On the Age-Determination of Mystacoceti, Chiefly Blue and Fin Whales

By
Masaharu Nishiwaki

(Received October 9, 1951)

CONTENTS

Introduction

Because of its bearing on the conservation of whale resources, the problem of age and growth of Mystacoceti (whalebone whales) has been studied by many workers, and the results applied to clarification of the life history and analysis of the stock of these whales. Until very recently, however, studies of this sort had a fundamental limitation, i.e. the lack of an adequate method to determine the age of an individual whale exactly.

Seeking for such a method, both A. G. Tomilin of USSR and a group of Norwegian scientists led by J. T. Ruud (1940) came around 1940 independently to the same preliminary result that it might be possible to estimate the age of an individual whalebone whale on the basis of the surface structure of its baleen plates. Through further investigations with the material from the Norwegian and Antarctic waters, Ruud and his collaborators have nearly established a new method of age determination of whalebone whales (Ruud, 1945), and particularly of blue whales (Ruud, 1950 & Ruud et al, 1950). This method is based on the theory that the main sculptures (or the "transverse stripings") found on the surface of a baleen plate demarcate the annual growths of the plate. Though a variety of indirect evidences were accumulated in support of this theory, a direct proof had not been given prior to my work (Nishiwaki, 1950 c) which was submitted for publication in December 1950. In fact, Ruud (1950) called this theory a "working

hypothesis" in an article published in June 1950 and stated as follows: "There can hardly remain any doubt therefore that the number of growth periods in the baleens depends on the age of the animals, but it is not proved thereby that the periods are annual." (Op. cit., p. 3)

Since Japan resumed her participation in the Antarctic pelagic whaling in the 1946–47 season after an interruption due to the World War II, I have been studying the life history of southern blue and fin whales with special references to age and sexual maturity, the factors most intimately connected with the conservation of whale stocks. In the age studies I have followed two different approaches, namely measurement of the colouration of the crystalline lens and examination of the surface structure of baleen plates.

In the first approach I (Nishiwaki, 1950 a) have shown that the degree of colouration of the crystalline lens is very closely correlated to the length of the whale as well as to other age data such as the number of corpora lutea, the weight of testes, and sexual and physical maturity. It was therefore concluded that this factor can be utilized as a measure of the age, provided that its relation to the true age of whale be successfully formulated.

I began my study of baleen plates being stimulated by Ruud's work (1940), in which the author reported a new apparatus to record on a sheet of paper an amplified image of the system of the transversal ridges and hollows in the cortical layer of baleen plates, and termed the recorded image the "baleen record". With a similar apparatus I also prepared baleen records, and the results of my observation on them have generally agreed with Ruud's findings.

Furthermore, I (Ibid., 1950 c) have proved with a considerable success that the part[1] of a baleen plate demarcated by two successive main sculptures corresponds to the annual growth of the plate, and thus justified the theory underlying the new method of age determination by means of the baleen record reading. Other possible approach to the proof of this theory may lie either in marking suckling calves,

1) The terminology for this item was not consistent in my previous studies: in the first report (Nishiwaki, 1949 c) it was termed the "period", "periodic cycle" or "cycle" on the baleen plates, and the "periodic cycle of the sculptures" or the "interval zone between the two successive main sculptures" in the second report (Ibid., 1950 c). Ruud (1940 & 1945) have termed it the "growth level" in the case of the baleen plates of fin whales and the "growth period" for both blue and fin whales. In following discussions I shall consistently use the "growth period" after Ruud because of the relevancy of the term and for the purpose of preventing a confusion due to arbitrary terminologies.

as suggested by Ruud (1950, p. 2), or in rearing, if possible at all, and observing a whale for a certain length of time.

In the present study I attempt to synthesize the results of my previous studies on the age and growth of Mystacoceti and to develop such overall and thorough-going discussions on the life history of these whales as were not possible in my earlier works partly because of the limited scope of these studies and partly for the lack of reliable method of age determination.

After the first manuscript of this paper was written up in December 1950, Dr. N. A. Mackintosh and Dr. J. T. Ruud kindly granted me current bibliographies and informed me of their recent progresses in this field. With these informations I made minor revisions of the manuscript. But the principal parts of the present work have been kept as it was first prepared.

I would like to acknowledge most gratefully the kindness shown by Dr. N. A. Mackintosh and Dr. J. T. Ruud. My sincere thanks are also due to the Japan Whaling Association for supplying a part of the research fund for this study, and to the Taiyo Fishing Co., Ltd., the Japan Marine Products Co., Ltd., and the government inspectors of the Fisheries Agency, Ministry of Agriculture and Forestry for cooperation in the collection of the material. Finally, I wish to acknowledge my indebtness to Dr. Ikusaku Amemiya, Dr. Hideo Omura and Dr. Yoshio Hiyama for their invaluable advice on the preparation of the manuscript.

Chapter I

Material

The data serving as the material for this study are all taken from my previous papers (cf. References), with the exception of a few unpublished data concerning the colouration of crystalline lenses of foetuses. They include the results of general surveys and special studies on the southern blue and fin whales caught by the Japanese Antarctic whaling expeditions in the four seasons 1946–47 through 1949–50. Though my original studies mentioned above covered also the southern humpback whale and the fin, sei and humpback whales from Japanese waters, they are not included in this study, because the data on southern humpbacks are too scanty and those on the whales from Japanese waters are to be analyzed in a separate work.

In each of the four seasons, with which the material of this study is concerned, Japan sent two whaling fleets which nearly matched each

other in strength as well as in amount of actual catch. And the data to be analyzed in this study cover at least the whole catch by one fleet, they may well be regarded as a representative sample of the Japanese catch in respective the seasons.

The question whether the present material can be considered as a representative sample of total Antarctic pelagic catch in the respective seasons must be answered on the basis of a statistical comparison between the size compositions of the two groups. For reference purposes, the length frequencies of the blue and fin whales taken in seasons 1946–47 to 1949–50 by Japanese fleets and all Antarctic pelagic expeditions are given in the Appendix. The figures concerning the total Antarctic pelagic catch are based on the International Whaling Statistics.

Chapter II

The Age of the Female Whale at Sexual Maturity as Determined by the Number of Growth Periods in its Baleen Plates

In my first study on the age determination of whales by means of baleen record reading (Nishiwaki, 1949c, p. 169), I pointed out that the data strongly suggested that the females of the southern blue whale should attain sexual maturity at the age between 5 and 6 years and those of the southern fin whale at the age of 4 years. But I was prevented from advancing any decisive conclusion in this respect by the lack of a proof that each growth period in a baleen plate represents the annual growth of the plate. This study deals with the major part of the blue and fin whales caught by the Hashidate-maru fleet in the 1948–49 season.

In my second study on the same topic (Nishiwaki, 1950c) I proved successfully that each growth period in the baleen plates of the southern blue and fin whales is completed annually. The material for this study consists of the baleen plates of the blue and fin whales taken by the same fleet in the 1949–50 season. Now that this proof has been given, it seems appropriate to discuss again on the age at which these whales reach their sexual maturity.

All female blue and fin whales investigated in the previous two studies again serve as the material for the analysis. In Fig. 1-a and -b is plotted the number of corpora lutea of each of these whales against the age of the whale as determined on the basis of the number of growth periods found in the baleen plates, for blue and fin whales separately.

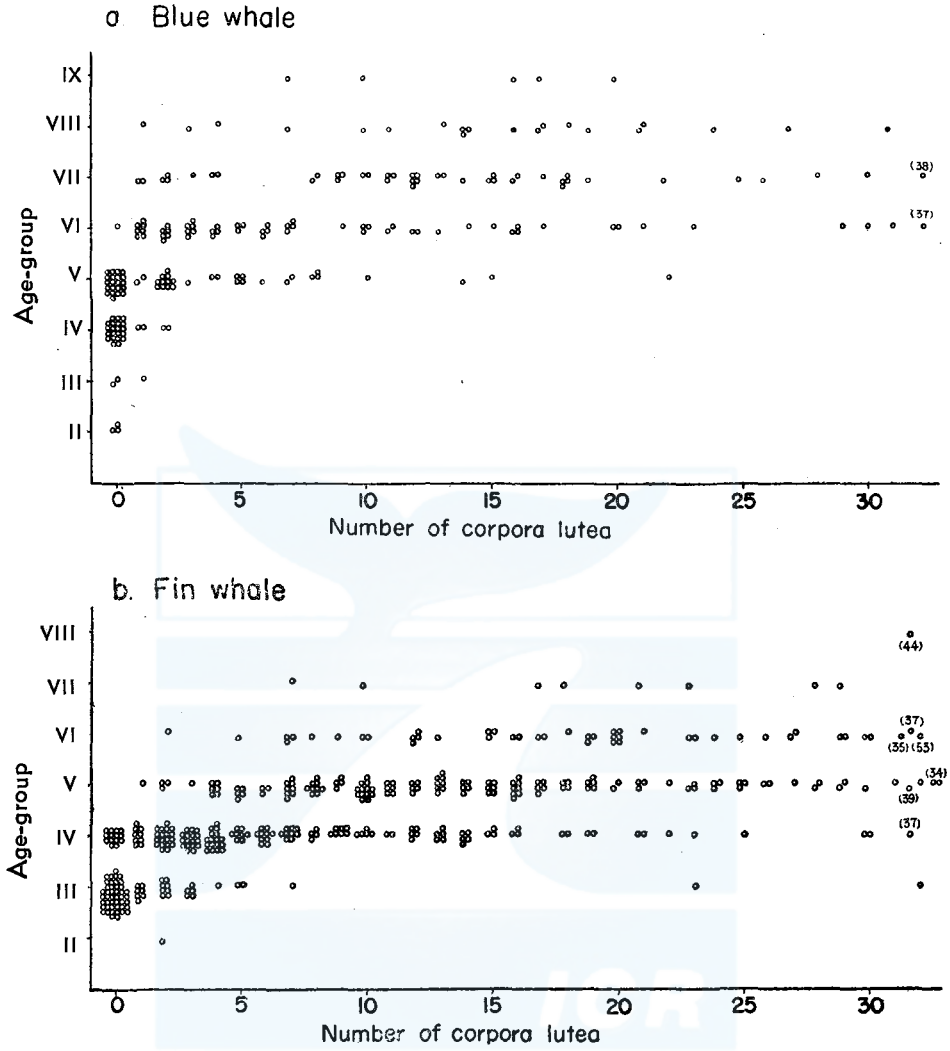

Fig. 1. Number of Corpera lutea and Age-group.

