On the Periodic Mark on the Baleen Plates as the Sign of Annual Growth

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(5. Dec. 1950)

CONTENTS

Introduction

It was concluded in the previous report (Nishiwaki: 1949b) that one can not trace the life of a whale back to its birth by the study of the sculptures on the surface of its baleen plates, because not merely the tips of the plates are chipping away gradually and incessantly after the whale has attained a certain age, but also it is very difficult to determine whether or not, and how much the tips of the plates of a given whale have been chipped away after its birth. At the same time, however, it was also pointed out that these sculptures were worth of further investigation, because the structure of the baleen plates relates fairly correctly the life history of the whale during a certain number of years prior to its catch and slaughter. And the necessity of such studies was also emphasized at the same time in order to know whether the interval zone between the two successive sculptures shows the annual growth of the baleen plate, or the said zone shows the growth cycle for more than one year; or moreover to know the number of the periodic cycles per year, if more than one cycle are completed annually.

From this point of view, the present study is attempted to know the growth rate of the baleen plates for a certain length of time and then, being based on the result of that study, to settle the problem that the annual growth of the baleen plate really corresponds to the periodic cycle of the sculpture, i. e., the interval zone between the neighbouring two main sculptures. The baleen plates of the Antarctic whales were used as the material, because they were available in large numbers and in the most reliable condition. As was in the previous study, the present materials of the baleen plates were collected from all the whales caught by both the two Japanese whaling fleets, the Hashidate-maru Fleet of the Japan Marine Products Co., Ltd., and the Nisshin-maru Fleet of the Taiyo Fishing Co., Ltd.

The collection of the material was carried out through the cordial cooperation of the crews of the two fleets, under the direction of the inspectors-on-board of the Japanese Government, Messrs. Haruyuki Sakiura, Yoshiro Teraoka, Koji Ishizuka, Yasuo Usukura, Kazuhiro Mizue and Tadashi Murata. The Japan Whaling Association rendered much cooperation and gave facility to the writer in preparing the special apparatus for measuring the sculptures of the baleen plates. Mr. Minoru Kubota offered much assistance in the calculation of the data. These cooperations and assistances, which made this study possible, are all heartily appreciated.

Chapter I

The Material

On board the factory ships, the largest left and right baleen plates were collected as the sample from each whale. On this sampling, the line of insertion of the baleen plate into the gum (the intersection of the baleen plate with the contour of the gum) was clearly marked on the baleen plate with a knife-cut, as designated by "a" in Fig. 1. There are in the baleen plate several number of thin zones which are recognizable superficially by rough sculptures. Among them, that nearest to the said knife-cut is designated by "b" in Fig. 1, and is called the first main sculptnre" in the present paper. At this part of the baleen plates of some whales, there are recognizable some distinct pockmark-like spots. The next thin zone to that of the mark "a" is denoted by "c" (the "second main sculpture"), and the base of the baleen plate by "d" (Fig. 1.).

The growth of the baleen plate takes place at the base "d", not at the line of the insertion into the gum, "a". Now, assume that the baleen plate grows in such a way as human nails do. Then, "a", "b" and "c" will go apart from "d" at an equal rate as the baleen plate grows.

Therefore, in the study distances "ab" and "bc" were measured to estimate the annual growth of the baleen plates from the change of the ratio ab/bc during the whaling season. This ratio was chosen as the index of the growth of the baleen plates, and not the actual length of ab, which varies much from whale to whale, because the rate of the growth of the baleen plate during the formation of the interval zone between the main sculptures, and consequently the width of that interval zone, seemed to be considered as constant for each individual whale. (Speaking more precisely, however, the width of the interval zone becomes smaller, though slightly, toward the younger part of the plate, i. e., toward the gum.)

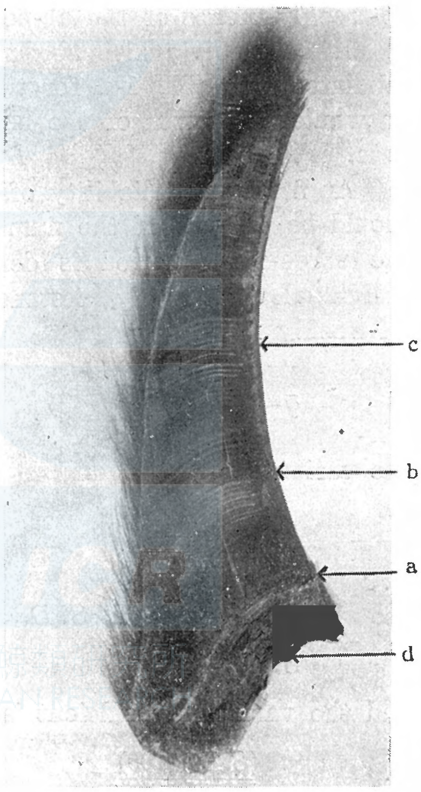

Fig. 1. Growth Index of Baleen Plate (ab-Percentage) measuring point.

The percentage value fo the ratio ab/bc is called the "ab-percentage" in the following discussion. The average of the ab-percentages for the right and left plates of the individual whale was defined as the ab-percentage for that individual. The ab-percentages for the individuals caught in each one- and three-week period were averaged, thus yielding the weekly and tri-weekly mean of the ab-percentage respectively. The tri-weekly mean was adopted instead of the mean for four-week period or the monthly mean, because the former seemed to be compared with each other more fairly than the latter in the case of the 1949–50 whaling season, which lasted for only ten weeks. In averaging three weekly means to obtain the tri-weekly mean, the formers were weighted with the number of the whales caught in the respective weeks.

Following discussions are primarily based on the data for all the fin whales (211 famales and 248 males, totaling 459) and all the blue whales (114 females and 270 males, totaling 384) that were caught by the Hashidate-maru Fleet. On the course of reasoning, the data for all the fin and blue whales, 597 fin and 433 blue whales, that the

Nisshin-maru Fleet caught, were also referred to. The baleen plates of 37 fin and 18 blue whales, on which the collectors failed to cut the "a" marks, were inevitably excluded from the data.

