AGE DETERMINATION AND REPRODUCTION OF FEMALE FIN WHALES

Balaenoptera physalus (Linnaeus, *1758*)

WITH SPECIAL REGARD TO BALEEN PLATES AND OVARIES

by

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CHAPTER I

INTRODUCTION

Under normal circumstances the composition of an animal population depends on the rate of reproduction and on the natural mortality. In economically important animals, such as Whales (Cetacea), additional losses brought about by the yearly catches may become more important a factor than natural mortality. It is evident that the yearly catches are limited. Hence a knowledge of the dynamics and composition of such a population or stock is of great importance. For population calculations a compilation of the precise data concerning the number of animals in a stock, the natural mortality, the rate of reproduction, the age at which the animals attain sexual maturity and the maximum age, is absolutely necessary.

In the case of Whales it is impossible, or at least very difficult, to count or to calculate the total size of a population since the territories of these animals are very large. Changes in the age composition of catches from a particular population area to a higher or a lower level, might be an indication of an under- or over-taxation of this population by whaling. If we want to use the changes in the age composition of the catches one of the conditions is that each catch must be a random sample of the stock, and the animals of which the material is examined must be a random sample of each catch. Most probably the catches, especially the catches of the Antarctic pelagic whaling after the Second World War, are not random samples of the total stock. The experience of the individuals, which will increase as they grow older, will play an important role in evading the catchers. This fact is also known from other economically important species. The younger, inexperienced animals will preponderate in the catch. There is also a fair possibility that the catch of younger animals may increase because the whaling factories have a yearly total quota and as a result of striving to obtain a great part of this quota on the part of these factories, the chances for a selection to the larger and, as a rule older animals will be rather low. On the other hand, a minimum length laid down will keep the youngest animals out of the catch. It is reasonable to assume that the maximum taxation will be in that part of the stock of young animals which is just above the minimum length. However, according to the opinion of the Committee of Three Scientists set up by the International Whaling Commission (Supplementary Report), it seems that the inexperience of the young animals is not so important.

The second condition is that the animals of which the material is examined must be a random sample of the total catch of the factory ship, and that the total catch of that ship must be a random sample of the total catch of all factory ships in the hunting area. In this research all material has been taken from Fin Whales caught in Antarctic pelagic whaling. In general, the distribution of length classes in both the catch and the sample of material is used in the calculations. According to the latest results of the investigations of the Committee of Three Scientists (Final Report, 1963) there is a reasonable certainty that, if the material is a random sample in length distribution, it is the same in age distribution ("age-length key").

There is a reasonable certainty concerning the rate of reproduction of the Fin Whale. Every year about 50% of the total catch of sexually mature females is pregnant. It is commonly accepted that, as a rule, in the case of Fin Whales, pregnancy, lactation and a "resting" period, together occupy about two years; so we have to allow for a reproductive cycle of about two years. Nevertheless, there are always small numbers of animals that are pregnant and lactating at the same time. It may be assumed that they are pregnant in two successive years. On the other hand, however, there are also small numbers of female Fin Whales that appear to rest for an extra year. This does not affect the assumption that, as a rule, the animals will become pregnant every two years.

Age determination is very important in calculations concerning population dynamics. In most of the calculations the time at which sexual maturity is attained, and also the maximum age the animals can attain, must be known. It is possible to construct a curve of the age composition, using age determinations. When the data collected meet certain demands with regard to numbers of animals and representation, it is possible to deduce the natural mortality in a given population of Fin Whales by using certain assumptions. It is also possible to compare the curves of age composition of successive years. This information can be used to calculate the optimum annual catch that should be allowed to a given whaling fleet.

Due to the lack of animals of known age, accurate age determinations are very difficult. One way of checking the age determination is by marking the animals. Up to this moment calves have not been marked in sufficient numbers; only animals of unknown age. Hence the only thing we know of these animals is their minimum age. In most cases this minimum age differs much from the real age of the animals. Moreover, the numbers of marks that have returned are very small; so only few animals of a known minimum age are available for study.

In most cases age determination is based on such phenomena as the wearing of, or distinct irregularities in, some particular organ. In the first case it is an absolute necessity to have animals of known age with which to make comparisons, as e.g. in the age determination of domestic animals, based on wearing of the teeth. In the second case the cause of the irregularities must be periodically recurring events. But also to get an insight into the absolute age we must have "reference" animals of known age.

In Balaenopteridae the organs so far used in age determinations have been: ovaries, baleen plates, scars in the skin, colour of crystalline lenses and, especially in the last few years, earplugs. The method which uses changes in the colour of crystalline lenses is insufficient. Although the lenses grow continuously darker with increasing age this is also the case during the period between the death of the whale and the time the lenses are collected.

The other organs fulfil the condition of discontinuity. In most of the organs used in age determination the irregularities are supposed to be based on influences of migration, except probably the ovaries, where the sexual cycle is the prime cause. However, it is unknown whether these phenomena are exactly annual. For example, in the earplugs an increase of two laminations per year was originally assumed but at present there is doubt about the rate of accumulation. According to the latest work of Ohsumi (1964) it is possible that the accumulation may be less than two but not less than one lamination per year.

The method based on the yearly formation of scars in the skin is useless as only few time units in the process of healing can be distinguished. This method, therefore, is of no use for older animals. Age determination with the aid of baleen plates is based on the presence of variations in the thickness of the baleen plate as expressed in the records made of them. These variations in thickness are caused by irregularities in the growth of these plates. By means of the irregularities it is possible to divide the baleen record into a number of levels which are assumed to represent a growth period of one year each. An objection to the method is the wearing off of the baleen plate, in particular at the free end. Full application of the method is only possible on young animals, where the wearing has not yet had a disturbing influence on the baleen plate. A full discussion of this method and its difficulties will be given in Chapter II. Counting the corpora albicantia and corpora lutea in the ovaries is one of the oldest methods used in age determination of Whales. To be useful the corpora albicantia have to persist in the ovaries during the whole life of the animal. They should therefore not become reduced in such a way, in a shorter or longer time, that they become unrecognizable. It is evident that the total number of corpora increases with the increase in length of the whale and, moreover, there is a strong correlation between the number of corpora and the moment the animal attains physical maturity. This means that the rate of ovulation is very small and/or very regular. It is reasonable to assume that the corpora will persist during the whole life of the whale (see also Laws, 1961) and do not disappear after each breeding period. Probably the ovulation rate is very constant, and the counting of corpora albicantia will therefore be useful for age determinations. A difficulty of this method is that it is only possible in mature females. A full discussion will be given in Chapter II and III.

The most important species in modern pelagic whaling is the Fin Whale, Balaenoptera physalus. For this reason special aspects of the age determinations of only this species will be discussed. These include age determinations with the aid of baleen plates. The results obtained by this method of age determination will be compared and possibly correlated with data of the yearly increase of corpora in the ovaries of the same animals.

CHAPTER II

BALEEN PLATES

1. Introduction

As early as 1820 Scoresby had shown the existence of a certain wave-like periodicity in the thickening of baleen plates, which might be useful in age determination. He compared these waves, perpendicular to the direction of the horny tubes and at more or less regular distances from each other, with the rings on the horns of cows and with the year rings in trees. Eschricht and Reinhardt (1866) have shown this surface structure to be the result of periodic growth in thickness of the cortical layer of the baleen plate. They were unable to find a correlation with the age of the animals.

In about 1940 Tomilin and Ruud, working inde-

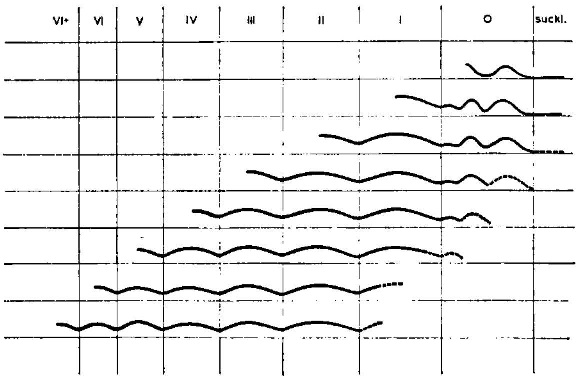

Fig. 1. *Diagram of baleen records divided into "growth periods" and arranged into age groups according to RUUD.*

pendently, each constructed an apparatus with which it is possible to make records of the variations in thickness of the baleen plate. This method is described by RUUD (1940, 1945). He developed a method of age determination based on the presence of irregularities in the record of the thickness of the baleen plate. Owing to growth and wearing, the baleen plate is as a rule thickest at its base near the gum, and thinnest at the tip. On the tip wearing has a great influence. By these irregularities in thickness an effect of large waves is obtained. By means of these waves it is possible to divide the record of the baleen plate in a number of levels or "growth periods" (fig. 1).

RUUD interprets each of these levels or "growth periods" as representing one year, and maintains that the "jumps" to higher levels in the record are caused by differences in the amount of food taken, which might be correlating with seasonal migrations of the whales. A modification of his method by means of photographic registration of the thickness in longitudinal section of the baleen plate has been developed by HIRATA (1959, personal communication).

RUUD (1940, 1945) believes that each period represents one year since he assumes that there is a correlation with migration, which he bases on material taken from one animal that, according to the age determination of MACKINTOSH and WHEELER (1929), was two years old. Nearly three "growth periods" were present in the baleen record. "We can assume therefore, with a great degree of certainty that this whale was pregnant for the first time and, in agreement with Mackintosh and Wheeler, we must assume that it was between 2 and 3 years of age" (RUUD, 1940).

However, this assumption is based on very incomplete material only, since one of the ovaries of this animal had been destroyed. Moreover, from recent research it is clear that the ideas of MACKINTOSH and WHEELER concerning the age at which sexual maturity is attained, are questionable. NISHIWAKI (1951) tried, on a mathematical basis, to prove that each "growth period" in the baleen record represents a period of one year.

A difficulty in age determination by means of the baleen plates is the wear at the tip of the plate. At a certain moment it is possible that the growth of a baleen plate equals the wear at the tip. In this case a maximum number of "growth periods" in the baleen plate is attained. The actual age of such an animal is uncertain since the number of "growth periods" worn away is unknown. Age determination by means of baleen plates can only be applied in certain animals: those in whose records the indication formed in the first year of life i.e. indications of suckling or weaning, are present. In most cases these indications of suckling or weaning are very clear. RUUD and his co-workers have, however, used this method of age determination to determine the age composition of a sample of baleen plates taken from the catches of pelagic whaling fleets. NISHIWAKI (1950, 1951) and CHITTLEBOROUGH (1959) also used the same method. As the wearing off at the free end of the baleen plate is rather great, all older animals have to be lumped together in one age group. A curve of age composition can only be obtained by extrapolation of the right hand part of the curve. These difficulties will not be discussed here since there are objections against the above mentioned method of age determination based on the large waves of the baleen plates.

The first objection is that records made by the above mentioned authors are only made of that part of the baleen plate which protrudes from the gum. Only the whole baleen plate can give an indication of the age of the animal. The part of the baleen plate which is hidden in the gum gives a considerable increase in length of the baleen record, and not only is this part of the baleen plate not subject to wearing but it is the youngest part of the plate, representing the most recent reflections of the life cycle of the animal.

Secondly, the records of baleen plates of immature animals and sexually mature males have such a regular course that there are scarcely any "jumps" (to use RUUD's expression). If these "jumps" result from the influences of feeding and migration, they must be present in the baleen plates of immature Fin Whales and mature male as well as mature female Fin Whales (fig. 2). Moreover, there are indications that the migrations of the Fin Whale are not as regular as was supposed originally. It is very probable that a given number of animals stays in the tropics in summer, and in fairly high latitudes in winter (SLIJPER, VAN UTRECHT and NAAKTGEBOREN, 1964). MACKINTOSH (1942) had already drawn the attention to this possibility before. Moreover, in the records of baleen plates given by RUUD (1940, 1945), it is not always clear why the limit between two levels is at a certain point in the curve and not somewhere else, as there is a considerable variation in distances between the different "jumps". In mature females these variations might be caused by a succession of periods of pregnancy and lactation. Then, however, there should be a regular succession of shorter and longer levels in the curve, but these are not shown in the records given by RUUD. Furthermore, no correlation is proved

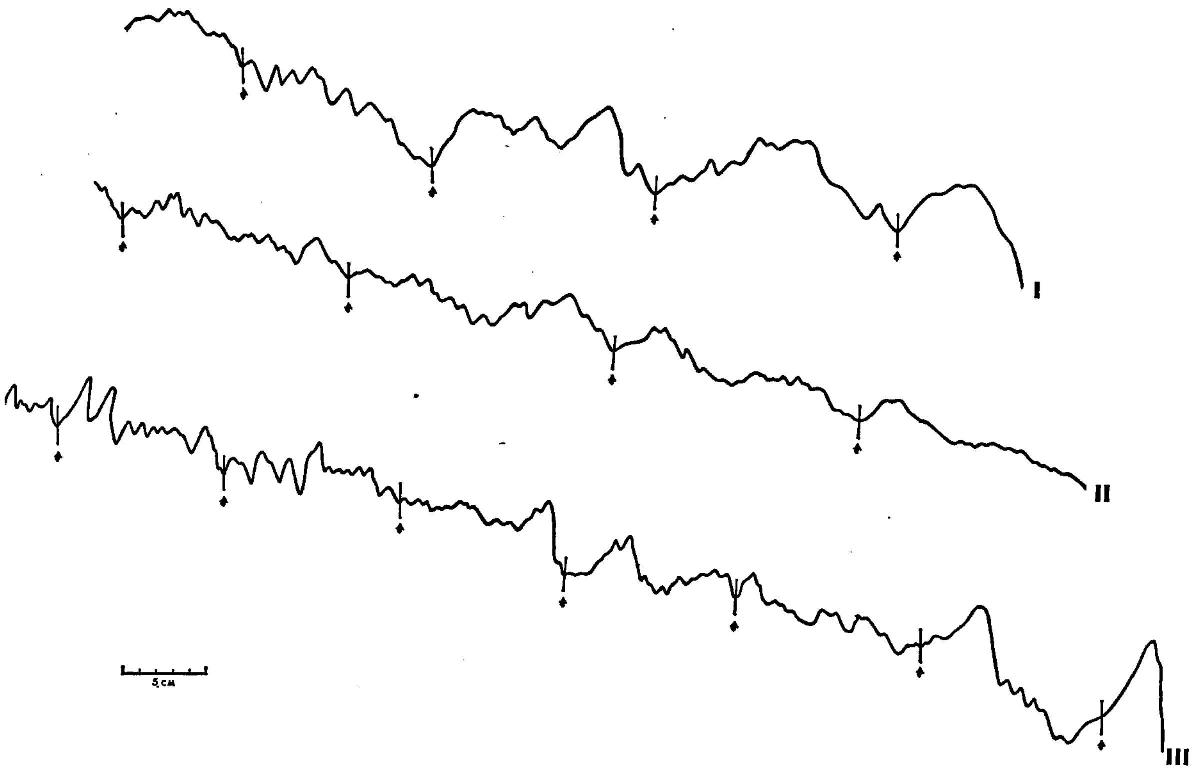

Fig. 2. *Records of the outer baleen plates of Fin Whales. I. Immature animal. II. Mature male animal. III. Mature female animal.*

between the increment in length and the increment in thickness in a certain "growth period".

Thirdly the above mentioned method of dividing a record into levels does not take into account the superimposed peaks and hollows of the baleen plate. By this superimposed system are meant the smaller variations in thickness, the peaks and hollows in the record of the baleen plate ("relief"). They show a certain periodicity. These small and sudden variations in the thickness of the baleen plate are caused, as is evident from histological research, by variations in the amount of material added in one limited place in the "root" of the baleen plate in contrast with the general increment in thickness of the baleen plate (VAN UTRECHT, 1965). Since the peaks and hollows are narrow they can be ascribed to events in the life of the animal, which are of a comparatively short duration.

The above evidence justifies the supposition that factors other than external influences such as food, migration etc., will influence the growth rate of the baleen plate. One of these factors may be the sexual cycle, for it is difficult to see why in both sexes the influence of external factors should give different results in the records of the baleen plates. The sexual cycle on the contrary will be different in the two sexes. The sexual cycle of the male Fin Whale is of a more regular pattern than the sexual cycle of the female. In males the cycle is rhythmically divided into an active and an inactive period (MACKINTOSH and WHEELER, 1929; LAWS, 1959), whereas in females pregnancy and lactation will disturb the rhythm. So it seems possible to suppose that apart from external influences the condition of the animal itself will also have a great influence.

In mammals it has been shown that there is a relation between factors such as food, migration, rate of growth, and sexual cycle on the one hand, and cornification of certain epidermal derivatives on the other hand. The ways in which these factors act on growth and cornification are complex (BULLOUGH, 1962).

As is shown above, there is some doubt about the validity of the "jumps" and levels used by RUUD in his age determinations. It is possible that the system of peaks and hollows superimposed on the general trend of the record is more useful. Moreover, this will lead to the conclusion that the sexual cycle has more influence than was generally supposed, apart from the influence of the annual migrations. The immature animals and sexually mature males have a certain periodic pattern of peaks and hollows though less pronounced than in sexually mature females. The cornification, influenced by the sexual cycle, will be responsible for special peaks and may be superimposed on the general increase in thickness of the baleen plate influenced by the migratory movements (VAN UTRECHT, 1965). This might explain the fact that records of immature animals and mature males show a greater aspect of regularity than the records of mature females.

2. Material

The material consists of baleen plates inclusive of the parts of the baleen plates hidden in the gum, from both sexually immature and sexually mature female as well as from male Fin Whales, *Balaenoptera physalus*. This material was collected on board the f.f. "Willem Barendsz". Age determination with the aid of baleen plates only does not suffice in older animals. Since in females the age can also be determined with the aid of the ovaries, and since the baleen records of these animals show a more pronounced "relief", as a result of the influence of the sexual cycle on the growth of the plates, only female Fin Whales were used in this research. The ovaries were examined for numbers of corpora lutea and corpora albicantia.

By means of the method described in Chapter II, 3, the number of "growth periods" in the records was determined in the baleen plates of 199 animals taken during the seasons 1953/1954 to 1958/1959 inclusive. Of all animals the ovaries were examined. During the season 1959/1960, of 211 female Fin Whales only the ovaries were collected and examined.

By means of the analyses of the records of the baleen plates and of the ovaries I tried to obtain data about the mean age at which sexual maturity is attained, and about the mean rate of ovulation. By means of the mean age at which sexual maturity is attained and the mean rate of ovulation it is possible to estimate the age of the animal by counting the corpora present in the ovaries.

It is important, as shown in Chapter I, to know the distribution of the numbers of animals in the different length classes in the catch of Fin Whales of the "Willem Barendsz" compared with those in the total Antarctic pelagic catch. In this respect it is necessary to compare also the distribution of the numbers of female Fin Whales, from which material is sampled ("examined animals" = "ex.an.") in the different length classes with the same distribution of the total catch of female Fin Whales of the "Willem Barendsz".

The following length classes are used: 57′-60′; 60′-63′; 63′-66′; 66′-69′; 69′-72′; 72′-75′; 75′-78′.

The calculation applied is a normal chi-square test (see tables 4 and 5, p. 46). In a number of seasons, the group 75′-78′ of "ex.an." is not used in the calculations because the number of the calculated frequency (s) is too small.

It is possible to make the following calculations:

1. Total catch of the "Willem Barendsz" (♂♂+♀♀) in relation to the total Antarctic pelagic catch.
2. Total catch of females in the catch of the "Willem Barendsz" compared with the proportion of females in the total Antarctic pelagic catch.
3. "Ex.an." compared with the total catch of females of the "Willem Barendsz".

There is no point, in this context, in making calculations regarding the sample of "ex.an." compared with the total catch of females and males of the "Willem Barendsz" since all "ex.an." used are females.

In these calculations a number of difficulties were caused by the fact that the material was not uniform.

There is a difference in the material sampled during the seasons 1953/1954 to 1958/1959 inclusive and the season 1959/1960. Firstly, there is a fair chance that in the latter season selection to a greater length was possible since this season was considerably extended (in the season 1959/1960 the Netherlands were out of the International Whaling Convention). Secondly in the latter season no material of baleen plates was sampled but only ovaries. Even more important, however, is the fact that the method of sampling ovaries was changed. Formerly material was sampled e.g. from one out of ten animals. In the last season (1959/1960) ovaries of as many female Fin Whales as possible were collected. Lack of storage facilities for this material was the only limiting factor.

Table 1 gives the numbers of animals per season available for age determination by means of the records of the baleen plates and of the ovaries.

The results of calculations regarding the total catches

Table 1

Season	Ovaries	Baleen plates
1953/1954	11	7
1954/1955	12	5
1955/1956	14	6
1956/1957	48	32
1957/1958	98	88
1958/1959	75	61
1959/1960	211	—
	469	199

Table 2

Season	Length distribution in the catch of the "Willem Barendsz" differs from the total Antarctic pelagic catch:	
	♂♂ + ♀♀	♀♀
1953/1954	significantly	significantly
1954/1955	significantly	significantly
1955/1956	significantly	significantly
1956/1957	not significantly	not significantly
1957/1958	not significantly	not significantly
1958/1959	significantly	significantly
1959/1960	significantly	significantly
1953/54-1958/59	significantly	significantly
1953/54-1959/60	significantly	significantly

(♂♂+♀♀) of the "Willem Barendsz" compared with the total Antarctic pelagic catches (♂♂+♀♀) are (table 2):
From table 2 it is clear that the catch of the "Willem Barendsz" differs significantly from the total Antarctic pelagic catch in all seasons except in two: 1956/1957 and 1957/1958. This is the case with respect to the total catch and the catch of females. Whether the seasons 1953/1954 to 1958/1959 inclusive are lumped together, or the seasons 1953/1954 to 1959/1960 inclusive, the catch of the "Willem Barendsz" differs significantly from the total Antarctic pelagic catch. In these calculations there is no difference if either only the catch of females is taken into account or the total catch of the "Willem Barendsz". However, there is no difference in mean length of the catch of the "Willem Barendsz" compared with the catch of the Antarctic pelagic catch in the different seasons.

Considering the results of the calculations of the "ex. an." compared with the total catch of females of the "Willem Barendsz", it is evident that in most seasons the length distribution of "ex.an." does not differ significantly from the catch of females of the "Willem Barendsz" (table 3). These calculations were not made for the seasons 1953/1954, 1954/1955 and 1955/1956 because the numbers of "ex.an." were too small.

Table 3

Season	Length distribution of "ex.an." differs from the catch of the "Willem Barendsz"
1953/1954	—
1954/1955	—
1955/1956	—
1956/1957	not significantly
1957/1958	not significantly
1958/1959	significantly1)
1959/1960	not significantly
1953/54-1958/59	not significantly
1953/54-1959/60	not significantly

1) the material of this season was a selected sample.

Considering the length distribution of the "ex.an." compared with the catch of females of the "Willem Barendsz" either in the seasons 1953/1954 to 1958/1959 inclusive, or the seasons 1953/1954 to 1959/1960 inclusive, it is evident in both cases that the material does not differ significantly from this catch (table 3); so these animals can be used in the calculations below.

In calculations about the random sample the numbers of the animals of which material of ovaries was available are used because of these animals more data and data about a longer period of each animal's life, are available. Moreover, the numbers of these animals were much larger than those used in baleen analyses.

Conclusions based on these calculations are:

1. There is a significant difference in length distribution in the catch of the "Willem Barendsz" compared with the total Antarctic pelagic catch.
2. There is no significant difference in length distribution of the females of which material was sampled compared with the length distribution of the females in the catch of the "Willem Barendsz".

3. Method

The material examined consists of baleen plates including the part embedded in the gum of the Fin Whale, *Balaenoptera physalus*. Baleen plates of male and female, immature and mature, animals were collected. Some of the mature females were pregnant, others lactating or "resting". Of each animal, only the longest plate of the whole set of baleen plates

Table 4. *1953/1954 to 1958/1959 inclusive (♀♀)*

	W.B. "ex.an." observed frequency r	Total catch W.B.	Theoretically expected frequency s	s-r	$\frac{(s-r)^2}{s}$	$\frac{(s-r)^2}{n-s}$
57'-60'	13	292	21	+ 8	3.048	0.236
60'-63'	28	427	30	+ 2	1.333	0.010
63'-66'	44	432	31	−13	5.452	0.421
66'-69'	33	482	34	+ 1	0.029	0.002
69'-72'	56	799	56	0	0.000	0.000
72'-75'	48	747	53	+ 5	0.472	0.036
75'-78'	24	294	21	− 3	0.429	0.033
	246[1])	3473	246	0	10.763	0.738

$\chi^2 = 11.501$ $v = 6$ $P = 0.08$

Table 5. *1953/1954 to 1959/1960 inclusive (♀♀)*

	W.B. "ex.an." observed frequency r	Total catch W.B.	Theoretically expected frequency s	s-r	$\frac{(s-r)^2}{s}$	$\frac{(s-r)^2}{n-s}$
57'-60'	39	363	40	+ 1	0.025	0.003
60'-63'	47	507	56	+ 9	1.446	0.180
63'-66'	65	538	60	− 5	0.417	0.056
66'-69'	52	583	65	+13	2.600	0.326
69'-72'	125	1038	116	− 9	0.698	0.088
72'-75'	107	971	108	+ 1	0.009	0.001
75'-78'	56	416	46	−10	2.174	0.270
	491[2])	4416	491	0	7.369	0.690

$\chi^2 = 8.059$ $v = 6$ $P = 0.25$

1) 12 Fin Whales were outside these size limits.

2) It was found that the ovaries of 34 animals were immature in the 1959/1960 season. These animals are included in this table.

was collected. It is permissible to do this since, as was shown by RUUD (1940, figs. 8, 9; 1945, fig. 5), all baleen plates of one animal give an identical record, also for the smaller "relief", although the longest plate has the maximum number of "growth periods". This is also confirmed by the present writer's analysis.

Only the plates of the fore- and hindmost parts of a set of baleen plates are much more worn off, in particular at the tip, and the records of these plates show only part of the records of the longer plates of the middle of the set. It is evident that the physiological events which cause the periodic changes in the thickness of the cortical layer, act simultaneously on all baleen plates of a set.

According to RUUD (1940, 1945) the longest strip of the longest baleen plate of the set is used for recording (fig. 3). The correspondence of the different parts of one plate is perfect (RUUD, 1945, fig. 10). This longest strip, about 2½ cm broad, is cut out of the plate along lines indicated by the longitudinal striation of the plate. In addition, of the female animals, ovaries and mammae, and of some females also earplugs were sampled. The following data were recorded for all animals: date of catch, sex, length of the animal, registration number, number of hours of post mortem period, presence or absence of a foetus, number of foetuses, length of the foetus(es), sex of the foetus(es), position of catch, and, moreover, the

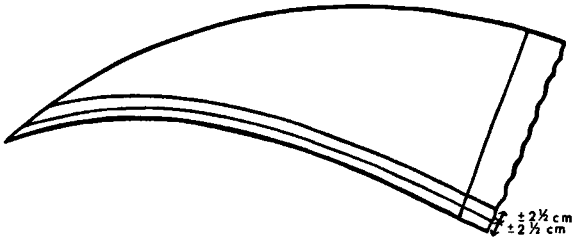

Fig. 3. *Part of the outer baleen plate used in the registration.*

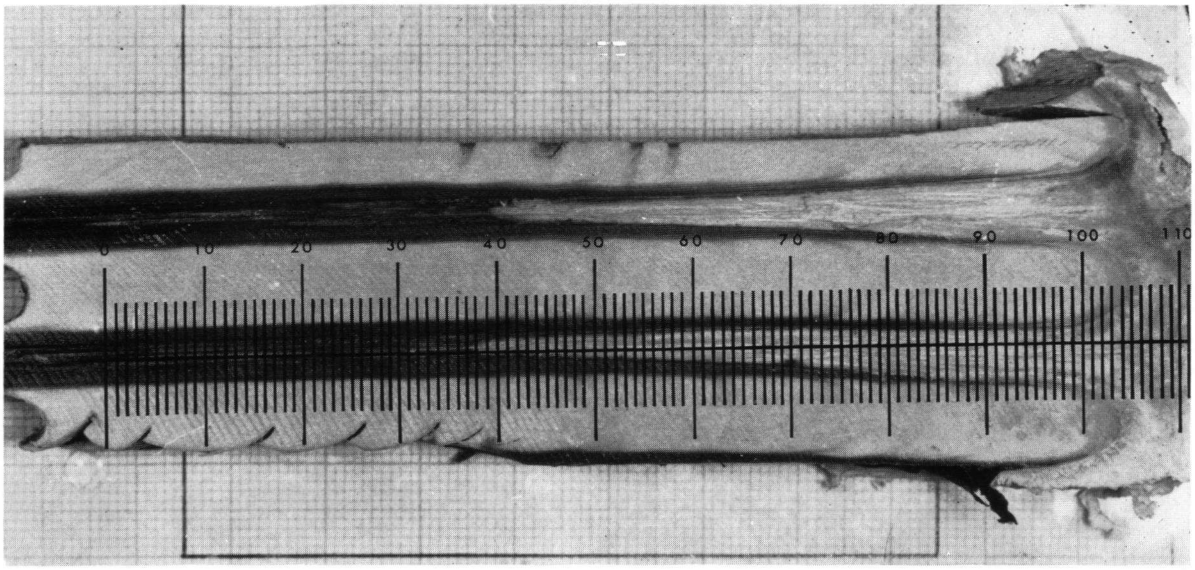

Fig. 4. *Section of the part of the baleen plate hidden in the gum, used in the measurements to obtain a record of the variations in thickness of this part.*

conclusions of the Whaling Inspector concerning the mammary glands in case the animal concerned was lactating.

