GROWTH OF FIN WHALE IN THE NORTHERN PACIFIC

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On the growth of the fin whales (*Balaenoptera physalus*, Linn.), Mackintosh & Wheeler (1929) reported first in detail for the southern stock At that time, however, available age characters were not yet known. Therefore, chiefly on the age of the whale, their paper was incomplete. They pointed out the possibility of the number of ovulations and ossification of vertebral column as age characters. Wheeler (1930) developed this method and classified several groups by means of the number of ovulations. Peters (1939) calculated the number of ovulations in each breeding season.

Ruud (1940, 1945) discovered the age determination for whales by means of baleen plates. And then Tomilin (1945), Nishiwaki (1950, 1951a) and Utrecht (1956) advanced this method. Furthermore Nishiwaki (1951b) showed the colourlation of crystalline lens as an age character.

These age characters, however, are somewhat incomplete. In 1955, Purves discovered lamination in the core of the ear plug. This is now regarded as the best age character for baleen whales. Then, Laws & Purves (1956) and Nishiwaki (1957) studied the age of baleen whales chiefly fin whales using the number of the laminations.

On investigations of life history for the southern fin whales, many reports have been presented. On the other hand, the studies of growth for the northern fin whale have been relatively scanty. The reason will be that the whales caught in northern hemisphere have been relatively rare and so we have not been blessed with chances of investigation of whales. On the growth of the fin whale in adjacent waters to Japan, Tago (1922), Matsuura (1935), Omura (1950), Kasahara (1950), Mizue & Jimbo (1950), Sakiura, Nozawa & Ozaki (1953), Mizue (1956) and Mizue & Fujino (1957) reported. Pike (1953) reported on the fin whale from the coast of British Columbia. Papars of Matsuura & Maeda (1942), Omura (1955) and Sleptsov (1955) were described on the fin whale in the northern part of the North Pacific. On the growth of the fin whale in the North Atlantic, there are some papers by Ruud (1945), Jonsgård (1952) and Laws & Purves (1956). We shall discuss the above papers in the following chapters.

Since 1952 Japanese whaling in the fleets have operated in northern part of the North Pacific. The area includes the Pacific northern 48°N and

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Bering Sea. Inspectors and biologists on board have been engaged in biological investigations on each whale pulled up on deck. The purpose of the present paper is to describe the growth and age of the fin whale in the northern part of North Pacific. Although according to the investigation of blood groups by Fujino (1956), the northern fin whales are distinguished into east and west populations, the result of the marking investigation shows the intermixture between west and east groups in the northern Pacific. Therefore, in the present paper we study the growth representing the total northern Pacific fin whale.

We don't think this paper shows the growth of the fin whale in total North Pacific. In the North Pacific, several stocks of the fin whale will be existed. For instance, Mizue & Fujino (1957) and Ichihara (1957) describe that the fin whale caught in the East China Sea should be regarded as a independent stock because of a shape of baleen plates, body proportion, body length at sexual maturity and so on. Much less, we never think our paper will deduce the northern fin whale, for the fin whale in the North Atlantic is thought as a different stock in the northern hemisphere.

We devide the process of growth into the following stages.

1. *Fertilization*
2. *Birth*
3. *Weaning*
4. *Prepuberty*
5. *Sexual maturity*
6. *Physical maturity*

In above stages, we have very little data on the weaning. So this stage is substituted for the growth of calf.

We wish to express our thanks to inspectors and biologists and to Kyokuyo Hogei Co., Taiyo Gyogyo Co. for the investigations and sampling of our material. We are indebted to Mr. Tadayoshi Ichihara of the Whales Research Institute for his kind help to sampling and reading laminations in ear plug. We are also indebted to Mr. Takehiko Kawakami of the Fisheries Agency for giving us the data of marking whales in the northern Pacific.

MATERIAL AND METHOD

The material for the present study is based on the data of the biological investigation of fin whales mainly caught in the northern part of the North Pacific for the six years from 1952 to 1957. The inspectors and the biologists who pursued the investigation are as follows.

1952 Haruyuki Sakiura, Katunari Ozaki, and Kazuo Fujino.
1953 Yasutake Nozawa, Iwao Takayama, and Tahahisa Nemoto.

1954 Setsuo Nishimoto, Tamenaga Nakazato, Takehiko Kawakami, Ikuyo Hasegawa, Kazuo Fujino, and Seiji Kimura.
1955 Yasutake Nozawa, Saburo Ikeda, Ken-ichi Iguchi, and Kazuo Fujino.
1956 Heihachiro Kawamura, Sumio Matono, Sadao Ishii, and Seiji Kimura.
1957 Yasutake Nozawa, Takehiko Kawakami, Itaru Chihara, and Tadayoshi Ichihara.

The items of the investigation used in the present paper are date caught, sex, body length, thickness and condition of mammary gland, number of corpora lutea and albicantia in ovaries, weight of testes and collection of their samples, sex and body length of foetuses, condition of ossiffication of vertebral column and the collection of ear plugs.

On the lactation it was judged whether white milk was secreted or not. The thickness of the mammary gland was measured in the thickest portion of the gland, and then the maturity of the gland was judged by the condition of the gland. The immature mammary gland was thin and white or pink in colour, but the mature gland was thick and brown.

TABLE 1. NUMBER OF FIN WHALES CAUGHT AND INVESTIGATED BY JAPANESE EXPEDITIONS IN THE NORTHERN PACIFIC

Year	Males	Females
1952	104	109
1953	238	232
1954	675	641
1955	710	650
1956	755	657
1957	736	668
Total	3218	2957

The numbers of the corpora albicantia and lutea were counted with naked eye by slicing the right and left ovaries. The right and left testes were weighed in 0.1kg unit with spring balances after cutting off the epididymis. Thereafter a small piece was cut off from each testis and was directly fixed with the 10% formalin. The fixed samples were cut into the sections 10 micron thick by the paraffin method, double-stained with haematoxylin-eosin, and subjected to the microscopic examination.

On the ossiffication of the vertebral column, it was cut along the axis with a bone-saw and the presence of cartilaginous layer between the epiphysis and the centrum was examined with naked eyes. Conditions were classified as follows.

N: Not ankylosed. Thick cartilage.
n: Not ankylosed. Thin cartilage.
a: Ankylosed. Join visible.
A: Ankylosed. No sign of Join.

The samples of ear plugs were collected in 1956 and 1957, After fixation with 10% formalin, the samples were grinded down to the level of the longitudinal axis, and laminations in core were counted with naked eyes or by means of a dissecting-microscope.

THE BIRTH

THE GROWTH OF FOETUSES

The foetuses investigated in the northern Pacific from 1952 to 1956 consisted of 461 males, 461 females, 4 of indistinct sex because of a small size, and 4 couples of twins. In the twins, three couples of dizygotic (♂♀, ♂♀,♂♂) and one couple of monozygotic twins (♂♂) were included. Frequency of the twins was 0.43 per cent in the total foetuses. According to Kimura (1957), the frequency of multiplets in southern fin whales was 0.872 per cent.

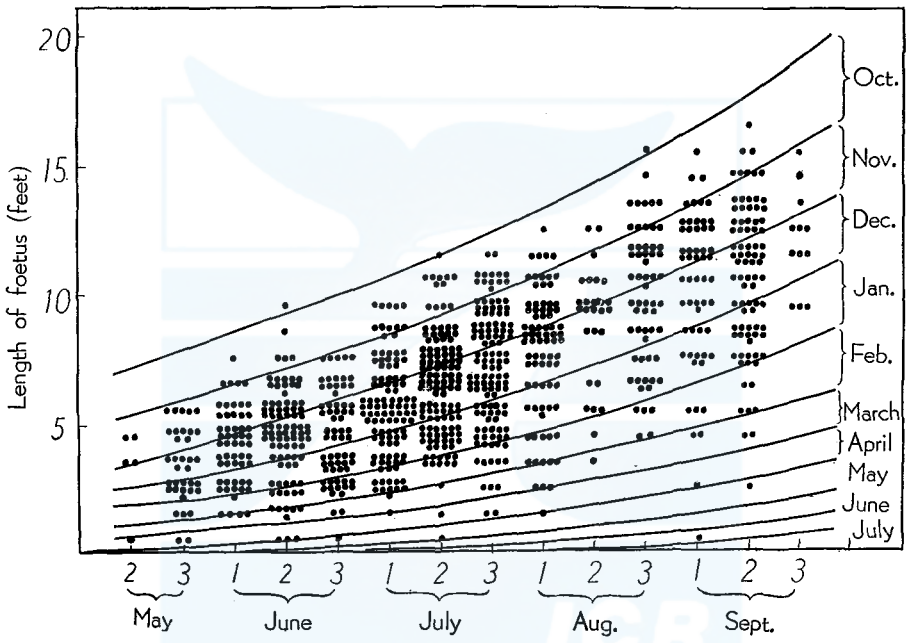

Fig. 1. Growth of fin whale foetuses from the northern part of the North Pacific.

Figure 1 shows the length and date (by the interval of ten days) of killing of each foetus. The whaling season usually sets in the middle of May and closes by the end of September in the northern Pacific. It is regrettable, therefore, that the growth of foetuses of the fin whales cannot be investigated throughout the year.

It is obvious from this figure the length of foetuses disperse at any time. This means that the pairing season is prolonged considerably, and there is also an individual variation in the growth. According to Kimura (1957), the difference of body length of two foetuses in a couple of twins increases usually with the growth, and it will be about two feet at birth.

The average length of our material in each ten-day period shows in figures 2 and 3. The growth of foetuses shows nearly parabolic curve.

The growth equation in this stage is represented by the following formula.

$$L=0.329M^{1.61}$$

L: Body length in feet. M: Time in month.

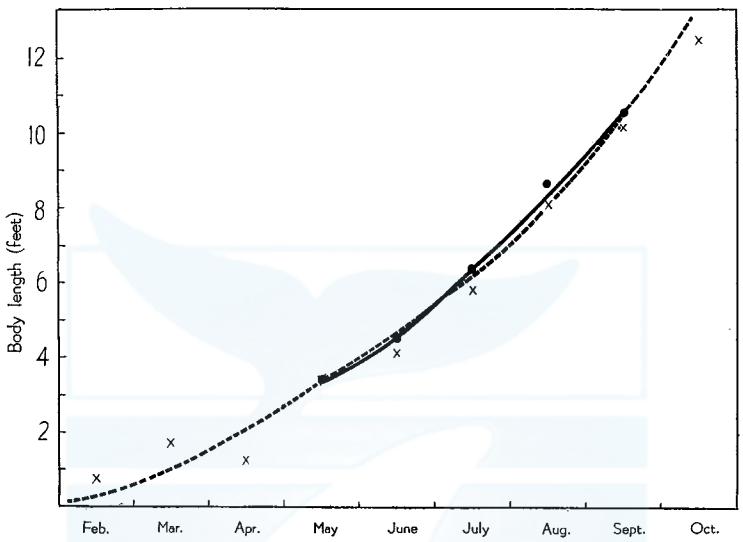

Fig. 2. Mean growth curve of fin whale foetuses from the northern Pacific, adjacent waters to Japan and the North Atlantic. Dotted line: adjacent water to Japan (Mizue, 1950). Solid line: northern Pacific. Cross: the North Atlantic.