Before proceeding further, mention should be made of the definition of the "age of a whale" as employed in following discussions. According to my last study (Op. cit.) a main sculpture is formed on the baleen plates of a southern blue or fin whale annually, and emerges out of the gum about July and August to be recognized in baleen records. It is therefore at this time of the year that a new growth period is completed in the baleen record. It has been generally accepted, on the other hand, that the calves of these whales are born mostly during the season of the year centering in June. It then follows

that the baleen records of the southern blue and fin whales, if taken in August, should usually consist of as many complete growth periods as the approximate age of the whale expressed in years. During the Antarctic whaling season extending from December to next March the whales must be some years plus 6 to 9 months old, and, provided that the tips of the baleen plates are not worn significantly, their baleen records must consist of as many complete growth periods as the number of full years in their age and another growth period that is still forming. Alternatively, if a whale caught during an Antarctic season gives a baleen record comprising n growth periods including one forming period, it may be correctly inferred that its age should be (n-1) years plus 6 to 9 months, provided that its baleen plates are not worn significantly at the tip. In case that this wear is heavy, however, the whale may be older than that above inferred. Therefore, (n-1) years and 6 to 9 months is the minimum probable age for a whale showing a total of n growth periods in the baleen record.

When the baleen records were read in my previous studies, merely the number of actually existing growth periods was counted without trying to determine the extent of the wear at the tip of the plates, because it was not feasible to carry out such a determination on every examined baleen plate. The minimum probable age of the whale estimated from these data according to the formula described in last paragraph is termed the age of the whale in this study. For example, if 6 growth periods are found in the baleen record of a female whale including one forming period, the whale is regarded as being $5^1/_2$ to $5^3/_4$ year old when hunted regardless of the extent of the wear of the baleen plate, and is assigned to the age group V in Table 1. The age group V refers to animals of ages between 5 and 6 years.

The data presented in Fig. 1-a and -b are respectively summarized in Table 1-a and -b so as to show the number and percentage of sexaully mature females in different age groups. The same percentage for the 1948–49 and 1949–50 seasons combined, which appears in the last column of the tables, is plotted in Fig. 2-a and -b respectively for the blue and fin whales.

Table 1 and Fig. 2 indicate that 75% of the females of the southern blue whale has reached sexual maturity in the sixth year (age group V) of their life, and the same percentage of the females of the southern fin whale in their fifth year (age group IV) of life. Therefore, are considered the majority of the females of the southern blue and fin whales to ovulate and conceive for the first time respectively in their sixth and fifth year of life.

Table 1-a Number and Percentage of Sexually Mature Animals in the Catch of Female Blue Whales

Age group(1)	Number of growth periods in the baleen-record	Season				Total	
		1948-49		1949-50			
		Number	Percent	Number	Percent	Number	Percent
III	4	0	0.0	1	50.0(2)	1	33.3(2)
IV	5	1	9.1	4	26.7	5	20.0
V	6	15	53.5	15	65.2	30	58.8
VI	7	27	100.0	30	96.8	57	98.3
VII	8	21	100.0	32	100.0	43	100.0

Note: (1) Whales have been assigned to the minimum probable age. Since southern blue and fin whales are born mostly around June and caught between December and March, and each growth period in their baleenplates represents one year in their life, the animals showing 5 growth periods in their baleen-records, for example, must have been about $4^1/_2$ to $4^3/_4$ year old when hunted, provided that the wear of the tips of the baleen plates was not significant. Accordingly, these whales have been assigned to age group IV, though they may prove to have been older if the wear of baleen plates is taken into account.

(2) These figures seem too high to be accepted as an estimate of the value for the stock. Probably, the lengths of female blue whales seldom exceed the size limit of 70 ft., and this causes a tendency that only a few fast-growing individuals are caught and a high percentage of sexual maturity results.

Table 1-b Number and Percentage of Sexually Mature Animals in the Catch of Female Fin Whales

Age group(1)	Number of growth periods in the baleen-record	Season				Total	
		1948-49		1949-50			
		Number	Percent	Number	Percent	Number	Percent
II	3	1(2)	100.0(3)	0	0.0	1	100.0(3)
III	4	13	32.5	13	50.0	26	39.4
IV	5	51	87.7	89	91.8	140	90.9
V	6	74	100.0	41	97.6	115	99.1
VI	7	36	100.0	10	100.0	46	100.0
VII	8	7	100.0	1	100.0	8	100.0

Note: (1) Whales have been assigned to the minimum age without considering the wear of the tips of the baleen plates. See the footnote (1) of Table 1-a for details.

(2) This specimen, in its third year after birth, already had two corpora lutea in the ovaries.

(3) These figures are too high to be accepted as an estimate of the value for the stock, and it is inferred, as in the case of female blue whales, that females of southern fin whales seldom exceed the size limit of 55 ft. at this age.

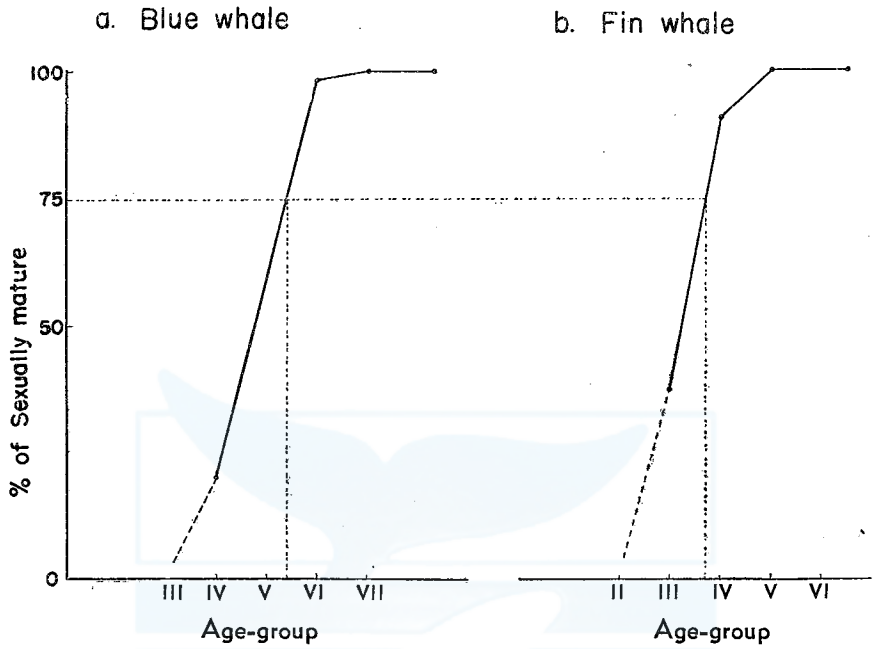

Fig. 2. Percentage of Sexual Maturity in Female Whale according to Age-group.

But the data also indicate that the minor part of the whales attain sexual maturity at younger or older ages than stated above. Of the three female blue whales belonging to the age group III in Table 1-a, one was found to be sexually mature with one corpus luteum in the ovary. And the single female fin whale belonging to the age group II in Table 1-b was sexually mature with two corpora lutea. The latter example will be cited again in Chapter V.

One would notice that Table 1 gives very high values of percentage of sexually mature females for the foregoing two age groups. And it does not seem that these values can be accepted as the estimates for the true values in the stocks of southern blue and fin whales. Perhaps, such unduly high values of percentage of sexual maturity are due partly to the variation inherent in small samples and partly to the tendency on the part of gunners to hunt larger whales. As is indicated by the scarce catch of female blue whales of the age group III and female fin whales of the age group II, the majority of the females

of the southern blue and fin whales are probably below or not much above the size limits. Such being the case, the gunners' efforts to prevent violating the size regulations must result in a tendency that only the exceedingly fast-growing individuals are caught at these age levels. It is very probable that in such individuals the sexual development, as well as the physical growth, is accomplished much earlier than in the average individuals, for a number of such examples are known in terrestrial mammals.

Table 1 and Fig. 2 indicate also that a minor part of the females of the southern blue and fin whales are still immature respectively in their seventh and sixth year, though the majority of them attain sexual maturity respectively in the sixth and fifth year of their life.

It is noteworthy that the foregoing analysis shows that the majority of the females of the southern blue and fin whales respectively attain sexual maturity in the sixth and fifth year of their life, instead of in the third year as has been generally accepted. Ruud and his colleagues (Ruud et al, 1950), however, have already reached the same result regarding the age at which females of the southern blue whale attain sexual maturity with the catch by Norwegian fleets in the 1945–46 to 1947–48 seasons as the material. It is particularly interesting that the percentages of sexually mature females in different age group obtained by Ruud et al (Op. cit., Table 7) agree quite well with the corresponding figures in Table 1-a of this work.

