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On the Body Weight of Sperm and Sei Whales located in the Adjacent Waters of Japan

By Hideo Omura

I. Introduction

Because whales have such huge bodies and measuring of body weight is not easy, there have been extremely few data concerning it hitherto. As for the Antarctic, on blue whales, there are only two results. (a report in Norsk Hvalfangst-Tidenda and another on measurements taken by Capt. Srlle in South Georgia). Even for the Arctic, the only data to date are reports by Dr. Lukas on 1 blue whale and by Zenkovic on 3 fin whales, 2 humpback whales, 1 grey whale and 2 sperm whales. Attention to these data has also been called by Laurie, Peters and Brandt.

Till now, the 11 instances abovementioned have been the only available data concerning the body weight of whales. However, information concerning body weight is very important from both the biological and the practical whaling point of view. So lately we have made every possible endeavour to carry on such measuring and have succeeded in collecting considerable quantity of data. This report is on the body weight of sperm and sei whales located in the adjacent waters of Japan. A separate report on whales in the Antarctic Ocean will probably be made elsewhere.

Regarding the whales found in the adjacent waters of Japan, 3 sperm and 7 sei whales, 10 in total, were measured on board the "Kaiko-maru", the mother ship of the Nihon Suisan Co. Ltd. which operated in the adjacent waters of Bonin Island in 1948; and 10 sperm whales and 16 sei whales, 26 whales in all, were measured at the Kamaishi Plant of the Nihon Suisan Co. Ltd., in 1949. The present report is based on all of the above, namely 13 sperm whales and 23 sei whales.

Sincere thanks are expressed to Mr. Yutaka Nakano, chief of working division of the "Kaiko-maru" and all member of its crew and Mr. G. Nakamura, chief of Kamaishi Plant and his staff who did the work of weighing the whales, as well as Mr. H. Sakiura and Mr. S. Nishimoto, whaling inspectors of Fisheries Agency, who directed the weighing operation.

II. Method

When flensing the whales both on board the "Kaiko-maru" and at the

Kamaishi Plant, the whale carcasses were divided into blubber, meat, bones, internal organs etc., which were further cut up and then weighed with the use of a 50 kg scale. Blood was not weighed. This process of measurement was an extremely complicated job and took so long (4 to 5 hours) to finish one whale that it was carried out when only a few whales were caught. Owing to the long time taken and dissection into small blocks, there was some loss in weight; so the figures given in this report are probably smaller than the actual weights. However, the percentage of discrepancy for the total body weight is very small and hence serves as a fairly satisfactory data for studying the general trend.

The weighing result is as shown in the appendix table.
The items in it are as follow.

a. Sperm whales

Though Meat was weighed separately by dorsal meat, thoracic plate and meat around ribs, etc., they were collected into the single item "Meat" in this table.

Though Blubber was weighed by head and abdominal blubber etc., they were totalled into the single item "Blubber" in this table. It was so done because there was no clear cut border between them. And this weight of blubber includes tail flukes, fin and flipper blubber, but not bones.

"Others" among bones includes all bones not specifically indicated by name. "Others" among Internal organs includes all organs not specifically indicated, and includes fat of internal organs.

The final item "Others" includes tendon and spermaceti case just under head blubber, and white gelatinous matter around it (commonly called "white-horse" or "junk") and caudal tendon, as well as tongue, scraps of bones and meat, etc., that are left after dissecting.

b. Sei whales

Mostly same as in the case of sperm whales, with the following differences: Blubber includes ventral grooves and meat attached to it. The single item "Others" includes caudal tendon, baleen plates and tongue. Such is the general classification used. Strictly speaking, however, it cannot be said that all the whales recorded in this table have been so classified. For instance, tongue, being used for food in Japan, was weighed with meat through carelessness, and could not be separated afterward. And the cartilage in the upper jaw bone was in some cases included in the final item "Others". As this cartilage too is used for food, it was carelessly removed from skull and could not later be added to it. There was thus some lack of uniformity owing to carelessness in measuring. Taken as a whole, however, it is not believed that it will make a very great difference.

Sperm whale (*Phyester catodon Linaeus*)

Of the 13 whales measured, 11 were males and 2 females. No difference between male and female could be recognized. As shown in Fig. 1, their body weight can be indicated on a chart by a single curve. And on logarithmic section paper, it can be indicated by one straight line. Accordingly, taking L as body length (in feet), W as body weight (in metric tons), a as a certain constant and b as increasing ratio of body weight to body length, the relatisn between body length and weight is shown by the following equation :

$$W = aL^b$$

Calculating a and b from the actually measured values, $a = 0.000137$ and $b = 3.18$. So the relation between the body weight and length of sperm whales is shown by the following equation :

$$W = 0.000137\ L^{3.18}$$

In the same way, calculating a and b for each part of meat and blubber weighed, the following equations were obtained.

Meat : $W = 0.0000367\ L^{3.24}$

Blubber : $W = 0.0000452\ L^{3.18}$

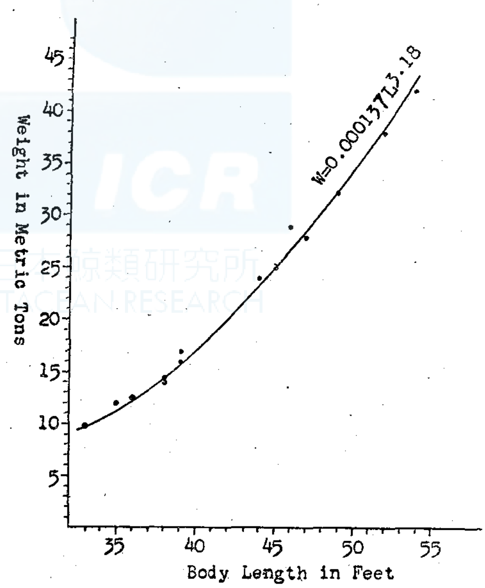
Bones : $W = 0.000041\ L^{2.88}$

Internal organs : $W = 0.0038\ L^{1.64}$

Figs. 2 to 5 show the actually measured values and the above curve for each part.

As seen in the above equations, the largest increasing ratio of weight for body length is on meat. Blubber shows the same ratio as on the total body weight. The least is on internal organs, and next on bones.

Fig. 1. Sperm whale, Total weight.



As the appendix table shows, bones was further classified into skull, back jaw and rib and internal organs was divided into heart, lung, stomach, liver, kidney and intestines. Spermaceti, too, was weighed separately. But they showed so much fluctuation that it was difficult to obtain an equation like the above on the basis of the data obtained. I think, this was due to the fact that while the actual measurement was generally accurate for the major classification, the minor classification may not always have been strictly made. For instance, as bones were measured in such a size that they could be thrown into the boiler, it cannot be said with certainty that no misclassification took place. Nor do I believe that the classification of internal organs was

Fig. 2. Sperm whale, weight of meat.

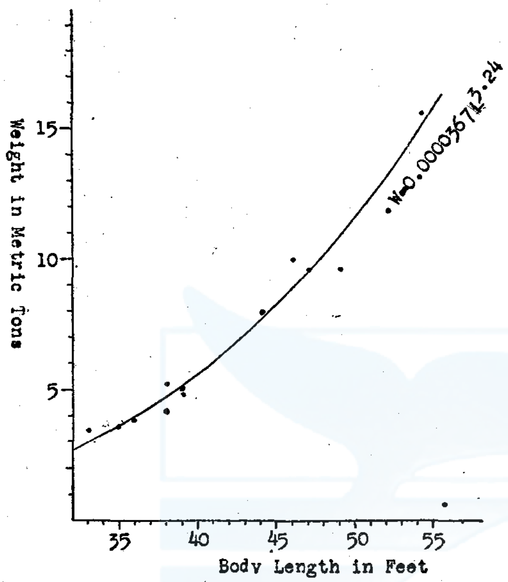


Fig. 3. Sperm whale. Weight of blubber

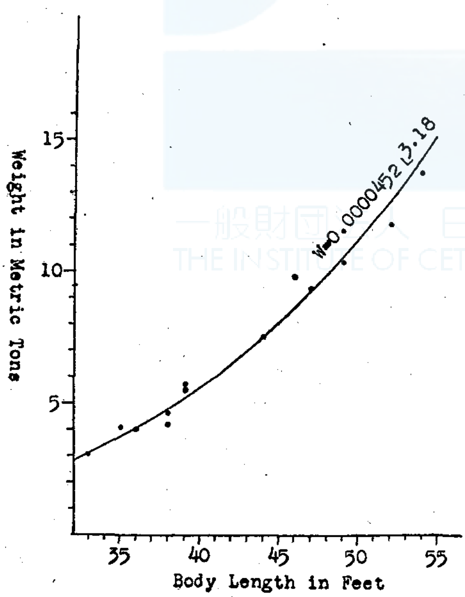


Fig. 4. Sperm whale. Weight of bones

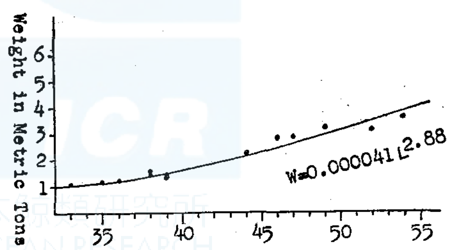
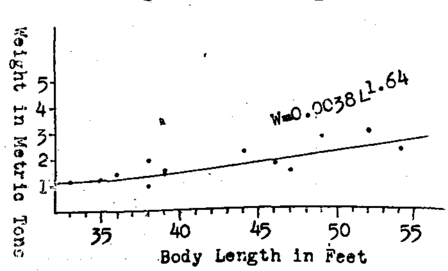


Fig. 5. Sperm whale.
Weight of internal orgnas.



always strictly carried out. Therefore, in order to produce equations like the above on these individual parts, further strict measurement would be necessary.

On the basis of the above equations, the total body weight and the percentage of weight of each part for it were calculated for whales whose body length were 30, 35, 40, 45 and 50 ft., as shown in Table 1. "Others" in this table indicates total body weight minus weight of meat, blubber, bones and internal organs.

Table 1. Standard weight of Sperm whales

Body length in feet.	Total Weight	Meat	Blubber	Bones	Internal organs	Others
	(metric tons)	%	%	%	%	%
30	6.820	32.8	33.0	10.9	14.8	8.5
35	11.140	33.1	33.0	10.3	11.6	12.0
40	17.030	33.4	33.0	9.9	9.5	14.2
45	24.770	33.7	33.0	9.6	7.9	15.8
50	34.630	33.9	33.0	9.3	6.7	17.1
55	46.890	34.1	33.0	9.0	5.8	18.1

As seen in Table 1, the items of parts whose ratio to the total body weight increases with the body length are "Meat" and "Others." Since the principal things included in "Others" are spermaceti, its case, junk, etc., the above fact means that the ratio of head part to body weight increases with the increase in body length. For blubber always shows the same percentage. While bones and internal organs decrease in percentage as the body length increases.

Sei Whales (*Balaenoptera borealis Lesson*)

The relation between body length and total weight of sei whales is shown in Fig. 6. As can be seen therein, sei whales, even of same body length, show considerable differences in weight. Especially, some whales located in Bonin Island Area are far heavier than those located in Kamaishi. This agrees with the results of our biological investigation for the last 2 years. (The details will be reported separately) According to this investigation, the adjacent waters of Bonin Island are more abundant in food for sei whales than the waters off Kamaishi. It has further been found that the body length at which sexual maturity is reached is shorter in the case of sei whales located in the adjacent waters of Bonin Island than in the case of those found around Kamaishi.

From such facts, we can see that there may be considerable differences in weight even among sei whales of same body length.

The weight of each part is shown in Fig. 7 to Fig. 10. There is no notable difference on meat and internal organs between whales found in Bonin Island area and those found near Kamaishi. However, on blubber there is a considerable difference, while on bone the Bonin Island whales are much heavier. On the average, the blubber weight constitutes 25.4% of the total body length in the case of Bonin Island whales, and only 17.7% in the case of whales around Kamaishi, as Fig. 6 shows. It can thus be seen that the difference in body weight in the two cases is mainly due to the difference in the weight of blubber.

Fig. 6. Sei whale. Total weight.

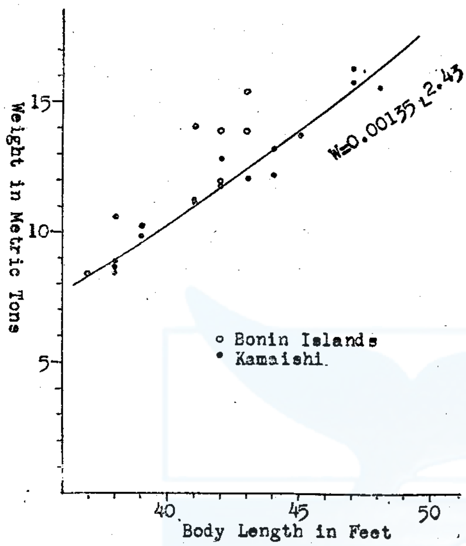


Fig. 7. Sei whale. Weight of meat.

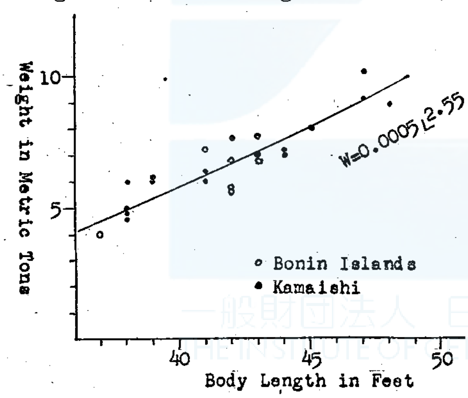


Fig. 8. Sei whale. Weight of blubber.

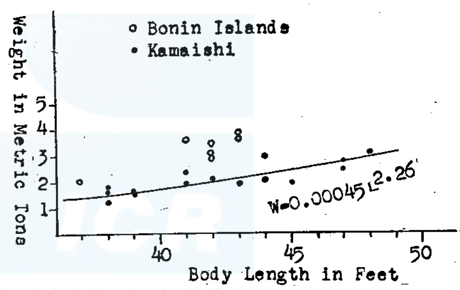


Fig. 9. Sei whale. Weight of bones.

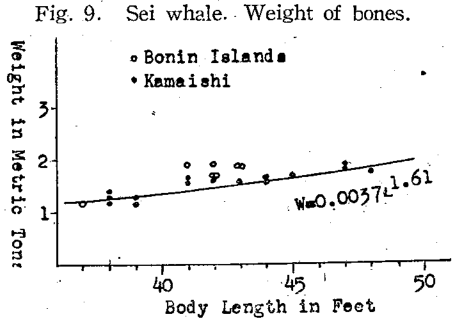
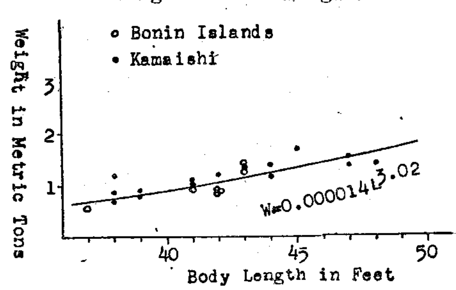


Fig. 10. Sei whale. Weight of internal organs.



Next, I will study this point in further detail. Although in the appendix table blubber is indicated simply as "Blubber" without any subdivision, here it is fortunately classified into head, blubber, body blubber, ventral grooves, tail flukes, etc. Their figures are shown in Table 2.

Table 2. Sei whales. Weight of blubber
(unit : metric tons)

Location	Head blubber	Body bluuber	Ventral grooves	Tail flukes	Total	Remarks
Bonin Is.	3.010 13.23%	9.360 41.12%	9.510 41.78%	0.880 3.87%	22.760 100.00%	Total of 7 whales
Kamaishi	3.350 9.86%	18.122 53.32%	10.527 30.97%	1.988 5.85%	33.987 100.00%	Total of 16 whales

As shown in this table, the percentage of the various subdivisions of blubber to the total weight of blubber differs greatly. The most remarkable one is ventral grooves, heavier about by 10 % in whales located in Bonin Island area than those in Kamaishi. Head blubber and body blubber follow it. The former is heavier in Bonin Island area and the latter in Kamaishi. If measurement is not incorrect, this fact must mean that whales located in Bonin Island area have a heavier head part than those in Kamaishi. As already mentioned, our investigation showed that the whales of the two areas differed in the body length at which they attained sexual maturity. From this point, it would appear that sei whales located in the adjacent seas of Japan should probably be classified into two local races, viz. southern and northern types. However, whether proportions of the various parts of the body also differ between the two races is an unknown question until actual measurements have been taken. And it is planned to do just that in the near future.

The difference of weight of ventral grooves, unless there is a striking difference in thickness, probably depends upon whether the groove comes close to the umbilicus or ends short of it. But this too must be verified by future investigation.

Thus, the weight of the various subdivisions of blubber shows some differences which are probably due to differences between local race. But the differences in the total weight of blubber is probably due largely to differences in food between the two whaling grounds.

Since, as stated above, there seem to be essential differences between sei whales located in Bonin Island area and those near Kamaishi, the two should probably not be considered together. Rather should the data be collected separately for the two, and their results compared. But on whales located in the Bonin Island area, data are not sufficient yet especially as no whale of 44 feet or over in body length has been measured. Leaving that to such time as when more data has been collected, therefore, the study here will be confined to whales located in Kamaishi.

By the same method as was used in the case of sperm whales, the equations showing body length and weight of sei whales located around Kamaishi were calculated as follow. All the curves in Figs. 6 to 10 concerning whales located around Kamaishi, ____ there being none included from the Bonin Island area.

Total weight : $W = 0.00135\ L^{2.43}$
Meat : $W = 0.0005\ L^{2.55}$
Blubber : $W = 0.00045\ L^{2.26}$
Bones : $W = 0.0037\ L^{1.61}$
Internal organs : $W = 0.00014\ L^{3.02}$

As seen in the above equations, on sei whales, the highest ratio of increase is on internal organs, next meat, blubber and bones. Based on these equations, standard body weight of sei whales located in Kamaishi was calculated as shown in Table 3.

Table. 3. Standard weight of Sei whales caught off Kamaishi

Body length	Total weight	Meat	Blubber	Bones	Internal organs	Others
(in feet)	(metric tons)	%	%	%	%	%
35	7.630	56.7	18.2	14.8	8.4	1.9
40	10.550	57.7	17.8	13.4	9.1	2.0
45	14.050	58.5	17.4	12.1	9.8	2.2
50	18.150	59.2	17.1	11.1	10.4	2.2
55	22.880	59.9	16.9	10.3	11.0	1.9

III. Conclusions :

In the adjacent waters of Bonin Island and Kamaishi in 1948 and 1949, body weight was measured on 13 sperm whales and 23 sei whales. Studying these data, it was found that the relation between body length and weight on sperm whales could be expressed by the following equations.

Total weight : $W = 0.000137\ L^{3.18}$
Meat : $W = 0.0000367\ L^{3.24}$

Blubber : $W = 0.0000452\ L^{3.18}$

Bones : $W = 0.000041\ L^{2.88}$

Internal organs : $W = 0.0038\ L^{1.64}$

In the case of sei whales there was a different tendency in body weight between whales located in Bonin Island area and those in Kamaishi. The blubber, in particular, was heavier in the former than in the later. Studying this in greater detail, it was found that ventral grooves which was a part of blubber was heavier, and among other parts head blubber was heavier, while the other parts were lighter. It is, therefore, presumed that these two differ in body proportion.

According to the results of another investigation, it seems appropriate to classify these two as belonging different local races; so it is essential that the relation between body length and weight should also be studied separately for the two. However, as data are insufficient yet for whales located in Bonin Island area, that will be left to the future. On sei whales located in Kamaishi, the relation between body length and weight is as follows:

Total weight : $W = 0.00135\ L^{2.43}$

Meat : $W = 0.0005\ L^{2.55}$

Blubber : $W = 0.00045\ L^{2.26}$

Bones : $W = 0.0037\ L^{1.61}$

Internal organs : $W = 0.00014\ L^{3.02}$

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Weight of Various Parts of Sperm Whale

Body length in feet	Sex	Meat	Blubber	Bones						Internal		
				Skull	Back	Jaw	Ribs	Others	Total	Heart	Lung	Stomack
33	♂	3,478	3,029	409	466	29	138	52	1,094	41	85	111
35	♂	3,611	4,116	466	423	33	163	113	1,203	52	89	89
36	♀	3,880	3,972	439	493	34	156	74	1,196	41	134	145
38	♂	5,204	4,212	508	556	45	168	74	1,351	60	100	118
38	♀	4,210	4,687	550	581	41	178	82	1,432	85	205	193
39	♂	4,870	5,647	581	526	45	206	111	1,469	70	150	145
39	♂	5,045	5,677	566	545	45	208	112	1,476	89	182	93
44	♂	7,960	7,611	1,080	743	81	222	157	2,283	100	260	130
46	♂	10,110	9,870	1,210	950	120	340	130	2,750			
47	♂	9,730	9,370	1,270	1,050	110	350	150	2,930			
49	♂	9,715	10,425	1,310	1,310	104	353	198	3,275	117	167	212
52	♂	11,860	11,850	1,360	970	126	431	249	3,136	134	185	280
54	♂	15,560	13,940	1,570	1,250	220	340	170	3,550			

Unit : Kirogrammes.

Organs					Sperm-Aceti	Others	Total	Date and Place, Catch
Liver	Kidney	Intest	Others	Total				
156	104	205	478	1,180	520	550	9,851	22 Aug. '49 Kamaishi
156	48	205	542	1,181	710	1,110	11,931	23 Aug. '49 Kamaishi
192	180	222	586	1,500	680	734	11,962	22 Aug. '49 Kamaishi
182	52	203	279	994	1,180	1,336	14,277	11 Aug. '49 Kamaishi
235	150	276	873	2,017	1,040	452	13,838	19 Sep. '49 Kamaishi
260	71	242	704	1,642	1,110	1,376	16,114	4 Sep. '49 Kamaishi
235	64	230	652	1,545	1,080	1,990	16,814	26 Sep. '49 Kamaishi
328	100	279	1,091	2,288	1,710	2,046	23,898	14 Oct. '49 Kamaishi
350		350	1,060	1,760	2,390	2,040	28,920	21 Apr. '48 Bonin Is.
350		350	800	1,500	2.550	2,080	28,160	24 Apr. '48 Bonin Is.
284	150	297	1,613	2,840	2,150	3,827	32,232	13 Sep. '49 Kamaishi
390	148	426	1,397	2,960	2,760	5,147	37,713	23 Apr. '49 Kamaishi
370		370	1,530	2.270	2,810	3,600	41,730	21 Apr. '48 Bonin Is.

Weight of Various Parts of Sei Whale

Body length in feet	Sex	Meat	Blubber	Bones					
				Skull	Back	Jaw	Ribs	Others	Total
38	♂	5,131	1,273	352	600	97	171	49	1,269
38	♀	4,724	1,704	383	532	89	141	60	1,205
38	♀	6,061	1,830	427	550	156	151	63	1,347
38	♀	4,926	1,736	459	545	171	134	86	1,395
39	♂	6,155	1,675	361	618	97	185	63	1,327
39	♀	6,061	1,674	424	493	85	134	60	1,196
41	♂	6,460	1,959	470	714	164	174	118	1,640
41	♂	6,058	2,421	516	618	148	193	93	1,568
42	♀	7,714	2,192	454	695	156	174	114	1,593
43	♀	7,053	1,985	500	668	145	193	82	1,588
44	♀	7,135	2,946	460	733	168	193	118	1,672
44	♀	7,220	2,062	503	678	151	197	90	1,619
45	♀	8,133	2,044	500	760	151	193	105	1,709
47	♀	9,202	2,808	594	729	222	218	152	1,915
47	♀	10,340	2,530	588	790	160	208	149	1,895
48	♀	8,958	3,148	480	760	178	197	126	1,741
37	♀	4,040	2,040	290	580	90	140	40	1,140
41	♀	7,240	3,620	520	860	170	280	90	1,920
42	♂	5,820	3,100	440	760	180	250	90	1,720
42	♂	5,770	2,930	490	750	170	220	90	1,720
42	♂	6,970	3,510	510	820	200	260	110	1,900
43	♀	6,940	3,670	500	800	190	260	100	1,850
43	♀	7,700	3,890	490	820	210	240	90	1,850

Unit : Kilogrammes

Internal Organs								Others	Total	Date and Place, Catch
Heart	Lung	Stomach	Liver	Kidney	Intest.	Others	Total			
29	71	68	104	34	223	175	704	150	8,527	3 Aug. '49 Kamaishi
41	71	99	130	45	268	186	840	110	8,583	16 Aug. '49 〃
48	89	111	156	41	203	557	1,205	166	10,609	27 Aug. '49 〃
34	85	77	68	41	186	217	708	127	8,892	27 Sep. '49 〃
41	79	101	130	37	355	180	923	173	10,253	7 Aug. '49 〃
45	81	104	156	41	201	180	808	163	9,902	24 Aug. '49 〃
48	74	126	130	37	259	458	1,132	186	11,377	10 Aug. '49 〃
37	89	97	130	60	209	446	1,068	169	11,284	14 Oct. '49 〃
64	126	71	134	52	230	562	1,239	204	12,942	20 Sep. '49 〃
48	108	130	119	68	193	712	1,378	213	12,217	9 Oct. '49 〃
68	138	160	182	68	314	454	1,384	179	13,316	16 Aug. '49 〃
48	111	111	289	52	202	391	1,204	234	12,339	5 Oct. '49 〃
68	138	145	260	71	372	647	1,701	209	13,796	14 Sep. '49 〃
48	77	115	156	52	479	608	1,535	302	15,762	19 Sep. '49 〃
60	145	130	205	68	203	574	1,385	208	16,358	4 Oct. '49 〃
60	156	134	185	60	260	532	1,387	323	15,557	24 Jul. '49 〃
			100		150	290	540	630	8,390	12 Apr. '48 Bonin Is.
			150		220	570	940	400	14,120	16 Apr. '48 〃
			100		190	570	860	480	11,980	13 Apr. '48 〃
			110		190	610	910	440	11,770	15 Apr. '48 〃
			130		220	550	900	590	13,870	15 Apr. '48 〃
			140		240	870	1,250	200	13,910	14 Apr. '48 〃
			130		190	1,070	1,390	600	15,430	16 Apr. '48 〃

Diatom Infection on Blue and Fin Whales in the Antarctic Whaling Area V (the Ross Sea Area)

By Hideo Omura

I. Introduction

On the subject of infection diatom of whales, there is an excellent study by Hart and Karcher. Its summary is that diatom infection is extremely rare on the whales caught in the tropics but in the Antarctic the whales are infected with the spores of diatom, which stick to their skin film and continue to grow. Almost without exception this diatom is *Cocconeis ceticola*. After *Cocconeis ceticola* spore infection has taken place, it takes about a month for that spore to develop into a yellowish brown diatom film visible to the naked eye. So it may be said that whales without diatom infection are those which have only recently arrived in the Antarctic. As the whaling season progresses, not only does diatom infection spread over the individuals affected but the number of infected whales also increases. The infection rate among fin whales is higher than among blue whales.

And Karcher found that the infection rate among mature whales is higher than among immature ones, males higher than females, and higher in the Weddell Sea Area (Area II) than in the Bouvet Area (Area III).

Since the end of the war, Japan has despatched the Antarctic whaling expedition, three times. Each time the whaling ground was in the Ross Sea Area (Area V.). In every expedition; the biological observations were carried out with the record of diatom infection on each whale caught. The present report has brought together the data based on those observations, and has sought principally to study the difference in the infection rate between the Ross Sea Area and the Weddell Sea and Bouvet Area. The Ross Sea Area extends from Longitude 130°E. eastwards to Longitude 170°W. However, as the boundary line of the Sanctuary in the Antarctic is Longitude 160°W., the above figure should naturally be corrected to Long. 160°W. The Japanese whaling fleets operated right up to this boundary line, so the data in this report covers this area also. Even from the point of view of distribution of the whales, there seems to be no reason for taking Long. 170°W. as the boundary line. It is inappropriate moreover to put the boundary line there for the Ross Sea extends east of Long. 170°W. too.

II. Materials and Methods

The materials upon which this report is based were observed by the following men, during the following seasons :

1946/47	"Hashidate-maru"	Mr. Haruyuki Sakiura
		Mr. Setsuo Nishimoto
	"Nissin-maru No. 1"	Mr. Hideo Omura
		Mr. Toshio Deie
1947/48	"Hashidate-maru"	Mr. Keijiro Maeda
		Mr. Toshio Deie
		Mr. Tomoo Hayashi
	"Nissin-maru No. 1"	Mr. Setsuo Nishimoto
		Mr. Katsunari Ozaki
		Mr. Masaharu Nishiwaki
1948/49	"Hashidate-maru"	Mr. Yoshio Teraoka
		Mr. Katsunari Ozaki
		Mr. Masaharu Nishiwaki
	"Nissin-maru No. 1"	Mr. Keijiro Maeda
		Mr. Tadanori Oye
		Mr. Norio Miyamoto

The number of whales observed was as follows.

1946/47	678 blue whales	464 fin whales
1947/48	701 〃	599 〃
1948/49	625 〃	992 〃
Total	2,004 〃	2,005 〃

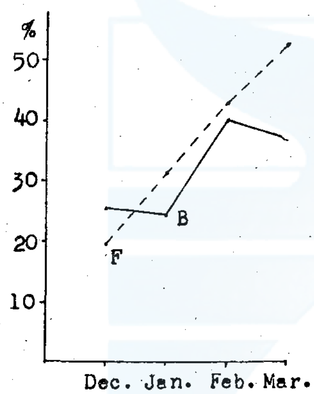
Observation for diatom infection was made on each whale with the naked eye as soon as it was hauled on to the deck of the factory ship for processing. The measure of diatom infection was recorded according to the following four classes; 0 where no infection could be observed with the naked eye; + where diatom infections appeared on a small part of the whale as small patches. ⧺ where a considerable portion was infected and ⧻ where the infection formed a thick film formation nearly covering the whale body. However, because the difference between + and ⧺ was not always clear and the estimates of the observers were not always in agreement, + and ⧺ were put into one group in this report. Thus, the signs in this report are as follows;

0 .... not infected
\+ .... with diatom patches
++ .... with thick film

III. Monthly variation

As is known already, diatom infection rate is low in the early stage of the whaling season and increases as the season progresses. The total for three seasons, 1946/47, 1947/48 and 1948/49 is shown in Fig. 1.

Fig. 1. Diatom infection on Blue and Fin Whales by month.
B : Blue Whale
F : Fin Whale



It can be seen there that the infection rate shows a steady increase in fin whale. In December it was about 20 % and increased to 31 %, 43 % and 53 % in January, February and March respectively. But in the case of the blue whale it is not so simple as that. As a general tendency the infection rate is lower than among fin whales and increases with the progress of the whaling season. But in December it is higher than among fin whales; in January it decreases a little; in February it shows sudden increase and in March it decreases a little again. The fact of the infection rate being higher among blue whales than among fin whales in December may be due to the earlier arrival of the former

Fig. 2. Diatom infection in the season 1946/47
B : Blue Whale
F : Fin Whale

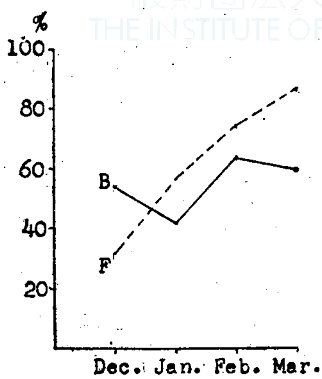
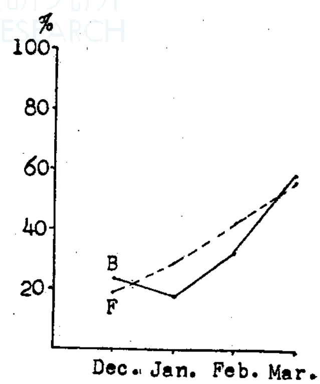
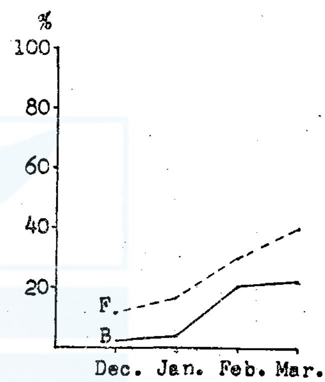


Fig. 3. Diatom infection in the season 1947/48
B : Blue Whale
F : Fin Whale



in the Antarctic. The small decreases in January and March are probably evidence that whales arrive in the Antarctic in considerable numbers in those two months. It can thus be seen that result obtained on fin whales nearly coincides with Karcher's, but differs on blue whales. The fact is probably an indication that blue whale migration to this area is not so regular as to the Weddell Sea Area and Bouvet Area. That fact is made even clearer by Fig. 2. to Fig. 4., which show the conditions for the seasons 1946/47, 1947/48 and 1948/49 respectively. In each of those three seasons the rate shows a regular increase for fin whales but is quite complicated in the case of blue whales. In 1946/47 and 1947/48 a decrease is seen for January; and in 1948/49 an increase, though very small. Decrease in March is seen only in 1946/47, in other two seasons the March rate being higher than for February. That was especially pronounced in 1947/48. Moreover, the December infection rate on blue whales was higher than on fin whales in 1946/47 and 1947/48 but lower in 1948/49.

Fig. 4. Diatom infection in the season 1948
B : Blue Whales
F : Fin Whales



The above facts probably show, in short, that the migration of blue whales to this area is very irregular. But since this irregularity may be due in part to the number of whales studied, I would like to await the results of investigations to be continued hereafter before drawing definite conclusions. Besides, though it has not been published yet, the results of blubber thickness investigation on blue whales show the blubber is thinner in January than in December. This may be evidence that quite a large number of blue whales enter this area in January. The figures which form the basis for Fig. 1. to Fig. 4. are as shown in Table No. 1 and Table No. 2.

IV. Difference of infection by maturity

According to Karcher's report, both blue whales and fin whales show higher infection rate on mature individuals than on those immature. The results of Japanese investigation are shown in Fig. 5 and Fig. 6. Table No. 3 shows the figures upon which they are based. According to them, blue

Table 1.

Diatom infection on blue whales in the last three seasons.

(Shown in the percentage figure)

Season / Month	1946/47				1947/48				1948/49				Total			
	No. observed	0	+	++	No. observed	0	+	++	No. observed	0	+	++	No. observed	0	+	++
Dec.	122	45.9	48.4	5.7	305	76.4	23.0	0.6	122	98.4	1.6	0	549	74.5	23.9	1.6
Jan.	333	58.0	39.6	2.4	214	81.3	17.8	1.2	235	95.7	3.0	1.3	782	75.7	22.6	1.7
Feb.	188	36.2	52.6	11.2	160	67.5	27.5	5.0	178	78.7	18.5	2.8	526	60.1	33.5	6.4
Mar.	35	40.0	54.3	6.7	22	40.9	36.4	22.7	90	76.7	21.1	1.2	147	62.6	31.3	6.1
Total	678	48.8	45.6	5.6	701	74.8	22.8	2.4	625	88.6	9.8	1.6	2004	70.3	26.4	3.3

Table 2.

Diatom infection on fin whales in the last three seasons.

(Shown in the percentage figure)

Season / Month	1946/47				1947/48				1948/49				Total			
	No. observed	0	+	++	No. observed	0	+	++	No. observed	0	+	++	No. observed	0	+	++
Dec.	40	67.5	32.5	0	136	80.9	19.1	0	61	88.5	8.2	3.3	237	80.6	18.6	0.8
Jan.	148	42.6	45.9	11.5	184	70.7	22.8	6.5	259	83.0	14.3	2.7	591	69.0	24.9	6.1
Feb.	209	25.8	50.7	23.5	261	57.1	31.4	11.5	498	69.9	25.1	5.0	968	56.9	32.3	10.8
Mar.	67	13.4	64.2	22.4	18	44.4	55.6	0	174	60.3	33.3	6.4	259	47.1	42.4	10.0
Total	464	33.0	49.6	17.4	599	66.3	26.7	7.0	992	72.8	22.7	4.5	2055	61.9	29.9	8.2

whales and fin whales show exactly opposite tendencies.

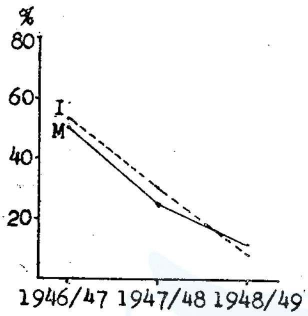


Fig. 5. Difference of infection by maturity Blue Whale
M : Mature
I : Immature

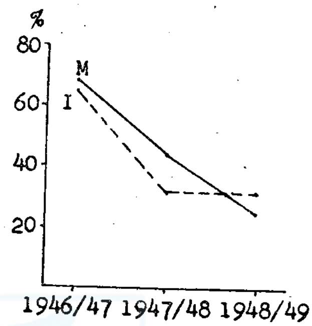


Fig. 6. Difference of infection by maturity Fin Whale
M : Mature
I : Immature

In the two seasons excepting 1948/49, immature blue whales showed higher infection rate, but among fin whales, the immature showed a higher infection rate than the mature only for the 1948/49 season. For the purposes of this study, the classification as to mature and immature whales are based simply on the standard of body length. It may be difficult to get any conclusion only with these data, because as Table No. 3 shows, the number of immature whales studied was not very large. In Fig. 7 to Fig. 12 the rates of infection in mature and immature whales are shown by month. About the only conclusion that can be drawn from these figures is that mature fin whales are regularly infected with diatom. That, too, is due to the small number of whales, especially those immature studied; so that the effort to draw any conclusion at all may in itself be unreasonable. The figures on which these are based are appended at the end of this report.

Table 3. Difference of infection by maturity.
(Shown in the percentage figure)

Species and Seasons	Mature				Immature			
	No. observed	0	+	++	No. observed	0	+	++
Blue Whale								
1946/47	433	49.9	43.9	6.2	245	46.9	48.6	4.5
1947/48	596	75.5	21.8	2.7	105	70.5	28.6	0.9
1948/49	532	88.2	10.0	1.8	93	91.4	8.6	0
Fin Whale								
1946/47	303	31.7	51.8	16.5	161	35.4	45.3	19.3
1947/48	561	66.1	27.1	6.8	38	68.4	21.1	10.5
1948/49	872	73.5	22.2	4.3	120	67.5	25.8	6.7

Fig. 7. Diatom infection on mature and immature whale
Blue whale 1946/47
M : Mature
I : Immature

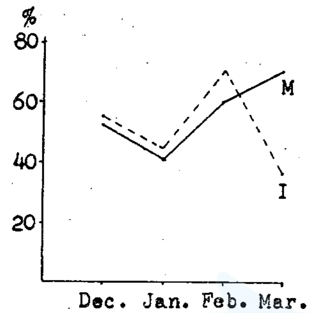


Fig. 8. Diatom infection on mature and immature whale
Blue whale 1947/48
M : Mature
I : Immature

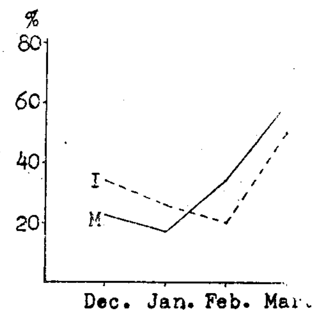


Fig. 9. Diatom infection on mature and immature whale
Blue whale 1948/49
M : Mature
I : Immature

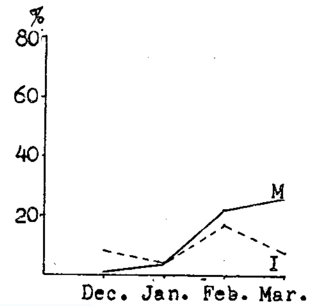


Fig. 10. Diatom infection on mature and immature whale
Fin whale 1946/47

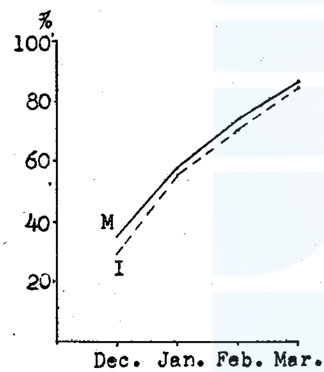


Fig. 11. Diatom infection on mature and immature whale
Fin whale 1947/48

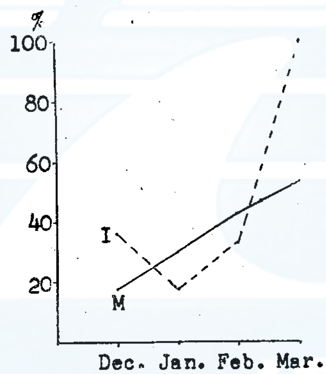
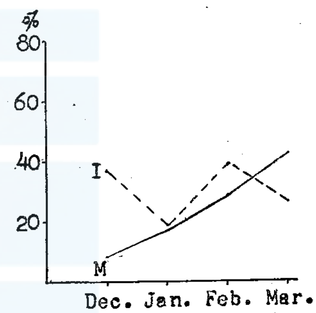


Fig. 12. Diatom infection on mature and immature whale
Fin whale 1948/49



V. Difference of infection by year.

As shown in Fig. 2 to Fig. 12, there is a remarkable variation by year in this area. On both blue whales and fin whales, the infection rate is the highest in 1946/47, descending remarkably year by year from 1947/1948 to 1948/49. According to Karcher, there is some variation in some years both in the Weddell Sea Area and the Bouvet Area, though not so much as this. Further there is a wide difference between the Weddell Sea Area and the Bouvet Area. The former shows a high infection rate, and the latter is very low by comparison. In the Ross Sea Area, however, the rate in 1946/47 was nearly equal to the former, and in 1948/49 to the latter.