Chapter II

The Periodic Cycle of the Sculptures on the Baleen Plates of Fin Whales

The ab-percentages for individual whales as defined in the preceding chapter are plotted against the date of catch in Fig 2-a for the female and in Fig. 2-b for the male fin whales. Daily, weekly and tri-weekly means of the ab-percentage are computed from the values of all the individuals caught during the respective periods, and are tabulated in Table 1-a for the female and in Table 1-b for the male fin whales. Growth of the baleen plates can be estimated from these data.

At first, the reliability of the tri-weekly means of ab-percentage should be tested. If the number of the sample whales caught during the three-week period is denoted by N, and the ab-percentage of individual whale by y_i, i standing for each of the N whales, then the tri-weekly mean $\bar{y}$ is

$$\bar{y}=\frac{\Sigma y_i}{N},$$

the variance, V, is

$$V=\frac{\Sigma(y_i-\bar{y})^2}{N-1},$$

the standard deviation, $S.D.$, is

$$S.D.=\sqrt{V},$$

and the variation coefficient is

$$v=\frac{(S.D.)(100)}{\bar{y}}$$

To determine the fiducial limits of the unknown population mean m from the sample mean $\bar{y}$

$$F \geqq N(\bar{y}-m)^2/V$$

Taking the square roots of both members,

$$-\sqrt{\frac{F.V}{N}} \leq (\bar{y}-m) \leq +\sqrt{\frac{F.V}{N}}$$

This formula indicates the range of the tri-weekly mean. The values computed with these formulae are entered in the columns right to the tri-weekly means in Table 1's.

If an approximately constant growth rate is postulated for the baleen plates, the relation between the accumulated growth of the baleen plate and the number of weeks that have elapsed can be considered as being linear. Now, assume a linear relation between the number of weeks, symbolized by the variable x, and the accumulated growth of the baleen plate, the variate y. Then, based on the points (x_1, y_1), (x_2, y_2), $(x_3, y_3), \ldots .(x_N, y_N)$, the regression equation which is expressed in the following form is obtained:

$$y=\bar{y}+b(x-\bar{x})=A+B_x$$

where $\bar{x}=\frac{\Sigma x_i}{N}$ and $\bar{y}=\frac{\Sigma y_i}{N}$, A and B being the constants. If the variances and the covariance are defined as

$$S_x=\Sigma(x_i-\bar{x})^2,$$

$$S_y=\Sigma(y_i-\bar{y})^2,$$

and $$C=\Sigma(x_i-\bar{x})(y_i-\bar{y}),$$

then the constant B is written

$$B=C/S_x$$

And if $(C^2/S_x)(\Delta/(N-2))>F'_{N-2}$, where

$$\Delta \equiv (y'_i-y_i)^2-S_y-C^2/S_x,$$

then much of the variation in y is attributable to the variation in x, that is, the accumulated growth of the baleen plate varies much from week to week.

To simplify the calculation, the week January 19–25, 1950, is taken as the origin of x, that is, for this week $x=0$. This week is the fifth and middle week in the 1949–50 whaling season which lasted for ten weeks from December 22, 1949.

Then, the values are computed with the formulae above and are listed in Tables 2–a and –b for the females and for the males respectively.