According to RUUD's method and by means of an apparatus similar to that described by him, a record was made of the strip of the baleen plate. This method is insufficient as the part of the baleen plate hidden in the gum cannot be used. As this part is embedded in the epithelium of the gum it is impossible to make a record of it in the same way as of the free part of the plate. It is impossible to remove the gum from the already cornified plate without inflicting serious damage to its surface. A different technique had to be found to obtain records of the varying thickness of this part. The technique used is as follows: with a circular saw the piece of the baleen plate hidden in the gum is cut parallel to the longitudinal axis of the baleen plate. A photograph is made of this longitudinal section (fig. 4). The thickness of this part of the baleen plate, visible in the section, is transferred on to millimetre-paper (fig. 5). The thickness of this part of the baleen plate hidden in the gum, is measured on the macrophotograph at regular distances corresponding to 1 mm in the gum itself. On the photograph lines are drawn corresponding with its enlargement. If e.g. the enlargement of the photograph of this part of the baleen plate is 2.01 times, on the photograph lines are drawn at intervals of 2.01 mm, perpendicular to the longitudinal axis. The thickness of this part of the baleen plate is measured on these transverse lines. These measurements are transferred on to millimetre-paper and the points of measurements are marked out at the real distances of 1 mm and the thickness is enlarged 50 times. This enlargement in vertical direction is applied in agreement with the way of recording and the size of enlargement of the recording apparatus used. The "relief" in the records of the part of the baleen plate hidden in the gum, obtained in this way, is analogous to the "relief" in the record of the free baleen plate of the same set of an individual animal obtained by means of the baleen recording apparatus.

To obtain both curves, both the longest plate and the part of the neighbouring plate hidden in the gum, are used. It is impossible to make the two records of one baleen plate because a small part of the plate hidden in the gum must be used to attach the free part of the plate to the recording apparatus. So a small hidden part of the plate is lost. The use of the part of the baleen plate hidden in the gum has the undeniable advantage that this part is not worn off and moreover the end of the cortical layer at the base of the "root" of the baleen plate, i.e. the place where

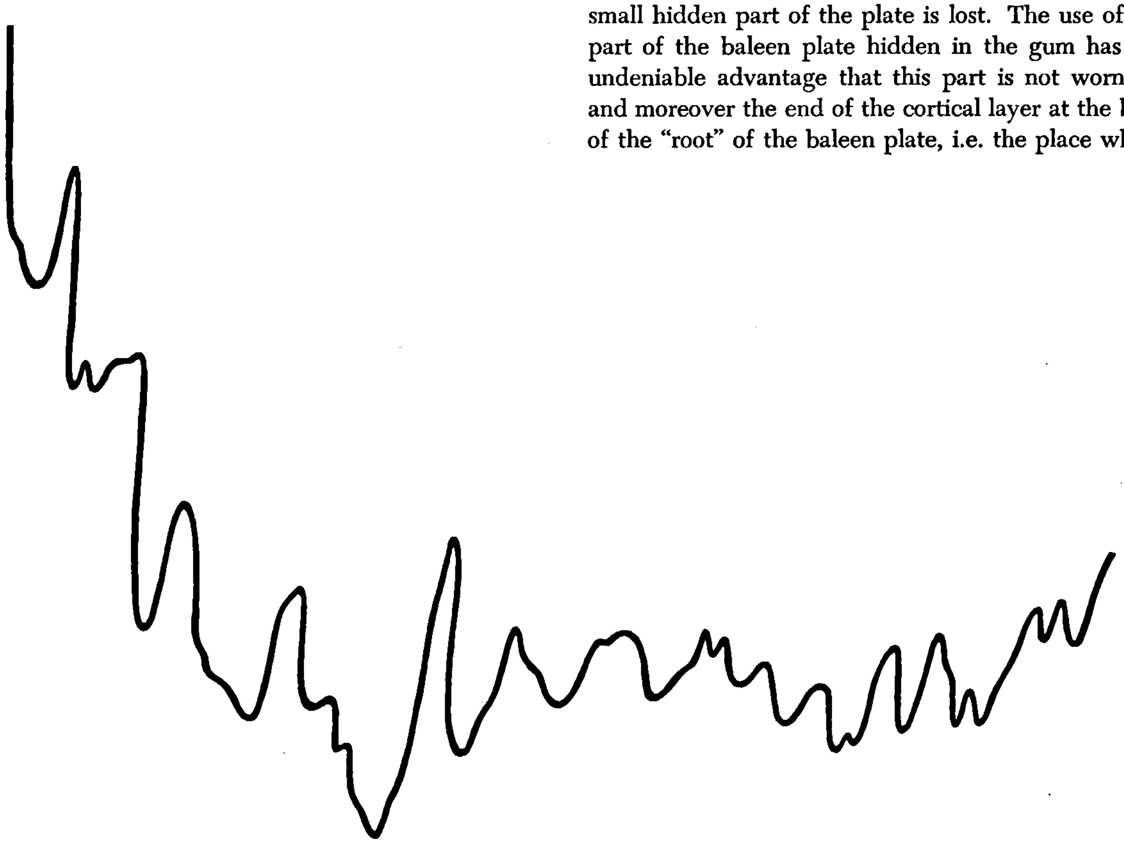

Fig. 5. *Record obtained from fig. 4.*

the cortical layer is formed, represents the only known date: the moment at which the animal was killed (fig. 6). The curve is then examined for a certain system of peaks and hollows, which prove to be present at regular intervals. Mostly a combination of two or more secondary peaks, often combined in one large striking peak, is found, a combination which is repeated in the whole baleen record at regular distances and which is easily recognizable (peak A). All peaks between two of those similar A-peaks appear to be the same in number and form. In the diagram (fig. 7), the peaks B and C etc., for instance, repeat in each interjacent period A-A ("growth period").

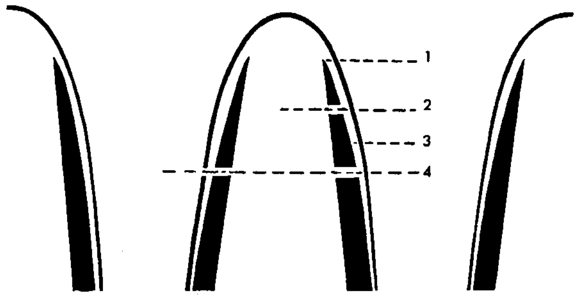

Fig. 6. *Diagram of the part of the baleen plate hidden in the gum. 1 = date point; 2 = gum; 3 = cortex; 4 = corium wall.*

In an actual baleen record the forms of the peaks are never so similar as in the diagram, because in the older (earlier formed) "growth periods" wearing has a disturbing influence. In the record of an individual animal the numbers of peaks in any "growth period" remain constant. Moreover, in mature females there is a second factor, viz. the sexual cycle which disturbs the regular pattern. The record is divided into "growth periods" based on these regularly repeating configurations of peaks and hollows. All such "growth periods", at least in older, mature animals, have about the same length. In younger animals the "growth periods" formed at a younger age have, as a rule, a greater length than the "growth periods" formed later. Also in comparing the records of different mature animals, it was seen that the "growth periods" all have about the same length. Even in animals with exceptionally long baleen plates the "growth periods" are of a normal length (Jonsgård, 1964). The measured length varies between 10 and 13 cm with a few exceptions. These variations can be correlated with the lengths of the baleen plates themselves and the heights of the heads of the animals (available space in the mouth). However, for one particular individual the number of peaks and hollows and their configuration is constant in all "growth periods". But particularly in younger animals there is a variation in length of the "growth periods". It is reasonable to suppose that the growth of the baleen plate is not only possible because the tip of it is worn away, but also because the height of the head of the animal increases. Consequently the growth in length of young animals is faster than in older ones.

The criterion used to divide the curve of the record into "growth periods" in this method is the most obvious repeating configuration of peaks and hollows. As a result the division lines do not represent the same date in all baleen records, or in other words, the "growth periods" have no strict relation to the division of the calender year. Instead of A-peaks it was possible to take B- or C-peaks.

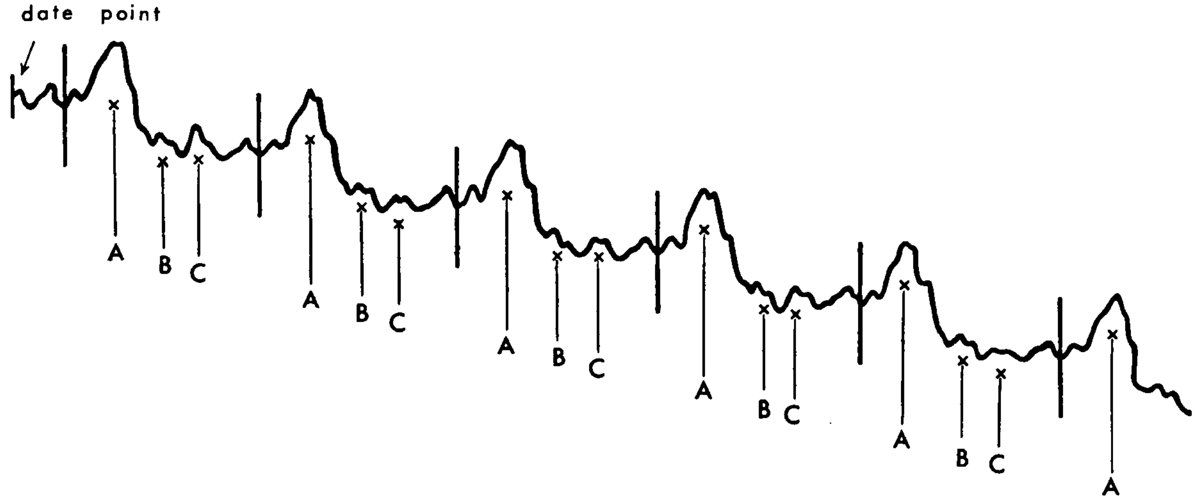

Fig. 7. *Diagram of a combined baleen record (for details see text).*

By means of records of different baleen plates of one Fin Whale, made by RUUD (1945, fig. 5), it was possible to see that the above mentioned "growth periods" of about the same length and showing the same "relief", occur in all baleen plates of one animal. This means that the "relief" is not formed in an arbitrary way, but that it is a reflection of particular events in the life of the animal. There must be a regularity in the succession and the height of the peaks and hollows in the different "growth periods" of the baleen plate. I have tried to prove this by means of a "regularity-calculation" based on FRIEDMANN's method of m-ranking. The regularity is expressed as the coefficient of agreement (W), variable between 0 (no agreement, i.e. regularity) and 1 (complete regularity).

Example: (fig. 8)

The division of the record is as follows: one of the "growth periods" is divided by means of a number of peaks and hollows. The lengths of the remaining "growth periods" will be divided in the same proportion as the lengths of the different consecutive parts of the first divided period. In this way not all vertical lines will end in peaks or hollows.

The coefficient of agreement W is expressed as:

$$W = \frac{12.S}{m^2.\ (n^3\text{-}n)}$$

m = number of "growth periods" indicated as I, II, III, etc.

n = number of peaks and hollows indicated as a, b, c, etc.; the lowest peak has the number 1

S = Σ (deviation)^2

m					n					
	a	b	c	d	e	f	g	h	i	j
I	8	6	10	3	5	2	1	9	4	7
II	8	7	10	5	6	3	1	4	2	9
III	8	6	10	4	5	3	1	9	2	7
IV	8	7	10	2	5	4	1	9	3	6
V	9	7	10	5	6	3	1	4	2	8
	41	33	50	19	27	15	5	35	13	37

mean: 27.5

dev.: 13.5; 5.5; 22.5; –8.5; –0.5; –12.5; –22.5; 7.5; –14.5; 9.5.

Σ deviation^2 = S = 1810.50

$$W = \frac{12 \times 1810.50}{5^2 \times (10^3\text{-}10)} = 0.88$$

In general there is no significant regularity for one individual animal. This means there is no coefficient of agreement that differs significantly from 0. This was to be expected from the disturbing influence of peaks caused by the sexual cycle, and by wearing, as the highest peaks will be most flattened. If the coefficients W of all records are taken together, there is an evident coefficient of agreement, significantly differing from 0.

$(\Sigma n = 2050,\ \Sigma\chi^2 = \Sigma \frac{12.S}{mn\,(n+1)} = 2272$, so $\sqrt{2\Sigma\chi^2} - \sqrt{(2\Sigma n\text{-}1)} = 3.39,\ P = 0.001)$.

The division shows an evident regularity. This method of age determination based on the division of baleen records into "growth periods" by means of the regular occurrence of particular peaks and hollows and their configuration, will certainly be useful. In

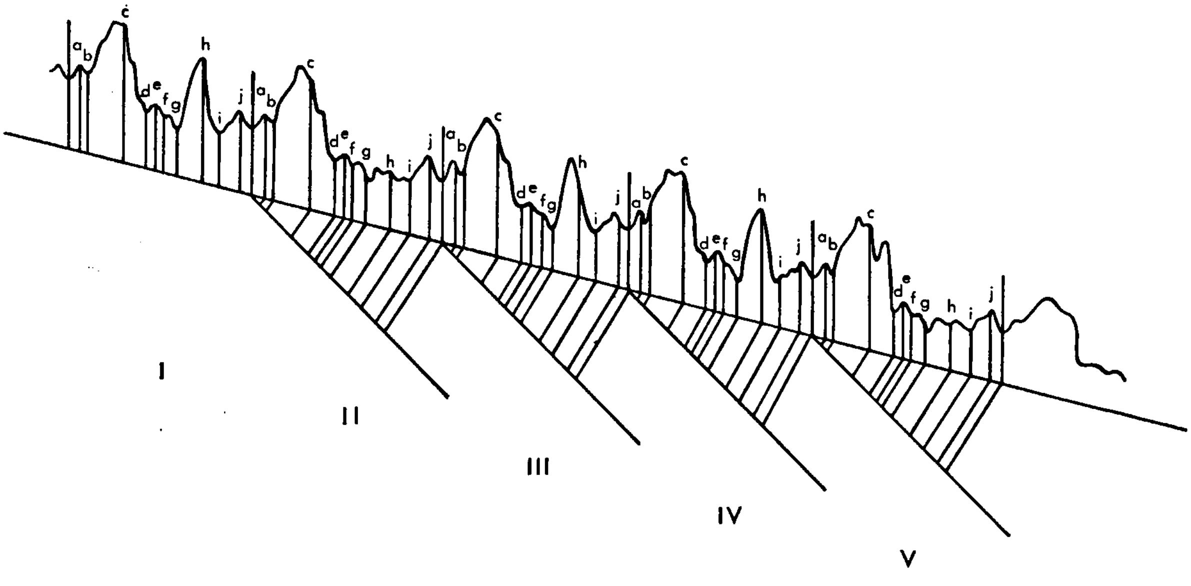

Fig. 8. *Diagram of a baleen record. Example for the regularity calculation.*

fact the agreement in regularity is greater than will appear at first, as is shown by **Friedmann**'s mechanical analysis.

On the ground of the fact that, although possibly unknown numbers of animals do not migrate every year, in general the life cycle (migrations, feeding, etc.) will probably be the same in most years and on the ground of the fact that there is a significant regularity of the "relief" of the baleen plate, it may be assumed that the "growth periods" in question each represent a period of one year in the life of the animal. The length of time represented by the length of the curve of the part of the baleen plate hidden in the gum, can be determined with this division into "growth periods" of one year.

The above mentioned facts do not exclude the possibility that each "growth period" in the baleen plates will represent a cycle covering two years since, in general, the life cycle of the mature female Fin Whale can be divided into periods of two years, viz. two-year sexual cycles, although exceptions are possible in this regularity. A small number of animals will be pregnant in two successive years, as small numbers of lactating animals are found which are pregnant. On the other hand, a number of females will have an extra period of "rest" between two pregnancies. Support for the supposition that a "growth period" corresponds to a period of one year, is found by determining the time represented by the length of the part of the baleen plate between the base in the gum ("date point") and the first so-called "ovulation peak" in the records of the baleen plates of pregnant females. This will be discussed below. Hence the duration of one "growth period" will be considered to be one year.

If the baleen record is divided into "growth periods", according to the above mentioned method, it is possible to estimate the number of months represented by the remaining parts of the baleen plate at the base and at the tip, on the ground of the length of the "growth periods" (years). In this way the number of years indicated by the record of the baleen plate of an animal is determined. This estimation is only reliable if the increment in length of the baleen plate is more or less regular during the whole year, and the increment of length per month can be estimated. In the diagram (fig. 9) the distance between date point and first division line will be seen to correspond with circ. 3½ months. The distance between the last division line and the end of the baleen record covers a period of circ. 8 months, so that the whole baleen plate will cover five periods of 12 months, one of 3½ months and one of 8 months. In the baleen record of this diagrammatized animal there are nearly six complete "growth periods".

In a record of a baleen plate divided into a number of "growth periods" of one year it is possible to estimate the month in which each part of the curve was formed. This implies that the curve can be analysed for the presence of particular peaks or configurations of peaks in certain periods of the year. In this way special events such as migration, lactation, weaning, pregnancy etc., can also be located in the curve.

Peaks resulting from the sexual cycle ("ovulation peaks"), are located in order to determine the mean rate of ovulation. These peaks are not found by means of calculations because in pregnant Fin Whales, in the youngest "growth period" (the period nearest to the date point) a characteristic and different type of peak was found. Besides this in these animals it was also possible to determine the age of the foetus by means of its length (**Mackintosh** and **Wheeler**, 1929, fig. 155; **Naaktgeboren**, **Slijper**

Fig. 9. *Diagram of a combined baleen record. 1 = date point; 2 = ovulation peak.*

and van Utrecht, 1960, fig. 1). With the aid of this foetus' age the moment of fertilization, which is about the time of ovulation, is determined. It is evident that the period of time between the moment of the formation of this peak and the moment of killing the mother (calculated from the length of the part of the record from the peak to the date point considering the total length of one "growth period" (year)), is equal to the age of the foetus. It may be assumed that this peak occurs because of special irregularities in the growth of the baleen plate as a result of ovulation. An indication that this peak is really an "ovulation peak" and that it is, for instance, not caused by implantation, is that similar peaks occurred in the baleen records of animals which had just attained sexual maturity and which had only one corpus albicans in the ovaries. These animals were not pregnant. They had never been pregnant, because the lapse of time between the "ovulation peak" and date point is too short for a completed pregnancy (fig. 10).

In other mammals a definite relation between the sexual cycle and the cornification of epidermal structures is found (Bullough, 1962). It is evident that these characteristic "ovulation peaks" are present throughout the whole length of the baleen record. However, these peaks are not present in every "growth period" (year) and not always at the same place in different "growth periods".

If the animal concerned is not pregnant it is in most cases possible to use the condition of the ovaries and mammary glands to make an estimate of the length of time elapsed after the last ovulation. In this way there is also certainty about the last "ovulation peak". Moreover, the correctness of determination of such a peak as the "ovulation peak" appears from the analyses of baleen records of animals which have just attained sexual maturity. In the baleen record of these animals a certain part of the curve always represents the period of sexual immaturity: a part with a less pronounced "relief" at the right hand side of the curve. At the end of this immature part is one "ovulation peak", while in the ovaries there is one corpus luteum or albicans (fig. 11). In lactating animals that are pregnant at the same time, there are always two "ovulation peaks" at the expected points in the baleen record (fig. 12). In a given curve the "ovulation peaks" are more or less similar in appearance. In baleen records of different animals they may have different shapes.

In conclusion, it is evident that the above mentioned modified method, used in my analyses of the records of baleen plates, will give improved results compared with Ruud's method.

The most important points in this improved method are:

1. The whole baleen plate is used in the analysis.
2. Besides the large waves, the so-called "relief" of the baleen plate is taken into account.
3. It is possible to determine the mean rate of ovulation.

A disadvantage of this method is that it is extremely time consuming.

4. Data obtained by means of the method

A. NUMBER OF "GROWTH PERIODS" IN THE PART OF THE BALEEN PLATE HIDDEN IN THE GUM

The number of "growth periods" in the part of the baleen plate hidden in the gum, must be known for comparison of the results of the older method of analyses of records of baleen plates (Ruud, 1940, 1945) with the results of the method described. The numbers of these "growth periods" must be added to the results of the analyses of baleen plates by Ruud and Nishiwaki.

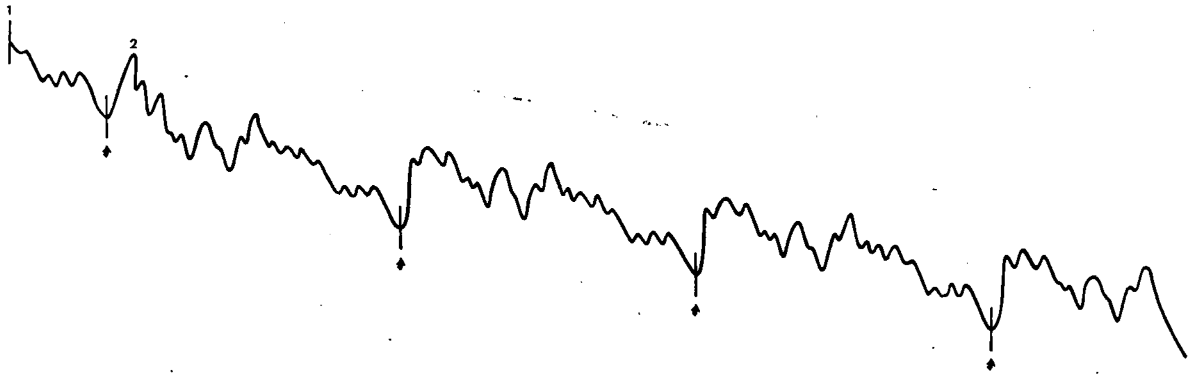

Fig. 10. *Diagram of a combined baleen record of a female Fin Whale, which had recently ovulated but was not pregnant.*

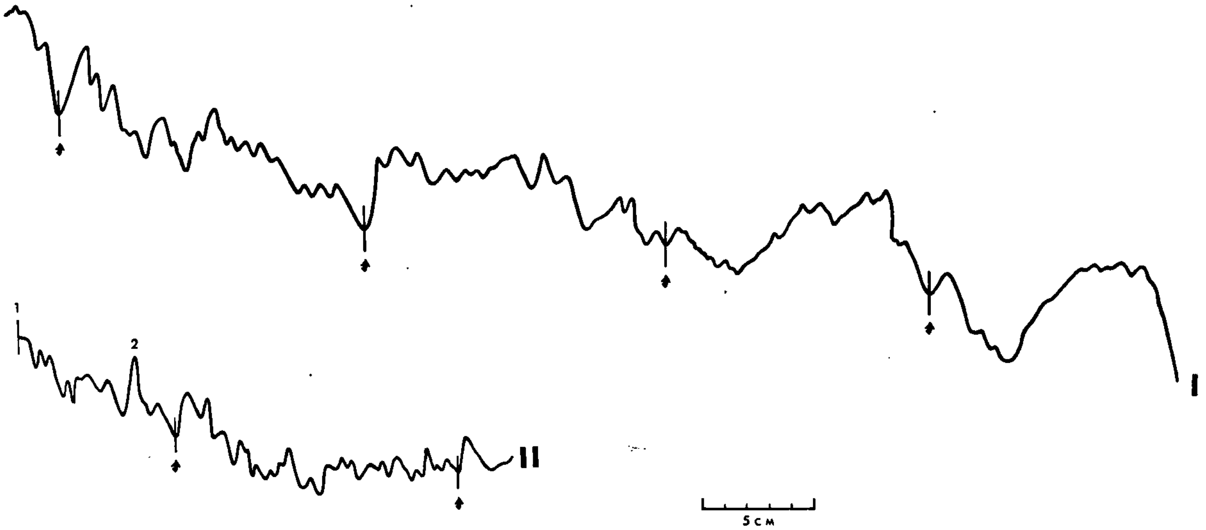

Fig. 11. *Complete baleen record of a female Fin Whale which had just attained sexual maturity. I. Record outer baleen plate. II. Record of the part of the baleen plate hidden in the gum. 1 = date point; 2 = ovulation peak.*

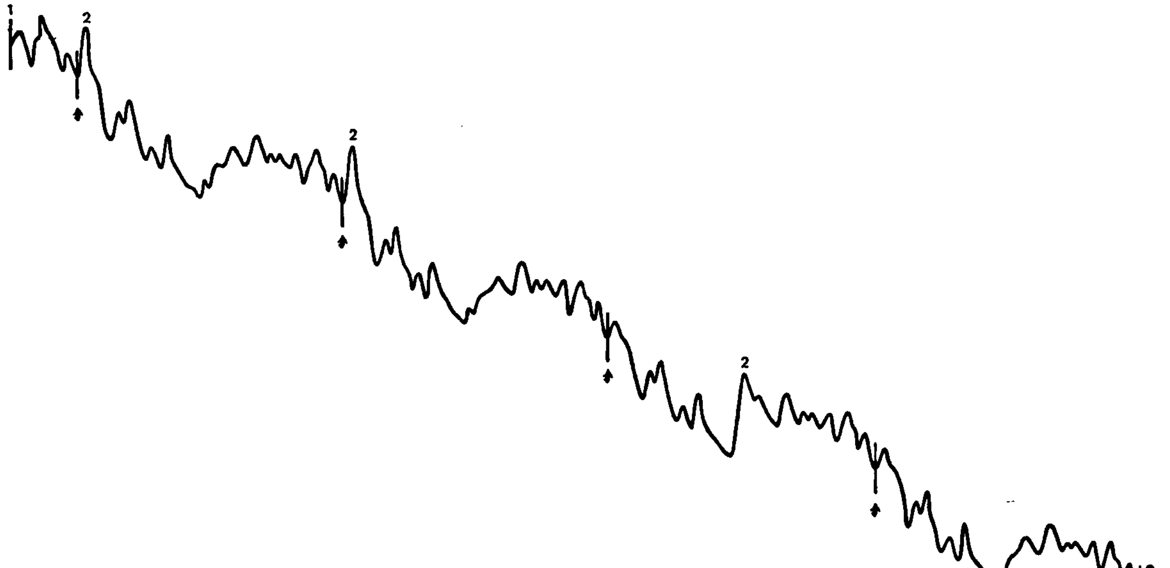

Fig. 12. *Diagram of a combined baleen record of a pregnant lactating animal. 1 = date point; 2 = ovulation peak.*

The question arises whether the number of "growth periods" in this part of the baleen plate is constant during the whole life of the animal or whether there is a correlation between this number and e.g. a.) the total number of "growth periods" in the whole baleen plate, i.e. the number of "growth periods" in the outer baleen plate (part of the baleen plate protruding from the gum) + number of "growth periods" hidden in the gum; b.) the number of "growth periods" in the outer baleen plate; c.) length of the animal or d.) the age of the animal, determined on the number of corpora in the ovaries.

From these analyses some data are obtained, but since the numbers of animals are very small, they give only a general indication.

a. *Number of "growth periods" in the gum compared with the total number of "growth periods" in the whole baleen plate*

From fig. 13 it is evident that in the first part of the curve the number of "growth periods" increases very quickly, afterwards the increase gradually slows down. A maximum is probably reached when there were baleen plates with more than ten "growth periods". But as the maximum number of "growth periods" found is ten, it is most likely that in baleen plates of this length, wearing at the tip of the plate is equal to the growth in length of such plates.

The mean numbers of "growth periods" in the part of the baleen plate hidden in the gum compared with the numbers of "growth periods" in the whole baleen plate are (table 6):

Table 6

Total number of "growth periods"	Mean number of "growth periods" in the gum	Min.	Max.	Number of animals
<1	0.5	—	—	1
1+	0.8	—	—	1
2+	1.1	—	—	1
3+	1.4	1.2	1.7	5
4+	1.5	1.2	2.0	15
5+	1.6	1.3	2.0	58
6+	1.8	1.4	2.5	53
7+	2.0	1.4	2.8	36
8+	2.1	1.6	2.6	21
9+	2.2	1.9	2.5	7
10+	2.4	—	—	1

b. *Number of "growth periods" in the gum compared with the number of "growth periods" in the outer baleen plate*

The curve in fig. 14 has nearly the same trend as that in fig. 13, only the line in fig. 14 is somewhat steeper.