TABLE 2. LENGTH OF FOETUSES IN THE MIDDLE OF EACH MONTH AND THEIR CONCISE CALCULATION

Month	Body length in feet	Concise calculation
1st	0.1	$1\times1\times0.1$
2nd	0.6	$2\times3\times0.1$
3rd	1.5	$3\times5\times0.1$
4th	2.4	$4\times6\times0.1$
5th	3.5	$5\times7\times0.1$
6th	4.8	$6\times8\times0.1$
7th	6.3	$7\times9\times0.1$
8th	8.2	$8\times10\times0.1$
9th	10.4	$9\times12\times0.1$
10th	13.4	$10\times13\times0.1$
11th	16.7	$11\times15\times0.1$
12th	20.5	$12\times17\times0.1$

Table 2 shows the body length of foetuses at the middle of each month and the easy method of calculating it. In the growth curves of both sexes we did not notice any variation. From figure 2 it is clear

that the growth curve of the fin whale foetuses in the northern Pacific is almost similar to that in the coastal region of Japan and the North Atlantic. Thus, it is supposed that the growth curves of the fin whale foetuses are similar in all regions of the northern hemisphere. As shown in figure 3, if the growth curve of foetuses in the northern Pacific is removed just six months, it coincides closely with the curve of the southern fin whale foetuses. This means that in gestation period the growth rate of fin foetuses is similar all over the world.

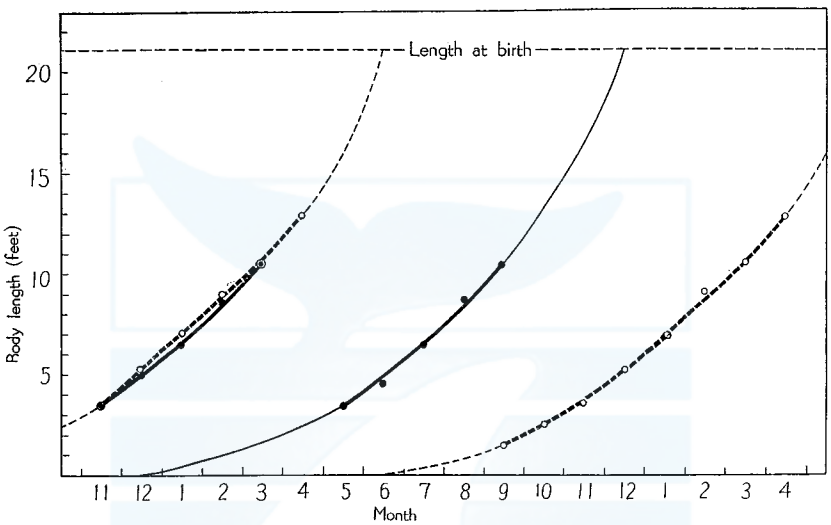

Fig. 3. Growth curve of the fin whale foetus from the northern Pacific and the Antarctic. Solid line: northern Pacific. Dotted line: Antarctic. Left solid line: northern Pacific, slided down six months.

BODY LENGTH AT BIRTH

The largest foetus of our materials is 16 feet 4 inches (497 cm) long. It was caught in the middle of September. But it is too short for a foetus at full term. Tago (1922) reported a 22 shaku (one shaku ≒ one foot) long calf which seemed to have been just born in the eastern sea of Korea in winter. Matsuura (1935) estimated that the body length of the fin whale at birth was about 6.0m (19 feet 8 inches). Kasahara (1950) estimated also that the fin whale was born at the length from 18 to 21 shaku. According to Mackintosh & Wheeler (1929), the fin whales were born at about 6.5m (21.3 feet) on the average. Table 3 shows the size of maximum foetuses, minimum calves and maximum adult whales in the North Pacific in each year since 1910, and summarized data from the Japanese Whaling Statistics from 1910 to 1945. The maximum foetus is 20 feet and minimum calf is 20 feet in the table.

According to the International Whaling Statistics, the maximum foetus

is 22 feet 10 inches long and there are two 20 feet foetuses of the fin whales in the North Atlantic. We have suggested in above section that the mean growth curves of foetuses in various grounds of the world are similar with each other. And discussing the previous papers and the present data, we conelude that the body length at birth of the fin whale in the northern Pacific is estimated to be from 20 to 22 feet long and 21 feet long in an average.

TABLE 3. THE MAXIMUM AND MINIMUM BODY LENGTH OF THE NORTH PACIFIC FIN WHALES IN EACH YEAR (1910–56)

Year	Maximum length		Minimum length		Maximum foetuses		
	Males	Females	Males	Females	Sex and length		Date
1936	72feet	72feet	42feet	48feet	—		
1937	71	68	46	48	M.	10′-6″	3/8
1938	66	69	50	50	F.	10-1	26/8
1910–45*	75	76	20		?	20	?/7
1946	65	70	50	41	F.	7-8	22/7
1947	66	72	50	50	F.	13-3	20/8
1948	68	69	50	47	M.	13-6	1/10
1949	70	69	50	49	M.	14-3	22/8
1950	75	70	37	47	M.	13-0	3/8
1951	73	73	41	46	M.	16-6	14/9
1952	70	71	48	48	M.	14-3	14/9
1953	69	72	45	43	F.	15-8	10/10
1954	69	73	40	47	F.	16-5	12/9
1955	77	74	44	49	F.	17-2	10/9
1956	74	74	45	45	M.	13-4	4/9

* Coast of Japan

BREEDING SEASON

Owing to the limitation of whaling season (from May to September), we do not know much about the breeding season of the northern fin whales.

Thus we must assume the breeding season by means of length of foetuses in the whaling season.

In figure 1, each curve indicated the mean growth curve of foetuses shifted to lateral intervals of one month so as to include all the points plotted. If all foetuses grew at an equal speed, the foetuses measured would be conceived within the term from September to July.

Figure 4 shows the pairing season which is obtained by counting the number of plotted points between two parallel curves in figure 1. Majority of pairings take place between November and January, the maximum falling about in the middle of December. On the duration of pairing season, we found a very small foetuses 2.0cm long in the beginning of September.

In figure 3, it is found that the growth is very similar to that of

southern fin whales being just six months behind. According to Mackin tosh & Wheeler (1929), May, June, July and August are the months-which the majority of pairing take place, the maximum falling at about the end of June or beginning of July. Tago (1922) stated that pairing season is not constant (he observed a copulation of fin whales in the middle of March), but he assumed that pairing season of the fin whales in the coast of Japan was the early spring. Kasahara (1950) assumed that the season of pairing and parturition is winter.

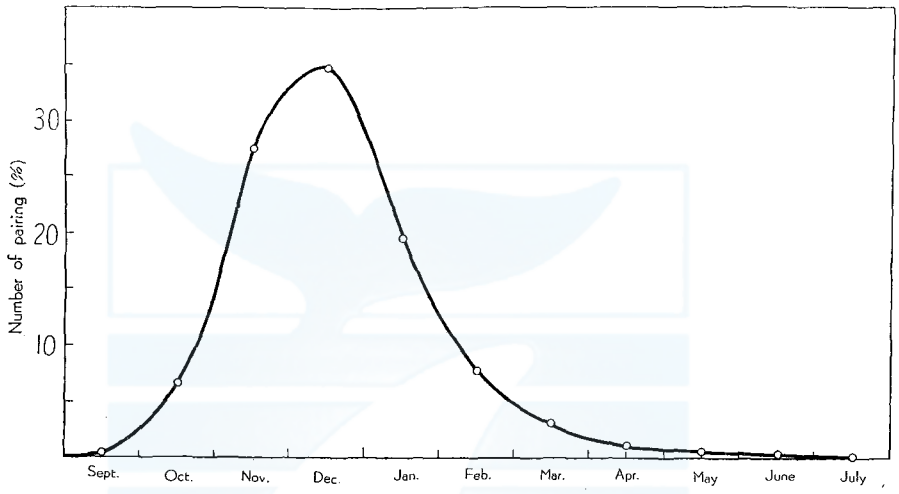

Fig. 4. Frequency curve of pairing for the fin whales from the northern part of the North Pacific.

We have no data on the gestation period and the season of parturition. According to the Japanese whaling statistics a calf which is 20 feet long is caught in December in the coast of Japan. In the International Whaling Statistics on the North Atlantic fin whales, a large foetus which is longer than an 18 feet foetus occur mostly in October, November and January. But a foetus of 22 feet 10 inches have been once caught in June. Mackintosh & Wheeler estimated that the midseason of parturition is the middle of June and the period of gestation is eleven months and a half.

Basing on the above result, we should expect that the season of parturition of the fin whale in the northern Pacific will be winter, from November to January, and gestation period will be almost one year.

THE GROWTH OF CALF

The period of nursing and the body length at weaning are very difficult to determine owing to the size regulation upon the fin whale. We have no data available on them. According to Mackintosh & Wheeler (1929),

the nursing period is estimated to last about six months and the body length at weaning is assumed to be 12 meters (39 feet 5 inches). Considering the difference of the length at sexual maturity between southern and northern fin whales as we discuss in the following chapter, it is assumed that the length at weaning of the fin whale in northern fin whale is about 37 feet.

The youngest fin whales of our materials employed have 5 laminations in the ear plug. These are a male which is 56 feet and two females which are 52 and 55 feet long. It has been suggested that two laminations are deposited every year (Purves, 1955; Laws & Purves, 1956). If so, these whales are estimated to be two and a half years old. From figures 18 and 19, the mean length at that time is about 51 feet in male and 52 feet in female. In this stage fin whales are completly immature.

Of the sexually immature whales, we defined the stage of prepuberty as follows. The prepuberal female has ovaries of which ovarian follicles grow approaching maturity. And in the testes of the adolescent male as may be described in the following chapter, the majority of seminiferous tubules are open while closed tubules are not uncommon.

The body length of prepuberal females are between 55 feet and 65 feet and the average is 58.8 feet, while immature whales are under 61 feet. The former has from 8 to 12 laminations in the ear plugs and the latter has under 8 laminations. Of the male prepubertal whale, the body length is 57.7 feet in an average and the age corresponds with from 8 to 12 laminations. Estimating from above result it takes the fin whale about four years after its birth to attain its prepuberty.

SEXUAL MATURITY

DETERMINATION OF SEXUAL MATURITY IN FEMALE

The sexual maturity of female whales is determined easier than that of male whales. That is to say, we can determine the sexual maturity of females by means of corpus luteum or corpus albicans in ovaries. It is regarded that corpus albicans in ovaries remains recognizable and countable throughout the life of the whales. And if corpora lutea or albicantia are present in the ovary, the whale must, of course, be mature. Mackintosh & Wheeler (1929) stated that it might be argued that a female need not be regarded as mature until it has actually ovulated.

Concerning the sexual maturity of females, following characters are investigated.

Varginal band. We cannot determine sexual maturity by means of

varginal band. Mackintosh & Wheeler (1929) reported that the bands were present in 31 (21.4%) of the 145 immature females of the southern fin whales. As shown in table 4, of 34 whales which have never been pregnant, 19 individuals (55.9%) have varginal bands, but 15 whales which have been pregnant have no bands.

