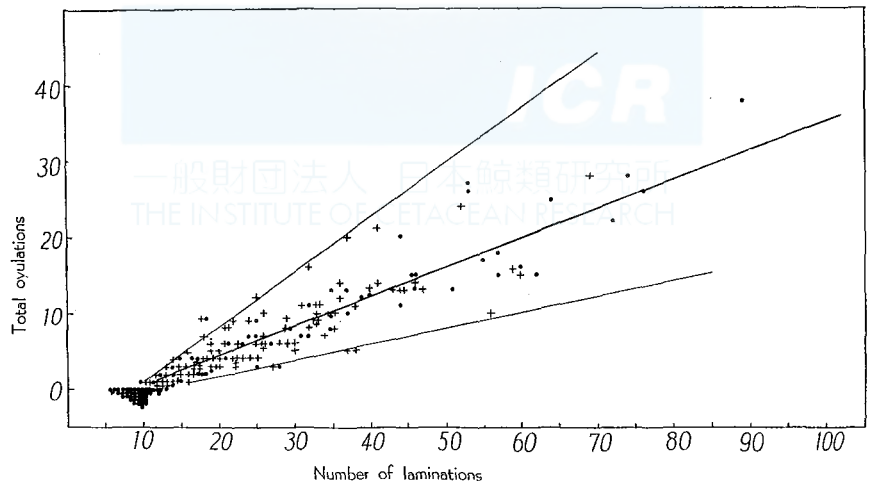

Fig. 5. Relation between the number of laminations and the total ovulations for the northern Pacific fin whale in 1957. cross: Pregnant.

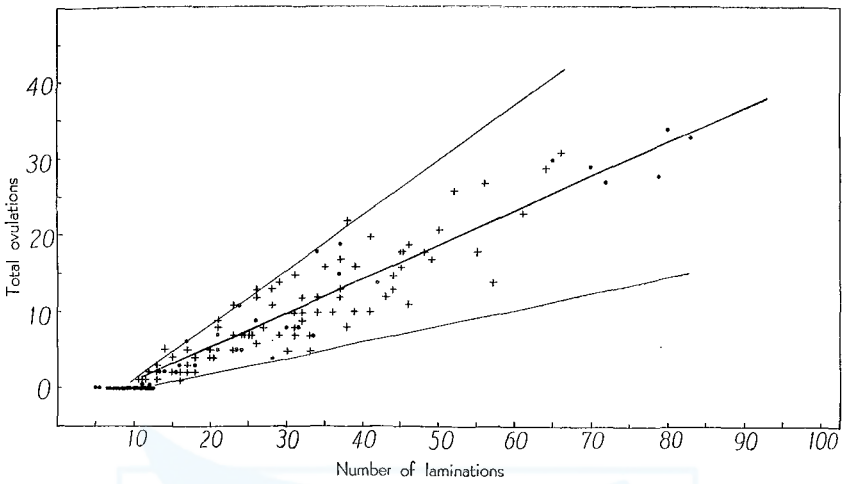

Fig. 6. Relations between the number of laminations and the total ovulations for the Antarctic fin whale in 1956~57. cross: Pregnant.

showing about 5.5 years after birth and this finding is shown in Figs. 4, 5 and 6.

From Figs. 4, 5 and 6 valuable suggestions are obtained on the relation between age of whales and number of ovulations. After the sexual maturity, individuals repeat ovulations, pregnancies and lactations in their breeding cycles but each ovulation does not always bring forth pregnancy. When ages increase more and more, total ovulations of individuals scatter in numbers wider and wider. In Fig. 3 of the previous paper (Nishiwaki, 1957), the variations of number of ovulations were in the same range both for younger and for older whales. This is a wrong assumption coming from scanty data and this must be rectified in the present paper. The differences between pregnant whale and resting whale are negligible in the range of such dispersion. For the present purpose, females maturing at the same age will be divided into two groups. Granted that one group has frequently pregnant chances following ovulations and the other has not frequently pregnant chances following ovulations, number of ovulations are more in the former group than in the latter group with increasing of ages.