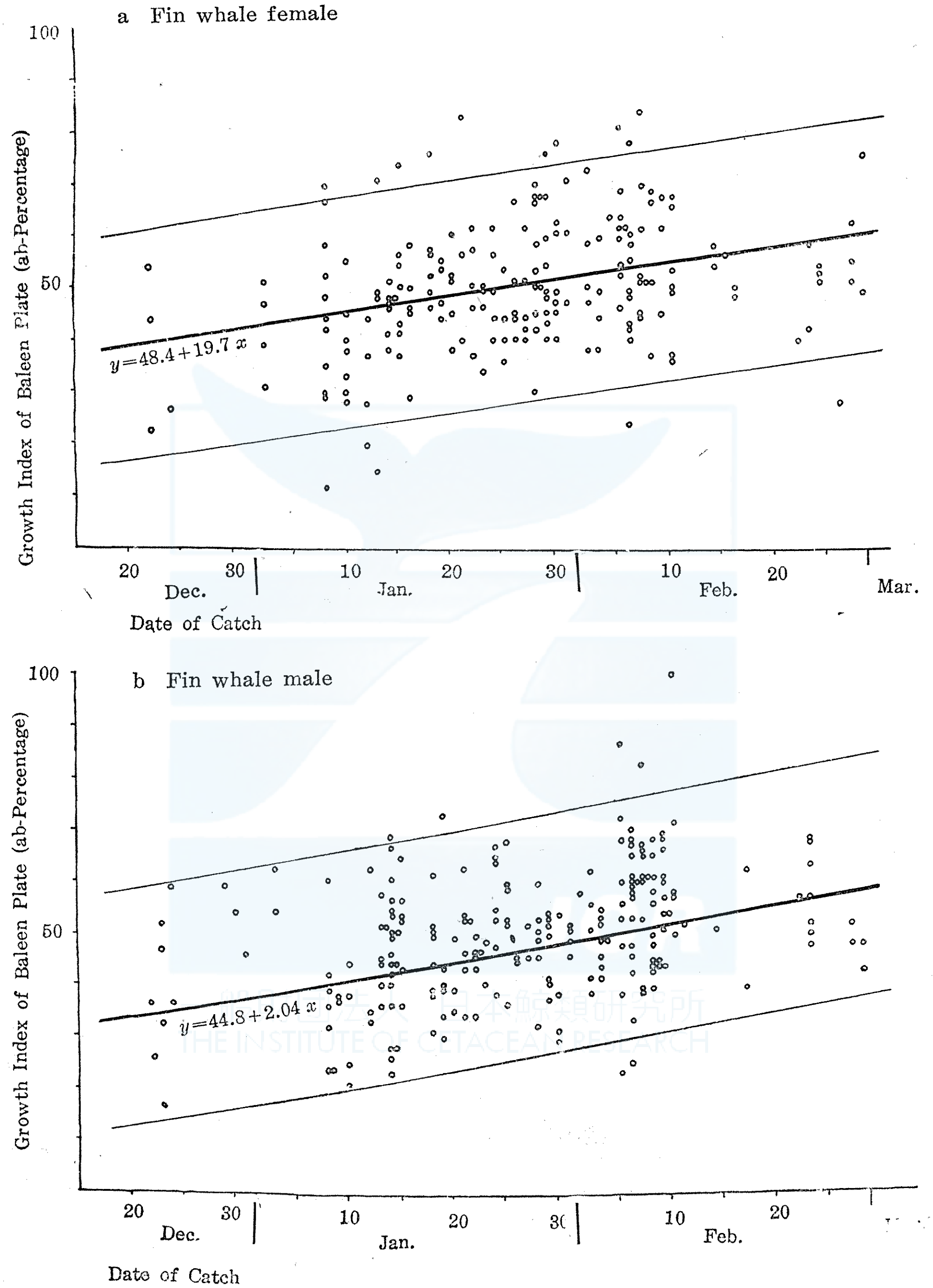

Fig. 2. Growth Index of Baleen Plate (ab-Percentage) in Fin Whales, by Date of Catch.

Table 1. Number of Fin Whales caught (N) and Mean accumulated Growth of their Baleen Plates (Mean ab-Percentage) for each day, Week and 3-Week Period.

a. Fin Whale Female

Week		For Each Day of the Week														For Each Week		For Each 3-week Period		
		Thurs.		Fri.		Sat.		Sun.		Mon.		Tues.		Wed.						
Week Number	Date	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	Mean ab-%	Range of Mean	Level of Significance in
I	12/22–12/28	4	44.6			1	21.5									5	35.6			
II	12/29–1/4									2	35.1	2	48.8			4	42.0	39.7	±5.20	5.26
III	1/5–1/11							11	42.2			7	38.4			18	40.3			
IV	1/12–1/18	4	32.4	4	45.3	10	46.7	4	51.8	5	45.6			6	55.9	33	46.3			
V	1/19–1/25	4	49.8	5	49.1	3	59.2	5	50.2	4	44.6	5	49.9	4	43.3	30	49.4	48.9	±6.30	5.17
VI	1/26–2/1	5	49.3	5	47.5	11	54.5	9	52.7	7	54.3	3	58.7			40	52.8			
VII	2/2–2/8	5	52.9	4	47.5	1	63.2	9	60.5	10	49.6	8	56.9	5	55.7	42	55.2			
VIII	2/9–2/15	3	57.5	7	51.0	2	55.9							1	56.3	13	54.9	54.6	±5.98	4.39
IX	2/16–2/22	2	49.1											1	39.6	3	44.4			
X	2/23–3/1	2	50.1	3	52.7			1	28.4	3	56.2	2	61.9			11	54.2			

b. Fin Whale Male

Week		For Each Day of the Week														For Each Week		For Each 3-week Period		
		Thurs.		Fri.		Sat.		Sun.		Mon.		Tues.		Wed.						
Week Number	Date	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	Mean ab-%	Range of Mean	Level of Significance in
I	12/22–12/28	2	31.6	4	37.2	2	47.8									8	38.4			
II	12/29–1/4	1	59.0	1	54.1	1	41.3					2	32.8			5	40.0	37.9	±4.75	5.73
III	1/5–1/11							7	36.5	2	37.8	4	31.9			13	35.1			
IV	1/12–1/18	3	43.3	7	46.2	19	45.5	6	50.4					8	45.3	43	46.1			
V	1/19–1/25	6	43.0	3	41.1	8	46.9	7	45.2	2	44.1	7	54.9	6	53.7	39	47.9	46.5	±2.91	2.52
VI	1/26–2/1	2	44.5	2	48.0	6	47.5	7	47.6	4	37.1	4	48.7	1	56.8	36	45.1			
VII	2/2–2/8	5	49.1	8	47.5			9	55.2	16	53.5	10	58.3	12	59.1	66	52.7			
VIII	2/9–2/15	10	57.3	5	65.9	1	51.2					1	49.8			17	59.0	54.0	±6.42	4.78
IX	2/16–2/22			2	49.9									1	56.4	3	52.1			
X	2/23–3/1	7	56.8							2	49.1	2	44.4			11	53.1			

Table 2
Formulae and Values of Calculation for Fin Whales.

Formula	(a) Value for Females			(b) Value for Males		
Σay	−79.8			−273.1		
Σay^2	5498.52			7591.23		
Σaxy	1658.20			1882.6		
$S_x=\Sigma a(x_i-\bar{x})^2$	869			1010		
$S_y=\Sigma a(y_i-\bar{y})^2$	5466.52			7591.23		
$C=\Sigma a(x_i-\bar{x})(y_i-\bar{y})$	1709.20			2061.68		
$\bar{y}=\Sigma ay/N$	−0.40			−1.21		
$\bar{x}=\Sigma ax/N$	0.65			0.96		
$N=\Sigma a$	199			225		
$B=C/S_x$	1.97			2.04		
A	48.4			44.8		
C^2/S_x	3164.12	1	3164.13	3509.09	1	3509.09
$\Delta=S_y-C^2/S_x$	2302.39	197	11.69	4082.14	223	18.35

As the summary, the growth of the baleen plates of fin whales is expressed in the general formula

$$y = A + Bx,$$

where y stands for the weekly mean of ab-percentage (the index of the accumulated growth), and x for the week number as taken to be zero for the week, January 19-25, 1950. B, being defined as C/S_x, is the mean weekly growth rate of the baleen plate. Substituting the values of Table 1's in the general formula,

for females:

$$y=48.4+1.97x$$

and for males:

$$y=44.8+2.04x$$

From these equations, it can be seen that by the week January 19–25, 1950 for which $x=0$, the baleen plates of female and male fin whales have already grown by 48.4% and 44.8% of the width of the interval between the two successive main sculptures, respectively.