Therefore, with these data it is difficult to state definitely whether the infection rate in the Ross Sea Area is higher or lower than in the Weddell Sea Area and the Bouvet Area. However, on the average of three years it can safely be said that the infection rate is at least higher in the Ross Sea Area than in the Bouvet Area. According to Karcher, although the diatom infection frequency is the highest in the region from Long. 50°W. to 70°W. and drops as one goes eastward, the chances are that the frequency rises again in the Ross Sea Area beyond the Bouvet Area and the Kerguela Area. Both in 1946/47 and 1947/48, the Japanese whaling fleets operated mainly between Long. 150°E. and 180°E. In the season of 1948/49, although some operation was carried out in the above area too, most of it was done further east from Long. 180°W. to 160°W. The especially low infection frequency in 1948/49 may be due to this fact. From the geographical point of view, the Ross Sea Area resembles the Weddell Sea Area. There are similarities in oceanographical condition also. In all probability, therefore, what has been stated regarding diatom infection in the Weddell Sea Area may also be said for the Ross Sea Area.

Table 4. Number of "Eiswalen" observed

	Total No. observed	in which with thick film	%
Blue			
1946/47	122	7	5.7
1947/48	305	2	0.6
1948/49	122	0	0
Total	549	9	1.6
Fin			
1946/47	40	0	0
1947/48	136	0	0
1948/49	61	2	3.3
Total	237	2	0.8

Table No. 4 shows the percentage of so-called "Eiswalen" or badly infected whales, which were caught in December.

According to Karcher, the average rate in 1937/38 and 1938/39 was 12.93% for blue whales and 6.57% for fin whales in the Weddell Sea Area: and 0.12% for blue whales and 0% for fin whales in the Bouvet Area. So from this table it can be said that the rate in the Ross Sea Area is higher than in the Bouvet Area, though lower than in the Weddell Sea Area.

VI. Difference of infection by sex.

The infection frequency by sex is shown in Fig. 13 to 18. The statistics on which these figures are based are appended at the end of this report. As can be seen from these figures, for every year, males show a higher infection rate than females both among blue and fin whales without distinction as to degree of maturity. Although it is to be assumed that this phenomenon is due not to physiological differences between sex but rather to the fact that the males reach the Antarctic earlier than the females, there is no data to prove it.

Fig. 13. Difference of diatom infection by sex Blue whale 1946/47

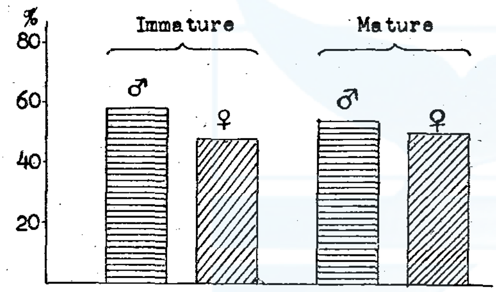


Fig. 14. Difference of diatom infection by sex Blue whale 1947/38

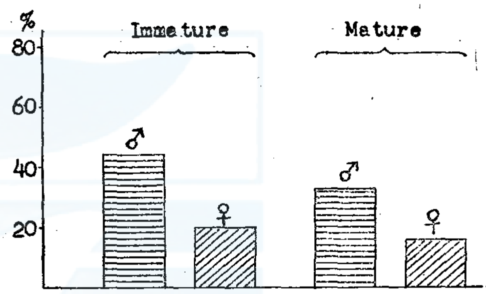


Fig. 15. Difference of diatom infection by sex Blue whale 1948/49

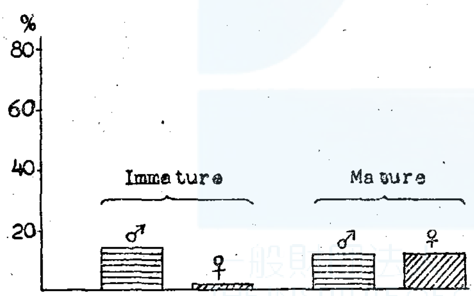


Fig. 16. Difference of diatom infection by sex Fin whale 1946/47

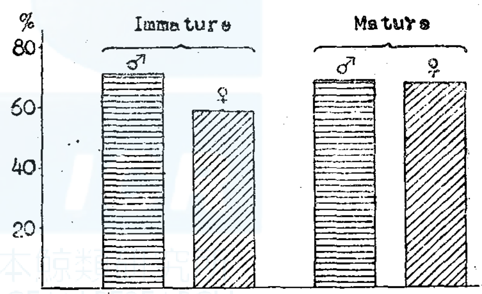


Fig. 17. Difference of diatom infection by sex Fin whale 1947/48

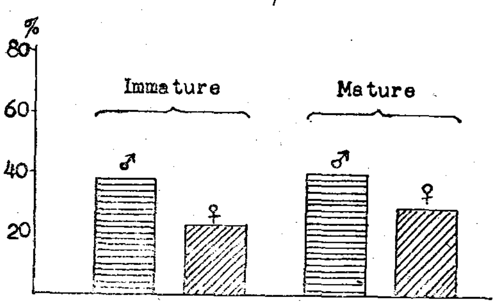
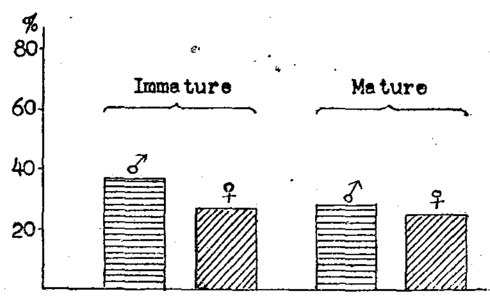


Fig. 18. Difference of diatom infection by sex Fin whale 1948/49



IIV. Diatom infection in the Ross Sea.

In the season of 1947/48, the "Hashidate-maru" operated in the narrow area near Long. 175°W. Lat. 75°S. in the Ross Sea Area from 12 February to 26 February 1948.

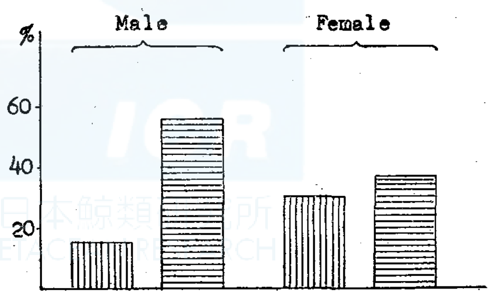
79 blue whales were caught here, of which 77 whales were processed. No fin whale was caught. On all 77 blue whales processed, the existence of diatom infection was observed. The results have been collected in Fig. 19 and Table No. 5. And for comparison all the figures for the Ross Sea Area, with the exception of those for the Ross Sea in February 1948, were appended.

Table 5. Diatom infection on blue whale in Ross Sea Area.
(Shown in the percentage figure)

	Male				Female				Total animals			
	No. observed	0	+	++	No. observed	0	+	++	No. observed	0	+	++
Ross Sea	47	85.1	14.9	0	30	70.0	30.0	0	77	79.2	20.8	0
Other area												
Mature	41	43.9	36.6	19.5	27	63.0	37.0	0	68	51.5	36.8	11.7
Immature	8	75.0	25.0	0	7	85.7	14.3	0	15	80.0	20.0	0
Total	49	49.0	34.7	16.3	34	67.6	32.4	0	83	56.6	33.7	9.7

As can be seen from Fig. 19 and Table No. 5 there are fewer diatom infected whales in the Ross Sea. All the data excepting those given for the Ross Sea for the purpose of comparison, were obtained between Long. 160°E. and Long. 170°E.

Fig. 19. Difference of diatom infection by sex



The entrance to the Ross Sea which is generally blocked by ice packs opens up from the end of January to March as the ice packs swept away. But there have been years when whaling fleets could not enter at all because the entrance did not open up.

In 1948/49 both the Japanese whaling fleets tried to enter the Ross Sea but failed due to the blocking ice packs. Among the whales observed there, none was found with thick diatom film. This probably indicates that all the whales, instead of wintering in the Ross Sea, leave there before the entrance is closed up. The whales in the Ross Sea are very fat as compared with those in other seas. For instance, the "Hashidate-maru" obtained 1846 metric tons of whale oil from 77 blue whales processed or an average of 24 metric tons per blue whale unit. And that, notwithstanding that the Japanese whaling fleets salted all the whole ventral grooves for use as food, without extracting oil from this part. Accordingly, if oil were extracted from this part also, oil production per blue whale unit would be even higher.

Table 6. Size of blue whales caught in Ross Sea.

Body length in feet	73	74	75	76	77	78	79	80	81	82	83
Male	1	1	3	5	5	7	9	5	3	6	0
Female						4	3	0	3	4	4
Total	1	1	3	5	5	11	12	5	6	10	4

Body length in feet	84	85	86	87	88	89	90	91	Total	Average length
Male	2								47	78.6
Female	3	2	5	0	1	0	0	1	30	82.8
Total	5	2	5	0	1	0	0	1	77	80.3

To be sure the biological investigation made of the whales in the Ross Sea proved that they were all mature, there being not one immature whale among them. The classification by body length is shown in Table 6. Even taking that into consideration, it can be safely said that the whales in the Ross sea are extremely fat. In the Antarctic, as a general rule, the diatom infected whale has a thicker blubber and consequently yields more oil than those not infected. But as stated above, this does not apply to the Ross Sea. As to the latter sea, the following two possibilities come to mind:

a. Whales which enter the Ross Sea, reach the Antarctic from January to February and directly enter the Ross Sea and there grow fat rapidly.

b. Whales in the less diatom infected areas of the Antarctic, though their arrival there may not necessarily have been from January to February, eventually enter the Ross Sea and there grow fat.

If case (a) were true, some lean whales should be found in the Ross Sea, for the whales which have just reached the Antarctic are thin as a general rule. However, such an example has never been reported. In case of (b), if it is assumed as mentioned already, that there is more diatom infection west of Longitude 180° and less east of it, we arrive at the conclusion that whales in the Ross Sea migrate there from the east. This consumption is a plausible one, for in the season of 1947/48 not may whales were found by scouting boats which operated far to the east of Long. 180° E., while in the season of 1948/49 when the entrance to the Ross Sea was closed, many were caught east of Long. 180° which was the principal whaling ground in that season. The most likely explanation is that these whales were headed for the Ross Sea but blocked by the ice pack, thus turning this area into a good whaling ground. According to Hart, spore formation of *Cocconeis ceticola* takes place twice a year in spring and autumn. Consequently it is probably extremely rare that a diatom infection that has started on a whale after it has arrived in the Ross Sea, develops into diatom film.

VIII. Summarized conclusions

As a result of the observation made for 3 years, 1946/47, 1947/48 and 1948/49, the following can be said concerning diatom infection in the Area V (the Ross Sea Area) in the Antarctic.

a. Fin whale showed higher diatom infection rate than blue whale.

b. As months went by, from December to March, diatom infection increased regularly on fin whale but irregularly on blue whale.

c. No conclusion could be reached on the infection rate by maturity.

d. Of the 3 years in which observations were made, 1946/47 showed the highest infection rate, and 1948/49 the lowest: and the difference between those 2 seasons was very wide.

e. The infection rate in the Ross Sea Area was higher than in the Bouvet Area.

f. More males were infected than females.

g. The whales in the Ross Sea were all fat and mature with high whale oil production but low diatom infection as compared with other sections of this area.

IX. References

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3) Hvalrodets Skrifter, Oslo.

Whales in the Adjacent Waters of Japan

By Hideo Omura

Introduction

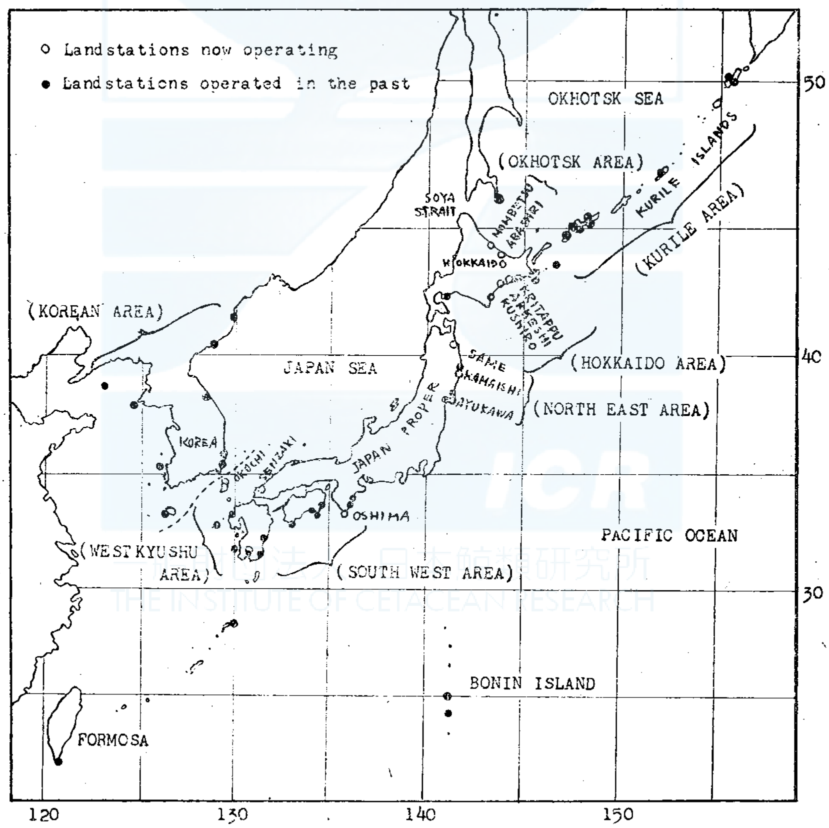
At present, the following two types of whaling are operated in the adjacent waters of Japan.

a. Landstation whaling.

b. Factory ship whaling.

Landstations are located as shown in Fig. 1.

Fig. 1. Locations of landstations in Japan.



Till the end of World War II, whaling industry had been conducted with land stations on Bonin Island. Since the end of the War, small size whaling factory ships have been used there because of the impossibility of using land. Whaling inspectors are sent by the Japanese Government to every landstation and factory ship. As it is fundamentally important for maintenance of the whale stock to grasp an oecological and resource survey of whales, we decided to carry on the biological investigation by these inspectors for every whale caught with a certain method since 1948. At the end of 1949, the number of whales investigated reached 1,785 in all as shown in Table 1.

Table 1. Number of Whales Observed.

Year	Species	Male	Female	Total
1948	Blue whale	3	7	10
	Fin whale	47	33	80
	Sei whale	222	163	385
	Humpbacks	2	4	6
	Sperm whale	149	212	361
	Total	423	419	842
1949	Blue whale	1	3	4
	Fin whale	39	43	82
	Sei whale	313	333	646
	Humpbacks	2	2	4
	Sperm whale	182	25	207
	Total	537	406	943
Total of both years	Blue whale	4	10	14
	Fin whale	86	76	162
	Sei whale	535	496	1,031
	Humpbacks	4	6	10
	Sperm whale	331	237	568
	Total	960	825	1,785

This report is based on these data as shown in Fig. 1, whaling landstations are scattered all over Japan. To our regret, the investigation could be carried on at only 7 landstations,—Ayukawa, Kamaishi, Kushiro, Akkeshi, Kiritappu, Abashiri, Mombetsu, and Bonin Island. Though extremely few whales are caught around Oshima and west of it, that ground is also an important location for survey of whales' stock and migration. So in the near future the author hopes to be able to carry on the same investigation at these landstations too.

Sincere thanks are expressed to the following men for their cordial cooperation in carrying on the investigations at each landstation.

Mr. Keijiro Maeda	Mr. Haruyuki Sakiura
Mr. Yoshiro Teraoka	Mr. Setsuo Nishimoto
Mr. Toshio Deiye	Mr. Yuji Tobita
Mr. Yasuo Usukura	Mr. Tomozo Ishizuka
Mr. Hirosaku Koda	Mr. Kazuhiro Mizue
Mr. Katsunari Ozaki	Mr. Nario Miyamoto

Methods.

Excepting various parts of the body measurement was carried on with nearly same method as in Discovery Investigation. Namely, notes on external characters, food, external parasites, condition of genitalia and degree of physical maturity were investigated. However, sometimes not all of them could be investigated on all individuals. Therefore, not all the items were recorded on all the whales shown in Table 1. On some whales only a part of the items was observed.

Details of items observed are as follows:

a. Colour.

Blue whales: Observations were made on the same items as in Discovery Investigation. But there were only 4, so few that no conclusion could be drawn.

Fin whales: There are normally grey but sometimes blackish in back; so classification was made on that point. Distribution of pigment on the side of the body was divided into three groups; (1) normal, (2) those in which the pigmentation did not come down so far as in the normal and (3) those in which the pigmentation extended below the normal. Moreover, there were some whales, of which pigment projected in triangle from a little behind the anus toward the anus, so this was recorded too. Then there were some whales on which the right and left pigments met just in front of the tail flukes on the ventral side of tail; and some on they did not meet. So this was recorded too.

Sei whales: Are generally grey in back, and somewhat lighter on ventral side. Ventral grooves have a large white area. The dark or pigmented area on the side projects into this white area like tongues. It was recorded whether this pigment was very pronounced, normal or not so pronounced, and whether the dark areas on the right and left sides met around the posterior end of ventral grooves. The state of development of white area near the chin was classified into three classes: below normal, normal and above normal. It was recorded too whether or not the right and left pigments met just in front of the tail flukes. And *Sei whales* have light coloured spots on the flanks and side of the tail, which develop an appearance resembling new galvanized iron. This condition was classified into none, few, moderate, and many for recording.

Humpback whales: though they were very small in number, were recorded under classification of four fundamental and three medium types, according to Lilly.

Sperm whales were divided into 4 classes, for colour recording: black all over, light greyish on lower part of head, light whitish colour all over head, and whitish light colour all over the body.

And there were some sperm whales with light coloured spiral markings at the tip of head. They were recorded under 4 classes: clear, normal, indistinct and none. As some whales had light spotted marks near umbilicus, they were divided into 5 classes: none, rare, normal, abundant and extremely abundant for record. As for distinct white area around umbilicus, it was classified into 3 classes: none, normal and abundant.

b. White scars:

White scars are commonly seen on whales in the Southern hemisphere. The same is true also of whales in the North hemisphere. While open pits were found on whales caught around the Bonin Islands, only healed scars were found on whales caught in the other whaling grounds. These white scars were recorded, dividing into 4 classes: none, extremely rare, many, extremely many. The oldest distinguishable scars were 3 to 4 years old.

c. External parasites:

External parasites of whales in the adjacent waters of Japan are similar to those of whales in the Southern hemisphere. Namely, they are Cyamus sp, Coronula sp, Conchoderma sp, Pennella sp, and diatoms. Where these parasites were found, their species, number and position were recorded.

d. Number of teeth of sperm whales:

The number of functional teeth of lower jaw was counted, separately for right and left sides. Then as there were some teeth in the inner part of the mouth which were not exposed above the gum, these were counted with care. And on the largest of right and left teeth, the length and diameter of its exposed part were measured. The number of rudimental teeth of upper jaw was also counted, separately for right and left sides.

e. Thickness of blubber.

Thickness of blubber was measured at the following two points:

Point 1, (flank) : the point on a vertical line from the dorsal fin, where it intersects the horizontal cut side of the body.

Point 2, (neck) : the point on the vertical cut near the ear hole where it intersects the mid-dorsal line. In the Discovery Investigation, the thickness of shoulder was measured. But as the measurement of this part was so difficult owing to a different flensing method used in Japan, it was especially measured at Point 2 also. This is not because this point was specially important, but because it was easy for measurement.

f. Thickness of Mammary gland.

The thickness of the thickest part of mammary gland was measured and its colour recorded. But judgment as to its colour was liable to depend upon the observer, so no specially important results were obtained.

g. Stomach Contents.

Kinds, size, quantity and freshness of the first stomach were recorded.

h. Genitalia.

The three dimensions of testis were measured in cms, and multiplied to calculate its volume (Volume 1 was for 1,000 cc). Its weight was recorded in kgs. The weight of ovary and the number of corpus luteum were recorded separately for functional and old. The diameter of the largest Graafian follicle was measured also.

i. Ossification of vertebrae.

At two points, thoracic and lumbar vertebrae, examination was made as to whether or not epiphyses and centra fused. These points were between 7th and 8th bones, both thoracic and lumbar.

Blue whale (*Balaenoptera musculus Linnaeus*)

Blue whales are rarely caught in the adjacent waters of Japan. Even in this investigation, only 4 males and 10 females, 14 whales in all, were examined. And that data are so insufficient through all the items that full discussion cannot be made. Here, only the outline is reported.

a. Color.

Only 4 whales (1 male and 3 females) were recorded for colour. 3 of these whales had many pale spots scattered all over from shoulder to tail. But no mention is made of the 4th whale. As for the clearness of color, one was not so clear, another clear and the third extremely clear. The one whose color was recorded as "extremely clear" was probably immature. while the other two were mature.

White flecks at the posterior part of ventral grooves were extremely few for 1 whale, few for 2 whales, and normal for 1 whale.

White striation on undersurface of tail flukes was clear on 1 whale, and not very clear on the other 3.

b. White scars.

4 whales were recorded for white scars. The details were : 1 whale with extremely few white scars. 1 with a few scars and 2 with many scars. The first two whales were probably immature and the latter mature.

c. External parasites.

One whale was heavily infected with Cyamus sp. on its head. It was an immature female, 62 feet long, caught at a point 70 miles SE from the Bonins.

d. Thickness of blubber.

Thickness of blubber was measured for 6 whales but no conclusion can be drawn from the results obtained. For reference, the values are shown in Table 2.

Table 2. Blue whale. Thickness of blubber.

Date of Catch	Body length in ft.	Sex	Blubber thickness Point I	Point II	Ground	Remarks
			cm.	cm.		
14 Oct. 1949	72	M	6.0	9.0	Kiritappu	Mature
12 Mar. 1948	62	F	7.5	—	Bonin island	Immature
13 Oct. 1949	67	F	12.0	12.5	Kushiro	〃
27 Jul. 1948	70	F	8.8	7.0	Ayukawa	〃
19 Jun. 1949	70	F	6.5	7.0	〃	〃
6 May. 1948	73	F	11.5	12.5	〃	Pregnant or recently ovulated

e. Food.

Record was made of the stomach contents of 7 whales. In 5 of them the stomach was found to be empty. The other two whales had a small quantity of tiny euphausias. Their species were not identified.

f. Maturity.

As shown in Table 3, the weight (in kgs.) and volume of testis were measured for 4 males. This volume means length, width and thickness in cms, simply multiplied; and 1,000 cm^3 is given as the unit. According to Mackintosh and Wheeler, Antarctic whales which have a testis volume of more than 5 under this method of calculation are regarded as adults.

Table 3. Blue whale. Weight and volume of testis.

Body length in feet	Weight in kg.	Volume	Maturity
65	(1.9 (2.1	2.4 2.5	Immature
65	(0.5 (0.8	1.0 1.0	〃
72	(17.1 (17.0	19.5 24.6	Mature
74	(12.4 (13.5	18.5 19.7	〃

As table 3 shows, a whale 65 feet long was immature but whales 72 and 74 feet in length were undoubtedly mature. For 10 females, as shown in table 4, ovaries were weighed and number of corpora lutea was counted.

Table 4. Blue whale. Weight of ovaries and number of corpora lutea.

Body length in feet	Weight of ovaries	Number of corpora lutea		Remarks
		Functional	Old	
	kg.			
62	(0.2 (0.3	0 0	0 0	Immature
66	(0.2 (?	0 ?	0 ?	Immature ?
67	(0.2 (0.2	0 0	0 0	Immature
70	(0.3 (0.3	0 0	0 0	〃
70	(0.2 (0.3	0 0	0 0	〃
70	(0.8 (0.9	0 0	0 0	〃
73	(2.0 (3.0	0 1	4 1	Pregnant or recently ovulated.
74	(0.7 (?	0 ?	0 ?	Immature ?
78	(1.5 (1.4	0 0	2 1	Resting
81	(3.7 (3.3	? ?	? ?	Resting ?

In table 4 there is no mention of one of the ovaries of a whale 66 feet long, which was undoubtedly immature.

The same with that of a whale 74 feet long; but in this case the one ovary that was found contained no corpus luteum.

A whale 81 feet long of which only the weight was recorded, was probably in the resting stage.

As mentioned above, there was a male 72 feet long that was mature, and a female 73 feet in length that was mature. For whales located in the Antarctic, such a fact would be exceptional. Matsuura obtained the results shown in table 5, after his investigation on 14 female blue whales which were caught off the east coast of Kamchatka.

Table 5. Blue whale. Number of corpora lutea.
(After Mr. Matsuura)

Body length in feet	Number of corpora lutea (total of both ovaries)										
	1	2	3	4	5	6	7	8	......	14	Total
71	0										1
72	0										1
73											–
74	△0					□				□	4
75					□						1
76								0			1
77				□							1
78		0		0							2
Total	4	1		2	1	1		1		1	11

0 ...... Pregnant, △ ...... lactating, □ ...... Resting

While Table 5 shows mature whales only, there were 2 other whales of 74 ft. length that were immature.

Though the number of whales investigated was small, Matsuura pointed out on the basis of the above fact and the results of measurement of the various body parts that blue whales located in the Northern Pacific were probably different from those in the Antarctics and that the size at which sexual maturity was attained was smaller in the case of the North Pacific whales.

The number of whales investigated this time was even smaller and hence inadequate as a basis for any definite conclusions, but they would seem to endorse Matsuura's opinion.

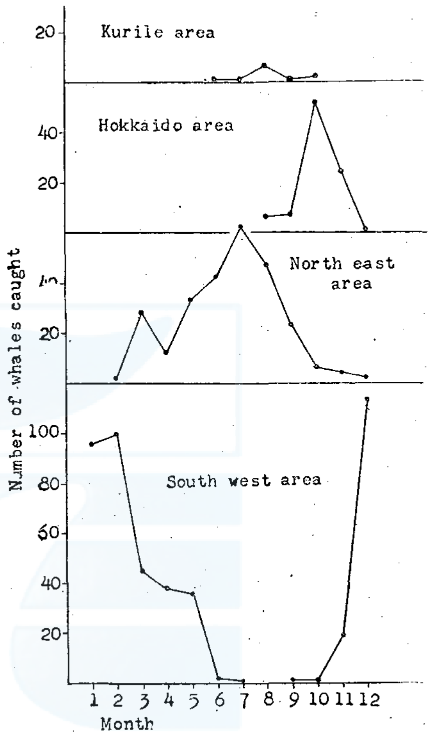
g. Migration and Stock.

On the basis of the past 18 years' whaling data, number of whales caught monthly in each area (see Fig. 1) is as shown in Fig. 2. By "past 18 years" means 1910, 1911, 1914, 1919, 1921, 1922, 1926, 1932, 1934, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947 and 1948. Data for the other years were lost by fire during the war.

As seen in Fig. 2, the best season for blue whales in the Southwest area, was in Dec. Jan. and Feb. In the Northeast area it is July, and in Hokkaido Oct.

In the Kuriles area, although only a small number of whales are caught, the peak of the season is August. From this fact it can be seen that these whales stay in the warm sea of the South west area during December to February and then gradually migrate northward along the Pacific side of Japan to reach the east side of Kamchatka Peninsula, through the north east area and off Kurile Islands.

Fig. 2. Blue whale. Monthly catch in different areas.

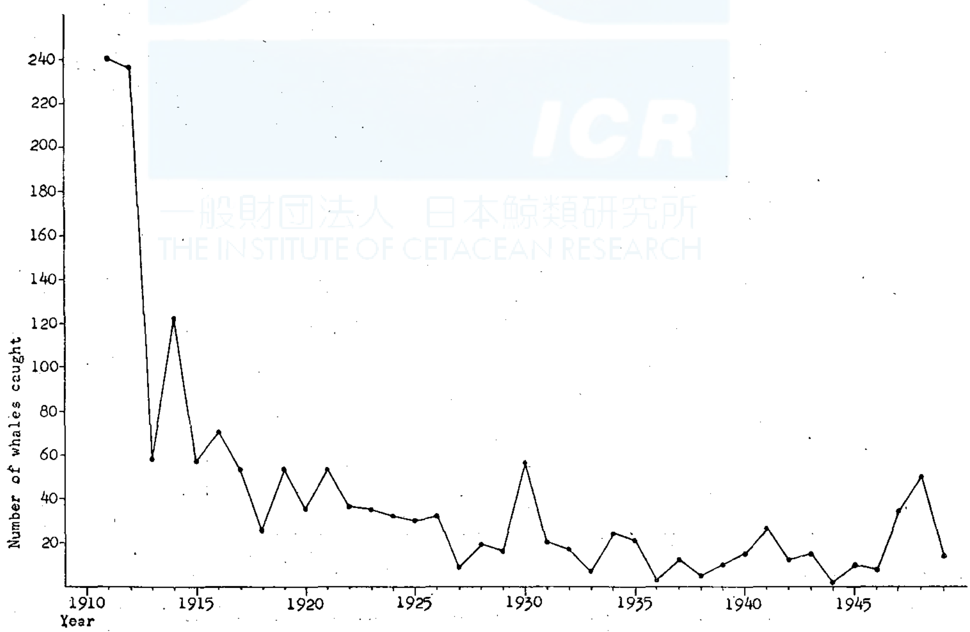


In 1940 and 1941, the whaling factory ship Tonan-maru operated off the east coast of Kamchatka Peninsula and caught 34 blue whales in 1940 and 40 in 1941, the seasons being June and July. It can thus be seen that the whales have already reached this area by that time. In both years, however, there were no blue whales caught north of Lat. 52° N. So it would seem that their northward migration does not extend to such a high latitude, as in the Southern hemisphere. The whales which are caught in the Hokkaido waters are those which, having migrated to the north are on their way southward. The fact that there is almost no catch around Hokkaido before October is indication that the whales when migrating northward follow routes much further off the coast. Both the northward and southward courses, seem to pass through the Northeast area. And in Bonin Island blue whales were caught but very rarely. And as those few catches were during January to May, nothing can be said about the route of the southward migration; but in the northward movement, very few seem to pass through the Bonin area.

In the South west area, Oshima and its neighbouring area were the principal whaling grounds. Off the west coast of Kyushu, whales were rarely caught. Along Korea both east and west sides, whales were caught very rarely. Consequently, it can be said that blue whales seasonally migrate along the east coast of Japan from South to north, and rarely from west coast of Kyushu to Korea. Blue whales have never been caught from Japan sea to Okhotsk sea. Though it is not clear how far south they migrate, no blue whales have been caught around Formosa.

The above is the information bases on whaling data of the past 18 years'. We can see therefrom that there has been a marked decrease blue whale stock, and that notable changes have taken in their whaling grounds. In Fig. 2, it is in the south west area that the most whales were caught. But that was generally the situation before 1920; and today not a single whale is caught around Oshima which was the principal whaling ground in

Fig. 3. Blue whale. Variation of catch.



that area at that time. Though only rarely, it is in the northeast area and the Hokkaido area that they are caught now. Fig. 3 shows the fluctuations in the catch of blue whales from 1911 to 1949.

Though more than 200 blue whales were caught in 1911 and 1912, there was a sudden decrease thereafter; and in no single year since 1917 have more than 60 whales been caught. Comparatively big peaks were seen in 1930 and 1948 but fell again in the following years. The relatively heavy catch in 1948 is to be explained by the fact that more than the usual number of whales migrated to the Hokkaido area on their way from north to south.

As already stated, catch of blue whale in the South west area today is nil but some are caught in the Hokkaido area and the Northwest area. So it would appear that along with the decrease in stock, there has been a change in the migration route of blue whales.

Fig. 4. Blue whale. Size distribution of whales caught in past 18 years.

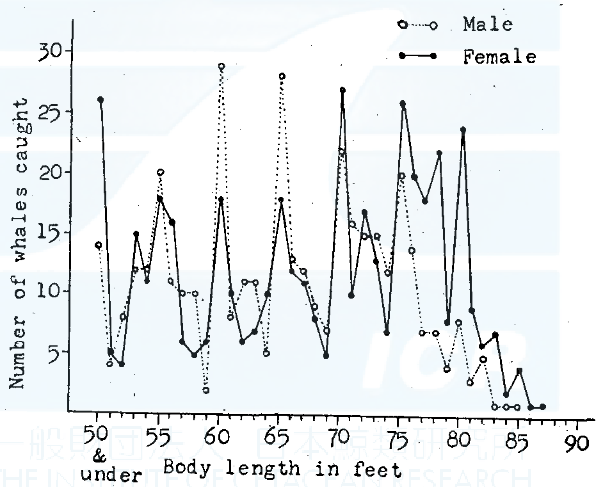


Fig. 4 shows number of blue whales caught in the past 18 years, classified by body length. Even granting that their body length at sexual maturity was not so long as in the case of the Antarctic whales, this chart suffices to show that great many immature whales caught. That this was an important cause of stock depletion can be easily surmised.

Fin Whale (*Balaenoptera physalus Linnaeus*)

a. Colour.

The result of colour observation was summarized as shown in Table 6.

Table 6. Fin whale. Body Colour.

	Actual number			Per cent		
	Male	Female	Total	Male	Female	Total
Body colour, grey	26	25	51	92.9	83.3	87.9
〃 , blackish	2	5	7	7.1	16.7	12.1
Extention of pigment on side, upper	9	10	19	34.6	37.0	35.8
〃 , normal	14	12	26	53.8	44.4	49.1
〃 , lower	3	5	8	11.6	18.6	15.1
Pigment project towards anus	16	16	32	61.5	59.3	60.4
〃 not projects 〃	10	11	21	38.5	40.7	39.6
Pigment of both sides meets in front of tail-flukes.	13	14	27	61.9	51.8	56.3
〃 〃 not meets	8	13	21	38.1	48.2	43.7

No color difference can be noted between male and female. Though this table shows slight difference between male and female this was probably due to the small number of whales observed.

Normal body color is greyish. But blackish whales made up about 10% of the total. About 50% of them showed normal color distribution on body side. In about 35% the pigmentation did not extend so low as in normal distribution, while in about 15%, it extended below normal distribution.

Whales having a projection toward anus, a little behind anus were more numerous than those without it,—the former being about 60% and the latter about 40%.

On slightly more than a half of the whales observed, the color on the right and left sides met just in front of tail flukes (at ventral side).

b. White scars.

White scars were recorded on 31 males, and 30 females, 61 in total. All the whales observed had white scars in varying degrees. Most of them were caught in the adjacent sea of Hokkaido, above all in the Okhotsk sea. Open pits could not be seen on whales caught in this area, but were observed on all whales (3) caught aronund Bonin Island. The number of white scars was classified into 4 classes, very few (up to 10), few (11-20) many (21-40) and numerous (over 41) as shown in Table 7. Most of the whales had less than 20 white scars. The difference was noted between male and female.

Table 7. Fin whale. Number of white scars.

	Male	Female	Total
Very few	16	12	28
Few	12	10	22
Many	2	7	9
Numerous	1	1	2
Total	31	30	61

c. External parasites.

As for external parasites, two whales were infected with a coronula sp. Pennella sp. was seen on 3 whales,—the number on each being 14, 2, and about 50.

The whale which was found with about 50 Pennellas was a female 66 feet long. The number of its corpora lutea was 30 in right and left ovaries and its epiphysis of vertebrae was completely fused into its centrum. So it was a whale which had attained physical maturity. The parasites were found all over body.

Diatom shows much local variety. Excepting one whale which was caught at Ayukawa on 24 June, 1949, there was no whale with parasites caught in any areas outside the Okhotsk Sea.

Table 8. Fin whale. Diatom infection in the Sea of Okhotsk.

	Actual number			Per cent		
	Male	Female	Total	Male	Female	Total
Not infected	4	3	7	14.3	20.0	16.3
with diatoms	19	9	28	67.9	60.0	65.1
with thick film	5	3	8	17.8	20.0	18.6
Total of infected	24	12	36	85.7	80.0	83.7

As seen in Table 8, about 86% of males and 80% of females caught in the Okhotsk Sea were infected with diatomes. It is generally from June to September every year that whales are caught in the Okhotsk Sea. This observation was carried on, in June and July, 1948. In 1949 no investigation was made on whales in this area. Most of the whales caught there were fin whales, and in addition some sperm whales, all of which were mature males,—an indication that so-called "harem" did not migrate to this area.

The number of caught whales fluctuates much from year to year.

Humpback whales were rarely caught there. Sperm whales obviously migrate from the Pacific to the Okhotsk Sea through the Channels between Kurile Islands, while other whales in the Japan Sea probably migrate through the Soya channel. They are fin whales which follow the cold current of the Japan Sea along the Russian coast. That is probably the reason why they show such high diatom infection. Species of diatoms have not been studied yet.

d. Thickness of blubber.

The actual measurements of thickness of blubber, classified by body

Fig. 5. Fin whale. Thickness of blubber. 1. Male Point 1.

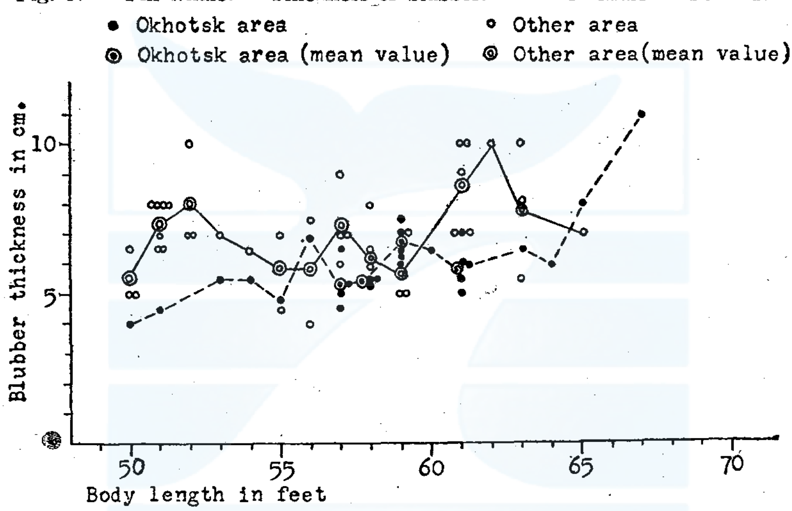


Fig. 6. Fin whale. Thickness of blubber. 2. Female. Point 1.

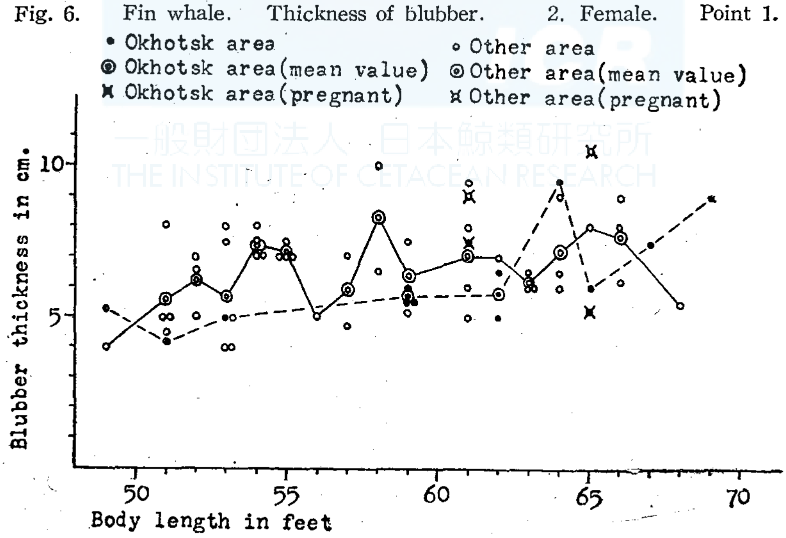


Fig. 7. Fin whale. Thickness of blubber. 3. Male. Point 2.

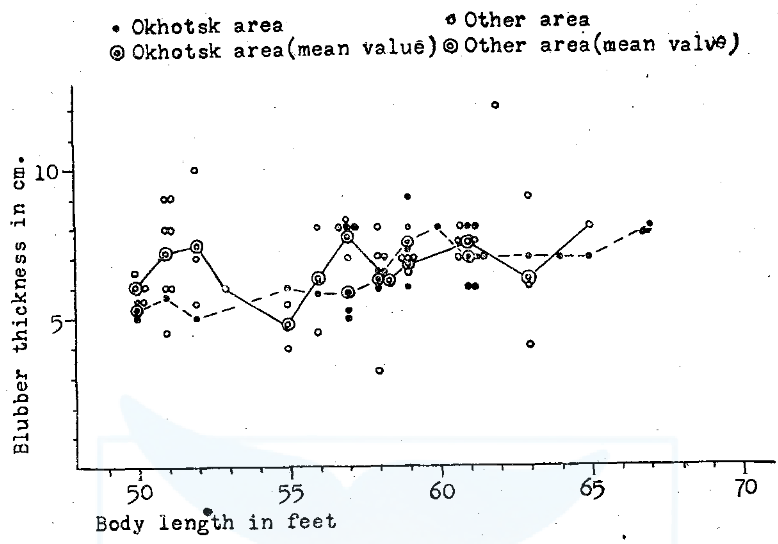
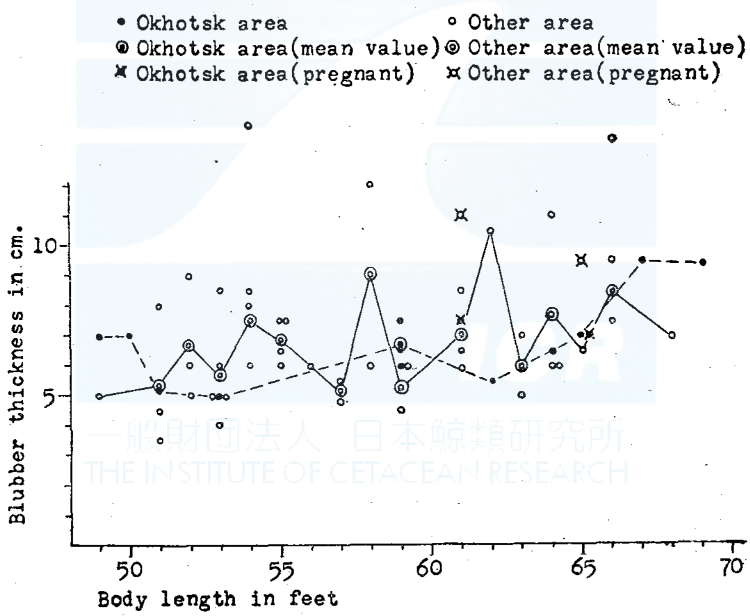


Fig. 8. Fin whale. Thickness of blubber. 4. Female. Point 2.



length, are as shown in Figs. 5 to 8. Figs. 5 and 6 concern Point 1, and Figs. 7 and 8, Point 2. Figs. 5 and 7 are for males, and Figs. 6 and 8 are for females. In all of the above figures, main division is made by two whaling grounds. The one is the Okhotsk Area, and the other is the Hokkaido and North east areas totalled (Ayukawa-Kiritappu). Although a few fin whales were caught in the

Bonins also, and blubber thickness was measured on three whales, the results were not included here because of the different whaling ground and the small number studied. Figs. 5 to 8, though based on insufficient data, show that blubber increases in thickness in proportion to the increase in body length, and that blubber of whales in the Okhotsk sea tends to be thinner than in other areas. As mentioned above, 86 % of fin male whales and 80 % of fin female whales in the Okhotsk area were infected with diatoms. In other areas, however, whales were rarely infected. The fact that whales in the Antarctic are infected with diatom is indicative of their long stay there and hence of thick blubber. Figs. 5 to 8 show that the trend in the adjacent waters of Japan is just the reverse. This means that in the adjacent seas of Japan the relation between the amount of krill as food for whales and diatoms — though their species are still unknown — is reverse to that of the Antarctic.