It is assumable that there is a linear relation between number of laminations and number of ovulations. Using the samples in the northern Pacific season 1957 an equation is given by drawing a line among the upper dots as shown in Fig. 5. It is

$$Y=0.70X-5.67$$

Where Y is the number of ovulations and X is the number of lami-

nations. In the same manner, a lower linear equation is

$$Y=0.21X-2.30$$

These both linear equations are applied to the samples in the northern Pacific season 1956 and in the Antarctic season 1956–57 being shown in Figs. 4 and 6. This important fact includes that, in the southern and northern hemispheres, the female fin whale matures at the same ages after birth and it accumulates about the same number of corpora lutea in its ovaries during a breeding season.

In the female fin whale, the numbers of ovulations and laminations are supposed to indicate its age, even if these show relative and absolute ages. Generally speaking, the frequency distributions of female whales based on the numbers of ovulations and laminations after the sexual maturity are expressed as exponential types in the catch of the Japanese expeditions. In such case, a regression line presumed to obtain the average number of ovulations for a year is not always effective. However, for the present purpose, the regression line of total ovulations to total laminations is given for each season, although our samples are small in numbers of the high age groups.

These linear equations are as follows.

Northern Pacific season 1956 : $Y=0.42X-4.10$
Northern Pacific season 1957 : $Y=0.38X-2.84$
Antarctic season 1956–57 : $Y=0.45X-3.48$

Those lines are drawn in Figs. 4, 5 and 6. From these results, the average number of ovulations for a year ranges between 0.8 and 0.9, varing a little in each season. From a recovered female fin whale bearing a mark for 6 years, Mackintosh (1942) estimated the rate of accumulation of corpora lutea could not be much more than about one a year (or two every two years), although one could not draw any final conclusions from the particulars of a single whale. Peters (1939) estimated also that in the fin whale there was an average of 1.8 ovulations in two years. Our study is compatible with these estimations. The whale marking has been conducted every year since 1949 in the North Pacific by the Japanese whaling boats. However no biological information available for the number of accumulation of corpora lutea has been given from the fin whale recaptured until now. The variation among three seasons may depend upon the sampling errors as well as the localities of whales. As shown in the fact that the average number of ovulations for a year is in rather smaller figures in the northern Pacific than in the Antarctic, pregnancies following ovulations may appear more frequently in the former than in the latter, chiefly because the stock of whale is smaller in the former than in the latter.

From the upper line above mentioned, the number of ovulations for a year is obtained as about 1.4, corresponding to Laws' estimation in his provisional report (1956). Judged from this assumption, when the oestrus cycle without fertilization is repeated, ovulation of 2.8 and over occurs sometimes for a breeding season which is supposed to be 2 years for the fin whale. On the other hand, from the lower line, the number of ovulation for a year is given as about 0.4. When each ovulation always bring forth pregnancy, the fin whale sometimes ovulates in the ratio of 0.8 for a breeding season. This assumption supports that a breeding season for fin whale generally covers 2 years but it sometimes covers 3 from 2 years.

LAMINATION AND BODY LENGTH

In previous papers (Purves, 1955; Laws & Purves, 1956; Nishiwaki, 1957), the growth curve of fin whales based on the number of laminations is not enough, owing to the scanty samples.

Figs. 7 and 8 show the relation between the number of laminations and the body length for the southern and norther fin whales with our data. Since the young whales below 4 laminations are not caught, the earlier part of growth curve is not completed. But the body length at the birth is about 21 feet for fin whales, therefore the growth of early ages is presumed from these points of view. As shown in these figures, the individual variations of the body length are very large. For instance, the body lengths in the northern females at 30 laminations vary from 60 to 67 feet.