Mammary gland. We can determine the maturity of mammary glands by observing the colour of them, that is to say, the immature gland is whitish pink while the mature gland is brown. This distinction is very

TABLE 4. THE EXISTENCE OF VERGINAL BANDS

	Exist	None	Total	%
Sexually immature	7	6	13	53.8
Prepuberal	9	8	17	52.9
Sexually mature, but never pregnant	3	1	4	75.0
Sexually mature	15	0	15	0.0

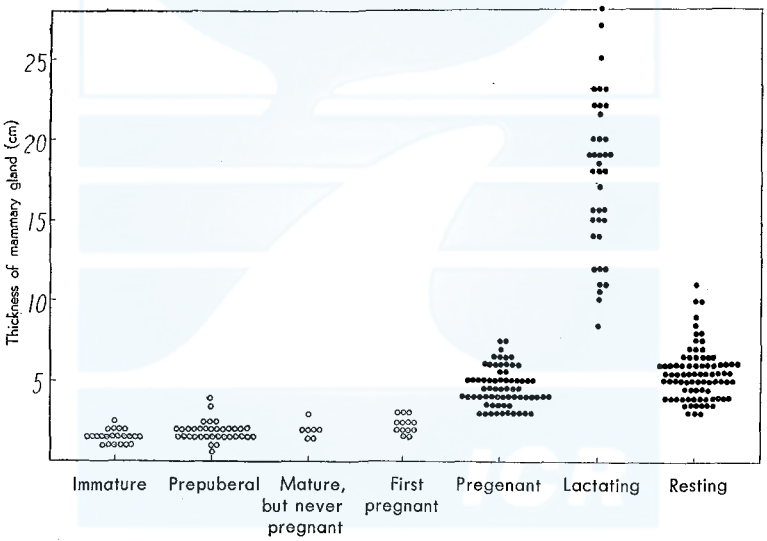

Fig. 5. Thickness of mammary gland in several sexual conditions for the female fin whale from the northern part of the North Pacific. Closed circle: mature type. Open circle: immature.

clear as stated by Mackintosh & Wheeler (1929) and in the macroscopic structure, the former is fine but the latter is coarse. Nishiwaki & Oye (1951) classified the colour of mammary glands into 7 tones, but those are pretty difficult to distinguish one another. Figure 5 shows the thickness and the maturity of mammary glands of the fin whales in various sexual phases. In the immature stage, mammary gland is of course immature type and the thickness does not exceed 3.0cm. (average thickness is 1.5cm). In prepuberty, the gland is almost similar with

immature stage and average thickness is 1.8cm, but red gland of 4.0cm thick appears.

After attainment of sexual maturity, there are some whales whose mammary glands are still immature. These are supposed to be the whales which have never serected milk. Mackintosh & Wheeler supposed that it altered permanently after the first pregnancy. But we should correctly change their word "the first pregnancy" into "the first lactation", because in early pregnant period, mammary gland does not alter

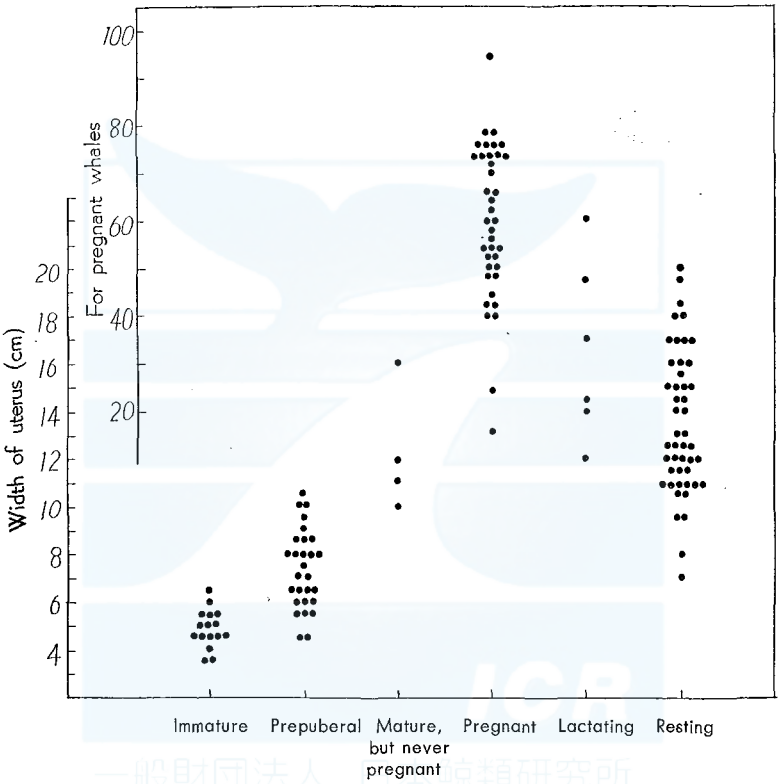

Fig. 6. Width of uterus cornu in several sexual conditions for the fin whale from the northern part of the North Pacific.

the condition as shown in figure 5. Then we can distinguish a mature whale which has never been pregnant and the first pregnant whale from other sexually mature whales by investigating the mammary gland and the ovaries.

In sexually mature but mammary immature whales the thickness of mammary gland is not different from that of sexually immature ones. We have never found the whale whose mammary gland is mature but is not sexually immature.

Mature mammary gland usually exceeds 3.0m in thickness, and in a sexually resting whale, mammary gland which is 8.0cm or more over in thickness are very rare. Average thickness is 4.5cm. The thickness of the gland in pregnant whales of our material is not so different from that of the resting stage and between 3.0cm and 7.5cm. The gland during lactation varies between 8.5cm and 27.0cm.

As the conclusion of this section, in female whales we can easily distinguish sexual maturity by investigating the mammary gland but it is a rough method in sexually mature but never lactated whales, whose gland still remain in immature stage.

Size of uterus. Size of uterus across the cornu was measured when it lay in the collapsed condition.

Figure 6 shows the size of uterus in various sexual phases. In sexually immature stage, the size is between 3.5cm and 8.5cm (average size is 5.1cm). In prepuberal whales, uteri grow a little and the sizes are between 4.5cm and 10.5cm (average size is 3cm). We decided the size of uteri of sexually mature whales was over 10cm. This is a little shorter than the result by Mackintosh & Wheeler.

In sexually mature but never pregnant whale, the range was from 10cm to 16cm and the average was 12.3cm. In pregnancy the uterus grew to an enormous size. The smallest uterus of pregnant whale was 16cm in size. This whale was pregnant with small foetus (10cm). The largest uterus of our materials was 95cm. After parturition, involution may take place very rapidly. In lactating whales the largest size was 22cm and smallest was 12cm. Resting whales had uterus of 13.5cm in average size. But the range was between 7.0cm and 20cm.

DETERMINATION OF SEXUAL MATURITY IN MALE

It is difficult to determine sexual maturity of male whale with naked eyes. Mackintosh & Wheeler (1929) showed the maturity character of male as follows.

1. *Size of penis.*
2. *Size of testis.*
3. *Histology of testis.*

As Mackintosh & Wheeler stated, the size of the penis can be used only to distinguish definitely mature from definitely immature whales, although it is the readiest method to distinguish mature from immature males. Table 5 shows the length of the penis of ten males. A penis exceeding 1.3m usually indicate maturity for the fin whale in the northern Pacific.

Mackintosh & Wheeler used the size of the testis as a practical age character. The size was calculated in a manner to multiply together the length, breadth and depth in cm. And they said that if the size

exceeded about 4l the fin whale was generally mature. Although Mackintosh & Wheeler considered that the size of testis was more convenient than the weight, recently many authors have employed the weight of testes for judging the sexual maturity.

TABLE 5. LENGTH OF PENIS OF FIN WHALES IN THE NORTHERN PACIFIC

Body length (feet)	Length of penis (cm)	Length of circumference at root of penis (cm)	Weight of testes (kg)		
58	84	52	2.3	2.5	Immature
59	105	—	1.4	1.5	〃
59	114	—	3.9	4.7	Mature
65	115	93	13.9	16.0	〃
63	135	—	5.9	6.2	〃
62	145	59	6.8	7.9	〃
63	145	—	9.5	8.9	〃
61	152	78	2.2	3.5	〃
63	155	88	4.9	5.3	〃
62	174	56	8.0	8.5	〃

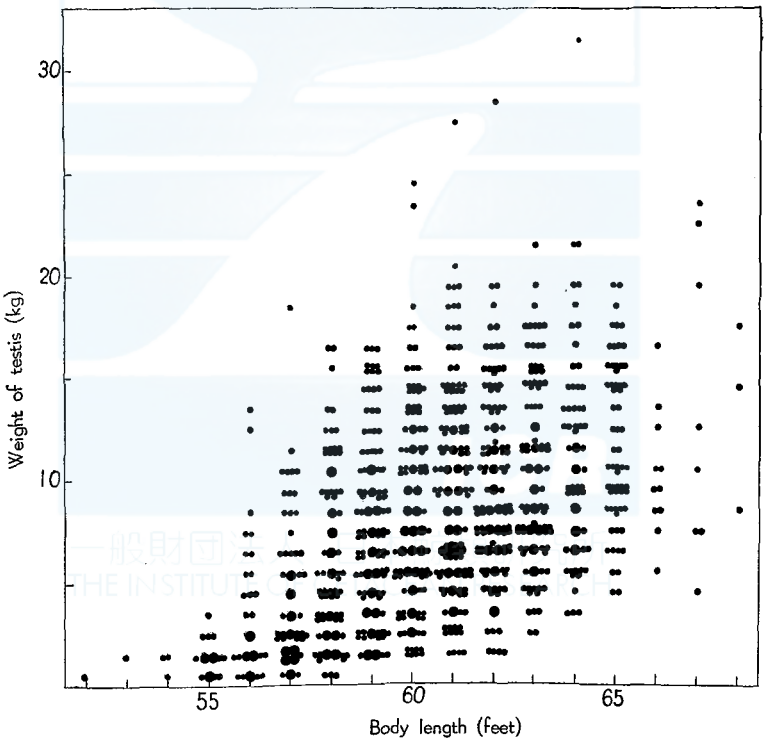

Fig. 7. Relation between body length and weight of larger testis for the fin whales in the northern Pacific.

Figure 7 shows the relation between the body length and the weight of the larger testis in each specimen. In our material the heaviest testis is 31.7kg, and the lightest is 0.3kg. Owing to size regulation,

we have little data for the small whales under 54 feet.

From this figure it may be clear that the whale over 59 feet is sexually mature and the testis over 4kg is mature. But we cannot determine sexual maturity only by means of weight of testis. Therefore histological examination of testis should be employed to determine the sexual maturity of male whale as stated by Mackintosh (1942).