Fig. 9. Fin whale. Mature.
Mean blubber thickness by months.

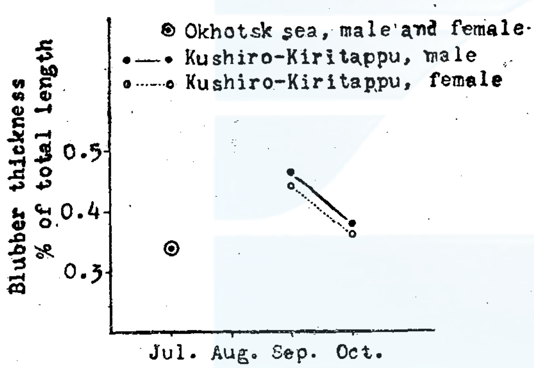
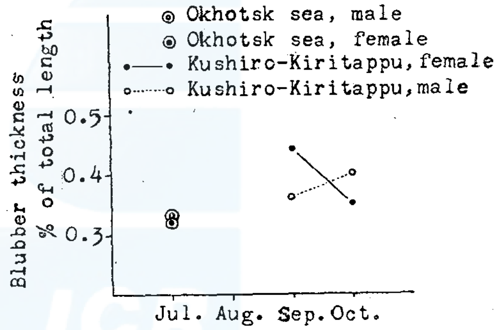


Fig. 10. Fin whale. Immature.
Mean blubber thickness by months.



Figs. 9 and 10 show the percent of blubber thickness to body length by months. Months in which few whales were investigated were omitted. These figures clearly show that blubber of whales in the Okhotsk sea is thinner than that in the Hokkaido area (Kushiro-Kiritappu). It is further shown that in the Kushiro-Kiritappu area blubber of whales, with the exception of immature females, becomes thicker in September and thinner in October. This fact of the blubber which was thick in September becoming thin in October probably has a close bearing on the migration. Namely, fin whales in this area are whales which have migrated southwards from off the Kurile Islands or further north. Owing to the abundant food, their blubber would become thicker there; but during their stay in the Hokkaido area it probably becomes thinner because of the poorer food supply there. This is the same with Sei whale which is mentioned later.

e. Food.

There is a record on food for 153 whales, of which 57 whales had no food in their stomach. This is about 37 % of the total. Food was almost all Krill (Euphausidae),— there being only one whale that had eaten calanus and another that had eaten sardine. The principal Euphausidae in the adjacent waters of Japan is Euphausia pellucida Dana. As food is most closely related to thickness of blubber, the details are shown in table 9, classified into the Okhotsk and the Ayukawa areas. In the Bonin Island area, all of the 3 whales investigated were found to have empty stomachs. Table 9 is confined to Krill.

Table 9. Fin whale. Quantity of stomach contents.

	Sea of Okhotsk		Ayukawa-Kiritappu	
Number observed	54	%	94	%
None	11	20.4	43	45.7
Few	29	53.7	19	20.2
Moderate	10	18.5	15	16.0
Rich	3	5.6	16	17.0
Full	1	1.8	1	1.1

As seen in Table 9, there were far more whales with empty stomachs in the Ayukawa-Kiritappu than in the Okhotsk Sea. While whales with empty stomachs were 40 % of the total in this area, they were only about 20 % in the Okhotsk area. While a larger percentage of whales in the Okhotsk Sea thus had food in their stomachs than the whales in the Ayukawa-Kiritappu area, the quantity of food found in the former was generally smaller than in the latter.

It may therefore be said that owing to scarcity of food in the Okhotsk sea, the blubber does not get thick while the whales are staying in that area. And that fact would further support the view that as feeding chance for whales is scarce in the Hokkaido area, the blubber that had thickened in northern waters becomes thin during stay around Hokkaido.

f. Genitalia and Maturity.

Ovaries were investigated for 62 females. It was recorded whether they had corpus luteum or not and, when they had, the number of corpus luteum was classified into "functional" and "old".

It is true that whales have attained sexual maturity when either the right or left ovary has 1 or more corpus luteum.

Table 10. Fin whale. Females classified according to maturity.

Body length in feet	49	50	51	52	53	54	55	56	57	58	59
Mature	0	0	0	0	0	0	0	1	0	1	1
Immature	2	1	4	1	6	2	5	2	2	2	5
Total	2	1	4	1	6	2	5	3	2	3	6

Body length in feet	60	61	62	63	64	65	66	67	68	69	Total
Mature	0	5	2	3	2	5	3	2	1	1	27
Immature	0	1	1	0	1	0	0	0	0	0	35
Total	0	6	3	3	3	5	3	2	1	1	62

In Table 10 the 62 whales investigated are classified by body length into mature and immature, — the mature being those having at least 1 corpus luteum, and immature being those without any.

The shortest mature was 56 feet long, and the longest immature was 64 ft. While no whale exactly 60 feet in length came under observation, most whales up to and including 59 feet in length were immature, there being only three exceptions: 56 ft., 58 ft. and 59 ft. each. On the other hand, most whales—61 ft. long and over were mature, with only three exceptions: 61 ft., 62 ft. and 64 ft. each. Consequently we may regard whales over 61 feet as mature. From this Table we cannot tell whether the border between mature and immature is 60 ft. or 61 ft. It can at least be said, however, that they were smaller than those of the Antarctic. According to Mackintosh & Wheeler, female fin whales located in the Antarctic attain sexual maturity when 20.0 m. (65′ 7″) long. So female fin whales in the adjacent waters of Japan come to maturity when about 5 ft. shorter. Matsuura too reported that female fin whales came to maturity when 61 ft. long, after observation of whales off coast of Kamchatka in 1941. Our present investigation also endorses this fact.

Number of corpora lutea of mature female fin whales is shown in Table 11.

Table 11. Fin whale. Number of corpora lutea in the ovaries.

Body length in feet	Number of corpora lutea (Total of both ovaries)														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14……30	
56			*												1
57															0
58		*													1
59		*													1
60															0
61		**	o	o		*									5
62	0	*													2
63	0			*										* (14)	3
64		*									0				2
65	*o					0o		*							5
66					*			*						* (30)	3
67					0							*			2
68						*									1
69										*					1
Total	4	6	2	2	2	4	0	2	0	1	1	1	0	1 1	27

o .... Pregnant. * .... Resting. 0 .... Pregnant or recently ovulated.

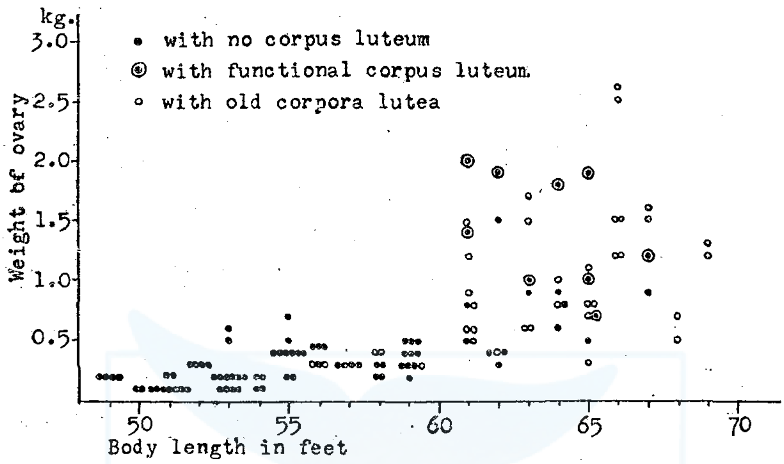
Only one whale was found to have 30, which was the largest number found. All the others had 14 or less. Those with Functional corpus luteum but without fetus were indicated with 0, as in the following three cases.

1) Mere ovulation followed by no pregnancy.
2) In the extremely early stage of pregnancy, when presence of fetus was not confirmed.
3) Though there was a fetus, it was lost while the whale was being towed to landstation.

The case mentioned in (3) seems to take place quite often in Japan. That is because the ventral blubber is cut and internal organs are exposed to the sea water in order to preserve the freshness of meat which is used as food. This is commonly called "blood removing". Owing to this "blood removing", foetuses are often lost. In table 11, there are considerable number of whales with functional corporus luteum and yet no fetus. Most of them were probably lost in that way. Though in those cases careful observation could have determined the existence or absence of foetus, unfortunately such record was not made.

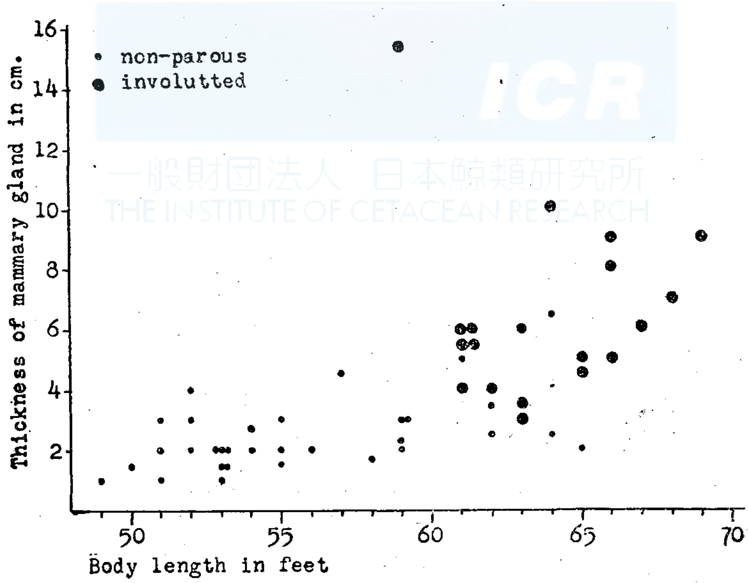
Weight of ovary is as shown in Fig. 11.

Fig. 11. Fin whale. Weight of ovary.



Excepting 2 instances, all whales up to 59 ft. long had ovaries 0.5 kg. or under in weight. The same with whales with old corpora lutea. But in whales 61 ft. or more in length, with a few exceptions, the weight of ovaries was 0.6 kg. or over. And most of them had corpora lutea. Whales with body length of 61 ft. or more which had no corpus leteum in neither ovary were confined to the 3 set forth in Table 10, — their lengths

Fig. 12. Fin whale. Thickness of mammary gland.



being 61 ft., 62 ft. and 63 ft. All the others had corpus luteum in either one or both ovaries. Where only one of the ovaries had corpus luteum, it was usually found that even the ovary which had no corpus luteum was heavier than that of immature whales. We may say from Fig. 11, that female fin whales are immature up to 59 ft. in body length and mature from 61 ft. long, and that the ovary weighs more than 0.6 kg.

Fig. 12 shows thickness of mammary gland. It was generally under 4 cm. in non parous glands. The mature ones, including even those involuted, were mostly more than 4 cm. thick. No lactating whale was observed. For males, weight and volume of their testis were measured.

They are shown in Fig. 13 & 14.

Weight and volume of testis show the same general trend, though

Fig. 13. Fin whale. Weight of testis.

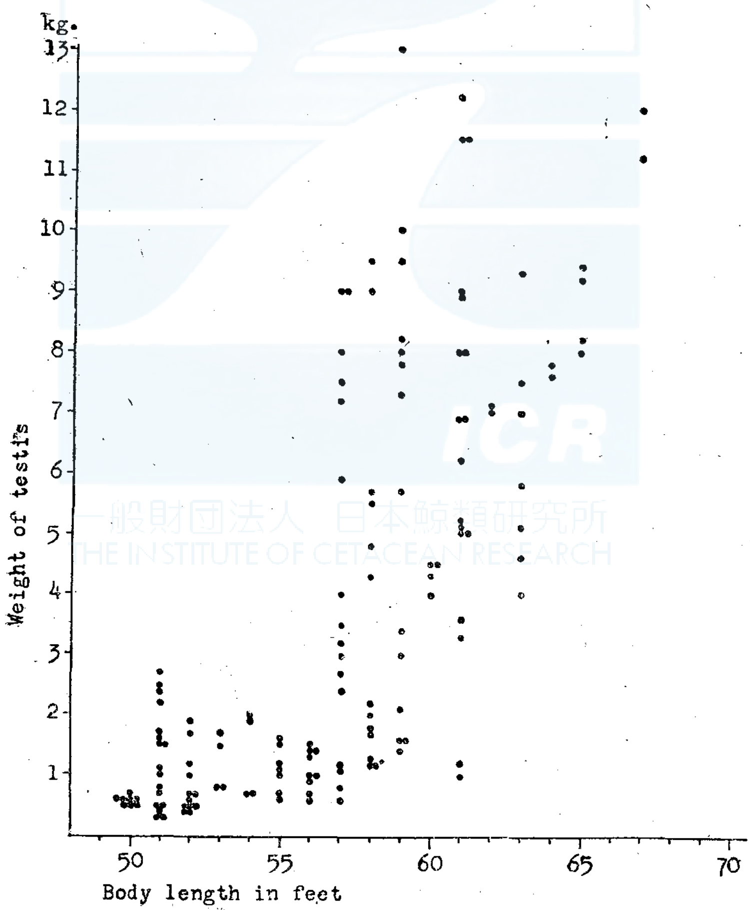
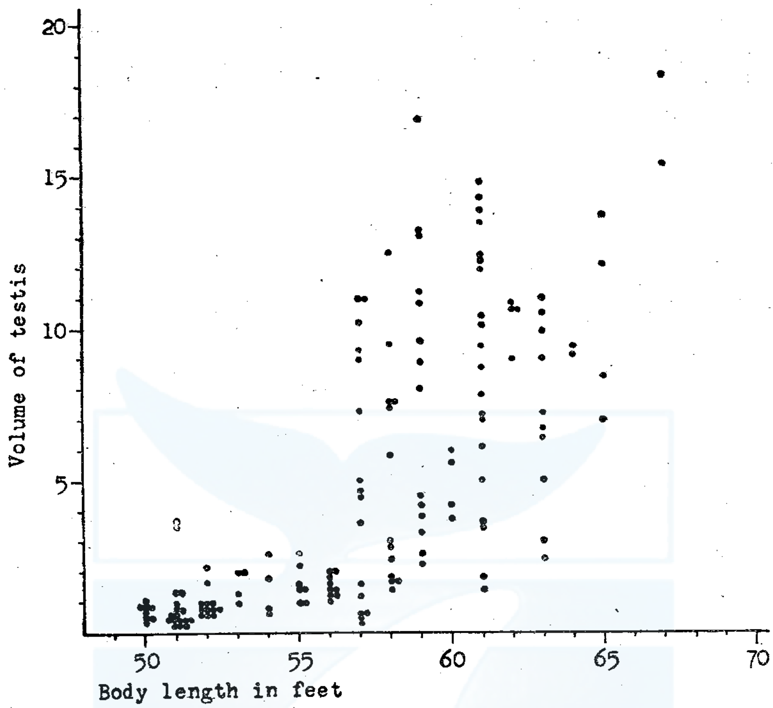


Fig. 14. Fin whale. Volume of testis.



there is some discrepancy as to details. Both in Figs. 13 and 14, a sharp line of demarcation may be drawn between whales of 56 feet and less and those 57 feet and over. According to Mackintosh & Wheeler, male fin whales located in the Southern hemisphere, whose testis has a volume of 4 or more may be regarded as adult. In case of whales in the adjacent seas of Japan, borderline between immature and mature is probably 3 in volume and 2.5 kg. in weight. Taking volume 4 as the standard, however, all male whales studied have been classified into mature and immature by body length, as shown in Table 12.

Table 12. Fin whale. Male classified according to maturity.

Body length in feet	50	51	52	53	54	55	56	57	58	59	60
Mature	0	0	0	0	0	0	1?	5	3	5	2
Immature	4	8	6	2	2	3	3	3	3	2	0
Total	4	8	6	2	2	3	4	8	6	7	2

Body length in feet	61	62	63	64	65	66	67	Total
Mature	9	2	4	1	2	0	1	35
Immature	2	0	0	0	0	0	0	38
Total	11	2	4	1	2	0	1	73

Where only one testis of a whale could be investigated, such whale was regarded as mature if the testis volume was 4 or more. But where the volume was less than 4, such whales were excluded from this Table because of the possibility of the other testis having a volume of 4 or more. From Table 12, it is appropriate in the case of male fin whales to treat whales 58 ft. or 59 ft. and over as mature and whales under it as immature. According to Mackintosh & Wheeler, male fin whales in the Southern hemisphere reach sexual maturity at 19.5 meters (63′ 8″). So compared with them, male fin whales in the adjacent seas of Japan are shorter by 5 feet at sexual maturity. So what was said regarding females may also be said for the males. The constitution of fin whales observed may be summarized as shown in Table 13.

Table 13. Fin whale. Constitution of whales observed.

	Female	Male	Total
Total number observed	62	73	135
Immature	35(56.5) %	38(52.1) %	73(54.1) %
Mature	27(43.5) %	35(47.9) %	62(45.9) %
in which Resting	18		
Pregnant	4		
Pregnant or recently ovulated	5		
Lactating	0		

As seen in Table 13, more than half of the whales observed were immature. This, however, is hardly indicative of the composition of fin whales caught in the adjacent waters of Japan. So a study has been undertaken here, on the basis of the body length, on all fin whales which were lately caught in the adjacent seas of Japan.

Table 14 shows the result on whales caught from 1946 to 1948. When, based on the above mentioned body length, they were classified into mature and immature, the result was as shown in Table 15.

Table 14. Size of fin whales caught in the adjacent waters of Japan during the year 1946/48.

	Males				Females			
	1946	1947	1948	Total	1946	1947	1948	Total
50 & under	20	14	4	38	15	13	5	33
51	9	5	6	20	6	8	10	24
52	6	5	11	22	9	8	8	25
53	7	6	4	17	5	4	4	13
54	4	3	6	13	5	6	4	15
55	12	6	5	23	8	5	3	16
56	7	9	10	26	9	11	5	25
57	5	4	7	16	9	7	3	19
58	6	10	5	21	4	2	5	11
59	9	9	8	26	3	3	5	11
60	8	14	6	28	4	6	3	13
61	2	13	12	27	3	3	3	9
62	4	10	2	16	9	6	5	20
63	3	9	2	14	6	11	2	19
64	2	5	1	8	5	10	5	20
65	2	5	1	8	6	5	5	16
66		1	1	2	6	7	3	16
67					5	5	4	14
68					2	4	1	7
69					4	2	2	8
70					3	1		4
71						1		1
72						1		1
Total	106	128	91	325	126	129	85	340

Table 15. Fin whale. Mature and immature whales caught in the adjacent waters of Japan during the year 1946/48.

	Females		Males		Total	
	Number	Percent	Number	Percent	Number	Percent
Immature	205	60.3	175	53.8	380	57.1
Mature	135	39.7	150	46.2	285	42.9
Total	340	100.0	325	100.0	665	100.0

Table 15 also shows the immature were over 50 % of the total caught, and that that preponderance is especially high for females. It must therefore be said that that is a very high percentage as compared with situation in the Antarctic where only about 15 % of the fin whales caught are immature.

g. Migration.

Relative to the migration of fin whales in the adjacent waters of Japan, there are 2 groups. One migrates from South to north along the Pacific side of Japan; and the other, along the Japan sea side. These two groups probably mingle with each other in the south seas during winter, but not so while in the north sea during summer. Figs. 15 and 16 show monthly catch by area, on the basis of the last 18 years' whaling statistics. Fig. 15 shows the Pacific side group and Fig. 16 the Japan Sea group.

Fig. 15. Fin whale. Monthly catch in different areas. I. East side.

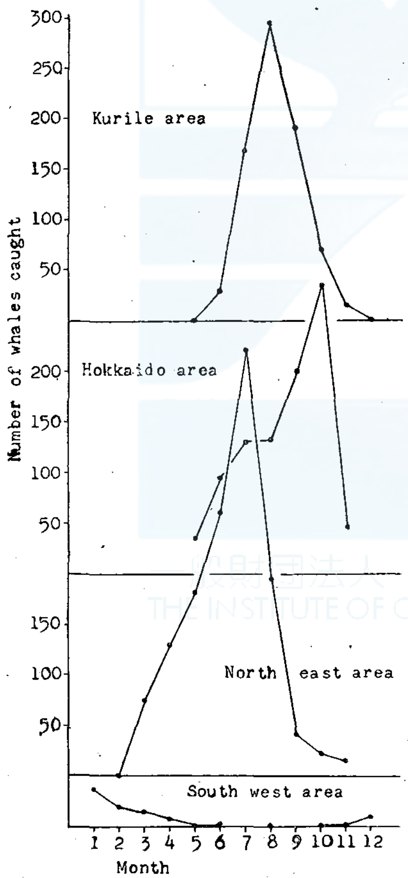
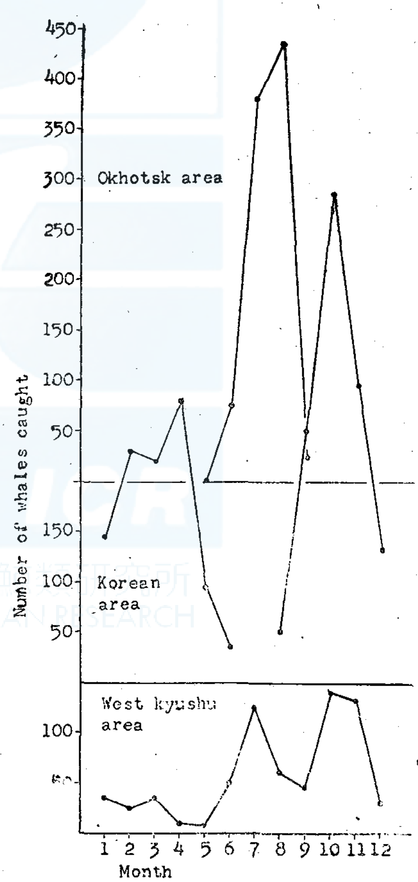


Fig. 16. Fin whale. Monthly catch in different areas. II. West side.



As seen in Fig. 15, the former group was caught in the South West area in winter. The best season was Jan., although the number caught was not very large. In the northeast area, the peak was in July; and in the Kurile area, August. When the Tonan-maru operated in the Arctic, it caught 221 fin whales in 1940 and 370 fin whales in 1941. The season was from June to August. In 1941, most of the catch was made southeast off Paramushir island, only a few being in the waters from Commander Island to Olyutorsk Cape. In 1940, however, out of 221, 74 whales were caught in the Arctic, north of the Behring Strait. While it is not clear whether these fin whales belong to the same group as whales in the adjacent waters of Japan or to a group on the American side, the chances are that the two groups mingle in the waters around there.

In the Hokkaido area, whales caught from June to August are probably those migrating northwards, while those caught after that are probably whales migrating southwards. As October is the best whaling season, it must mean that more whales migrate through this area in their southward course than in the northward course.

In the Bonin Island area, fin whales are rarely caught, — probably because not so many enter that area. Fig. 16 is concerned with the west side group. In the West Kyushu area, the best catch is seen in October and November. Strange to say, a big peak is sometimes seen in July, although confined to only Tsushima and that mostly in 1911 and 1914. With this one exception the best catch in this area is also seen in winter. The following two causes are conceivable:

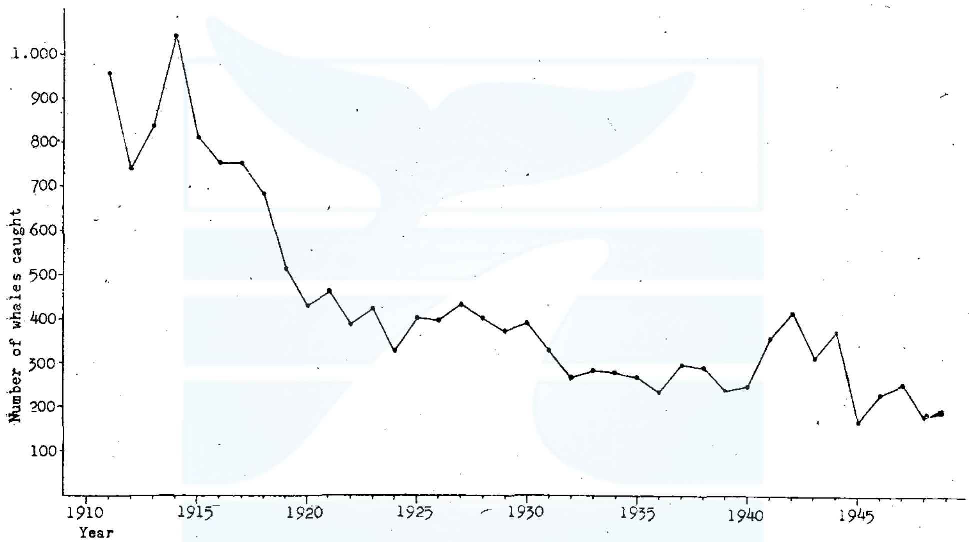
1. There is a group which does not migrate north even in summer but stays around Tsushima.
2. There was a group which for some reason stayed in that area in summer of 1911 and 1914.

It is not clear which is the correct explanation. It suffices for the present to say that very few fin are being caught there now.

In the Korean area, two peaks can be found. One is in April and the other in October. The former is southward migration and the latter is northward migration. Catches in Korean waters take place off the south coasts. Off west coast, fin whales are mainly caught from January to May, and a few from October to December. This is probably due to southward migration through the West Kyushu area by a part of them and migration to the Yellow Sea round the south coast of Korea by another part.

Fin whales which have entered the Yellow Sea would stay there during winter and migrate northwards through the Japan sea in May or June. These whales seem to enter in Okhotsk Sea through the Soya strait. The whaling season in the Okhotsk sea is July and August. As mentioned in the paragraph on "Blubber", the thickness of blubber differs between whales in the Okhotsk area and those in the Hokkaido area. And when considered from the standpoint of diatom infection, there appears to be little likelihood of both groups migrating through the Straits between the Kurile Islands.

Fig. 17. Fin whale. Variation of catch.



h. Stock.

Fig. 17 shows number of fin whales caught annually since 1911. The maximum catch was in 1914, when 1,043 fin whales were caught; and after that there was a sudden decrease. Though in 1942 some increase was seen, it has been on the decline again. After the War, Japan does not operate off Korea, the main whaling ground of fin whales. So the catch since 1946 can not directly be compared with that before it but it is an undeniable fact that fin whale stock tends to decrease. The number of catchers in the adjacent seas of Japan was limited to 30 till 1934, and to 25 since then. (As some substitute ships operate, total number may exceed this. But the number in actual operation is within the limit.) The size and H. P. of the catchers increased, especially since 1935; and the present total tonnage is two times and total H. P. is over 2.5 times the figures for 1910. Therefore the whaling effort must have increased remarkably. Taking this point into consideration, we cannot help thinking that fin whale stock must have decreased as markedly as blue whale stock.

As mentioned in the paragraph on "Maturity" more than 50% of whales caught from 1946 to 1948 were immature.

Fig. 18. Fin whale. Size distribution of whales caught in past 18 years.

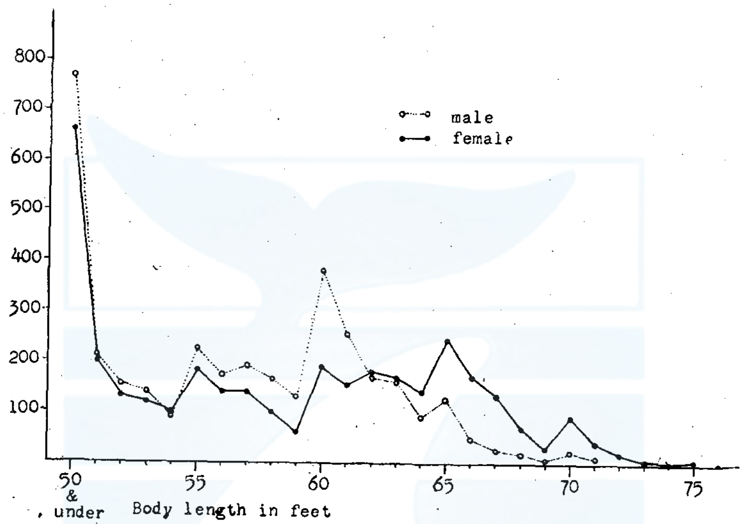


Fig. 18 which shows the total whaling catch for the last 18 years clearly shows how many immature fin whales were caught. This is probably one of the important reasons for the decrease of fin whale stock.

The latest whaling grounds for fin whales are the Okhotsk area, the Hokkaido area and the Northeast area,—catches in other areas being extremely rare.

Humpback Whales. (*Megaptera nodosa Bonnaterre*)

Only 4 males and 6 females, 10 humpback whales in all, were observed. That is but natural, for humpback whale catch is extremely rare in the adjacent seas of Japan. Body color was observed for 7 humpback whales. The details are: 2 whales in group 1, 1 each in groups 2 and 3, and 3 in group 4. Of 7 whales observed for white scars, 3 had "very few" 2 "few", and 2 had "many". As for external parasites, they were infected with Coronula and Chonchoderma as in the case of humpback whales in other seas. According to the record, 4 humpback whales out of ten were infected with cyamus sp. Thickness of their blubber is as shown in Table 16.

Table 16. Humpback whale. Thickness of blubber.

Date of catch	Body length in ft.	Sex	Thickness of blubber		Ground	Remarks
			Point I	Point II		
			cm.	cm.		
21 Mar. 1949	39	M	12.5	12.0	Bonin island	
25 Feb. 1948	41	M	13.0	11.0	〃	
23 Feb. 1948	45	M	13.5	——	〃	
6 Mar. 1949	45	M	12.0	12.5	〃	
22 Mar. 1949	35	F	11.0	12.0	〃	Immature
8 May, 1948	36	F	3.5	7.5	Ayukawa	Immature ?
13 May, 1948	36	F	7.5	9.5	〃	Immature
21 Mar. 1949	43	F	12.0	13.0	Bonin island	Pregnant or recently ovulated.
26 Jan. 1948	44	F	15.0	13.0	Mombetsu	Pregnant
4 Apr. 1948	45	F	8.0	9.5	Bonin island	Lactating

As for food, out of 10 humpback whales, 7 whales had empty stomachs and 2 had krill in their stomachs and of 1 there is no record. Out of the above 2 whales found with krill in stomach, one had a small amount of krill and the other had a large amount.

As for genitalia, weight and volume of testis of males were measured. The results are as shown in Table 17.

Table 17. Humpback whale. Weight and volume of testis.

Body length in feet	Weight in kg.	Volume in 1,000 cc	Maturity
41	(10.5 ?)	(6.3 ?)	Mature
45	(5.5 5.5)	(6.2 6.3)	〃
45	(9.5 9.4)	(14.0 15.8)	〃

They were all mature. In addition, there was 1 male 39 ft. long; but it is unknown whether it was mature or immature because no observation seems to have been made of it. Ovary of 4 females was observed. The results are as shown in Table 18.

Table 18. Humpback whale. Weight and condition of ovaries.

Body length in feet	Weight of ovaries	Number of corpora lutea: Functional	Number of corpora lutea: Old	Sexual condition
35	0.1 kg. 0.1	0 0	0 0	Immature
43	0.3 0.2	0 1	1 0	Pregnant or recently ovulated
44	4.0 2.5	1 0	3 1	Pregnant
45	1.6 0.9	1 0	2 3	No fetus Lactating

Among the whales indicated in Table 18, a whale 45 feet long was in an extremely early stage of pregnant or of recent ovulation, for it had one functional corpus luteum. Nevertheless, it was lactating. Such instances are sometimes observed even in the Antarctic. Humpback whales that are lactating and pregnant are probably found more often than among other baleen whales.

Fig. 19. Humpback Whale. Monthly catch in different areas. I. East side.

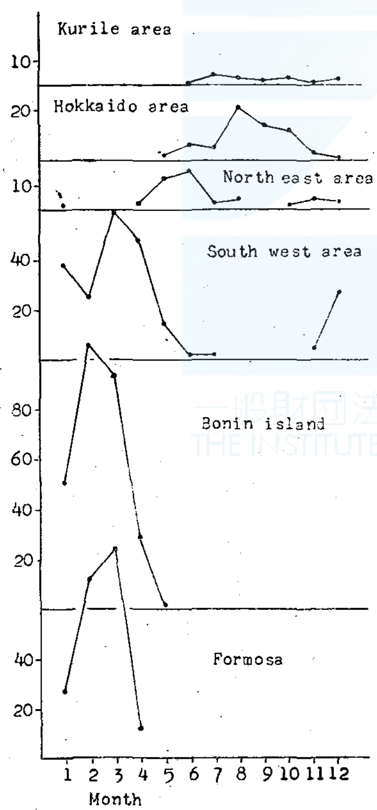
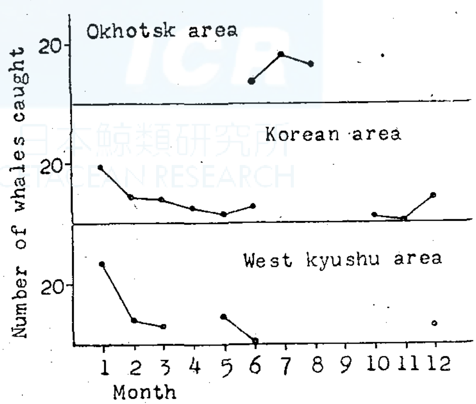


Fig. 20. Humpback Whale. Monthly catch in different areas. II. West side.



Figs. 19 and 20 show monthly catch of Humpback whales in each area for the past 18 years. Fig. 19 concerns whales in the east side of Japan and Fig. 20 with those in the west side of Japan.

As seen in Fig. 19, the best season is in February and March in Formosa and the Bonin Island area, and in June in the South west area. In this order, therefore, they probably migrate from south to north. In the Kurile area very few were caught; and same with the east side of Kamchatka Peninsula when the Tonan-maru operated there in 1940 and 1941 (7 humpback whales in 1940 and 6 in 1941). In addition, however, 101 whales were caught in the Arctic in 1940. Whether these belong to Japanese group or American group is not known; but since it is known that a considerable number of whales migrate along the Alaskan coast, these probably belong to the American group.

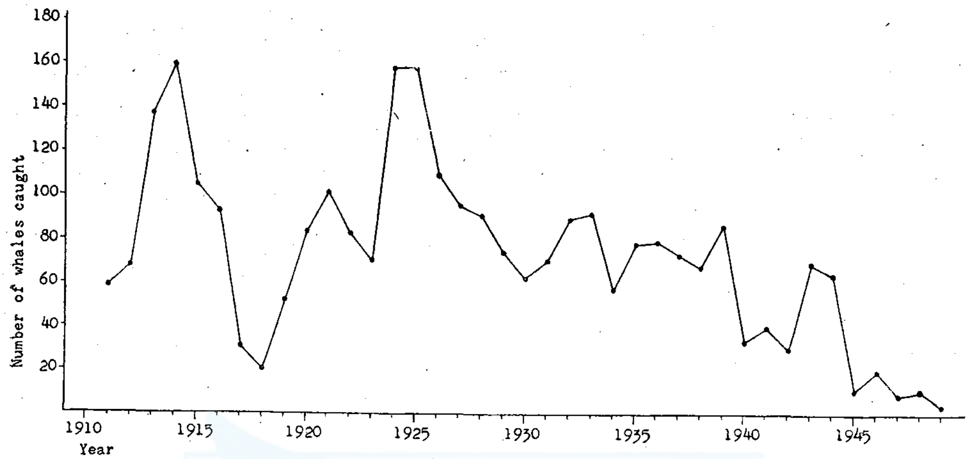
The fact that they were mostly caught in the east side of the Kamchatka Peninsula in July, means they migrate that far north in this season. In the Hokkaido area they were mainly caught beginning in August, indicating that they were probably on their way from North to South. The same is true with other baleen whales such as blue, fin and sei whales.

As shown in Fig. 19, Bonin Island, Formosa and South west area were the principal whaling ground. But Japanese whaling no longer operates in Formosa, and the catches in the other two grounds are virtually nil.

As Fig. 20 shows, extremely few whales were caught in any west side area. In both the West Kyushu and the Korean areas, the catches were made in winter, and in the Okhotsk area, they were caught in summer, from June to August. In the Korean area, some whales were caught off all the coasts, — east, west and south. Consequently, migration from the west Kyushu area and the Korean area to the Okhotsk sea through the Japan sea appears plausible. Their number, however, was very small. It may be that the east side group and the west side group mingled in the south seas in winter, though there is no positive proof of it. Nor is it clear whether whales around Formosa migrate northeast-wards to the east side or northward to west side. But since the Formosa and Bonin island seasons are generally the same, the chances are that the two belong to different groups.

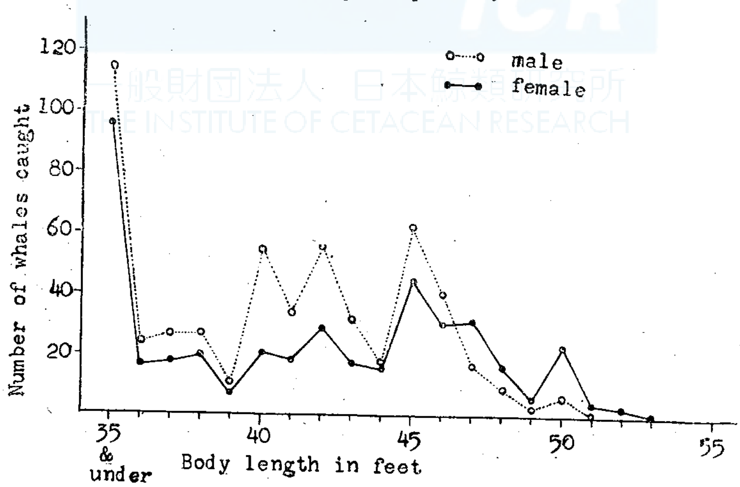
Fig. 21 shows fluctuations in the annual number of Humpback whales caught since 1911. There are two big peaks, —in 1914 and 1924 (or 1925).

Fig. 21. Humpback whale. Variation of catch.



The 2nd peak in 1924 (or 1925) was due to a sudden increase of catch as a result of commencement of whaling in Formosa and Bonin Islands, the principal whaling grounds for Humpback whales. But they have decreased since then. Thus, Humpback whale catch in the adjacent waters of Japan increased sharply and reached the maximum in 1914, and then decreased suddenly. Some years later, however, the newly begun whaling in Formosa and the Bonin Islands area, made Humpback whale catch increase again as high as the 1914 peak. There has since been a gradual decrease, and the present annual catch is probably only 10 whales or so. Another reason for sudden decrease since the end of war is of course the fact that

Fig. 22. Humpback whale. Size distribution of whales caught in past 18 years.



there is no operation in Formosa.

Fig. 22 shows size distribution of total Humpback whales caught in the last 18 years. It is true that considerable number of small sized Humpback whales were caught, though not to such an extent as in the case of blue whales and fin whales.

Sei Whales (*Balaenoptera borealis Lesson*)

Sei whale, like sperm whale, is a species which is caught in large numbers in the adjacent sea of Japan. Accordingly, the number of whales observed was also large, — it being 1031, as Table 1 shows.

a. Colour.

As mentioned earlier sei whale is usually of grey colour on the back and of somewhat lighter colour on the ventral side. And they have large spots on their ventral grooves. On the back, the dark or pigmented areas extend in tongue-like shape toward ventral grooves, and in the extreme cases the right and left pigmented areas meet at the posterior end of the ventral grooves. The state of pigmentation was classified under 3 heads: "not developed," "normal," "well developed". The number of whales observed was 300 males and 284 females, or a total of 584. The results are shown in Table 19.

Table 19. Sei whale. Degree of pigmentation towards posterior end of ventral grooves.

Degree of Pigmentation	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Not developed	84	28.0	76	26.7	160	27.4
Normal	139	46.3	149	52.5	288	49.3
Well developed	77	25.7	59	20.8	136	23.3
Total	300	100.0	284	100.0	584	100.0

Although this table shows some difference between the sexes, that difference is probably not an essential one. For an observation of this kind may sometimes differ according to the observers engaged in it, and at times even when the observer is the same. So it may be safely said that Table 19 shows the same general trend for male and female. White areas of ventral grooves of 428 whales were also classified as "not developed", "normal" and "well developed". The results, set down in Table 20, show no great difference by sex on that point.

Table 20. Sei whale. Development of white area on the ventral grooves.

Degree of development	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Not developed	40	20.2	57	24.8	97	22.7
Normal	94	47.5	112	48.7	206	48.1
Well developed	64	32.3	61	26.5	125	29.2
Total	198	100.0	230	100.0	428	100.0

"Not developed" is about 20 % of the total and "well developed" is about 30 %.

According to Matthews's observation on 96 Antarctic Sei whales, about 20 % had a well developed white area and about 3% only slightly developed. So the reverse result is seen for Sei whales in the adjacent seas of Japan.