Chapter III

The Colouration of the Crystalline Lens of the Sexually Immature Female

Crystalline lenses of blue and fin whales are usually coloured more or less in yellow, though some of them are colourless. And it is believed that this colour, ranging from slight yellow to deep yellow, is due to the pigment which is incessantly deposited in the lens during the life of the whale.

In the 1948–49 season I (Nishiwaki, 1950 a) measured the degree of colouration upon the crystalline lenses from 288 blue and 419 fin whales taken by the Hashidate-maru fleet. The measurement was made on board the floating factory by means of a photocell-ammetertype photometer expressly designed for this purpose. The percentage of

the incident light absorbed by a crystalline lens was read on the ammeter. This, after being adjusted in respect to various errors, was termed the degree of colouration of the crystalline lens. Accordingly, the stronger was a lens coloured, the larger value of the degree of colouration resulted.

The analysis of the results of the measurement showed that the degree of colouration of the crystalline lens was closely correlated to the length of the whale, the number of corpora lutea and the weight of testes. This suggests that the colouration of the crystalline lens progresses at an approximately constant rate throughout the life of a whale, and that the degree of the colouration can be utilized as a measure of the age of whales.

In the same study females of the blue and fin whales were classified according to the degree of the colouration of the crystalline lens. In each class the percentage of sexually mature females was computed. By plotting this percentage against the degree of colouration of the crystalline lens, curves analogous to those in Fig. 2-a and -b were obtained for the blue and fin whales separately (Op. cit., Fig. 22). These curves indicate that 75% of the female blue and fin whales are sexually mature when the degree of colouration of their crystalline lens respectively reaches 9.5% and 8.7%.

The next problem is how to estimate the degree of colouration of the crystalline lens immediately after the birth of the whale. Though it is most desirable to have fresh samples of crystalline lenses of very young calves soon after birth, such calves are not caught under existing conditions of the whaling operations. Large foetuses may serve as the substitute to a certain extent. During the 1948–49 season I had opportunities of measuring the colouration of crystalline lenses of two large blue whale foetuses. These foetuses were 21 ft. 6 in. and 18 ft. 10 in. long, and their crystalline lens gave the degree of coloration of 4.7% and 4.4%.

The crystalline lens of a foetus differs from that of a young calf particularly in that blood vessels are distributed over its surface as well as through its center. As these blood vessels will have been lost before the calf acquires sight, a crystalline lens of a foetus is likely to absorb more light and consequently give a larger value of degree of colouration than that of a young calf. In addition, the degree of colouration of the crystalline lens of a young blue whale calf may differ from that of a young fin whale calf. Yet I propose to adopt 4.5%, the average for the two blue whale foetuses, as an approximate estimate

for the degree of colouration of the crystalline lens in very young calves of the blue and fin whales.

Then it can be concluded that the degree of colouration of the crystalline lens of a sexually immature female blue whale increases from about 4.5% at the birth to about 9.5% at the attainment of sexual maturity and the same of a sexually immature female fin whale from about 4.5% at the birth upto about 8.7% at sexual maturity.

Chapter IV

The Frequency of Ovulation

Though the frequency of ovulation in southern blue and fin whales has been investigated by several authors, their results do not agree perfectly with each other. According to Laurie (1937) the average number of ova discharged by a female of the southern blue whale is 1.91 for the first year of sexual maturity and 1.13 for every following year. Peters (1939) considered a female of the southern blue and fin whales to shed not more than two ova during every two year period following the attainment of sexual maturity, while Wheeler (1930) estimated that a female of the sourthern fin whale will discharge 4 to 5 ova during the same period.

In this chapter I intend to describe a new method of estimating the frequency of ovulation in the southern blue and fin whales in which the result of my study on the colouration of crystalline lenses is incorporated. As has been shown in Chapter II of the present paper, it may be correctly deduced that the majority of the females of the southern blue whale attain sexual maturity in their sixth year of life and those of the southern fin whale in their fifth year, assuming that the investigated baleen plates are not worn significantly. In Chapter III it has been shown that the increase in the degree of colouration of the crystalline lens during the period from the birth to the attainment of sexual maturity is about 5.0% and 4.2% respectively in the females of the southern blue and fin whales. If we postulate an approximately constant increase of the degree of colouration of the crystalline lens during this period of whale's life, the average annual increment is given by the simple division:

$5.0\% \div 5.75 = 0.87\%$ per year for sexually immature blue whales,
and $4.2\% \div 4.75 = 0.88\%$ per year for sexually immature fin whales.

In my study on the 1948–49 catch (Nishiwaki, 1950a) I showed that

the increase in the degree of colouration of the crystalline lens during the period between the attainments of sexual and physical maturity was about 5.3% in female blue whales and about 5.5% in female fin whales, and that the average increase in the number of corpora lutea during the same period was 10.0 and 9.5 respectively in the females of the blue and fin whale. If it is assumed that the degree of colouration of the crystalline lens continues to increase at the same constant rate during this period as prior to the attainment of sexual maturity, the approximate length of this period is 6 years for either species,

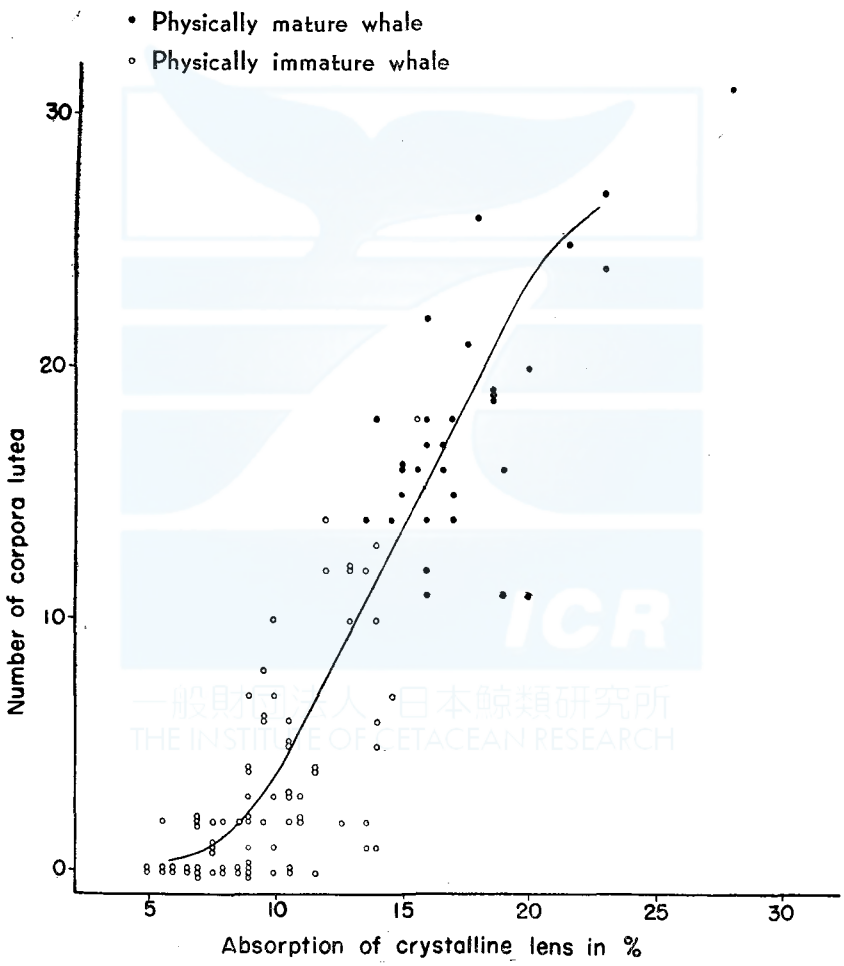

Fig. 3a. Number of Corpora Lutea and the Degree of Lenticular Colouration. (Blue whale female)

by dividing the increase in the degree of colouration during this period by the annual average increment determined in the foregoing paragraph.

By dividing the average increase in the number of corpora lutea during the period between the attainments of sexual and physical