We examined histologically on 118 individuals and 227 testes, and classified as sexually immature, prepuberal and mature. The definition is owed to Chittleborough (1955); that is to say, in the immature testes all seminiferous tubules are closed, in the prepuberty testes the majority of tubules were open while closed tubules are not uncommon, and

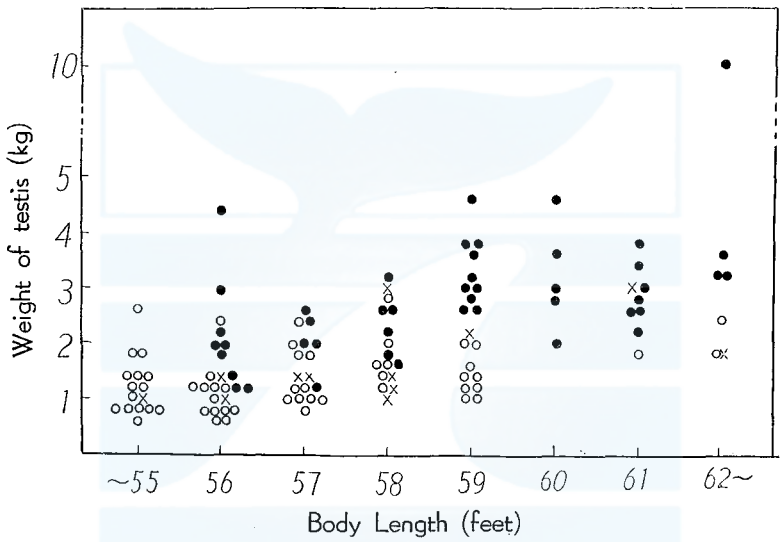

Fig. 8. Body length and maturity of testis in the fin whales from the northern Pacific. Solid circle: mature. Cross: prepuberal. open circle: immature.

in the mature testes all tubules are open. Confirming the exitense of spermatozoa is not a suitable manner for determination of maturity, because in the times but the breedings season spermatozoa are very few in the tubules.

Figure 8 shows the weight of testis (the larger one of the two) and body length of males whose testes were examined histologically. We could find from this figure, sexual maturity is concerned not with body length but with the weight of testis. So we should determine the sexual maturity by weighing testes which are examimed histologically simultaneously. Table 6 shows the weight frequency of immature, puberal and mature testes examined histologically. The heaviest immature testis is 3.0kg and the lightest mature testis is 1.0kg. And from figure 9, the weight of the testis

of 75% in maturity is estimated to 2.6kg. In conclusion, the whale whose larger testis is 2.6kg or more over is regarded as sexually mature.

TABLE 6. NUMBER OF IMMATURE, PRE PUBERAL AND MATURE TESTIS EXAMINED HISTOLOGICALLY

Weight of testis in kg.	Immature	Prepuberal	Mature	Total
0.5-0.6	11	—	—	11
0.7-0.8	13	—	—	13
0.9-1.0	20	4	1	25
1.1-1.2	24	3	4	31
1.3-1.4	13	5	3	21
1.5-1.6	3	2	3	8
1.7-1.8	13	4	6	23
1.9-2.0	9	—	7	16
2.1-2.2	2	2	5	9
2.3-2.4	2	—	5	7
2.5-2.6	1	1	9	11
2-7-2.8	3	1	9	13
2.9-3.0	1	1	9	11
3.1-3.2	—	—	5	5
3.3-3.4	—	—	4	4
3.5-3.6	—	—	6	6
3.7-3.8	—	—	3	3
3.9-4.0	—	—	1	1
4.1-	—	—	9	9
Total	115	23	89	227

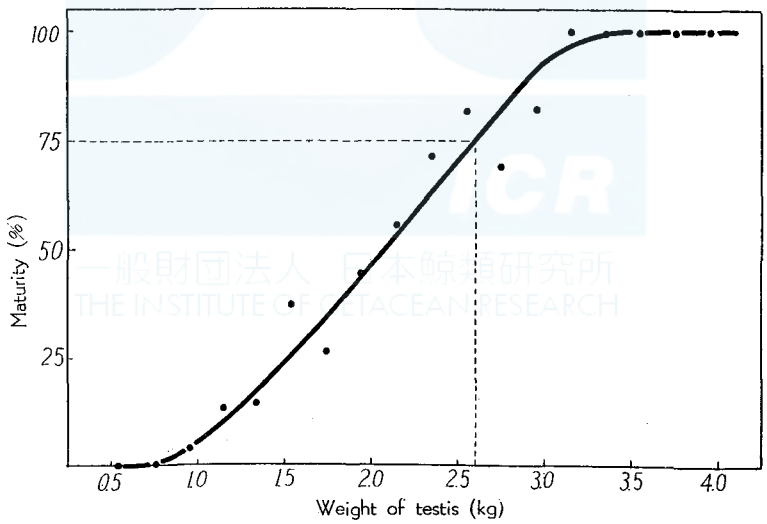

Fig. 9. Mature curve of testis based on the histological examination.

Matsuura & Maeda (1942) indicated that in the male fin whale from the northern Pacific combined testes over 7.5kg in weight is almost

mature. Omura (1950) states that in the case of whales in the adjacent seas of Japan, the borderline between immature and mature is probably 3*l* in volume and 2.5kg. in weight. According to Ruud (1945), combined testes which are 6.7kg and less in weight are histologically immature for the fin whale from the North Atlantic. Nishiwaki & Hayashi (1950) states that if the combined weight of both testes is less than 5kg in the Antarctic fin whales, they are considered immature.

TABLE 7. SIZE DISTRIBUTION OF SEXUALLY MATURE AND IMMATURE FIN WHALES IN NORTHERN PACIFIC (1952-56)

Body length (feet)	Males			Females		
	Immature	Mature	Total	Immature	Mature	Total
50	1	—	1	—	—	—
51	—	—	—	—	—	—
52	2	—	2	4	—	4
53	3	—	3	2	—	2
54	5	—	5	2	—	2
55	71	5	76	47	1	48
56	75	28	103	62	2	64
57	89	87	176	73	1	74
58	54	181	235	96	21	117
59	48	272	320	108	43	151
60	22	347	369	55	71	126
61	10	372	382	39	153	192
62	10	310	320	32	184	216
63	1	241	242	22	194	216
64	—	132	132	7	253	260
65	—	75	75	3	244	247
66	—	20	20	3	225	228
67	—	10	10	1	163	164
68	—	3	3	1	88	89
69	—	—	—	—	50	50
70	—	—	—	—	18	18
71	—	—	—	—	4	4
72	—	—	—	—	5	5
73	—	—	—	—	2	2
74	—	—	—	—	1	1
Total	391	2,083	2,474	557	1,723	2,280
Average length	57.13	60.86	60.27	58.54	64.18	62.80

But above-mentioned results are not due to a histological examination exceping that by Ruud (1945). However. Ruud's value (3.3 ig in one testis) seems to be relatively heavier than our result.

BODY LENGTH AT SEXUAL MATURITY

By means of above method, we judged sexual maturity upon the fin whales investigated. Table 7 shows size frequencies of sexually mature and immature whales. Total whales examined are 2474 males and 2280

females. The largest sexually immature whales are 63 feet long in the males and 68 feet long in the females. The shortest sexually mature whales are 55 feet in both sexes. Size regulation is in force on the factory ship whaling in northern hemisphere and the size of limitation is fixed as 55 feet. So we have scanty data on short whales under 54 feet. Therefore we wonder whether the shortest sexually mature whales is under 54 feet long or not. According to Omura (1950) the shortest sexually mature fin whales in Japanese coastal whaling (size regulation is 50 feet) are 56 feet in both sexes.

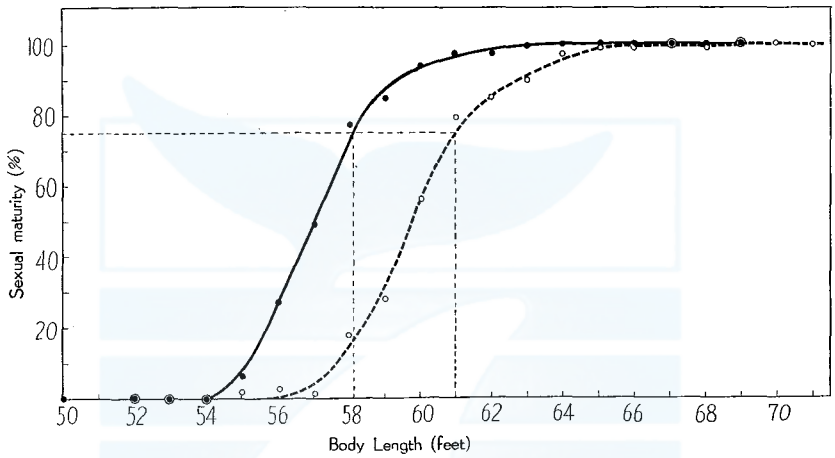

Fig. 10. Sexual mature curve of the fin whale from the northern part of the North Pacific. Solid circle and solid line: male. Open circle and broken line: female.

From our result it is known that the range of body length at sexual maturity is very wide. The range is 9 feet in the male and 14 feet in the female.

Figure 10 illustrates the percentages of sexually mature males and females in body length. The curve in this figure indicates that the body length in which the sexual maturity is 50 per cent is 57.1 feet in the male and 59.8 feet in the female and the same in which the maturity is 75 per cent is 57.9 feet in the male and 60.8 feet in the female. Therefore the mean body length of fin whales at sexual maturity in the northern Pacific will be 57 or 58 feet in the male and 60 or 61 feet in the female. And we conclude that the male attains sexual maturity at 58 feet and female does at 61 feet. Body lengths at sexual maturity of northern fin whales reported by previous authors are as follows.

Author	Body length		Locality
	male	female	
Matsuura (1935)	60′	64′	Coast of Japan
Omura (1950)	58′—59′	60′—61′	〃
Kasahara (1950)	58′—59′	60′—61′	〃
Sakiura & Others (1953)	58′—59′	61′	〃
Mizue & Fujino (1957)	56′	59′	Eastern China Sea
Matsuura & Maeda (1942)	58′—59′	61′	Northern Pacific
Omura (1955)	58′	61′	〃
Sleptsov (1955)	—	58′—62′	〃
Pike (1953)	57′—59′	60′	Coast of Canada
True (1904)	—	60′	Newfoundland
Ruud (1945)	17.5m(57′5″)	18m(59′1″)	North Atlantic
Jonsgård (1952)	58′	61′—62′	〃
Laws & Purves (1956)	58.5′	—	〃

Excepting the fin whale from the Eastern China Sea, the body length at sexual maturity of the northern fin whale is 57–59 feet in male and 58–62 feet in female.

Figure 11 shows the size distribution of the northern Pacific fin whale. Sexually mature whales distribute in nearly normal type. Average length of sexually mature whale is 60.86 feet in male and 64.18 feet in female. These are about 3 feet longer than the length at sexual maturity.

AGE AT SEXUAL MATURITY

Now, the number of laminations in the ear plug is regarded as the best age character of baleen whales. Since 1956 we have collected ear plug of whales in the northern Pacific. And the results are shown in table 8. In males, the eldest of sexually immature whales had 12 laminations, and the youngest mature whale had 8 laminations. In female, the eldest immature whale had also 12 laminations and youngest mature whale had 9 laminations. Furthermore the figure of 12 laminations and more is estimated as a mean age at sexual maturity. Purves (1955) and Laws & Purves (1956) estimated that 2 laminations are formed every year. If so, the fin whale in the northern Pacific will attain sexual maturity in early term of 7th year after birth. And the precocious will be mature sexually by 5th year. By 8th year all the fin whales will attain sexual maturity.