If it is assumed that the main sculptures are formed at that period of the year when the whales are most poorly nourished, such period can be estimated by substituting $y=0$ in the growth equations. Then, the results are for females:

$$y=0 \doteqdot 48.4+(1.94)(-25)$$

and for males:

$$y=0 \doteqdot 44.8+(2.04)(-22),$$

indicating that the nutrition of the female and the male fin whales would have been worst 25 and 22 weeks before the origin week respectively, i. e., in late July and in middle August.

Again assume that the length of ab would have attained the width of the interval of the two successive main sculptures in the next malnutritious period, had the whales survived. By definition, $y=100$ for that period. Substituting this in the equations,

for females:

$$y=100 \doteqdot 48.4+(1.94)(+27)$$

and for males:

$$y=100 \doteqdot 44.8+(2.04)(+26)$$

Accordingly the fin whales of both sexes would have met the malnutritious period 27 weeks after the origin week or in early August.

Furthermore, 52, which is the number of weeks in a year, times of the mean weekly growth rate B is approximately equal to 100% for both sexes, proving that the interval zone between the two successive main sculptures corresponds to the annual growth of the ballen plate. (More precisely, the products 52B exceed 100% slightly. But this seems quite natural because the material baleen plates were sampled during the feeding season of the whales, when the growth rate of the baleen plates, which varies from one week to another, was probably at the maximum level of the year.)

From the foregoing estimates of the malnutritious periods, it can be deduced that the nutrition of fin whales is at the lowest level between late July and middle August. This presumption perfectly coincides with the findings hitherto made on the life history of fin whales. It was also found, at 5% level of significance, that the interval zone between the two successive main sculptures on the baleen plates of fin whales corresponds to the annual growth of the baleen plate. In other word, the periodic cycle of the main sculptures on the baleen plates of the fin whales is one year.

Chapter III

The Periodic Cycle of the Sculptures on the Baleen Plates of Blue Whales

The baleen plates of blue whales were also treated by the same method as those of fin whales. In Figs. 3–a and –b are plotted the ab-percentages for the female and the male individuals, respectively, against the date of catch. Daily, weekly and tri-weekly means of ab-percentage are listed in Tables 2–a and –b for the females and for the males respectively. In these tables are also listed the range and the level of significance of the tri-weekly means. Both of these were computed by the same statistical procedures as in the case of fin whales. The process of the calculation is tabulated in Table 4.

From these data, the equation of the growth of the baleen plates of the female blue whales (Fig. 3–a) is doubtless

$$y=41.0+2.04x,$$

which is similar to the equation for the fin whales.

Substitute 0 and 100 for y as in the case of fin whales, yielding

$$y=0\fallingdotseq 41.0+(2.04)(-20)$$

and

$$y=100\fallingdotseq 41.0+(2.04)(+29)$$

Accordingly both of the estimates of two malnutritious periods are around the middle and late August. And 52 times of the mean weekly growth rate approximates to 100%, also as in the case of fin whales.

For the male whales, however, the equation of growth of baleen plates is deduced as being

$$y=41.0+0.68x$$

from Fig. 3–b (regardless of black and white of the dots) and Table 3–b. Accordingly the time required to complete the interval zone between two successive main sculptures is, by solving $y=100\fallingdotseq 41.0+0.68x$, 96 weeks or about 1.8 years. This result is contrary to those for the fin whales and for female blue whales.

Now, examine Fig. 3–b carefully but regardless of black and white of the dots: then, it is noticed that the dots are concentrating between

20 and 50% of the ab-percentage value for the period from the middle (about the 14th) of February to the beginning of March. The same fact is also observable in Table 3-b: the weekly mean of ab-percentage is 29.4% and 32.7% for the first and second week of the season respectively, and thereafter increases with the week number, till 48.4% is reached in the seventh week; then the value turns to decrease; 48.3% for the eighth week, 40.5% for the ninth and 41.8% for the tenth. For the first seven weeks, when the mean ab-percentage increases steadily, the growth of the baleen plates of male blue whales does not differ much from that of female blue or fin whales. It is for the later part of the season that the growth of baleen plates disagrees between the two groups. And this disagreement is the cause of the difference between the growth equations of the two groups.

The only possible explanation for this disagreement seems to postulate some unknown factor which might have come into effect in the later part of the whaling season.

Along this line of reasoning, the male blue whales were divided into two groups: those caught on and before February 13, 1950 and those caught thereafter. Regarding the former group, the equation of the growth of the baleen plates is

$$y=43.4+2.01x$$

The constants in this equation hardly differ from those in the equations for female blue whales and fin whales of both sexes.

The whales killed after February 14, 1950 were classified on basis of the rate of diatom infection; but this analysis did not lead to any helpful conclusion. Then the thickness of the blubber was considered. The thickness of blubber of each whale, as measured at the body part P_1 (the point on the horizontal cut side of the body, where it intersects a vertical line from the dorsal fin), was expressed in the percentage to the body length and was plotted against the date of catch (Fig. 4.). The straight line appearing in that figure is the standard trend of the change of the thickness of blubber throughout the whaling season, as computed with the data published in September 1949 (Nishiwaki: 1949a).

Such dots are stained black in Fig. 4, that are located above the standard trend line in that figure and correspond to the dots situated below the straight line $y=43.4+2.01x$ in Fig. 3-b. It seems to be one way of thinking to consider the individuals represented by these black dots as such whales that arrived to the Antarctic Ocean comparatively late and grow fat thereafter pretty fast. In other word, we can consider them as being engaged in a different migration from that of the normal whales. The calculation with these (black dots) whales omitted will yield Fig. 3-c and, for and after the eighth week of the season, Table 3-c in place of Fig. 3-b and Table 3-b.