However it will be seen that the type of growth curves of the southern and northern fin whales are very similar each other. At the earlier age, males and females grow similarly and their growth rates are very large. From about 5 to 11 laminations the female grows more rapidly than the male. The body lengths at sexual maturity are as follows.

	Male	Female
Northern fin whale	58 feet	61 feet
Southern fin whale	63 ,,	67 ,,

The age at the maximum lengths is estimated to correspond about 40–45 laminations, according to these figures. That is to say, if the 2 laminations are deposited in one year, the age will be about 20-23 years at the maximum length. The number of ovulations at the physical maturity is about 15 for the fin whale. According to our studies on the fin whale there is the ovulation of 0.8–0.9 for a year and the age at sexual maturity is 5.5 years after birth. Then the age at physical maturity

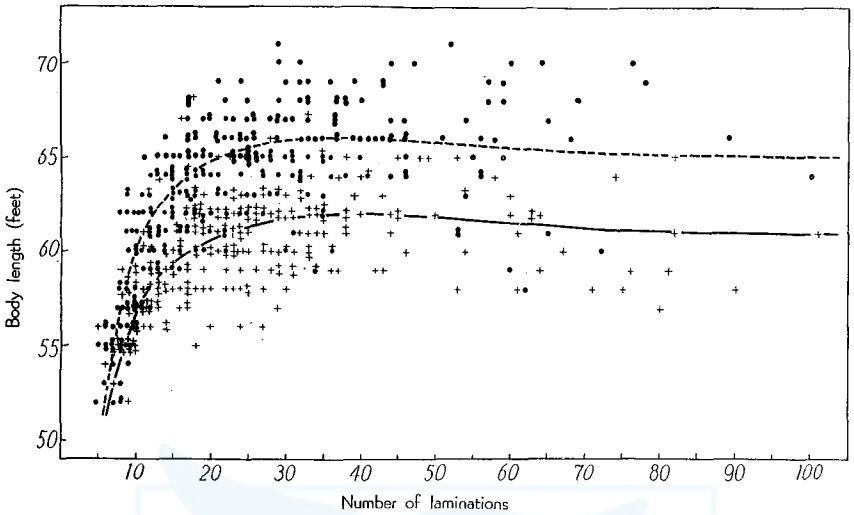

Fig. 7. Relation between body length and number of laminations for the northern Pacific fin whale. Black circle: Female, cross: Male.

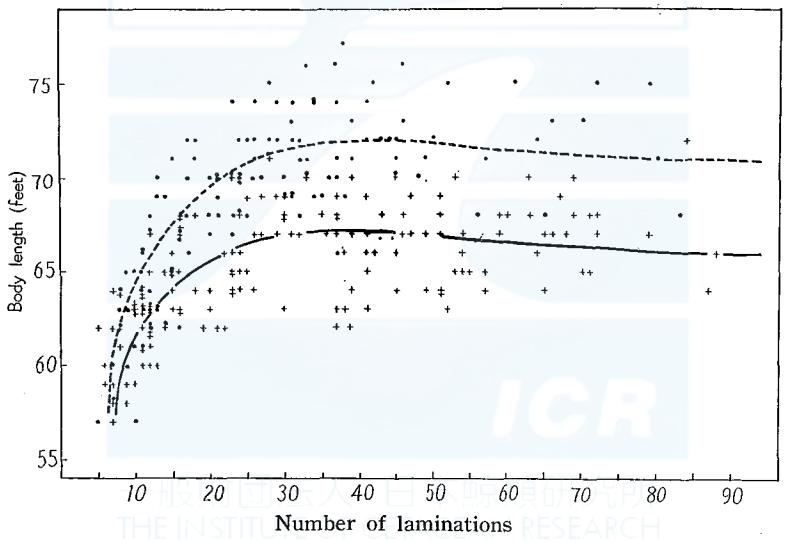

Fig. 8. Relation between body length and number of laminations for the Antarctic fin whale. Marks are the same as figure 8.

is between 21 and 24 years after birth. Therefore, the age at the maximum length is the same age at the physical maturity. The lengths at this age are as follows.