On the southern fin whale, Mackintosh & Wheeler (1929) assumed that the age at sexual maturity was three years old according to the size distribution. Kasahara (1950) got the same result by the same method about the fin whale in adjacent waters to Japan.

Mackintosh (1942) states, however, that it is not certain that this estimation was correct, but the recovery of a mark showed that a fin

whale did not take more than three years to grow from birth to sexual maturity and could have down it into two years.

By means of baleen plates of the fin whale from the North Atlantic, Ruud (1945) considered the age at sexual maturity as 3-4 years. Nishiwaki (1952) stated that from the study of surface structure of

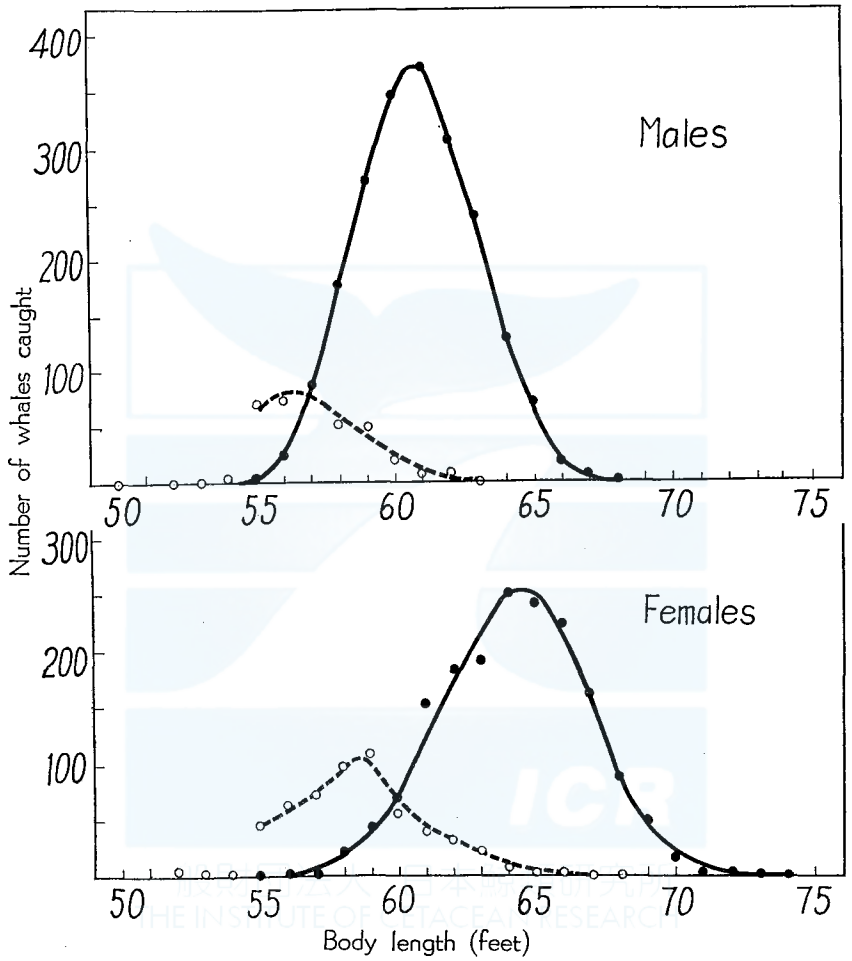

Fig. 11. Size distribution of sexually mature and immature fin whales from the northern Pacific (1952-56). Open circle and broken line: Immature, closed circle and solid line: mature.

baleen plates, the females reach sexual maturity in the pairing season following the fourth birthday and the males at the age of about three years and a half in the case of the southern fin whales. In the modified method of surveying baleen plates, Van Utrecht (1956) obtained a result that the age at which the female becomes sexually mature lies between 5 and 6 years.

Since the discovery of laminations in ear plug, Laws & Purves (1956) reported that sexual maturity was reaches at the age of from four to six years in the male in the North Atlantic. Nishiwaki (1957) learned in the same method the age of sexual maturity of the southern fin whale was four or five years.

Referring to these results, the age determination based on the frequency of body length is incomplete owing to the bias of samples in the selection of whales for profit by the whalers and the size regulation. The method with baleen plates is dangerous because of wearing of the tip of plate. Then laminations in ear plug will show the correct periods. But now we have never confirmed the number of laminations

TABLE 8. AGE OF SEXUAL MATURITY

No. of laminations	Estimated age (Year)	Males		Females	
		Immature	Mature	Immature	Mature
5	II	1	—	2	—
6	III	1	—	5	—
7		2	—	6	—
8	IV	5	1	12	—
9		10	—	12	1
10	V	3	1	13	2
11		4	4	6	2
12	VI	2	5	3	9
13		—	6	—	10
14	VII	—	6	—	7
15		—	4	—	12
16	VIII	—	6	—	6
17		—	10	—	16

formed every year. And if 2 laminations do not be formed every year, the age assumed by us should be corrected. Further studies on this point are necessary.

PHYSICAL MATURITY

DETERMINATION OF PHYSICAL MATURITY

As an index of the physical maturity, the condition of cartilage layer between the epiphyses and centrum of the vertebral column has been employed. On the southern fin whales Wheeler (1930) studied the process of ossification of the vertebrae and he stated that an ankylosis commenced at both ends of the column and was completed among the anterior part of dorsal vertebrae. Of the northern Pacific fin whale there is no report on the process of ossification of the vertebrae. Only Pike (1953) investigated the physical maturity but he did not discussed on it.

So we studied the process of ossification in 1954. First we counted the number of vertebrae for the 19 whales. Table 9 shows the

vertebral formula. Then we selected 20 points as follows ; i.e., C2, C5, D1, D4, D7, D10, D13, L1, L4, L7, L10, L13, Ca1, Ca4, Ca7, Ca10, Ca13, Ca16, Ca20 and Ca24. Namely, the vertebrae was examined at intervals of three on each individual in the present study, while only

TABLE 9. NUMBER OF VERTEBRAE OF THE NORTHERN PACIFIC FIN WHALES (EXAMINED 19 WHALES)

	Cervical	Thorathic	Lumbar	Caudal	Total
Range	7	14—15	14—16	24—27	60—64
Average	7.0	14.7	15.0	25.3	62.0

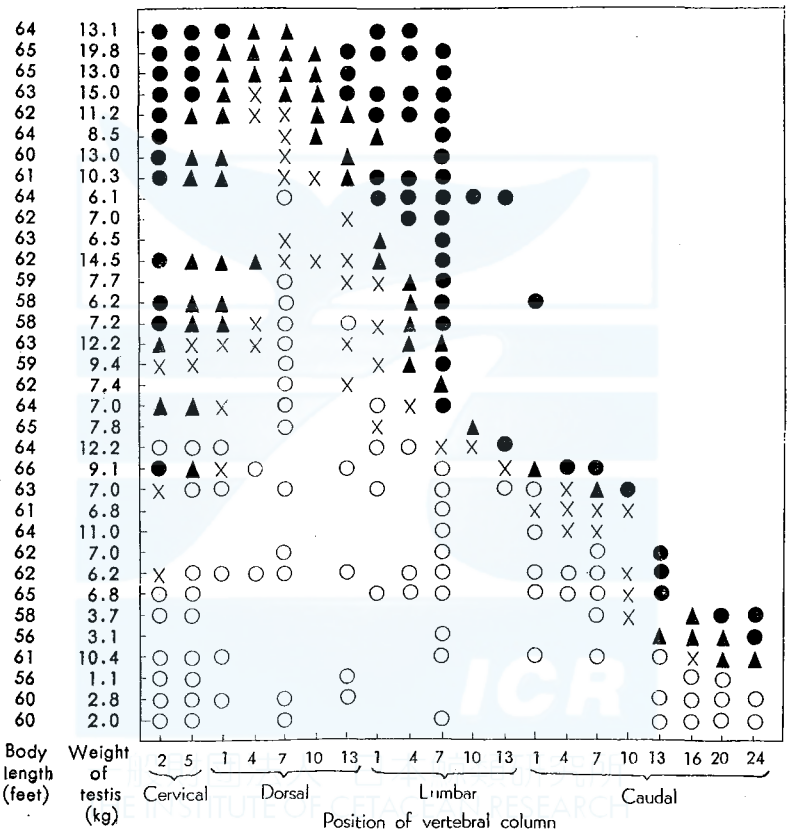

Fig. 12. Condition of cartilage layer between epiphyses and vertebral column in the male fin whales from the northern Pacific. Open circle: not fused, thick cartilage. Cross: not fused thin cartilage, Solid triangle: fused, but join visible. Solid circle: fused, no sign of join.

two or three vertebrae was examined in each individual by Wheeler (1930) and Laws & Purves (1957). Therefore the present method will be better for investigating the process of ossification of vertebrae.

The results are shown in figures 12 and 13. We arranged the data in order from that of the physically youngest whales in these figures.

And the data of body length, the weight of bigger testis and the number of ovulations were shown on the left side of each figure. Total whales examined were 34 males and 45 females.

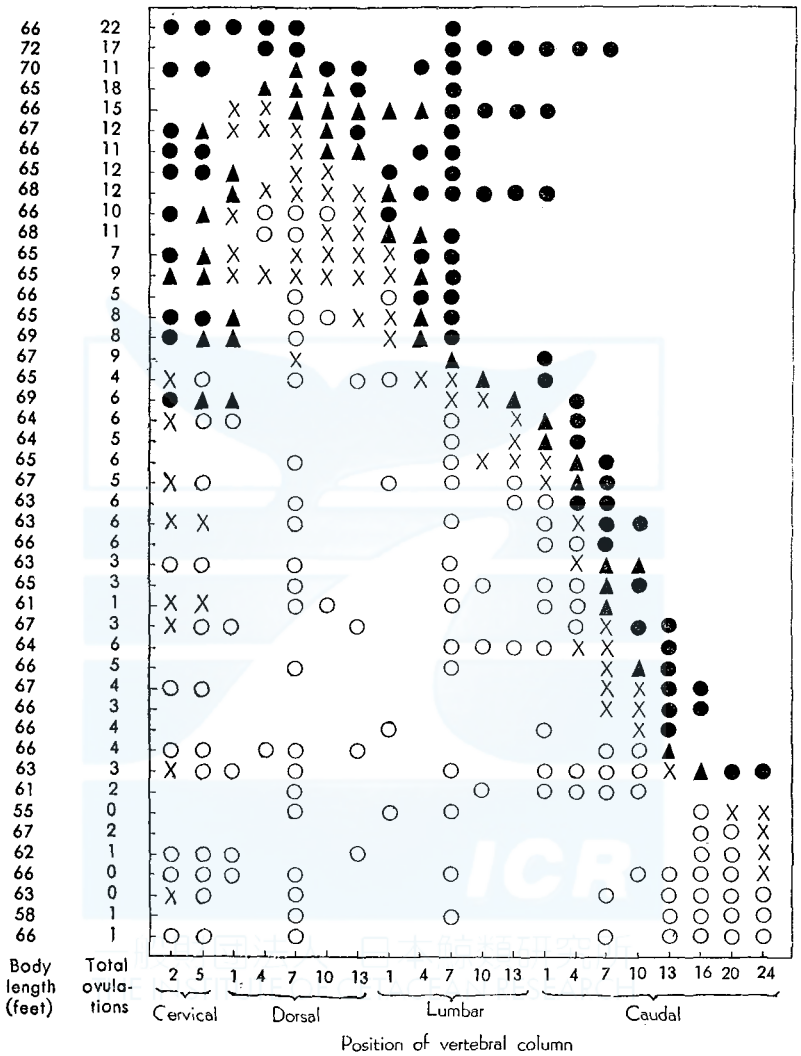

Fig. 13. Condition of cartilage layer between epiphyses and vertebral column in the female fin weales from the northern Pacific. Mark is the same as in figure 12.