From Table 3-c the mean ab-percentage for the last three-week period of the season (from the seventh to the ninth week) is 48.7%, which agrees, at 1.5% level of significance, with the mean computed for the same period with the equation we obtained for the whales caught before February 13 ($y=43.3+2.01x$), 49.4%.

Therefore, it is possible to conclude that the growth of the baleen plates of male blue whales is expressed as

$$y=43.4+2.01x$$

From this, the periods of undernourishment are estimated around early and middle August, and the interval between the two successive main sculptures is proved to correspond to the annual growth of the baleen plate.

If the growth of the baleen plates is influenced by the feature of the migration of the whale, as we have assumed for the male blue whales, the baleen plates of the female must be affected in a similar way. So, the data of female blue whales were treated by the same method. But it was found that the equation of the growth of their baleen plates is hardly affected by this factor. This proves that the migration of the blue whales differs by sexes. A very similar conclusion was reached regarding the migration of this species by Hideo Omura in his study on the diatom infection on blue and fin whales in the Antarctic Whaling Area V (Omura: 1950).

Finally, some references will be made to the variation in growth of baleen plates among those individuals which were considered as arriving comparatively late to the Antarctic Ocean in the foregoing discussions. As indicated in Fig. 3-b, there is the variation as much as 13% in terms of ab-percentage or about 6 weeks in terms of time in the growth of the baleen plates among these late-arriving male blues. This implies that there is as much variation in the nutritious period of these whales. Then, there may be as much variation in their migration, in the growth of their bodies and, probably, in the period of their births. These subjects, however, will be studied in other occasions, for such studies are not the purpose of the present work.

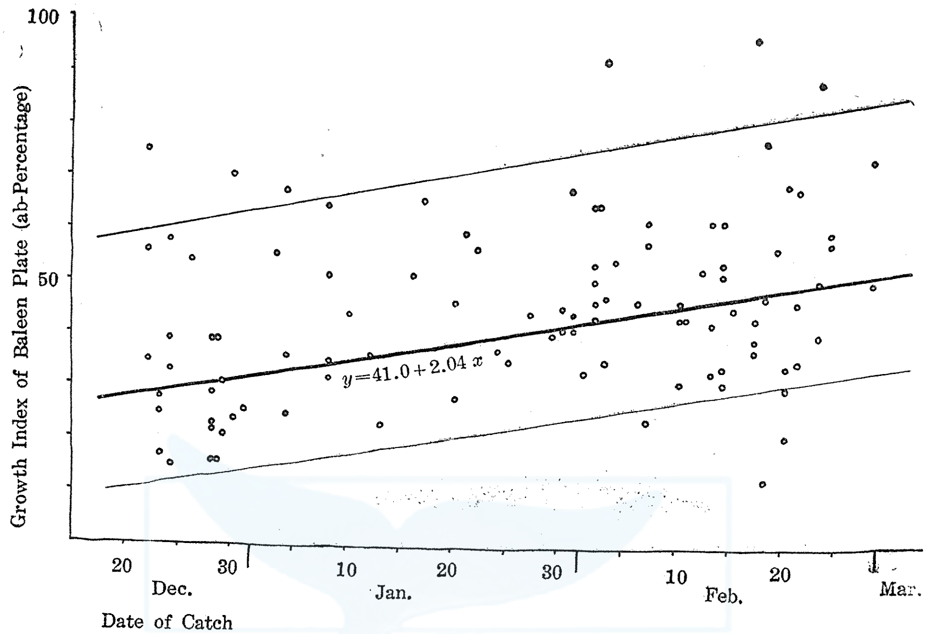

Fig. 3a. Growth Index of Baleen Plate (ab-Percentage) in Blue Whale Females, by Date of Catch.

• Individual caught on or after February 14 with growth index of baleen plate smaller and thickness of blubber large than average trends.