As the number of "growth periods" in the outer baleen plate increases, the mean number of "growth periods" in the part of the baleen plate hidden in the gum increases.

The mean numbers are (table 7):

Table 7

Number of "growth periods" in the outer baleen plate	Mean number of "growth periods" in the gum	Min.	Max.	Number of animals
<1	0.6	0.5	0.8	2
1+	1.3	1.1	1.4	2
2+	1.5	1.2	1.8	10
3+	1.6	1.2	2.0	42
4+	1.8	1.3	2.5	73
5+	2.0	1.5	2.8	38
6+	1.9	1.4	2.5	25
7+	2.1	1.9	2.4	7

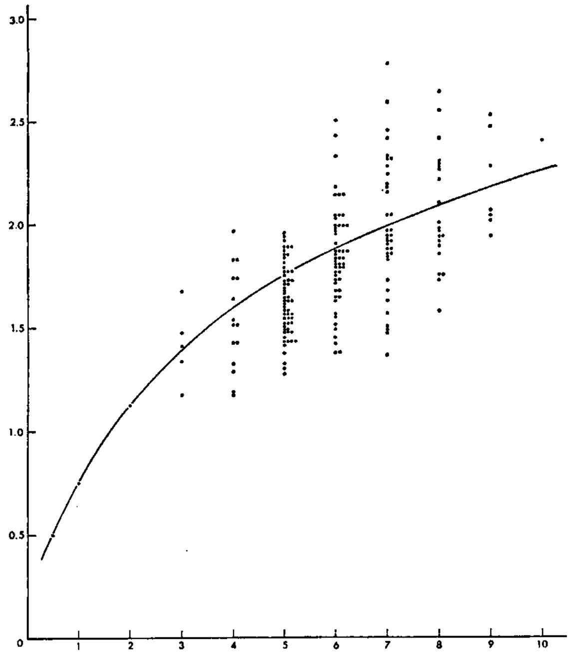

Fig. 13. *Number of "growth periods" in the part of the baleen plate hidden in the gum compared with the total number of "growth periods" in the whole baleen plate. Abscis: number of "growth periods" in the whole baleen plate. Ordinate: number of "growth periods" hidden in the gum.*

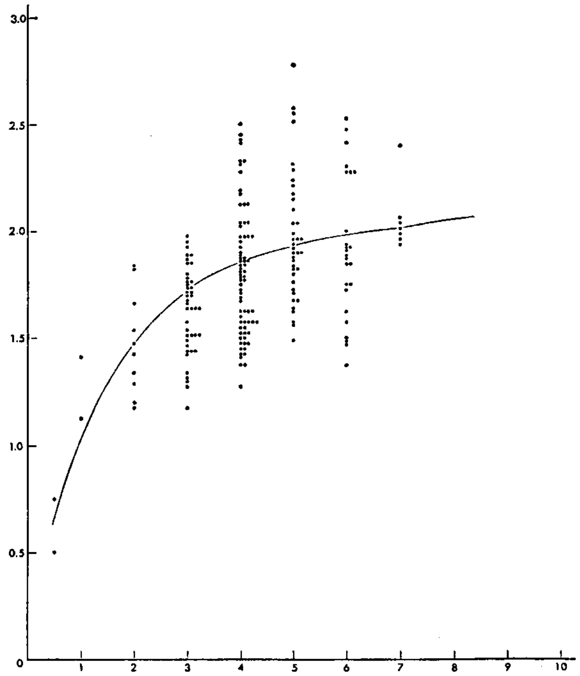

Fig. 14. *Number of "growth periods" in the part of the baleen plate hidden in the gum compared with the number of "growth periods" in the outer baleen plate. Abscis: number of "growth periods" in the outer baleen plate. Ordinate: number of "growth periods" hidden in the gum.*

c. *Number of "growth periods" in the gum compared with the length of the animal in feet*

If the number of "growth periods" is plotted against the length of the animal (fig. 15) it is possible to calculate the best fitting straight line, showing the correlation between these factors. Its equation is $y = 0.012\ x + 0.960$ (y = number of "growth periods" in the gum, x = length of the animal in feet). The minimum value used for x was 60, because the number of animals shorter than 60′, was very small, and also sexual maturity may be attained at 60′ (see also sub d).

From the graph it is evident that the number of "growth periods" in the part of the baleen plate hidden in the gum increases with the length of the animal. The question was whether this line differs significantly from the horizontal line in $\bar{y}$ (1.8). This was the case as is proved by STUDENT's t-test ($\nu = 181$, $t = 2.7$, $P < 0.05$, $r = 0.20$). It may be assumed that the number of "growth periods" will increase with the increase in length of the animal.

It is important to know whether or not this is the same in animals which have attained physical maturity, as, then, there is no increase in length of such animals. On board the f.f. "Willem Barendsz" no notes were made about the fusion of the vertebral epiphyses with the vertebral bodies of the animals, so a special length class had to be taken as a criterion of physical maturity. Following MACKINTOSH and WHEELER (1929) it is assumed that, on an average, 74 feet can be used for this purpose. From my own results, which are in agreement with those of MACKINTOSH and WHEELER, it appears this is not the case for all animals. Even in the available material one animal of 74′ was sexually immature. Nevertheless, this size limit is used in the calculations for a possible change in number of "growth periods" in the part of the baleen plate in the gum in relation to the length of the animal.

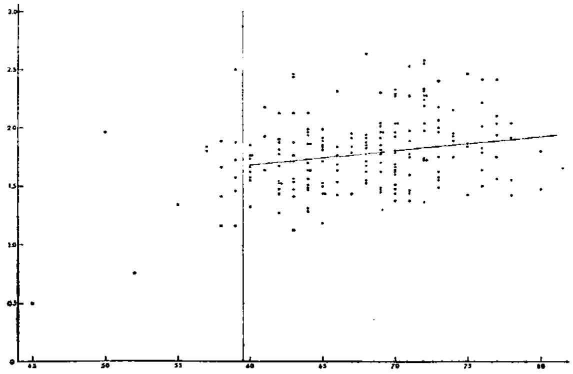

Fig. 15. *Number of "growth periods" in the part of the baleen plate hidden in the gum compared with the length of the animal. Abscis: length in feet. Ordinate: number.*

The analysis of covariance for the best fitting straight lines I (60′ to 73′ inclusive: $y = 0.020\ x + 0.492$) and II (74′ and longer: $y = -0.023\ x + 3.584$) is used. These lines are not significantly different ($\nu = 180$, $F = 1.882$, $P < 0.95$), so we must assume that an increase in length of the body gives an increase in the number of "growth periods" of the part of the baleen plate in the gum regardless of physical maturity.

The mean numbers of "growth periods" in the part of the baleen plate hidden in the gum, compared with the different length classes of the animals are (table 8):

Table 8

Length in feet	Mean number of "growth periods" in the gum	Min.	Max.	Number of animals
45	0.5	—	—	1
50	2.0	—	—	1
52	0.8	—	—	1
55	1.3	—	—	1
57	1.8	1.8	1.8	2
58	1.5	1.2	1.9	4
59	1.7	1.2	2.5	6
60	1.8	1.3	2.8	9
61	1.9	1.6	2.2	3
62	1.7	1.3	2.1	12
63	1.8	1.1	2.5	11
64	1.7	1.3	2.1	15
65	1.7	1.2	2.0	12
66	1.7	1.4	2.3	7
67	1.8	1.3	2.0	5
68	1.8	1.5	2.6	13
69	1.8	1.5	2.3	14
70	1.8	1.4	2.3	18
71	1.9	1.4	2.5	10
72	2.1	1.4	2.6	14
73	1.9	1.5	2.4	10
74	1.9	1.8	2.2	5
75	1.8	1.3	2.5	5
76	1.9	1.5	2.4	7
77	2.0	1.6	1.4	6
78	1.7	1.4	2.0	4
80	1.6	1.5	1.8	2
81½	1.9	—	—	1

d. *Number of "growth periods" in the gum compared with the age of the animal*

The numbers of corpora lutea and corpora albicantia present in the ovaries are used as a measure of age. Sexually immature animals are consequently excluded.

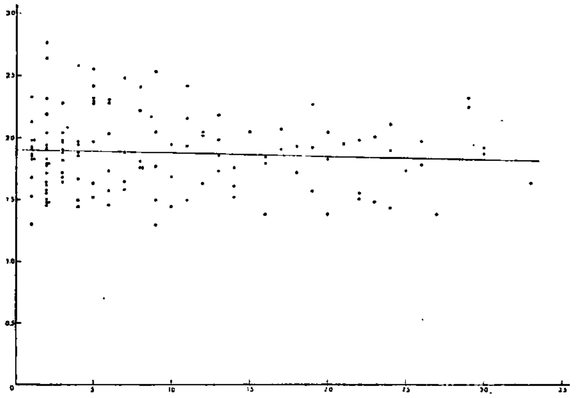

Fig. 16. *Number of "growth periods" in the part of the baleen plate hidden in the gum compared with the age of the animal. Abscis: number of corpora present in the ovaries. Ordinate: number of "growth periods".*

From the regression calculation follows the equation:

$y = -0.003\ x + 1.900$ for the best fitting straight line (fig. 16) (y = number of "growth periods" in the gum, x = number of corpora present in the ovaries). Application of STUDENT's t-test shows that this line does not differ significantly from the horizontal line in $\bar{y}$ (1.9) ($\nu = 126$, $t = 1.135$, $P > 0.10$, $r = -0.078$).

The number of corpora present in the ovaries can also be used to distinguish animals that are sexually mature, but not physically mature, from animals that are sexually mature and physically mature, because WHEELER (1930) comes to the conclusion that animals with more than 15 corpora in the ovaries are physically mature.

By means of an analysis of covariance the influence of physical maturity is examined. Also in this case the best fitting straight lines I (animals with 1 to 15 corpora inclusive in the ovaries): $y = -0.0001\ x + 1.900$ and II (animals with 16 or more corpora present in the ovaries): $y = 0.005\ x + 1.694$, do not differ significantly ($\nu = 125$, $F = 0.1393$). So we have to assume that the number of "growth periods" in the gum is independent of the age of the sexually mature animal.

The mean number of "growth periods" in the different age classes (number of corpora present in the ovaries) are (table 9):

Table 9

Number of corpora	Mean number of "growth periods" in the gum	Min.	Max.	Number of animals
1	1.9	1.3	2.3	13
2	1.9	1.5	2.8	20
3	1.9	1.6	2.3	10
4	1.9	1.4	2.6	8
5	2.1	1.5	2.6	8
6	1.9	1.5	2.3	6
7	1.9	1.6	2.5	4
8	2.0	1.8	2.4	5
9	1.8	1.3	2.5	5
10	1.7	1.4	1.9	3
11	2.0	1.5	2.4	4
12	1.9	1.6	2.0	3
13	1.9	1.7	2.2	4
14	1.6	1.5	1.8	3
15	2.0	—	—	1
16	1.7	1.4	1.8	3
17	2.0	1.9	2.1	2
18	1.8	1.7	1.9	2
19	1.9	1.6	2.3	3
20	1.8	1.4	2.0	3
21	2.0	—	—	1
22	1.7	1.5	2.0	3
23	1.7	1.5	2.0	2
24	1.8	1.4	2.1	2
25	1.7	—	—	1
26	1.9	1.8	2.0	2
27	1.4	—	—	1
29	2.3	2.2	2.3	2
30	1.9	1.9	1.9	2
33	1.6	—	—	1

Conclusions with regard to the number of "growth periods" in the gum are as follows:

1. The mean number of "growth periods" in the gum for all animals sampled is 1.8. The maximum number found is 2.8, the minimum 0.5.
2. The mean number of "growth periods" in the gum increases with the increase in number of "growth periods" in the whole baleen plate (outer baleen plate + part of the plate hidden in the gum).
3. The mean number of "growth periods" in the gum increases with the increase in number of "growth periods" in the outer baleen plate.
4. The mean number of "growth periods" in the gum increases with the increase in length of the animal.
5. The mean number of "growth periods" in the gum of sexually mature animals does not increase with the increase of age, i.e. with the increase in number of corpora present in the ovaries.

In one respect conclusions 4 and 5 are contradictory as in younger animals there is some correlation between length and age (number of corpora present in the ovaries). An explanation for this fact is lacking. It should be taken into account that this is only a general trend. The variation in the values is very great. This may be due to the material being sampled from different "constitution types" (see p. 59).

B. LIMITS OF THE METHOD OF AGE DETERMINATION WITH THE AID OF BALEEN PLATES

RUUD (1940, 1945), NISHIWAKI (1950, 1951), CHITTLEBOROUGH (1959) and others have shown that age determination by means of baleen plates is only useful in younger animals. This is because wearing at the tip of the baleen plate is rather great, so that this portion is soon lost. It is obvious that estimation of the number of "growth periods" which have disappeared in this way is impossible.

This wearing is mainly caused by two factors. Firstly, there is the water running along the outer baleen plate, which gives a regular wearing off of the whole surface of the baleen plate. Therefore, the "relief" of the part of the baleen plate hidden in the gum, is much more pronounced than it is at the surface of the outer baleen plate. Moreover, the "relief" of the oldest "growth periods" of the outer part of the baleen plate is less clear than it is in the younger "growth periods" nearer to the gum. The older "growth periods" were exposed to this wearing off for a longer time.

Secondly, the tips of the baleen plates, when they reach the bottom of the mouth, are pushed against each other; thus causing wearing at the tips. Consequently the maximum length of the baleen plate is fixed, and an extra decrease in thickness is brought about so that the end of the plate is worn away.

Because of this wearing only a small number of "growth periods" (years) is visible in the record of a baleen plate. RUUD (1945) tried to determine the number of "growth periods" worn away by means of the convergence of the horny tubes in the baleen plates. This convergence is caused by the fact that the horny tubes increase in diameter with the increase of age. Hence in the younger part of the baleen plate, formed at a relatively late date, the distance between the centres of the horny tubes is greater than it is at the tip of the baleen plate. In young animals this convergence is clearly visible. All horny tubes converge to one point which is the tip of the foetal baleen plate ("zero point") (RUUD, 1945). In this way it is possible to determine the length of the part of the baleen plate worn off and to estimate roughly the number of "growth periods" lost. A difficulty in older animals is that this convergence is very small; so it is hardly possible to determine the "zero point" and consequently the number of "growth periods" lost. Estimation of the age of an animal in this way is questionable. RUUD (personal communication) therefore abandoned the method.

HYLEN, JONSGÅRD, PIKE and RUUD (1955) tried to obtain an age composition of their material, by means of the known minimum age of the animals. They are of opinion that the age groups 0, I, II and III can be determined with great certainty. In all records of baleen plates of animals classified in these age groups, part of the "suckling baleen" is recognizable or part of the record is recognizable as having been formed in the animal's first season in the Antarctic. Animals classified in age group IV and V are sometimes wrongly determined as in the records of the baleen plates of all these animals three complete "growth periods" and part of another are present. This part of a "growth period" at the tip of the baleen plate may have been formed during the first season (animal classified in age group IV) or during the second season in the Antarctic (age group V). However, they believe that the number of mistakes in the classification will be very small. All animals with four complete "growth periods" and part of a fifth in the record are classified in age group VI, unless it is evident from the record that the part of first season in the Antarctic. Mistakes in the interpretation of this part of the record are possible, resulting in an overestimation of the number of animals in age group V and an underestimation of the number of animals in age group VI. All animals with five complete "growth periods" are placed in age group VII, animals with six complete "growth periods" in age group VIII. Animals with more than six complete "growth periods" are rare in their analyses. Animals placed in the age groups VI, VII and VIII may be older than the number of years indicated by the number of "growth periods" in the records of the baleen plates if the yearly increment in length of the baleen plate is equal to the wear at the tip. Such animals have a more or less constant number of "growth periods" in the baleen plate. The number of "growth periods" worn off is unknown. These age groups are indicated by these authors preferably as groups VI+, VII+ and VIII+. By using this division, obtained by means of the classification into age groups, the age composition of a sample can be determined. The right hand part of a curve – based on these data – is obtained by extrapolation (all older animals are lumped together in age groups VI+, VII+ and VIII+). With this curve of age frequencies the authors tried to obtain an impression of the age composition of the stock and also about their natural mortality.

Hylen et al. consider the age groups II and III as absolutely certain. From Hylen, Jonsgård, Pike and Ruud (1955, table 5) it appears that in some cases there are corpora albicantia and lutea in the ovaries of animals belonging to age groups II and III. This is contradictory to my own results (table 10):
Animals with corpora in their ovaries in spite of a small number of "growth periods" in their baleen plates (three or four), are certainly older than is indicated by this number of "growth periods". In such animals there is a considerable wearing at the tip of the baleen plate at an early age. If the baleen records of these animals give no clear indications of suckling or weaning, in our method the baleen record is insufficient for age determination. Moreover, from my analyses it is evident that the age at which sexual maturity is attained is much higher than is accepted by Hylen et al. The records of baleen plates of animals of the age groups II and III of Hylen et al. have three and four complete "growth periods" if the part of the baleen plate hidden in the gum, is added. However, from the results of my research, the number of years based on this number of "growth periods" is lower than the age at which sexual maturity is attained. A number of periods must have worn away when an animal is sexually mature and has only three or four complete "growth periods" in the whole baleen record. The results of age determinations by means of the baleen method will, according to Hylen et al., be uncertain in age group II.

Table 10

Number of corpora	Number of "growth periods" in the total baleen plate										
	0	I	II	III	IV	V	VI	VII	VIII	IX	X
0	1	1	1	5	15	35	10	3	—	—	—
1	—	—	—	—	—	4	7	2	—	—	—
2	—	—	—	—	—	10	5	4	1	—	—
3	—	—	—	—	—	2	4	3	1	—	—
4	—	—	—	—	—	3	2	3	—	—	—
5	—	—	—	—	—	1	2	2	3	—	—
6	—	—	—	—	—	—	2	2	2	—	—
7	—	—	—	—	—	—	1	1	1	1	—
8	—	—	—	—	—	—	2	—	2	—	1
9	—	—	—	—	—	1	2	1	—	1	—
10	—	—	—	—	—	1	1	—	—	1	—
11	—	—	—	—	—	—	—	3	1	—	—
12	—	—	—	—	—	—	1	1	—	1	—
13	—	—	—	—	—	—	1	2	1	—	—
14	—	—	—	—	—	1	1	—	1	—	—
15	—	—	—	—	—	—	1	—	—	—	—
16	—	—	—	—	—	—	1	2	—	—	—
17	—	—	—	—	—	—	—	1	—	1	—
18	—	—	—	—	—	—	1	—	1	—	—
19	—	—	—	—	—	—	1	—	1	1	—
20	—	—	—	—	—	—	2	—	—	1	—
21	—	—	—	—	—	—	1	—	—	—	—
22	—	—	—	—	—	—	2	1	—	—	—
23	—	—	—	—	—	—	—	1	1	—	—
24	—	—	—	—	—	—	1	—	2	—	—
25	—	—	—	—	—	—	—	—	1	—	—
26	—	—	—	—	—	—	1	—	1	—	—
27	—	—	—	—	—	—	1	—	—	—	—
28	—	—	—	—	—	—	—	—	—	—	—
29	—	—	—	—	—	—	—	2	—	—	—
30	—	—	—	—	—	—	—	1	1	—	—
31	—	—	—	—	—	—	—	—	—	—	—
32	—	—	—	—	—	—	—	—	—	—	—
33	—	—	—	—	—	—	—	1	—	—	—

After determination of the number of "growth periods" in the whole baleen plate (outer baleen plate + part of the baleen plate hidden in the gum) and the number of corpora (lutea + albicantia) in the ovaries of my material, it is evident that (see table 10):

1. In animals with baleen records having up to and including four complete "growth periods", no corpora are present in the ovaries.
2. In animals with baleen records having five complete "growth periods", the number of corpora in the ovaries ranges from 0-14.
3. In animals with baleen records having six complete "growth periods", the number of corpora in the ovaries ranges from 0-27.
4. In animals with baleen records having seven complete "growth periods", the number of corpora in the ovaries ranges from 0-33.

Hence follows that age determination on baleen plates is unreliable in all animals with at least five complete "growth periods" in their record, except if in such a baleen record there is a part formed during suckling or weaning ("double hump"). If this is not the case the determination is unreliable. The differences may be caused by wearing at the tip of the plate. This will vary in different animals so that in one animal there will be five complete "growth periods" in the record, in another six or seven, although they have the same number of corpora in the ovaries.

These differences may be caused by individual differences in the rate of growth of the baleen plate. In animals with three complete "growth periods" in the outer baleen plate (four or five "growth periods" in the total baleen plate) the mean length of the "growth period" is significantly longer than the mean length of the "growth period" of animals with seven periods in the record of the outer baleen plate (eight or nine "growth periods" in the total baleen record). The mean lengths in mm (table 11) were:

Table 11

Number of "growth periods" in the outer baleen plate	Mean length "growth period" in the outer baleen plate	Min.	Max.	Number of "growth periods"
3	149	119	175	33
4	125	94	180	216
5	117	85	164	165
6	99	74	140	138
7	94	78	122	49

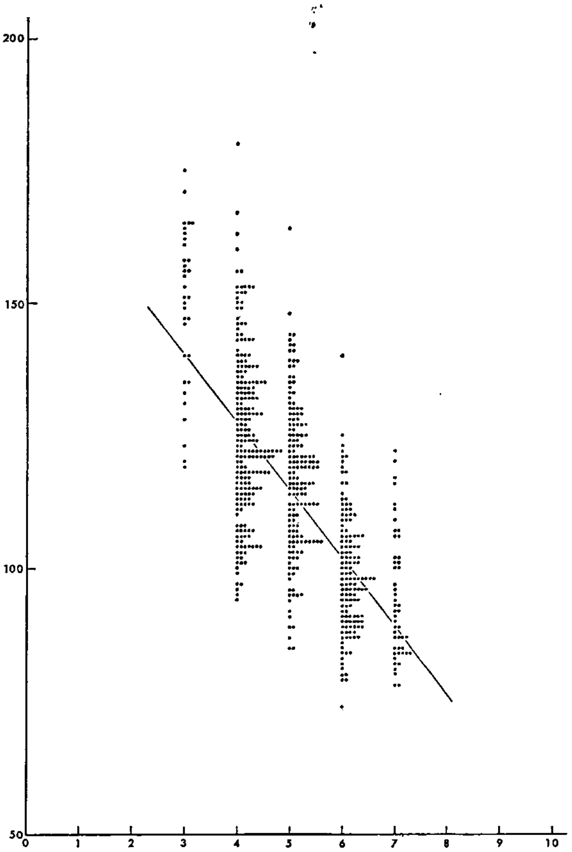

Fig. 17. *Number of "growth periods" in the outer baleen plate compared with the length of these periods. Abscis: number. Ordinate: length in mm.*

The equation of the best fitting straight line (fig. 17) is: $y = -12.766\ x + 178.58$ (x = number of "growth periods" in the outer baleen plate, y = length of the "growth periods" in the outer baleen plate in mm). This line differs significantly from the horizontal straight line ($\nu = 599$, $t = 23.2$, $P < 0.001$, $r = -0.693$).

The total length of the outer baleen plate may be constant. As, however, is shown in fig. 18 this is not the case (the best fitting straight line $y = 26.71\ x + 526.34$ (x = number of "growth periods" in the outer baleen plate, y = length outer baleen plate in mm) significantly differing from the horizontal line ($\nu = 126$, $t = 5.76$, $P < 0.001$, $r = 0.456$)). A baleen plate having more "growth periods" is longer than a baleen plate with a lower number of periods.

It is certain that there must be differences in the individual rates of growth, but a second cause may be found in the size of the head: in particular in the distance between the "root" of the baleen plate (in the palate) and the bottom of the mouth where the wearing is very great at the tip of the baleen plate. Indeed, MACKINTOSH and WHEELER (1929, fig. 6) found a linear correlation between these two factors. Ruud (1945, fig. 12) also proved this. From my own results this is again evident (fig. 19). The lengths of the baleen plates are determined on the lengths of the records of the longest baleen plate. The equation of the best fitting straight line is $y = 8.015\,x + 97.24$ (x = length of the animal in feet, y = length of the outer baleen plate in mm). This line differs significantly from the horizontal line ($\nu = 126$, $t = 7.36$, $P < 0.001$, $r = 0.548$). The variation in the different length classes is very great. These differences may be connected with the existence of special "constitution types" in the stock of the Fin Whale. From data sampled on board the "Willem Barendsz" during the season 1959/1960, the impression was obtained that three different types of Fin Whales may be distinguished, viz.:

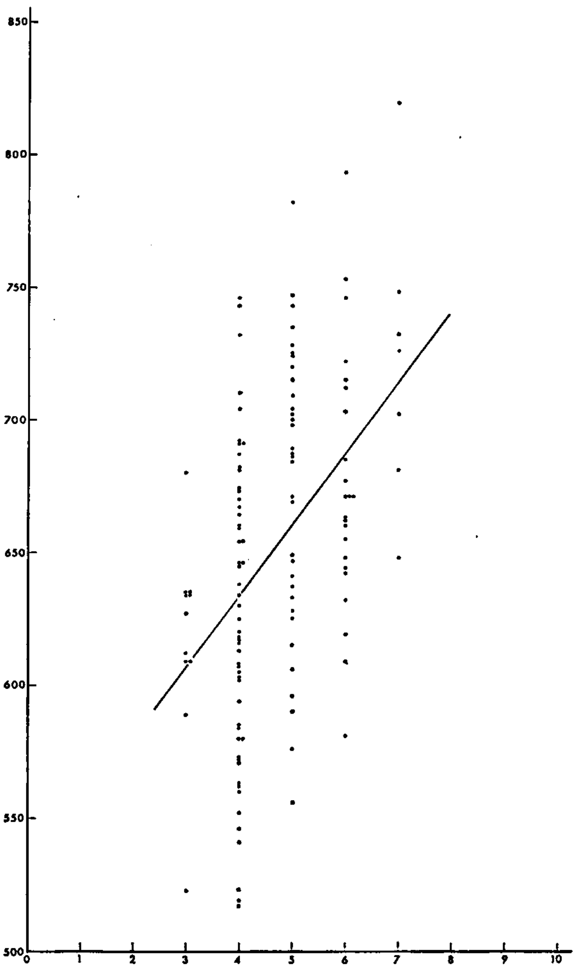

Fig. 18. *Number of "growth periods" in the outer baleen plate compared with the total length of the outer baleen plate. Abscis: number. Ordinate: length in mm.*

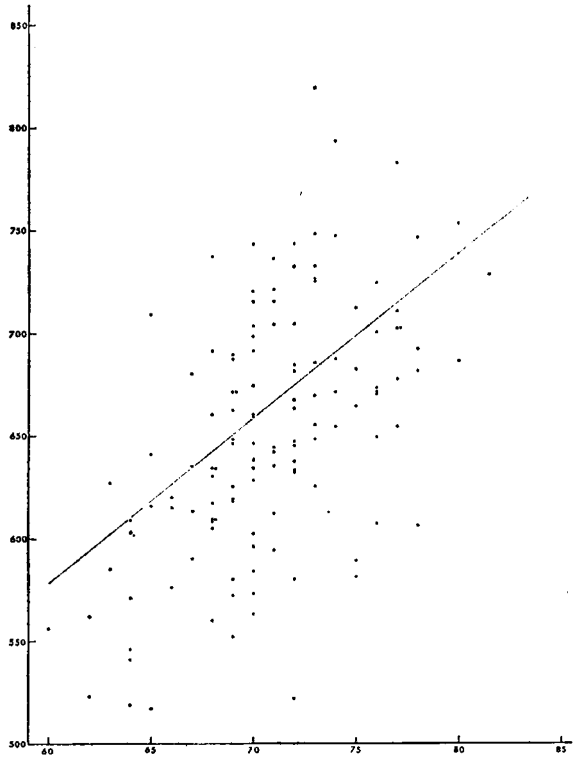

Fig. 19. *Length of the outer baleen plate compared with the length of the animal. Abscis: length of the animal in feet. Ordinate: length outer baleen plate in mm.*

1. Animals which are short, dumpy, dark coloured, with pigment running far out to the ventral side, with a high head and a big girth. They may attain sexual maturity at an early age. They probably attain sexual maturity when about 60 feet long. These animals have a thick layer of blubber consisting of much fat. The growth of these animals is probably very slow and also the growth of their baleen plates. Owing to this and also because of the great size of the head, a large number of "growth periods" in the record of the baleen plates of these animals may be expected.
2. The normal type of Fin Whale.
3. Animals which are very long, slender, and light coloured, with a flat, low head and a thin layer of blubber. Probably they attain sexual maturity some years later than the animals described under 1., and when about 71 feet long (once an immature animal of 74 feet was caught). The number of "growth periods" in the baleen plate is small, due to the small size of the head and probably the more rapid growth of the animal.