As to whether the right side and left side pigmented area met just in front of tail flukes below the tail or not, 425 whales were observed. The results are as shown in Table 21. Those that met slightly outnumbered those that did not. There was no difference between sexes on that point.

Table 21. Sei whale. Meeting of pigments just in front of the tail flukes.

Pigments of both sides	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Meet	111	56.1	131	57.7	242	56.9
Not meet	87	43.9	96	42.3	183	43.1
Total	198	100.0	227	100.0	425	100.0

Table 22. Sei whale. Presence of light-coloured Spots on the flanks and side of the tail.

Light-coloured spots	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
None	115	41.8	97	33.6	212	37.6
Few	48	17.5	65	22.5	113	20.0
Moderate	95	34.5	87	30.1	182	32.2
Many	17	6.2	40	13.8	57	10.1
Total	275	100.0	289	100.0	564	100.0

Light coloured spots and white scars: There are some sei whales which have light coloured spots on the flanks and the side of the tail which have an appearance resembling new galvanized iron. The density of these scars was recorded as "none", "few" "moderate" and "many". The results are as shown in Table 22.

Females with light coloured spots were slightly more numerous than males. These spots, however, are probably not original coloration, but secondary, with sei whales. These "white scars" are found also on blue and fin whales almost exception in both the South and the Northern hemispheres. The cause for these white scars is still unknown, but according to Mackintosh & Wheeler, they are probably due to the infection of ciliated protozoas. Though Mackintosh & Wheeler says "The open pits seem never to have been described in whales of the Northern hemisphere", such open pits have often been found on whales in the Bonin Island area. (See Fig. 23) and open pits in the healing stage have also been found. (See Fig. 24). But they have rarely been found in Japanese whaling grounds other than Bonin Island. So in the northern hemisphere, as in the Southern hemisphere, open pits probably develop while the whales are in the warm sea and appear as white scars on the skin when they have healed. The white scars are usually found on flank and tail, as in the southern hemisphere. "New galvanized appearance" of sei whales is probably due to these white scars accumulated year after year.

Fig. 23. Sei whale. Open pit.

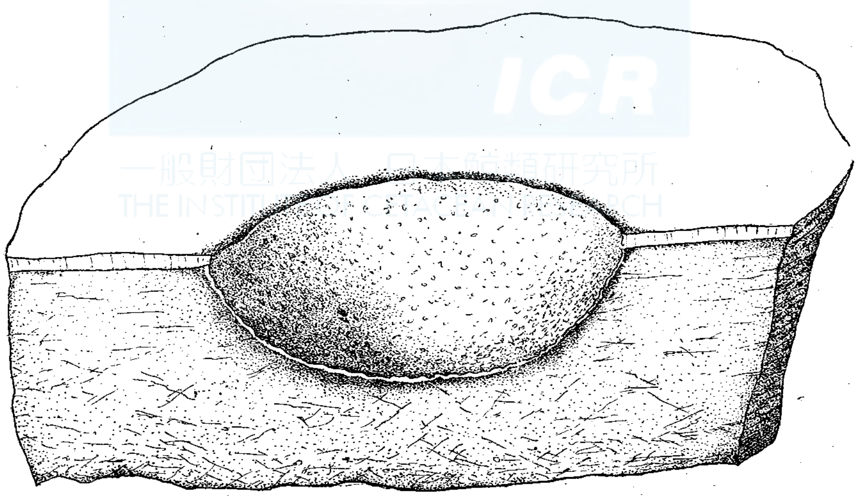


Fig. 25 shows the so-called "new galvanized appearance" of Sei whale,

Fig. 24. Sei whale. Healed pit.

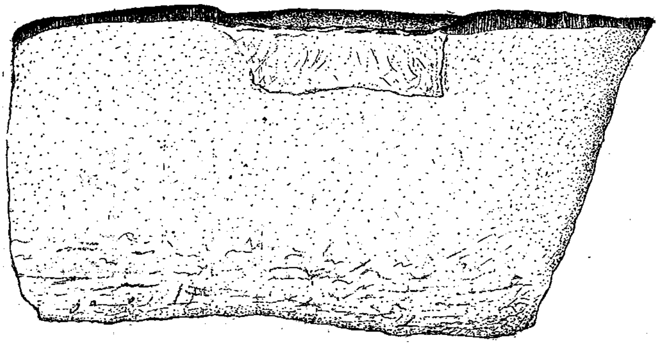
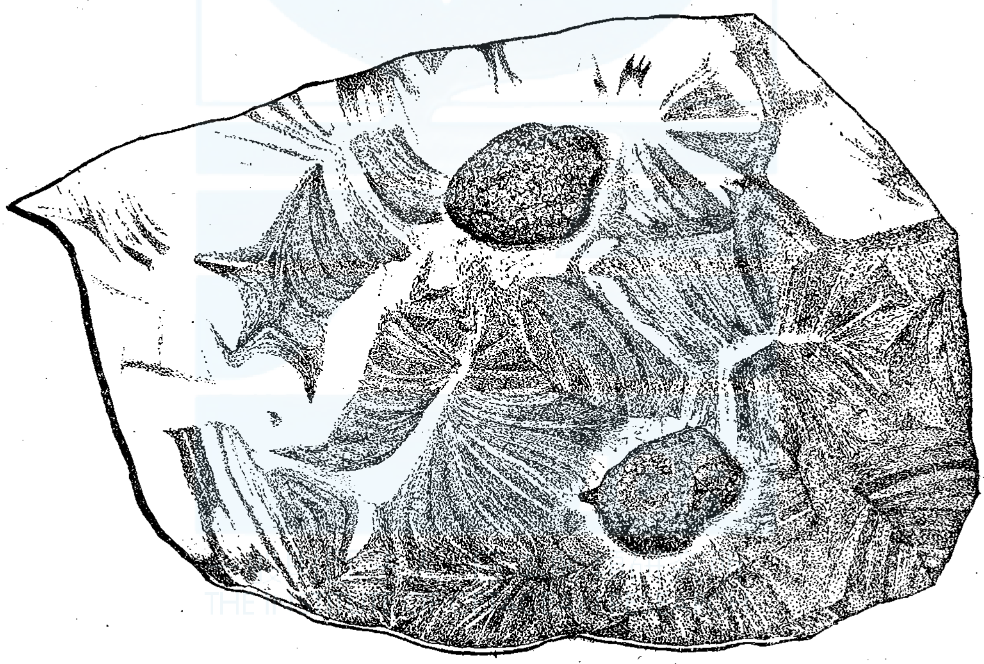


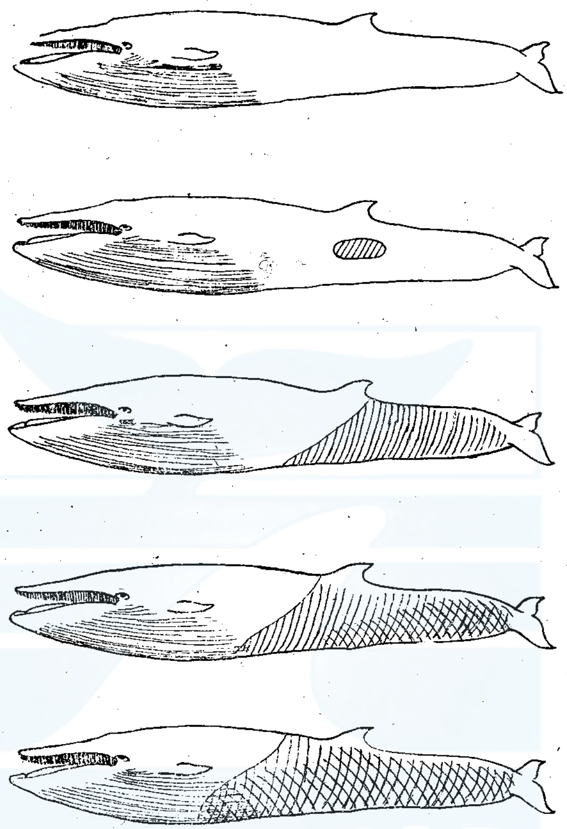
Fig. 25. Sei whale. Light coloured spots.
O. P. ....Open pit



male 46 ft., which was caught in the adjacent sea of Bonin Island on 29 March, 1948. Its location was just below the dorsal fin. The two ellipses shown in the Figure are open pits, which look as though blubber were scooped out with a spoon. The other marks are the so-called "new galvanized appearance"; without any doubt these are older white scars. Generally speaking, therefore, it would be reasonable to say that a whale with many light-coloured spots is one of considerable age.

The stages in the development of light coloured spots are shown in Fig. 26.

Fig. 26. Sei whale. Development of light-coloured spots.



Briefly stated, these spots seemed to be caused by the white scars which develop and change the original skin colour, and finally give a different appearance to the whale. Though white scars are seen on almost all sei whales such is not always the case with light coloured spots. It would therefore seem that the formation of light coloured spots depends upon a certain external condition, — probably water temperature, and hence closely connected with their migration.

Table 23 shows development of light coloured spots classified according to maturity and sex. As seen in Table 23, there is some difference between male and female, and that in both sexes there are fewer and less developed spots in the immature than in the mature. When male and fe-

Table 23. Sei whale. Difference of light-coloured spots presence by sex and maturity. Shown in percentage.

	Immature			Mature		
	Male	Female	Total	Male	Female	Total
Number observed	100	109	209	159	160	319
None	51.0	42.2	46.4	38.4	27.5	32.9
Few	22.0	24.8	23.4	14.5	20.0	17.2
Moderate	26.0	26.6	26.3	37.1	32.5	34.8
Many	1.0	6.4	3.9	10.0	20.0	15.1

male are totalled, "none" and "few" are about 7% of total immature and about 50% of total mature. Whales with well developed spots constitute only about 4% of total immature, and 15% of total mature, indicating that light coloured spots develop with increase in age. As compared with female, male has better developed spots. That is true of both immature and mature. It probably means that the females stay in the southern warm seas for a longer period than the males. For spots are due to white scars, and scars are attributable to open pits which have been formed while in warm seas. Could this fact have some relation to the nurturing of calves? In any case, there may be some difference of migration between male and female.

The details by area are as shown in Table 24.

Table 24. Sei whale. Difference of light-coloured spots presence by ground. Shown in the percentage figure.

	Bonin Island			Ayukawa-Kamaishi			Kushiro-Kiritappu		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Number observed	98	96	194	103	91	194	74	102	176
None	23.5	15.6	19.6	76.7	74.7	75.8	17.6	13.7	15.3
Few	19.4	21.9	20.6	1.0	6.6	3.6	37.8	37.3	37.5
Moderate	45.9	44.8	45.4	19.4	16.5	18.0	35.1	28.4	31.3
Much	11.2	17.7	14.4	2.9	2.2	2.6	9.5	20.6	15.9

The number of whales with light coloured spots varies greatly by area. They are extremely rare in the Ayukawa-Kamaishi area and most numerous in the Kushiro-Kiritappu area, with the Bonin Islands coming in between. But when the Kushiro-Kiritappu area is compared with the Bonin Island area, we find more "few" in the former and more "moderate" in the latter. This phenomenon is probably closely related to their migration. The development of spots is due primarily to the existence of many open pits. But it is thought that their development into light coloured spots through the intermediate state of white scars requires their stay in low temperature area. That is probably the reason why there are more whales with spots in the Kushiro-Kiritappu area. The whales in this area, however, stay in the warm sea for so short a time and hence have so few chances for the formation of many open pits, that there may be many whales for which the stage of developement must be classified as "few" notwithstanding that the percentage having light coloured spots is high. The difference between Ayukawa-Kamaishi and Kushiro-Kiritappu may be partly due to the fact that in the latter area the whales are caught while migrating southward from off Kurile Islands, while in the Ayukawa-Kamaishi area they are caught while migrating northward as well as when returning southward.

In the Bonin Island area, more whales with spots are caught than in Ayukawa-Kamaishi area. The explanation is that more mature whales are caught around Bonin Islands. In the Bonin Island area, the minimum size permitted to be caught is 40 ft. in length because of operation with factory-ship; and in other areas 35 ft. As will be mentioned later, however, whales at sexual maturity are considerably shorter in the Bonin area than elsewhere. That explains why in the Bonin area the percentage of immature caught is low. The fact that there are more whales with light-colored spots in the Bonin Island is probably due to the fact that light colored spots are more often found on mature whales than on the immature.

The number of white scars not developed to the stage of light coloured spots was recorded by area in Table 25.

Table 25. Sei whale. Number of white scars. Shown in the percentage figure.

	Bonin Island			Ayukawa-Kamaishi			Kushiro-Kiritappu		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Number observed	109	100	209	185	137	322	96	141	237
None	13.8	7.0	10.5	0	2.9	1.2	2.1	0.8	1.2
Few	16.5	8.0	12.4	25.9	22.6	24.5	42.7	26.2	32.9
Moderate	21.1	23.0	22.0	28.6	32.1	30.1	32.3	39.0	36.3
Many	43.1	57.0	49.8	40.0	35.8	38.2	14.6	24.1	20.3
Numerous	5.5	5.0	5.3	5.5	6.6	6.0	8.3	9.9	9.3

In the Bonin Island area about 10% of the total have "None"; and in other areas the percentage is much lower. Those with "Many" constitute about 50% of the total in the Bonin Island area, and somewhat less in other areas. The presence of more whales with many white scars in the Bonin Island area may be explained by the fact that Bonin Island whales do not migrate very far north; but it is not so easy to explain the reason for the relative abundance there of whales with "none".

In the Ayukawa-Kamaishi area, whales with no scars are about as many as in the Kushiro-Kiritappu area, being a little less than 1 per cent of Total. In the former area, there are more whales with "many" scars and in the latter area, there are more "few" and "moderate". This agrees with the fact mentioned in paragraph "light-coloured spots". Namely, more whales with spots are captured in the Kushiro-Kiritappu area, but the spots are not highly developed, probably due to the abundance of whales with few white scars. If the number of white scars is in proportion to the length of period which whales stay in the warm seas, it must mean that the Kushiro-Kiritappu whales do not migrate to such low latitudes or, even if they do, their stay there is short.

c. External parasites.

External parasites were not so often recorded for Sei whales. Pennella sp. was found on 7 males and 8 females in the Bonin Island area and on 5 males and 4 famales in the Ayukawa area. The number found per whale was normally from 1 to 5, and the highest was 19. The place of infection varied. As for other parasites, there were only 1 instance of coronula sp. infection and 2 of conchoderma infection. A female which was captured in the Ayukawa area was infected with many coronula sp. on its tail flukes. This female was found to be infected with conchoderma sp. also. The other instance of conchoderma sp. infection was found on the baleen plate of a female which was caught in the Akkeshi area.

d. Thickness of blubber.

Regarding thickness of blubber, as shown in Table 26, 900 Sei whales were measured at Point 1 and 870 at Point 2.

The results were as shwon in Figs. 27 to 30, by area and body length. In preparing these figures, whales whose blubber thickness measurement was less than 3 were excluded, as were pregnant females. As can be seen from

Fig. 27. Sei whale. Average thickness of blubber. Male. Point 1.

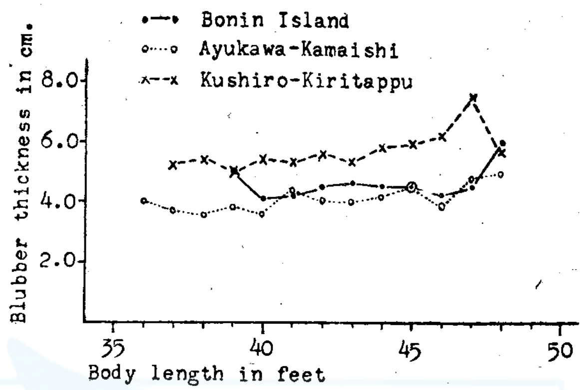


Fig. 28. Sei whale. Average thickness of blubber. Male. Point 2.

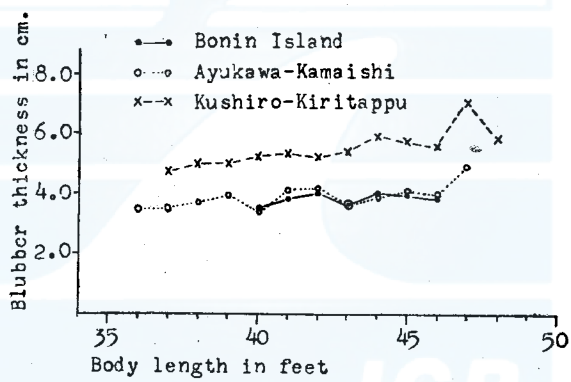


Fig. 29. Sei whale. Average thickness of blubber. Female. Point 1.

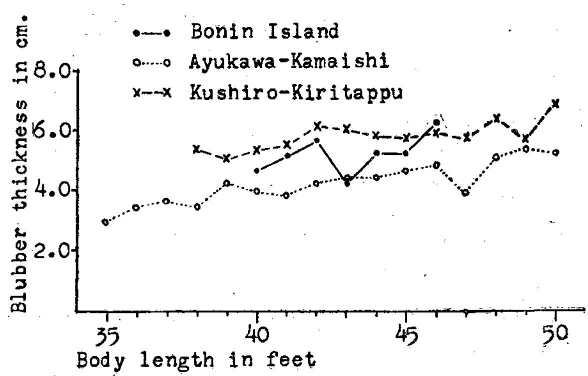


Fig. 30. Sei whale. Average thickness of blubber. Female. Point 2.

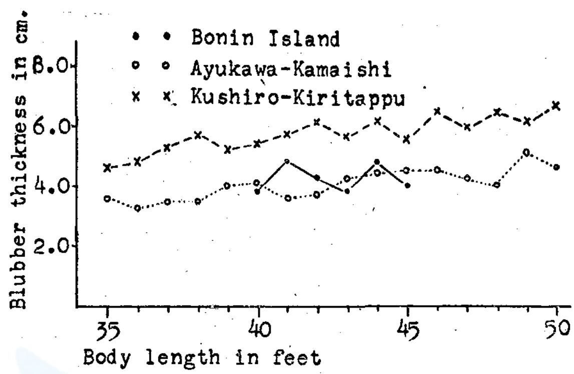


Table 26. Sei whale. Number of measurements of blubber thickness.

	Point 1			Point 2		
	Male	Female	Total	Male	Female	Total
Bonin Island	61	101	162	73	70	143
Ayukawa-Kamaishi	262	193	455	254	185	439
Kushiro-Kiritappu	122	161	283	122	166	288
Total	445	455	900	449	421	870

these tables, thickness of blubber increases in proportion to the increase of body length for both male and female, although with considerable differences according to areas. Points 1 and 2 show the same general trend. The thickest blubber is seen in the Kushiro-Kiritappu area and the thinnest in the Ayukawa-Kamaishi area. Though in Fig. 28, the whales in the Bonin Island are seen to have the thinnest blubber, we may safely say it is nearly as thick as in Ayukawa-Kamaishi area. From the latitudinal point of view, the Kushiro-Kiritappu area is located the farthest north, followed by Ayukawa-Kamaishi area; and the Bonin Island area is the farthest south. And the best season in the Bonin Islands, moreover, is from winter to spring. Consequently, one might well expect the blubber to be the thinnest there. So the explanation must be that although the Bonin area is located the farthest south, this area, unlike the Ayukawa-Kamaishi area, has such favorable oceanographical conditions that there is more abundant food for sei whales.

Various parts of sei whales which were caught in the Bonin Island area and the Kamaishi area in 1948 and 1949, were weighed. From this result too, blubber of sei whales in the Bonin Island was found to be heavier than those in the Kamaishi area.

The blubber weight of whales in the Bonin Island area was 25.4 % of the total body weight on the average, and only 17% in the Kamaishi area.

For a further study of this relationship, calculation was made of the relation of thickness of blubber to body length in terms of percent by months, for the 3 areas, as shown in Figs. 31 to 34.

Fig. 31. Sei whale. Blubber thickness expressed as percentage of total length, by months.
Male. Mature.

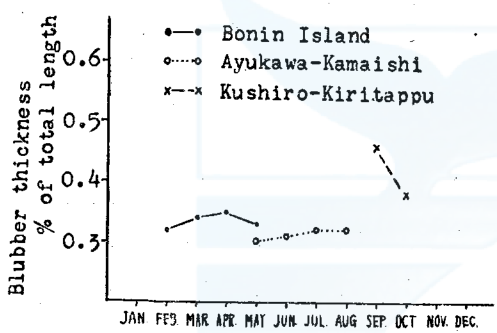


Fig. 32. Sei whale. Blubber thickness expressed as percentage of total length, by months.
Male. Immature.

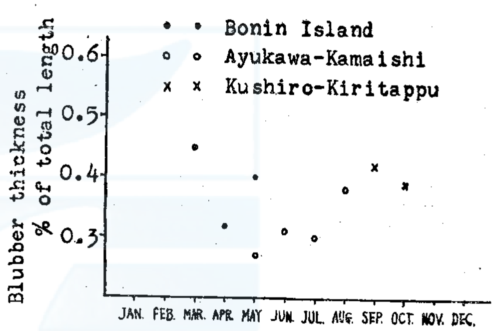


Fig. 33. Sei whale. Blubber thickness expressed as percentage of total length, by months.
Female. Mature.

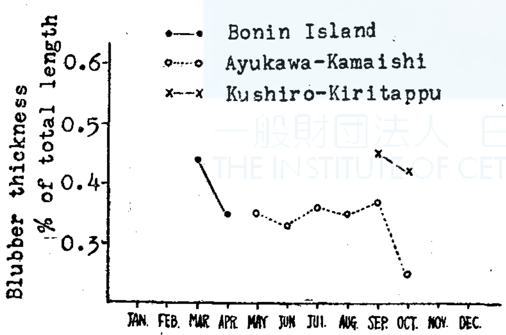
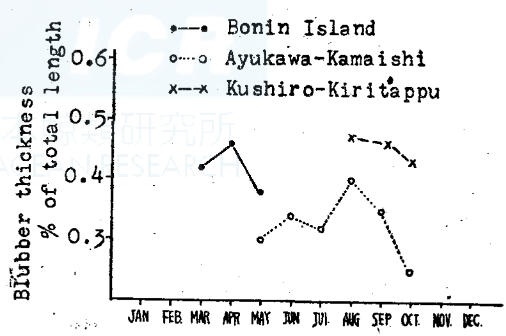


Fig. 34. Sei whale. Blubber thickness expressed as percentage of total length, by months.
Female. Immature.



Since nearly the same trend is seen at Points 1 and 2, only the former was indicated in these Figures by maturity and sex. In these figures, as in Figs. 27 to 30, pregnant females were omitted. In the Bonin Island area, excepting the immature males, blubber is thin in the early parts of the whaling season and becomes thick in mid-season, then becomes thin again towards the end.

The trend is the same in the Ayukawa-Kamaishi area, — the blubber being thin around May, becoming thicker till August, and then suddenly thin. In the Kushiro-Kiritappu area, the blubber is thickest early in the season (Aug. to Sept), and thins rapidly by October. Generally speaking, blubber is the thickest in the Kushiro-Kiritappu, and next, in the Bonin Island area, and the thinnest in the Ayukawa-Kamaishi area. The tendency of blubber setting thicker as the season advances in the Kushiro-Kiritappu area is closely related to migration. Sei whales caught in this area are those which had stopped there on their way south from the Kurile Islands to which they had earlier migrated. Owing to abundant food off the Kurile Islands, they grow fat while staying there. But as food is less abundant off Kushiro-Kiritappu, the blubber gets thin there.

e. Food.

In regard to stomach contents, 215 Sei whales were recorded in the Bonin Island area, 475 whales, in the Ayukawa-Kamaishi area and 344 whales, in the Kushiro-Kiritappu area. The results by area are as shown in Table 27.

Table 27. Sei whale. Stomach content.

	Bonin Island	Ayukawa-Kamaishi	Kushiro-Kiritappu
Number of whales observed	215	475	344
Empty	71 (33.0)	223 (46.9)	211 (61.3)
Few	35 (16.3)	119 (25.0)	65 (18.9)
Moderate	52 (24.2)	92 (19.4)	37 (10.8)
Rich	33 (15.3)	27 (5.7)	22 (16.4)
Full	24 (11.2)	14 (3.0)	9 (2.6)

Note : Figures in parenthesis show the percentage.

Those with empty stomachs were most numerous in Kushiro-Kiritappu, followed by Ayukawa-Kamaishi and the Bonins in that order. Those whose stomach contents are designated as "few" were also most numerous in Ayukawa-Kamaishi and Kushiro-Kiritappu, while in the Bonin Island area the "moderate" were the most numerous, and the "Rich" and "Full", too, were far more numerous in the Bonin Island than in other areas. This means that the Bonin Island area is the richest in food for sei whales. It was explained in paragraph (d) "Thickness of blubber" that blubber of whales in Bonin Island is thicker than that of whales in the Ayukawa-Kamaishi area. It can now be understood that that was due to the more abundant food, and it was mentioned that blubber becomes thinner with the advance of the whaling season in the Kushiro-Kiritappu area. From this table, it can be seen that that is due to the less abundant food. The variation in stomach contents by months in each whaling ground is shown in Tables 28 to 30.

Table 28. Sei whale. Monthly variation of Stomach content.
Bonin island.

	February	March	April	May
Number of whales observed	11	58	93	53
Empty	9 (81.8)	17 (29.3)	30 (32.3)	15 (28.3)
Few	2 (18.2)	6 (10.4)	13 (14.0)	14 (26.4)
Moderate	0	9 (15.5)	32 (34.4)	11 (20.8)
Rich	0	14 (24.1)	11 (11.8)	8 (15.1)
Full	0	12 (20.7)	7 (7.5)	5 (9.4)

Note : Figures in parenthesis show the percentage.

Table 29. Sei whale. Monthly variation of Stomach content.
Ayukawa-Kamaishi

	May	June	July	August	September	October
Number of whales observed	55	164	142	95	10	9
Empty	32 (58.2)	51 (31.1)	82 (57.7)	52 (54.7)	4 (40.0)	4 (44.4)
Few	12 (21.8)	52 (31.7)	26 (18.3)	23 (24.2)	1 (10.0)	1 (11.2)
Moderate	10 (18.2)	44 (26.8)	21 (14.8)	13 (13.7)	2 (20.0)	4 (44.4)
Rich	0	13 (7.9)	9 (6.3)	4 (4.2)	1 (10.0)	0
Full	1 (1.8)	4 (2.5)	4 (2.9)	3 (3.2)	2 (20.0)	0 0

Note : Figures in parenthesis show the percentage.

As these tables show, there are some months for which there are very few data. No comparison is possible between such months and other months for which there is abundant data. The percentages, however, have been calculated. For all of the areas, no great difference by month could be discerned, with the one exception that in the Ayukawa-Kamaishi area,

Table 30. Sei whale. Monthly variation of Stomach Content. Kushiro-Kiritappu.

	August	September	October
Number of whales observed	10	192	142
Empty	2 (20.0)	119 (62.0)	90 (63.4)
Few	1 (10.0)	37 (19.3)	27 (19.0)
Moderate	1 (10.0)	21 (10.9)	15 (10.6)
Rich	4 (40.0)	10 (5.2)	8 (5.6)
Full	2 (20.0)	5 (2.6)	2 (1.4)

Note : Figures in parenthesis show the percentage.

there was more abundant food in June than in other months.

As for kinds of food, plankton was Euphausia and Copepoda and fish were principally sardines. In some cases mackerel, herring and saurypike were found. Squid was sometimes seen also. In the Bonin Island area, there was 1 instance of Decapoda.

Kinds of foods by area are as shown in Table 31.

Table 31. Sei whale. Kind of food.

	Bonin Island	Ayukawa-Kamaishi	Kushiro-Kiritappu
Euphausia or Copepoda	70	76	118
Sardine	72	59	3
Mackerel	0	8	2
Herring	0	0	3
Saury	0	0	2
Squid	0	9	5
Decapoda	1	0	0
Other	1	0	0

As Euphausia and copepoda were recorded in some cases separately and together in others, they are not treated separately here. Since these investigations are being continued. In the future reports they are to be classified separately. Where several kinds of foods were mixed, they were all recorded under the kind which was largest in quantity.

As seen in Table 31, in the Bonin Island area and the Ayukawa-Kamaishi area sardine, as well as Euphausia or Copepoda, are the principal food while in the Kushiro-Kiritappu area food was nearly all Euphausia or Copepoda. Other kinds of foods were also found, but only rarely. "Other" in the column "Bonin-Island" are fish eyes; and although it is not clear from the record, the other parts were probably digested in some stomach, other than the first stomach, leaving only the eyes there.

Table 32. Sei whale. Difference of food by month.

Ground	Month	Euphausia or copepoda	Sardine	Mackerel	Herring	Saury	Squid	Decapeda	Other
Bonin Island	Feb.	2	0	0	0	0	0	0	0
	Mar.	25	15	0	0	0	0	1	1
	Apr.	25	37	0	0	0	0	0	0
	May	18	20	0	0	0	0	0	0
Ayukawa-Kamaishi	May	23	1	0	0	0	0	0	0
	June	110	0	3	0	0	1	0	0
	July	30	21	5	0	0	4	0	0
	Aug.	11	28	0	0	0	4	0	0
	Sept.	0	6	0	0	0	0	0	0
	Oct.	2	3	0	0	0	0	0	0
Kushiro-Kiritappu	Aug.	7	0	1	0	0	0	0	0
	Sept.	68	0	1	1	0	4	0	0
	Oct.	43	3	0	2	2	1	0	0

Table 32 shows the variation of kinds of foods by month. There were more Euphausia or Copepoda than sardines in the Bonin Island till March. From April, sardines were the more numerous. The same was true of the Ayukawa-Kamaishi area, with some time-lag. Namely, almost all the food was Euphausia or Copepoda in May and June; sardines were found in considerable numbers in July; and from August on, sardines were the principal food.

In the Kushiro-Kiritappu area, other foods were found in all the months, but principal food was Euphausia or Copepoda.

As mentioned above, there is a monthly variety in kinds of foods. That probably is not because the sei whale chooses from among the kinds available, but probably because there are more chances for the whale to eat the kind of food that is most abundant.

f. Genitalia and Maturity.

For 95 females in the Bonin Island area, 185 females in the Ayukawa-Kamaishi area and 159 females in the Kushiro-Kiritappu area, it was observed whether their ovaries had corpus luteum or not; and, if they had, the number of corpus luteum was counted and the weight of ovaries measured. In addition, there were some whales for which observation could be made of only one of the ovaries by reason of the other ovary having gotten lost while the whale was being towed or in process of dissection. But when such data could be effectively utilized, such as for weight of ovary alone, they were used with the above data. On the basis of the above data, whales with 1 or more corpora lutea in their ovary were regarded as mature and those without any corpora luteum, as immature.

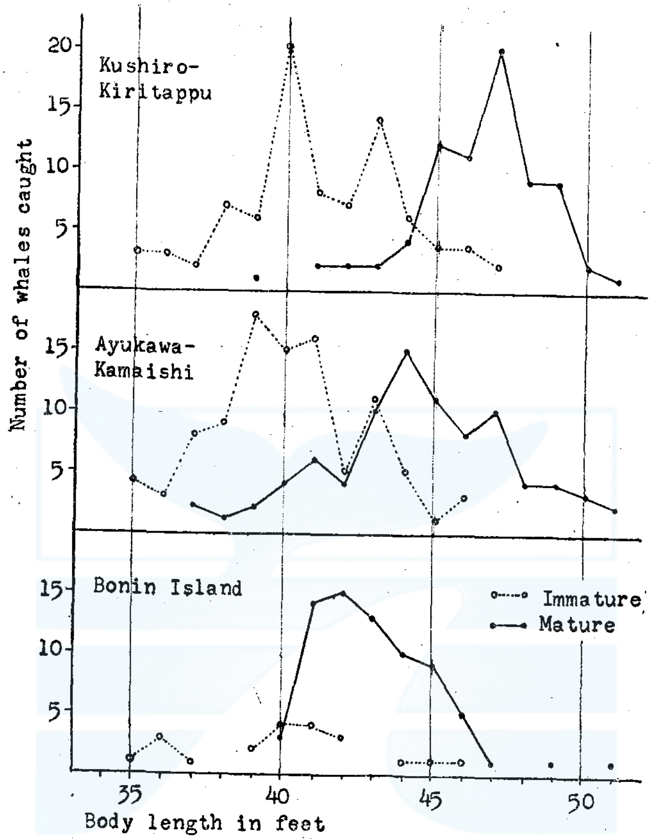
Table 33. Sei whale. Number of .immature and Mature female whales in each length.

Body length in ft.	Bonin island			Ayukawa-Kamaishi			Kushiro-Kiritappu		
	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total
33	0	0	0	1	0	1	0	0	0
34	0	0	0	0	0	0	0	0	0
35	1	0	1	4	0	4	3	0	3
36	3	0	3	3	0	3	3	0	3
37	1	0	1	8	2	10	2	0	2
38	0	0	0	9	1	10	7	0	7
39	2	0	2	18	2	20	6	1	7
40	4	3	7	15	4	19	20	0	20
41	4	14	18	16	6	22	8	2	10
42	3	15	18	5	4	9	7	2	9
43	0	13	13	11	10	21	41	2	16
44	1	10	11	5	15	20	6	4	10
45	1	9	10	1	11	12	3	12	15
46	1	5	6	3	8	11	3	11	14
47	0	1	1	0	10	10	2	20	22
48	0	0	0	0	4	4	0	9	9
49	0	1	1	0	4	4	0	9	9
50	0	0	0	0	3	3	0	2	2
51	0	1	1	0	2	2	0	1	1
52	0	0	0	0	0	0	0	0	0
Total	21	72	93	99	86	185	84	75	159
%	22.6	77.4	100.0	53.5	46.5	100.0	52.8	47.2	100.0

Table 33 shows the results classified by body length. The body length at which maturity is reached shows a considerable difference according to locality. For instance, in the Bonin Island area, whales 41 ft. or longer may be regarded as mature. In the Ayukawa-Kamaishi and the Kushiro-Kiritappu areas, however, whales of 41 ft. length that are still immature far outnumber those of the same length that are mature. 41 feet in the Bonin Island area corresponds to 44 ft. in the Ayukawa-Kamaishi area, and 45 ft. in the Kushiro-Kiritappu area. This relation can be seen more clearly in Fig. 35, in which table 33 has been reduced to chart form.

In the 1937 International Agreement for the Regulation of Whaling, there was no restriction as to body length for sei whales. But the Japanese Regulation prohibited the catching of whales less than 35 ft. long, both for

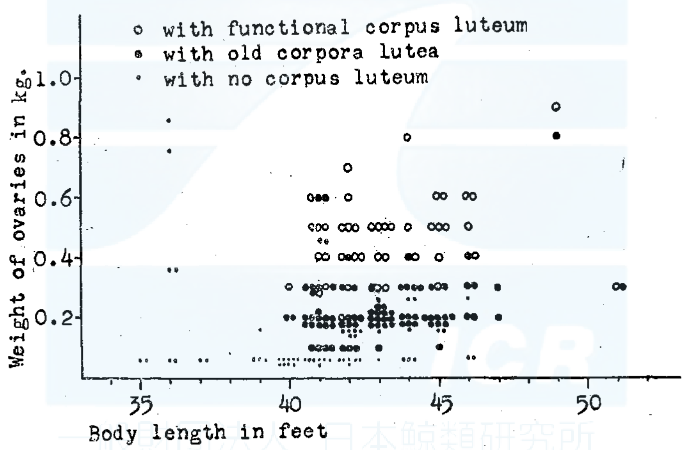
Fig. 35. Sei whale. Mature and immature females observed in three areas.



landstations and factory ships. The International Convention for the Regulation of Whaling which was signed at Washington on Dec. 2, 1946 fixed the limit at 40 ft, but allowed catches down to 35 ft. in case of landstation whaling. As this convention took effect in October, 1948, the limited body length of sei whales in the Bonin Island area which was 35 ft. in 1948 was raised to 40 ft. from 1949. As compared with other areas, therefore, there is less material available on sei whales of less than 40 ft. for the Bonin Island area. But that fact does not have any effect upon the decision to set 41 ft. and over as the body length at which sexual maturity is attained in the Bonins. In any case, from Fig. 35 we may consider 41 ft. and over in the Bonin Island area, 44 ft. and over in the Ayukawa-Kamaishi area and 45 ft. and over in the Kushiro-Kiritappu area as body length at which sexual maturity is reached. According to Matthews, female sei whales located in the Antarctic come to sexual maturity at the length of 14.5 meters: (47 ft. 7 inches) this is 48 ft. under the measuring method provided for in the Present Convention. As compared with this length, all sei whales located in the adjacent seas of Japan are smaller, — the difference for the Bonin Islands being about 7 ft. Of the sei whales caught in the Bonins, only 2 were 48 ft. or over; that number is but 2.15% of the total caught in that area.

Table 33 shows the ratio between mature and immature in each area. Immature is 22.6% in the Bonin Island Area and about 53% in both Ayukawa-Kamaishi and Kushiro-Kiritappu areas. This is due to the fact that though sei whales in the Bonin Island area become adult at smaller size than those in other areas, the minimum body length is fixed at 40 ft. for the Bonin Island area (because of factory ship operation) and 35 ft. for other areas. This is an illogical situation which should be corrected soon.

Fig. 36. Sei whale. Weight of Bonin island.



Figs. 36 to 38 show weight of ovary by areas. In this respect, too, the Bonin Island area show a different trend from other areas. In the Bonin Island area, the weight of ovary of immature (with no corpus luteum in ovary) was 0.3 kg. or less, with a few exceptions. Those of 0.1 kg. or even lighter were most numerous. In the Ayukawa-Kamaishi and Kushiro-Kiritappu areas, the weight was generally less than 0.5 kg. and most often under 0.2 kg. The heaviest ones were about 0.6 kg. in the Bonin Island, with a few exceeding that. In other areas there were a

Fig. 37. Sei whale. Weight of ovaries. Ayukwa-Kamaishi.

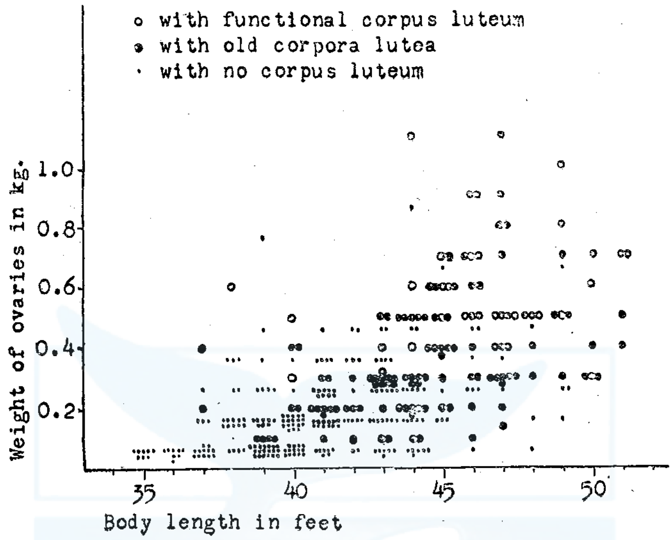
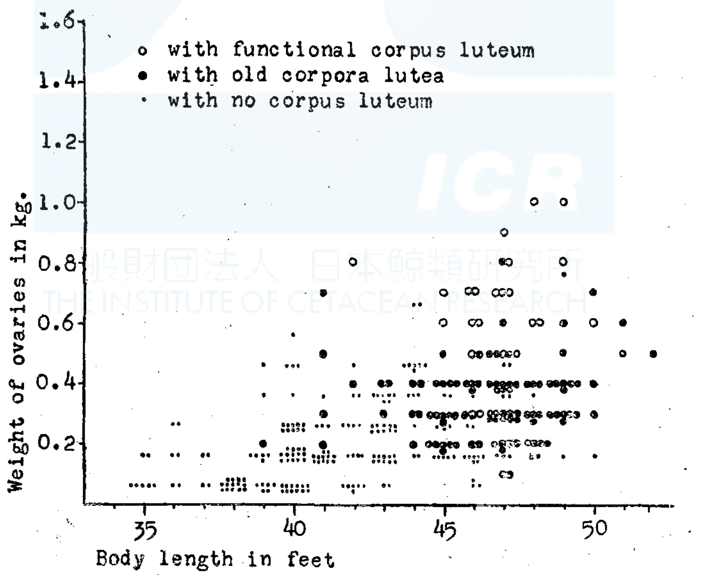


Fig. 38. Sei whale. Weight of ovaries. Kushiro-Kiritappu



considerable number of ovaries over that figure, and the heaviest one was 1,6 kg. which was seen in the Kushiro-Kiritappu area.

Figs. 39 to 41. show the number of Corpora lutea by body length and area. The maximum far all the areas was 20, with Kushiro-Kiritappu area alone having exceptions of 21 and 22.

In the Bonin Island area, there were comparatively few whales with small number of corpora lutea, but great many in the other two areas.

This relation can be seen more clearly in Fig. 42. Namely, in the Ayukawa-Kamaishi and Kushiro-Kiritappu areas those with only 1 corpora

Fig. 39. Sei whale. Female. Number of corpora lutea. Bonin island.