	Male	Femle
Northern fin whale	62 feet	66 feet
Southern fin whale	67 ,,	72 ,,

After the attainment of physical maturity, the body lengths seem to shrink in both sexes. This shrinking tendencies are shown in Figs. 7 and 8.

SUMMARY

1. With regard to the fin whales of the same ages, the length of core is generally shorter in the northern Pacific than in the Antarctic. Since the core length has wide individual variations, the measuring of them is not effective method for determining of age.

2. The growth of testis based on the number of laminations does not differ between fin whale in the Antarctic and that in the northern Pacific. In the female fin whale, the number of ovulations distributes with the same range against the number of laminations both in the Antarctic and in the northern Pacific.

3. In the Antarctic the body lengths at sexual maturity are 63 and 67 feet, and besides the body lengths at physical maturity are 67 and 72 feet, in males and females respectively. In the northern Pacific the body lengths at sexual maturity are 58 and 61 feet, and the body lengths at physical maturity are 62 and 66 feet, in males and females respectively.

4. Male and female fin whales mature at about 11 laminations. Judged from the relation between the number of laminations and the number of ovulations, female fin whales ovulate in the average between 1.5 and 2.0 per one breeding season. However, it is supposed that there is slight difference between the Antarctic and the northern Pacific fin whales. In the present work the Antarctic fin whale ovulates in 1.8, whereas, the northern Pacific fin whale ovulate 1.6 per one breeding season in average.

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APPENDIX. DISTRIBUTION OF THE NUMBER OF LAMINATIONS IN THE EAR PLUG OF FIN WHALES.

I. NORTHERN PACIFIC FIN WHALES (1956)

Number of lamination	Females					Total	Males		Total
	Immature	Ovulating	Pregnant	Lactating	Resting		*Immature	Mature	
5	2					2	1		1
6	2					2	1		1
7	1					1	2		2
8	5					5	3		3
9	2		1			3			
10	2					2			
11	3					3	1	1	2
12					3	3	1	1	2
13			1		2	3		1	1
14					1	1		1	1
15			2		4	6			
16			1	1	1	3		1	1
17			3	1	3	7		2	2
18				1	2	3		6	6
19			2		2	4			
20			1		2	3		1	1
21			1		1	2		1	1
22					2	2			
23					1	1		2	2
24			2			2		1	1
25			4			4			
26			2			2			
27			2			2			
28					3	3			
29			1		2	3		1	1
30			2			2			
31			1		2	4×		2	2
32			1		2	3			
33					1	1		2	2
34			1			1			
36			2			2		1	1
37			1	1	1	3		1	1
38								1	1
39			1			1		1	1
40			1			1			
42					1	1			
43					2	2			
44					1	1			
46			1		1	2			
48			1			1			
54			2			2			
56			1		1	2			
58			1			1			
59			2			2			
63								1	1
64								1	1
65			1		1	2			
67								1	1
68			1			1			
78					1	1			
82								1	1
100				1		1			
Total	17		43	5	43	109×	9	31	40