No exact data about these types are available as yet. However, material and data concerning the different types were collected during the season 1962/1963, with regard to the general appearance, pigmentation, thickness of the layer of blubber, state of the ovaries, size of the head, length of the animal and data and material of baleen plates and earplugs. The results of these investigations will be published later. Further evidence for the existence of these three "constitution types" is given by Fujino (1964) by means of blood tests. He found three subpopulations of the Antarctic Fin Whale. It is possible that these subpopulations correspond with the "constitution types".

The mean length of the "growth period" in the outer baleen plate may change with the age of the animal. Ruud, Jonsgård and Ottestad (1950) noted in the case of the Blue Whale, that the length of the "growth period" in the record of the baleen plate decreased with the increase in age. They gave no data about the Fin Whale. As my material consists mainly of Fin Whales an attempt was made to get some idea concerning correlation between the ages of the animals of this species and the lengths of the periods in their records. In immature animals there is a decrease in length of the "growth period" as there is an increase in age. The values are as follows (this is only an impression, the numbers of animals are too small) (table 12):

Table 12

	Length in mm	Number of "growth periods"
First year after "double hump"	140	17
Second year after "double hump"	130	17
Third year after "double hump"	125	16

For the later years these values are not worth giving as the numbers of animals in each year class are too small.

The mean lengths of the "growth periods" in the different age classes of mature females are given in table 13.

Table 13

Number of corpora	Mean length in mm of the "growth period" in the outer baleen plate	Min.	Max.	Number of periods
1	118	85	175	53
2	124	83	163	82
3	115	84	165	41
4	128	89	165	31
5	116	87	155	36
6	119	87	180	29
7	103	79	164	23
8	112	85	143	27
9	119	85	144	26
10	109	82	133	15
11	106	80	135	21
12	107	77	135	17
13	113	85	144	22
14	132	100	156	13
15	141	128	149	4
16	111	87	134	15
17	113	91	140	11
18	115	88	148	11
19	102	74	139	16
20	104	81	138	15
21	132	125	137	4
22	117	91	153	15
23	111	90	140	12
24	114	94	143	15
25	111	105	119	5
26	108	84	135	11
27	125	122	132	4
28	—	—	—	—
29	114	96	133	10
30	107	90	130	11
31	—	—	—	—
32	—	—	—	—
33	106	101	112	6

The equation of the best fitting straight line (fig. 20) is: $y = -0.38\,x + 119.6$ (x = number of corpora present in the ovaries, y = length in mm of the "growth period" in the outer baleen plate). It differs significantly from the horizontal line in $\bar{y}$ (115.7) ($\nu = 599$, $t = 4.1$, $P < 0.001$, $r = -0.165$). So,like in the Blue Whale, the mean length of the "growth period" in the outer baleen plate in the Fin Whale decreases with the increase in age (the increase in number of corpora in the ovaries). There is, however, a very great individual variation in length of the "growth periods". The relationship between the number of "growth periods" in the outer baleen plate and the age of the animal, is not evident in animals with five or more "growth periods" in the total baleen plate (see p. 58). The shortening of the mean length of the "growth period" in the outer baleen plate does not solely depend on the increase in number of periods.

Hylen et al. (1955) are of opinion that age determination by means of the Norwegian method of analysis (excluding the part of the baleen plate hidden in the gum) is completely reliable for age groups O, I, II and III, providing the record contains the "double hump". Converting these age groups of Hylen et al.

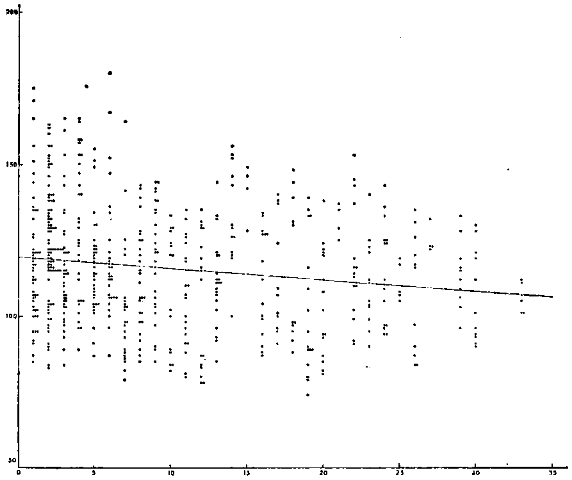

Fig. 20. *Length of the "growth period" in the outer baleen plate compared with the age of the animal. Abscis: number of corpora present in the ovaries. Ordinate: length in mm.*

into age groups, determined with the baleen records and the analysis of the part of the baleen plate hidden in the gum, we get the age groups 0, I, II, III or IV and IV or V of my method. From HYLEN et al. (1955, table 5) it appears that animals of group II (three or four "growth periods" according to my method) may have corpora in the ovaries, and that in animals of group III (four or five "growth periods" according to my method) a great variation occurs in the number of corpora present in the ovaries. In my results there is also a variation in number of corpora present in the ovaries of animals with five "growth periods" in the baleen plate. However, contrary to the results of HYLEN et al. there was not any mature animal with three or four "growth periods" in the baleen plate in my material (age group II of HYLEN et al.). This points to the possibility that age determination by means of the Norwegian method is unreliable for age group II of HYLEN et al. (three or four "growth periods" according to my method using the total baleen plate), and that therefore only the age groups 0 and I of HYLEN are reliable. Evidence of not only the part of the baleen plate hidden in the gum (in age group 0 as a mean 0.63 "growth periods" to age group VI with as a mean 1.92 "growth periods"), but also of the contradiction between the number of corpora albicantia and the age determination according to RUUD, suggests that in the baleen plates used by HYLEN et al., the ages of the animals are too low. Each animal, depending on the number of "growth periods" in the record of the baleen plate will be from six months to two years older than is estimated (individual variations are greater: up to 2.8 "growth periods"). A considerable part of the material is probably older than was determined by HYLEN et al.

In general, baleen plates are useful for age determination up to and including the fourth year in the life of an animal. This would mean that, already in the last period before the age at which the animals attain sexual maturity (NISHIWAKI, ICHIHARA and OHSUMI, 1958, five years; LAWS, 1961, five years) the method is useless for all animals; so other methods for age determination must be applied. One of the methods for sexually mature females is analysing the ovaries, providing it is possible to determine the mean age at which the animals attain sexual maturity and the mean rate of ovulation. A drawback is that only an estimation of the individual age of the animal can be obtained. However, these estimations are sufficiently reliable to be used in statistical studies.

C. MOMENT OF ATTAINMENT OF SEXUAL MATURITY

Estimations of the age at which the Fin Whale ovulates for the first time, have changed very much in the course of time.

MACKINTOSH and WHEELER (1929) supposed that the animal attained sexual maturity at about two years after birth. Their conclusion was based on a curve of growth compiled by them from data of the catch of Fin Whales from South Georgia (MACKINTOSH and WHEELER, 1929, fig. 155). The left hand part of this curve, the period between impregnation and birth and between birth and weaning is based on data, the right hand part between weaning and sexual maturity is, in default of sufficient fixed data, speculative. "As to the rest of the curve of growth, the fact that adolescent Blue Whales at South Georgia tend to approximate to one or two lengths is attributed to the production of annual batches of calves, and from this, the length of maturity being known, it is estimated that maturity is reached some two years after birth." This was in the case of Blue Whales. According to these authors there is no essential difference between the rates of growth of Blue and Fin Whales ("As the growth rate of Fin Whales is unlikely to be substantially different from that of Blue Whales a provisional curve for the former can be constructed by analogy from weaning at 12 m. to sexual maturity at 20 m. for females and 19.4 m. for males") so also the Fin Whales might attain sexual maturity two years after birth.

Using scars in the skin WHEELER (1934) divided the catch of immature Fin Whales into three age groups and reached the conclusion that, in a number of animals, sexual maturity will be attained three years after birth.

Ruud (1940) investigated this problem using baleen plate determinations. At this time he also postulated a period of two years between birth and sexual maturity. His material included one particular animal, a mature female of 64′, caught off the west coast of Norway, which had in its baleen plate record clear signs of the first "growth period", which is the suckling period, another complete "growth period" and the beginning of a third. The greater part of the third "growth period" was, according to **Ruud**, hidden in the gum. An animal with such a record would be between two and three years old. However, in this case the foetus and one of the ovaries were lost. Part of the chorion and the other ovary were present, and in this last ovary were neither corpora lutea nor corpora albicantia. **Ruud** (1940) concludes: "We can assume therefore, with a great degree of certainty, that this whale was pregnant for the first time and in agreement with Mackintosh and Wheeler, we must assume that it was between 2 and 3 years of age." There is no certainty that it was the first time this particular animal ovulated and moreover, the entire evidence for determining the age at which this species attains sexual maturity, was based on material from one single animal. In 1945, **Ruud** determined that the age at which sexual maturity is attained, is three years, which is one year later. In his opinion, animals with one to three corpora in the ovaries belong to age group III and must have three "growth periods' 'in the record, and should attain sexual maturity at an age of three years. In his opinion, the exceptions he found were:

1. Attainment of sexual maturity at an age of two years.
2. Oestrus without impregnation.
3. A calf in two successive years.
4. Accumulation of more than four or five corpora in the ovaries per breeding season.

This latter exception is based on the work of **Wheeler** (1930). By means of counting the corpora in the ovaries his material is divided into groups with 1-4, 5-9, 10-14 corpora etc. A full discussion is given below in the section concerning the rate of ovulation.

Nishiwaki (1950) found a greater age of sexual maturity with the baleen method. In female Fin Whales he found sexual maturity (in the ovaries only one corpus luteum) at the fourth or fifth "growth period" in the record of the baleen plate. So in female Fin Whales there would be a period of four years between birth and sexual maturity. Later, in 1952, **Nishiwaki** retained the same idea, only he accepted a greater distribution in ages at which the animals attained sexual maturity. He found that sexual maturity was attained by 75% in their fifth year, the remainder would attain this stage at a greater or lesser age. He did not consider an age of four years before attaining sexual maturity as representative for the stock, notwithstanding the high percentage. In his opinion this was caused by the sample being too small and by the selection made by the gunners, by which animals attaining sexual maturity at an earlier age would not be caught or might even be below the minimum size limits. In his opinion, a greater percentage would attain sexual maturity after three years, that is in their fourth year, and there would be a number of animals which would not be sexually mature in their sixth year, so that they would have at least five years between birth and sexual maturity.

Laws and **Purves** (1956) pointed to a new method of age determination based on the analyses of earplugs. Unfortunately, their material was too scanty for any conclusions to be reached about the age of sexual maturity. The results of the analyses of the records of both the baleen plates and the earplugs were similar in their first four years. In the older age groups the results of the analyses of the records of the baleen plates were too low because of the wearing at the tip of the plates.

Nishiwaki (1957) also published a paper describing age determination of Fin Whales based on analyses of earplugs. From this investigation it appeared that in the southern Fin Whales sexual maturity is attained at a number of ten laminations, which means at an age of four or five years, supposing a deposition of two laminations per year. In 1958 the same author and his co-workers indicate a number of 11 laminations before attainment of sexual maturity, which is at an age of five and a half years.

Purves (1958), however, found about 12 laminations, which means five or six years between birth and sexual maturity. **Purves** and **Mountford** (1959) also postulated an age of five or six years before sexual maturity is attained. **Laws** (1961) concludes that in the case of the female Fin Whale sexual maturity is on an average attained at an age of five years.

Ohsumi (1964) supposes the deposition of laminations of the earplug to be at a rate of less than two per year and not less than one. If he accepts a deposition of one lamination per year, the age of sexual maturity is estimated to be about ten years.

Of my own material I also tried to determine the moment of first ovulation by means of the analyses of the baleen records. The material available was rather scanty, so it has been impossible to reach reliable conclusions.

For this part of the investigation 19 mature animals were available. In the ovaries of these animals one to five corpora were present. The records of the baleen plates show clear indications of the period of weaning ("double hump").

The animals concerned were:

1954/1955	no. 530
1955/1956	no. 1157
1956/1957	nos. 140, 192, 260, 372, 378, 560, 630, 817, 1058
1957/1958	nos. 252, 392, 404, 572, 649
1958/1959	nos. 377, 715, 2127

By means of the numbers of "growth periods" in the baleen records, it was determined that:

5 animals attained sexual maturity in their 6th year.
11 animals attained sexual maturity in their 7th year.
3 animals attained sexual maturity in their 8th year.

Moreover, there was material of 13 immature animals. According to the condition of the ovaries, they were nearly sexually mature (neither corpora lutea nor albicantia, only great follicles were present in the ovaries), so it is to be expected that an ovulation would take place in this year of life. In the records of the baleen plates indications of weaning were present.

The animals concerned were:

1956/1957	nos. 446, 610, 825, 1068
1957/1958	nos. 419, 774
1958/1959	nos. 421, 486, 1079, 1424, 1714, 1951, 2020

In the records of the baleen plates of these animals there were:

5 "growth periods"	5 animals
6 "growth periods"	5 animals
7 "growth periods"	3 animals

It could be expected that these animals would ovulate for the first time in their sixth, seventh or eighth year, respectively.

In the remaining material were five immature animals of which the records of the baleen plates of some individuals represented five "growth periods" and of others six "growth periods". In these records there were no indications of weaning. These animals were at least one year older than the number of "growth periods" in their records indicates.

The animals concerned were:

1958/1959	nos. 848, 893, 1709, 1894, 2029

Only one animal, 1958/1959 no. 848, was nearly sexually mature to judge from the state of the ovaries. Animal 1958/1959 no. 893 has six "growth periods" in the record of the baleen plate, the other animals five. These animals had a period of at least six or seven years between birth and sexual maturity.

Moreover, among the mature females there were two pregnant animals. In the records of their baleen plates were five, and six "growth periods" respectively and there were no indications of weaning. In the ovaries of these animals there was only one corpus luteum. It was evident that these animals had ovulated only once. Furthermore, these animals must have passed at least six and seven years respectively, between birth and sexual maturity. If we accept that for these animals the minimum age at which they could have attained sexual maturity is the actual age at which the animals could have ovulated for the first time, their distribution is as follows:

10 animals (25%) have attained sexual maturity in their 6th year.
21 animals (55%) have attained sexual maturity in their 7th year.
8 animals (20%) have attained sexual maturity in their 8th year.

From the above it can be concluded: the female Fin Whale of the Southern Hemisphere will attain sexual maturity after its fifth, sixth or seventh year, averaging six years between birth and sexual maturity. This difference in ages at which the animals attain sexual maturity may be linked with the presence of three "constitution types". The short, dumpy animals would attain sexual maturity after five years, the normal type after six years and the long, slender, light coloured animals after seven years. There is no certainty about this. It is only a preliminary impression from material already available. As there were no other data available, the Fin Whale population of the Southern Hemisphere should be considered as a whole, in which on an average the females attain sexual maturity in their seventh year of life.

D. RHYTHM OF OVULATION

Mackintosh and Wheeler (1929) showed that, in general, the numbers of corpora lutea and corpora albicantia in the ovaries increase with the increase in length of the animal. This points to the possibility that the corpora persist during the whole life and increase in number. They do not disappear after the breeding season and new corpora are formed during the next breeding season. Also there is a close correlation between the moment of attainment of physical maturity and the number of corpora present in the ovaries.

We can use the fact that the corpora persist in the ovaries, to determine the age of the animals if the age at which sexual maturity is attained, and the rate of ovulation per year are known. In practice, this means that it is only possible to use mean values. In this way we get an estimation of the age of the animal. The use of mean values has no particular influence on the distribution of the ages of the animals of which material was collected, or if this material is a random sample of the catch, of the distribution of ages of this catch. The real number of ovulations per two years (i.e. per breeding season) will vary. From the work of LAWS i.a., it is known that the female Fin Whale does not ovulate regularly once every two years. This general law will be disturbed by individuals coming into heat during lactation, by other individuals taking a longer "resting" period than normal after weaning their calves, and those which show other variations from the normal scheme (pregnancy about 11 months, lactation about six months, "rest" about seven months). Moreover, this regularity is disturbed when ovulation is not followed by impregnation (SLIJPER, 1949). MACKINTOSH and WHEELER (1929), WHEELER (1930, 1934) and BRINKMANN (1948) tried to determine the rhythm of ovulation from the frequency of occurrence of corpora albicantia in their material. They found a number of peaks representing the increase in corpora albicantia per period of two years. In the case of the Fin Whale, MACKINTOSH and WHEELER (1929) accept an average rate of ovulation of seven to eight ovulations per breeding season of two years. WHEELER (1930, 1934) found the rate to be four or five corpora per period of two years . BRINKMANN's (1948) results agree with those of WHEELER.

PETERS (1939) and VAN LENNEP (1950) made some suggestions to distinguish between the corpora albicantia of a pregnancy and those of an ovulation. PETERS calculated a rate of ovulation of 1.8 per breeding period. However, it is not certain whether he has distinguished differences between the two kinds of corpora or only various stages of regression. MACKINTOSH (1942) concluded that there was an accumulation of corpora of about two per breeding season. Since this conclusion is based on material from only one marked Fin Whale the evidence is rather meagre. RUUD (1945) and HYLEN, JONSGÅRD, PIKE and RUUD (1955) give comparisons between age determinations by means of baleen plates, and counts of corpora albicantia in the ovaries. RUUD (1945) suggests that five, six or seven ovulations may occur during oestrus before impregnation follows, after which a rate of four or five ovulations per breeding period will occur although he does not exclude the possibility that it may be less.

NISHIWAKI (1950, 1951) compared the numbers of corpora with the baleen plate analyses and the changes in colour of crystalline lenses. He deduces that four corpora will accumulate per breeding period. In 1952 the same author calculated an accumulation of 1.52 corpora per year after the first year of sexual maturity. In 1957, using the analyses of earplugs and assuming an increase of two laminations per year, the same author postulated that the mean rate of ovulation must be 2.4 corpora per two years. In 1958, using the same method, NISHIWAKI, ICHIHARA and OHSUMI found a mean rate of ovulation of 1.8 for the Fin Whales of the Antarctic.

LAWS (1958, 1961) calculated a mean rate of ovulation of 2.8 per breeding period. These calculations are based on the regression of the corpora. He differentiated between "old", "medium" and "young" corpora. He found no differences between the corpora albicantia of a pregnancy and corpora albicantia of an ovulation.

OHSUMI (1964) also gives data concerning the relation between the age determinations based on earplug laminations and those based on counts of the corpora present in the ovaries. He assumes an increase of one lamination per year and calculates an annual accumulation of 0.49 corpora for the Fin Whale, caught in the Antarctic areas IV and V. This means an ovulation rate of 0.98 per breeding season.

An attempt has also been made to get data about the mean rate of ovulation of the female Fin Whale of my own material. For this purpose the "ovulation peaks" in the records of the baleen plates are used. In these calculations the fact must be taken into account that the number of "ovulation peaks" will be smaller than the number of ovulations which actually occurred. A correction is therefore necessary.

Disturbing factors are:

1. Multiple foetuses. They all give more corpora albicantia in the ovaries but only one "ovulation peak" in the record of the baleen plate, except the monozygotic twins, which give only one corpus albicans.
2. Accessory corpora lutea.
3. Several simultaneous ovulations of which only one ovum is fertilized.

1. By means of the number of corpora lutea, deduced from the number of foetuses of Fin Whales, given in the Whaling Statistics of seasons 1945/1946 to 1958/1959 inclusive 55,681 single foetuses, 466 twins, 14 triplets, 3 quadriplets, 1 quintuplet, 2 sextuplets and one case of 8 foetuses were found. KIMURA (1957) found that 27.6% of the twins were monozygotic. All simultaneous ovulations show up as single "ovulation peaks" in the baleen plate record. So the number of "ovulation peaks" which can be found in the record will also be too low. The correction of this number of 55,681 ovulations is made as follows:

$$\frac{72.4}{100.0} \times 466\times1 + 14\times2 + 4\times3 + 1\times4 + 2\times5 + 1\times7 = 398$$ 1)

2. Accessory corpora lutea will also have a disturbing influence. LAWS (1958, 1961) found that 3.7% of the corpora were accessory ones. Therefore the number of corpora albicantia in the ovaries will be greater than the number of corpora lutea based on the number of foetuses.
3. Several simultaneous ovulations with only one ovum fertilized, can also have a disturbing influence. The percentages are not known. It is possible that part of the accessory corpora lutea originate from this influence. A correction cannot be calculated since this aspect is purely speculative.

The ratio between the real number of corpora formed in the ovaries and the number of corpora visible as the "ovulation peaks" in the records of the baleen plates is:

$$\frac{100.00}{96.30} \times (55681 + 398) : 55681 = 58234 : 55681$$

The correction factor will therefore be $\frac{58234}{55681}$

"Ovulation peaks" in the baleen plate records of my material showed 285 ovulations in a total period of 2878.25 months (the last ovulation of each animal is not taken into account as it is not known after which period the next ovulation will occur). The mean rate of ovulation after correction will be:

$$\frac{\frac{58234}{55681} \times 285 \times 24}{2878.25} = 2.5 \text{ ovulations per breeding period of two years.}$$

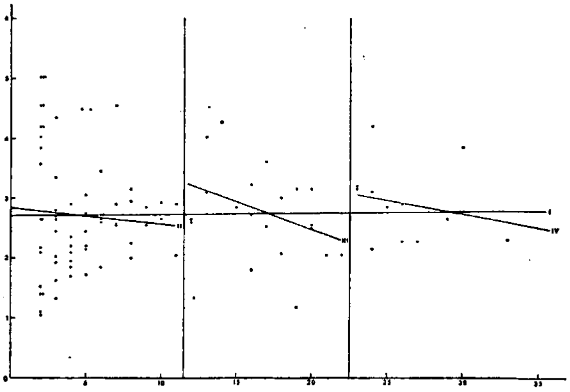

Fig. 21. *Correlation between the individual ovulation rate values and the age of the animal. Abscis: number of corpora present in the ovaries. Ordinate: rate of ovulation.*

This mean rate of ovulation (2.5 ovulations per two years) is intermediate between the values of LAWS (1958, 1961; 2.8 ovulations per two years) and NISHIWAKI (1957; 2.4 ovulations per two years).

This mean rate of ovulation can be a little greater (e.g. 2.6) if the percentage of monozygotic twins or the percentage of accessory corpora lutea is greater, or if a few "ovulation peaks" are not recognized as such in the records of the baleen plates because of wearing of the plate. We may now ask whether the mean rate of ovulation is constant during the whole life of the animal. To find an answer to this question the best fitting straight line is calculated, showing the correlation between all individual ovulation rate values and the ages (the number of corpora present in the ovaries). The equation of this line is: $y = 0.00177\,x + 2.717$ (fig. 21, x = number of corpora in the ovaries, y = individual rate of ovulation). This line does not differ significantly from the horizontal line in $\overline{y}$ (2.73) ($\nu = 93$, $t = 6.129$, $P > 0.10$, $r = 0.0169$). The conclusion must be that the mean rate of ovulation is independant of the age of the animal. There is a possibility, however, that the rate of ovulation increases at an early age, remains constant for some years and decreases in later years. That is why the material is divided into three groups, viz. 2-11, 12-22 and 23-33 corpora. The equations of the best fitting straight lines are:

2-11: $y = -0.0305\,x + 2.836$
($\nu = 60$, $t = 1.59$, $r = -0.0811$, $P > 0.10$)
12-22: $y = -0.0923\,x + 4.332$
($\nu = 19$, $t = 1.94$, $r = 0.4081$, $0.10 > P > 0.01$)
23-33: $y = -0.0455\,x + 4.096$
($\nu = 10$, $t = 1.40$, $r = -0.2205$, $P > 0.10$)

---

1) On multiple pregnancies other than twins no correction is applied, while in the case of monozygotic foetuses no data are available.

Not any of these lines differs significantly from the horizontal line, so no change in the rate of ovulation occurs in the life of the Fin Whale, i.e. there is no indication that fertility will decrease after the whale reaches a certain age.

E. MOMENT OF OVULATION

As peaks formed under the influence of an ovulation are recognizable in the records of baleen plates, a division can be made in the number of ovulations occurring in each month.

The numbers are (fig. 22):

January	23
February	35
March	29
April	33
May	26
June	46
July	34
August	46
September	34
October	28
November	28
December	25

Applying a 3-month mean the figures are:

December, January, February	January	27.7
January, February, March	February	29.0
February, March, April	March	32.3
March, April, May	April	29.3
April, May, June	May	35.0
May, June, July	June	35.3
June, July, August	July	42.0
July, August, September	August	38.0
August, September, October	September	36.0
September, October, November	October	30.0
October, November, December	November	27.0
November, December, January	December	25.3

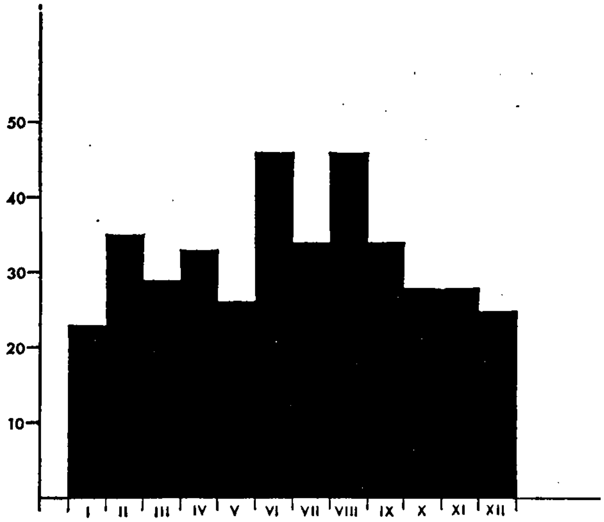

Fig. 22. *Number of ovulations occurring in each month. Abscis: months. Ordinate: number.*

It appears that most of the ovulations occur during the months of June, July, August and September, i.e. in the southern winter. However, a reasonable number of ovulations occur in the southern summer. Mackintosh and Wheeler (1929), Mackintosh (1942), Laws (1959, 1961), Frazer and Huggett (1958) and Naaktgeboren, Slijper and van Utrecht (1960) concluded that most pregnancies originate from ovulations occurring in the southern winter months and so the heat of the females occurs during these months. My results confirm this conclusion. Moreover, the heat of the males will influence the moment at which the calves are born and indeed, there is a certain periodicity in the testis activity (Mackintosh and Wheeler, 1929; Laws, 1959, 1961).

F. FREQUENCY OF THE INTERVALS BETWEEN OVULATIONS

As is stated above, distances between "ovulation peaks" are not equal in the records of the baleen plates. This agrees with the present opinion about the sexual cycle of female Fin Whales. In general, the following intervals can be expected and are indeed found:

1. 6 months. Ovulation in spring (respectively autumn) is not followed by fertilization. The next ovulation occurs during the following autumn (respectively spring). This agrees with the idea of Laws (1961) that the sexual cycle of the fe-

male Fin Whale is linked with the migratory cycle.

2. 12 months. Directly after parturition, during lactation, the next ovulation and fertilization may occur. Animals have been found which were lactating and pregnant at the same time. LAWS (1961) presented evidence which "suggests that nearly all multiparous females experience a post-partum heat, and that a proportion of primiparous females do not."
3. 18 months. Ovulation after lactation. This is also put forward by LAWS (1961). "Evidence is presented which strongly suggests that almost all Fin Whale females experience a post-lactation ovulation."
4. 24 months. A "resting" period of six months after lactation.

In practice the periods were:

4 - 9 months (maximum number at 6 months)
10 - 15 months (maximum number at 12 months)
16 - 21 months (maximum number at 18 months)
22 - 27 months (maximum number at 24 months)
28 - 33 months (one case)

The numbers were:	number	percentage
4 - 9 months	160	56.74
10 - 15 months	88	31.21
16 - 21 months	25	8.86
22 - 27 months	8	2.84
28 - 33 months	1	0.35

In conclusion it appears that most of the successive ovulations occur with an interval of about six months. In many cases an ovulation occurs after parturition, although fertilization seldom follows. According to LAWS (1961) some 18% of the females conceive at a post-partum ovulation.

CHAPTER III

OVARIES

1. Introduction

As already mentioned, counting corpora in the ovaries is one of the oldest methods for age determination in the Fin Whale females. As the corpora albicantia persist during the whole life of the animal and are formed at more or less regular intervals, the number of these corpora is an indication of the age of the animal. If the mean age of attainment of sexual maturity and the mean rate of ovulation, are known (see Chapter II) an estimation of the age of the sexual mature females can be made.

2. Material

Ovaries were collected of immature and mature Fin Whales, worked up on board the f.f. "Willem Barendsz".