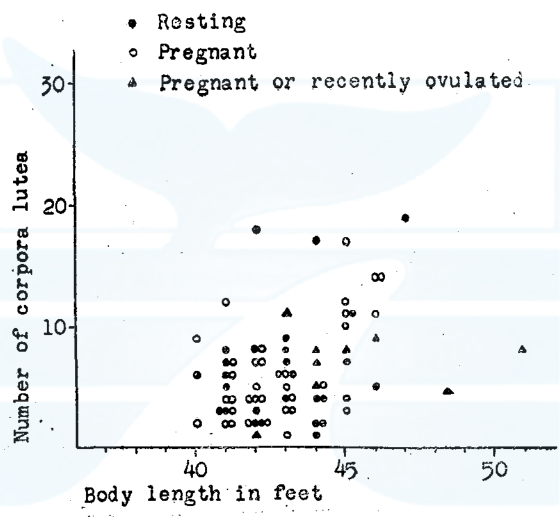
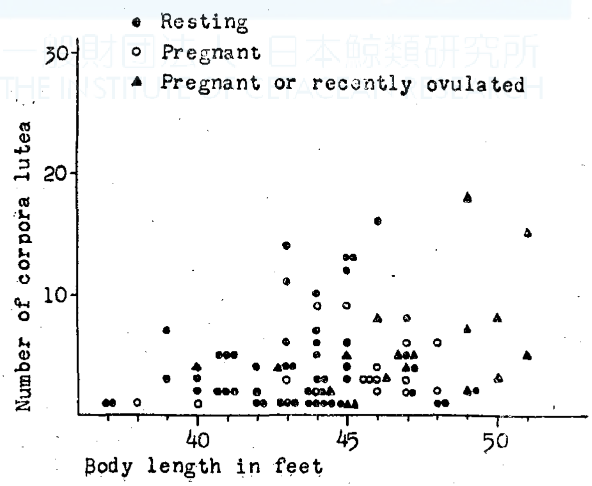


Fig. 40. Sei whale. Female. Number of corpora lutea. Ayukawa-Kamaishi.



lutea were the most numerous, followed by those having 2 and 3; while in the Bonin Island area the maximum was 4, and those with only 1 were far fewer than in the other 2 areas.

Fig. 41. Sei whale. Female. Number of corpora lutea. Kushiro-Kiritappu.

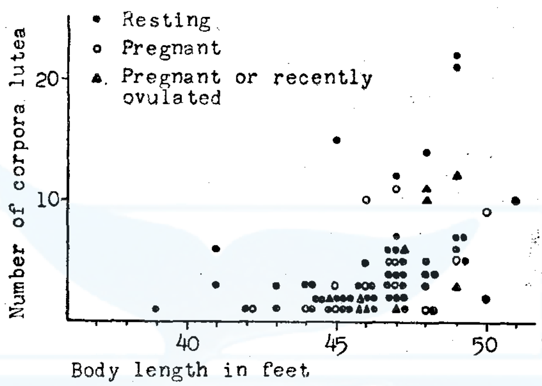
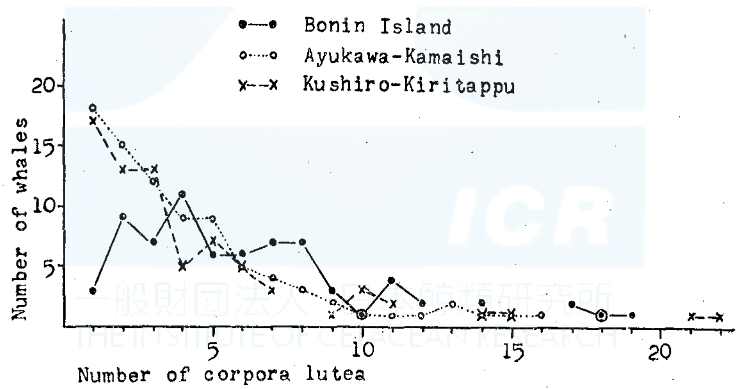


Fig. 42. Sei whale. Female. Number of corpora lutea.



Figs. 43 to 45 show the thickness of mammary gland. The small number of no-parous glands measured for the Bonin Island area made it impossible to compare the thickness of mammary gland of the 3 areas. There does, however, seem to be some difference in that respect between the Ayukawa-Kamaishi area and the Kushiro-Kiritappu area. The thickest of non-parous glands was about 3 cm. thick in the latter area but about 4 cm. in the former area. Involuted glands were generally thicker in the Bonin

Fig. 43. Sei whale. Thickness of mammary gland.
Bonin island

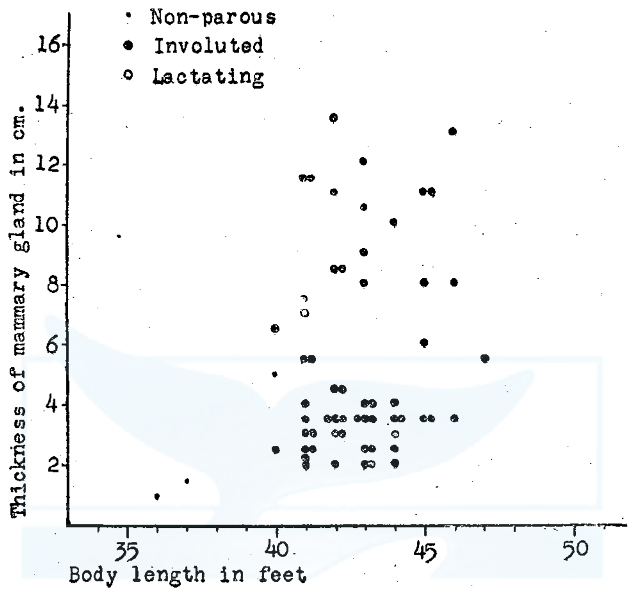


Fig. 44. Sei whale. Thickness of mammary gland.
Ayukawa-Kamaishi

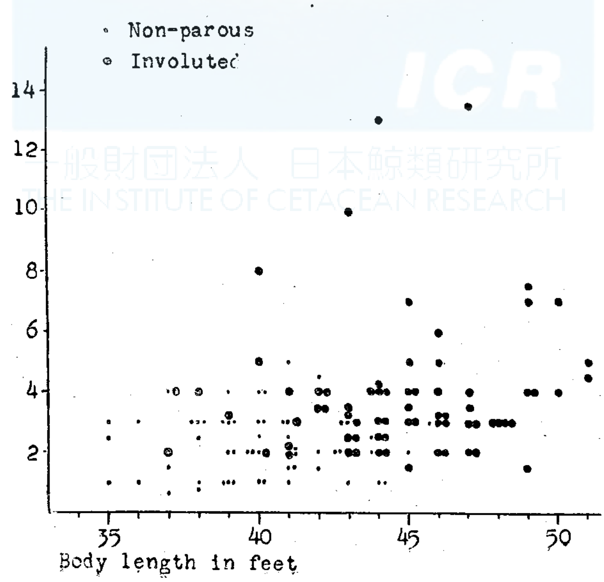
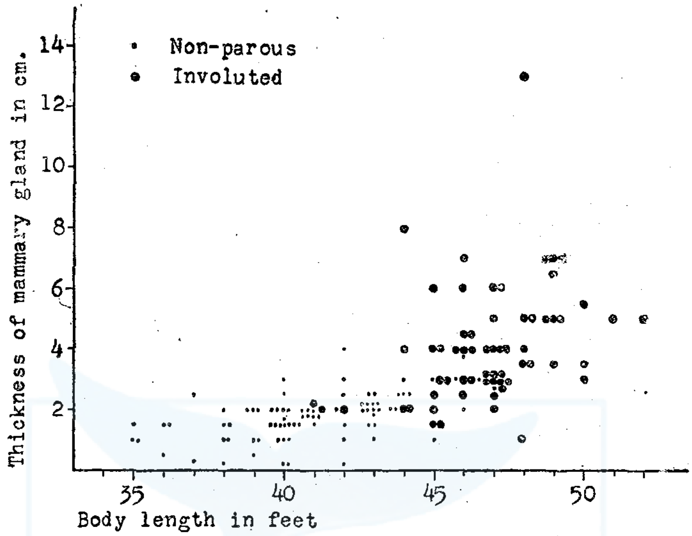


Fig. 45. Sei whale. Thickness of mammary gland. Kushiro-Kiritappu.



Island area than those in other areas. But it is not known whether this difference is due to group or seasonal differences. From what has been explained above, it may be said that female sei whales in different areas belong to different groups. The Ayukawa-Kamaishi area and the Kushiro-Kiritappu area have much in common, but the Bonin Island area plainly differs on the various points above mentioned. So, it would appear that the sei whales in the adjacent waters of Japan consist of at least 2 local races, northern and southern. But as it is necessary for this question to be studied for males also, and it has some relation to migration, it will be further discussed later.

The volume and weight of testis were measured for 99 males in the Bonin Island area, 226 males in the Ayukawa-Kamaishi area and 121 males in the Kushiro-Kiritappu area. There were, in addition, some whales of which only the right or the left testis was measured; but those data were also used whenever possible.

In Figs. 46 to 48, volume of testis of male sei whales in each area was plotted by body length. As shown in these Figures, the farther north the area is, the greater the volume of testis of immature whales seems to be even in the mature whales, the volume of testis is definitely greater in the Kushiro-Kiritappu area than in the Bonin Islands.

Fig. 46. Sei whale. Volume of testis. Bonin island.

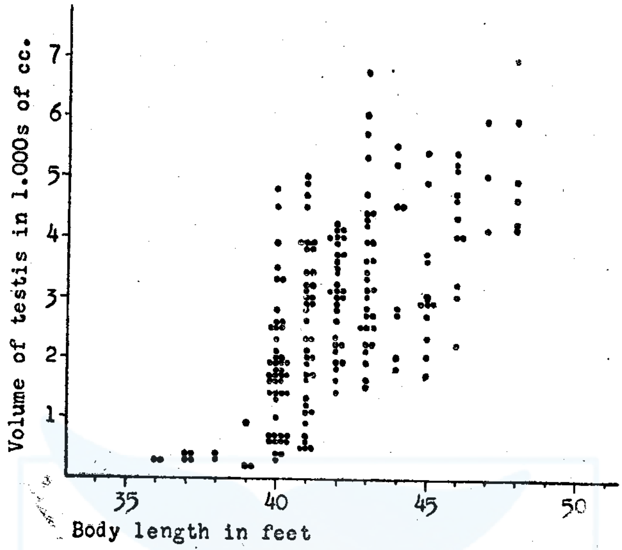


Fig. 47. Sei whale. Volume of testis. Ayukawa-Kamaishi

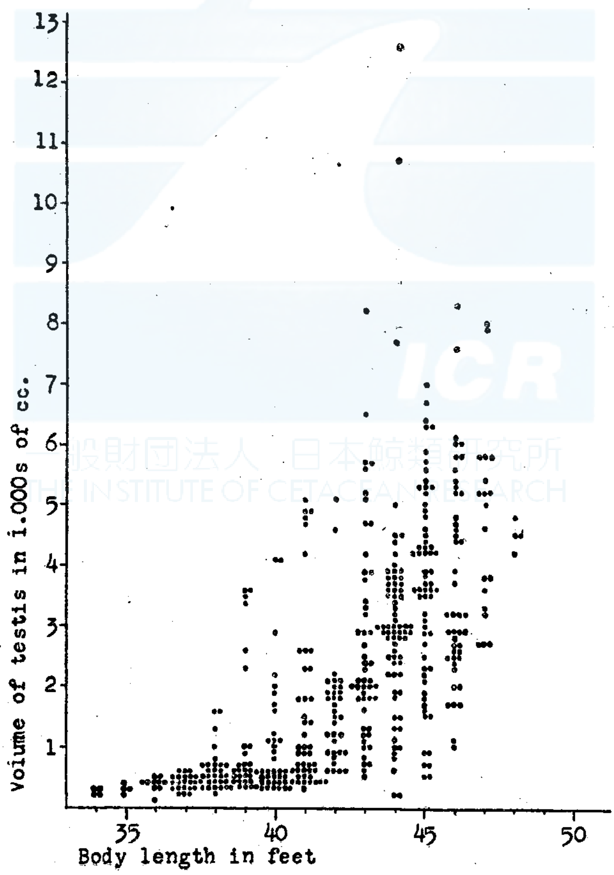


Fig. 48. Sei whale. Volume of testis. Kushiro-Kiritappu

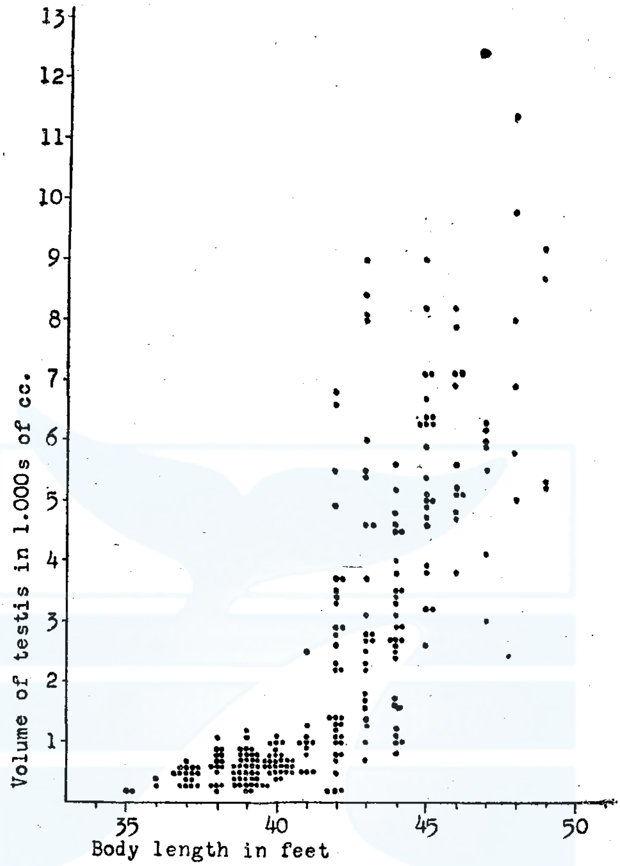
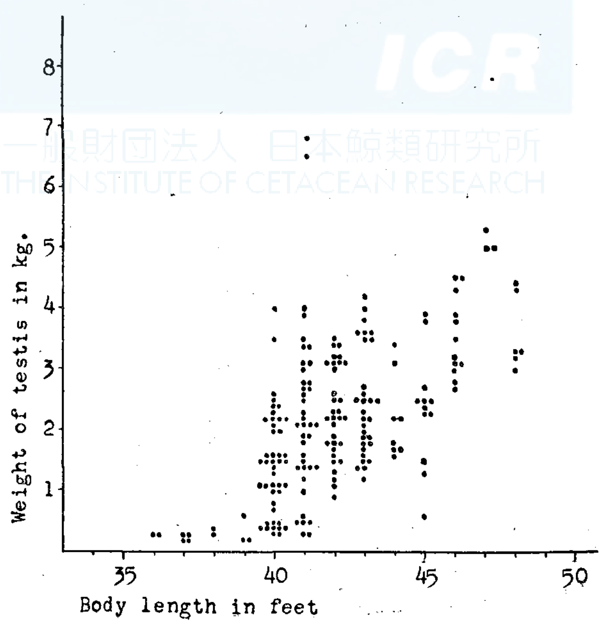


Fig. 49. Sei whale. Weight of testis. Bonin island.



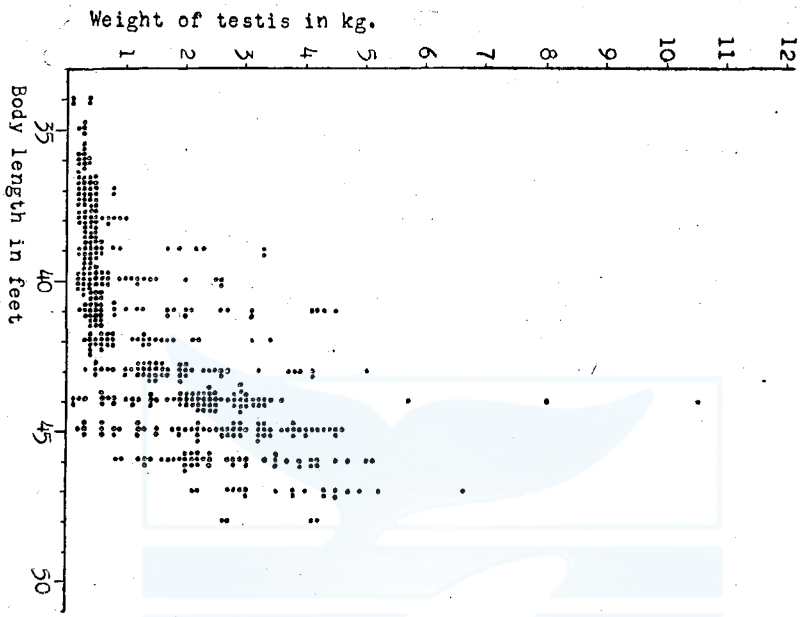


Fig. 50. Sei whale. Weight of testis. Ayukawa-Kamaishi

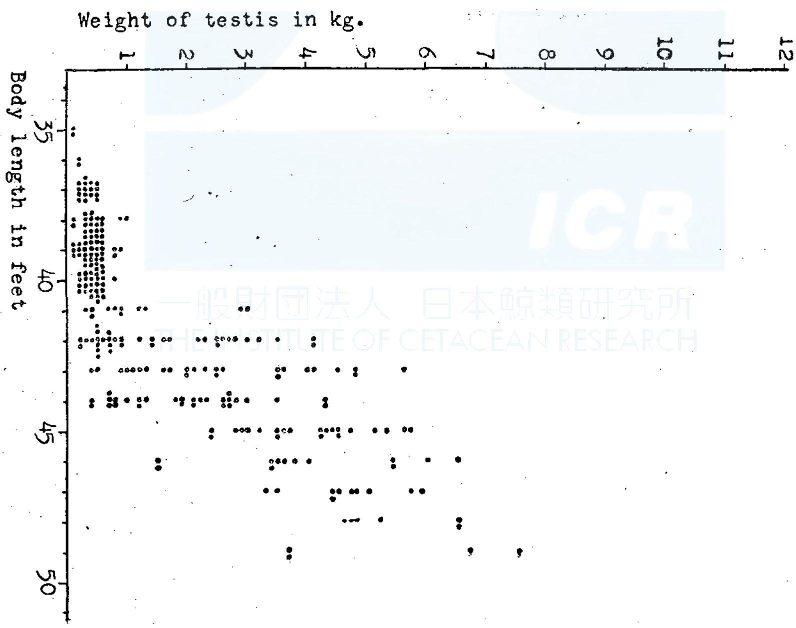


Fig. 51. Sei whale. Weight of testis. Kushiro-Kiritappu

In Figs. 49 to 51, the weight of testis was plotted by body length. Regarding weight also, the same thing can be said as was said regarding volume for these 3 areas. From tne above Figures on volume and weight, male sei whales in the adjacent seas of Japan whose testis is 1.5 or less in volume and 1 kg. or less in weight can be regarded as immature, and those over those figures, as mature.

Table 34. Sei whale. Number of immature and mature male whales in each length.

Body length in ft.	Bonin Island			Ayukawa-Kamaishi			Kushiro-Kiritappu		
	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total
34	0	0	0	2	0	2	0	0	0
35	0	0	0	2	0	2	1	0	1
36	1	0	1	3	0	3	1	0	1
37	2	0	2	9	0	9	7	0	7
38	1	0	1	11	1	12	6	0	6
39	1	0	1	9	3	12	17	0	17
40	8	15	23	13	4	17	14	0	14
41	2	15	17	12	8	20	4	1	5
42	0	16	16	6	10	16	9	9	18
43	0	15	15	4	21	25	1	11	12
44	0	5	5	4	31	35	2	12	14
45	0	6	6	3	32	35	0	11	11
46	0	7	7	1	25	26	0	6	6
47	0	2	2	0	10	10	0	4	4
48	0	3	3	0	2	2	0	3	3
49	0	0	0	0	0	0	0	2	2
Total	15	84	99	79	147	226	62	59	121
%	15.2	84.8	100.0	35.0	65.0	100.0	51.2	48.8	100.0

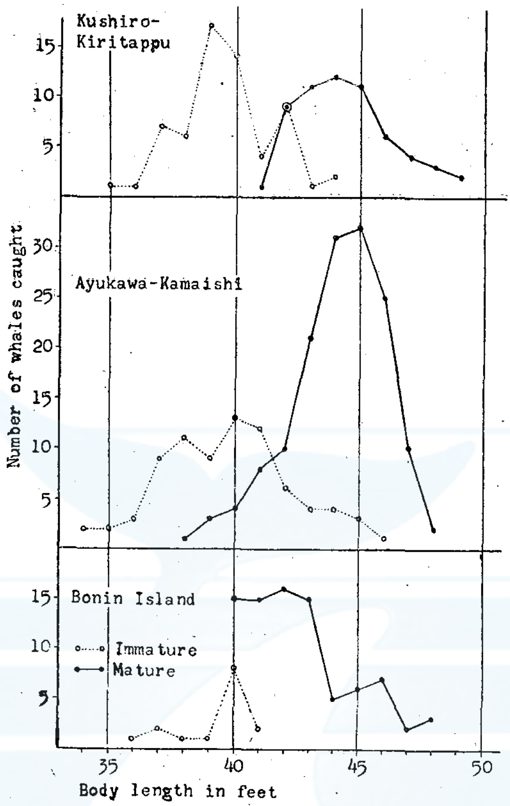
Table 34 shows all the males studied classified into mature and immature on the basis of volume of testis.

As seen there, it may be said that male sei whales reach sexual maturity at 40 ft. length in the Bonin Island area, 42 ft. in the Ayukawa-Kamaishi area, and, 43 ft. in the Kushiro-Kiritappu areas. These is, in other words, difference by locality in males as in females.

Fig. 52, which was prepared on the basis of Table 34, shows this relation even more clearly. According to Matthews, Sei whales located in the Antarctic, come to sexual maturity at the body length of 13.5 meters (45 ft. 3 inches). As compared with those, male sei whales in the adjacent seas of Japan area of smaller size, as in the case of females; — the difference in the Bonins being as much as 5 ft.

Table 34 shows the percentage of mature and immature in each area

Fig. 52. Sei whale. Mature and immature males observed in three areas.



as in the case of females, comparatively few immature males were caught in the Bonin Island area; but the number was far greater in the other two areas. Only in the Ayukawa-Kamaishi area was the percentage of immature males lower than in the case of females; it being 35% of total male. At any rate, the high ratio of immature whales in the whaling grounds other than Bonin Island area is noteworthy.

Table 35 shows the constitution of total sei whales observed.

Table 35. Sei whale. Constitution of total whales observed.

	Female	Male	Total
Total number observed.	437	446	883
Immature	204 (46.7%)	156 (35.0%)	360 (40.8%)
Mature	233 (53.3%)	290 (65.0%)	523 (59.3%)
Resting	131		
Pregnant	64		
Pregnant or recently ovulated	37		
Lactating	1		

g. Conclusion on sexual maturity and migration.

As mentioned above, the body length at which sei whales in the adjacent seas of Japan come to sexual maturity, is as follows:—

In Bonin Island area		
	Female	41 ft. long
	male	40 ft. long
In Ayukawa-Kamaishi area		
	female	44 ft. long
	male	42 ft. long
In Kushiro-Kiritappu area		
	female	45 ft. long
	male	43 ft. long

It may be that such a conclusion cannot be drawn regarding male whales in the "Bonin Island area, where their catch is poor there. It may be smaller by 1 foot. Thus, the above 3 areas show different body lengths; but there still remaines the question as to the situation in Oshima and areas west of it. Oh that, no investigations have been made.

However, from the past whaling statistics, the body length was examined for pregnant whales caught in these areas. The result is as follows:

Body length	Number of pregnant whales
40 ft.	4
41 ft.	1
42	3
43	1
44	0
45	5
46	0
47	2
48	1

It can thus be seen that there were recorded 4 pregnant whales 40 ft. long, which number is more than for whales of other body lengths. But the body lengths recorded are not always correct, because there is a tendency to exaggerate the size recorded because of the bonus involved. The temptation to stretch a 39 ft. whale to 40 ft. for the record is probably especially strong.

In view of such circumstances, it is quite possible that whales of only

39 ft, or some even smaller, may be included among those recorded as 40 ft. But in any case, it can be said that in these areas there are whales approximately 40 ft. long that are pregnant, and that the percentage of those pregnant at that size is not much lower than in whales of larger size.

From these facts, it appears possible that sei whales in Oshima and west of it, come to sexual maturity at least at the same body length as those in the Bonin Island area.

Although there are some very slight differences between the Ayukawa-Kamaishi area and the Kushiro-Kiritappu area, their points of similarity are considerable. It is therefore conceivable that Sei whales in the adjacent waters of Japan consist of two local races, northern and southern types. And the southern type whales migrate mainly to the Bonin Island, Oshima, and further west, and partly to the Ayukawa-Kamaishi area, and a few even to the Kushiro-Kiritappu area. The northern type whales, on the other hand, probably migrate up to Kurile Islands through the Ayukawa-Kamaishi area and off Kushiro-Kiritappu; and from there most of them probably migrate southward, while a very few continue their migration as far as to the east side of Kamchatka Peninsula. The question is how far they migrate southward. Judging from the fact that there are white scars on the body and that in the Ayukawa-Kamaishi area open pits which are the cause of scars are not found, it must be that they migrate to the warmer seas of low latitudes, but to areas other than the Bonin Islands. For if they migrated to the Bonin Island area, they would be caught there and thus alter the constitution of whales caught in the Bonins. Consequently the number migrating to the neighborhood of Bonin Islands must be very few, if any. And as stated in the paragraph "white scars", the northern type whales probably do not migrate so south as the southern type, and even if they did, their stay in the south must be shorter.

Fig. 53 was made on the basis of 6,939 Sei whales classified by area and body length which were caught for the past 18 years.

In Fig. 53, grounds I—V mean the following areas.

I. Oshima and west of it (Southwest area and West Kyushu area)

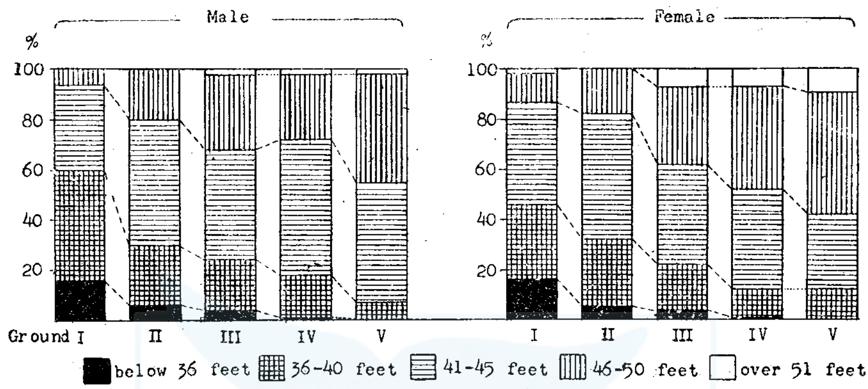
II Bonin Islands.

III Ayukawa-Same (North east area)

IV Muroran-Kiritappu (Hokkaido area)

V Kurile Islands (Kurile area).

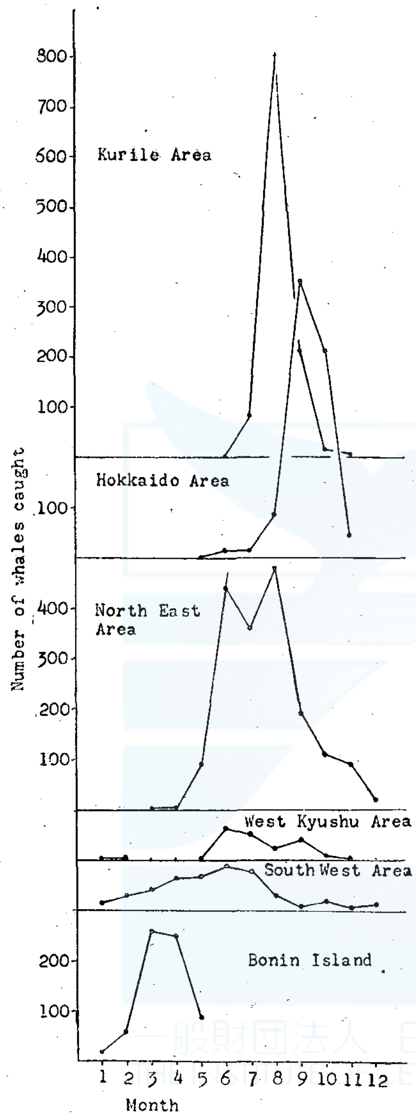
Fig. 53. Size of Sei whale in various grounds.



According to Fig. 53, the body length of Sei whales is smallest in the south west area, becoming larger as it goes north east. From this fact alone, therefore, it seems reasonable to classify them into local races for each area. But as their migrating route seems to differ by body length, that may be too hasty a conclusion. But since, as mentioned already, a clear-cut line can be drawn between the Bonin Island area and the Kushiro-Kiritappu area with regard to the body length at sexual maturity, it is impossible to say that Sei whales in the adjacent seas of Japan all belong to the same group, and that the difference in body length by area is simply due to their migration. That is why the author would like to divide them into 2 local races, northern and southern, and to explain the other details on the basis of migration. But that involves considerable assumption. It is hoped to obtain a more definite conclusion when sufficiently data has been collected through the measurement of the proportions of body parts. For the purpose of studying migration, in the adjacent seas of Japan whale marking have been carried on since 1949. Some data should be obtained from this field.

Fig. 54 shows monthly number of whales caught in each area, on the basis of the past 18 years whaling statistics. In the Bonin Island, the largest catch is seen in March and April. In the north east area, it is from June to August. In the Kurile area, the catch is mostly in August. When the Tonan-maru operated in the northern waters, only 3 Sei whales

Fig. 54. Sei whale. Monthly catch in each area.



were caught in 1940, and 7 in 1941; and the place of catch was generally south of Lat. 50°N. And since few sei whales were caught by the Russian Factory ship "Aleut" also it does not seem that many migrate north of the Kurile Islands. Even in the Kurile Islands, the principal whaling ground was south of middle Kurile Islands. In the Hokkaido area, most of them were caught in Sept. and Oct. These, as stated in the paragraph "thickness of blubber", were caught on their way southward from the Kurile area. Also the whales caught in the North east area after September, were probably southward bound.

It was mentioned in the paragraph "light-coloured spot" that female sei whales probably stayed in the south warm seas for longer time than males. There is also a difference in the sex composition of sei whales which migrate to the Hokkaido area and the Kurile area. On the basis of the past 18 years' data, catch by sex in these two areas is as shown in Table 36.

As seen there, in the Kurile area,

Table 36. Sei whale. Sex ratio of whales caught in Kurile and Hokkaido areas in past 18 years.

	Actual number		Percent	
	Kurile area	Hokkaido area	Kurile area	Hokkaido area
Male	749	420	67.7%	37.4%
Femal	357	702	32.3	62.6
Total	1,106	1,122	100.0	100.0

female was only 32.3 % of total, while in the Hokkaido area it was 62.6%. Consequently, in these areas too, migrating route might differ between male and female; but for the present, their actual route is not known.

In the South west area and the West Kyushu area, the best catch is seen in June and July. In Korea, catches are extremely rare. The same is true of the Okhotsk area. From this fact too, it may be inferred that sei whales in this area do not migrate north but stay in the waters nearly even during the summer. A part of the Sei whales in the Bonin Island area migrate to the North east area, while others may migrate to Oshima (the South west area). For the present, however, there is no data to prove it. It may be clarified in the future by the data of the present whale marking and of measurement of whale body proportion started this year.

h. Stock.

Fig. 55. Sei whale. Variation of catch.

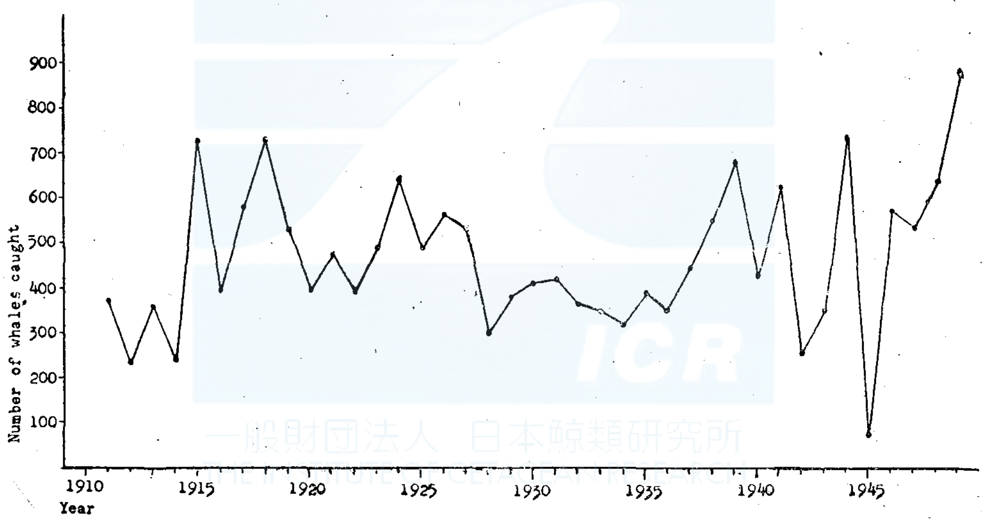


Fig. 55 shows annual variation of Sei whale catch since 1911. Although there is some variation by years, there is no decrease in catch as there is in other baleen whales. The very poor catch in 1945 was due to the War, and was not confined to Sei whales. Consequently, we may say that among baleen whales, sei whale is the most stable in stock. As stated already, however, catch ratio of immature whale is so high especially in the Hokkaido area that there is danger of depleting the stock unless this point is borne in mind.

From the point of view of stock conservation, therefore, the limit on body length should probably be raised from 35 ft. to 40 ft. in the North east area and the Hokkaido area.

Fig. 56. Sei whale. Size distribution of whales caught in the past 18 years.

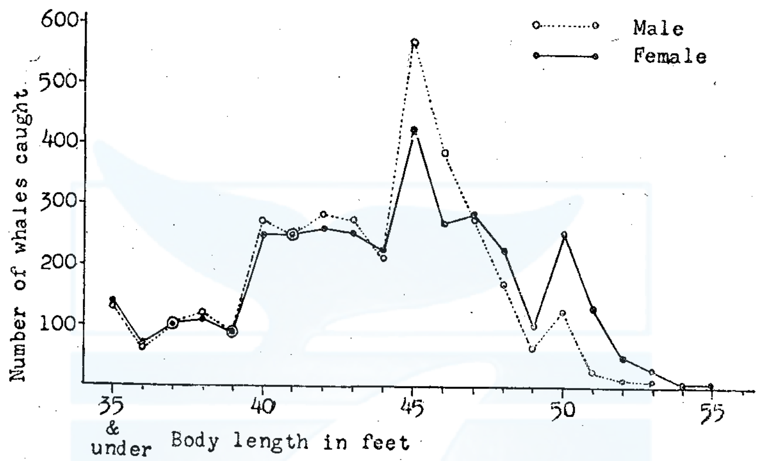


Fig. 56 shows the size distribution of all Sei whales caught in the last 18 years.

Both for males, and females the peak catch were in 45 ft. Being different from other baleen whales, Sei whales under the present limited body length were not caught in such large numbers.

Sperm whale (*Physeter catodon Linnaeus*)

The Sperm whale, like the sei whale, is a specie which is caught in great abundance in the adjacent seas of Japan. Number of sperm whales observed is over 500, as shown in Table 1.

a. Colour :

Sperm whales are generally dark grey all over the body. When studied in detail, sperm whales in the adjacent waters of Japan can be classified into the following 4 classes:

A. Uniform dark greay all over the body.

B. Lighter on the under surface of the head and lower jaw.

C. Light whitish all over the head.

D. Light whitish all over the body.

The results of recording for 283 whales are as shown in Table 37.

Whales light colored over the greater part of the ventral surface had been classified by Matthews, but only in rare instances; more common were whales light colored all over the body, which were included in class "D".

Table 37. Sperm whale. Body colour

	Actual number			Percent		
	Male	Female	Total	Male	Female	Total
Number whales observed	179	104	283	100.0	100.0	100.0
A	121	76	197	67.6	73.1	69.6
B	23	18	41	12.8	17.3	14.5
C	3	2	5	1.7	1.9	1.8
D	32	8	40	17.9	7.7	14.1

As seen in this table, about 70 % of total was nearly uniform dark grey, or about the same percentage as observed by Mathews in sperm whales in the Antarctic. Of the rest according to Matthews 25.7 % were considerably lighter on the under surface of the head and lower jaw, and 4.3 % were conspicuosly lighter over the greater part of the ventral surface. Among sperm whales in the adjacent seas of Japan, however, whales lighter on the under surface of the head were 14.5 % and whales lighter all over the body were about 14 %. Whales lighter all over the head were very few, being only 1.8 % of total. The greatest difference between male and female was seen in "D", lighter all over the body, male being about 18 % and female being not more than 8 %. Next in order came A and B, in both of which there were more females by about 5 %. But such a classification of colouration often differs according to the observers, so that detailed comparative study would not have much significance.

Some sperm whales had light coloured spiral markings on their head, which were classified into 4 classes for observation. The results are as shown in Table 38.

As seen in Table 38, only about 13 % of total had no spiral markings at all, and all the rest had them, though in varying degrees of clarity. Though some difference between male and female, was seen also, it is impossible to discuss it on the base of this table, for the number of females

Table 38. Sperm whale. Colour, Light-coloured spiral marking on head.

	Actual number			Percent		
	Male	Female	Total	Male	Female	Total
Number whales observed	150	23	173	100.0	100.0	100.0
Very clear	10	3	13	6.7	13.0	7.5
Clear	56	9	65	37.3	39.1	37.6
Not clear	64	8	72	42.7	34.8	41.6
None	20	3	23	13.3	13.1	13.3

observed was especially small.

Sperm whales have white markings near umbilicus. There are two kinds. One is light grey flecking, which consists of patches or flecks of light pigment. The other is white splash, which is generally triangular in shape with its apex pointing forward.

The light grey flecking condition of 231 whales was divided into 5 classes: none, few, moderate, many, numerous, for recording. The results are as shown in Table 39.

Table 39. Sperm whale. Colour. Light grey fleching.

	Actual number			Percent		
	Male	Female	Total	Male	Female	Total
Number whales observed	182	49	231	100.0	100.0	100.0
None	27	3	30	14.8	6.1	13.0
Few	67	10	77	36.8	20.4	33.3
Moderate	31	22	53	17.0	44.9	22.9
Much	47	12	59	25.8	24.5	25.5
Numerous	10	2	12	5.6	4.1	5.3

Accoding to Matthews, 67 per cent of sperm whales found in the Antarctic had this light grey flecking. In the adjacent seas of Japan, flecking is seen more often.

As seen in Table 39, male had more "none" and "few" than female. It is doubtful whether such a conclusion is warranted, for the number of females observed was small as in case of table 38.

White splash was observed for 215 whales, and classified into none, normal and remarkable, as shown in Table 40.

As in the case of light grey flecking there were more males than fe-

Table 40. Sperm whale. Colour. White splash

	Actual number			Percent		
	Male	Female	Total	Male	Female	Total
Number whales observed	155	60	215	100.0	100.0	100.0
None	46	9	55	29.7	15.0	25.6
Normal	99	46	145	63.9	76.7	67.4
Remarkable	10	5	15	6.4	8.3	7.0

males that had no white splash at all. About 75% of males and females together had this white splash.

b. White scars.

White scars were observed for 244 males, and 85 females. If these were to be divided into three areas, as in case of sei whales, the number of whales in each area would be so small as to render their comparison meaningless, and it is thought that moreover, sperm whales in the adjacent seas of Japan, unlike the sei whales, belong not to local seas in a narrow sense but to same group for all areas. Therefore they were studied without classification into 3 areas. The results are as shown in table 41.

Table 41. Sperm whale. White scars.

	Actual number			Percent		
	Male	Female	Total	Male	Female	Total
Number of whales observed	244	85	329	100.0	100.0	100.0
None	25	36	61	10.2	42.4	18.5
Very few	124	24	148	50.8	28.1	45.0
Few	62	14	76	25.4	16.5	23.1
Many	30	11	41	12.3	13.0	12.5
Numerous	3	0	3	1.3	0	0.9

In Female "none" was 42 percent of total female; and in male, only about 10% had "none", but "very few" was about 50%. According to Matthews, all sperm whales found in the southern hemisphere have white scars, though in varying degrees. In this respect, therefore, sperm whales in the adjacent seas of Japan are different.

Matthews further stated that sperm whales had fewer white scars than Rorqual. The same seems to be true in the adjacent seas of Japan, for sperm whales generally have fewer white scars than sei or fin whales.

c. External parasites.

As in the case of other whales, Cyamus, Coronula, Conchoderma, Pennela and diatom were found as external parasites on sperm whales. 3 sperm whales in the Bonin Island area, 2 in the Ayukawa-Kamaishi area and 1 in the Kushiro-Kiritappu area, were infected with Cyamus sp.

Only 1 whale caught in the Ayukawa area, was infected with coronula sp. on the lower jaw, the number being 8.

Sometimes the functional teeth of the lower jaw are infected with Conchoderma sp. Such was the case with 3 whales in the Bonin Island area and 1 each in the Ayukawa-Kamaishi area and the Kushiro-Kiritappu area.

Pennella sp. was found to be most numerous, especially in the Bonin Island area, where 18 whales were infected with it. 6 whales were infected with it in the Ayukawa-Kamaishi area and none in the Kushiro-Kiritappu area. The number of Pennella sp. was usually not over 10, but, in the Bonin Island area there was one whale with about 50. Diatoms in the form of small patches were found on only 7 whales in the Ayukawa-Kamaishi area.

d. Number of teeth.

With regard to the functional teeth of lower jaw, their number was recorded separately for right and left side for 266 males and 119 females. The results are as shown in Table 42.

Table 42. Sperm whale. Number of functional teeth.

Number of teeth	Male		Female	
	Right side	Left side	Right side	Left side
17	2 (0.8)	3 (1.1)	0	0
18	3 (1.1)	1 (0.4)	0	1 (0.8)
19	4 (1.5)	7 (2.6)	2 (1.7)	3 (2.5)
20	17 (6.4)	16 (6.0)	12 (10.1)	9 (7.6)
21	28 (10.5)	33 (12.4)	17 (14.3)	21 (17.7)
22	37 (13.9)	35 (13.2)	30 (25.2)	28 (23.5)
23	60 (22.6)	60 (22.6)	28 (23.5)	23 (19.3)
24	53 (19.9)	54 (20.3)	17 (14.3)	21 (17.7)
25	36 (13.5)	29 (10.9)	9 (7.6)	8 (6.7)
26	16 (6.0)	15 (5.6)	2 (1.7)	4 (3.4)
27	8 (3.0)	9 (3.4)	1 (0.8)	0
28	2 (0.8)	3 (1.1)	1 (0.8)	1 (0.8)
29	0	1 (0.4)	0	0
Total	266 (100.0)	266 (100.0)	119 (100.0)	119 (100.0)

Note : Figures in parenthesis show the percentage.