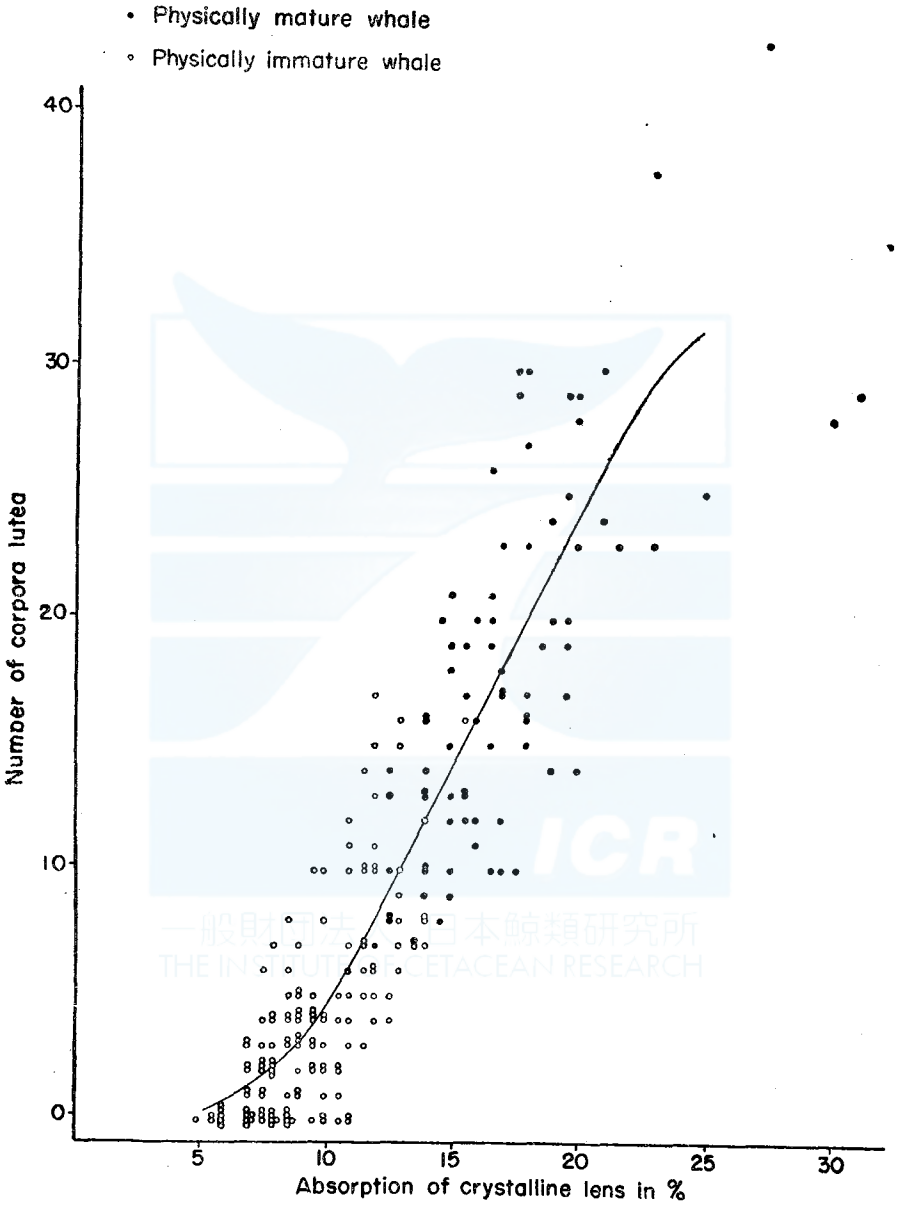

Fig. 3 b. Number of Corpora Lutea and the Degree of Lenticular Colouration. (Fin whale female)

maturity, 10.0 for the blue whale and 9.5 for the fin whale, by the length of the period, 6 years, we obtain 1.64 for the blue whale and 1.52 for the fin whale as the average number of ova discharged by a female whale per year.

If the foregoing estimates for the frequency for ovulation in the southern blue and fin whales are correct, it is inferred that a large part of the females of these whales should discharge two ova in the first year of sexual maturity. Such being the case, it does not seem unreasonable that one of the female fin whales listed in Table 1-b should have had two corpora lutea at the age of approximately $2^3/_4$ years and probably in the first year of sexual maturity.

Futher details basic to the foregoing discussions, e.g. the method to determine the physical maturity, appear in my original study (Op. cit.), of which the graphs showing the correlation between the colouration of the crystalline lens and the number of corpora lutea (Op. cit., Fig. 13 and 14) are reproduced in Figs. 3-a and -b because of their importance.

Chapter V

The Age of the Male Whale at Sexual and Physical Maturity

It is easy to determine whether a female whale is sexually mature or not, for this is accomplished by merely examining its ovaries for the presence of any corpora lutea. But there is much difficulty in the case of the male. The direct and probably most reliable method to determine the sexual maturity in the male whale consists in examining the testes histologically for the presence of spermatozoa or other evidences related to spermatogenesis. As this method is laborious, those indirect but easier methods are usually used, in which whales are classified into sexually mature and immature groups on the basis of the size of testes, the length of the whale or the like.

In recent years I have been using the weight of both testes combined as a criterion in determining the sexual maturity in the males of southern blue and fin whales. According to this method a blue whale showing the testes-weight of 10.0 kg. or more and a fin whale with the testes weighing 5.0 kg. or more are regarded as sexually mature. The usefulness of this criterion for southern blue whales has lately been confirmed by Norwegian scientists (Ruud et al, 1950, p. 33), though it was also pointed out at the same time that the weight of

testes varies considerably in the male blue whales at attainment of sexual maturity.

Data on both the age and the sexual maturity are available for the major part of the male blue and fin whales caught by the Hashidate-maru fleet in the 1948–49 and 1949–50 seasons (Nishiwaki, 1949c & 1950c). In these data the age has been estimated from baleen records according to the formula described in Chapter II and the sexual maturity determined by the testes-weight method described above. The data are broken down into age groups, for each of which the number and percentage of sexually mature males are computed (Fig. 4-a, -b and Table 2-a, -b). The percentages of mature males for the two combined seasons are plotted in Fig. 5-a and -b respectively for blue and fin whales. In both figures plots are connected by strait lines to yield curves.

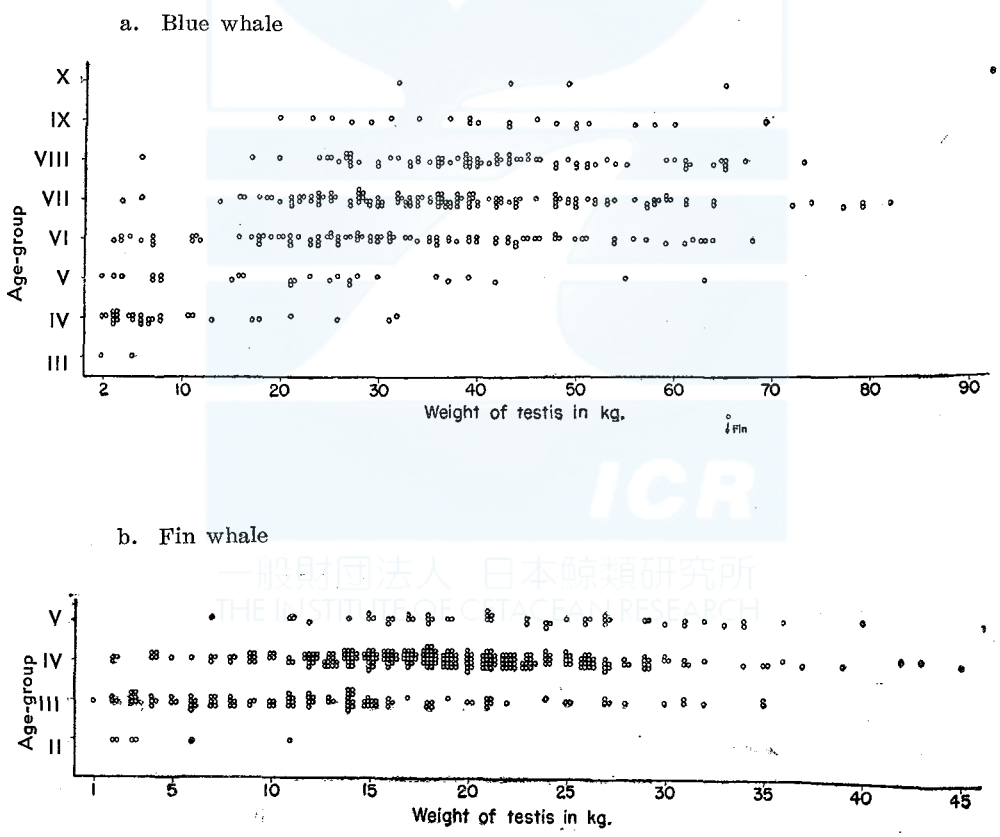

Fig. 4. Weight of Testes and Age-group.

Table 2-a Number and Percentage of Sexually Mature Animals in the Catch of Male Blue Whales

Age group(1)	Number of growth periods in the baleen record	Season				Total	
		1948-49		1949-50			
		Number	Percent	Number	Percent	Number	Percent
III	4	0	0.0	0	0.0	0	0.0
IV	5	5	33.3	4	28.6	9	31.0
V	6	9	81.8	10	33.3	19	73.1
VI	7	31	88.6	54	94.7	85	92.4
VII	8	64	100.0	65	98.5	129	99.2
VIII	9	43	100.0	39	97.5	82	98.8
IX	10	13	100.0	9	100.0	22	100.0

Note: (1) Whales have been assigned to the minimum probable age without considering the wear of the tips of baleen plates. See the footnote (1) of Table 1-a for details.

Table 2-b Number and Percentage of Sexually Mature Animals in the Catch of Male Fin Whales

Age group(1)	Number of growth periods in the baleen record	Season				Total	
		1948-49		1949-50			
		Number	Percent	Number	Percent	Number	Percent
II	3	2	33.3	0	0.0	2	33.3
III	4	63	86.3	27	79.4	90	84.1
IV	5	104	99.0	148	95.5	252	96.9
V	6	14	100.0	36	100.0	50	100.0

Note: See the footnote (1) of Table 2-a and 1-a.

Table 2-a and Fig. 5-a shows that more than 75% of male blue whales are already sexually mature in the sixth year of life, i.e. at the same age as the females, though there is a slight indication that males of this species attain sexual maturity at a little younger age than the females, when these table and figure are compared with Table 1-a and Fig. 2-a. Table 2-b and Fig. 5-b indicate that more than 75% of male fin whales are sexually mature in the fourth year of life, i.e. one year earlier than the females of the species. Consequently, we may consider the majority of male blue whales to be sexually mature at the age of about $5^3/_4$ years and the majority of male fin whales at the age of about $3^3/_4$ years.