The weights of the ovaries and the weights and the measurements of the corpora were determined in material of 469 animals taken during the seasons 1953/1954 to 1959/1960 inclusive. Moreover, of 34 animals taken during the season 1959/1960 the only fact known was that they were sexually immature.

The total material is a random sample of the total catch of females of the "Willem Barendsz" in these seasons. So this can be used in further calculations (see Chapter II, 2).

3. Method

The total weights of the ovaries were determined and the corpora present were cut out and weighed. The mean diameter of these corpora is determined according to LAWS' method (1958, 1961). This diameter is the measure of the corpus. In the smallest corpora mistakes in weighing and measuring are possible since it is almost impossible to separate the corpus completely from the surrounding tissue. Notes were made about the presence of a central cavity or a central core and about the shape of the connective tissue in the corpus (radiate, branched or amorphous). After removing the corpora the whole ovary was cut into slices of about ½ cm to make sure that no corpora were overlooked.

The corpora were designated as corpora lutea or corpora albicantia, as described by LAWS (1958). Several groups of Fin Whales were distinguished based on the condition of the ovaries as shown in the analysis of the material, as follows:

a. Sexually immature animals. The ovaries contain neither corpora lutea nor corpora albicantia.
b. Sexually mature animals.
    - b^1. Non pregnant animals. The ovaries contain one or more corpora. In most cases these are corpora albicantia, sometimes a corpus luteum is present although no foetus is found.

b². Pregnant animals. The ovaries contain one or more corpora. In addition to the presence of a certain number of corpora albicantia there is one corpus luteum. In a small number of cases more corpora lutea are present. One or more foetuses are found.

4. Data obtained by means of the method

A. WEIGHTS OF OVARIES

a. Sexually immature animals

The mean weight of the ovaries of these animals is 277.0 g (57.0 - 876.0 g). The curve of the frequencies of these weights is set out on logarithmic probability paper (fig. 23).

The weight of the ovaries increases with the length of the animal (fig. 24). As the length of these young animals is an approximate indication of the age, the weight of the ovaries will increase with the age. In the analyses of baleen plate records the age is known

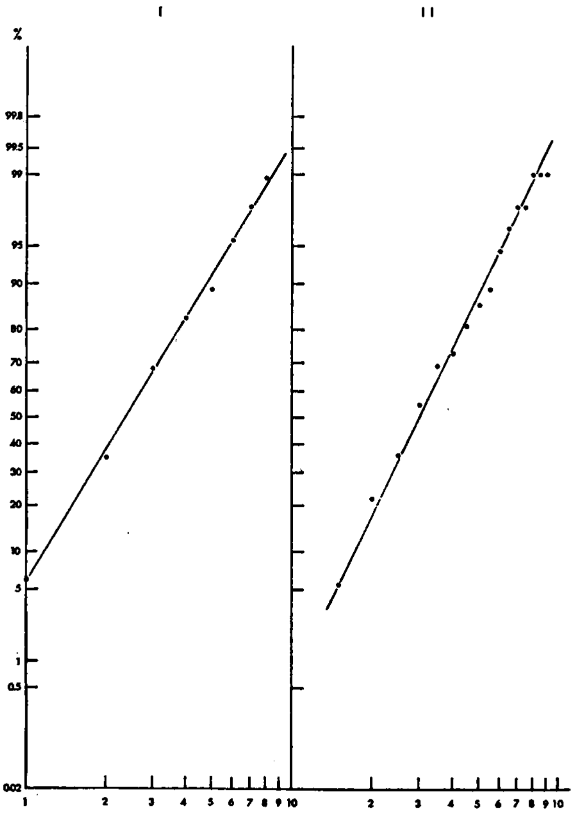

Fig. 23. *Frequencies of the weights of the ovaries of immature animals. I. Single ovary weight. II. Combined ovary weight. Weight in 100 g.*

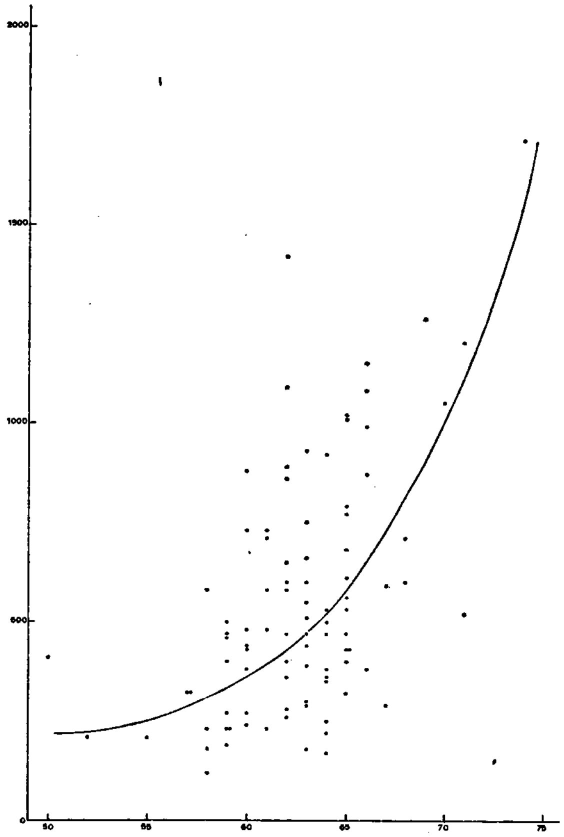

Fig. 24. *Correlation between the weight of the ovaries and the length of the immature animals. Abscis: length in feet. Ordinate: weight in g.*

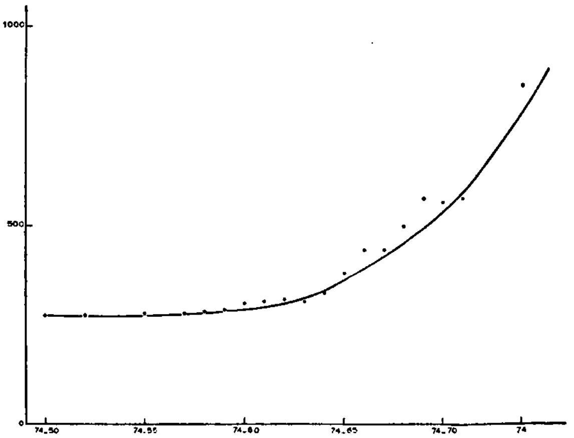

Fig. 25. *Mean cumulative weight of the ovaries compared with the length of the immature animals. Abscis: length in feet. Ordinate: weight in g.*

of too small a number of young animals; these data can only be used as a rough indication.

The weight of the ovaries increases with the length (age) of the animal. In other words the ovaries must attain a certain mean weight before the development of this organ has reached the stage at which ovulation can occur. Fig. 25 shows the mean cumulative weights of the ovaries to give a better impression of this increase in weight.

b. *Sexually mature animals*

In a number of sexually mature animals only one of the ovaries was found to be already ovulating. In this ovary one or more corpora were present, in the other, however, none. Comparing the weights of both ovaries of animals which are pregnant for the first time (only one corpus luteum present) and in particular the weights of the ovaries minus the weight of the corpus luteum ("basic substance"), we found a significant increase in the weight of the ovulating ovary. The mean increase is 39.3 g (mean weight of a non-ovulating ovary was 494.7 g, mean weight of the "basic substance" of an ovulating ovary was 534.0 g).

By comparing the weights of the ovaries of animals which have more than one corpus in one ovary and none in the other, the same phenomenon but more pronounced was found. The mean increase in weight amounts to 91.0 g (mean weight non-ovulating ovary was 580.9 g, mean weight "basic substance" (weight of ovary minus weight of all corpora) ovulating ovary was 671.9 g, significance 1% determined by the sign-test). Consequently when the animals have attained sexual maturity further growth of the ovaries will occur, in addition to the normal growth as is shown in figs. 24 and 25.

The majority of the mature animals had corpora in both ovaries but there are great differences in their respective numbers. According to Laws (1958, 1961) of 724 corpora 52.4% were present in the right ovary. Laws concludes "there is a slight prevalence of the right ovary". According to Ohsumi (1964) 51.9% of the corpora were accumulated in the left ovary. However, the difference between Ohsumi's results and Laws' results is included in the standard deviation given by Laws (1961). Also on board the "Willem Barendsz" during the season 1962/1963 an attempt was made to solve this problem. Of a total of 600 corpora of 44 animals 52.2% were present in the right ovary. This is in close agreement with Laws' conclusion. Of this number of 44 animals 24 had more corpora in the right ovary, 4 had the same numbers in both ovaries and 16 had more corpora in the left ovary. The greater number of corpora is situated in the so-called anterior half of the ovary. Laws (1958) found a percentage of 74.1 of the corpora. In my material 80.0% of the corpora were situated in the half of the ovary adjacent to the bursa ovarica.

b^1. *Non pregnant animals*

The mean weight of the ovaries of mature non pregnant animals was 1073.0 g (248.0 - 3777.0 g). The curve of frequencies of the weights of these ovaries is given in fig. 26 on logarithmic probability paper.

In these animals there is a correlation between the lengths of the animals in feet and the weights of their ovaries, and also between the lengths of the animals and the weights of their "basic substances", given in figs. 27 and 28. This is the case with the weights of the separate ovaries, as also for their combined weights.

The equations for the best fitting straight lines are:

combined weights of the ovaries: $y = 144.19\ x - 8025.69$ (x = length animal in feet, y = weight ovaries in g)

This line differs significantly from the horizontal line in $\bar{y}$ ($\nu = 97$, $t = 4.97$, $P < 0.001$)

combined weights of "basic substances": $y = 111.75\ x - 6076.33$ (x = length animal in feet, y = weight "basic substances" in g)

This line differs significantly from the horizontal line in $\bar{y}$ ($\nu = 97$, $t = 4.51$, $P < 0.001$).

b^2. *Pregnant animals*

The mean weight of the ovaries of the mature pregnant animals was 1771.5 g (215.5 – 6084.0 g). The curve of frequencies of the weights of these ovaries is given on logarithmic probability paper in fig. 29.

In these animals there is a similar correlation as in the non-pregnant animals between the lengths of the animals and either the weights of the ovaries, the weights of the ovaries without weight of the corpus luteum or the weights of the "basic substances" (fig. 30, 31, 32).

The equations for the best fitting straight lines are:

combined weights of the ovaries: $y = 195{,}46\ x - 10416.69$ (x = length animal in feet, y = weight ovaries in g)

This line differs significantly from the horizontal line in $\bar{y}$ ($\nu = 227$, $t = 10.6$, $P < 0.001$)

combined weights of ovaries without weight of corpus luteum: $y = 177.97\ x - 10112.48$ (x = length animal in feet, y = weight ovaries – weight c.l. in g)

Fig. 26. *Frequencies of the weights of the ovaries of mature non pregnant animals. I. Single ovary weight. II. Single weight of "basic substance". III. Combined ovary weight. IV. Combined weight of "basic substance". Weight in 500 g.*

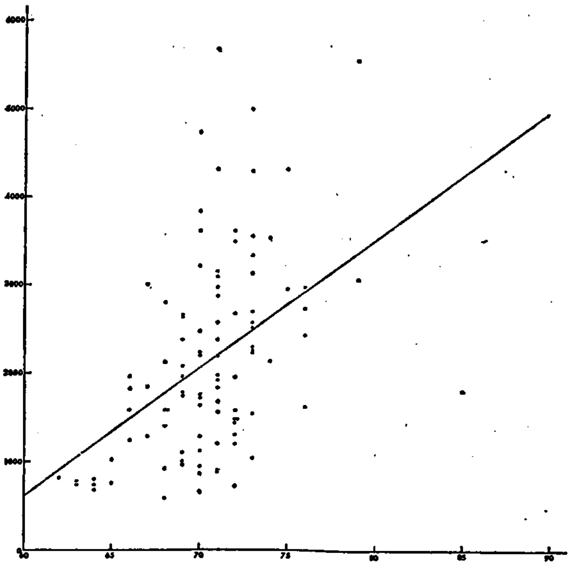

Fig. 27. *Correlation between the length of mature non pregnant animals and the weight of their ovaries. Abscis: length in feet. Ordinate: weight in g.*

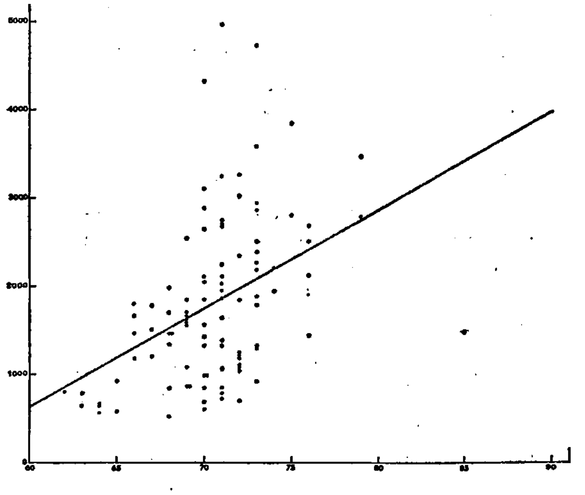

Fig. 28. *Correlation between the length of mature non pregnant animals and the weight of the "basic substances" of their ovaries. Abscis: length in feet. Ordinate: weight in g.*

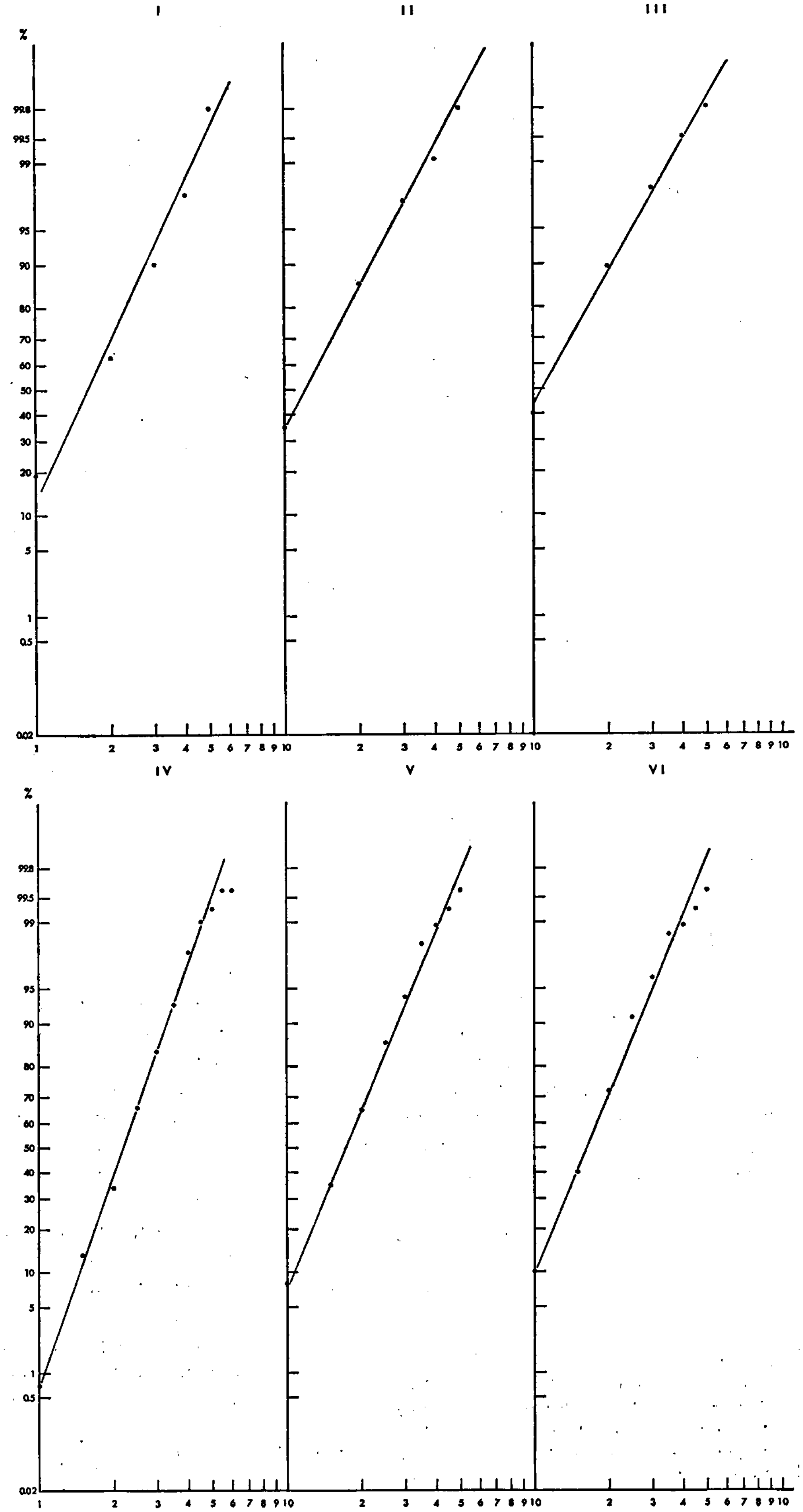

Fig. 29. *Frequencies of the weights of the ovaries of mature pregnant animals. I. Single ovary weight. II. Single ovary weight minus weight corpus luteum. III. Single weight of "basic substance". IV. Combined ovary weight. V. Combined ovary weight minus weight corpus luteum. VI. Combined weight of "basic substance".*
Weight in 1000 g.

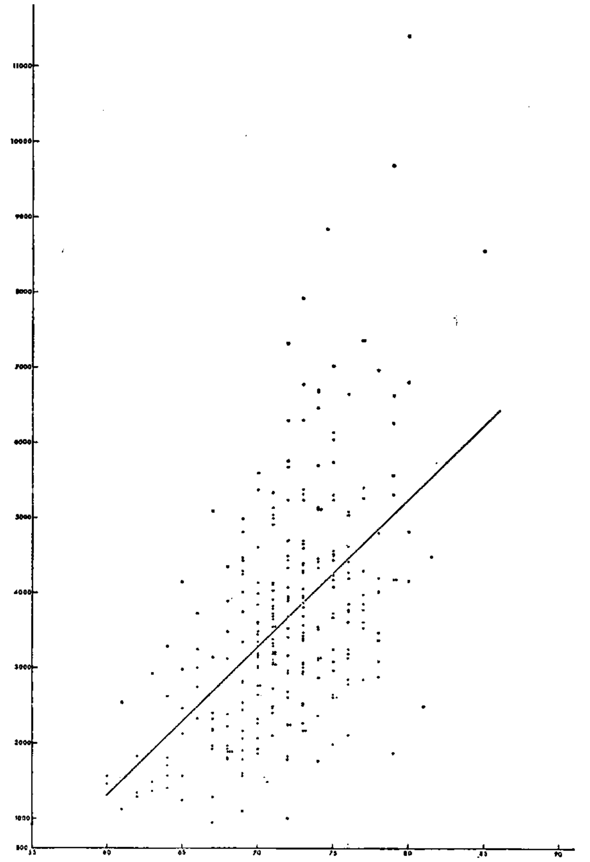

Fig. 30. *Correlation between the length of mature pregnant animals and the weight of their ovaries. Abscis: length in feet. Ordinate: weight in g.*

This line differs significantly from the horizontal line in $\bar{y}$ ($\nu = 227$, $t = 10.6$, $P < 0.001$)

combined weights of "basic substances": $y = 161.82\, x - 9163.39$ (x = length animal in feet, y = weight "basic substances" in g)

This line differs significantly from the horizontal line in $\bar{y}$ ($\nu = 227$, $t = 10.0$, $P < 0.001$)

Table 14 gives single ovary and "basic substances" weights of my own material and Laws' (1961)

Table 14

	Own material	Laws
Immature	0.28 kg	
Non-pregnant ovary weight	1.07 kg	1.04 kg
Non-pregnant "basic substance"	0.90 kg	
Pregnant with corpus luteum	2.22 kg	2.13 kg
Pregnant, lacking corpus luteum	1.32 kg	1.24 kg
Pregnant "basic substance"	1.23 kg	

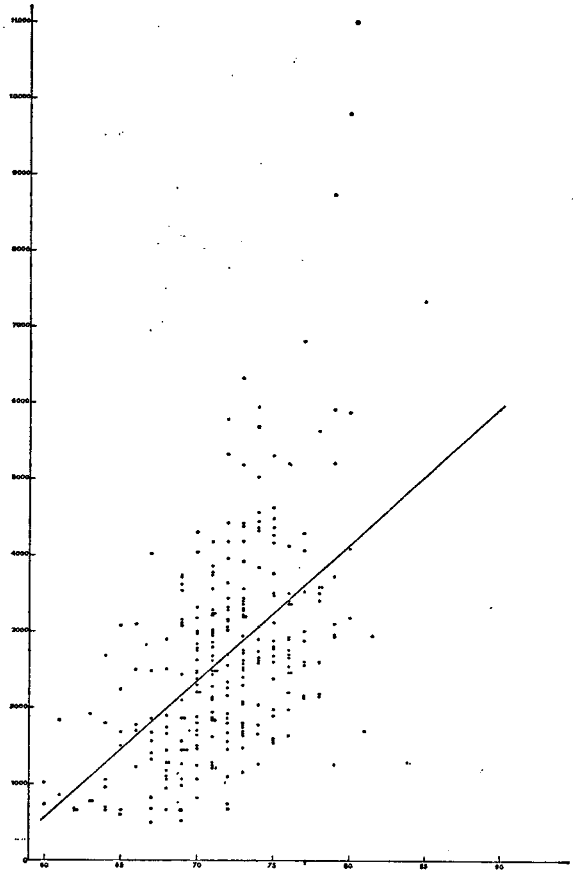

Fig. 31. *Correlation between the length of mature pregnant animals and the weight of their ovaries minus the weight of the corpus luteum. Abscis: length in feet. Ordinate: weight in g.*

The mean weight of the corpus luteum is 0.94 kg. The mean of the single ovary weight of pregnant females minus the weight of the corpus luteum is 1.30 kg. Consequently the difference between the weights of the ovaries of pregnant and non pregnant females is 0.23 kg.

Comparing the weights of the ovaries of pregnant and non pregnant animals Laws (1958) concludes: "The increased weight of the ovaries of pregnant females is statistically significant and is only partly explained by the presence of a large corpus luteum. The mean weight of 372 corpora lutea of pregnancy was 0.88 kg and the ovaries of pregnant females weigh on (an) average 1.17 kg more than those of non pregnant females. The discrepancy (0.29 kg) is probably to be accounted for the increased vascularization and increase in follicle size and numbers".

In immature female Fin Whales there is a definite relation between the age and the length of the ani-

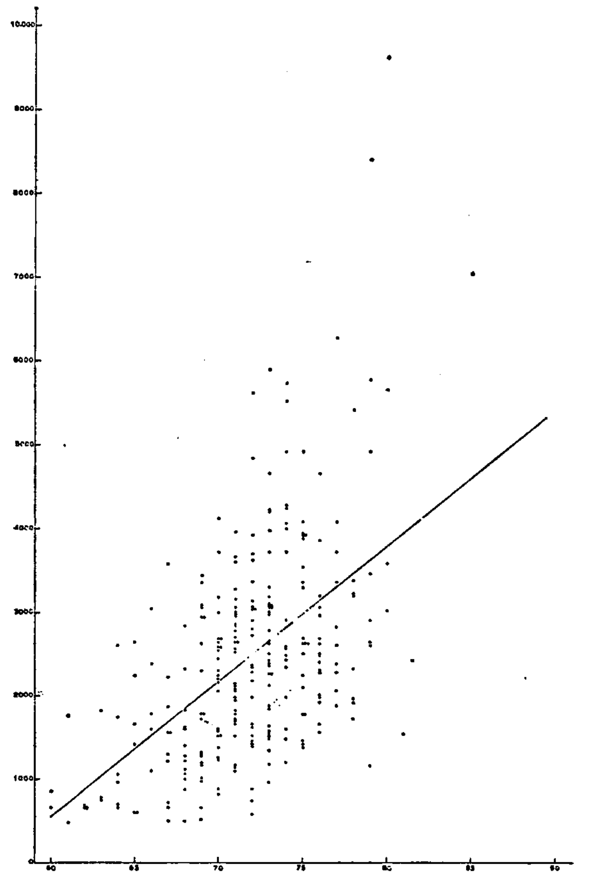

Fig. 32. *Correlation between the length of mature pregnant animals and the weight of the "basic substance" of their ovaries. Abscis: length in feet. Ordinate: weight in g.*

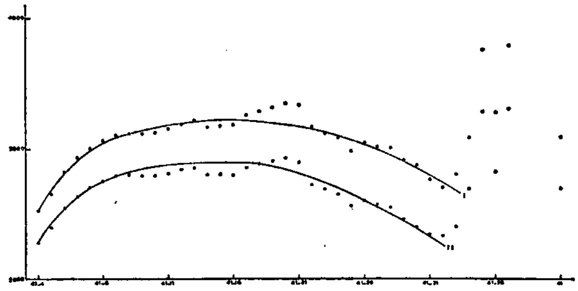

Fig. 35. *Correlation between (I) cumulative combined ovary weight (weight of corpus luteum excluded) and the age of the animal, and (II) cumulative combined weight of the "basic substance" of the ovaries and the age of the animal. Abscis: number of corpora. Ordinate: weight in g.*

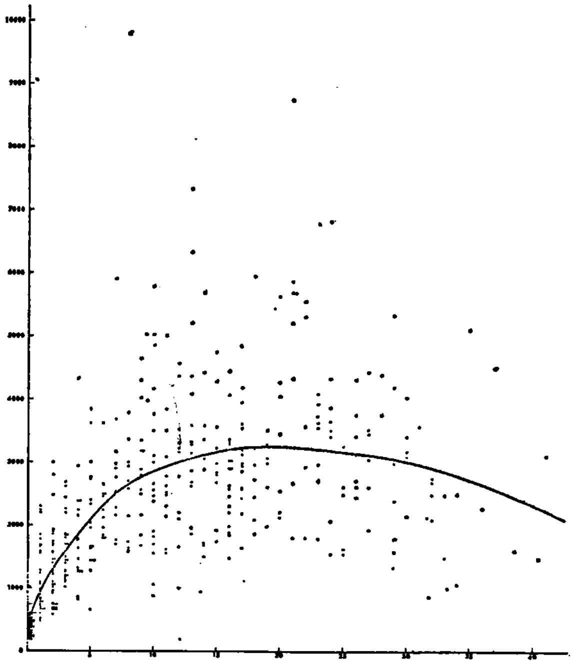

Fig. 33. *Correlation between the weight of the ovaries (weight of corpus luteum excluded) and the age of the animal. Abscis: number of corpora present in the ovaries. Ordinate: weight in g.*

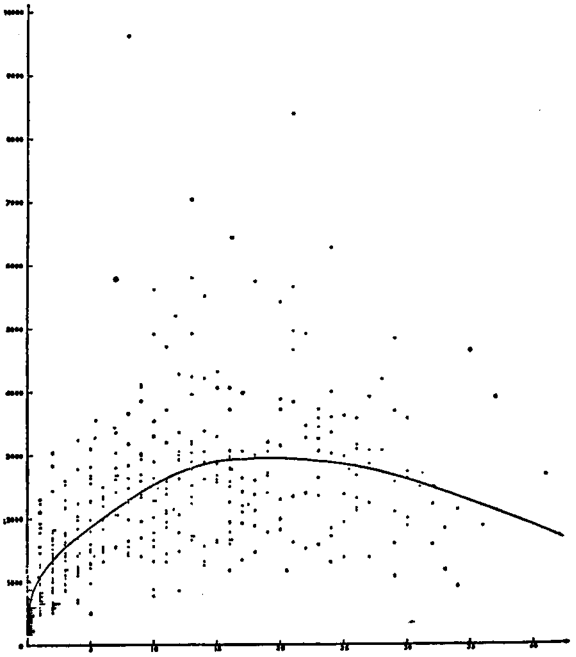

Fig. 34. *Correlation between the weight of the "basic substances" of the ovaries and the age of mature animals. Abscis: number of corpora present in the ovaries. Ordinate: weight in g.*

mal. As the mean weight of the ovaries increases with the length of the animal, it increases also with the age. Probably this is the same in the case of the mature animal. There is probably an increase of the ovary weight with the increase in age (increase in number of corpora in the ovaries) or an increase in ovary weight until a certain age and after this a decrease in weight.

To get some idea of these changes the ovary weights of all mature animals of the material were considered, of non pregnant and pregnant animals. Only of pregnant animals the weight of the corpus luteum is excluded. The relation is given in figs. 33 (ovary weights) and 34 ("basic substances"). In both cases an initial increase and subsequent decrease of the weights occur. In fig. 35 the cumulative weights are given to illustrate this. In general, a decrease in the weight of the ovary is an indication of a decrease in sexual activity after a certain age. As the rate of ovulation is constant during the whole life of the animal (Chapter II, 4, D) and the percentage of pregnant animals does not decrease with the increase in age (increase in number of corpora (see table 15)), it seems that female Fin Whales never attain an age after which a decrease of sexual activity occurs.