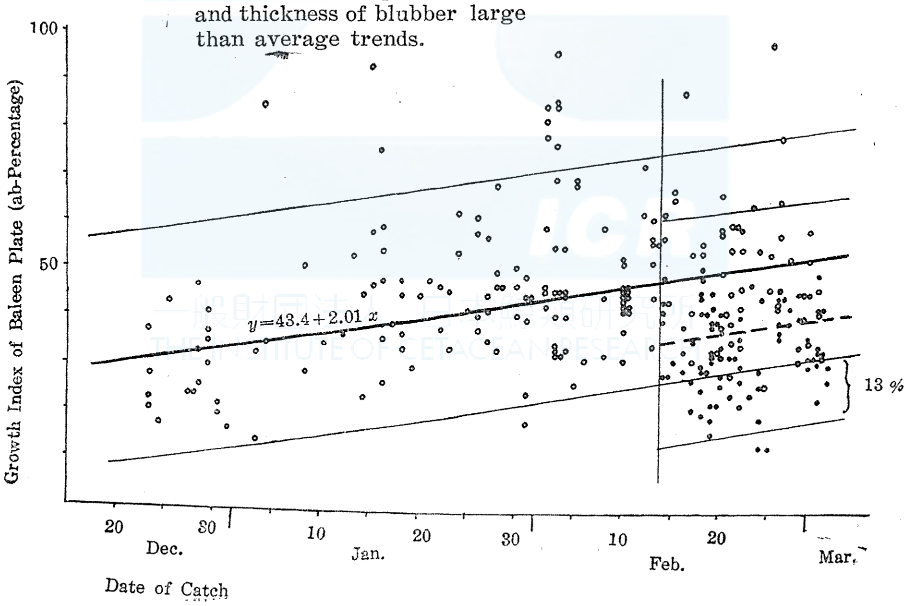

Fig. 3b. Blue whale male

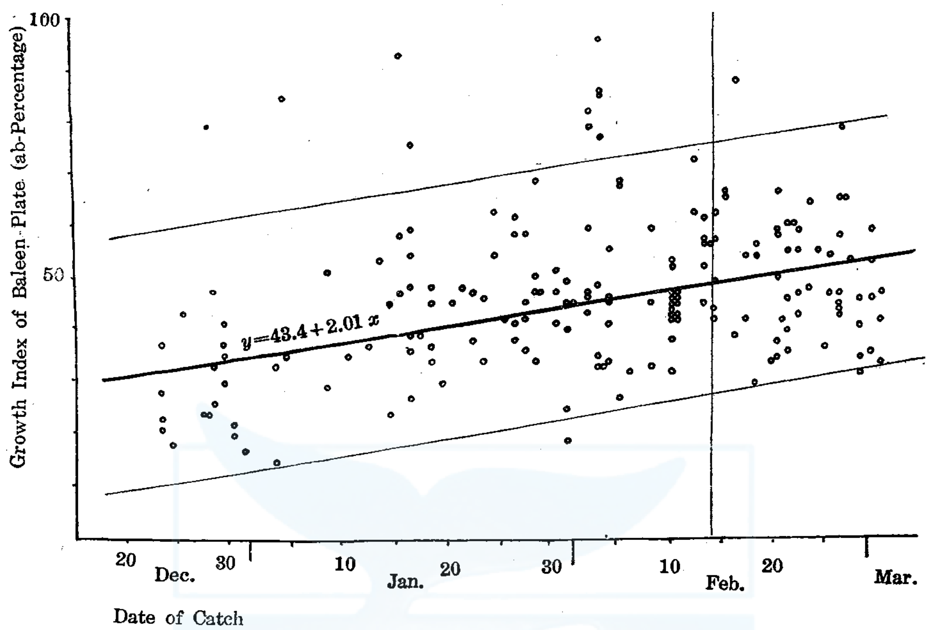

Fig. 3c. Blue whale male (Catch on and after February 14 are adjusted with regard to the influence of migration)

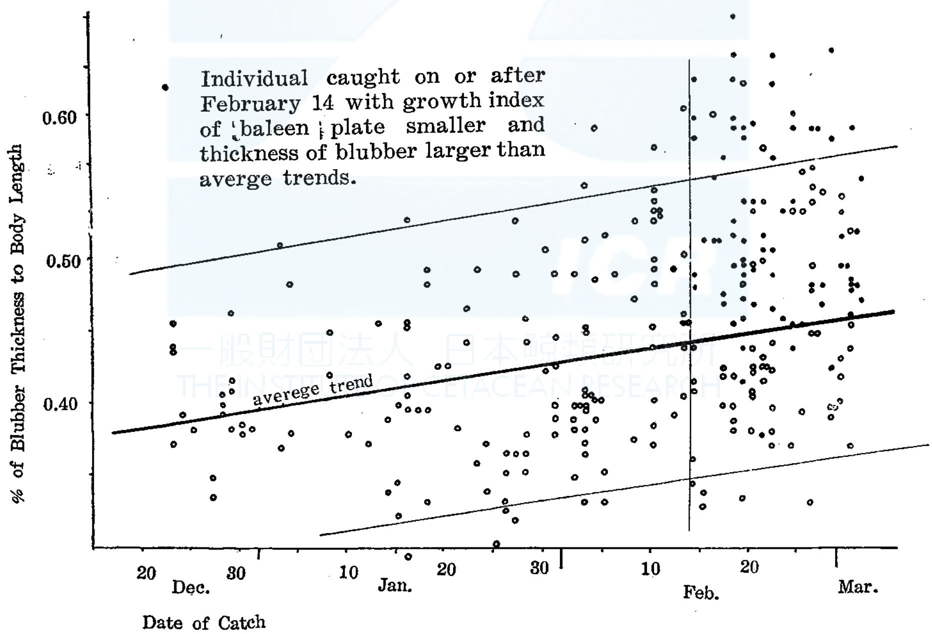

Fig. 4. Thickness of Blubber at Body Part P_1 in Male Blue Whales.

Table 3. Number of Blue Whales caught (N) and Mean accumulated Growth of their Baleen Plates (Mean ab-Percentage) For Each Day, Week and 3-Week Period.

a. Female

Week		For Each Day of the Week														For each Week		For Each 3-week Period		
Week Number	Date	Thurs.		Fri.		Sat.		Sun.		Mon.		Tues.		Wed.						
		N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	N	Mean ab-%	Mean ab-%	Range of Mean	Level of Significance in
I	12/22–12/28	1	35.0	3	23.4	3	28.9							7	26.3	14	26.9			
II	12/29–1/4	2	26.0	1	34.3	1	26.2					1	55.0	2	30.3	7	31.1	30.3	±11.06	14.65
III	1/5–1/11							3	39.4			1	44.0			4	40.5			
IV	1/12–1/18	1	35.7	1	22.5	1	36.1			1	51.3					4	36.4			
V	1/19–1/25			2	36.9	1	59.2	1	55.8			1	37.1	1	34.6	6	43.4	40.9	± 6.58	6.45
VI	1/26–2/1			1	43.8			1	40.0	2	43.0			1	33.4	7	41.2			
VII	2/2–2/8	6	53.1	3	41.9					1	45.7	3	47.3			13	48.6			
VIII	2/9–2/15			4	43.4			1	51.5	3	45.4	5	45.9	1	45.2	14	44.8	45.8	± 6.45	4.17
IX	2/16–2/22			3	39.4	1	46.5	1	56.1	2	27.5	5	49.6			12	43.8			
X	2/23–3/1	2	45.0	2	57.7							2	61.4			6	54.7			