The points seen from figures 12 and 13 will be as follows. The difference in the process of fusion of the vertebrae does not seen between the male and the female. In sexually immature stage no ossification of epiphyses occurs. The fusion of epiphyses begins from both ends of vertebral column, but the process of fusion from the

anterior end progresses more slowly than that from the posterior end. The fusion of cartilage layer at the anterior end appears in the stage that fusion from posterior end attains at posterior parts of lumbar.

The end point of ossification throughout vertebral column is estimated to be from the 3rd to 6th dorsal vertebrae. This agrees with the result by Wheeler for southern fin whales.

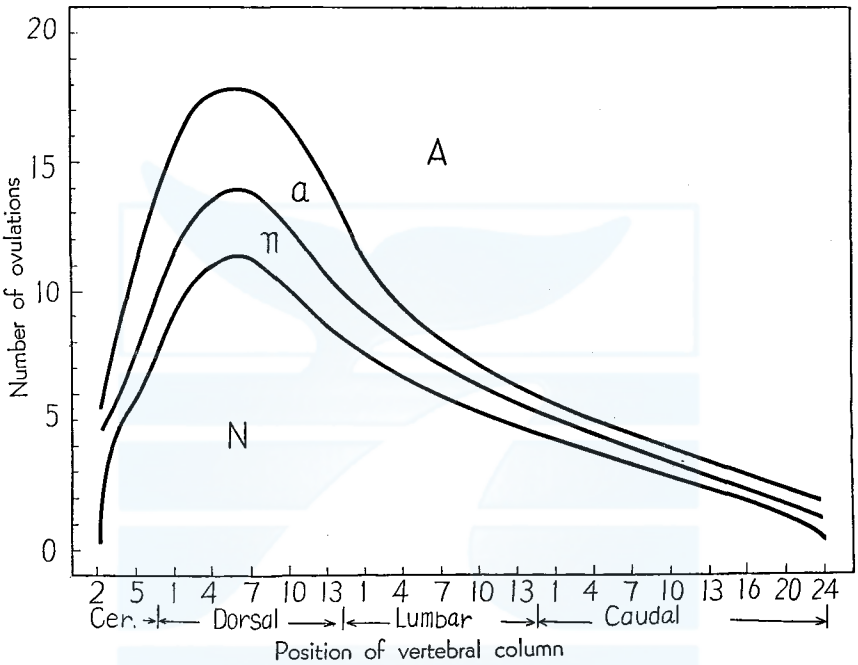

Fig. 14. Process of the fusion of the epiphyses cartilage layer for the female fin whales from the northern Pacific. N: not fused, thick cartilage. n: not fused, thin cortilage. a: fused, but join visible. A: fused, no sign of join.

Therefore, for the purpose of investigation of physical maturity, condition of epiphyses cartilage in 3rd to 6th dorsal vertebrae should be examined. In figure 14 the process of fusion of the epiphyses cartilage layer for female whales is shown based on the number of ovulations. When we investigated the process of ossification of vertebrae, we did not sampled their ear plugs. So we use the number of ovulations as the age character. It has been regarded as a good age character for whales. Therefore this may show the periodical process of ossification of vertebrae.

Above-mentioned phenomena are clearly shown with this figure. And the age at complete ankylosis, that is to say, physical maturity will be 14 to 16 ovulations. Laws & Purves (1956) gave similar figure for the female fin whale in the North Atlantic based on the number of laminations in ear plug.

Number of ovulation at physical maturity was calculated by Wheeler (1930), Peters (1939) and Nishiwaki & Oye (1948) for southern fin whale. Their value are 14~15 ovulations. This accords with our result. But Brinkmann (1948) calculated that it was 13. Furthermore, Pike (1953) states that those whose number of ovulations is under 19 are physically immature.

BODY LENGTH AT PHYSICAL MATURITY

Individual variation of body length becomes vast in progression of age. Figure 15 shows the variation of body length on the condition of ossification in verteblae. Although our data are scanty, the complete ankylosis will bear little relation to length as stated Wheeler (1930).

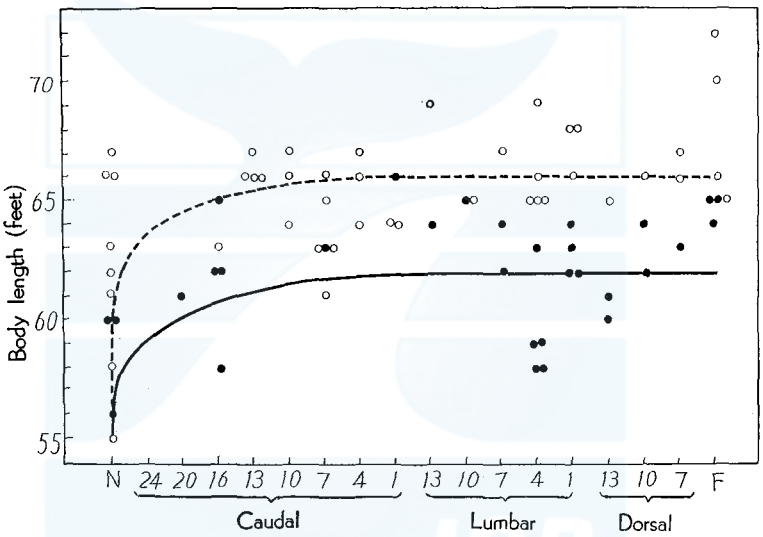

Fig. 15. Variation of the body length on the condition of ossification in vertebrae. Open circle and broken line: females. Closed circle and solid line: males.

Table 10 gives size distribution of sexually mature but physically immature and physically mature female whales judging with the number of ovulations. According to our result, those which are 15 ovulations and over are judged as physical mature. From this table, the largest physically immature whales is 74 feet long and the shortest physically mature whale is 59 feet long. The largest physically mature whale is 72 feet. Mean length of physically mature whale is 65 feet 5 inches. But by means of this table, the range of physically mature length cannot be given. Therefore, we used the number of laminations in ear plug as the standard to determine the physical maturity. According to figures 18 and 19, as we will mention latter, number of laminations at physical maturity are estimated to 40 to 45. So, we adopt 45 laminations and over

TABLE 10. SIZE DISTRIBUTION OF PHYSICALLY MATURE AND IMMATURE FEMALE FIN WHALES BASED ON NUMBER OF OVULATIONS

Body length (feet)	Physical		Total whales
	Immature*	Mature	
55	1	—	1
56	2	—	2
57	1	—	1
58	21	—	21
59	42	1	43
60	69	2	71
61	148	5	153
62	179	5	184
63	186	8	194
64	241	12	253
65	226	18	244
66	203	22	225
67	146	17	163
68	81	7	88
69	42	8	50
70	16	2	18
71	4	—	4
72	4	1	5
73	2	—	2
74	1	—	1
Total	1615	108	1723
Average length	64.10	65.43	64.18

* But Sexually mature.

TABLE 11. SIZE DISTRIBUTION OF PHYSICALLY MATURE AND IMMATURE FIN WHALE (OVER 45 LAMINATIONS)

Body length (feet)	Males		Females	
	Immature*	Mature	Immature*	Mature
55	2	—	1	—
56	5	—	—	—
57	9	1	—	—
58	22	4	1	1
59	23	4	5	1
60	29	3	9	1
61	23	3	16	3
62	38	5	20	
63	14	2	20	2
64	7	3	29	5
65	6	4	31	4
66	1	—	29	8
67	2	—	20	2
68	1	—	14	3
69	—	—	9	3
70	—	—	3	4
71	—	—	1	1
Total	182	29	208	38
Mean length	60.57	61.24	64.44	65.52

* But sexually mature.

as physical maturity. Table 11 shows that the size distribution of physically mature and immature but sexually mature whales based on the number of laminations. The largest physically immature male is 68 feet and shortest physically mature male is 57 feet. For the female, the largest physically immature whale is 71 feet and the shortest physically mature whale is 58 feet. And mean length of physically mature whales is 61 feet 3 inches in the male and 65 feet 6 inches in the female from this table.

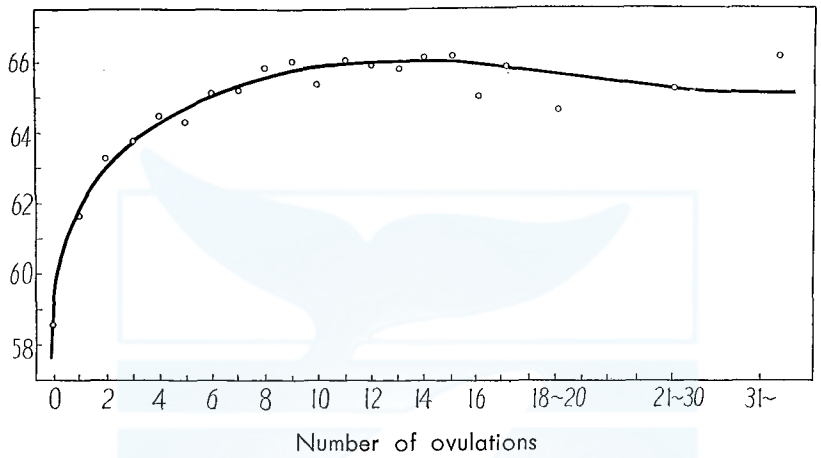

Fig. 16. Growth curve of the female fin whale from the northern part of the North Pacific, based on the total ovulation.

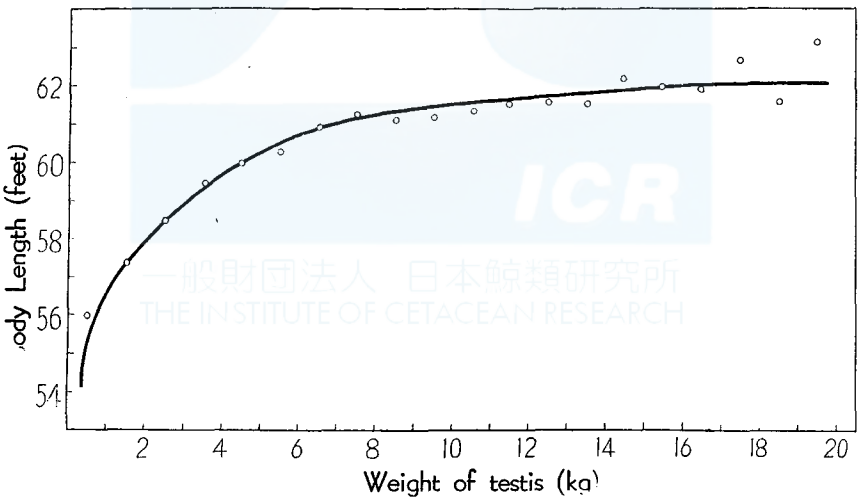

Fig. 17. Variation of the average size of fin whales in 1 kg groups of weight of testis.