In my previous study I (Nishiwaki, 1950a) showed that the degree

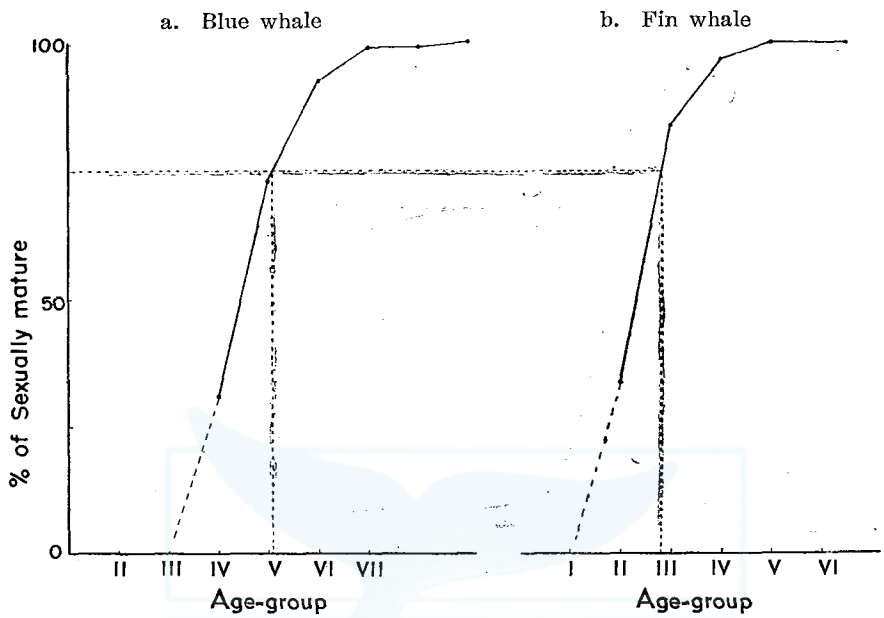

Fig. 5. Percentage of Sexual Maturity in Male Whale according to Age-group.

of colouration of the crystalline lens averages about 8.8% in male blue whales and about 8.2% in male fin whales at the attainment of sexual maturity. Assuming that the value of this factor is 4.5% at birth in both species as in the case of females in Chapter III, the increase during the period from birth to the attainment of sexual maturity is 4.3% in male blue whales and 3.7% in male fin whales. If it is assumed that this increase has taken place at an approximately constant rate throughout the period, the average annual increment is:

$4.3\% \div 5.75 = 0.75\%$ per year for sexually immature male blue whales,

and $3.7\% \div 3.75 = 0.98\%$ per year for sexually immature male fin whales.

These values differ from the corresponding values for females obtained in Chapter IV by about 0.1%. Then, it may be that the rate of increase of the degree of colouration of the crystalline lens differs according to sexes and species. But it is also likely that the difference of this magnitude can not be considered as significantly great, because a variation of this magnitude will easily result from a slight change in the value of the basic data to be involved in the foregoing equations.

In this connection we must consider the difference between the methods of determining sexual maturity in the two sexes of these whales.

In the case of females, with the approach of the sexual maturity approaching, ova are formed and gradually grow in the ovary. But the animal is not regarded as sexually mature until the ovum is shed in the first ovulation and the corpus luteum formed. It is well established that in southern blue and fin whales the ovulation takes place, with minor exceptions, during a limited season of the year, namely the pairing or the breeding season extending from June through August. As shown in Chapter II, the first ovulation generally takes place during the pairing season following the fifth birthday in female blue whales, and in the pairing season following the fourth birthday in female fin whales.

As the sexual maturity approaches in males, spermatozoa are formed and grow through metamorphosis in the testes, perhaps as gradually as the ova in ovaries of females. But, such a seasonal phenomenon as the ovulation is not known in the genital physiology of the male whale. And so, a male whale is usually regarded as sexually mature so long as spermatozoa are found in its testis, regardless of the extent of their development and whether coition or ejaculation has taken place or not. It is in this point that the method of determining sexual maturity in male whales primarily differs from the method for the females. Hence, it is to be expected that in male whales sexual maturity can be determined only less exactly than in females even by the direct method, i.e. the histological examination of testes, and also that the result of the determination will be such that suggests as if males attained sexual maturity earlier than females, even when both sexes really reach sexual maturity (i.e. the ovulation in females and, in males, the development of spermatozoa to a stage corresponding to the ovum at ovulation) at the same average age.

Moreover it is inevitable that additional disturbing factors will come into effect to reduce the exactness and reliability of the estimate of sexual maturity in males if the determination is made by such indirect methods as to employ testes-size or testes-weight as the criterion. Therefore, there is hardly any doubt that the estimated age at which male whales attain sexual maturity is less reliable than the similar estimate for females. Accordingly the data in Table 2 and the estimates of annual increment of the degree of colouration of the crystalline lens for males which are partly based on these data are less reliable than the data in Table 1 and the corresponding estimates for females.

Such being the case, I propose to use the estimates of the annual increment in the degree of colouration of the crystalline lens for females instead of the same estimates for males in estimating the age of males

at sexual maturity. Then, this age in question is given as follows:

4.3% ÷ 0.87% = 4.94 years for male blue whales,

and 3.7% ÷ 0.88% = 4.2 years for male fin whales.

This result, indicating that males attain sexual maturity about half a year earlier than females, coincides with the foregoing expectation that the estimated age of males at sexual maturity should be smaller than that for females. Following facts also suggests that one may accept this result. As sexual maturity has been determined with a high degree of reliability in female whales, the estimated annual increments of the degree of colouration of the crystalline lens for this sex (p. 97) are considerably reliable. These estimates, however, differ from the corresponding estimates for males by about 0.1%. This difference is not to be considered as significantly great, because a variation of this magnitude will be easily brought about by a slight shift in the boundary level of the testes-weight separating sexually mature males from immature. Therefore, one may consider that males of the southern blue and fin whales respectively attain sexual maturity at the average ages of about 5 and 4 years.

It was also shown in my previous study (Op. cit.) that the increase in the degree of colouration of the crystalline lens during the period from sexual maturity to physical maturity is 5.2% in male blue whales and 5.3% in male fin whales. Dividing these by the estimated annual increment of this factor in females, the length of this period is estimated at about 6 years for the males of both species, which is a little shorter than in the case of females.

Chapter VI

Average Length of the Whale at Different Ages

In my previous study (Nishiwaki, 1950a) it was shown that the degree of colouration of the crystalline lens was very closely correlated to the length of the whale as well as to such other age evidences as the number of corpora lutea, the weight of testes, and sexual and physical maturity in the southern blue and fin whales caught in the 1948–49 season, and the conclusion was advanced that this factor is most likely to increase exactly with the age in these whales and can be utilized as a measure of the age. In the foregoing two chapters the annual increment of this factor has been estimated at about 0.8% for both sexes of these whales. Therefore, it is now possible to determine the average lengths of these whales at various ages on the basis

of those curves showing the average lengths of the whale at various levels of the degree of colouration of the crystalline lens which were presented in Figs. 5 and 6 of the aforementioned study (Nishiwaki, 1950a). These figures are reproduced in Figs. 6-a and -b.

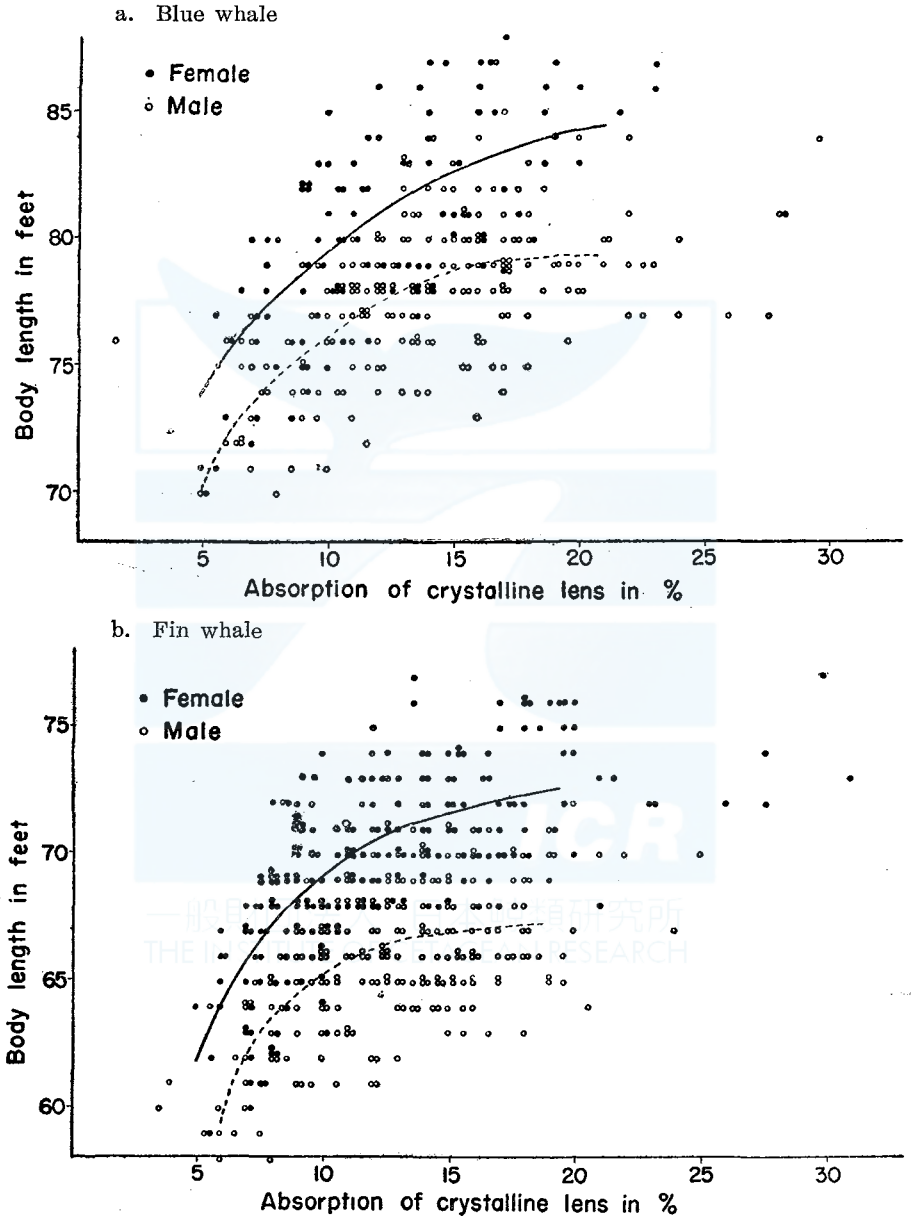

Fig. 6. Body Length and the Degree of Lenticular Colouration.