b. All Males

Week Number	Date	Thurs. N	Thurs. Mean ab-%	Fri. N	Fri. Mean ab-%	Sat. N	Sat. Mean abl%	Sun. N	Sun. Mean ab-%	Mon. N	Mon. Mean ab-%	Tues. N	Tues. Mean ab-%	Wed. N	Wed. Mean ab-%	For Each Week N	For Each Week Mean ab-%	For Each 3-week Period Mean ab-%	Range of Mean	Level of Significance in
I	12/22–12/28			4	27.2	1	18.3	1	43.1			2	24.4	3	34.9	11	29.4			
II	12/29–1/4	4	35.9	2	21.2	1	16.7					2	24.0	1	35.1	10	32.2	31.7	±6.85	8.68
III	1/5–1/11							2	39.8			1	35.3			3	38.3			
IV	1/12–1/18	1	36.6	1	53.4	2	34.6	2	52.7	6	43.9	1	38.6	4	40.9	17	43.0			
V	1/19–1/25	1	30.3	1	44.5	1	48.2	2	42.4	2	39.9	2	58.1	1	41.5	10	44.5	44.1	±2.04	1.86
VI	1/26–2/1	4	49.4	4	45.1	5	49.4			3	46.2	6	37.1			22	44.8			
VII	2/2–2/8	6	58.8	7	55.8	5	44.3	3	54.1	1	32.4			3	45.9	25	48.4			
VIII	2/9–2/15			15	44.4			2	67.4	7	51.3	9	48.3	3	54.1	36	48.3			
IX	2/16–2/22	4	47.6	6	35.6	13	40.2	13	38.3	12	46.3	10	41.8	10	39.7	68	40.5			
X	2/23–3/1	3	45.3	7	31.1	4	33.9	12	43.9	3	45.1	6	40.2	8	40.8	43	41.8			
XI	3/2–3/8	11	34.9	3	31.2											14	34.1			

c. Males caught after February 14, 1950: adjusted regarding the Migration by excluding the Individuals which arrived late to the Antarctic Ocean.

Week Number	Date	Thurs. N	Thurs. Mean ab-%	Fri. N	Fri. Mean ab-%	Sat. N	Sat. Mean ab-%	Sun. N	Sun. Mean ab-%	Mon. N	Mon. Mean ab-%	Tues. N	Tues. Mean ab-%	Wed. N	Wed. Mean ab-%	For Each Week N	For Each Week Mean ab-%	For Each 3-week Period Mean ab-%	Range of Mean	Level of Significance in
VII	2/2–2/8															25	48.4			
VIII	2/9–2/15											5	51.8	2	65.3	31	44.9	48.7	±2.56	2.12
IX	2/16–2/22	1	87.0	3	42.3	6	45.2	3	42.2	7	56.6	7	46.6	4	50.1	31	47.9			
X	2/23–3/1	1	63.0	2	40.6	3	40.7	7	46.1	1	52.8	4	48.4	4	48.3	22	48.4			
XI	3/2–3/8	3	46.9	1	35.7															

Table 4.
Formulae and Values of Calculation for Blue Whales.

Formula	(a) Values for Females			(b) Values for Males		
Σay	+83.5			+246.5		
Σay^2	5843.15			9658.29		
Σaxy	1795.19			4129.7		
$S_x=\Sigma a(x_i-\bar{x})^2$	834			2029		
$S_y=\Sigma a(y_i-\bar{y})^2$	5713.01			6589.49		
$B=\Sigma a(x_i-\bar{x})(y_i-\bar{y})$	1704.5			4083.7		
$\bar{y}=\Sigma ay/N$	+0.95			+1.34		
$\bar{x}=\Sigma ax/N$	+0.74			+1.96		
$N=\Sigma a$	87			198		
$B=C/S_x$	2.04			2.01		
A	41.0			43.4		
C^2/S_x	390.21	1	390.21	843.19	1	843.19
$\Delta=S_y-C^2/S_x$	5372.80	85	62.47	5746.30	196	29.12

Summary

In this study the periodic cycle of the sculptures on the baleen plates of whales were investigated. Through this investigation, it was intended to estimate the growth of the baleen plates and the time required to complete the interval zone between the successive two main sculptures.

The ab-percentage, namely, the percentage of the distance between the insertion of the baleen plates (into the gum) and the first main sculpture (as counted from the gum) to the distance between the first and the second main sculptures, was chosen as the index of the growth of the baleen plates.

It was found that the growth of the baleen plates can be expressed by the straight line which can be written

$$y=A+Bx$$

where x denotes the week number and y the weekly mean of ab-percentage, A and B being the constants. The constant B is the mean weekly growth rate of the baleen plates. The fifth week (January 19–25, 1950) of that whaling season which lasted for nine weeks from December 22, 1949 was taken as the origin for x, i. e., $x=0$ for that week. Consequently the constant A gives the mean accumulated growth of the baleen plates at the fifth week, in terms of ab-percentage.

Values of A and B were computed for each sex of fin and blue whales with the data of the measurements. Substituting these values in the foregoing formula, the following equations of the growth of the baleen plates were obtained:

for female fin whales: $y=48.4+1.97x$
for male fin whales: $y=44.8+2.04x$
for female blue whales: $y=41.0+2.04x$
and for male blue whales: $y=43.4+2.01x$

These equations were graphed together with the weekly and tri-weekly means of ab-percentage in Fig. 5.

From these equations it can be deduced that the nutrient of the whales is at the lowest level from late July to late August. This result is in line with the knowledges on the life history of whales so far obtained.

Also from the same equations the growth of baleen plates in each week is about 2% of their annual growth. This proves that the interval zone between the two successive main sculptures is formed in one year.

As to the migration, it was deduced that the fin whales arrive to the Antarctic whaling grounds earlier than the blue whales.