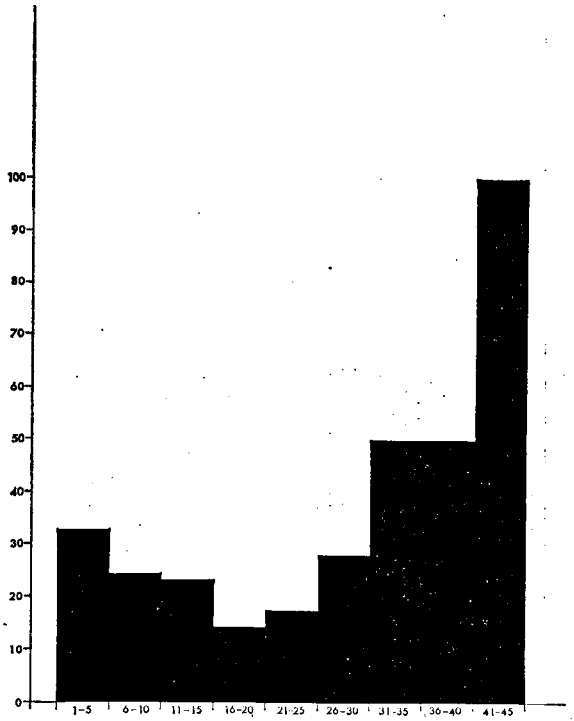

Fig. 36. *Percentage of pregnant animals compared with age groups. Abscis: number of corpora present in the ovaries. Ordinate: percentage of pregnant animals.*

Table 15

Number of corpora	Total number of animals	Number of pregnant animals
1	31	10
2	39	13
3	25	7
4	16	7
5	17	5
6	12	6
7	12	3
8	12	1
9	13	1
10	17	5
11	13	5
12	12	1
13	16	4
14	9	1
15	10	3
16	19	4
17	9	2
18	8	—
19	6	1
20	7	—
21	7	2
22	5	1
23	8	1
24	8	2
25	6	—
26	7	3
27	5	2
28	2	—
29	6	1
30	5	1
31	1	1
32	4	2
33	2	1
34	2	1
35	1	—
36	1	1
37	1	—
38	—	—
39	—	—
40	—	—
41	1	1

As the numbers of animals in the higher age classes were too small, and the percentage of pregnant animals too variable, the animals were lumped into groups: group I — animals with 1-5 corpora in the ovaries; group II — 6-10; etc. These percentages are given in fig. 36.

B. SHIFTING OF THE MAXIMUM ACTIVITY IN THE OVARY

As stated above, it was found that with the increase in age (increase in number of corpora in the ovaries), the rate of ovulation is constant. Consequently there

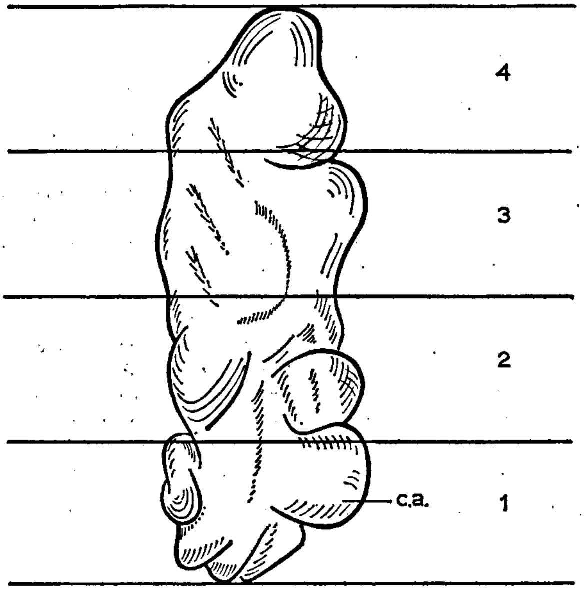

Fig. 37. *Diagram of an ovary divided into four parts.*

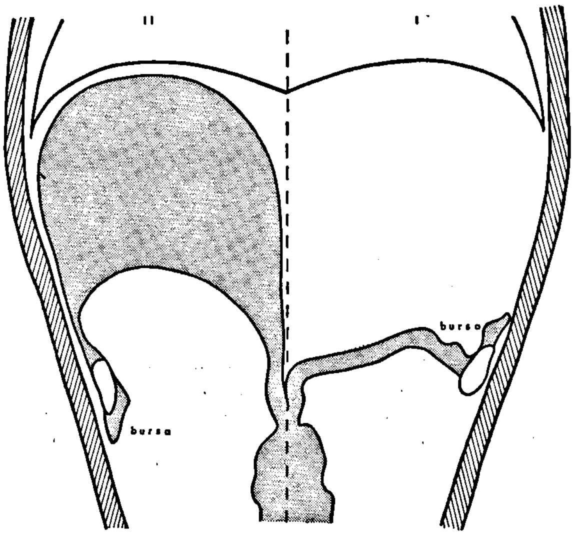

Fig. 38. *Position of ovary and bursa ovarica in I. Immature animals. II. Mature pregnant animals.*

Table 16

Number of corp.lut. + alb. in the ovary	Number of ovaries	Mean number of corp.lut. + alb. per part			
		I	II	III	IV
1	136	0.51	0.47	0.02	0.00
2	122	1.06	0.60	0.28	0.06
3	99	1.23	1.23	0.44	0.10
4	72	1.58	1.64	0.65	0.13
5	81	2.12	1.93	0.83	0.12
6	52	2.60	2.27	0.88	0.25
7	58	3.28	2.47	0.96	0.29
8	49	3.28	3.37	0.96	0.39
9	33	3.36	3.76	1.52	0.36
10	25	4.12	3.88	1.72	0.28
11	36	5.36	3.33	1.75	0.56
12	24	4.79	4.54	2.42	0.25
13	22	5.73	4.45	2.23	0.59
14	12	5.83	4.92	2.50	0.75
15	15	6.47	5.40	2.47	0.66
16	11	6.46	6.18	2.91	0.45
17	8	7.38	5.25	3.50	0.87
18	1	11.00	3.00	3.00	1.00
19	3	7.67	7.33	3.00	1.00
20	2	7.00	8.50	4.50	0.00
21	3	8.67	5.33	4.67	2.33
22	—	—	—	—	—
23	2	10.50	8.00	3.50	1.00
24	1	11.00	8.00	5.00	0.00
25	1	13.00	7.00	4.00	1.00
26	—	—	—	—	—
27	1	4.00	11.00	5.00	7.00

is no change in the percentage of pregnant animals. Nevertheless, at first an increase and later a decrease in the weights of the ovaries occurs with the increase in age. In general, decrease of this weight may be considered as an indication of the decrease of sexual activity after the females have attained a certain age. These facts are apparently contradictory.

In order to reach a conclusion about these changes in weight and the constant rate of ovulation and constant percentage of pregnant females, 869 ovaries of the season 1962/1963 were examined. Each ovary was divided into four parts, each of which is one quarter of the total length of this organ (fig. 37). Part I is that part of the ovary hidden in, or immediately adjacent to, the bursa ovarica (fig. 38). The following data were collected from each part: a. the number of corpora lutea and albicantia present, b. the total weight, c. the weight of the "basic substance", d. the weights and diameters of the corpora albicantia.

a. *The numbers of corpora lutea and albicantia present in the different parts of the ovary compared with the total number of corpora present in the ovary*

It is evident from table 16 and fig. 39 that the increase in number of corpora takes place more quickly in the parts I and II than in the parts III and IV. It is also evident that the greater number of corpora are situated in that half of the ovary adjacent to the

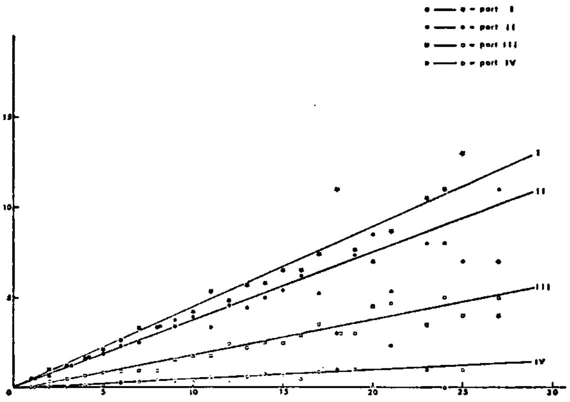

Fig. 39. *Correlation between the mean number of corpora present in the different parts of the ovaries compared with the total number of corpora present in the ovaries. Abscis: total number of corpora present in the ovaries. Ordinate: mean number of corpora present in the different parts of the ovaries.*

Table 17

Number of corp.lut. + alb. in the ovary	Number of ovaries	Mean total weights of the parts of the ovary I	II	III	IV
1	136	374.0	365.5	178.5	120.8
2	122	433.1	394.5	286.3	181.4
3	103	396.7	455.2	348.2	209.7
4	69	541.6	461.2	421.7	217.3
5	80	508.0	531.2	430.3	258.2
6	55	591.0	542.0	414.8	272.1
7	54	502.2	494.2	443.6	294.0
8	50	601.5	650.4	448.4	310.4
9	33	570.8	628.2	464.8	305.1
10	25	565.4	597.9	423.0	297.0
>10 & ≤15	109	548.4	549.7	539.0	332.9
>15 & ≤20	25	414.9	539.5	515.4	289.2

bursa ovarica (80.0% in part I and II). LAWS (1958) found the greater number of corpora in the "anterior" half of the ovaries, but from his description it is not clear whether he uses the term "anterior" as an indication of the real orientation in the animal or in anatomical sense. This is of importance, as the whole complex of cornua uteri and ovaries during the first pregnancy shows considerable changes in orientation due to the enormous growth in length of the cornua, so that the end of the cornua together with the ovaries is turned in such a way that the opening of the tubae is in a caudal direction. This would mean that what was formerly the anterior pole of the ovary later points in a caudal direction. It is not clear, although probable, that the "anterior" pole of the ovary according to LAWS is the same as the pole directed to the bursa (fig. 38).

b. *The total weights of the parts of the ovary compared with the total number of corpora present in the ovary*

For statistical reasons it was necessary to lump the ovaries with more than ten corpora into groups, viz. >10 & ≤15 and >15 & ≤20. Ovaries with a greater number of corpora were excluded. From table 17 and fig. 40 it is evident that parts I and II first show an increase in weight, although later there is a decrease. Parts III and IV are still increasing in weight. The maximum weight of part I is reached earlier than that of part II.

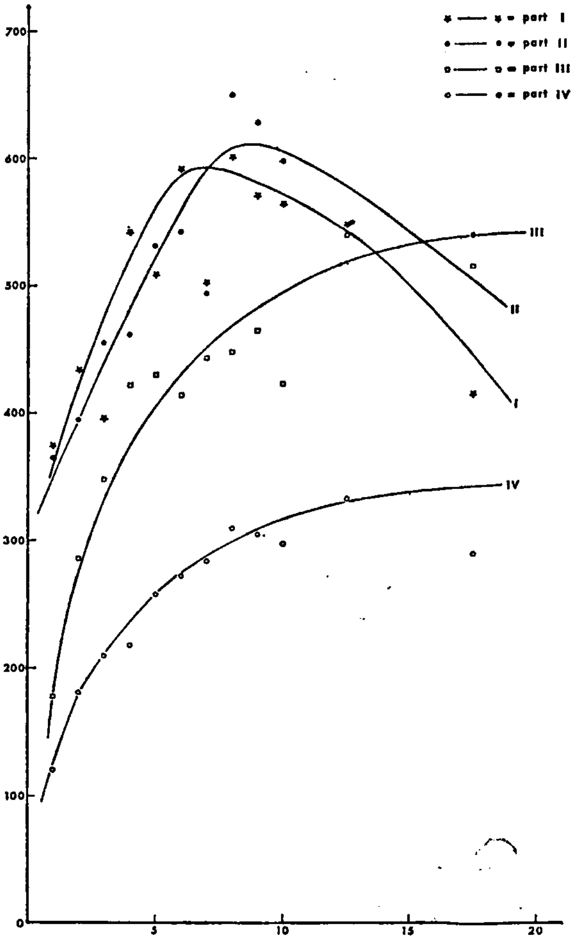

Fig. 40. *The mean total weight of the parts of the ovaries compared with the total number of corpora present in the ovaries. Abscis: number. Ordinate: weight in g.*

c. *The weights of the "basic substances" of the parts of the ovary compared with the total number of corpora present in the ovary*

From table 18 and fig. 41 the same conclusions are reached as in the case of the total weights. It is only much more obvious because the disturbing influence of the weights of the corpora, especially of the corpora lutea, is excluded.

Table 18

Number of corp.lut. + alb. in the ovary	Number of ovaries	Mean weight "basic substances" of the parts of the ovary I	II	III	IV
1	136	338.6	330.7	176.6	120.8
2	122	379.4	363.1	271.1	178.1
3	103	339.7	404.3	329.4	204.9
4	69	478.0	410.3	399.4	214.0
5	80	437.0	469.9	401.8	252.4
6	55	511.0	485.8	388.8	262.6
7	54	421.7	428.7	415.3	282.1
8	50	515.6	566.5	423.2	297.9
9	33	492.6	541.4	431.2	295.4
10	25	479.0	519.3	384.7	290.7
>10 & ≤15	109	439.1	472.0	491.1	315.7
>15 & ≤20	25	314.4	460.3	467.3	278.4

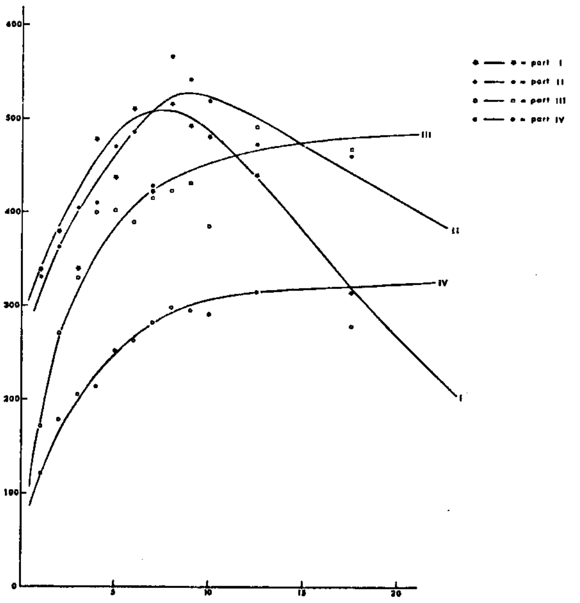

Fig. 41. *Mean weight of the "basic substances" of the parts of the ovaries compared with the total number of corpora present in the ovaries. Abscis: number. Ordinate: weight in g.*

d. *Diameters and weights of the corpora albicantia in the different parts of the ovary compared with the total number of corpora present in the ovary*

From table 19 it is evident that there is no, or hardly any, difference in the mean diameters and

Table 19

Number of corp. lut. + alb. in the ovary	Number of ovaries	part of ovary	Mean weight of the corp. alb. in g	Mean diameter of the corp. alb. in cm
1	136	I	53.0	4.7
		II	64.3	4.9
		III	71.8	5.4
		IV	—	—
2	122	I	40.7	4.2
		II	40.7	4.3
		III	48.2	4.6
		IV	31.7	4.5
3	103	I	32.5	3.9
		II	34.3	4.0
		III	31.9	4.0
		IV	39.6	4.3
4	69	I	28.7	3.7
		II	27.1	3.5
		III	25.1	3.6
		IV	27.2	4.0
5	80	I	27.2	3.6
		II	28.5	3.6
		III	28.2	3.5
		IV	27.5	3.5
6	55	I	19.7	3.2
		II	23.6	3.3
		III	23.4	3.4
		IV	30.3	3.8
7	54	I	21.2	3.3
		II	23.5	3.4
		III	21.7	3.3
		IV	33.8	4.0
8	50	I	21.0	3.3
		II	21.1	3.2
		III	21.4	3.2
		IV	19.7	3.4
9	33	I	18.1	3.1
		II	19.8	3.3
		III	19.4	3.4
		IV	20.5	3.4
10	25	I	16.7	3.1
		II	18.2	3.2
		III	22.3	3.3
		IV	14.4	3.2
>10 & <15	109	I	16.9	3.0
		II	16.4	3.0
		III	16.5	3.0
		IV	26.0	3.3
>15 & <20	25	I	13.7	2.7
		II	12.0	2.7
		III	12.7	2.7
		IV	16.8	2.9

weights of the corpora albicantia in the different parts of the ovary.

A plausible explanation for these facts is that a wave of ovulations proceeds in the ovary from the pole adjacent to the bursa to the opposite pole. First the ovulations take place in part I (fig. 38), the succeeding ovulations successively in parts II, III or IV. In this way it becomes possible to understand the fact that most of the corpora (80.0%) are situated in the half of the ovary in the vicinity of the bursa and the ostium tubae. This is the more evident as the greater part of the catch and the sample of material is composed of young animals. Before the female Fin Whale attains sexual maturity the ovaries must attain a certain mean weight. In young animals parts I and II of their ovaries appear to have a greater weight compared with parts III and IV. In older animals, before these latter parts start to be involved in the ovulatory cycle, parts III and IV must have attained a certain mean weight, analogous to the fact that the whole ovary must attain a certain mean weight before the animal attains sexual maturity. In this way the total weight of the ovary will increase.

After a certain number of ovulations the part near to the bursa shows a decrease in activity. Consequently there will be a decrease in weight of this part analogous to the phenomenon of decreasing fertility which can cause a decrease in total weight of the ovary. At a certain moment the increase in weight of parts III and IV will be equal to the decrease in weight of parts I and II. At this moment the ovary has the maximum weight. After this, decrease in weight will predominate, so that the total weight of the ovary will decrease. It is reasonable to suppose that parts III and IV of the ovary are fertile, while at the same time the total weight of the ovary decreases. This would mean there is a gradual change in maximum activity, going as a wave from part I, through parts II and III to part IV. However, in each part of the ovary there may still occur some ovulations.

As will be seen there is no significant difference in the weights and diameters of the corpora albicantia in the different parts of the ovary with respect to the age of the animal. If regression of the corpora to a certain diameter and weight is rather slow, it might be expected that a difference in the mean weight and diameter of the corpora in parts I + II and III + IV would be found. In the latter parts the corpora would be bigger since they are formed later. As this appeared not to be the case it can only be concluded that regression to a minimum diameter and weight occurs within a short period of time, probably shorter than the three years which LAWS (1961) determined as the regression time from "young" to "old" corpora albicantia.

The general conclusion from this part of the investigation is that a decrease in sexual activity in the female Fin Whale will not be attained in normal animals since the life span of these animals is too short. They generally die before activity in parts III and IV of the ovary is extinguished. This is independant of the recent great catches of this species since the maximum number of corpora found before the Second World War was the same as at present (WHEELER, 1934).

C. WEIGHTS AND SIZES OF THE CORPORA

As early as 1929 MACKINTOSH and WHEELER supposed that the corpora would not completely reduce because in general an increase in number of corpora occurs with an increase in length of the body. Moreover, there is a relation between the attainment of physical maturity and the number of corpora present in the ovaries. LAWS (1958, 1961) also reaches the same conclusion, based on the regression of corpora. "There is initially a rapid decrease in the percentage of 2-3 cm corpora albicantia and a complementary increase in the proportion of 0-2 cm corpora, but when about fifteen corpora have accumulated the proportions in each of these size groups stabilise. This means as before, that the corpora albicantia regress to a modal diameter of 2.0 cm and then no further." The mean weight of these corpora is 5 g.

From my own material sizes and weights of 308 corpora lutea and 4122 corpora albicantia are known.

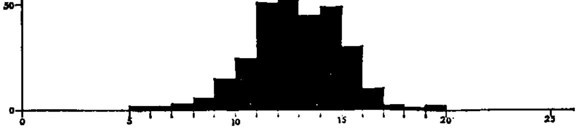

Fig. 42. *Frequencies of the sizes of corpora lutea. Abscis: diameter in cm. Ordinate: number.*

a. *Corpora lutea*

The frequencies of the sizes are given in fig. 42, the connection between diameters and weights in fig. 43. The diameters range from 5.6 to 19.8 cm, the weights from 87.0 to 2557.0 g. The mean diameter is 12.7 cm, the mean weight 900.5 g..

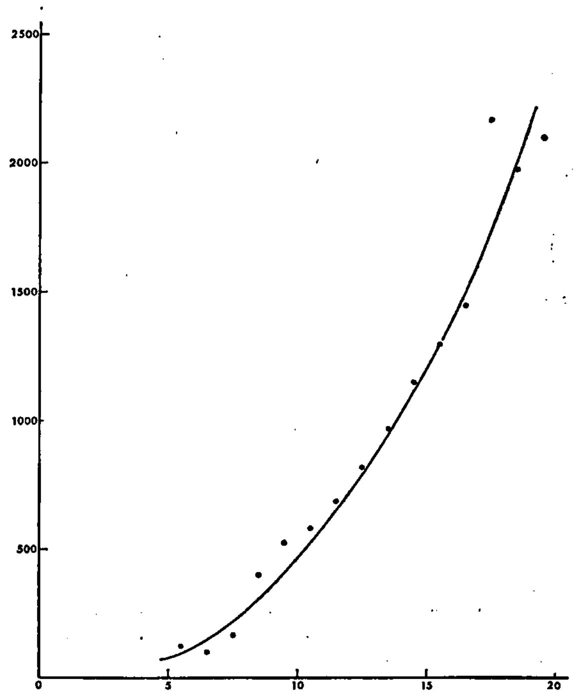

Fig. 43. *Relation between diameter and mean weight of corpora lutea. Abscis: diameter in cm. Ordinate: weight in g.*

When the sizes and weights of corpora lutea of 1.) animals possessing an equal number of corpora lutea and foetuses, 2.) animals possessing more corpora lutea than foetuses present (possibly accessory corpora lutea) and 3.) animals possessing one or more corpora lutea and no foetuses (possibly ovulatory corpora lutea or the foetus is not found), are compared, certain differences in sizes and weights of the corpora become apparent.

	Mean diameter	Mean weight
c.l. of pregnancy	12.9 cm	920.7 g
c.l. of ovulation	11.4 cm	761.0 g
accessory c.l.	8.1 cm	249.6 g

The normal corpus luteum of pregnancy of animals possessing also an accessory corpus luteum has a mean diameter of 12.7 cm and a mean weight of 804.9 g. These mean weights and sizes do not agree with the data given by LAWS (1958, 1961), as follows:

	Mean diameter	Mean weight
c.l. of pregnancy	11.4 cm	881.0 g
c.l. of ovulation	8.3 cm	375.0 g
accessory c.l.	3.9 cm	45.0 g

If we compare these figures it seems that in my material, as a rule, no accessory corpora lutea are present. Probably these differences are caused by differences in appreciation of the characteristics of the corpora.

b. *Corpora albicantia*

The frequencies of the diameters of these corpora are given in fig. 44, the relation between mean weight and groups of diameters in fig. 45. The diameters range from 0.8 to 7.9 cm, the weights from 0.5 to 236.0 g. The mean weight is 18.8 g, the mean diameter 3.2 cm.

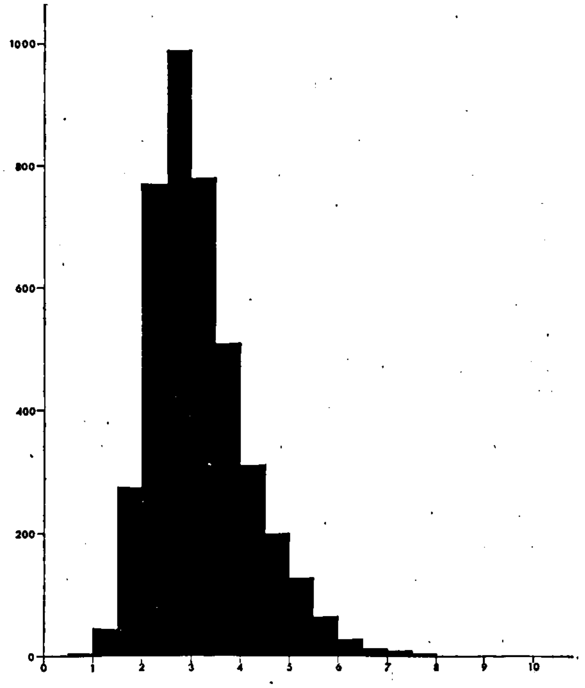

Fig. 44. *Frequencies of the sizes of corpora albicantia. Abscis: diameter in cm. Ordinate: number.*

From the curve of frequencies (fig. 44) it is evident that corpora in the largest group (42.60%) have a diameter of 2-3 cm. This agrees with LAWS' conclusion (1958, 1961). "Clearly there is in general no complete regression of corpora albicantia in respect of size, which is halted at an average diameter of 2.0 cm and an average weight of about 5 gms" (LAWS, 1958).

From my own results it is evident that only 7.86%

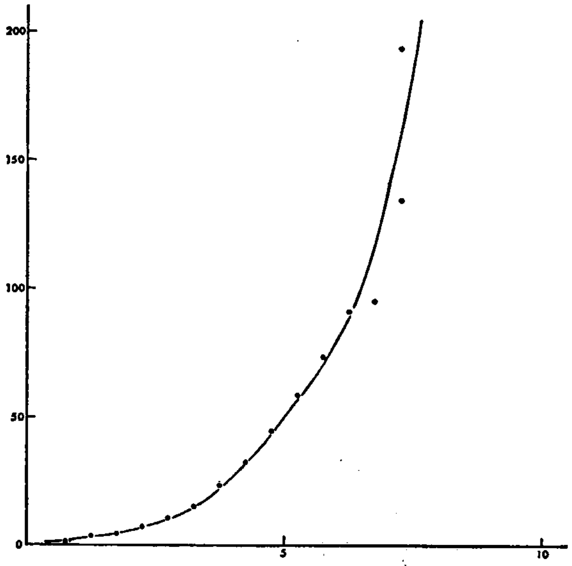

Fig. 45. *Relation between mean weight and groups of diameters of corpora abicantia. Abscis: diameter in cm. Ordinate: weight in g.*

of the corpora have a diameter smaller than 2 cm. The smallest diameter present in this material is 0.8 cm. It is evident that the corpora will not reduce to nil, but persist in the ovaries as recognizable bodies.

One of the possible ways to distinguish corpora albicantia of pregnancy and of ovulation is given by VAN LENNEP (1950). He uses the shape of the connective tissue of the corpora. "Most, if not all, corpora albicantia of the first (radiate) type are probably derived from corpora lutea of ovulation as only young corpora lutea of pregnancy have been found to possess the same structure and may therefore be supposed to become corpora albicantia of the second (branched) type. This does not necessarily mean that all corpora albicantia of the branched type have been corpora lutea of pregnancy as corpora lutea of ovulation may very well be of a complicated structure."

LAWS (1961) does not agree with him. From my own material notes were made concerning the shape of the connective tissue (radiate, branched or amorphous). Of the corpora 54.9% were amorphous, 30.1% radiate and 15.0% were of the branched type. The ratio between radiate and branched type is 2:1 and since the rate of ovulation is 2.5 per two years, it is very unlikely that the shape of the connective tissue in the corpora can provide a real basis for distinguishing corpora albicantia of an ovulation and of a pregnancy.

A second possible method of differentiating between the types of corpora albicantia might be the presence or absence of a central core or cavity. ROBINS (1954) based this conclusion on data from Humpback Whales. LAWS (1961) does not agree and also from my own material it is evident that this cannot be the case. In the corpora lutea of pregnant animals 56.1%, of non-pregnant animals 46.6% there was a cavity or core. In 46.5% of the corpora albicantia of my material there was a core or cavity.

Table 20

Number of corpora albicantia	Age in years	Number of animals
1	6.8	34
2	7.6	31
3	8.4	19
4	9.2	19
5	10.0	13
6	10.8	12
7	11.6	14
8	12.4	15
9	13.2	11
10	14.0	14
11	14.8	14
12	15.6	14
13	16.4	13
14	17.2	9
15	18.0	17
16	18.8	12
17	19.6	8
18	20.4	7
19	21.2	6
20	22.0	8
21	22.8	6
22	23.6	7
23	24.4	7
24	25.2	8
25	26.0	4
26	26.8	7
27	27.6	3
28	28.4	6
29	29.2	4
30	30.0	2
31	30.8	2
32	31.6	3
33	32.4	2
34	33.2	2
35	34.0	—
36	34.8	2
37	35.6	—
38	36.4	—
39	37.2	—
40	38.0	—
41	38.8	1

D. AGE COMPOSITION OF THE MATERIAL

As has been shown the corpora persist in the ovaries during the whole life of the Fin Whale. From my analyses it is evident that female Fin Whales attain sexual maturity as a mean in their seventh year, and the mean rate of ovulation is 2.5 per breeding period of two years. So it is possible to estimate the age of the animals by means of counts of corpora in the ovaries.