Figure 16 shows mean length against number of ovulations. This figure may show growth curve of the female fin whale. But the growth in sexually immature stage cannot be drawn in this figure.

Now, from figure 16 it will be seen that maximum length is 66 feet long and number of ovulations at maximum length is 14–15. The length will be meant length of female fin whale at physical maturity. And the mumber of ovulations at that point corresponds to the result in figure 14. After that time body length seems to shrink a little about one foot.

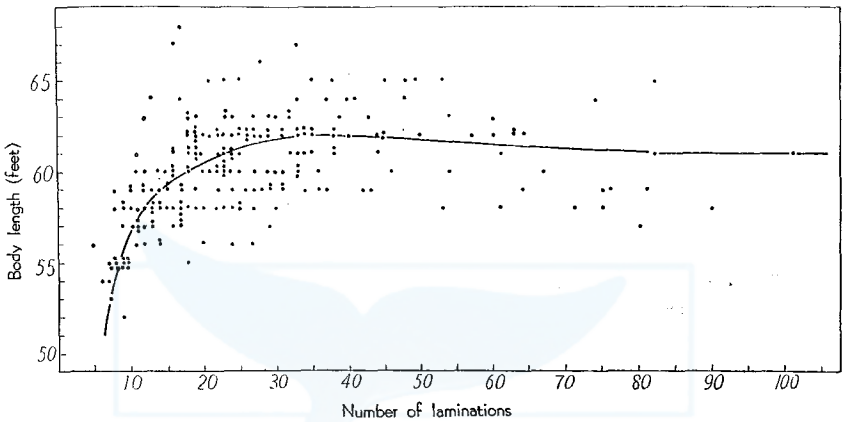

Fig. 18. Growth curve of the northern male fin whales based on the number of laminations in ear plug.

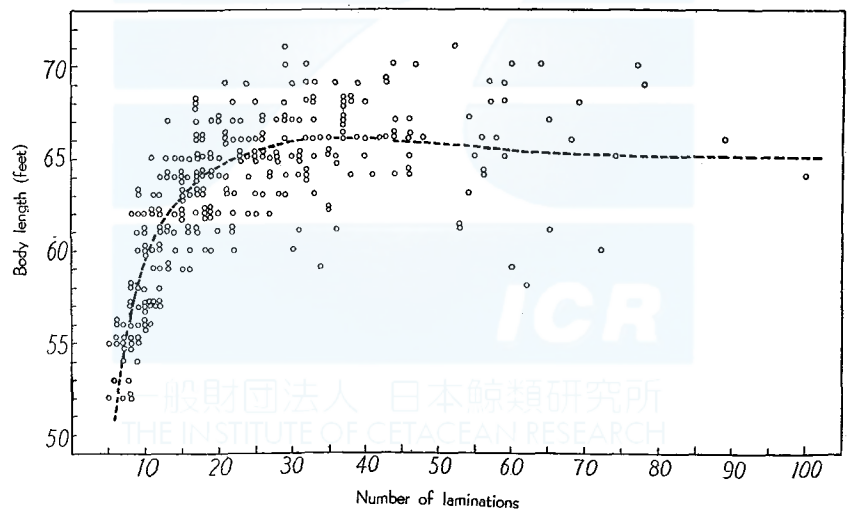

Fig. 19. Growth curve of the northern female fin whales based on the number of laminations in ear plug.

According to similar figure by Pike (1953) the body length at physical maturity is 68 feet.

Weight of testis is not a good age character as shown by Nishiwaki, Ichihara & Ohsumi (1958). Although it is dangerous to use weight of testis as an age character, we show the mean length against weight of testis in figure 17. This does not show the growth curve of male

whale, but from this figure we can suggest the mean maximum length of male. It is 62 feet long.

Figures 18 and 19 shows relation between number of laminations and body length of males and females respectively. With the discovery of lamination in ear plug by Purves (1955), we could obtain the best age character for baleen whales. And then we can show the growth curve of fin whale based on number of lamination. On the growth curve we shall mention in the following chapter.

Even if vast individaul variation is seen, the mean maximum length is estimated to be 62 feet in males and 66 feet in females. Number of laminations at maximum length is from 40 to 45.

Furthermore after attainment of maximum length the shrinkage is seen in both male and female like as figure 16. Average length of shrinkage is seems to be about one foot. We have never known the paper on the shrinkage of whales after physical maturity.

From these series of our results, although there is vastly individual variation, the mean length at physical maturity is estimated to be 62 feet in male and 66 feet in female.

On the northern Pacific fin whale, the largest male is 68 feet long and the largest female is 74 feet in our material. According to the International Whaling Statistics from 1936 to 1956, the largest male is 77 feet and the largest female is 74 feet for the fin whale in the North Pacific. For the fin whale from the adjacent water to Japan, from 1910 to 1945 (during these periods Japan had not join the International Whaling Convention) these values are 75 shaku in male and 76 shaku (one shaku is almost one foot) in female. Therefore the largest fin whale in the North Pacific is 77 feet in male and 76 feet in female. But we wonder male fin whales which are over 70 feet are exsist realy. They may be mistaked the determination of the sex. Tago (1922) reported that the largest fin whale in adjacent waters to Japan was 82 shaku. And Cocks (1886) reported 24.6m (81 feet) long fin whale in the North Atlantic.

AGE AT PHYSICAL MATURITY

Nishiwaki, Ichihara & Ohsumi (1958) calculate number of ovulation in an year by means of the figure between number of laminations and number of ovulations. According to their study fin whale ovulates 0.8–0.9 times an year. We estimate number of ovulation at physical maturity is 15, and the age at sexual maturity is 5–6 years old. By means of these data, the age at physical maturity is calculated. It is 22 to 25 years old. Two laminations are estimated to deposit every year (Purves, 1955 ; Laws & Purves, 1956). If so, 40–45 laminations which we estimate as physical matulity are counted for 20–22½ years of age.

Table 12 shows estimated the age distribution of physically immature and mature female whale based on number of ovulations. We consider those who accumulate 15 and over corpora lutea or albicantia in their ovaries are physically mature. The eldest physically immature female is estimated to 30 years old (60 laminations) and youngest physically mature female is estimated 15 years old (30 laminations). And 25 years old whale (50 laminations) is recongnized to the age at physical maturity.

Age at physical maturity for male will be same as female, for figures 18 and 19 shows the almost simmilar growth curve in male and female. As the conclusion, if the northern fin whales deposits 2 laminations in ear plugs every year, they will attain at physical maturity by 22 to 25 years after birth.

TABLE 12. AGE AT PHYSICAL MATURITY OF FEMALE FIN WHELES IN THE NORTHERN PACIFIC

Number of laminations	Estimated age (Year)	Physical'y	
		Immature	Mature
26—29	XIII-XIV	24	—
30—33	XV-XVI	23	2
34—37	XVII-XVIII	17	—
38—41	XIX-XX	7	2
42—45	XXI-XXII	7	2
46—49	XXIII-XXIV	6	2
50—53	XXV-XXVI	—	3
54—57	XXVII-XXVIII	1	8
58—61	XXIX-XXX	1	4
62—65	XXXI-II	—	3

On the age at physical maturity, Wheeler (1930) states that the female fin whale attains physical maturity at 6–8 years of age. He considers that after attainment of sexual maturity at 2 years, of age 4 or 5 ovulations take place in every 2 years and it attains physical maturity after 14 or 15 ovulations. Nishiwaki (1952) states that southern fin whales attain physical maturity at about 11 years after birth, for he supposed female fin whale attains physical maturity at about 6 years after attainment of sexual maturity which is 5 years of age. According to the figure in the paper by Laws & Purves (1956), they seem to suppose that female fin whale attains physical maturity at 12–14 years of age.

Our result is significantly different from above papers. We consider that it dues to the difference of number of ovulations in every breeding season. The values of the authors are as follows.

Wheeler (1930)	4—5
Ruud (1940, '45)	6—7
Nishiwaki (1952)	2 in first year, 3.04 in succeeding period
Laws & Purves (1956)	2.8
Our result	1.6—1.8

Peters (1939) supports our result. He calculates 1.8 ovulations in every breeding season. Chittleborough (1954) suggested that the rate of number of ovulation in the humpback whale a little more than on per breading season.

Ruud, Jonsgård & Ottestad (1950) suggested that in the blue whale corpora albicantia accumulate at a rate of a little more than one a year.

GROWTH CURVE OF THE NORTHERN FIN WHALE

LONGEVITY

The oldest whale has 101 laminations in the ear plugs for male and 100 laminations in female. These whales are estimated to be $50\frac{1}{2}$ years old and 50 years old respectively. On the other hand, the number of ovulations which we had observed in the Northern Pacific is 49. If 0.8 or 0.9 corpora albicantia accumulate in one year (Nishiwaki, Ichihara & Ohsumi, 1958) and the age at sexual maturity is six years after

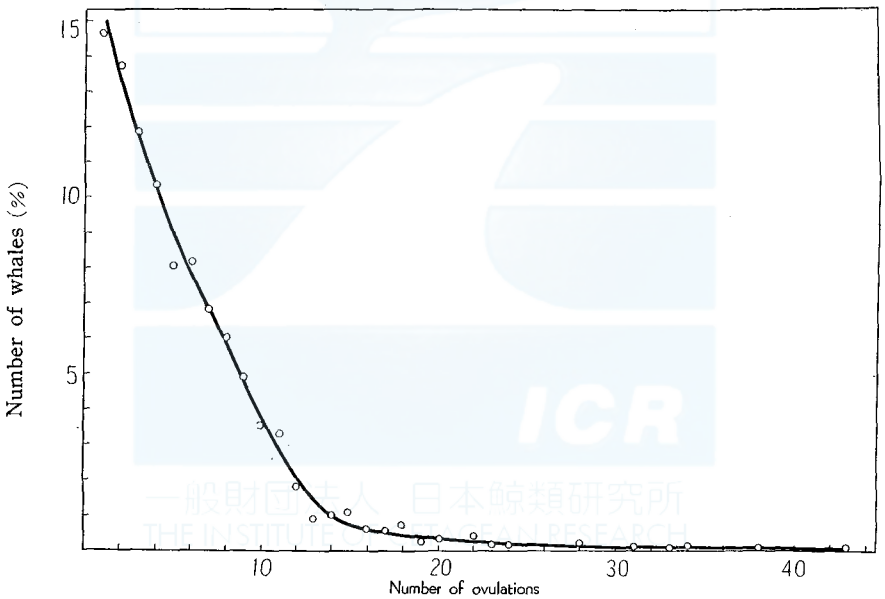

Fig. 20. Frequency of total ovulations for the female fin whale from the northern part of the North Pacific from 1952 to 1955.

birth, the whale is estimated to be from 60 to 67 years old. However, number of laminations of this whale was 100. So, this is estimated to be 50 years old.

Figure 20 shows the frequency of number of ovulations for the fin whale in the northern Pacific from 1952 to 1955. The number of female whales which has more than 15 corpora lutea and albicantia in the

ovaries are only 4.93 per cent of all sexually mature whales. Thus, the physically mature female whales (more than 24 years old) are very rare in the northern Pacific.