In the material upon which these curves are based, the average length of the whale at sexual maturity was determined as follows (Op. cit., p. 160):

Blue whale, male: 74.9 Eng. ft., female: 79.1 Eng. ft.

Fin whale, male: 63.5 Eng. ft., female: 67.8 Eng. ft.

From Chapter II and V of the present paper, blue and fin whales attain sexual maturity in the sixth and fifth year of life respectively. Hence, it is possible to express the scale of the abscissa of Figs. 6-a and -b in terms of the age of the whale instead of the degree of colouration of the crystalline lens. By doing so, the average lengths of the whale at different ages are read from the curves and tabulated in Table 3.

Table 3. Average Length of the Whale at Different Ages (Expressed in English feet)

Age group	III	IV	V	VI	VII	VIII	IX	X	XI
Approximate age (in years)	$3^3/_4$	$4^3/_4$	$5^3/_4$	$6^3/_4$	$7^3/_4$	$8^3/_4$	$9^3/_4$	$10^3/_4$	$11^3/_4$
Blue whale male	73.2	74.2	74.9	75.6	76.2	76.8	77.4	78.0	78.5
Blue whale female	77.0	78.1	79.1	79.9	80.6	81.3	81.8	82.2	82.6
Fin whale male	62.2	63.5	64.4	65.2	65.7	66.1	66.4	66.6	66.8
Fin whale female	67.0	67.8	68.7	69.5	70.1	70.6	71.0	71.3	71.5

It should be mentioned that this table gives unduly large average lengths for younger age groups. This is explained as the influence of the size limit. In other words, whales are not much larger at these ages than the size limits set forth by the International Whaling Conventions, and the catch of these age groups consisted of a small number of those fastgrowing individuals which were relatively large at respective ages.

It is well established that weaning blue whale calves measure about 53 Eng. ft. in length. Therefore, the increase in length from weaning to attainment of sexual maturity is 22 to 25 Eng. ft. in this species. Table 3 indicates that this increase takes place during about 4 years, i.e. an average increase of 5 to 6 Eng. ft. per year. This seems more reasonable than to consider the whole increase to take place during one and a half years as suggested in the conventional theory.

Chapter VII

Conclusions

The conclusions reached in the foregoing chapters are summarized as follows.

From the evidences derived from the study of the surface structure of baleen plates the age at attainment of sexual maturity has been estimated. Females of the blue whale reach sexual maturity in the pairing season following the fifth birthday, and the males at the age of about four and a half years, or somewhat earlier than the females. In the case of the fin whale, females attain sexual maturity in the pairing season following the fourth birthday and males at the age of about three and a half years.

This result entirely differ from the conventional theories proposed by Mackintosh & Wheeler (1929), Laurie (1937) or Peters (1939). But Ruud (1950) and his collaborators (Ruud et al, 1950) have already reached the same result upon the hypothesis that each growth period appearing in the baleen record represents the annual growth of the baleen plate. I proved in my previous study (Nishiwaki, 1950c) that this hypothesis is true to the fact, and have reached the foregoing result by analyzing the material for that and the preceding study (Nishiwaki, 1949c).

It is very difficult, however, to determine the frequency of ovulation simply from the investigation of baleen plates. This is because baleen plates gradually wear at the tip after when once a whale reach a certain age or a certain stage of physical growth. In the consequence of this tendency, exact age-determinations become nearly impossible by the baleen record method after blue whales are 7 to 9 year old and fin whales 6 to 8 year old, i.e. a few years after the sexual maturity is attained. Therefore, I have made use of the evidences concerning the colouration of the crystalline lens reported in my previous study (Nishiwaki, 1950a) together with the results of the baleen record reading in order to determine the frequency of ovulation.

By this method it has been found that the average number of ova shed by a female blue whale is 2 during the first year of sexual maturity and 1.64 per year during the following period, and in the case of a female fin whale 2 during the first year of sexual maturity and 1.52 per year during the succeeding period.

This result, though reached through an entirely different approach,

agrees with the findings made by precedent authors.

Mackintosh (1946, p. 254) reported a case in which a female fin whale caught 6 years after marking had a total of 8 corpora lutea in ovaries. There is no means of determining in what period of life history this whale was marked. But if it was marked in the first year of sexual maturity, ova must have been shed at the rate of 1.33 per year during the period between marking and capture. If it was marked in the year preceding the attainment of sexual maturity, the ovulation took place at the rate of 1.6 ova per year. This example as well as the result of the present study suggests in blue and fin whales that an average of 2 to 3 ova are discharged every breeding season that lasts two years.

The length of the period from attainment of sexual maturity to that of physical maturity has been also estimated by a similar method. In both sexes of blue and fin whales the length of this period has been estimated at about 6 years. A whale is regarded as physically mature if epiphyses are ankylosed to the centrum in the middle vertebrae of both thoracic and the lumbar series.

In the present study I have employed, as far as possible, the material already dealt with in my previous works, though a few new data have been introduced when they are necessary to develop sound conclusions partly, because this material, having been collected prior to the formulation of the theory presented in this study, is entirely free from its influence and partly because I wished to proceed with the auguments which were not concluded in my earlier studies.

In short, the results of the present study differ from conventional theories most significantly in that they indicate that southern blue and fin whales attain sexual maturity at much older ages than suggested before. According to conventional theories it takes a weaning blue whale calf about one and a half years to reach sexual maturity, during which period the whale grows by 22 to 25 Eng. ft. in length, and thereafter the growth slows down to a rate of about 3 Eng. ft. per year.

In comparison, the present result indicates that the increase in length of 22 to 25 Eng. ft. takes place during about four and a half years, i.e. an average annual increase of 5.5 Eng. ft. But this average increase will not be maintained throughout the period from birth to the attainment of sexual maturity, for the growth must slow down with the age. Now let us assume that the blue whale attains sexual maturity at 5 years after birth and approximates its growth curve for this period with a logarithmic curve. Then the annual increase in

length is 28 Eng. ft. for the first year following birth (including the suckling period), and 7.4, 5.9, 4.8 and 3.9 Eng. ft. for the subsequent years.

By extrapolating the same curve, annual increments in length in the years following the attainment of sexual maturity are 3.3, 2.9, 2.5, 2.1, 1.8 and 1.5 Eng. ft. These figures almost coincide with those obtained by previous workers. Then, can this fact not be taken as an indication that this logarithmic curve adequately depicts the growth of the blue whale and that the whale grows at the abovementioned rate to reach sexual maturity at the age of about 5 years?

From the results of the present study the life history of the southern blue and fin whales appears as follows. In the blue whale, males reach sexual maturity about four and a half years after birth and females about five years after birth. Both sexes experience the first coition between June and August following the fifth birthday. Thereafter, the breeding period of two years recurs in females, during which a series of gestation, parturition and lactation takes place. Physical maturity is reached about 6 years after the attainment of sexual maturity, i.e. about 11 years after birth. The average life of this species would be 25 to 30 years under natural conditions.

It does not seem that the life history of the fin whale much differ from that of the blue whale except that the sexual, and consequently the physical, maturity is attained about one year earlier in the former species.

It seems necessary to reexamine the age composition of the catch and analyze the situation of the stocks of blue and fin whales in the light of the result of the present study and to contrive an adequate system of regulating the whaling operations, if the whaling industry is to enjoy permanent prosperity and the whale resources to be conserved for the benefit of mankind. This problem will be dealt with in a separate work.

References

Committee for Whaling Statistics. International Whaling Statistics XX (1948), XXII (1949), XXIV (1950) and XXVI (1951).

Laurie, A.H., 1937. The Age of Female Blue Whales and the Effect of Whaling on the Stock. Discovery Reports, Vol. XV.

Mackintosh, N. A. and J. F. G. Wheeler, 1929. Southern Blue and Fin Whales. Discovery Reports, Vol. I.

Mackintosh, N. A., 1942. The Southern Stocks of Whalebone Whales. Discovery Reports, Vol. XXII.

———, 1946. The Natural History of Whalebone Whales. The Smithsonian Report for 1946.

Nishiwaki, M. and Hayashi, K., 1948. Biological Survey of Fin and Blue Whales taken in Antarctic Season 1947-48 by the Japanese Fleets. The Scientific Reports of the Whales Research Institute, No. 3.

Nishiwaki, M. and Oye, T., 1949a. Biological Survey of Fin and Blue Whales taken in Antarctic Season 1948-49 by the Japanese Fleets. The Scientific Reports of the Whales Research Institute, No. 5.

Nishiwaki, M., 1949b. On the Relation between Testis Weight and Sexual Maturity in the Southern Male Blue and Fin Whales. (in Japanese) Published by the Japan Whaling Association (Nihon Hogei Kyokai), Tokyo.