In the group of sexually mature animals of which material was sampled during the seasons 1953/1954 - 1959/1960, the distribution of ages, based on the counting of the corpora in the ovaries is as follows (table 20):

Apart from the animals stated above, each of 23 specimens had only one corpus luteum in the ovaries, so that their age can be estimated at six years.

The total collection of material examined comprised 379 sexually mature, and 112 sexually immature animals.

From calculations based on the random sample (Chapter II) it is shown that the material sampled in the seasons 1953/1954 to 1959/1960 inclusive, is a random sample of the total catch of females of the "Willem Barendsz" in these seasons. For these seasons therefore, the age distribution of these animals is a good indication for the age distribution in the total catch of female Fin Whales of the "Willem Barendsz".

CHAPTER IV

1. Summary

1. From Antarctic female Fin Whales, *Balaenoptera physalus*, a collection, consisting of baleen plates and the parts of these plates embedded in the gum, ovaries, and a number of earplugs was examined, in order to determine the age of these animals and to get a better insight in some characteristics of their reproduction. Data concerning pregnancy and lactation were also recorded. The material was sampled from animals worked up on board the f.f. "Willem Barendsz" during the Antarctic seasons 1953/1954 to 1959/1960 inclusive. The possibilities and values of age determination for this species were considered, based on the results of the analyses of the above material.

2. In most seasons the length distribution of the female Fin Whales, from which the material for the age determination was sampled ("examined animals"), did not differ significantly from that of the total catch of females of the "Willem Barendsz" in the same seasons. Neither was there any significant difference in length distribution between the total number of females from which the material was sampled and that of the females in the catch of the "Willem Barendsz" in all seasons. However, the length distribution of the catch of the "Willem Barendsz" differed significantly from the total Antarctic pelagic catch.

3. Baleen records were made according to the method described by RUUD (1940). In contrast with his age determinations with the aid of the part of the baleen plate protruding from the gum also the part of the plate hidden in the gum was used. A method of reading this part was developed. The advantage of this method is that the total length of baleen plate examined is much longer, and that the part hidden in the gum is not yet worn. In addition, the use of the part hidden in the gum has the undeniable advantage that the end of the cortical layer at the base of the "root" of the baleen plate represents the only exact date: the date at which the animal was killed.

4. Apart from the large waves of the cortical layer of the baleen plate the so-called "relief" was also used to divide the record of the baleen plate into "growth periods". The large waving is probably caused by variation in growth resulting from migration and available food, whereas the "relief" is probably a reflection of certain physiological events in the life of the animal, e.g. the sexual cycle. The influence of the sexual cycle may account for the fact that the records of the sexually immature animal and the sexually mature male animal and female animal show obvious differences, the external circumstances of life being more or less equal for all animals. LAWS (1961) is of the opinion that there is a certain relation between the sexual cycle and migration. "It is suggested that, as in females at puberty, the biannual ovulatory periods are primarily related to the twice-yearly period of increasing day lengths associated with the north and south migrations." If this is correct migration (day-light, feeding) might reinforce the influence of the sexual cycle on the growth of the cortical layer of the baleen plate. In that case the so-called "ovulation peaks" would

become very prominent in the "relief" of the baleen plate, which they actually do.

5. With the aid of periodical configurations of peaks and hollows in the baleen records the curves were divided into "growth periods", which were supposed to represent periods of one year each.

One special configuration of peaks was regarded as an "ovulation peak". This was confirmed by the condition of the animal with regard to pregnancy or the age of the foetus.

6. It was proved that there was a significant regularity in the succession and the heights of the peaks and hollows of the "relief" of the baleen plate according to FRIEDMANN's method of m-ranking. This means that the "relief" is not formed in an arbitrary way but is a reflection of particular events in the life of the animal. Besides it was shown by VAN UTRECHT (1965) that each peak will be formed at a particular time and place in the "root" of the baleen plate.

7. The method of age determination described by the present author is to be regarded as an improvement of RUUD's method since a. the entire baleen plate is used in the analyses as stated above sub 3., b. besides the large waving also the "relief" of the baleen plate is taken into account.

Though in itself too time-consuming for routine examinations it already offers the possibility of c. determining the mean rate of ovulation by means of "ovulation peaks" and d. determining the moment of attainment of sexual maturity.

8. It is evident that as to the Fin Whale, age determination with baleen plates can generally be used up to and including the fourth year of life. In the records of the baleen plates of all these animals there are indications of their suckling or weaning periods. If the baleen plates contain more than four "growth periods" the part of the baleen plate formed during the weaning period is generally worn off and then only a minimum age can be determined. Consequently in those animals having more than four "growth periods" in their baleen plate records and showing indications of at least the weaning period ("double hump"), the baleen plate can also be used in age determinations.

9. So far the baleen plate method was only used to determine minimum ages. Now further analyses of baleen plates were made to gain an insight into the mean age at which the animals attain sexual maturity and into the mean rate of ovulation. In age determinations of mature females these results enable us to use the ovaries only.

10. It is necessary to know something of the number of "growth periods" hidden in the gum and of the way this number varies to be able to compare earlier determinations of the age at which the animals attain sexual maturity by means of baleen plates, with my results.

11. Of all examined animals the mean number of "growth periods" hidden in the gum appeared to be 1.79. In young animals (up to and including 4+ "growth periods") this number varied from 0.5 to 2.0. This is contrary to RUUD's idea that in animals younger than five years, only part of one "growth period" is present in the gum, which can be ignored. The maximum number of "growth periods" found in the part of the baleen plate hidden in the gum appeared to be 2.8.

12. The mean number of "growth periods" hidden in the gum increases with

a. the increase in number of "growth periods" in the total baleen plate,

b. the increase in number of "growth periods" in the outer baleen plate,

c. the increase in length of the animals.

In sexually mature animals the mean number of "growth periods" hidden in the gum does not increase with the increase in age.

13. If there is a small number of "growth periods" in the outer baleen plate they are significantly longer than those in baleen plates with a greater number of "growth periods". The mean length of the "growth periods" decreases with the increase in age.

14. The number of "growth periods" in the baleen plate depends on the length of the baleen plate. In a longer plate the number of "growth periods" is significantly greater. Moreover, there is a linear correlation between the length of the baleen plate and the length of the animal.

15. Female Fin Whales in the Southern Hemisphere attain sexual maturity in their sixth, seventh or eighth year of life. Most of them will attain sexual maturity in their seventh year. In most of the earlier investigations it was accepted that the female Fin Whale attained sexual maturity in the fifth or sixth year of life. This difference may be accounted for by the fact that, as a mean, 1.79 "growth periods" are hidden in the gum instead of only part of one "growth period" as RUUD supposed. In investigations carried out by the Committee of Three Scientists appointed by the International Whaling Commission, it is commonly accepted that female Fin Whales attain sexual maturity in their fifth year of life. This age is probably too low.

16. The variation in age at which sexual maturity can be attained is probably caused by the existence

of three so-called "constitution types". These different types in the catch may also be responsible for the considerable variation in length of the baleen plates and the number and length of the "growth periods" in the baleen plates of the different types.

17. The mean rate of ovulation is 2.5 per period of two years. This calculation is based on the presence of the "ovulation peaks" in baleen plate records, and the lapse of time represented by that portion of the record between two such peaks. This is based on the assumption that each "growth period" represents a period of one year and that the growth of the baleen plate is, as a mean, regular. A correction factor is applied because multiple foetuses, accessory corpora lutea and several simultaneous ovulations are found.

During the whole life of the female Fin Whale the mean rate of ovulation is constant. A decrease of fertility will not occur at all, or only very late in its life.

18. Most ovulations of the examined animals occurred during the southern winter (June to September inclusive), although a reasonable number of ovulations occurred in the southern summer.

19. If no pregnancy follows the interval between two ovulations is in most cases circ. 6 months, other possibilities are circ. 12, circ. 18 and circ. 24 months. In one case an interval of circ. 30 months was found.

20. It is proved and accepted that corpora albicantia persist during the whole of the whale's life, although they do reduce to a mean diameter of 2.0 cm. This persistence makes it possible to make an estimation of the age of an individual. In a large sample such an estimation is sufficient to reach a conclusion about the age distribution.

21. The weight of the ovaries in immature females increases with the increase in length. To a certain extent the age of these young animals correlates with their length, so there is also a correlation between the weight of the ovaries and the age of the animal.

22. When the animals attain sexual maturity there is a significant increase in weight of the ovaries.

23. In mature females there is a correlation between the weight of the ovaries and the length of these animals. With regard to the age of the animals there is at first an increase and subsequently a decrease in weight of the ovary. This may be an indication of a decrease of the sexual activity in some species. However, this is not the case in the female Fin Whale. The mean rate of ovulation and the percentage of pregnant females remains constant as age increases. A plausible explanation for these facts is that there is a proceeding wave of ovulations, from the pole of the ovary directed to the bursa ovarica to the opposite pole. If the main ovulatory activity occurs in the first half of the ovary (i.e. the part adjacent to the bursa) both halves will increase in weight; if the ovulatory activity occurs mainly in the second half, the first half is mainly inactive and will decrease in weight. At a certain time the decrease in weight of the first half will be greater than the increase in weight of the second half, so that the total weight of the ovary will decrease while the mean rate of ovulation remains constant.

Samenvatting

1. Het doel van dit onderzoek was het ontwikkelen van een verbeterde methode voor de leeftijdsbepaling bij de Gewone Vinvis, *Balaenoptera physalus*, met behulp waarvan tevens een inzicht verkregen kon worden in bepaalde aspecten van de voortplanting van deze dieren. Om dit te bereiken werd materiaal onderzocht bestaande uit baleinen met de daarbij behorende in het tandvlees gelegen delen, ovaria en een aantal oorpluggen. Tevens werd gebruik gemaakt van gegevens betreffende dracht en lactatie. Het bewerkte materiaal was afkomstig van vrouwelijke dieren, gedurende de seizoenen 1953/1954 tot en met 1959/1960 verwerkt aan boord van het m.s. "Willem Barendsz".

2. De lengteverdeling der vrouwelijke Gewone Vinvissen, waarvan materiaal is verzameld ten behoeve van het leeftijdsonderzoek, is in de meeste seizoenen niet significant afwijkend van die der totale vangst aan vrouwelijke dieren door de "Willem Barendsz" in die seizoenen. Ook de lengteverdeling van het totale aantal der dieren, waarvan materiaal is verzameld, is niet significant afwijkend van dat der totale vangst aan vrouwelijke dieren door de "Willem Barendsz" over de genoemde seizoenen tesamen. De lengteverdeling van de totale vangst aan vrouwelijke dieren door de "Willem Barendsz" bleek significant afwijkend te zijn van de totale Antarctisch pelagische vangst aan vrouwelijke dieren.

3. Bij dit onderzoek is, in tegenstelling met oudere leeftijdsbepalingen met behulp van baleinen, tevens gebruik gemaakt van het deel van de balein dat in het tandvlees gelegen is. Het voordeel hiervan is dat het te onderzoeken deel van de balein aanzienlijk langer is en het deel van de balein dat in het tandvlees gelegen is, nog niet aan slijtage blootgesteld geweest is. Bovendien heeft het gebruik van het deel van de balein, dat in het tandvlees gelegen is, het onmiskenbare voordeel dat een punt aan te wijzen is

dat een bekende datum representeert. Het einde van de schorslaag aan de basis van de baleinwortel komt overeen met het moment van doden van het dier.

4. Van de baleinen werden curven gemaakt volgens een methode beschreven door RUUD (1940). Bij de indeling van de baleincurve in groeiperioden werd, behalve met de grove golving van de schorslaag tevens rekening gehouden met het zogenaamde "relief" van de balein. De grove golving wordt zeer waarschijnlijk door de trek en de daarmee samenhangende voedselopname veroorzaakt, het "relief" is zeer waarschijnlijk een weerspiegeling van bepaalde andere physiologische gebeurtenissen in het leven van het dier, bijvoorbeeld de sexuele cyclus. Dit zou kunnen verklaren waarom de baleincurven van juveniele dieren, mannelijke geslachtsrijpe en vrouwelijke geslachtsrijpe dieren duidelijk verschillen ten opzichte van elkaar vertonen terwijl de invloed van het milieu op de dieren toch vrijwel identiek is. Volgens LAWS (1961) zou er een relatie bestaan tussen de sexuele cyclus en de trek. Wanneer dit juist zou zijn, zou de trek (daglicht, voedsel) de invloed van de sexuele cyclus op de groei van de schors van de balein kunnen versterken, waardoor juist de zogenaamde "ovulatietoppen" extra duidelijk in het "relief" tot uiting komen.

5. Met behulp van steeds terugkerende configuraties van toppen en dalen in de baleincurven, werden deze curven ingedeeld in groeiperioden, die geacht werden ieder een periode van één jaar te representeren. Vervolgens werden bepaalde configuraties van toppen als ovulatietoppen aangemerkt, waarna een bevestiging hiervan werd gezocht en gevonden met behulp van gegevens omtrent de toestand waarin het dier verkeerde (drachtig of niet drachtig, grootte van de vrucht enz.).

6. Er is aangetoond dat een significante regelmaat in de hoogte en de volgorde van de toppen en dalen van het "relief" van de baleincurve bestaat. Het "relief" ontstaat dus niet op willekeurige wijze, maar weerspiegelt bepaalde gebeurtenissen in het leven van het dier. Bovendien is door VAN UTRECHT (1965) aangetoond dat elke top op één bepaald moment en op één bepaalde plaats in de balein gevormd wordt.

7. Het is duidelijk dat de beschreven methode van leeftijdsbepaling, die gebruikt is in onze analyse van de baleincurve, beschouwd moet worden als een verbetering van de methode van RUUD, omdat a. de gehele balein gebruikt wordt voor de analyse, zoals reeds onder 3 gezegd is, b. er behalve met de grove golving ook rekening gehouden wordt met het "relief" van de balein, c. het mogelijk is de gemiddelde ovulatiesnelheid te bepalen met behulp van de ovulatietoppen, d. het mogelijk is de gemiddelde leeftijd te bepalen waarop de dieren geslachtsrijp worden. Een bezwaar van deze methode is dat zij te tijdrovend is om als routineanalyse op een groot materiaal toe te passen. Daarentegen kan men echter met deze methode veel gegevens verkrijgen over de biologie van deze voor onderzoek zo moeilijk toegankelijke zoogdieren.

8. Er is gebleken dat de leeftijdsbepaling met behulp van de balein in het algemeen slechts tot en met het vierde levensjaar van het dier betrouwbaar is. Bij alle dieren jonger dan vijf jaar zijn in de baleincurve nog tekenen van de zoogperiode en/of het spenen aanwezig. Bij dieren die meer dan vier groeiperioden in de balein bezitten, is in de meeste gevallen het deel dat tijdens het zogen of spenen gevormd is afgesleten. Bij deze dieren kan dus hoogstens een minimum leeftijd bepaald worden. Slechts bij die dieren, waar naast een groter aantal groeiperioden in de baleincurve nog tenminste tekenen van het spenen (de z.g.n. "double hump") duidelijk aanwezig zijn, is de balein nog voor leeftijdsbepaling te gebruiken.

9. Getracht is met behulp van de balein, naast het vaststellen van de individuele minimum leeftijd van de dieren, een inzicht te verkrijgen in de gemiddelde leeftijd waarop de dieren geslachtsrijp worden, terwijl tevens is getracht de gemiddelde ovulatiesnelheid te bepalen, zodat verder voor de leeftijdsbepaling van de geslachtelijk volwassen wijfjes gebruik gemaakt kan worden voor de ovaria.

10. Bij de bepaling van de gemiddelde leeftijd waarop de dieren geslachtsrijp worden, moest, om de resultaten van RUUD te kunnen vergelijken met de door mij verkregen uitkomsten, een inzicht worden verkregen in het aantal groeiperioden dat in het tandvlees verborgen is en in de wijze waarop dit aantal kan veranderen.

11. Het aantal groeiperioden in het tandvlees bedraagt voor alle dieren tesamen, gemiddeld 1.79. Bij jonge dieren (tot en met 4+ groeiperioden in de totale baleincurve) kan dit variëren van 0.5 tot 2.0. Dit is in tegenspraak met de mening van RUUD, dat bij dieren tot vijf jaar slechts een gedeelte van een groeiperiode in het tandvlees aanwezig zou zijn en dat deze daarom verwaarloosd zou mogen worden. Het maximum aantal groeiperioden, dat verborgen kan zijn in het tandvlees, bedraagt 2.8.

12. Het gemiddelde aantal groeiperioden in het deel van de balein dat in het tandvlees verborgen is, neemt toe bij a. toenemend aantal perioden in de totale balein, b. toenemend aantal perioden in de

uitwendige balein, c. toenemende lengte van de dieren.

Het gemiddelde aantal perioden in dit deel van de balein neemt bij geslachtsrijpe dieren niet toe met de leeftijd.

13. Bij een klein aantal perioden in de uitwendige balein zijn deze perioden significant langer dan wanneer een groter aantal daarin voorkomt. De gemiddelde lengte van de periode neemt af bij toenemende leeftijd.

14. Het aantal in een balein voorkomende perioden hangt af van de lengte van die balein. Een groter aantal perioden komt voor in een gemiddeld langere balein. Bovendien is de lengte van de balein recht evenredig met de lengte van het dier.

15. Vrouwelijke Gewone Vinvissen van het Zuidelijk Halfrond zullen in hun zesde, zevende of achtste levensjaar geslachtsrijp worden. Het merendeel zal geslachtsrijp worden in hun zevende levensjaar. Door vroegere onderzoekers werd veelal aangenomen dat de dieren in hun vijfde of zesde levensjaar geslachtsrijp worden. Dit verschil kan mogelijk verklaard worden doordat gemiddeld 1.79 groeiperioden in het deel van de balein, dat in het tandvlees gelegen is, aangetroffen werden in plaats van slechts een deel van een groeiperiode.

Bij onderzoekingen van de Commissie van Drie, aangesteld door de International Whaling Commission, is in het algemeen aangenomen dat de vrouwelijke Gewone Vinvis geslachtsrijp wordt in het vijfde levensjaar. Dit is zeer waarschijnlijk te vroeg gesteld.

16. De spreiding in leeftijd, waarop de geslachtsrijpheid bereikt wordt, wordt misschien veroorzaakt door het bestaan van drie zogenaamde "constitutietypen". Het voorkomen van deze typen zou ook de oorzaak kunnen zijn van de sterk wisselende lengte van de balein en de lengte van de daarin voorkomende groeiperioden bij de verschillende individuen.

17. De gemiddelde ovulatiesnelheid bleek 2.5 per twee jaar te bedragen. Deze berekening is geschied aan de hand van de in de baleincurve aanwijsbare ovulatietoppen en de berekening van de tijdsduur van het deel van de curve tussen twee van dergelijke toppen, waarbij aangenomen wordt dat elke periode één jaar vertegenwoordigt en de groei van de balein regelmatig is en niet schoksgewijs heeft plaats gevonden. Een correctiefactor moest toegepast worden, omdat meerlingen, accessorische corpora lutea en meer ovulaties te zelfder tijd kunnen voorkomen.

18. Het merendeel der ovulaties vindt op het Zuidelijk Halfrond gedurende de winter (Juni tot en met September) plaats, hoewel een niet te verwaarlozen aantal gedurende de zuidelijke zomer plaats vindt.

19. Meestal bedraagt het tijdsverloop tussen twee ovulaties, wanneer geen dracht volgt, ca. 6 maanden. Andere mogelijkheden zijn ca. 12, ca. 18 en ca. 24 maanden. In één geval bleek een tijdsverloop van ca. 30 maanden tussen twee ovulaties te zijn voorgekomen.

20. Nu bekend is op welke leeftijd de dieren gemiddeld geslachtsrijp worden en hoe groot de gemiddelde ovulatiesnelheid is, kan voor de leeftijdsbepaling van de geslachtsrijpe vrouwelijke dieren het aantal groeiperioden in de balein buiten beschouwing gelaten worden. Er kan nu uitsluitend gebruik gemaakt worden van de telling van alle aanwezige corpora in de ovaria, aannemende dat deze corpora gedurende het gehele leven blijven bestaan. Dit is reeds vele malen aangetoond en het bleek ook uit mijn eigen onderzoek. De corpora albicantia reduceren tot een gemiddelde diameter van 2.0 cm. Men verkrijgt met behulp van de telling van de corpora in de ovaria een schatting van de leeftijd van ieder dier afzonderlijk. Hiervan kan echter bij een groot materiaal gebruik worden gemaakt om een inzicht te verkrijgen in de leeftijdsopbouw.

21. Het gewicht van de ovaria van juveniele dieren neemt toe bij toenemende lengte van de dieren. Daar de leeftijd van deze jonge dieren enigermate gecorreleerd kan worden met hun lengte, zal het ovariumgewicht ook toenemen met de leeftijd.

22. Wanneer de dieren het geslachtsrijpe stadium bereikt hebben, treedt een significante gewichtstoename van de ovaria op.

23. Bij geslachtsrijpe dieren is een correlatie aan te tonen tussen het ovariumgewicht en de lengte van de dieren. Ten opzichte van de leeftijd van de dieren bleek eerst een toename plaats te vinden, waarna later weer een afname volgt. Dit zou kunnen wijzen op een afname van de geslachtsactiviteit, een verschijnsel dat echter niet plaats vindt bij de vrouwelijke Gewone Vinvis. De ovulatiesnelheid en het percentage drachtige dieren blijken bij toenemende leeftijd constant te blijven. Een mogelijke verklaring ligt in de verschuiving van de plaats waar de ovulaties in het ovarium optreden, n.l. van de naar de bursa gerichte pool naar de tegenoverliggende pool. Wanneer de ovulaties plaats vinden in de naar de bursa gerichte helft van het ovarium, zullen beide helften in gewicht toenemen; wanneer de ovulaties in de andere helft plaats vinden, zal de eerste helft in gewicht afnemen. De gewichtsafname van de eerste helft zal op een gegeven moment groter zijn dan de gewichtstoename van de tweede helft, zodat het to-

tale ovariumgewicht zal afnemen, terwijl de frequentie der ovulaties constant zal kunnen blijven.

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4. Material

LIST I

Season	Number	Sex	Length in feet	Number of periods in baleen	Ovaries		Foetus		Conclusion mammae	Number of laminations in earplug
					c.l.	c.a.	Sex	Length in feet		
1953/1954	199	♀	72	7	—	6	—	—	N.L.	?
„	464	♀	62	5	immature		—	—	N.L.	?
„	541	♀	70	6	—	15	—	—	N.L.	?
„	631	♀	73	5	1	1	♀	7	N.L.	?
„	694	♀	70	6	—	14	—	—	N.L.	?
„	1110	♀	77	6	1	7	♂	18	D.	?
„	1293	♀	69	5	—	2	—	—	L.	?
1954/1955	254	♀	63	5	immature		—	—	N.L.	?
„	316	♀	76	6	1	5	♀	8	N.L.	?
„	530	♀	64	6	1	—	♂	6	N.L.	?
„	700	♀	72	7	—	4	—	—	N.L.	?
„	810	♀	81½	7	1	16	♂	10	N.L.	?
1955/1956	302	♀	73	7	1	12	♀	3	N.L.	?
„	364	♀	75	9	—	7	—	—	N.L.	?
„	366	♀	50	4	immature		—	—	N.L.	?
„	421	♀	71	8	—	30	—	—	N.L.	?
„	578	♀	69	7	—	13	—	—	L.	?
„	1157	♀	68	8	1	1	?	?	N.L.	?
1956/1957	106	♀	74	8	1	13	♀	6	N.L.	?
„	107	♀	64	6	1	2	♀	8	N.L.	?
„	140	♀	70	6	1	—	♂	3½	N.L.	?
„	161	♀	73	8	1	6	♀	11	N.L.	?
„	177	♀	71	9	1	8	♂	2	N.L.	?
„	192	♀	60	7	1	1	♀	1'3"	N.L.	?
„	205	♀	60	5	immature		—	—	N.L.	?
„	218	♀	68	5	—	3	—	—	N.L.	?
„	227	♀	58	5	immature		—	—	N.L.	?
„	260	♀	72	8	1	4	♂	6½	N.L.	?
„	267	♀	60	5	immature		—	—	N.L.	?
„	336	♀	70	8	—	5	—	—	L.	?
„	372	♀	68	6	—	2	—	—	N.L.	?
„	378	♀	65	6	1	—	♂	5	N.L.	?
„	446	♀	62	6	immature		—	—	N.L.	?
„	448	♀	74	6	1	20	♀	4	N.L.	?
„	499	♀	77	7	1	8	♂	5½	N.L.	?
„	513	♀	66	6	1	8	♀	8	N.L.	?
„	560	♀	69	7	—	4	—	—	D.	?
„	610	♀	59	6	immature		—	—	N.L.	?
„	620	♀	76	8	1	7	♂	9	N.L.	?
„	630	♀	69	7	1	—	♂	3½	N.L.	?
„	817	♀	72	7	—	2	—	—	N.L.	?
„	825	♀	59	6	immature		—	—	N.L.	?
„	910	♀	75	7	1	6	♀	13½	N.L.	?
„	917	♀	73	8	—	8	—	—	L.	?
„	1058	♀	68	7	—	3	—	—	N.L.	?
„	1068	♀	60	6	immature		—	—	N.L.	?
„	1099	♀	80	6	1	7	♀	16	N.L.	?
„	1113	♀	71	6	1	21	♂	7	N.L.	?
„	1166	♀	73	9	1	16	♂	15	N.L.	?
„	1196	♀	70	8	1	5	♂	11	N.L.	?
1957/1958	3	♀	72	7	—	5	—	—	L.	?
„	4	♂	45	<1	—	—	—	—	—	?
„	6	♀	55	3	immature		—	—	N.L.	?
„	19	♀	52	1	immature		—	—	?	?

? — no material available N.L. — not lactating D. — dubious L. — lactating

LIST I *(Continued)*

Season	Number	Sex	Length in feet	Number of periods in baleen	Ovaries c.l.	c.a.	Foetus Sex	Foetus Length in feet	Conclusion mammae	Number of laminations in earplug
1957/1958	155	♀	64	5	1	—	♂	3	N.L.	?
„	158	♀	70	5	1	2	♂	6	N.L.	?
„	163	♀	65	4	immature		—	—	N.L.	?
„	189	♀	60	4	immature		—	—	N.L.	?
„	191	♀	64	5	immature		—	—	N.L.	?
„	197	♀	75	6	1	19	—	—	?	?
„	205	♀	65	4	immature		—	—	N.L.	?
„	236	♀	59	4	immature		—	—	N.L.	?
„	238	♀	61	4	immature		—	—	N.L.	?
„	241	♀	69	6	1	4	♂	1	N.L.	?
„	252	♀	70	7	—	4	—	—	N.L.	?
„	254	♀	71	5	1	3	♂	8	N.L.	?
„	262	♀	78	6	1	23	♀	2	N.L.	?
„	272	♀	65	4	immature		—	—	?	?
„	276	♀	72	8	1	12	♀	9	N.L.	?
„	283	♀	57	4	immature		—	—	?	?
„	287	♀	64	5	—	2	—	—	D.	?
„	363	♀	57	6	immature		—	—	N.L.	?
„	369	♀	70	5	1	13	♂	4	N.L.	?
„	388	♀	73	8	—	26	—	—	L.	?
„	392	♀	72	8	1	2	♂	2	N.L.	?
„	400	♀	58	3	immature		—	—	N.L.	?
„	403	♀	67	4	immature		—	—	N.L.	?
„	404	♀	66	6	—	1	—	—	end of L.	?
„	419	♀	63	7	immature		—	—	N.L.	?
„	428	♀	75	5	1	8	♂	10	N.L.	?
„	467	♀	62	6	1	2	♂	3	N.L.	?
„	468	♀	61	6	immature		—	—	N.L.	?
„	477	♀	77	8	1	23	♂	6	N.L.	?
„	572	♀	72	7	1	1	♀	6	N.L.	?
„	573	♀	68	5	1	4	♀	8	D.	?
„	582	♀	59	5	immature		—	—	N.L.	?
„	598	♀	67	5	1	3	?	?	N.L.	?
„	646	♀	58	3	immature		—	—	N.L.	?
„	649	♀	64	6	1	—	—	—	N.L.	?
„	651	♀	68	5	1	1	♀	4	N.L.	?
„	668	♀	68	5	1	1	♂	7	N.L.	?
„	682	♀	77	6	1	18	♀	8	N.L.	?
„	692	♀	66	4	immature		—	—	?	?
„	774	♀	62	6	immature		—	—	N.L.	?
„	790	♀	76	6	1	6	♂	5½	N.L.	?
„	801	♀	70	6	1	4	♀	9	N.L.	?
„	1161	♀	65	5	1	1	♀	7	N.L.	?
„	1166	♀	71	5	1	3	♀	8	N.L.	?
„	1184	♀	69	6	1	1	♀	3½	N.L.	?
„	1199	♀	62	5	immature		—	—	?	?
„	1208	♀	63	5	immature		—	—	N.L.	?
„	1220	♀	64	5	immature		—	—	N.L.	?
„	1280	♀	70	6	1	3	♀	9	N.L.	?
„	1287	♀	72	6	—	13	—	—	N.L.	?
„	1289	♀	76	7	1	10	♂	5	N.L.	?
„	1299	♀	60	5	immature		—	—	N.L.	?
„	1301	♀	73	6	1	11	—	—	N.L.	?
„	1307	♀	69	8	1	5	lost		N.L.	?