* Whose heavier testes are under 2.5 kg. Grand Total 149

× The mark includes a whale whose ovaries are not observed

II. NORTHERN PACIFIC FIN WHALES (1957)

Number of lamination	Females						Males		
	Immature	Ovulating	Pregnant	Lactating	Resting	Total	*Immature	Mature	Total
6	3					3			
7	5					5			
8	7					7	2	1[d]	3
9	10					10	10		10
10	11	1	1			14×	3	1	4
11	3		1		1	5	3	3	7×
12	3		3		3	9	1	4	5
13		1	5(1)[a]	(1)[a]		7		5	5
14		(1)[b]	3	(1)[b]	2	6		5	5
15			5		1	6		4	6×
16			3			3		5	5
17			6		3	9		8	8
18			4		3	7		3	4×
19			5		1	6		9	9
20			3			3		5	5
21			3		2	5		4	4
22			6			7×		7	7
23			3		1	5×		9	9
24			3		1	5×		8	8
25			3		3	6		7	7
26			5			5		4	4
27			1	1		2		7	7
28			1		1	2		4	4
29			3	1	1	5		6	6
30			2			2		3	3
31			1		1	2		3	3
32			2		2	4		3	3
33			6			6		6	6
34			1			1		4	4
35			3	1	2	6		4	4
36			2			2		1	1
37			2		2	4		1	1
38			3			4×		5	5
39					1	1			
40			1		1	2		2	2
41			2			2		1	1
42								1	1
43			1			1		1	2×
44			2		2	4		2	2
45								3	3
46			1		3	4		1	1
47			1			1			
48								2	2
49								1	1
50								1	1
51					1	1			
52			1			1			
53					2	2		2	2
54								1	2×
55				1		1			
56			1			1			
57					2	2			
58								1	1
59			1			1			
60			1		1	2		2	2
61								2	2
62					1	1			
63								1	1

Number of lamination	Females						Males		
	Immature	Ovulating	Pregnant	Lactating	Resting	Total	*Immature	Mature	Total
64		1				1		1	1
69			1			1			
71								1	1
72					1	1			
74		①[c]		①[c]		1		1	1
75								1	1
76				1		1		1	1
80								1	1
81								1	1
89					1	1			
80								1	1
101								1	1
Total	42	5	103	8	46	206×	19	172	197×
							Grand Total		403

* Whose heavier testes are under 2.5 kg.
a) The pregnant and lactating whales
b, c) The ovulating and lactating whales
d) Its testes are 2.6 kg. and 2.0 kg.
× Marks includes whales whose ovaries and testes are not observed

III. ANTARCTIC FIN WHALES (1956-57)

Number of lamination	Females						Males		
	Immature	Ovulating	Pregnant	Lactating	Resting	Total	*Immature	Mature	Total
5	2					2	1		1
6							3		3
7	2					2	5		5
8	3					3	4		4
9	3					3	2		2
10	2				1	3	1	3	4
11	4		3			7	2	6	8
12	4	1	1		1	7	2	5	7
13			3		1	4	1	1	2
14			1		1	2		3	3
15			2		1	3		4	4
16			2		1	3		8	8
17		1	3			4			
18			2		1	3		2	2
19								2	2
20			3			3		3	3
21			2		2	4		2	2
22								2	2
23			3		1	4		7	7
24			2		3	5		3	3
25			2			2		2	2
26			3		1	4		3	3
27			1			1		2	2
28			2		1	3		1	1
29			2			2		2	2
30		1	1			2		4	4
31			4		1	5		1	1
32			3			3		1	1
33		1	2			3		2	2

Number of lamination	Females						Males		
	Immature	Ovulating	Pregnant	Lactating	Resting	Total	*Immature	Mature	Total
34			2		1	3			
35			1			1		1	1
36			1			1		1	1
37			3		2	5		6	6
38			2			2		3	3
39			2			2		3	3
41			2			2		5	5
42					1	1		1	1
43			1			1		1	1
44			2			2			
45			3			3		3	3
46			2			2		3	3
47								2	2
48			1			1			
49			1			1		2	2
50			1			1			
51								6	6
52			1			1		1	1
53								2	2
54								3	3
55			1			1		1	1
56			1			1			
57			1			1		2	2
59								3	3
60								1	1
61			1			1			
63								2	2
64			1			1		1	1
65					1	1		2	2
66			1			1		1	1
67								2	2
68								1	1
69								2	2
70				1		1		1	1
71								2	2
72					1	1		2	2
79					1	1		1	1
80		1				1			
83					1	1			
84								1	1
87								1	1
88								1	1
Total	20	5	78	1	24	128	21	139	160
							Grand Total		288

* Whose heavier testes are under 2.5 kg.