———, 1949c. On the Periodic Mark on the Baleen Plate. The Scientific Reports of the Whales Research Institute, No. 4.

———, 1950a. On the Colouration of Crystalline Lens Available for the Age-Determination of the Antarctic Blue and Fin Whale. The Scientific Reports of the Whales Research Institute, No. 4.

———, 1950b. Report on the Biological Investigations on the Antarctic Whales in the Years 1946-1950. (in Japanese) Published by the Japan Whaling Association (Nihon Hogei Kyokai), Tokyo.

———, 1950c. On the Periodic Mark on the Baleen Plates as the Sign of Annual Growth. The Scientific Reports of the Whales Research Institute, No. 6.

Omura, H., 1944. Whales. (in Japanese) Fishery Processing Technology Series (Suisan Seizo Kogaku Koza), Vol. 7.

Peters, N., 1939. Über Grösse Wachstum und Alter des Blauwales und Finnwales. Zool. Anz., Bd. 127.

Ruud, J.T., 1940. The Surface Structure of the Baleen Plates as a Possible Clue to Age in Whales. Hvalrådets Skrifter, Nr. 23.

———, 1945. Further Studies on the Structure of the Baleen Plates and Their Application to Age Determination. Hvalrådets Skrifter. Nr. 29.

———, 1950. Investigations of the Age of the Blue Whales in the Antarctic Pelagic Catches 1945/46—1948/49. The Norwegian Whaling Gazette (June 1950).

———, A. Jonsgard and P. Ottestad, 1950. Age-Studies on Blue Whales. Hvalrådets Skrifter, Nr. 33.

Tomilin, A. G., 1945. The Age of Whales as Determined from Their Baleen Apparatus. Comptes Rendus (Doklady) de l'Académie des Sciences de l'USSR, Vol. XLIX, No. 6.

Wheeler, J. F. G., 1930. The Age of Fin Whales at Physical Maturity. Discovery Reports, Vol. II.

APPENDIX

Blue and Fin Whales Caught in the Antractic in the Season 1946-47 to 1949-50, by Species, Sex and Body Length

a. Blue Whale

Season / Body Length of Whale (ft) / No. of	1946 ~ 47											
	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
55												
56												
57												
58												
59	2		2									
60	2	3	5									
61	2	5	7									
62	4	2	6									
63	3	10	13	1		1				1		1
64	12	9	21									
65	15	15	30									
66	31	18	49									
67	26	24	50	1	1	2				1	1	2
68	22	15	37	1		1	1		1			
69	4	4	8									
70	231	186	417	9	10	19	6	2	8	3	8	11
71	216	161	377	23	18	41	13	12	25	10	6	16
72	210	124	334	21	13	34	8	6	14	13	7	20
73	234	146	380	29	10	39	16	5	21	13	5	18
74	260	183	443	34	17	51	19	6	25	15	11	26
75	342	216	558	27	15	42	11	9	20	16	6	22
76	389	216	605	35	21	56	15	9	24	20	12	32
77	324	197	521	31	26	57	13	14	27	18	12	30
78	419	256	675	34	29	63	13	11	24	21	18	39
79	366	252	618	33	25	58	10	12	22	23	13	36
80	407	346	753	28	26	54	10	9	19	18	17	35
81	261	227	538	19	25	44	10	5	15	9	20	29
82	219	269	488	15	10	25	5	6	11	10	4	14
83	154	282	436	9	19	28	4	6	10	5	13	18
84	100	258	358	5	14	19		9	9	5	5	10
85	75	264	339	9	14	23	3	7	10	6	7	13
86	36	196	232	3	11	14		3	3	3	8	11
87	17	144	161	1	4	5		1	1	1	3	4
88	9	121	130		7	7		2	2		5	5
89	3	93	96	1	5	6	1	2	3		3	3
90	3	82	85		1	1					1	1
91		39	39									
92		17	17									
93		19	19									
94		7	7									
95		5	5									
96		1	1									
97		1	1									
98		1	1									
99												
100		1	1									
101		1	1									
102												
103												
104												
Sum	4398	4466	8864	369	321	690	158	136	294	211	185	396
Average length (ft)	76.84	79.72	78.29	76.64	78.61	77.54	76.12	78.24	77.09	77.03	78.99	77.89
Sex ratio	49.62	50.38		53.48	46.52		53.74	46.26		53.28	46.72	

Season	1947 ~ 48											
Body Length of Whale (ft) / No. of	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
55	1		1									
56												
57		2	2									
58	1		1									
59		1	1									
60	2	3	5									
61	3	3	6									
62	4	2	6									
63	3	6	9									
64	14	16	30		1	1		1	1			
65	20	13	33									
66	25	22	47									
67	33	20	53	1		1	1		1			
68	22	17	39									
69	6	5	11	2		2	1		1	1		1
70	219	222	441	1	4	5		3	3	1	1	2
71	194	135	329	6	1	7	3		3	3	1	4
72	150	118	268	10	6	16	4	3	7	6	3	9
73	146	118	264	8	6	14	3	3	6	5	3	8
74	153	102	255	15	12	27	9	5	14	6	7	13
75	222	114	336	27	12	39	16	4	20	11	8	19
76	236	131	367	44(1)	19	63(1)	18	9	27	26(1)	10	36(1)
77	246	98	344	36	10	46	12	1	13	24	9	33
78	287	148	435	48	24	72	20	12	32	28	12	40
79	276	113	389	43	24	67	16	8	24	27	16	43
80	313	219	532	29	30	59	8	11	19	21	19	40
81	220	171	391	22	42	64	9	15	24	13	27	40
82	200	187	387	27	38	65	13	15	28	14	23	37
83	136	182	318	7	35	42		13	13	7	22	29
84	115	191	306	5	25	30	3	4	7	2	21	23
85	69	197	266	3	25	28		11	11	3	14	17
86	45	155	200	2	22	24	1	10	11	1	12	13
87	28	113	141	2	18	20	1	1	2	1	17	18
88	21	97	118		7	7		4	4		3	3
89	4	60	64		6	6		2	2		4	4
90	9	84	93		1	1					1	1
91	7	47	54		3	3		1	1		2	2
92	2	41	43		1	1					1	1
93		26	26									
94		20	20									
95		9	9									
96		12	12									
97		3	3									
98		3	3									
99												
100												
101		1	1									
102		1	1									
103												
104												
Sum	3432	3228	6660	338(1)	372	710(1)	138	136	274	200(1)	236	436
Average Length (ft)	77.11	79.87	78.45	77.86	81.09	79.55	77.52	80.52	79.01	78.09	81.42	79.89
Percent	51.53	48.47		47.58	52.42		50.37	49.63		45.87	54.13	

(1)····1 Dauhval

Season	1948 ~ 49											
Body Length of Whale (ft) / No. of	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
55												
56												
57												
58												
59	1		1									
60	1	3	4									
61	2		2									
62	4	3	7									
63	7	1	8									
64	12	7	19									
65	21	22	43									
66	20	15	35									
67	18	16	34									
68	16	22	38									
69	6	7	13									
70	180	111	291	3	2	5	2	1	3	1	1	2
71	147	111	258	4	2	6	3	2	5	1		1
72	154	120	274	9	2	11	5	1	6	4	1	5
73	165	97	262	14	4	18	5	3	8	9	1	10
74	164	100	264	22	6	28	12	1	13	10	5	15
75	248	138	386	21	9	30	13	5	18	8	4	12
76	270	119	389	33	10	43	20	6	26	13	4	17
77	267	110	377	51	9	60	22	5	27	29	4	33
78	363	137	500	54	18	72	27	12	39	27	6	33
79	287	126	413	62	22	84	28	11	39	34	11	45
80	363	199	562	34	23	57	20	11	31	14	12	26
81	281	184	465	27	23	50	9	8	17	18	15	33
82	280	203	483	31	20	51	8	10	18	23	10	33
83	166	239	405	11	23	34	3	9	12	8	14	22
84	115	217	332	11	11	22	4	4	8	7	7	14
85	88	245	333	2	15	17	1	6	7	1	9	10
86	35	221	256	1	19	20		6	6	1	13	14
87	37	187	224	1	13	14	1	6	7		7	7
88	18	139	157		4	4		1	1		3	3
89	9	75	84									
90	7	100	107		3	3					3	3
91	3	43	46		2	2					2	2
92		39	39									
93		19	19									
94		10	10									
95		9	9									
96		3	3									
97		1	1									
98												
99		1	1									
100		1	1									
101		1	1									
102												
103												
104												
Sum	3755	3401	7156	391	240	631	183	108	291	208	132	340
Average length (ft)	77.57	80.83	79.12	77.98	81.04	79.15	77.68	80.23	78.63	78.49	81.71	79.74
Sex ratio	52.47	47.53		61.95	38.05		62.89	37.11		61.18	38.82	