Wheeler (1930) states that no signs of a climacteric have been observed in whales up to 20 years of age. Nishiwaki (1952) indicates that the average life of fin whale would be 25 to 30 years under natural conditions. And according to Brown (1957), the oldest marked fin whale had been recovered in the Antarctic is 22 years after marking. As the first year when the marking for whales took place in the Antarctic was 1934, we have not yet confirmed the whole life of the whales is whether older or not.

GROWTH CURVE

From the above results concerning birth, sexual maturity and physical maturity, we drew the mean growth curve of fin whale in the northern

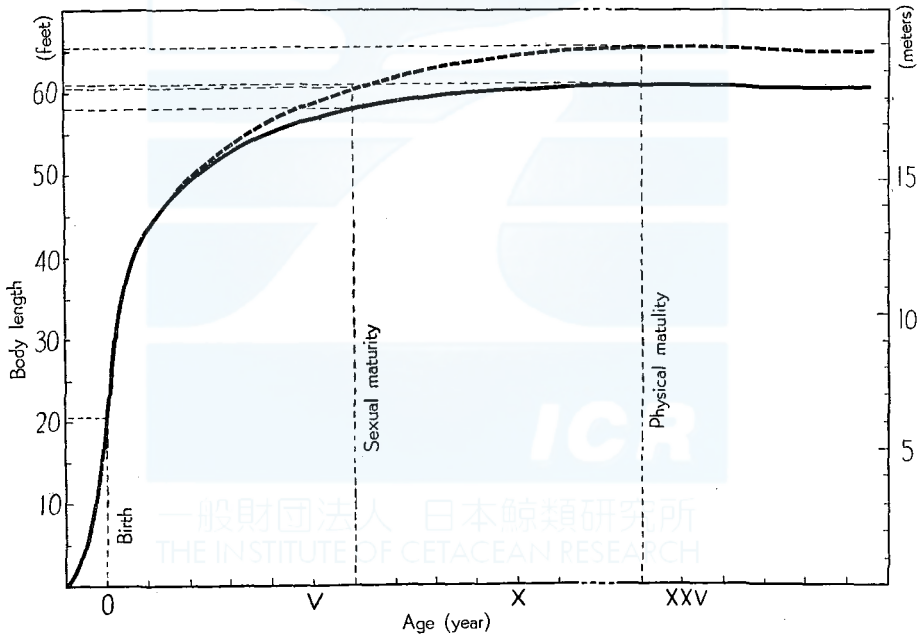

Fig. 21. Growth curve for the fin whale from the northern part of the North Pacific. Solid line: male. Broken line: female.

Pacific as shown in figure 21. This is nearly sygmoidal curve. In the first 2 years after birth, fin whale grows very rapidly and it is not seen the difference of growth rate between male and female. But after then it grows more slowly by degree and females exceeds males.

After attainment of physical maturity, the fin whale seems to shrink a little. This figure is different from the previous growth curves drawn

by Mackintosh & Wheeler (1929), Kasahara (1950), Laws & Purves (1956). The individual variation of the body length at birth has been estimated to be two feet according to Kimura (1957). Furthermore as shown figures 18 and 19, it becomes very wide in adult whales. Therefore, we must perceive it on considering the growth curve of the whales.

DISCUSSION

We must discuss first in this chapter on the age of the fin whale. We used the number of laminations in ear plug as the age character. Now, it has been considered that two laminations deposit every year in the core of ear plug. Purves (1955) assumes that each interlamellar space

TABLE 13. THE GROWTH OF MARKED FIN WHALES

Mark number	Sex	Estimated body length	Actual body length	Lapse of time	No. of lutea	Foetus	Weight of Testis in kg.	Number of laminations in ear plug
4658	Female	61 ft	58 ft	0—11	0-0, 0-0	None		—
4543	〃	62	66	0—11	0-5, 1-3	F. 8-3		—
3243	〃	70	55	3—0	0-1, 0 0	None		13
4267	〃	45	63	2—0	1-0, 0-2	F. 7-0		—
3213	〃	60	63	3—2	1-7, 0-8	F. 4-11		—
4552	〃	60	62	1—10	0-1, 0-0	None		11
6062	〃	55	64	1—8	0-3, 0-6	None		—
5995	〃	57	65	1—11	0-13, 0-2	None		—
6939	〃	62	64	1—11	1-5, 0-8	M. 11-6		41
6923	〃	62	64	2—0	1-4, 0-3	M. 3-11		32
4516	Male	65	61	0—10			14.5, 15.0	—
4451	〃	?	56	0—11			1.0, 1.0	—
4604	〃	55	61	0—11			1.8, 2.0	—
4641	〃	63	60	1—1			11.0, 11.5	—
7002	〃	60	58	0—10			4.7, —	—
4461	〃	57	59	1—11			7.2, —	—
6987	〃	50	62	1—10			5.1, 5.0	—
4558	〃	65	62	2—10			5.8, 5.7	21
5979	〃	60	58	2—0			1.1, 1.0	9

represents the period of migration north or south. Laws & Purves (1956), comparing with the estimated age from the baleen plates, describes that if two laminations deposit in ear plug, these is fair agreement up to the fourth year after which the age as determined by the ear plugs differs from that obtained from the baleen plates analyses. According to Nishiwaki, Ichihara & Ohsumi (1958), the mean number of ovulation in one year is calculated to be 0.8 or 0.9 if 2 laminations deposit in one year. This result agrees with that by Peters (1939). Mackintosh (1942) describes that the rate of accumulation of corpora albicantia cannot have been much more than about one a year for marked fin whale caught in the waters off South Georgia.

These results support our estimations, but for the certification of the theory, further studies should be needed. Marking investigation will be the most useful method for this purpose.

By the way, in the northern Pacific Japanese Government has continued marking investigation since 1953. Table 13 indicates the marked fin whales which recovered after the term of more than next whaling season since marking. It is difficult to estimate the body length of swimming whales. The estimated length of the whales which recovered within two weeks after marking are 2 or 6 feet (average 4 feet) longer than the actual length. Considering this result, growth rate of fin whale will be

TABLE 14. BODY LENGTH OF FIN WHALES IN SEVERAL REGIONS AT BIRTH, WEANING, SEXUAL MATURITY, PHYSICAL MATURITY AND MAXIMUM

	Northern Pacific		Coast of Japan		British Columbia		North Atlantic		Antarctic	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
At birth	21′		21′~23′a)		—	—	—	—	21′3″e)	
Weaning	—	—	—	—	—	—	—	—	39/4″e)	
Sexual maturity	58′	61′	58′~ 59′ b)	60′~ 61′b)	57′~ 59′c)	60′c)	58′d)	61′~ 62′d)	63′0″f)	65′3″f)
Physical maturity	62′	66′	—	—	—	68′c)	—	70′d)	69′g)	73′g)
Largest length	68′	74′	66′b)	72′b)	66h)	71h)	68′d)	73′d)	{82′h) {74′2″f)	{88′h) {80′5″f)

Remarks a) Mizue (1951) b) Omura (1950) c) Pike (1953) d) Jonsgård (1952) e) Mackintosh & Wheeler (1929) f) Mackintosh (1942) g) Nishiwaki (1953) h) I.W.S.

little. No. 3243 whale which was recovered in lapse of three years is accumulated one corpus albicans in ovaries. Considering to existence of verginal band and immaturity of mammary gland, this whale was assumed to had attained just sexual maturity. This means that it needs at least three years after birth to attainment of sexual maturity. This whale has 13 laminations in the ear plug.

A male fin whale (No. 5979) is sexually immature after 2 years since it was marked. As the estimated length is 60 feet, it might not be so short at marking. Number of laminations of this whale is 9.

From the biological data of No. 3443, 4552 and 5979 whales, fin whale is estimated to deposit at most 5 laminations in ear plug every year.

Laws (1956) reports on the growth and sexual maturity in aquatic mammals. He describes that if we convert the length of the female at puberty to a percentage of the size attained when growth ceases it is seen to be remarkably constant, averaging in cetaceans 85.1 per cent (range 80.0–85.5). Now we obtained the result that body length at sexual and physical maturity for the female fin whale in the northern Pacific are 61 feet and 66 feet respectively. Therefore, length at sexual

maturity as percent of final length is 92.4. This differs from the value by Laws.

Although Laws (1956) states in the same paper that male whale attaines sexual maturity at a later age than the female, our result on this subject differs from it. Both sexes of fin whale attain sexual maturity at about six years of age. Furthermore, the age at physical maturity of male seems also to be the same as the female.

Table 14 shows the body length at several stage of growth in several regions. Length at birth will be the same in all stocks of fin whales. However, after birth the stocks in the northern hemisphere will grow more slowly than the other. The length at weaing has not been reported yet. On the length at sexual maturity of northern fin whale all reporters obtain almost at the mean length of 57–59 feet and female does at 59–62 feet. These are about 5 feet shorter than the stocks of southern hemisphere.

The investigation of physical maturity for the stocks of northern fin whales have been imcomplete. Comparing the size distribution of female fin whale northern Pacific with British Columbia and the North Atlantic, 68 feet and 70 feet for the length of physical maturity seems too longer than the theoretical value. The length of northern hemisphere fin whale at physical maturity is considered about 7 feet shorter than the southern stocks.

SUMMARY

The growth of the fin whale in the northern Pacific is studied by means of some biological data investigated on board of factory ships from 1952 to 1957. The essential points are concluded as follows.

1. Although we have no data on the breeding in October to April, the pairing season is estimated to include almost all seasons. But majority take place between November and January, the maximum falling at the middle of December.

Growth rate of foetuses for the northern Pacific fin whale is closely similar to that of other regions – coast of Japan, the North Pacific and the Antarctic.

Gestation period is estimated to continue till about 12 months. Then the body length at birth is supposed to be average 21 feet long in both sexes growth curve of foetuses is parabolic and growth equation is

$$L = 0.329M^{1.61}.$$

2. The youngest fin whale caught in the northern Pacific is two and a half years old (5 laminations) and in this stage whales are completly immature. After four years old fin whale approach to sexual maturity.

3. By means of histological examinations male fin whale which has its heavier testis of more than 2.6kg is regarded as sexually mature. The largest sexually immature whale is 63 feet long in the male and 68 feet long in the female. The shortest sexually mature whales is 55 feet in both sexes. Furthermore the average lengths of sexual maturity is estimated to be 58 feet in male and 61 feet in female.

Fin whale attains sexual maturity from four years of age till six years of age. The average age at sexual maturity is eariler part of six years of age for both the male and female.

4. After attainment of sexual maturity, ossification of vertebral epiphises begins from both ends of vertebral column and ends at 3rd to 6th dorsal vertebrae.

5. Female attains physical maturity from 22 years of age till 25 years of age. The average age at physical maturity is estimated to be 24 years old. The largest physically immature whale is 68 feet in male and 71 feet in female. On the other hand the shortest physically mature whale is 57 feet in male and 58 feet in female. The average length at physical maturity is 62 feet in male and 66 feet in female.

6. Shrinkage of body occurs after attainment of physical maturity. Average length of shrinkage is about one foot.

7. The maximum life of fin whale is estimated to be 50 years old. However, the physically mature fin whales (more than 24 years old) are very rare in the northern Pacific.

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