LIST I (*Continued*)

Season	Number	Sex	Length in feet	Number of periods in baleen	Ovaries		Foetus		Conclusion mammae	Number of laminations in earplug
					c.l.	c.a.	Sex	Length in feet		
1957/1958	1317	♀	61	5	immature		—	—	N.L.	?
”	1343	♀	73	8	1	22	♂	5	N.L.	?
”	1346	♀	59	5	immature		—	—	N.L.	?
”	1349	♀	71	6	1	25	♀	6½	N.L.	29
”	1362	♀	65	7	1	29	—	—	D.	?
”	1369	♀	63	5	1	1	♀	3	N.L.	?
”	1372	♀	66	7	—	5	—	—	D.	?
”	1402	♀	73	10	1	7	♀	11	N.L.	?
”	1413	♀	65	4	immature		—	—	N.L.	?
”	1418	♀	78	8	1	18	♂	15	D.	39
”	1424	♀	72	8	1	24	♀	17	N.L.	?
”	1456	♀	72	7	1	28	♂	11	N.L.	?
”	1486	♀	63	5	immature		—	—	N.L.	?
”	1514	♀	74	8	1	23	♀	13	N.L.	48
”	1520	♀	67	5	1	—	♀	7	N.L.	?
”	1563	♀	70	6	1	3	♂	12	N.L.	16
”	1565	♀	76	7	1	21	♀	12	N.L.	?
”	1588	♀	72	7	1	15	♀	18	N.L.	40
”	1606	♀	63	2	immature		—	—	N.L.	3
”	1607	♀	76	7	1	15	♀	4	N.L.	27
”	1608	♀	77	8	1	4	♂	9	N.L.	17
”	1610	♀	80	7	1	22	♀	12	N.L.	30?
”	1677	♀	62	3	immature		—	—	N.L.	6
”	1678	♀	64	4	immature		—	—	N.L.	?
”	1737	♀	70	8	1	10	♂	8	N.L.	25
”	1742	♀	78	6	2	20	♂	9	?	?
							♂	10		
”	1750	♀	69	7	1	10	♀	18	?	?
”	1763	♀	72	6	—	3	—	—	N.L.	10
”	1772	♀	78	9	1	19	♀	9	N.L.	42
”	1820	♀	69	9	1	11	—	—	?	26
1958/1959	168	♀	74	7	1	10	♂	5½	?	18
”	191	♀	77	9	1	9	♀	4	?	20
”	197	♀	64	5	immature		—	—	N.L.	?
”	205	♀	75	5	2	8	♂	0′3½″	N.L.	?
”	212	♀	62	5	immature		—	—	N.L.	?
”	254	♀	62	5	1	—	♀	3	N.L.	?
”	349	♀	70	7	—	33	—	—	D.	?
”	360	♀	62	5	immature		—	—	N.L.	?
”	377	♀	68	7	1	1	♂	2½	N.L.	?
”	399	♀	69	7	1	11	♂	4	N.L.	30
”	400	♀	65	5	immature		—	—	N.L.	?
”	408	♀	69	7	1	2	♀	7	N.L.	?
”	421	♀	62	5	immature		—	—	N.L.	9
”	443	♀	63	6	immature		—	—	?	?
”	479	♀	64	6	1	—	♀	5	N.L.	?
”	480	♀	68	5	immature		—	—	N.L.	8
”	486	♀	66	5	immature		—	—	N.L.	10
”	552	♀	73	6	—	9	—	—	L.	?
”	601	♀	60	5	immature		—	—	N.L.	9
”	627	♀	63	5	immature		—	—	N.L.	?
”	665	♀	70	6	1	1	♀	4	N.L.	?
”	699	♀	67	5	1	1	♀	4	N.L.	?
”	715	♀	70	6	—	1	—	—	N.L.	?

LIST I *(Continued)*

Season	Number	Sex	Length in feet	Number of periods in baleen	Ovaries c.l.	Ovaries c.a.	Foetus Sex	Foetus Length in feet	Conclusion mammae	Number of laminations in earplug
1958/1959	717	♀	68	6	1	1	♂	7	N.L.	?
„	741	♀	63	5	1	—	♂	3	N.L.	?
„	777	♀	65	4	immature		—	—	N.L.	?
„	798	♀	65	5	—	2	—	—	N.L.	?
„	848	♀	62	5	immature		—	—	N.L.	12
„	880	♀	63	6	immature		—	—	N.L.	?
„	893	♀	64	6	immature		—	—	N.L.	?
„	966	♀	70	6	2	8	—	—	N.L.	?
„	1042	♀	68	6	1	1	♂	11	N.L.	?
„	1073	♀	70	6	1	19	♂	11	?	40
„	1079	♀	66	5	immature		—	—	N.L.	9
„	1138	♀	64	5	immature		—	—	N.L.	?
„	1364	♀	63	5	immature		—	—	N.L.	?
„	1424	♀	65	7	immature		—	—	N.L.	?
„	1432	♀	68	7	—	6	—	—	D.	?
„	1438	♀	76	6	1	15	♀	4	N.L.	?
„	1559	♀	69	5	1	1	♂	8	N.L.	?
„	1589	♀	69	6	1	2	♀	3	N.L.	16
„	1702	♀	58	3	immature		—	—	?	5
„	1704	♀	71	9	—	19	—	—	N.L.	?
„	1709	♀	60	5	immature		—	—	N.L.	?
„	1714	♀	71	5	immature		—	—	N.L.	?
„	1721	♀	64	5	immature		—	—	N.L.	?
„	1723	♀	66	5	immature		—	—	N.L.	?
„	1725	♀	71	6	—	17	—	—	end of L.	?
„	1839	♀	59	4	immature		—	—	?	?
„	1880	♀	71	6	1	17	♂	14	N.L.	?
„	1894	♀	65	5	immature		—	—	N.L.	?
„	1935	♀	72	7	—	29	—	—	N.L.	56
„	1951	♀	69	5	immature		—	—	N.L.	?
„	1987	♀	70	6	1	5	♂	11	N.L.	?
„	2006	♀	68	7	1	2	♀	9	N.L.	?
„	2014	♀	60	5	immature		—	—	N.L.	?
„	2020	♀	64	7	immature		—	—	N.L.	?
„	2029	♀	62	5	immature		—	—	N.L.	?
„	2035	♀	64	4	immature		—	—	N.L.	15
„	2127	♀	67	7	1	—	♀	4	N.L.	?
„	2179	♀	74	8	1	17	♀	11	N.L.	56

LIST II

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1953/1954	180	70	—	—	—	1	?
„	199	72	—	—	—	6	N.L.
„	274	73	—	—	—	11	?
„	464	62	—	—	immature		N.L.
„	541	70	—	—	—	15	N.L.
„	631	73	♀	7	1	1	N.L.
„	694	70	—	—	—	14	N.L.
„	1110	77	♂	18	1	7	D.
„	1151	69	♂	5	1	12	?
„	1293	69	—	—	—	2	L.
„	1295	73	♂	6	1	23	L.
1954/1955	254	63	—	—	immature		N.L.
„	287	72	♂	8′6″	2	13	N.L.
			♀	7′6″			
„	302	70	♂	2′6″	1	—	N.L.
„	316	76	♀	8	1	5	N.L.
„	530	64	♂	6	1	—	N.L.
„	548	68	—	—	—	2	?
„	551	66	—	—	—	2	N.L.
„	617	79	—	—	1	21	?
„	669	77	♀	14	1	15	?
„	700	72	—	—	—	4	N.L.
„	717	72	—	—	—	1	?
„	810	81½	♂	10	1	16	N.L.
1955/1956	302	73	♀	3	1	12	N.L.
„	364	75	—	—	—	7	N.L.
„	366	50	—	—	immature		N.L.
„	421	71	—	—	—	3	N.L.
„	425	71	♂	7′6″	1	12	?
„	426	63	—	—	immature		N.L.
„	455	62	—	—	immature		N.L.
„	556	71	—	—	—	30	N.L.
„	578	69	—	—	—	13	L.
„	1157	68	?	?	1	1	N.L.
„	1204	72	♀	15	1	—	N.L.
„	1255	67	—	—	—	3	L.
„	1279	85	—	—	1	5	N.L.
„	1411	70	♀	21	1	9	attaining L.
1956/1957	106	74	♀	6	1	13	N.L.
„	107	64	♀	8	1	2	N.L.
„	112	63	—	—	immature		?
„	140	70	♂	3½	1	—	N.L.
„	161	73	♀	11	1	6	N.L.
„	177	71	♂	2	1	8	N.L.
„	178	67	—	—	—	16	N.L.
„	192	60	♀	1′3″	1	1	N.L.
„	205	60	—	—	immature		N.L.
„	218	68	—	—	—	3	N.L.
„	222	70	♂	11	2	11	?
			♀	10			
„	227	58	—	—	immature		N.L.
„	234	68	—	—	immature		N.L.
„	242	70	—	—	—	3	end of L.
„	260	72	♂	6½	1	4	N.L.

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1956/1957	267	60	—	—	immature		N.L.
„	293	63	—	—	—	2	end of L.
„	302	72	♂	3	1	8	D.
„	319	70	—	—	—	7	end of L.
„	336	70	—	—	—	5	L.
„	372	68	—	—	—	2	N.L.
„	378	65	♂	5	1	—	N.L.
„	381	74	♂	7	1	10	N.L.
„	446	62	—	—	immature		N.L.
„	448	74	♀	4	1	20	N.L.
„	457	67	—	—	1	5	end of L.
„	499	77	♂	5½	1	8	N.L.
„	513	66	♀	8	1	8	N.L.
„	560	69	—	—	—	4	D.
„	606	76	♀	11	2	10	N.L.
			♀	11			
„	610	59	—	—	immature		N.L.
„	620	76	♂	9	1	7	N.L.
„	630	69	♂	3½	1	—	N.L.
„	643	72	♀	10	2	8	N.L.
			♂	11			
„	700	71	♀	5	1	9	?
„	817	72	—	—	—	2	N.L.
„	825	59	—	—	immature		N.L.
„	828	76	—	—	—	12	?
„	847	73	♂	10	2	26	N.L.
„	910	75	♀	13½	1	6	N.L.
„	912	73	—	—	—	16	D.
„	917	73	—	—	—	8	L.
„	1058	68	—	—	—	3	N.L.
„	1068	60	—	—	immature		N.L.
„	1099	80	♀	16	1	7	N.L.
„	1113	71	♂	7	1	21	N.L.
„	1166	73	♂	15	1	16	N.L.
„	1196	70	♂	11	1	5	N.L.
1957/1958	3	72	—	—	—	5	L.
„	6	55	—	—	immature		N.L.
„	19	52	—	—	immature		?
„	155	64	♂	3	1	—	N.L.
„	158	70	♂	6	1	2	N.L.
„	163	65	—	—	immature		N.L.
„	189	60	—	—	immature		N.L.
„	191	64	—	—	immature		N.L.
„	197	75	—	—	1	19	?
„	205	65	—	—	immature		N.L.
„	236	59	—	—	immature		N.L.
„	238	61	—	—	immature		N.L.
„	241	69	♂	1	1	4	N.L.
„	252	70	—	—	—	4	N.L.
„	254	71	♂	8	1	3	N.L.
„	262	78	♀	2	1	23	N.L.
„	272	65	—	—	immature		?
„	276	72	♀	9	1	12	N.L.
„	283	57	—	—	immature		?

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1957/1958	287	64	—	—	—	2	D.
„	363	57	—	—	immature		N.L.
„	369	70	♂	4	1	13	N.L.
„	388	73	—	—	—	26	L.
„	392	72	♂	2	1	2	N.L.
„	400	58	—	—	immature		N.L.
„	403	67	—	—	immature		N.L.
„	404	66	—	—	—	1	end of L.
„	419	63	—	—	immature		N.L.
„	426	73	♀	6	1	4	N.L.
„	428	75	♂	10	1	8	N.L.
„	467	62	♂	3	1	2	N.L.
„	468	61	—	—	immature		N.L.
„	477	77	♂	6	1	23	N.L.
„	572	72	♀	6	1	1	N.L.
„	573	68	♀	8	1	4	D.
„	582	59	—	—	immature		N.L.
„	598	67	?	?	1	3	N.L.
„	646	58	—	—	immature		N.L.
„	649	64	—	—	1	—	N.L.
„	651	68	♀	4	1	1	N.L.
„	668	68	♂	7	1	1	N.L.
„	682	77	♀	8	1	18	N.L.
„	692	66	—	—	immature		?
„	774	62	—	—	immature		N.L.
„	790	76	♂	5½	1	6	N.L.
„	801	70	♀	9	1	4	N.L.
„	1161	65	♀	7	1	1	N.L.
„	1166	71	♀	8	1	3	N.L.
„	1184	69	♀	3½	1	1	N.L.
„	1199	62	—	—	immature		?
„	1208	63	—	—	immature		N.L.
„	1220	64	—	—	immature		N.L.
„	1280	70	♀	9	1	3	N.L.
„	1287	72	—	—	—	13	N.L.
„	1289	76	♂	5	1	10	N.L.
„	1299	60	—	—	immature		N.L.
„	1301	73	—	—	1	11	N.L.
„	1307	69	lost		1	5	N.L.
„	1317	61	—	—	immature		N.L.
„	1343	73	♂	5	1	22	N.L.
„	1346	59	—	—	immature		N.L.
„	1349	71	♀	6½	1	25	N.L.
„	1362	65	—	—	1	29	D.
„	1369	63	♀	3	1	1	N.L.
„	1372	66	—	—	—	5	D.
„	1402	73	♀	11	1	7	N.L.
„	1413	65	—	—	immature		N.L.
„	1418	78	♂	15	1	18	D.
„	1424	72	♀	17	1	24	N.L.
„	1428	74	♀	4	1	15	N.L.
„	1456	72	♂	11	1	28	N.L.
„	1464	73	—	—	—	26	N.L.
„	1472	76	♀	7	1	19	N.L.

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1957/1958	1486	63	—	—	immature		N.L.
„	1493	71	♂	½	1	3	?
„	1514	74	♀	13	1	23	N.L.
„	1520	67	♀	7	1	—	N.L.
„	1563	70	♂	12	1	3	N.L.
„	1564	74	♂	13	1	4	?
„	1565	76	♀	12	1	21	N.L.
„	1588	72	♀	18	1	15	N.L.
„	1590	70	♀	13	1	15	?
„	1606	63	—	—	immature		N.L.
„	1607	76	♀	4	1	15	N.L.
„	1608	77	♂	9	1	4	N.L.
„	1610	80	♀	12	1	22	N.L.
„	1642	71	♂	7	1	15	?
„	1677	62	—	—	immature		N.L.
„	1678	64	—	—	immature		N.L.
„	1681	65	—	—	immature		N.L.
„	1737	70	♂	8	1	10	N.L.
„	1742	78	♂	9	2	20	?
			♂	10			
„	1750	69	♀	18	1	10	?
„	1761	75	♀	13	1	7	D.
„	1763	72	—	—	—	3	N.L.
„	1772	78	♀	9	1	19	N.L.
„	1817	59	—	—	immature		?
„	1820	69	—	—	1	11	?
1958/1959	166	73	—	—	1	5	N.L.
„	168	74	♂	5½	1	10	?
„	191	77	♀	4	1	9	?
„	197	64	—	—	immature		N.L.
„	205	75	♂	0′3½″	2	8	N.L.
„	206	74	♀	1	1	3	?
„	212	62	—	—	immature		N.L.
„	254	62	♀	3	1	—	N.L.
„	349	70	—	—	—	33	D.
„	360	62	—	—	immature		N.L.
„	376	67	♂	2	1	3	N.L.
„	377	68	♂	2½	1	1	N.L.
„	399	69	♂	4	1	11	N.L.
„	400	65	—	—	immature		N.L.
„	408	69	♀	7	1	2	N.L.
„	421	62	—	—	immature		N.L.
„	443	63	—	—	immature		?
„	479	64	♀	5	1	—	N.L.
„	480	68	—	—	immature		N.L.
„	486	66	—	—	immature		N.L.
„	552	73	—	—	—	9	L.
„	601	60	—	—	immature		N.L.
„	604	62	—	—	immature		N.L.
„	627	63	—	—	immature		N.L.
„	665	70	♀	4	1	1	N.L.
„	699	67	♀	4	1	1	N.L.
„	715	70	—	—	—	1	N.L.
„	717	68	♂	7	1	1	N.L.

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1958/1959	718	63	—	—	—	1	N.L.
„	741	63	♂	3	1	—	N.L.
„	754	61	—	—	immature		?
„	777	65	—	—	immature		N.L.
„	798	65	—	—	—	2	N.L.
„	848	62	—	—	immature		N.L.
„	873	76	—	—	—	32	?
„	880	63	—	—	immature		N.L.
„	893	64	—	—	immature		N.L.
„	907	69	—	—	—	12	N.L.
„	935	72	—	—	—	16	?
„	948	65	—	—	immature		N.L.
„	966	70	—	—	2	8	N.L.
„	1042	68	♂	11	1	1	N.L.
„	1073	70	♂	11	1	19	?
„	1079	66	—	—	immature		N.L.
„	1138	64	—	—	immature		N.L.
„	1364	63	—	—	immature		N.L.
„	1424	65	—	—	immature		N.L.
„	1432	68	—	—	—	6	D.
„	1438	76	♀	4	1	15	N.L.
„	1549	72	♂	14	1	18	N.L.
„	1559	69	♂	8	1	1	N.L.
„	1589	69	♀	3	1	2	N.L.
„	1600	61	♂	6	1	—	?
„	1605	66	♀	7	1	—	N.L.
„	1702	58	—	—	immature		?
„	1704	71	—	—	—	19	N.L.
„	1709	60	—	—	immature		N.L.
„	1714	71	—	—	immature		N.L.
„	1721	64	—	—	immature		N.L.
„	1723	66	—	—	immature		N.L.
„	1725	71	—	—	—	27	end of L.
„	1839	59	—	—	immature		?
„	1880	71	♂	14	1	17	N.L.
„	1894	65	—	—	immature		N.L.
„	1899	72	—	—	—	24	N.L.
„	1935	72	—	—	—	29	N.L.
„	1951	69	—	—	immature		N.L.
„	1987	70	♂	11	1	5	N.L.
„	2006	68	♀	9	1	2	N.L.
„	2014	60	—	—	immature		N.L.
„	2020	64	—	—	immature		N.L.
„	2029	62	—	—	immature		N.L.
„	2035	64	—	—	immature		N.L.
„	2127	67	♀	4	1	—	N.L.
„	2179	74	♀	11	1	17	N.L.
1959/1960	510	71	—	—	immature		N.L.
„	575	67	♂	8½	1	29	?
„	576	65	—	—	immature		?
„	577	71	—	—	1	—	?
„	583	71	—	—	—	1	?
„	584	76	—	—	—	20	?
„	591	63	—	—	immature		?

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1959/1960	592	65	—	—	immature		?
”	593	67	—	—	immature		?
”	596	61	—	—	immature		?
”	627	70	—	—	—	4	?
”	628	73	♂ ♂	6 5½	2	13	?
”	629	73	—	—	1	30	?
”	640	73	♀	8½	1	6	?
”	646	69	—	—	1	3	?
”	652	76	♂	11½	1	15	?
”	656	73	♂	5	1	10	?
”	701	71	—	—	—	17	N.L.
”	708	62	♂	2½	1	—	?
”	709	71	♂	3½	1	14	?
”	711	70	♂	3	1	8	?
”	713	73	♀	2	1	17	?
”	717	70	♀	3	1	4	?
”	718	73	♀	3½	1	16	?
”	719	74	♂	11	1	13	?
”	721	76	—	—	—	26	?
”	741	71	—	—	—	10	L.
”	742	69	♀	3	1	2	?
”	750	70	♀	9	1	11	?
”	753	79	♀	10	1	6	?
”	759	79	♂	9	1	12	?
”	761	72	♀	4	1	23	?
”	763	70	♀	5	1	8	?
”	764	85	♀	7	1	12	?
”	780	80	♀	11	1	8	?
”	784	70	—	—	1	4	?
”	785	71	—	—	—	3	?
”	789	60	♀	6	1	2	?
”	804	69	♀	1½	1	10	?
”	805	64	♀	6	1	—	?
”	821	69	—	—	—	10	?
”	824	71	♀	8	1	1	?
”	872	75	♂	2½	1	13	?
”	883	66	♂	5	1	1	?
”	888	62	—	—	—	1	?
”	897	70	♀	8½	1	2	?
”	911	64	—	—	—	2	L.
”	938	66	—	—	immature		?
”	946	73	♂	2½	1	25	?
”	958	68	♀	3	1	1	?
”	971	63	♂	4½	1	1	?
”	985	67	♂	3	1	1	?
”	1002	70	♂	7	1	4	?
”	1009	75	—	—	—	21	L.-D.
”	1011	64	♂	5	1	2	?
”	1021	74	♂	1½	1	15	?
”	1070	67	♀	4½	1	—	?
”	1139	72	♂	6	1	1	?
”	1177	68	♂	8½	1	1	?
”	1181	74	♂	9	1	4	?

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1959/1960	1183	71	♂	9½	1	12	?
„	1186	71	♀	4½	1	24	?
„	1205	70	—	—	—	15	L.
„	1245	76	♀	5	1	7	?
„	1248	79	♂	7	1	9	?
„	1250	74	♀	14	1	18	?
„	1253	71	♀	19½	—	10	?
			"mummified"				
„	1275	70	—	—	—	2	?
„	1287	71	♀	6	1	24	?
„	1297	61	♂	9	1	2	?
„	1299	72	♂	17	1	17	?
„	1301	73	♂	9½	1	5	?
„	1304	65	♂	8	1	—	?
„	1305	59	—	—	immature		?
„	1309	66	♀	9½	1	2	?
„	1317	71	♂	7	1	7	?
„	1322	75	♂	17	1	11	?
„	1324	72	♂	10	1	26	?
„	1328	70	♂	7½	1	14	?
„	1329	71	—	—	—	16	D.
„	1330	72	—	—	—	23	?
„	1332	74	—	—	—	11	?
„	1335	73	—	—	—	34	?
„	1341	73	—	—	—	36	?
„	1342	71	—	—	—	10	?
„	1345	69	♀	2½	1	22	?
„	1352	79	♂	8	1	3	?
„	1353	77	♀	11½	1	6	?
„	1356	70	—	—	—	4	?
„	1358	68	♂	7½	1	2	?
„	1359	68	♂	9	1	—	?
„	1360	69	—	—	—	15	?
„	1361	71	—	—	—	11	?
„	1362	67	♀	14	1	13	?
„	1363	78	♂	15½	1	13	?
„	1364	69	♀	14	1	27	?
„	1365	73	♀	5	1	15	?
„	1366	69	♂	12½	1	22	?
„	1367	73	—	—	—	27	?
„	1371	72	♂	9½	1	28	?
„	1374	75	♀	14½	1	28	?
„	1384	72	♂	9	1	2	?
„	1392	73	♀	7½	1	13	?
„	1393	76	—	—	—	7	?
„	1394	68	♂	2½	1	4	?
„	1395	65	♀	9	1	1	?
„	1396	69	♀	8½	1	1	?
„	1398	68	?	?	1	5	?
„	1399	73	♂	14	1	7	?
„	1408	79	♂	11½	1	7	?
„	1409	73	?	?	1	32	?
„	1414	70	♂	13	1	28	?
„	1416	76	♂	9½	1	29	N.L.

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1959/1960	1417	75	♂	6	1	31	?
„	1419	75	♀	12½	1	9	?
„	1420	76	♀	10½	1	8	?
„	1421	71	♀	10½	1	18	?
„	1423	75	♀	14	1	24	?
„	1424	78	♀	7½	1	12	?
„	1427	76	♂	12	1	20	?
„	1428	71	♂	13	1	15	?
„	1429	75	—	—	1	25	?
„	1435	70	—	—	immature		?
„	1439	72	♂	5	1	8	?
„	1440	79	—	—	—	13	?
„	1442	73	♂	5	1	34	?
„	1443	70	♂	12	1	2	?
„	1444	77	♂	3½	1	14	?
„	1445	71	♀	13	1	8	?
„	1446	73	♂	14	1	22	?
„	1447	65	♂	11½	1	2	?
„	1448	75	♀	8½	1	11	?
„	1449	73	♂	15	1	9	?
„	1450	77	♂	17½	1	24	?
„	1452	71	♀	7	1	6	?
„	1453	66	♀	7	1	1	?
„	1454	79	♀	6	1	20	?
„	1455	73	♀	4½	2	14	?
„	1460	71	♂	16	1	12	?
„	1461	74	♀	10	1	4	?
„	1464	72	♀	6½	1	20	?
„	1467	72	♂	11½	1	22	?
„	1468	73	♀	14	1	15	?
„	1478	75	♂	7	1	7	?
„	1479	73	♀	2½	1	11	?
„	1480	81	♂	10	1	6	?
„	1482	72	♀	13	2	18	?
„	1483	71	—	—	1	20	?
„	1484	71	♂	11	1	10	?
„	1486	72	♂	1½	1	14	?
„	1488	71	♀	8	1	19	?
„	1491	79	♀	12	2	16	?
			♂	12			
„	1492	72	♂	14½	1	12	?
„	1494	71	—	—	—	41	?
„	1495	75	♀	12	1	36	?
„	1497	77	♀	15½	1	11	?
„	1500	71	♀	7	1	14	?
„	1502	75	♂	9	1	9	?
„	1505	71	♂	12½	2	6	?
			♀	9½			
„	1506	75	?	1½	1	9	?
„	1507	78	♂	7	1	25	?
„	1508	71	♂	3½	1	17	?
„	1509	68	—	—	—	2	?
„	1510	74	♀	11	1	9	?
„	1516	67	?	7	1	31	?

LIST II *(Continued)*

Season	Number	Length in feet	Foetus		Ovaries		Conclusion mammae
			Sex	Length in feet	c.l.	c.a.	
1959/1960	1522	71	♂	12½	2	15	?
			♂	10½			
„	1525	69	—	—	—	1	?
„	1530	73	♀	2½	1	3	?
„	1532	71	♂	10	1	2	?
„	1533	78	♀	9	1	16	?
„	1534	73	♂	15	1	17	?
„	1535	69	♀	7	1	16	?
„	1537	76	♂	12	1	13	?
„	1538	71	♀	3	1	33	?
„	1540	75	♀	15	1	18	?
„	1543	66	—	—	—	10	?
„	1545	73	♂	16	1	11	?
„	1547	69	—	—	—	32	?
„	1548	73	♀	15½	1	15	?
„	1552	73	♂	12	1	21	?
„	1553	69	♀	4	1	5	?
„	1555	73	♂	8½	1	2	?
„	1556	72	♀	14	1	1	?
„	1558	76	♂	14	1	9	?
„	1564	69	♂	6	1	—	?
„	1566	72	♂	16	1	6	?
„	1568	75	♂	13	1	26	?
„	1569	69	♂	13½	1	4	?
„	1570	71	♂	13	1	17	?
„	1573	71	♂	12	1	23	?
„	1576	71	♂	11½	1	22	?
„	1577	70	♂	9	1	—	?
„	1578	73	♀	6½	1	16	?
„	1579	72	♂	2½	1	3	?
„	1581	65	—	—	—	2	?
„	1582	71	♀	7	1	12	?
„	1583	73	♀	10	1	26	?
„	1584	74	♀	8	1	28	?
„	1585	74	—	—	1	16	?
„	1590	71	♀	7	1	24	?
„	1591	75	♀	7½	1	21	?
„	1593	75	♂	8	1	14	?
„	1596	80	♂	8	1	20	?
„	1597	71	♂	8	1	7	?
„	1599	77	♀	14	2	28	?
„	1601	74	♀	11½	1	11	?
„	1604	74	—	—	immature		?
„	1607	65	—	—	immature		?
„	1610	74	♂	16	1	12	?
„	1750	73	—	—	—	24	L.
„	1867	72	♂	10	2	14	?
			♂	14			