Season / Body Length of Whale (ft) / No. of	1949 ~ 50											
	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
55												
56												
57												
58	1		1									
59												
60	4	1	5	1		1	1		1			
61	2	1	3									
62	3	2	5									
63	6	4	10									
64	12	17	29									
65	17	23	40									
66	21	13	34									
67	31	26	57									
68	27	14	41									
69	4	6	10									
70	142	101	243									
71	131	103	234	7	4	11	4		4	3	4	7
72	115	105	220	11	8	19	7	5	12	4	3	7
73	132	73	205	21	7	28	16	6	22	5	1	6
74	146	77	223	24	8	32	13	3	16	11	5	16
75	206	102	308	38	9	47	19	4	23	19	5	24
76	205	89	294	58	12	70	29	7	36	29	5	34
77	227	80	307	45	9	54	23	3	26	22	6	28
78	293	81	374	77	17	94	44	9	53	33	8	41
79	268	88	356	62	14	76	31	7	38	31	7	38
80	416	132	548	73	15	88	25	5	30	48	10	58
81	297	119	416	50	18	68	21	9	30	29	9	38
82	269	157	426	41	28	69	18	12	30	23	16	39
83	179	183	362	26	26	52	9	11	20	17	15	32
84	124	217	341	15	21	36	7	7	14	8	14	22
85	74	183	257	3	16	19		8	8	3	8	11
86	28	178	206	4	19	23	2	5	7	2	14	16
87	19	175	194	1	12	13	1	7	8		5	5
88	7	120	127		6	6		2	2		4	4
89	4	80	84		5	5		1	1		4	4
90	1	81	82		4	4		2	2		2	2
91	1	38	39		1	1		1	1			
92		19	19		1	1					1	1
93		12	12									
94		7	7									
95		4	4									
96		2	2									
97												
98												
99												
100												
101												
102												
103												
104												
Sum	3412	2713	6125	557	260	817	270	114	384	287	146	433
Average length (ft)	77.70	80.71	79.03	78.4	81.2	79.2	77.9	80.8	78.7	78.9	81.5	79.8
Sex raito	55.71	44.29		68.18	31.82		70.31	29.69		66.28	33.72	

b. Fin whale

Season / Body Length of Whale (ft) / No. of	1946 ~ 47											
	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
45												
46												
47												
48	1		1									
49												
50	2	1	3									
51	2	1	3									
52	2	1	3									
53	4	1	5									
54	3		3									
55	51	38	89	1	1	2	1		1		1	1
56	72	44	116	3	2	5		1	1	3	1	4
57	62	59	121	6	4	10	3	3	6	3	1	4
58	78	56	134	2	10	12	1	6	7	1	4	5
59	90	71	161	4	3	7	3	1	4	1	2	3
60	188	134	322	7	6	13	2	2	4	5	4	9
61	225	122	347	19	11	30	8	4	12	11	7	18
62	237	144	381	12	12	24	5	1	6	7	11	18
63	348	184	532	23	9	32	12	3	15	11	6	17
64	572	261	833	28	14	42	6	7	13	22	7	29
65	771	328	1099	26	16	42	13	7	20	13	9	22
66	752	341	1093	22	11	33	5	4	9	17	7	24
67	782	380	1162	27	16	43	12	4	16	15	12	27
68	696	447	1143	29	19	48	13	7	20	16	12	28
69	531	512	1043	20	16	36	8	6	14	12	10	22
70	485	671	1156	13	13	26	6	3	9	7	10	17
71	220	553	773	5	14	19	1	5	6	4	9	13
72	101	498	599	3	17	20	1	9	10	2	8	10
73	66	489	555		10	10		4	4		6	6
74	29	422	451		12	12		5	5		7	7
75	15	337	352		5	5		2	2		3	3
76	3	188	191		2	2					2	2
77	2	106	108		1	1		1	1			
78	4	48	52									
79		25	25									
80		11	11									
81		2	2									
82												
83												
84												
85												
86												
87		1	1									
88												
89												
90												
Sum	6394	6476	12870	250	224	474	100	85	185	150	139	289
Average length (ft)	65.83	69.00	67.43	65.07	66.83	65.90	64.97	66.78	65.26	65.14	66.86	65.96
Sex ratio	49.68	50.32		52.74	47.26		54.05	45.95		51.90	48.10	

Season	1947 ~ 48											
Body Length of Whale (ft) / No. of	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
45												
46												
47	1	1	2									
48												
49												
50	1	1	2									
51	3	5	8									
52	8	4	12									
53	11	3	14									
54	5	2	7									
55	45	34	79									
56	81	66	147		1	1					1	1
57	84	65	149									
58	99	77	176									
59	116	93	209									
60	231	147	378	1		1	1		1			
61	220	125	345	1		1	1		1			
62	305	168	473	4	3	7	1		1	3	3	6
63	474	251	725	12	3	15	8	1	9	4	2	6
64	651	288	939	33	6	39	13	1	14	20	5	25
65	1002	365	1367	35	11	46	10	3	13	25	8	33
66	1095	396	1491	46	17	63	15	5	20	31	12	43
67	1315	438	1753	49	12	61	12	6	18	37	6	43
68	1238	506	1744	33	22	55	12	8	20	21	14	35
69	1032	545	1577	27	36	63	7	12	19	20	24	44
70	958	724	1682	10	43	53	3	16	19	7	27	34
71	479	669	1148	8	54	62	3	23	26	5	31	36
72	292	696	988	2	46	48	1	15	16	1	31	32
73	179	614	793	2	34	36		14	14	2	20	22
74	119	603	722		35	35		14	14		21	21
75	62	470	532		9	9		4	4		5	5
76	21	293	314		10	10		1	1		9	9
77	6	196	202		2	2		1	1		1	1
78	9	128	137		1	1					1	1
79	1	53	54									
80	5	67	72									
81		11	11									
82		10	10									
83		3	3									
84		4	4									
85		2	2									
86												
87												
88												
89												
90												
Sum	10148	8123	18271	263	345	608	87	124	211	176	221	397
Average length (ft)	66.65	69.52	67.93	66.52	70.53	68.79	66.17	70.73	68.85	66.70	70.41	68.77
Sex ratio	55.54	44.46		43.27	56.73		41.23	58.77		44.33	55.67	

Season	1948 ~ 49											
Body Length of Whale (ft) / No. of	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
45												
46												
47												
48	1		1									
49	1	4	5									
50	1	2	3									
51	3	2	5									
52	6	6	12									
53	6	7	13									
54	7	1	8									
55	40	52	92									
56	56	59	115									
57	103	68	171									
58	88	60	148	2		2	2		2			
59	97	77	174	5	2	7	3	1	4	2	1	3
60	201	126	327	4	1	5	2	1	3	2		2
61	225	128	353	12	4	16	8	3	11	4	1	5
62	303	158	461	20	8	28	9	5	14	11	3	14
63	426	222	648	24	12	36	10	6	16	14	6	20
64	516	223	739	48	12	60	22	5	27	26	7	33
65	865	296	1161	69	14	83	34	6	40	35	8	43
66	916	300	1216	85	23	108	33	8	41	52	15	67
67	1101	427	1528	58	22	80	23	12	35	35	10	45
68	1116	479	1595	54	47	101	17	28	45	37	19	56
69	860	460	1320	59	50	109	18	26	44	41	24	65
70	758	837	1595	31	68	99	14	29	43	17	39	56
71	355	703	1058	11	66	77	7	21	28	4	45	49
72	224	795	1019	6	64	70	1	22	23	5	42	47
73	115	716	831		50	50		18	18		32	32
74	53	511	564		32	32		14	14		18	18
75	16	467	483		20	20		6	6		14	14
76	12	341	353		21	21		9	9		12	12
77	7	149	156		5	5		2	2		3	3
78	3	111	114		1	1					1	1
79	4	36	40									
80	1	38	39		2	2					2	2
81		11	11									
82		3	3									
83		2	2									
84												
85												
86												
87												
88												
89												
80												
Sum	8486	7877	16363	488	524	1012	203	222	425	285	302	587
Average length (ft)	66.40	69.65	67.96	66.2	70.2	68.3	65.88	69.70	67.87	66.5	70.6	68.7
Sex raito	51.86	48.14		48.21	51.79		47.78	52.22		48.55	51.45	

Season / Body Length of Whale (ft) / No. of	1949 ~ 50											
	Total Antarctic, Pelagic whaling			Japanese Expedition								
				Total			Hashidate Maru			Nisshin Maru		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
45												
46												
47												
48		1	1									
49	1	1	2									
50	2	7	9									
51	10	10	20									
52	14	5	19									
53	15	18	33									
54	17	12	29									
55	94	68	162									
56	119	113	232									
57	120	115	235									
58	159	140	299	1		1	1		1			
59	141	119	260	3	2	5	3	1	4		1	1
60	239	187	426	3	6	9		3	3	3	3	6
61	274	180	454	13	2	15	8	1	9	5	1	6
62	352	185	537	16	8	24	6	4	10	10	4	14
63	452	210	662	39	6	45	17	3	20	22	3	25
64	529	276	868	65	9	74	18	6	24	47	3	50
65	895	345	1240	95	15	110	41	4	45	54	11	65
66	1005	354	1359	106	19	125	46	8	54	60	11	71
67	1160	439	1599	89	31	120	35	14	49	54	17	71
68	1149	489	1638	87	33	120	35	20	55	52	13	65
69	972	546	1518	62	48	110	25	27	52	37	21	58
70	759	789	1548	24	58	82	8	25	33	16	33	49
71	365	729	1094	9	57	66	3	32	35	6	25	31
72	185	781	966	5	55	60	1	23	24	4	32	36
73	95	684	779	1	39	40	1	18	19	0	21	21
74	62	606	668	1	32	33		15	15	1	17	18
75	18	493	511		9	9		3	3		6	6
76	5	318	323		4	4		1	1		3	3
77	1	188	189		3	3		2	2		1	1
78	1	101	102		1	1		1	1			
79	1	44	45									
80	2	27	29									
81		8	8									
82		4	4									
83		3	3									
84		1	1									
85												
86												
87												
88												
89												
90												
Sum	9276	8596	17872	619	437	1056	248	211	459	371	226	597
Average length (ft)	65.98	69.07	67.46	66.2	69.8	67.7	66.1	69.7	67.7	66.3	69.9	67.7
Sex raito	51.90	48.10		58.62	41.38		54.03	45.97		62.14	37.86	