Now that the interval zone between the successive two main sculptures on the baleen plates is proved to correspond to the annual growth of the baleen plates, and these sculptures can be utilized as the age marks in the studies on such various important biological charactors

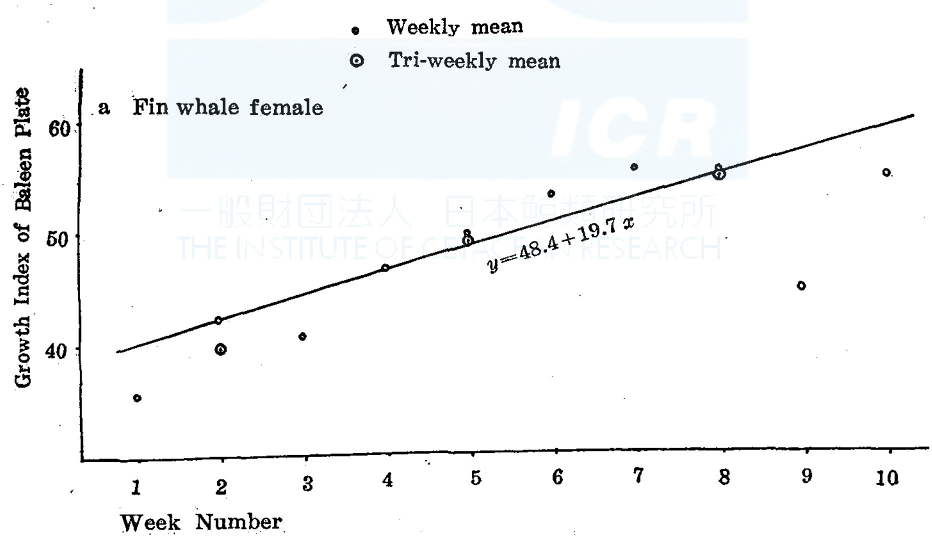

Fig. 5 a. Growth Index of Baleen Plate.

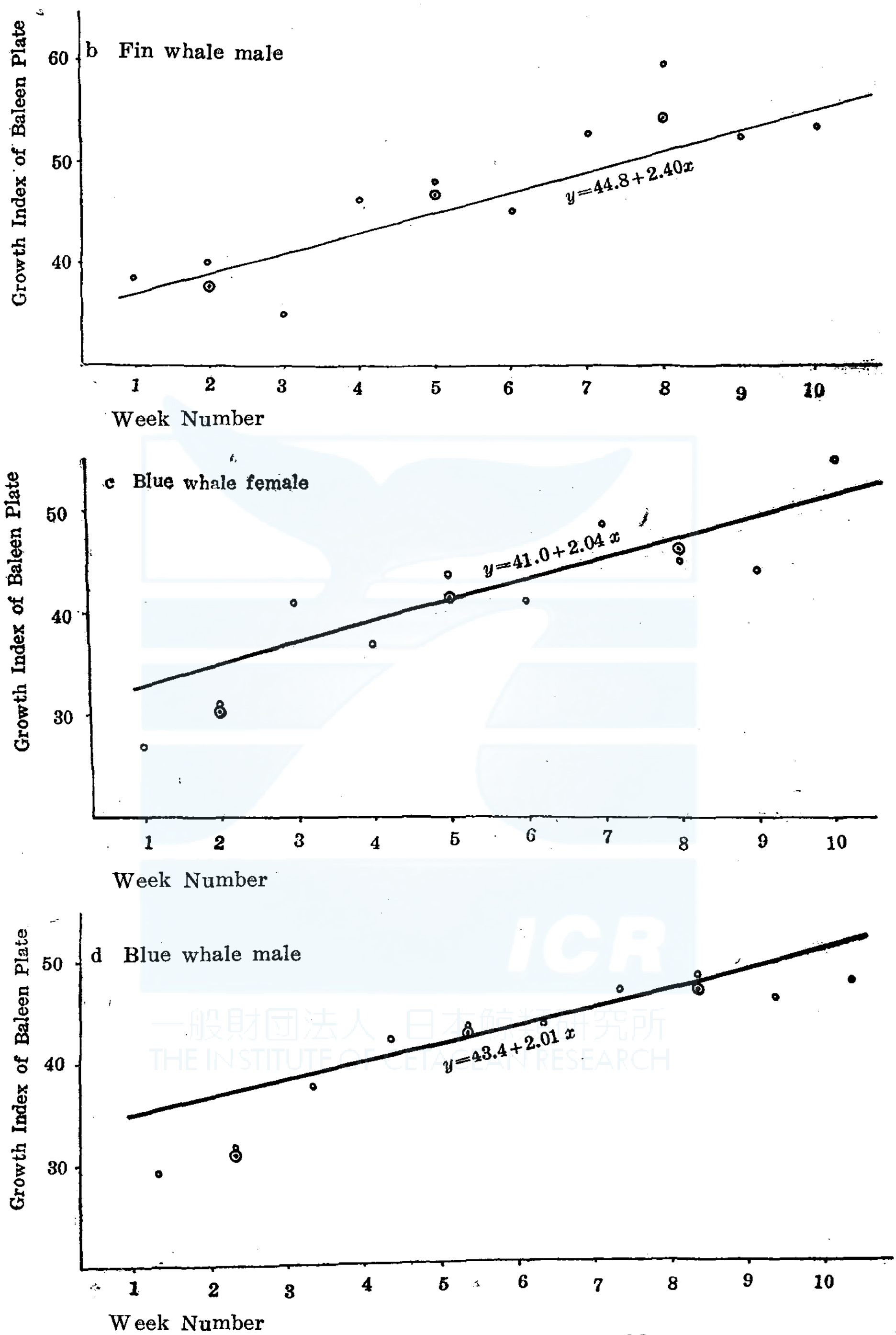

Fig. 5 b c d. Growth Index of Baleen Plate.

of the whales, as the age at sexual maturity, the number of ovulation in each breeding season, and many others.

Accordingly, the investigation on these sculptures seems to be an effective and essential tool for the study of the life history of Mystacoceti. These prospects will be examined in the following reports. Here the discussion will be confined to the conclusion reached in the present study.

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