The fewest was 17, and most numerous 29. They are chartred in Figs. 57 to 58.

Fig. 57. Sperm whale. Occurrence of functional teeth.
Male.

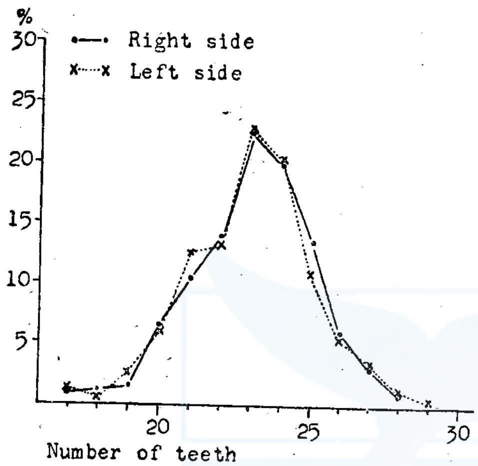
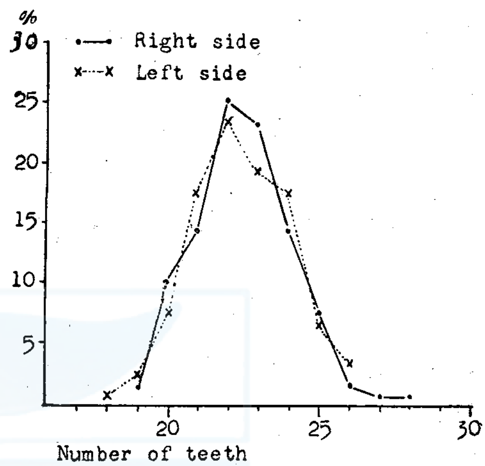


Fig. 58. Sperm whale. Occurrence of functional teeth.
Female.



Though there is some difference between right side and left side, that difference is so slight as to be negligible. The males had a few more than the females, the most common for males being 23, and 22 for females, for both the right and left sides.

There were also a greater percentage of males than females that had 25 or more teeth. On the contrary, the percentage of those with 20 or less was greater among the females. Accordingly it can be safely said that in general, the number of functional teeth of sperm whales is larger for male than for female. This is probably related to the fact that males grow larger in length than females. Rudimentary teeth of upper jaw were observed for 263 males and 118 females. The results are as shown in Table 43.

About 80 % of whales observed were formed to have no rudimentary teeth at all.

The number of teeth of sperm whales in the Antarctic Ocean was observed by Matthews, Matsura and Omura. Regarding the functional teeth of male, there was no remarkable difference, but as for rudimentary teeth, the occurrence in the southern hemisphere was nearly 50 %, or far greater than that in the adjacent waters of Japan. In the Antarctic, principally

Table 43. Sperm whale. Number of rudimentary teeth.

Number of teeth	Male		Female	
	Right side	Left side	Right side	Left side
0	200 (76.0)	212 (80.6)	96 (81.4)	97 (82.4)
1	18 (6.8)	16 (6.1)	5 (4.2)	3 (2.5)
2	18 (6.8)	13 (4.9)	3 (2.5)	5 (4.2)
3	10 (3.8)	2 (0.8)	4 (3.5)	4 (3.5)
4	7 (2.7)	8 (3.0)	2 (1.7)	3 (2.5)
5	2 (0.8)	4 (1.6)	4 (3.5)	3 (2.5)
6	1 (0.4)	0	1 (0.8)	1 (0.8)
7	5 (1.9)	3 (1.1)	1 (0.8)	1 (0.8)
8	1 (0.4)	1 (0.4)	1 (0.8)	0
9	0	1 (0.4)	0	0
10	0	0	1 (0.8)	1 (0.8)
11	1 (0.4)	3 (1.1)	0	0
Total	263 (100.0)	263 (100.0)	118 (100.0)	118 (100.0)

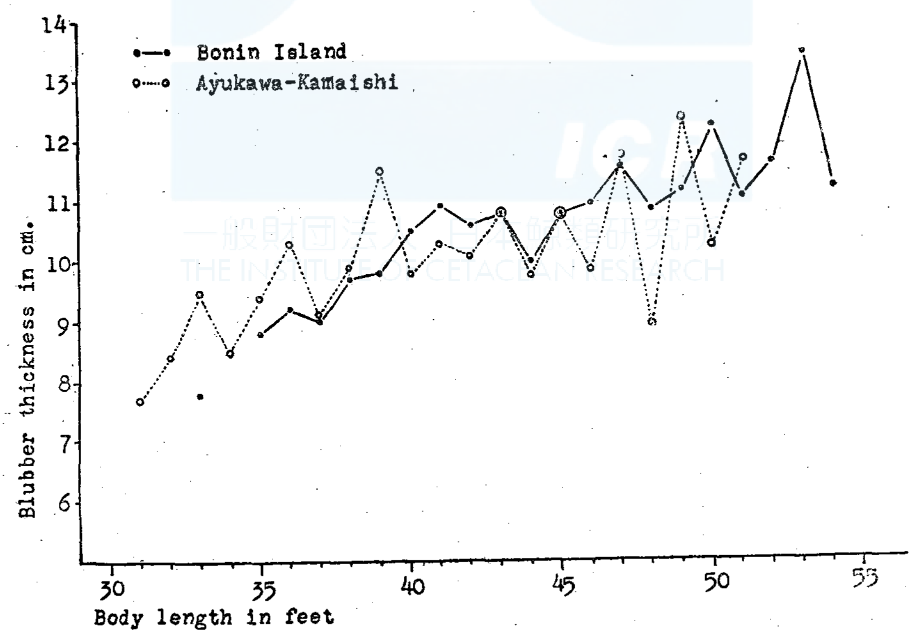
Note : Figures in parenthesis show the percentage.

southern hemisphere, however, extremely few females were observed; so there is little basis for comparison. Rudimentary teeth were usually small in number, both for male and for female. The largest number was 11.

e. Thickness of blubber.

Thickneness of blubber was measured for 349 males, and 181 females. As in the case of other whales, the measurement was taken at two points,

Fig. 59. Sperm whale. Blubber thickness. Male.



1 and 2. In this report, only the thickness at Point 1 is given, for point 2 varied too much by individuals.

The averange thickness for each body length by area was as shown in Fig. 59.

Sperm whales both in the Bonin Island area and in the Ayukawa-Kamaishi area increase thickness of blubber with increase in body length. Bonin area whales less than 40 ft. seem to have thinner blubber and those of 45 ft. or longer seem to have thicker blubber than whales of comparable size in the Ayukawa-Kamaishi area. But whether such is the case is doubtful. The chances are that there is no difference between areas. Fewer females than males were observed, and a considerable number of them were pregnant or lactating. So if these were to be divided into areas, the number of whales of each body length observed would become so small as to render their comparison of little measuring. So instead of dividing into areas, observed values divided into pregnant, lactating and resting and others, were plotted in Fig. 60.

Fig. 60. Sperm whale. Thickness of blubber. Female.

As seen in this figure, blubber was 6 cm and over in thickness, with only one exception. The thickest was 13 cm; but that was exceptional,—the majority being not more than 10.5 cm. Still, it can be seen that there were considerable individual variations. And it can also be seen that there was no particularly thick or thin blubber in pregnant and lactating whales. In female sperm whales, in other words, thickness of blubber seems to depend less upon whether they are pregnant, lactating or resting, than upon other conditions, e. g. the food situation.

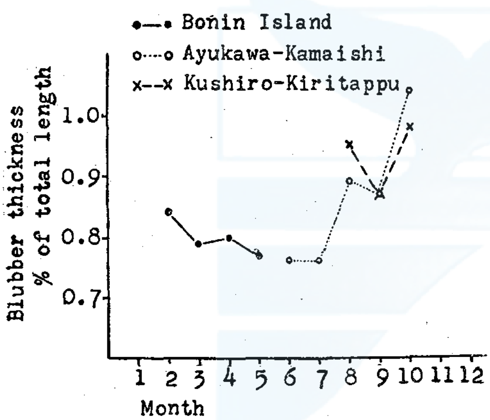


Fig. 61. Sperm whale. Male. Blubber thickness expressed as percentage of total length, by months.

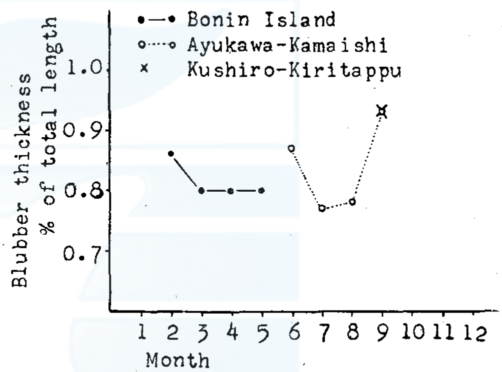


Fig. 62. Sperm whale. Female. Blubber thickness expressed as percentage of total length, by months.

Figs. 61 and 62 show average blubber thickness expressed as percentage of total length by months.

Fig. 61, which is concerned with males, show that blubber tends to get thicker in males after August.

From the point of view of area, the Kushiro-Kiritappu area shows the thickest blubber. Fig. 62 is for female excluding those pregnant and lactating. In the Bonin Island area, nearly same trend as for male is seen,—blubber being the thickest in February and then getting thinner. The different trend from male in the Ayukawa-Kamaishi area is probably due to the small number of whales observed. In the Kushiro-Kiritappu area, blubber was measured only in Sept. It seems the thickest in Sept., as in the case of males.

f. Food.

Food was observed for 215 sperm whales in the Bonin Island area, 302 in the Ayukawa-Kamaishi area and 38 in the Kushiro-Kiritappu area. The results are as shown in Table 44. Sperm whales in the Bonin Island area most often had food in their stomach. The Kushiro-Kiritappu area can not be compared directly with other areas, because of small number of whales observed.

Table 44. Sperm whale. Stomach contents.

	Bonin island	Ayukawa-Kamaishi	Kushiro-Kiritappu
Number of whales observed	215	302	38
Empty	71 (33.0)	125 (41.4)	21 (55.3)
Little	59 (27.4)	113 (37.4)	12 (31.6)
Moderate	51 (23.7)	54 (17.9)	4 (10.5)
Rich	28 (13.0)	9 (3.0)	1 (2.6)
Full	6 (2.9)	1 (0.3)	0

Note : Figures in parenthesis show the percentage.

In the Bonin Island area, whales with empty stomachs were few in number, and among those that contained some food, a few had "little", and those with "moderate" food were the most numerous. In the other areas, on the contrary, there those with little food were the most numerous. In the Bonin Island area, moreover, there were 10% more whales with rich food than in the other 2 areas.

Stomach contents for each area and month are shown in Tables 45 to 47.

Table 45. Sperm whale. Monthly variation of stomach contents.
Bonin island.

	February	March	April	May
Number of whales observed	48	86	43	38
Empty	21 (43.8)	30 (34.9)	8 (18.6)	12 (31.6)
Little	12 (25.0)	28 (32.5)	11 (25.6)	8 (21.1)
Moderate	11 (22.9)	16 (18.6)	15 (34.9)	9 (23.7)
Rich	3 (6.3)	9 (10.5)	8 (18.6)	8 (21.1)
Full	1 (2.0)	3 (3.5)	1 (2.3)	1 (2.5)

Note : Figures in parenthesis show the percentage.

As seen in these tables, when divided into each month, the number of whales observed becomes too small to give an accurate picture of the situation. Especially is that true of the Kushiro-Kiritappu area. From

Table 46. Sperm whale. Monthly variation of stomach contents.
Ayukawa-Kamaishi

	June	July	Aug.	Sept.	Oct.
Number of whales observed	67	115	62	38	20
Empty	26 (38.8)	55 (47.8)	23 (37.1)	14 (36.8)	7 (35.0)
Little	20 (29.9)	33 (28.7)	33 (53.2)	20 (52.6)	7 (35.0)
Moderate	16 (23.9)	23 (20.0)	5 (8.1)	4 (10.5)	6 (30.0)
Rich	4 (6.0)	4 (3.5)	1 (1.6)	0	0
Full	1 (1.4)	0	0	0	0

Note : Figures in the parenthesis show the percentage.

Table 47. Sperm whale. Monthly variation of stomach contents.
Kushiro-Kiritappu

	August	September	October
Number of whales observed	7	21	10
Empty	1 (14.3)	15 (71.4)	5 (50.0)
Little	3 (42.8)	4 (19.0)	5 (50.0)
Moderate	2 (28.6)	2 (9.6)	0
Rich	1 (14.3)	0	0
Full	0	0	0

Note : Figures in parenthesis show the percentage.

these tables, however, the following may be said:

In the Bonin Island area, though the food is not so abundant in February, it becomes richer till April and decreases again in May.

In the Ayukawa-Kamaishi area, food is most abundant in June. In the Kushiro-Kiritappu area, the number of whales observed was too small to permit of their discussion. Since the above mentioned facts do not agree with the variations of blubber thickness, any definite conclusions will have await the results of future investigations.

In all areas, as shown in Fig. 48, most of the food was squid; and octopus, rock cod, and cod were found only in a few instances. But the

Table 48. Sperm whale. Kind of food.

	Bonin island	Ayukawa-Kamaifhi	Kushiro-Kiritappu
Squid	136	170	170
Octopus	8	2	0
Menuke (Rockcod)	0	4	0
Cod	0	1	0

instances in which these lattey items were found mixed with squids were quite numerous.

g. Genitalia and maturity.

Ovary of 152 sperm females was observed. As in baleen whales, sperm whales with more than 1 corpus luteum in their ovary may be regarded as mature and those with none may be regarded as immature. As a result of the investigation, almost all whales were found to be mature, — there being only 3 immature, of which 1 was 30 feet long and 2 31 feet long and 2 31 feet in length. There were, on the other hand, 2 mature whales 30 ft. long and 12 mature whales 31 ft. in length; also of 28 ft. and 2 of 29 ft. which also were mature. Sperm whales, therefore, probably come to sexual maturity at the body length of 30 ft. or under. Under the "International Convention for the Regulation of Whaling", the minimum body length of sperm whales which may be caught in fixed at 35 ft. So, in future, catching of immature whales should almost disappear. It is not exactly known at how many feet female sperm whales come to sexual maturity. According to Matthews, that figure is from 9 meters to 9.5 meters (28′ 6″—31′ 2″). As stated above, of the sperm whales 31 feet long found in the adjacent seas of Japan, there were more mature than immature ones. So it would appear that they reach sexual maturity at 30 ft. or a little under it.

Weight of ovary is shown in Fig. 63. Ovary without functional corpus luteum is generally not more than 0.6 kg. in weight. Ovary with functional corpus luteum was of course heavier, but generally not more than 1.2 kg. There was, however, one exceptional instance of 2.0 kg. In immature whale the ovary was under 0.2 kg. in weight.

Number of corpora lutea (right and left totalled) is shown in Fig. 64.

Among whales 36 ft. or over in body length, there was only 1 instance in which the number of corpora lutea was less than 5. But among whales up to 35 ft. long there were quite a number that had less than 5. This fact means that female, sperm whales grow rapidly to 35 ft. in length after reaching to sexual maturity, but do not grow to 36 ft. or over till a certain period has elapsed after attaining sexual maturity. This "certain period" is the period during which ovulation takes place 5 times; but exactly how many years that covers is not known. But that period can hardly be so short as 1 year, because some whales with 1 or 2 corpora lutea were

Fig. 63. Sperm whale. Weight of ovary.

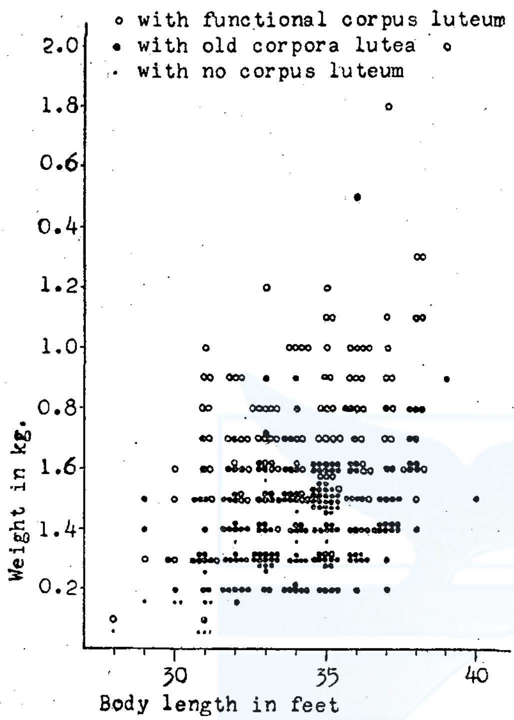
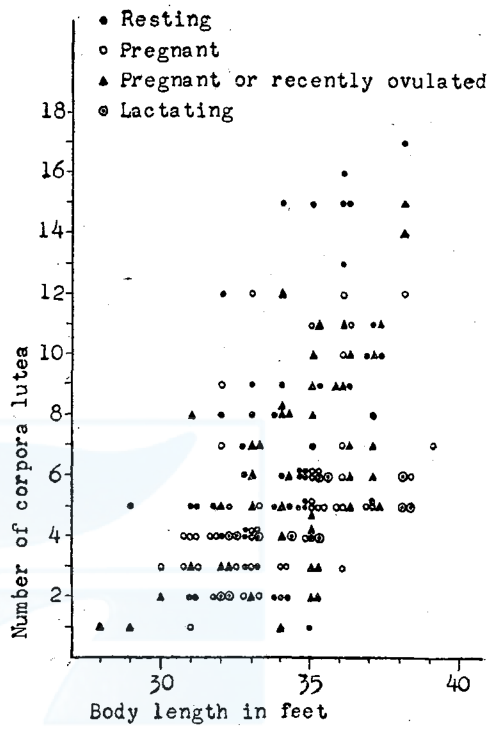


Fig. 64. Sperm whale. Number of Corpora lutea.



pregnant, and among those with 3 or 4 corpora lutea there were more pregnant or lactating than those resting and pregnant or recently ovulated. In any case, they probably attain a length of 36 ft. and over after several parturitions after a certain period has elapsed subsequent to attainment of sexual maturity. Considered from that point of view, the prohibition on the catching of sperm whale less than 35 ft. is a very effective one.

Fig. 65 shows the frequency of number of corpora lutea.

As seen in this figure, number of whales with only 1 corpora lutea was small and increased gradually up to those with 5, then decreased again. The maximum was 17 in number.

Fig. 66 shows the thickness of mammary gland. The thickness ranges widely from 2 cm to 15 cm. Many lactating whales were found among those with blubber thicker than 10 cm; but there was also a considerable number of whales not lactating whose blubber was 10 cm or more in thickness. From Fig. 66, it would appear that even after the completion of the lactating stage, mammary gland of sperm whales does not contract so ra-

Fig. 65. Sperm whale. Frequency of Number of corpora lutea.

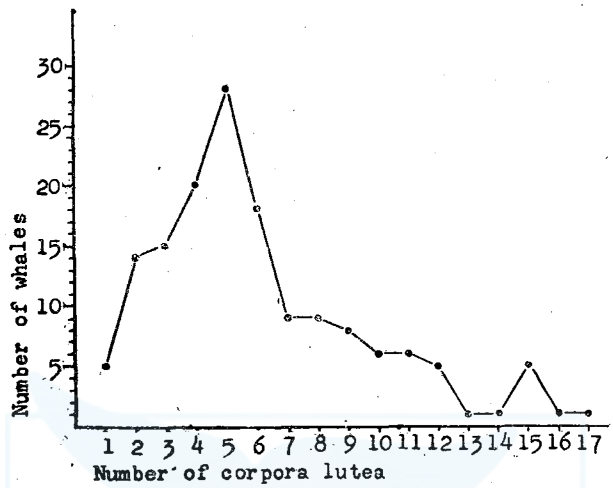
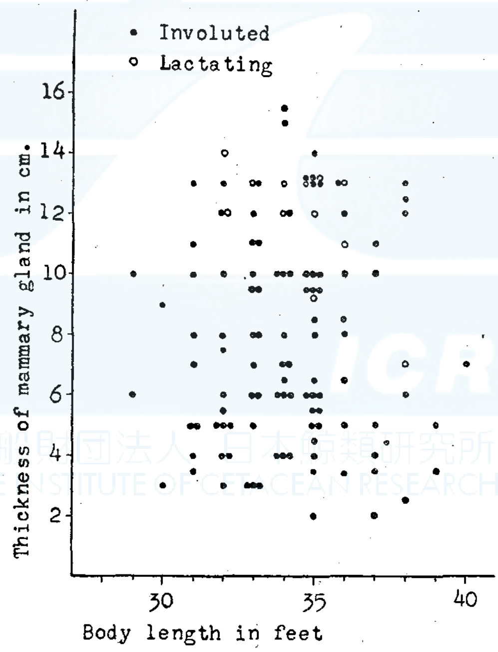


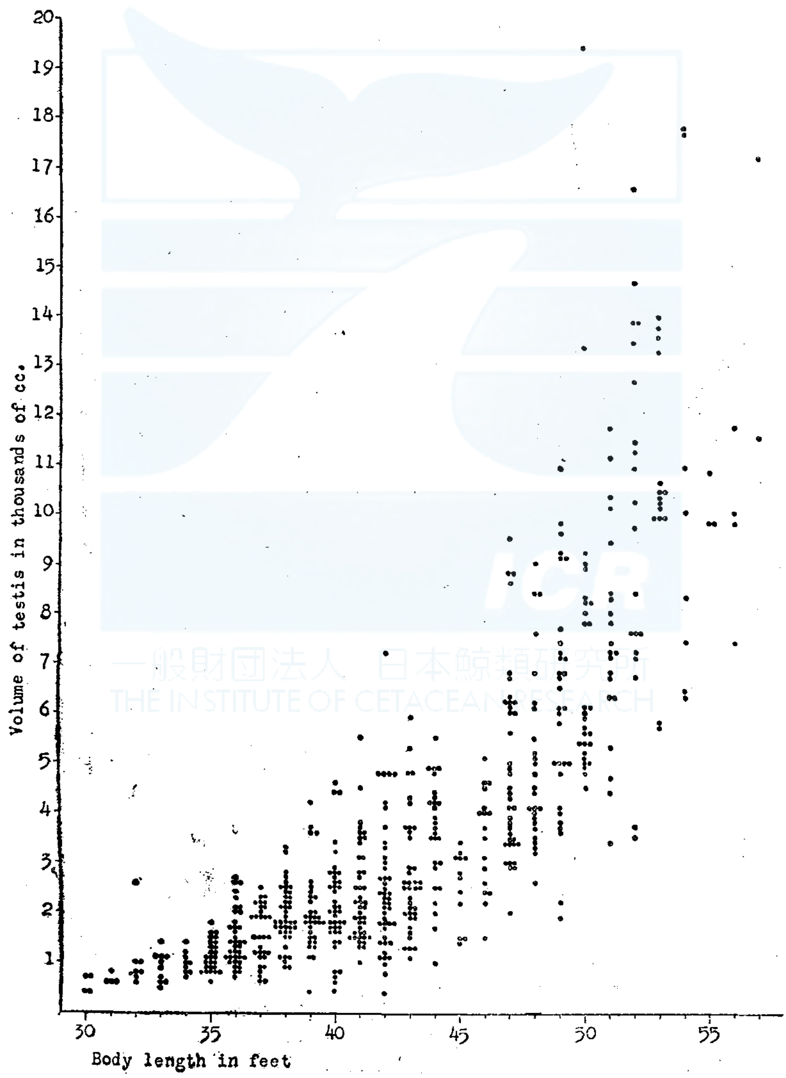
Fig. 66. Sperm whale. Thickness of mammary gland.



pidly, and that a considerable period elapses before a state of complete involution is reached.

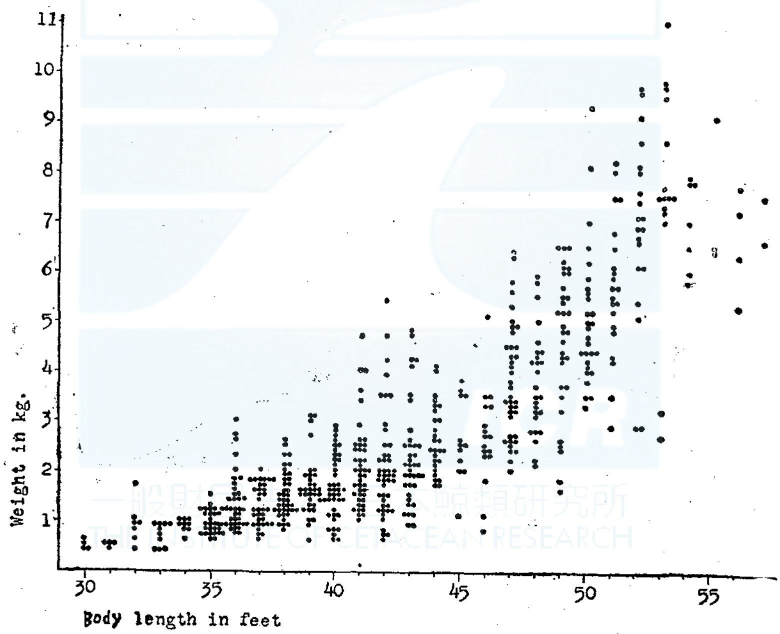
In the case of males, the volume and weight of testis were measured. In Figs. 67 and 68, they were plotted for each body length. Both volume and weight of testis increases with body length, at least up to 53 ft. Among the few of 54 ft. and over that were observed, this tendency was not found. In the other species of whales, the volume and weight of testis increase suddenly at sexual maturity; and after that they have almost no relation to body length. Sperm whales differ on that point, for the volume and weight of testis increased at a certain ratio in proportion to the increase of body length up to 53 ft, instead of increasing suddenly at sexual maturity. Consequently it is impossible to divide sperm whales into mature and immature through measurement of volume or weight of testis alone.

Fig. 67. Sperm whale. Volume of testis.



Microscopic investigation is absolutely necessary for that. Such investigation could not be made in the past for various reasons; but it is hoped to carry out such microscopic study hereafter in order to ascertain that point. According to Matthews, sperm whales found in the Southern hemisphere come to sexual maturity at the length of 11.5 m to 12.5 m (37′ 9″—41′ 0″). As in case of female, the body length at sexual maturity for male whales in the Antarctic is nearly the same as those in the adjacent seas of Japan. According to Matuura's observation for sperm whales caught by the Tonan-maru in the Antarctic Ocean in 1941, males reach sexual maturity at the length of 42 ft. That was based on observations with the naked eye; and the number of whales observed, moreover, was not so large, so that his conclusion can hardly be definite. The chances are, however, that 42 ft. is not very far from the correct figure.

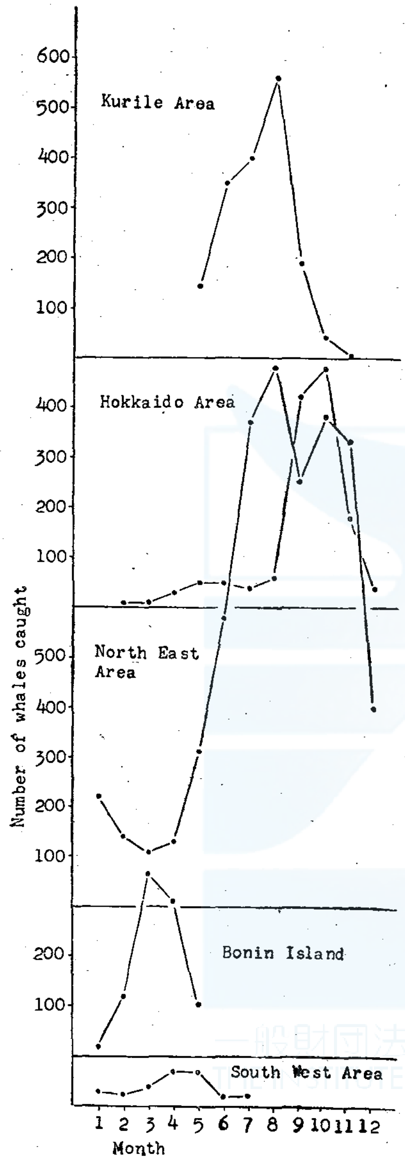
Fig. 68. Sperm whale. Weight of testis.



h. Migration and Stock.

Fig. 69 shows monthly catch in each area on the basis of the past 18 years whaling data. The Bonin Island area has its peak in March. It is regularly about 20 Feb. that the so-called "harems" migrate there. So, no female is caught until that time. The North east area is the area where

Fig. 69. Sperm whale. Monthly catch in different areas.



the most numerous sperm whales are caught, and it is here that harems come together. The best catch is seen from July to November. In the Kurile area the peak is in August. Harems do not migrate there so often. Most of the sperm whales caught are males,—females being only about 10% of the total. When the Tonan-maru operated in the Northern waters in 1940 and 1941, the most northern area in which sperm whales were caught was Lat 60°–50′N. It therefore appears that sperm whales do not migrate to such high lattitudes in the northern hemisphere as they do in the southern hemisphere. As in the Southern hemisphere, females do not migrate to such high latitudes. In the "Tonan-maru"'s operation, the northern most point at which female sperm whales were caught was Lat. 51° N. Consequently, the northern limit for harems is probably about there. They stay in the Kurile area and north of it till about August, and then most of them migrate south. The fact that the catches in the Hokkaido area are outstandingly large in Sept. and Oct. is indication that sperm whales, like the fin and sei whales, are caught in that area after coming there from waters further north. Sperm whales were caught in some years even in Okhotsk sea; these were all large males. They migrated there through the straits between the Kurile Islands, and were caught in the vicinity of the straits. It is said that these whales do not enter the Okhotsk sea through these straits where whaling operations are being carried on from landstations on the Kurile Islands. The best season in the South west area is April and May, though the catch is less than in other areas. Some sperm whales are caught in the West Kyushu area, where the best season is May. None are caught around Korea. Also at Senzaki, the entrance to Japan Sea, a few sperm whales are caught. So while it may be said that a few enter Japan Sea via. west coast of Kyushu, the majority of Sperm whales in the adjacent seas of Japan migrate along the Pacific side of Japan from the Bonin Islands to the North East area, Hokkaido, and the east coast of Kamchatka Peninsula, with a part migrating to the south west area also. A few sperm whales have been caught in Formosa also.

Fig. 70. Sperm whale. Variation of catch.

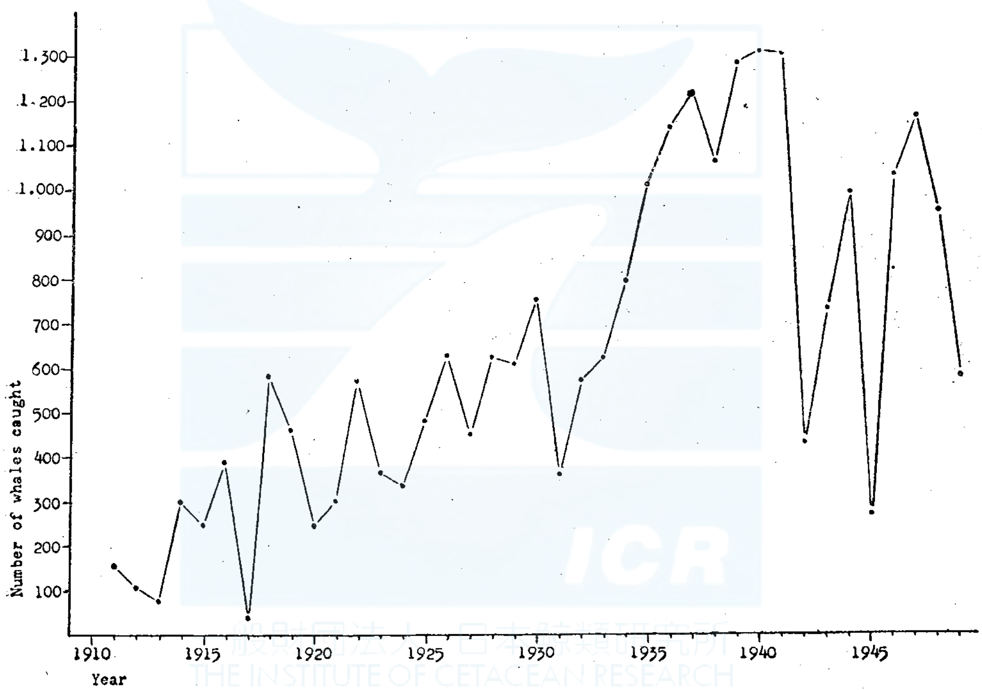
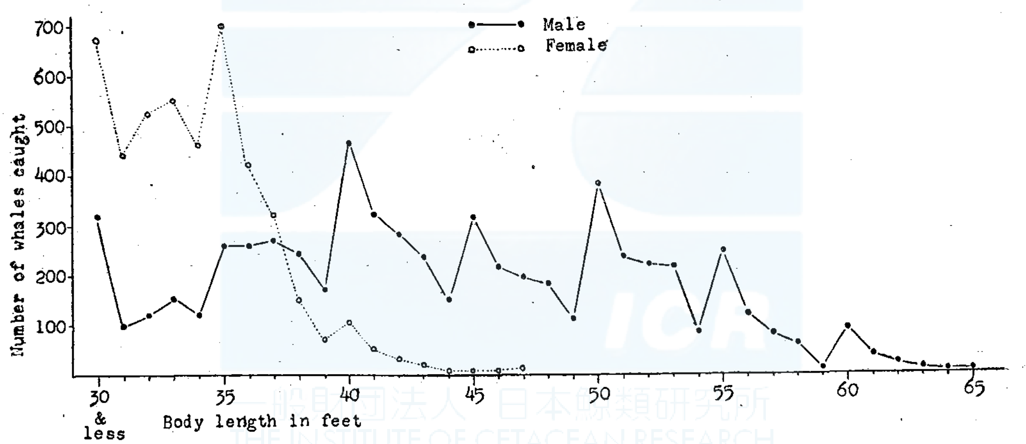


Fig. 70 shows annual number of sperm whales caught since 1911. Unlike in the case of baleen whales, catch of sperm whales increased remarkably during this period, with its maximum in 1939 and 1940. In the years following that peak, there was some drop due to suspension of operations in Kurile Islands after the War. The notable decrease in 1949 is due mainly to the change in the size limit from 30 ft. to 35 ft. Although we have no basic figure at present pertaining to sperm whale stock, there is probably no fear of a decrease. For while female sperm whales come to maturity at the body length of 30 ft. or under, catching of whales less than 35 ft. long is prohibited. Consequently there is no longer any possibility of immature sperm whales being caught. Moreover, sperm whales, unlike baleen whales, are polygamous. Many harems come into that part of the north east area commonly known as the Kinkazan coast, and females of those harems were often caught there in the past. But, such instances greatly reduced as a result of the raise in the minimum body length to 35 ft. And while this change in the limit on body length should, as already stated, prove immensely beneficial from the standpoint of stock conservation, its effect on the Japanese whaling industry is quite damaging.

On the basis of the last 18 years' whaling data, size distribution is shown separately for males and females in Fig. 71. To be especially noted from this figure is the fact that catches of females under 35 ft. were quite numerous in the past.

Fig. 71. Sperm whale. Size distribution of whales caught in past 18 years.



SUMMARIZED CONCLUSIONS

Biological observation was made for a total of 1,785 whales from among those caught in the adjacent waters of Japan in 1948 and 1949. On the basis of these data, supplemented by past whaling data, the following conclusions were drawn:

1. Body length at sexual maturity.

It is shorter for sei whales of Japan than for those of the Antarctic and shows variation, by localities, as follows.

Area	Male	Female
Bonin Island	40 ft.	41 ft.
Ayukawa-Kamaishi	42	44
Kushiro-Kiritappu	43	45

The whales in the Ayukawa-Kamaishi area and those in the Kushiro-Kiritappu area, although showing a slight difference in body length probably belong to the same stock. But since those in the Bonin Island area are clearly distinguishable, sei whales located in the adjacent seas of Japan should probably be classified into 2 local races, southern and northern. Fin whales of Japan, too, are smaller than those of the Antarctic. Males come to sexual maturity at the length of 58 ft. or 59 ft, and females at 60 ft. or 61 ft.

As for blue whales, it is believed that they are a little smaller than in the Southern hemisphere, although no definite statement can be made on that point because of the small number of whales observed. Sperm whales probably show no difference between the adjacent seas of Japan and the Antarctic.

For humpback whales, no conclusion can be drawn, due to the small number of whales observed.

2. As for migration, there are two routes, viz. east side (Pacific side) and west side (Japan sea side) of Japan. Fin whales migrate through these two routes, but most of the other whales take the east side route only, while a very few migrate from Korean waters to Okhotsk sea through Japan Sea. The southern migration limit is not clear, but the northern limit seems to be:

For blue whales, Lat 52°N.

For fin whales, the Arctic through Behring strait.

Humpback whales are seldom seen along the east coast of Kamchatka Peninsula, but are found in considerable numbers in the Arctics north of Behring strait.

It is unknown whether those that migrate into the Arctics belong to the same group as those of Japan or to the American group.

For sei whales, Lat. 56°N. But as stated already, they can probably be classified into two local races, northern and southern. Most of the southern race seem to stay around Oshima and areas west of it instead of migrating very far north, though a small part of them seem to migrate to the Ayukawa-Kamaishi area or the Kushiro-Kiritappu area.

For Sperm whales, Lat. 60°-50′ N; but the females do not go much beyond Lat. 51°N.

3. About all that we can know about the stock, on the basis of past whaling statistics is the general trend. But it is clear that Blue, Fin and Humpback whales have decreased. Sei and sperm whales do not show a downward trend. As the present body length limit for sperm whales fixed by "International Convention for the Regulation of Whaling" is 35 ft., the protection of females is nearly perfect. But as many immature sei whales are caught in areas other than the Bonin Islands, some protective measures may be necessary.

4. In other to the above points, body colour, external parasites, food and thickness of blubber were studied. Although nothing has been said regarding growth, that is to be studied in the future.

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Determination of the Age of Antarctic Blue and Fin Whales by the Colour Changes in Crystalline Lens

Masaharu Nishiwaki

CHAPTER I. FOREWORD

While on board a whaling factory ship as a research biologist in the 1947 - 1948 Antarctic whaling season, I noticed variation in the shade of of yellow colour in whale eyes. It reminded me of those ancient folk tales where "old badgers" and "ghostly cats" always had golden eyes that shone brightly in the dark. It finally led me to the discovery of a presence of a certain relationship between the colour changes of crystalline lens and the age of whales.

After returning to Tokyo in 1948, I looked up some literature and found some reference made already in 1883 to the lenticoular colour changes according to age in humans. However, no references as to the existence of this relationship in animals were found. None of the bibliographies contained any numerical data of the colour changes in these references.

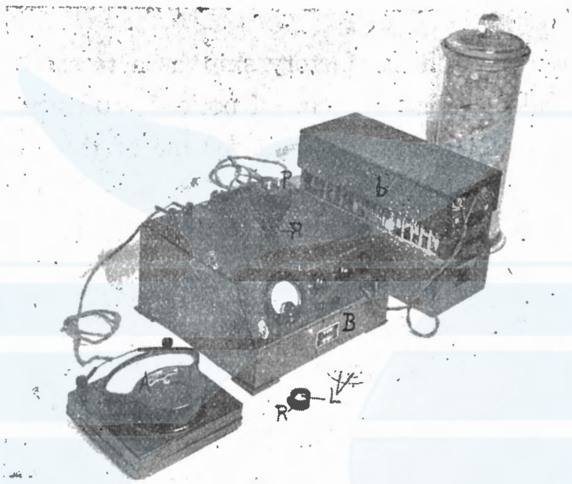
In order to express numerically such colour changes. I estimated the colour changes, i. e. the degree of colouration, during the whaling season of 1948-1949 when I was again on board a whaling factory ship in charge of biological research, by the method described in proceeding chapters. These were examined with data on age estimation in whales by some other methods.

CHAPTER II. Method of Determining Colouration, or Colour Changes in Crystalline Lens

During the 1947-1948 whaling season, lenses from 32 blue whales and 69 fin whales were studied. It was found that macroscopic examinations reveal varieties in colour ranging from colourless or clear, to light yellow and deep yellow. The development of colour was found to become darker with the increase in body length and the number of corpora lutea or the weight of testes, In order to express these colour changes in numerical values. An apparatus as shown in Figs. 1a and 1b were devised.

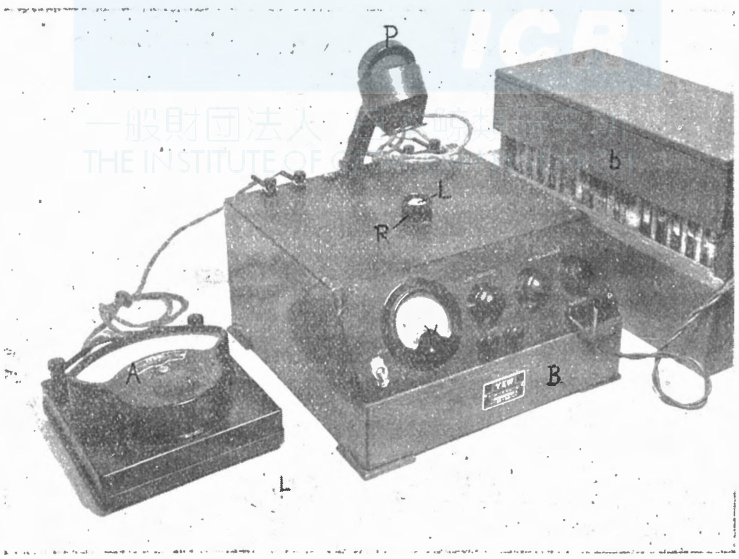
Deep thanks are expressed to Mr. Seiji Matsui, Mr. Yoshiaki Nakayama, Mr. Yoshio Sawaji, Mr. Mieyoshi Matsuzaki, Tokyo Shibaura Electric Company Ltd. and Mr, Takeshi Takei and Mr, Yoshitomi Harada, Yokogawa Electric works for their guidance and assistance for the deviee of this apparatus.

Fig. 1a. Absorption Measuring Apparatus.



The glass cylinder shown in Fig. 1a contains some crystalline lens already measured.

Fig. 1b. Miniature of Absorption Measuring Apparatus



The apparatus were based on the fact that stronger the colour, more absorption of light would take place. Therefore, a definite amount of light is passed through a crystalline lens, and the amount of light filtered therefrom, is received by a photocell by which the intensity of light would be recorded by an ammeter.

In Fig. 1, the electric current from the battery (b) is measured by the voltmeter (V) and reaches the light source (1) (contained in the central machine (B)) after voltage is made constant by a resistance. A light of definite intensity from the light source (1) is passed through a lens to become a parallel light, passes through a slit (S) to be radiated to upper part of the machine. At this place, the light passes through the crystalline lens (L) contained in a vessel (R) and is received by the photocell (P), the amount of current received there of being shown by the ammeter (A). The ammeter is graded from 0 to 100, 0 being at a point where no current is passing, and 100, when a definite intensity of current is registered. Prior to actual use (every time the crystalline lens is measured), this needle is set to 100 by the use of a resistance in the apparatus(B). A light passing through a lens would give a certain value in percentage minus the amount of light absorbed by the crystalline lens. The amount of light registered in percentage is the amount of light that has passed through the crystalline lens and, therefore, the amount of light obstructed and absorbed by the coloring in crystalline lens is the value obtained by substracting the value of percentage obtained on the ammeter from 100. This value is designated as the degree of lenticular colouration (light absorption by crystalline lens).

The crystalline lens become slightly larger (increase in diameter and height) with the increase of body length (i. e. age). It becomes slightly clouded with passage of time after the death of a whale so that the lens does not show absorption ratio proper to the degree of colouration.

The fact of an increase in the size of crystalline lens was not taken into consideration in checking the values. There may be some question of how a parallel light from a slit definite size would be affected by the difference in curvature due to size of a crystalline lens but it was found negligible and no correction was made on this account.

The turbidity of the lens was corrected by the values determined from the curve of rate of change after death described later. Table I shows the change in light absorption rate according to passage of time after killing.

Table I. Change in Light Absorption Rate According to Elapse of Time from Killing.

No.	Species of Whale	Sex	Time: Killed at	Time: Treated at	Time: Measured at	Elapsed time from killing to measuring: hr.	min.	1st Value %
46	Fin	Male	0330	0420	0450	1	20	88.5
200	〃	Female	1530	1600	1620	0	50	93.5
265	〃	Male	1800	1850	1900	1	00	77.0
294	Blue	Male	1515	2015	2130	6	15	84.0
311	Fin	Male	1615	1745	1755	1	40	79.5
379	〃	Female	1350	1425	1435	0	45	72.0
451	Blue	Male	1820	1850	1900	0	40	92.0
578	〃	Female	0800	0845	0900	1	00	82.0

No.	Measurements made after: 30 min %	1 hr. %	1.5 hrs. %	2 hrs. %	2.5 hrs. %	3 hrs. %	4 hrs. %	5 hrs. %	6 hrs. %	7 hrs. %
46	86.0	86.0	83.5	83.5	—	—	—	—	—	—
200	93.0	91.0	—	89.0	—	87.5	—	88.0	—	—
265	76.5	76.0	—	—	74.0	—	73.0	—	—	—
294	83.0	—	82.5	—	—	82.5				
311	79.5	—	77.5	—	75.5	—	—	—	—	—
379	—	70.0	—	68.0	—	66.0	66.5	66.0	—	65.0
451	92.0	—	90.5	88.0	87.0	—	86.5	—	—	—
578	81.5	—	81.5	79.5	—	77.5	76.5	—	76.5	

No.	Measurements made after: 8 hrs. %	9 hrs. %	10 hrs. %	11 hrs. %	12 hrs. %	Marks on Graph	Colouration (Living Index) %
46	83.5					•	90.0
200	—		87.5			○	94.0
265	72.0					△	78.0
294						□	89.0
311	75.0	—	—	—		★	82.0
379	—	—	—	—	65.5	*	73.0
451	—	86.0	—	—	85.5	不	92.5
578						×	83.5

The values in Table I was turned into a graph and a curve was obtained of the change in colouration by passage of time, as shown in Fig. 2. The solid line is the ratio of colour change after death. All the data contained in the present paper have been corrected by this curve.

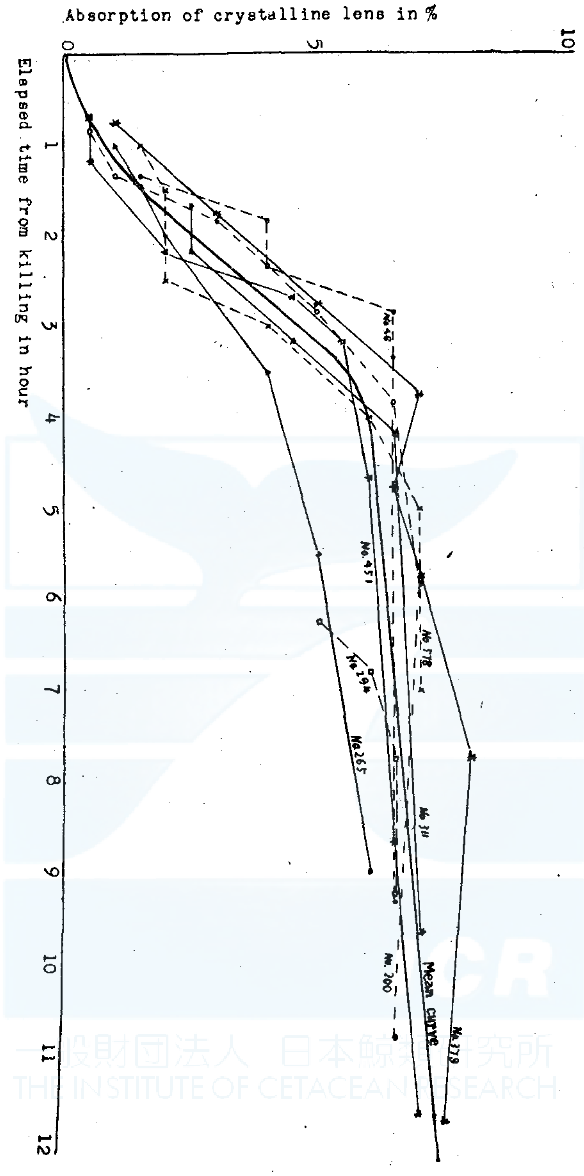


Fig. 2. Variation of Absorption of Crystalline Lens according to time elapsed from killing

CHAPTER III. Material of Investigation and Individual Data

Crystalline lens of both eyes were measured by the method previously described with all the whales caught by the Hashidate-maru fleet in the

Antarctic during the whaling season of 1948-1949. The number of whales caught were 291 heads of blue whales (183 males and 108 females) and 425 heads of fin whales (203 males and 222 females), of which 3 male blue whales, 3 male fin whales and 3 female fin whales were excluded owing to cataracts and other diseases of the eye. Individual data of whales are given in the Supplement according to the species and sex of whales.

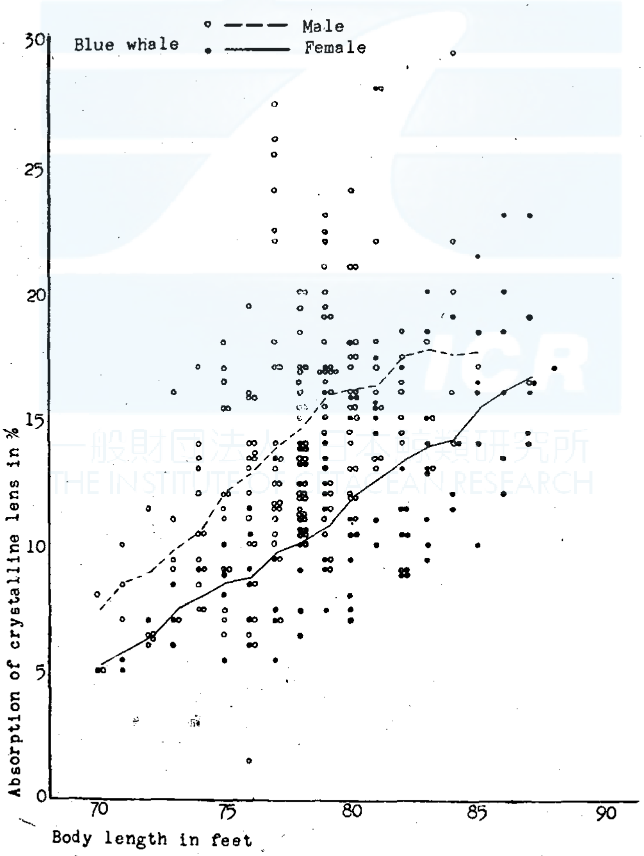
For printing reasons, measurement table of each whale was only sent to those who desired it, without appending to this report.

—(Compiler)—

Grateful thanks are expressed to General Manager Hiroshi Kurebayashi and the crew of the Hashidate-maru, Nihon Suisan Co. Ltd. for cooperation and to Mr. Masayuki Nakajima and Noboru Kanasaki for assistance.

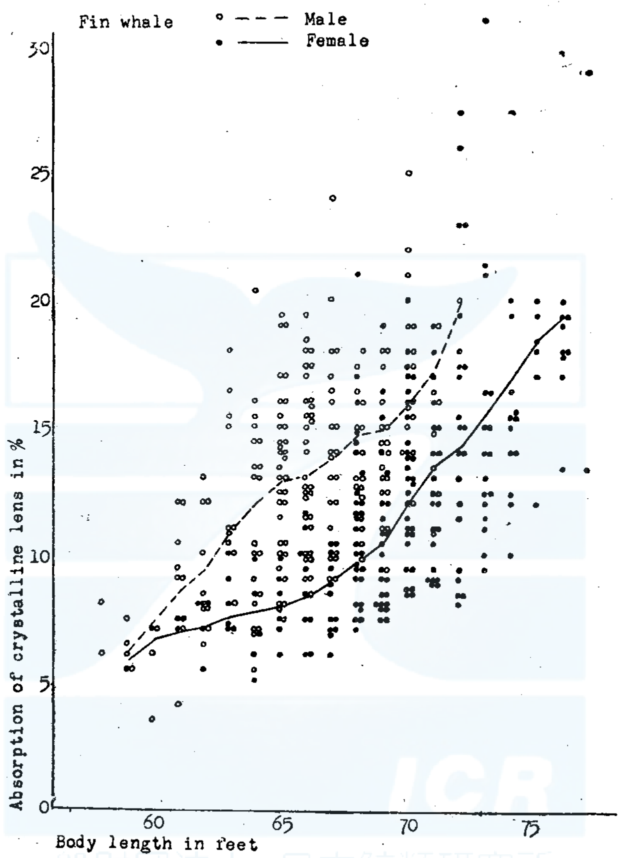
CHAPTER IV. Relationship between Lenticular Colouration and Body Length

Fig. 3. The Degree of Lenticular Colouration According to Body Length



The body length, naturally, increases with growth. Since the degree of lenticular colouration is one of the data showing growth, examination was made as to the presence of any relationship between body length and degree of colouration.

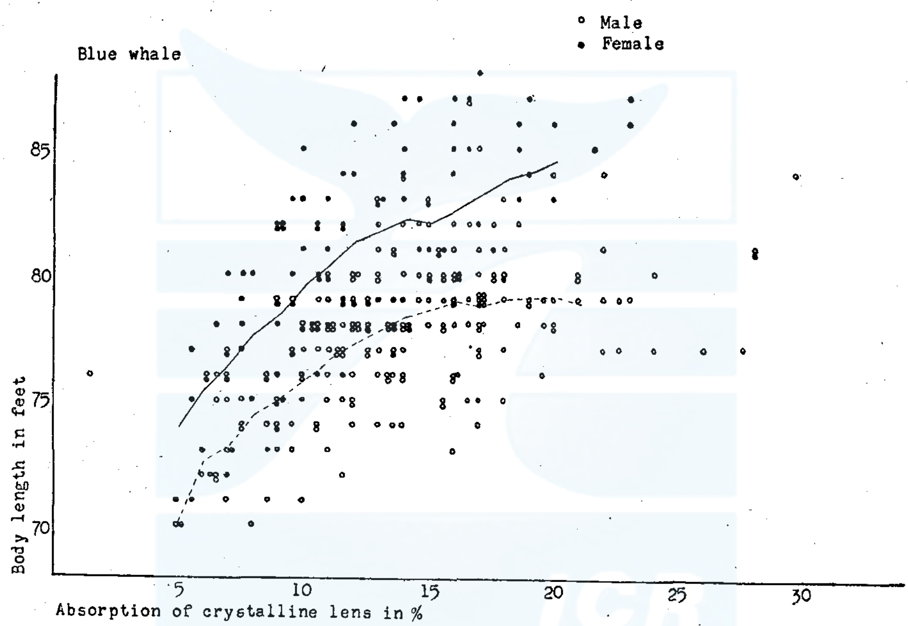
Fig. 4. The Degree of Lenticular Colouration According to Body Length



Figs. 3 and 4 show the distribution of the degree of lenticular colouration according to body length in blue and fin whales, respectively. White circles denote those of male whales, and black dots, those of females. It can be seen that both males and females show definite increase of colouration with the increase in body length. The broken lines in both Figs. 3 and 4 show the curve of average degree of lenticular colouration according to body length in male whales, and the solid lines show those of females. Average of male and female whales did not seem to show an average of whales in general and were, therefore, excluded. Both average lines show linear tendency. The colour of crystalline lens becomes darker with elongation of the body, i. e. with the elapse of time after birth.

The curve data for age estimation in whales in which male and female data could be combined include those for body weight and body length. In baleen whales, data for males generally come out below those of females. However, the curve for average degree of colouration in females are smaller than those for males. This must show that, in comparing male and female of the same lengths, females are generally younger than the males.

Fig. 5. Average Length of Whales According to Degree of Lenticular Light Absorption

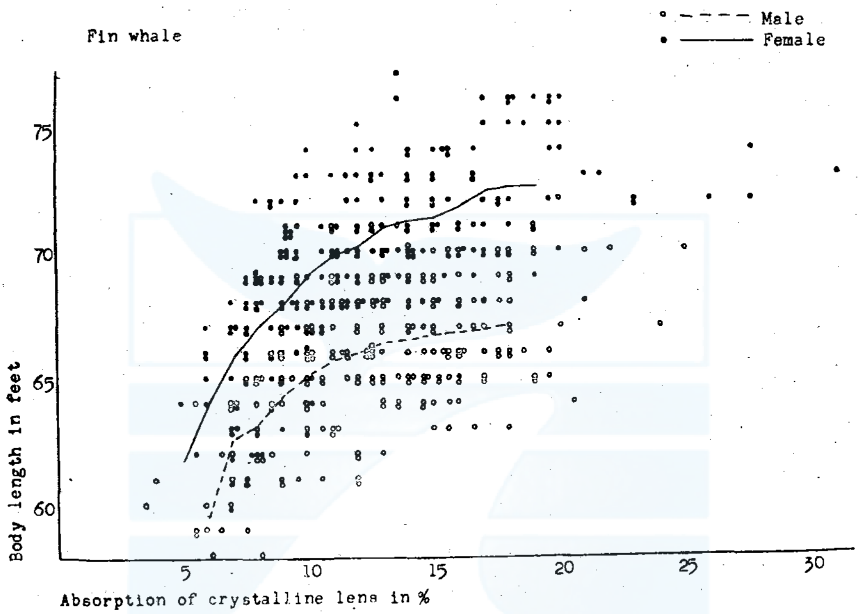


Figs. 5 and 6 show the distribution of body lengths according to degree of lenticular colouration in blue and fin whales, respectively. Notations on the graph are the same as those for Figs. 3 and 4.

The curve for average body lengths according to the degree of lenticular colouration shows that the increase in body length is rapid when colouration is slight, the increase becoming slow when colouration becomes deeper. The curves for male and female whales show about the same degree of colouration although that in female of sexual maturity is slightly below those of males. In other words, this shows the difference in average body length of male and female whales of similar age.

The trend of these curves are very similar to the growth curve obtained by Mackintosh and Wheeler ("Southern Blue and Fin Whales". Discovery Reports. Vol. I, pp. 442-443).

Fig. 6. Average Length of Whales According to Degree of Lenticular Light Absorption



Mackintosh and Wheeler determined an average growth curve in the pregnancy and lactating periods by the combination of standard monthly body growth curve obtained from the body length of whale foetus and the young, and of standard pregnancy period obtained in a similar manner. The growth curve mentioned above was obtained by the combination of this growth curve, body length of sexual maturity and the period needed for the attainment of sexual maturity obtained by other means, such as the relationship between body length and the number of corpora lutea, or between body length and volume of testis. Mackintosh and Wheeler's growth curve is the one most trusted as showing standard growth of whales up to the age of sexual maturity. I am also the one who has followed it as a text.

The average body length curve according to the degree of colouration was obtained according to individual data of each whale and no such curves for males and females could be drawn by any other data for the determination of age. It is easy enough to obtain separate curves for male and female. Same length of baleens in male and female whales do not denote that their ages are the same. Therefore, combined curve for male and female whales cannot be obtained from the relationship between body length and weight, or from body length and baleen length. Relationship becomes evident only after these data are combined with that of the degree of lenticular colouration.

The only data available for relating male and female whales was the fact that the ankylosis in centrum and epiphyses of vertebrae shows the degree of physical maturity. Many scientists have proved the reliability of this method, and I, too, believe that this is theoretically correct, and have used the data in the following chapters in the same degree of reliability as the relationship between the number of corpora lutea and sexual maturity in female whales. However, it has remained unknown whether the degree of sexual maturity occured at the same age level in male and female whales.

Figs. 5 and 6 can explain both the sexual and physical maturity, and they will often be referred to in the coming chapters.

CHAPTER V. Comparison of the Distributions in Degree of Lenticular Colouration and Number of Corpora Lutea According to Body Length in Female Whales.

Comparison of the distribution of the degree of lenticular colouration according to body length in female whales and that of the number of corpora lutea according to body length in same animals are shown in Fig. 7 for blue whales, and in Fig. 8 for fin whales. The latter data are considered to be the most reliable in estimating the age of whales at present.

The white circles in the two Figures show the number of corpora lutea, and black dots, the degree of colouration, both with respect to body length. In whales where colouration measurement could not be made due to cataract and other eye diseases, corresponding data for number of corpora lutea have been omitted. Therefore, the number of white circles and black dots are the same. Although the diagram was obtained by superimposing one diagram on the other, comparative graph cannot be obtained by ignoring a relationship between the number of corpora lutea and degree of colouration. The manner of obtaining coordinates by calculating the relationship between the two are explained below.

Fig. 7. Relationship between the Degree of Lenticular Colouration and Number of Corpora Lutea According to Body Length

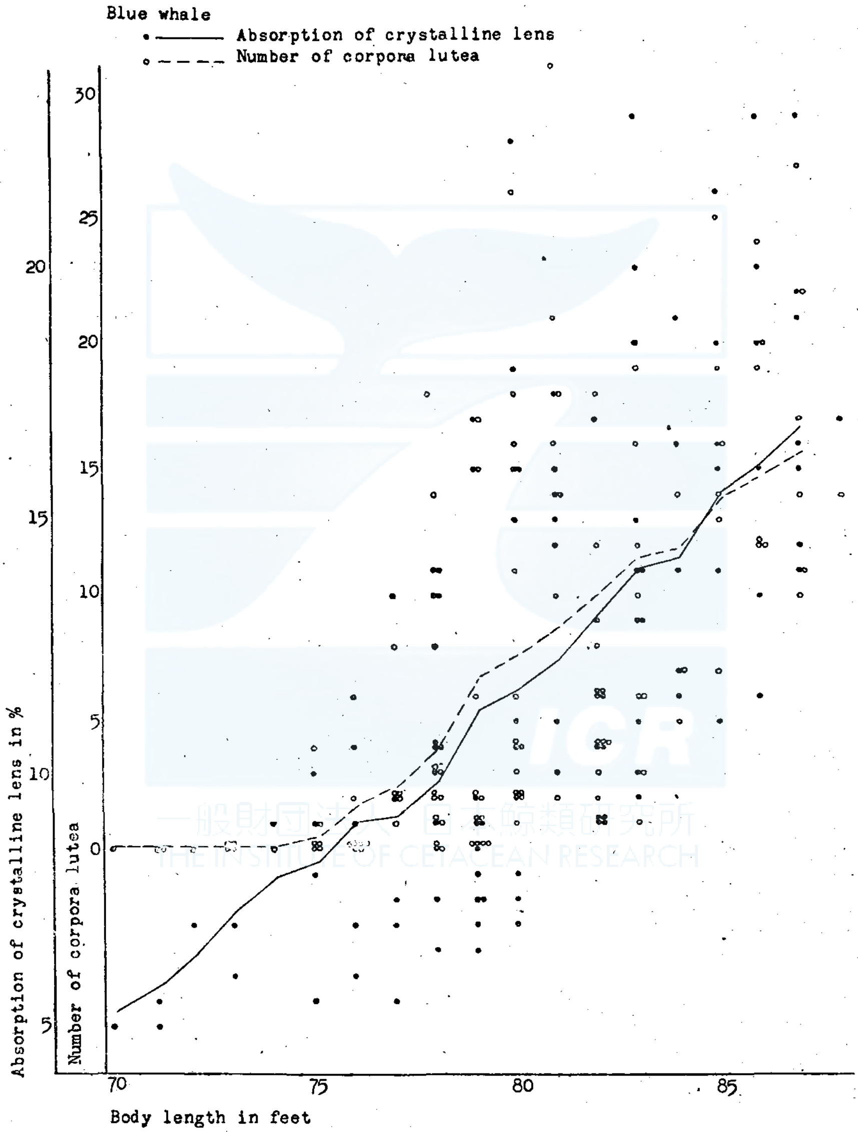
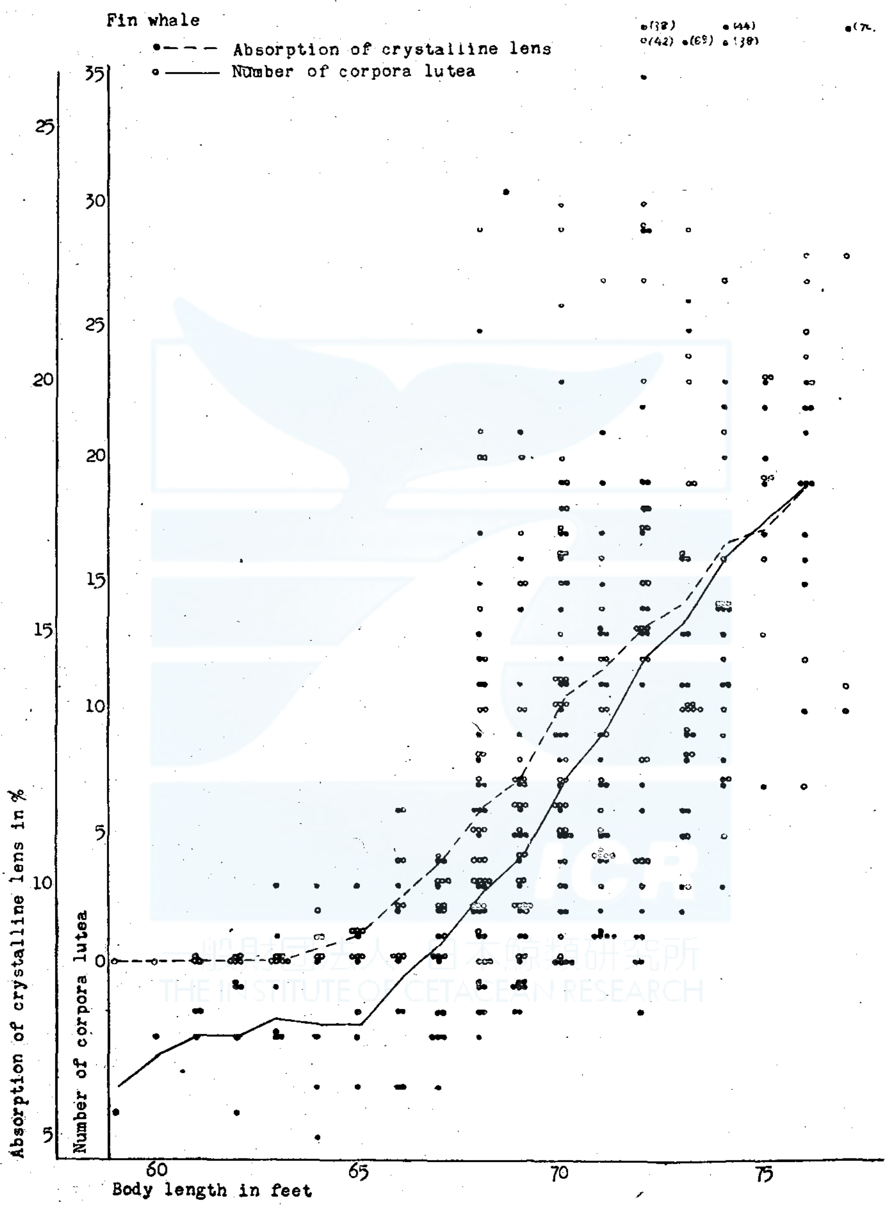


Fig. 8. Relationship between the Degree of Lenticular Colouration and Number of Corpora Lutea According to Body Length



The average number of corpora lutea in blue whales according to their body length is as follows:

(1)

Degree of Colouration *	5%	10%	15%	20%
Average No. of Corp. Lutea	0.7	3.1	12.6	14.8
No. of Whales examined	7	31	18	5

* Degree of colouration, as explained in Chapt. II, is the rate of light absorption by crystalline lens.

Average degree of colouration according to the number of corpora lutea is as follows:

(2)

No. of Corp. lutea	0	1	5	10	15
Average deg. of colouration	7.75%	9.86%	11.20%	14.20%	15.36%
No. of Whales examined	7	7	7	5	12

According to Table (1), the number of corpus luteum corresponding to 1 % of colouration is 0.94 , (A), and to Table (2), an average 5 corpora lutea corresponds to 1.67% of change in the degree of colouration (B).

By averaging (A) and (B), it is seen that 5 % of colouration corresponds to 9.85 of corpora lutea.

To obtain a common base-line for the number of corpus luteum and degree of colouration, what combination of the percentage of colouration and how many number of corpus luteum to be taken was derived as follows:

Since there are no number of corpus luteum smaller than 0, the age of whales having no luteal body cannot be defined. In other words, whales of the group having no corpus luteum contain many which should be in a group below that. On the other hand, degree of colouration classify whales in the group having no corpus luteum. It follows, therefore, that the base line would line at a point of 1 corpus luteum which, from Table (1), would give the colouration of 9.84 %. According to this, 10 corpora lutea would correspond to 13 % of colouration, and 15 % colouration, to 11 corpora lutea.

In the same manner, following data can be obtained for fin whales:

(1)

Degree of colouration:	5%	10%	15%	20%
Average No. of Corp. lut.:	0	4.0	9.8	22.5
No. of whales examined:	7	52	33	13

(2)

No. of Corp. lutea.:	0	1	5	10	15
Average Colouration:	7.12%	8.60%	10.65%	13.45%	13.42%
No. of whales examined:	33	9	30	19	20

From the above Table (1), the number of corpora lutea corresponding to 1 % of colouration is 1.5, (A), and from the above Table (2), the colouration of 2.27 % corresponds to 5 corpora lutea (B).

By averaging (A) and (B), it is seen that 5 % of colouration corresponds to 9.25 corpora lutea. The common base-line, calculated as for blue whales, is at about 9 %, since the colouration of 8.4 % corresponds to 1 corpus luteum. Accordingly, 10 corpora lutea would correspond to 14 % of colouration, and 15 % of colouration, to 9.2 of corpora lutea.

This difference between blue and fin whales can be assumed as difference in the number of ovulation in different species of whales. However, it seemed that there has been a slight difficulty in actual calculations so that the following basis was obtained by averaging the resulte of the two.

In order to facilitate preparation of a graph with 5 % of colouration corresponding to 9.55 corpora lutea, it was made in uniform intervals of 2 corpora lutea corresponding to 1 % of colouration.

The base line was taken at a point of 1 corpus luteum, and, since its colouration is at 9.18 %, colouration of 9 % was combined with one corpus luteum.

According to this, 15 % of colouration corresponds to 13, and 20 % of colouration to 23 of corpora lutea, or 5 corpora to 11.5 % of colouration or 10 corpora to 14 % of colouration. These values satisfy the conditions for both species of whales.

The trends in Figs. 7 and 8 are both entirely the same.

Generally speaking, the dispersion or white circles, i. e. showing the number of corpora lutea, is more scattered than the black dots, i. e. showing degree of lenticular colouration. It appears that the degree of colouration is present more in the lower part of the graph. However, this trend must be due to the fact that there are no presentation of figures below that of 0 for corpus lutea whereas those for colouration below that are present. In Fig. 8, showing values for fin whales, the group of black dots seem to lie slightly below that of white circles. This is in accordance with the explanation given in the paragraph on calculation of base-line and since 1 corpus luteum corresponds to 8.4 % of colouration, it should have been made to 8.5 % to facilitate perception, but it had been made to correspond to 9 % in averaging with data for blue whales. This was left as it was in this Chapter since it could not be determined whether the difference was due to the difference in the number of ovulation according to the species of whales, or whether this was obtained accidentally in calculation. As explained in Chapter VII, the relationship between the degree of colouration and the number of corpora lutea is definitely different in species of whales. However, no correction will be made in this chapter.

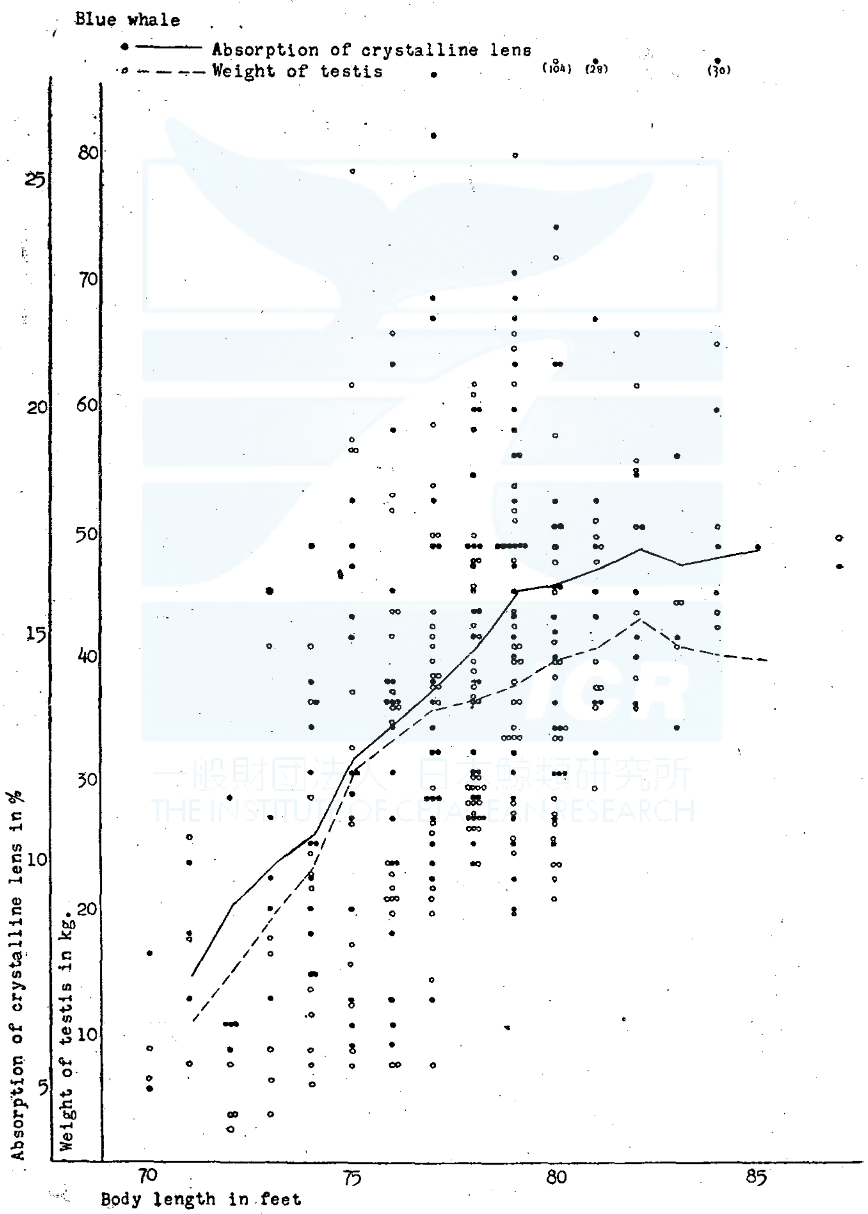
The average body length curves for both blue and fin whales coincide with each other in both calculated from the number of corpora lutea and from the degree of colouration. In those defined according to the number of corpora lutea, the number 0 is the minimum number, giving a lower limit, but the colouration was given for young whales in the group of those having no corpus luteum. This shows the definite advantage of employing the degree of colouration. The curves for the number of corpora lutea and the degree of colouration coincide well in parts where larger number of corpora lutea are present, i. e. where colouration is deeper. Where the number of corpora lutea is smaller, i. e. where the degree of colouration is low, the two curves are slightly set apart, and this may be due to the effect of aforementioned separation of some bodies in the group having no corpus luteum.

Differing from the data of male whales, the increase in the number of corpora lutea is supposed to change in accordance with the passage of time, so that the change in the degree of colouration should also change regularly with passage of time, i. e. with age.

CHAPTER VI. Comparison of the Distributions in the Degree of Colouration and the Weight of Tests according to Body Lengths in Male Whales.

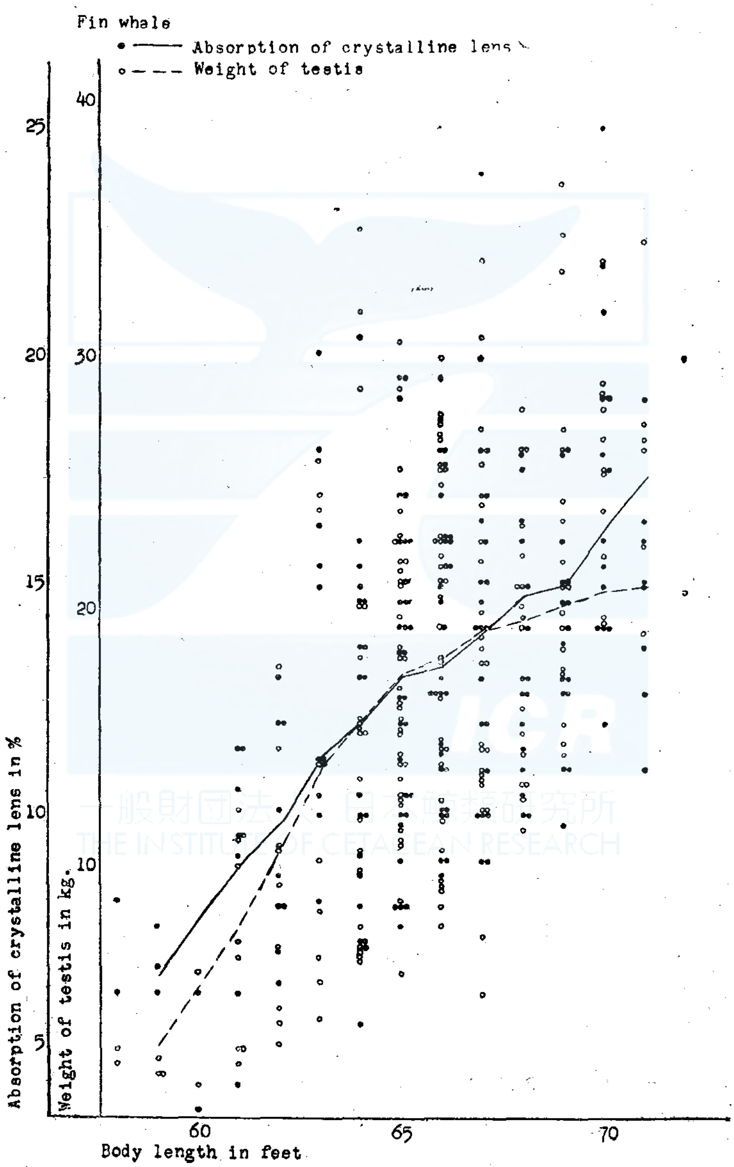
The consideration given to female whales in Chapter V was applied to male whales and the distribution of the degree of colouration and the

Fig. 9. Relationship between the Degree of Colouration and Weight of Testes According to Body Length



weight of testes according to body lengths were compared in one graph. Fig. 9 shows that of blue whales, and Fig. 10, that of fin whales. The reason why the weight of testes was used instead o its size that the former seemed to show values closer to actual figures than the latter.

Fig. 10. Relationship between the Degree of Colouration and Weight of Testes According to Body Length.



The white circles in the graphs denote the weight of testes, and black dots, the degree of colouration. As in the case of female whales, those having cataracts and other eye diseases necessitated removal of white circles corresponding to them, making the number of white circles and black dots the same.

The relationship between the weight of testes and the degree of colouration was calculated as in the case of female whales.

Average weight of testes in blue whales according to the degree of colouration were as follows:

(1)

Degree of Colouration:	5%	10%	15%	20%
Average Weight of Testes:	7.0	25.5	40.9	25.4
No. of Whales examined:	3	26	27	12

Average degree of colouration according to the weight of testes is as follows:

(2)

Weight of Testes:	10 kg.	20 kg.	30 kg.	40 kg.	50 kg.
Average degree of Colouration:	7.0%	9.5%	14.3%	15.3%	16.4%
No. of Whales examined:	3	8	12	17	9

In fin whales, values obtained were as follows:

(3)

Degree of Colouration:	5%	10%	15%	20%
Average Weight of Testes:	3.7	11.5	20.9	26.1
No. of Whales examined:	5	41	52	(11)

(4)

Weight of Testes:	5 kg.	10 kg.	20 kg.	30 kg.
Average Degree of Colouration:	9.8%	10.3	15.1	16.7
No. of Whales examined:	8	15	21	5

Values for blue and fin whales were obtained individually, and were used by averaging them in the first datum. Generally, the weight of the testes of blue whales is about twice that of fin whales, so that the values for fin whales were doubled to obtain an average value.

Average of data obtained by $\{(1)+(3)\times 2\}\div 2$ gave 13.9 kg. in weight of testes as corresponding to 5 % change in the degree of colouration (A). Average of data obtained by $\{(2)+(4)\times 2\}\div 2$ gave 0.2225 % of degree of colouration as corresponding to 1 kg. change in the weight of testes(B).

By averaging (A) and (B), it was found that 5 % of colouration corresponds to 18.2 kg. (taken as 18 kg.) of the weight of testes, in blue whales. In fin whales, the values are one-half of this, being 9 kg. of testicular weight corresponding to 5 % of colouration.

The base-line was obtained by the following method of calculation taking the weight of testes at 10 % of colouration. Blue whales = (Testicular weight of blue whales at 10% of colouration + testicular weight of fin whales at 10% colouration × 2) ÷2.

Fin whales = (Testicular weight of blue whales at 10% of colouration + testicular weight of fin whales at 10% of colouration × 2) ÷4.

By this method of calculation, it was seen that 24 kg. of testicular weight in blue whales, and 12 kg. of weight in fin whales correspond to 10% of colouration. This was taken as the common base-line.

According to this, 15% of colouration corresponds to 41.3 kg. of testicular weight in blue whales and 20.7 kg in fin whales. The coordinates in blue whales would then be at 42 kg., and that in fin whales, 21 kg., which would satisfy both values. The average colouration at 40 kg. of testicular weight in blue whales is 15.3%, that at 20 kg. in fin whales, 15.1%, giving values that satisfy conditions in both species of whales.

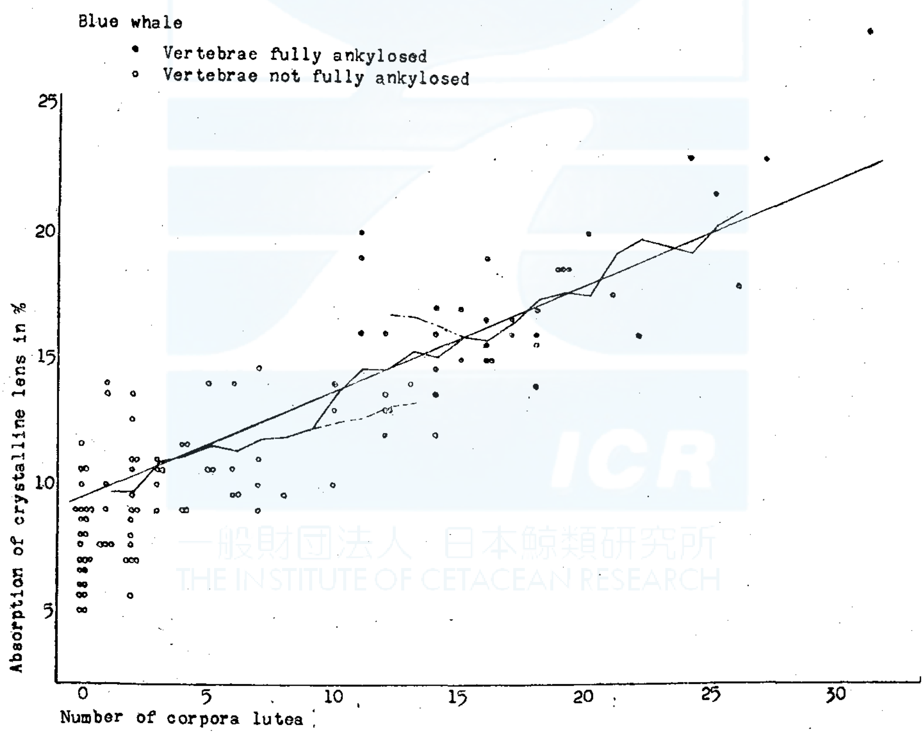
Curves in Figs. 9 and 10 show similar tendencies. As a whole, the white circles, i. e. the weight of testes, show greater degree of dispersion. The average curve for weight shows rapid development at sexually mature stage, after which, the increase in testicular weight has little relation to body length. The same can be said of the size of testes. The testicular weight curve, therefore, begins to slant off as the animals reach sexually mature body length.

As was explained in the chapter for female whales, the degree of colouration dose not seem to show any special development or declination with sexual maturity. It should change in relation only to passage of time, i. e. by age. It is natural, therefore, that these two curves should be separated at the beginning and the end of these graphs, coming close as a tangent at one point. This point should correspond to the neighborhood of the sexually mature body length. All these are borne out in Figs. 5 and 10.

CHARTER VII. Relationship between the Degree of Lenticular Colouration and Number of Corpora Lutea,

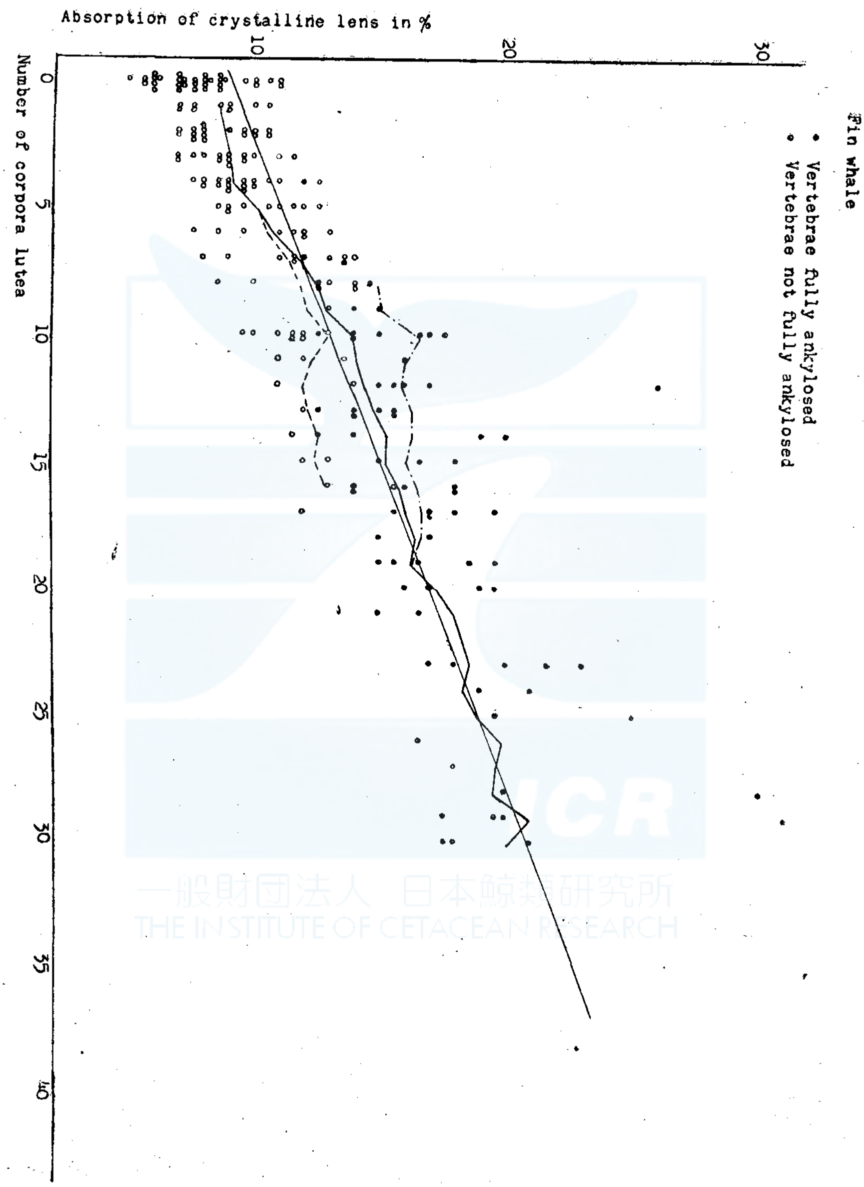
In preparing the graphs shown in Chapter V, some references were made as to the relationship between the degree of lenticular colouration and number of corpora lutea, These are shown in Fig. 11 for blue whales and in Fig. 12 for fin whales.

Fig. 11 The Degree of Lenticular Colouration According to Number of Corpora Lutea.



The black dots denote whales of physically mature, and the white circles those of physically immature. The solid line shows an average curve for the degree of colouration according to number of corpora lutea, and the broken line, an average curve for physically immature whales. The question of the maturity of whales will be discussed in the chapter under that heading, and only the relationship between the degree of colouration and number of corpora lutea will be discussed here.

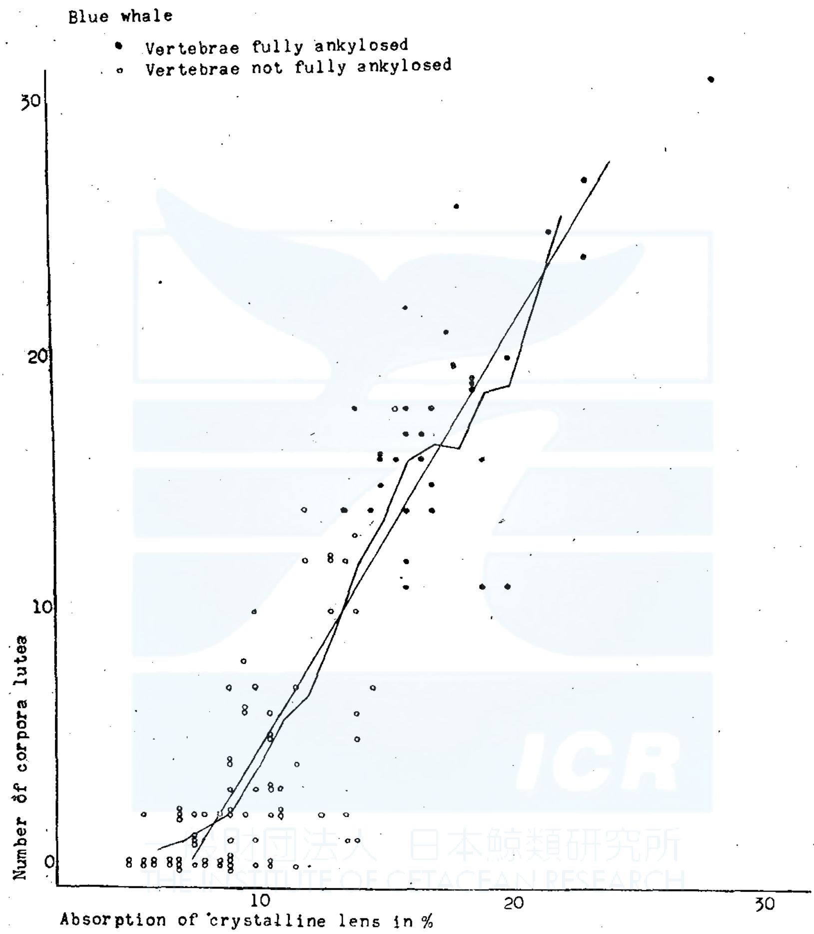
Fig. 12 The Degree of Lenticular Colouration According to Number of Corpora Luter



Average curves for both species of whales change lineally which must mean that there is a proportionate relationship between the colouration and number of corpora lutea. In blue whales, the ratio is 2.2% of colouration against an average of 5 corpora lutea in fin whales.

Figs. 13 and 14 show curves for the number of corpora lutea according to the degree of colouration in blue and fin whales, respectively.

Fig. 13. Number of Corpora Lutea According to the Degree of Lenticular Colouration.

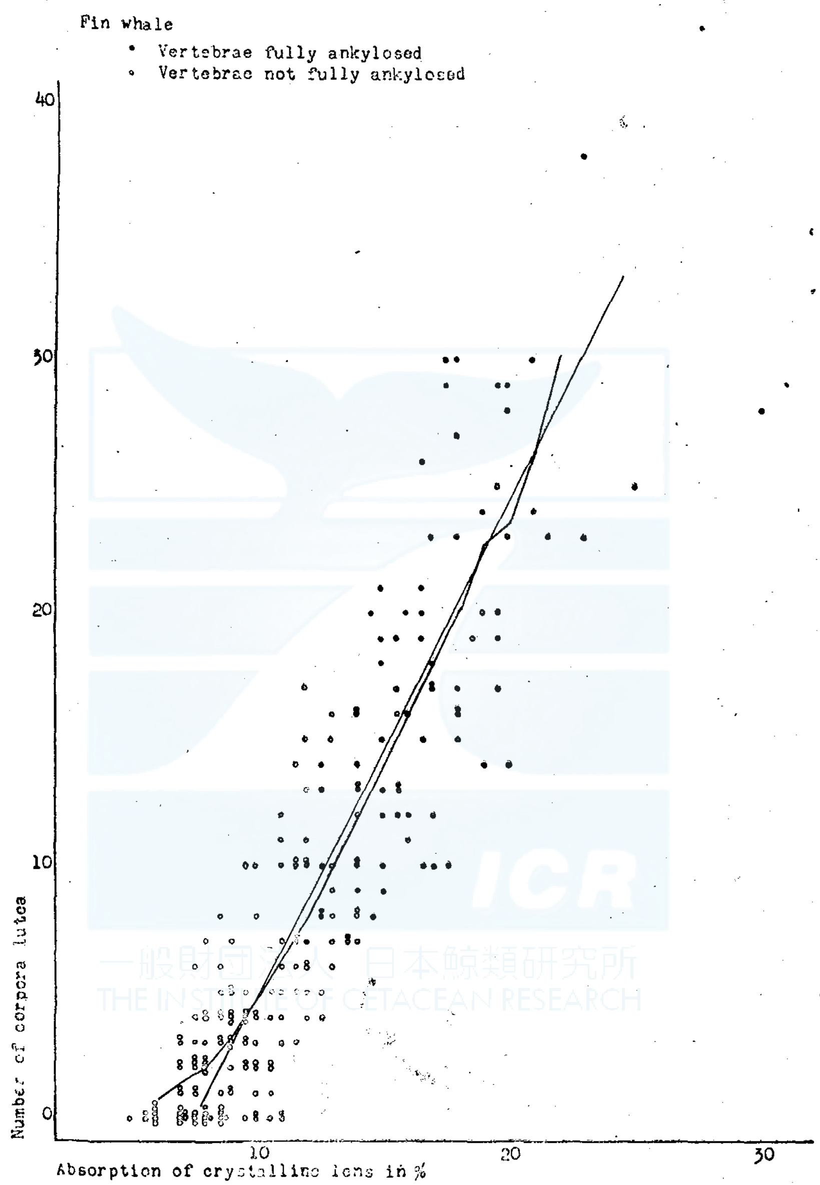


The relation of physical maturity is the same as for Figs. 11 and 12.

It can be seen from Figs. 13 and 14, that the curves for the two kinds of whales change lineally showing that there is a proportionate relationship between the degree of colouration and number of corpora lutea, the ratio being 17 corpora lutea in blue whales and 19 in fin whales against 10% change in the degree of colouration.

These values also approximately coincide with values described in Chapter V. It follows, therefore, that there must exist a certain difference in number of ovulation in blue and fin whales.

Fig. 14. Number of Corpora Lutea Accordind to the Degree of Lenticular Colouration



CHAPTER VIII. Relationship between the Degree of Lenticular Colouration and Weight of Testes.

Figs. 15 and 16 show the relationship between the degree of lenticular colouration and weight of testes in blue and fin whales, respectively. The latter values are thought to be the representative data for age determination of male whales.

Fig. 15. The Degree of Lenticular Colouration According to Weight of Testes.

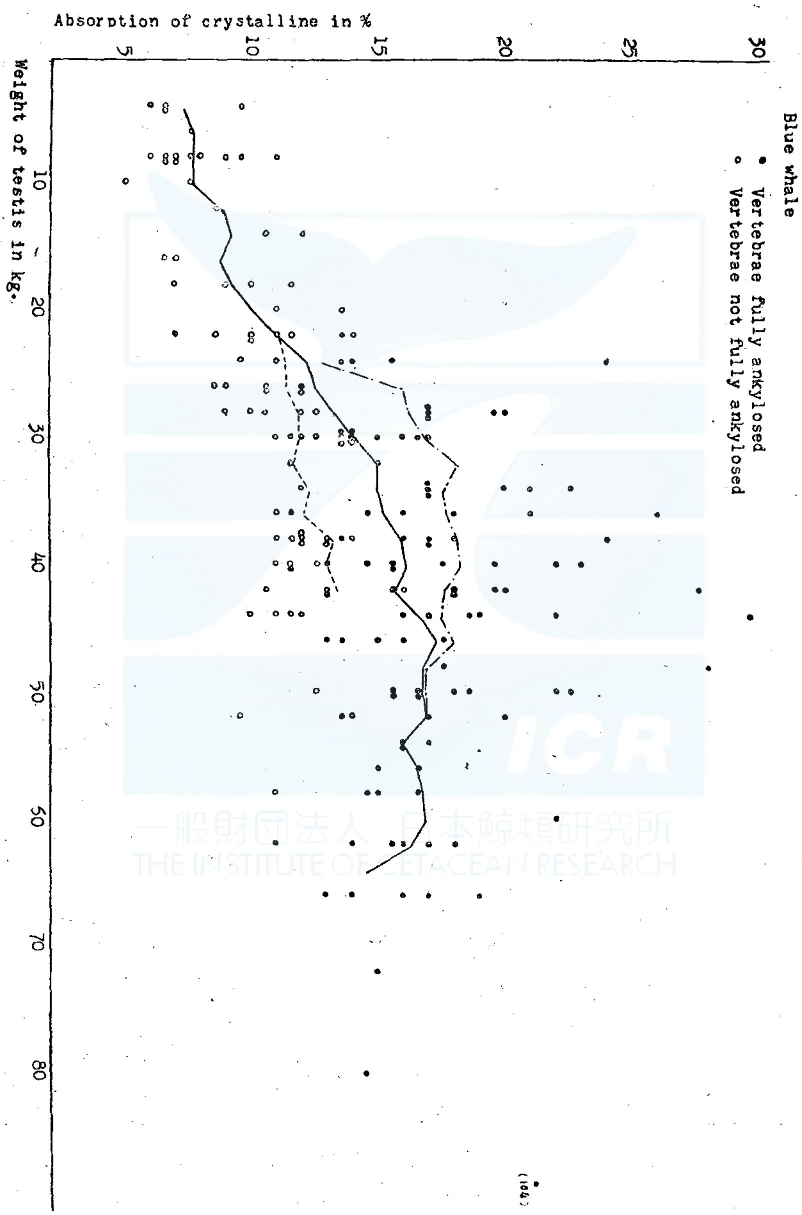
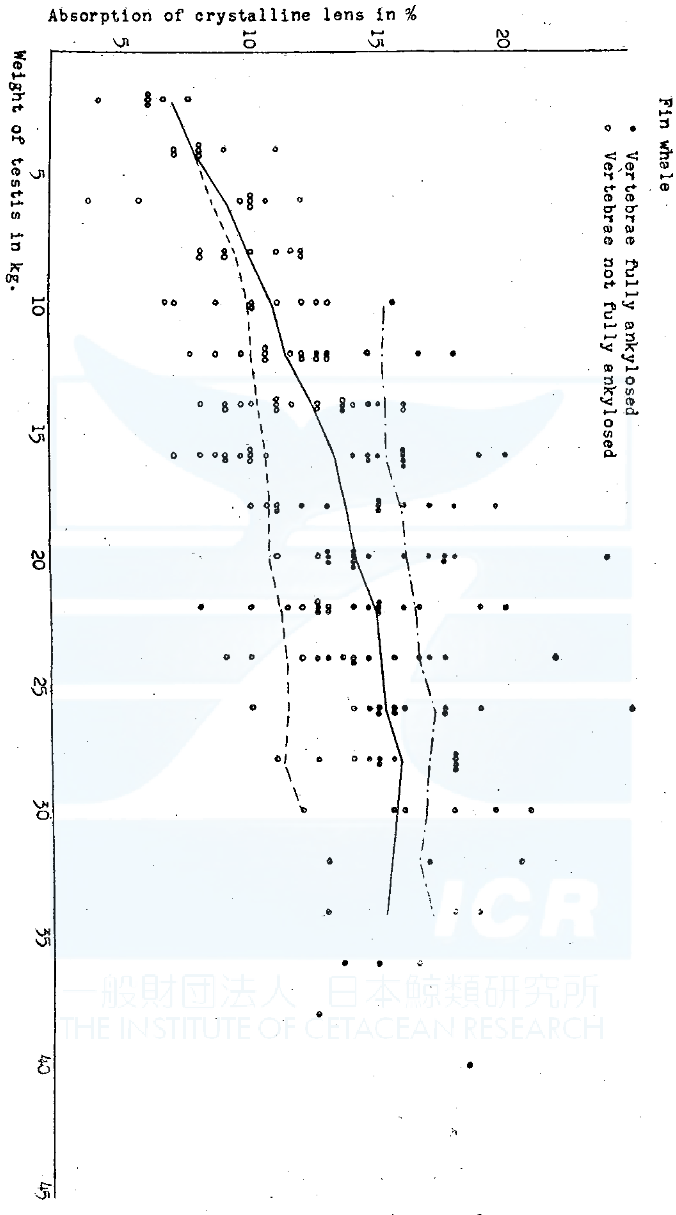


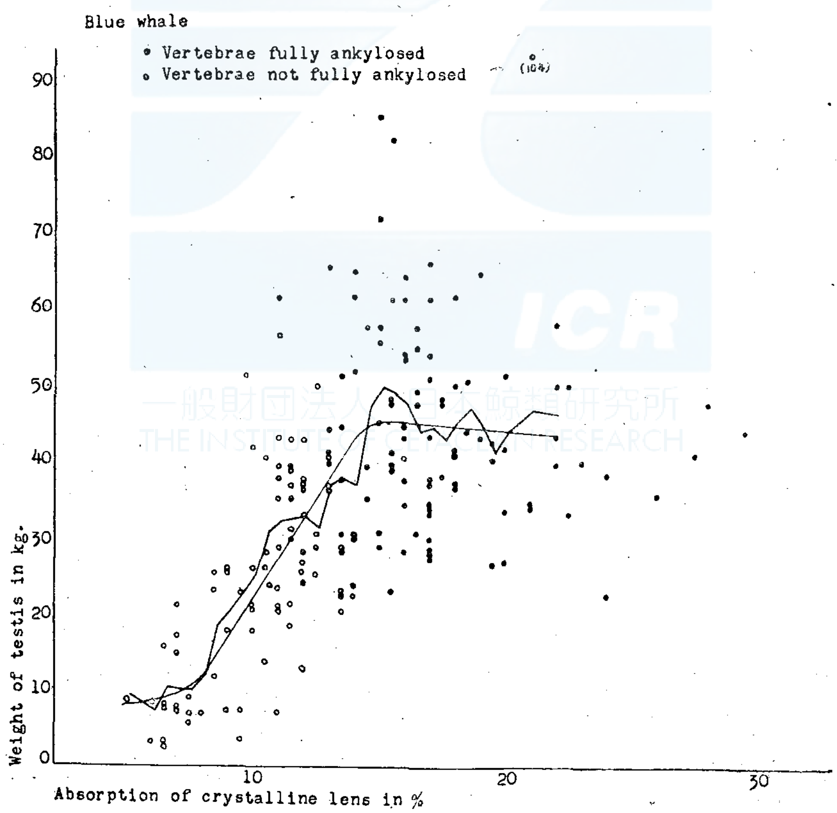
Fig. 16. The Degree of Lenticular Colouration According to Weight of Testes.



In these graphs, the white circles denote physically immature whales and the black dots, the physically mature. Broken and solid lines are the average degree of colouration according to testicular weight in physically mature and immature whales, respectively.

Contrary to the linear relationship existing between the degree of colouration and number of corpora lutea, the relationship between the degree of colouration and the weight of testes appear lineal at first but, after a certain testicular weight, it becomes irregular, and the line gose downward. This must mean that the testis develops regularly with age up to a certain point after which, its weight changes irrespective of age. The largest testis is found in a full-grown whales and testis of aged animals is lighter. Same tendency was observed in a relationship between body length and testicular weight, although it is dangerous to make any definite statement since body length itself is not always in direct proportion to passage of time. However, the degree of colouration seemed to be in direct proportion to the number of corpora lutea which changes regularly with passage of time, and its application to male whales must be taken definite unless

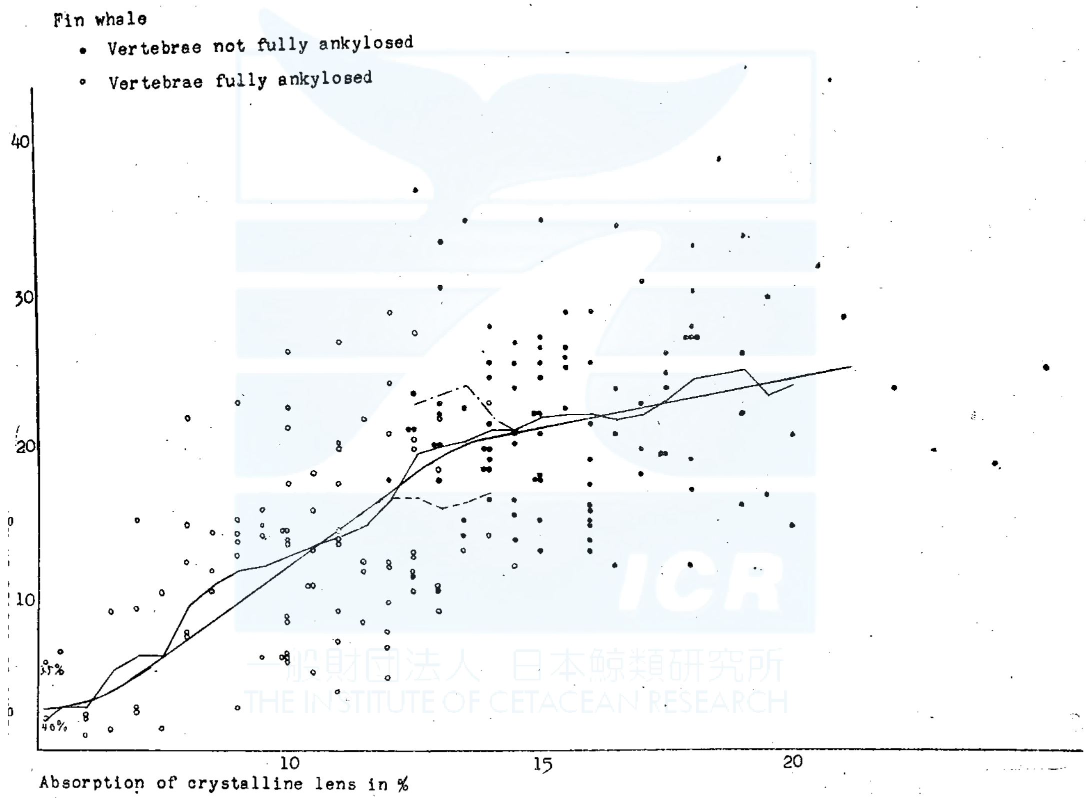
Fig. 17. Weight of Testes According to the Degree of Lenticular Colouration.



there exists a difference in the degree of colouration between the male and female whales. This was one of the phenomena found to differ in the male and female.

The same idea can be seen in the curve of testicular weight according to the degree of colouration which are shown in Fig. 17 for blue whales, and in Fig. 18 for fin whales.

Fig. 18. Weight of Testes According to the Degree of Lenticular Colouration.



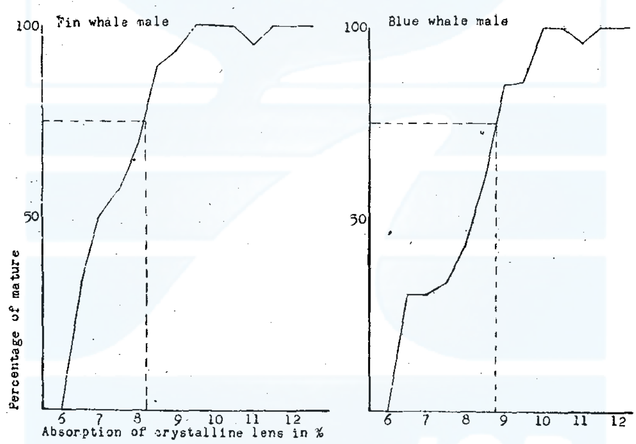
It is interesting to note that in the testicular weight curve according to the degree of colouration, the lower point of change corresponds to the testicular weight at sexual maturity, while that at the higher point corresponds approximately to the degree of colouration at physical maturity which is descrided in the next chapter.

CHAPTER IX. Relationship between the Degree of Lenticular Colouration and Sexual Maturity

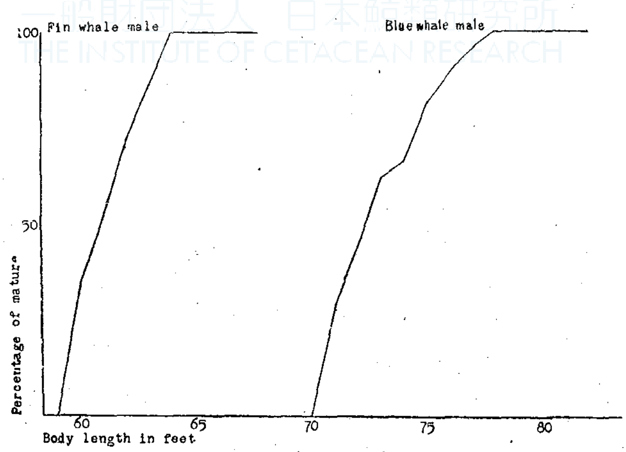
The degree of sexual maturity in female whales is easily determined by the existence of corpus luteum, but it is very difficult in the males. It has tentatively been presumed that sexual maturity has been attained in whales which has a combined testicular weight of 10 kg. in blue whales and 15 kg. in fin whales (This method of determining sexual maturity will be published in a separate paper).

Fig. 19. Percentage of Sexual Maturity in Male Whales

a) Degree of Maturity According to the Degree of Lenticular Colouration



b) Degree of Maturity According to Body Length



Male whales were classified into mature and immature animals according to this classification and the percentage of the number of mature animals according to the degree of colouration is shown in Fig. 19 a. The same percentage according to body length is shown in Fig. 19 b.

From these graphs, it can be seen that the degree of colouration at 75% of maturity is 8.8% in blue whales and 8.2% in fin whales. The body length at this percentage of colouration, calculated from the average body length curves according to colouration as shown in Figs. 5 and 6, are 75 feet in blue, and 64 feet in fin whales. The sexually mature body lengths derived from that at 75% maturity in Fig. 19b, are 75 feet in blue, and 64 feet in fin whales, showing a good coincidence.

An outstanding feature in the testicular weight curve according to the degree of colouration as shown in Fig. 17, as described in the previous chapter, is the fact that the point at which the weight increases suddenly corresponds to the percentage of maturity when the curve has been converted into a smooth one disregarding small, irregular increase and decrease. The testicular weight in blue whales at this point is approximately 10 kg. The same point in fin whales, as shown in Fig. 18, is at the testicular weight of about 5 kg., the degree of colouration being approximately 8%.

Outstanding features of curves in Figs. 15 and 16, are the facts that the point of change in curvature occurs at 10 kg. of weight and about 8% colouration in blue whales, and at 5 kg., and about 8% in fin whales, and these can be taken as the sexual maturity. However, these are curves for the degree of colouration according to testicular weight so that the change in weight according to passage of time (by age) as shown in Figs. 17 and 18, are more suitable to this theory.

Fig. 20 shows the average body length curve for sexually mature and immature whales according to the degree of colouration. This was obtained, first, by classifying the animals into the sexually mature and immature, and then by calculating average body lengths in each group by the degree of lenticular colouration. The curve for sexually mature whales show increase apporximately in accordance with changes as a whole. In immature whales, especially in fin whales, the curves show a remarkable change in body lengths against changes in the degree of colouration.

Fig. 20~. Average Body Length of Male Whales According to the Degree of Lenticular Colouration, divided into sexual Maturity.

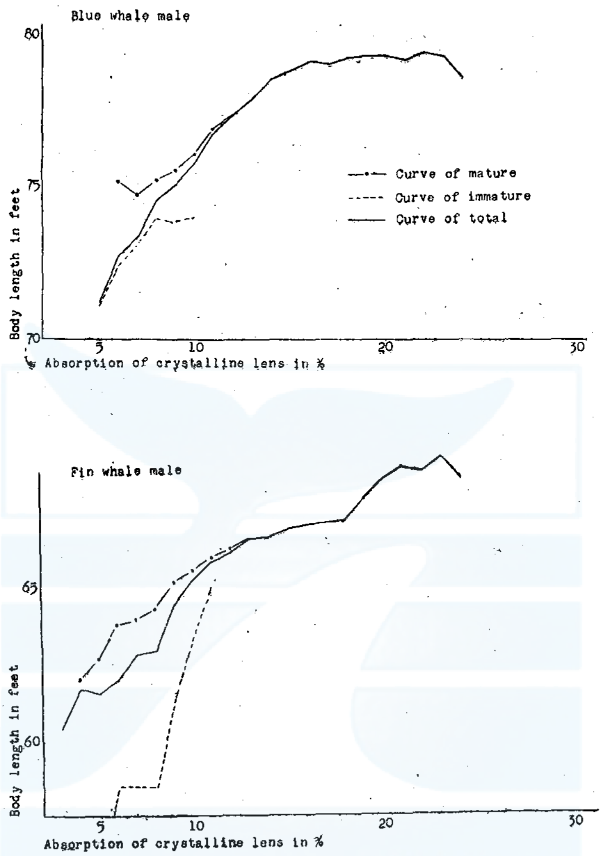
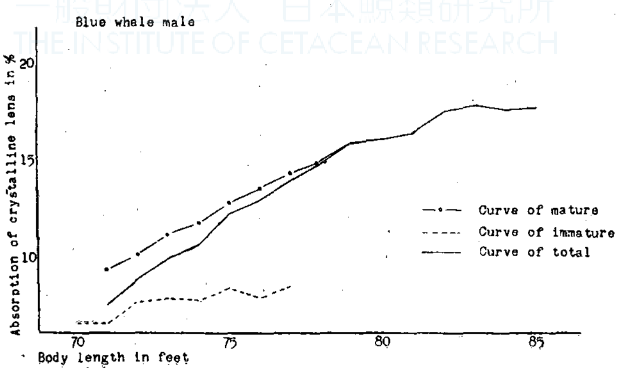


Fig. 21. Average Degree of Lenticular Colouration According to body Lengths, divided into the Sexual Maturity.



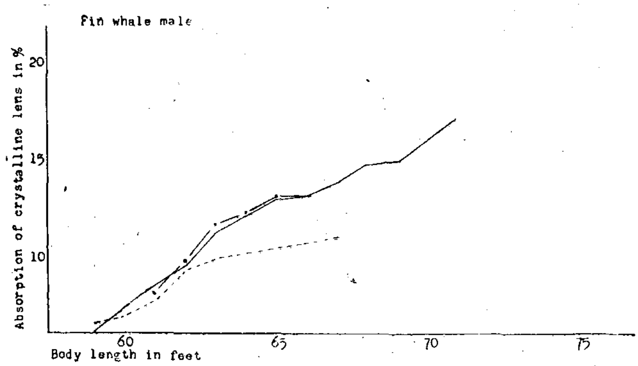
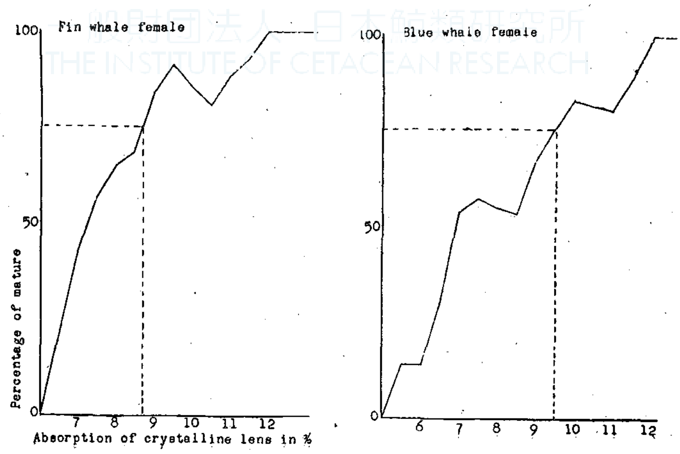


Fig. 21 gives the curve for the degree of colouration according to body length, the average values for which were obtained from whales classified by sexual maturity. In both the fin and blue whales, the changes in mature whales is the same as described for Fig. 20. The curve for immature whales varies in accordance with body length to a certain point in body growth. This point corresponds to the time when the body length and the degree of colouration change to those of mature whale. After this point, the curve levels off for immature whales. This must mean that, in baleen whales, the sexual maturity is attained at a certain age irrespective of the length of its body. Since the number of immature whales examined was small, it might not be correct to adopt this theory as being absolute but the immature whales represented in Fig. 20 would probably be explained by this reasoning.

Fig. 22. Percentage of Sexual Maturity in Female Whale

a) Degree of Maturity According to Lenticular Colouration



b) Degree Maturity According to Body Length.

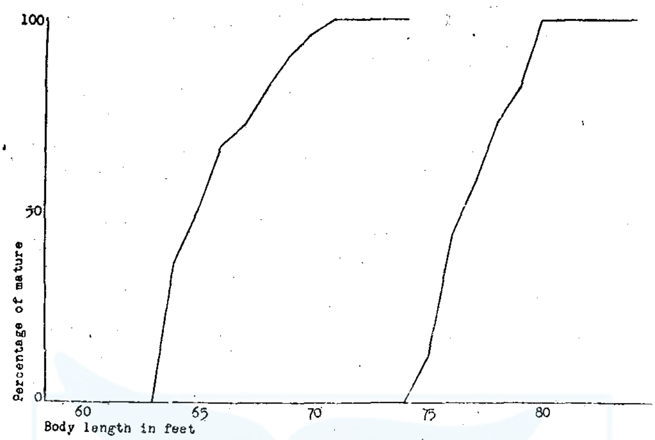


Fig. 22 shows the percentage of mature whales according to the degree of colouration, and Fig. 23, that according to body length, examined in female whales the sexual maturity of which was classified by the existence of corpora lutea.

From Fig. 22a, it can be learned that the degree of colouration at 75% of maturity is 9.5% in blue whales and 8.7% in fin whales. The body length of female whales at this colouration level, as calculated from Figs. 5 and 6, give 79 ft. for blue whales and 68 feet for fin whales. These values, obtained directly from Fig. 22b, 78 ft. for blue, and 67 ft. for fin whales.

Since the development of testes does not go parallel with age, this must constitute a point of argument in the question of sexual maturity in male whales. It is natural, therefore, that there should be a point of abrupt change in the curves for testicular weight by lenticular colouration and for average colouration by testicular weight. On the contrary, ovulation go parallel with age so that the curves for the average number of corpora lutea by lenticular colouration and for average colouration by number of corpora lutea are linear and there are no breaks. If the latter is present, it must be due to lack of the number of whales examined and will not be of a fundamental change. As has been described in Chapter V and VII, the curve change for whales having 0 to 1 corpus luteum cannot be considered on the same line. Classification by colouration was made on whales having no corpora lutea.

From this view-point, the lenticular colouration of whales having 1 corpus luteum as viewed in Figs. 11 to 14, is about 9.5% in blue whales and about 9% in fin whales, which coincides well with the results shown in Fig. 22.

Average body length of whales classified by sexual maturity as calculated from the degree of lenticular colouration is shown in Fig. 23. Average degree of lenticular colouration in whales classified by the degree of sexual maturity as calculated from body length is shown in Fig. 24. Since these figures are for female whales, they are further classified into stages

Fig. 23. Average Body Lengths of Female Whales According to Lenticular Colouration divided into Sexual Maturity.

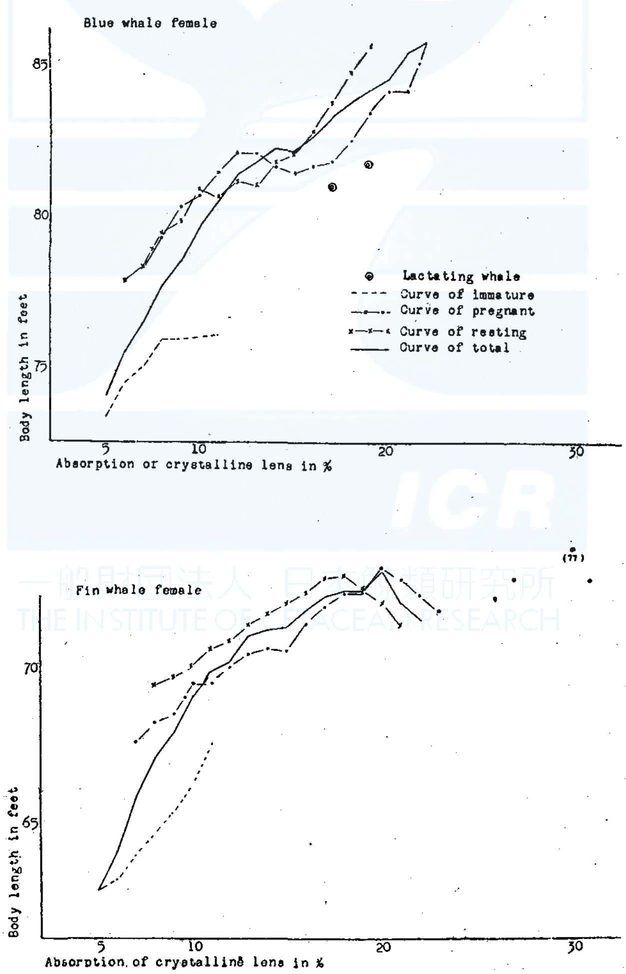
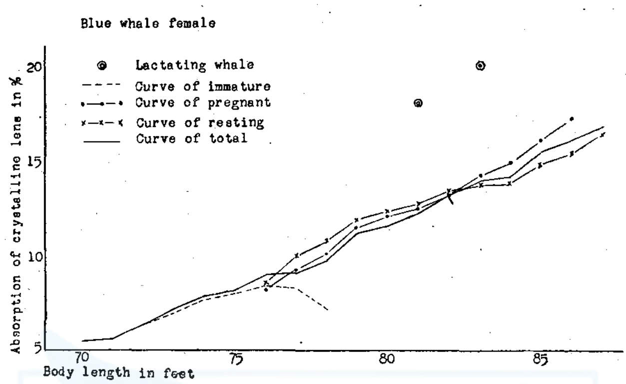
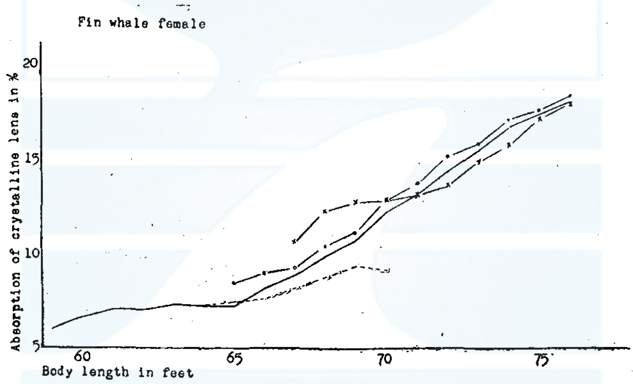


Fig. 24. Average Degree of Lenticular Colouration Female Whales According to Body Lengths Sexual Maturity.





of pregnancy, resting and lactating. Exactly the same idea as was found with the males is applicable here. Immature whales become sexually mature after a elapse of certain time, i. e. at a certain age, irrespective of body length. Of course, there is a basic body length for the sexually mature but, when a female whale passes a certain length of time from birth, it becomes sexually mature, whether it is large or small. No particular change can be learned from the classification of mature females into various stages of pregnancy resting and lactating. It seemed that blue whales of lactating stage apparently had higher degree of lenticular colouration but there had been only two heads of them so that it would be dangerous to draw any conclusion from just these two. At any rate, there are many other whales in pregnant and resting stages around this point.

CHAPTER X. Relationship between the Degree of Lenticular Colouration and Physical Maturity

In all the graphs given from Chapter VII to IX, in which the degree of lenticular colouration was combined with other data on age estimation, black dots denoted physically mature, and white circles, the physically immature whales.

As was explained earlier, physically mature whales are those in which the vertebrae were fully ankylosed, both in thoracic and lumbar series. If one or the other of these was not ankylosed, the whale was considered physically immature.

All theories to present date had it that in female whales, physical maturity was not related to body length but only to the number of corpora lutea. What then, can one find of a relationship between the degree of lenticular colouration and number of corpora lutea. Following could be learned from Figs. 11 and 12.

In blue whale females, 4 out of 78 whales having less than 12 corpora lutea were found to be physically mature, and 3 out of 30 whales having more than 13 corpora lutea were physically immature. Considered from lenticular colouration, 2 out of 77 whales with less than 14% colouration were found mature, and 2 out of 31 whales above 14.5% colouration were immature.

In fin whale females, 16 out of 146 having less than 11 corpora lutea were found mature, and 9 out of 74 having more than 12 corpora lutea were immature. In classification according to the degree of lenticular colouration, 7 out of 130 with less than 13% colouration were found to be mature, while 7 out of 81 with more than 13.5% colouration were found immature.

The range of mixed appearance of mature and immature whales in blue whale females was between 11 to 14 corpora lutea, or between 13.5 to 15.5% of colouration. In fin whale females, this was between 4 to 17 corpora lutea, or between 12 to 15.5% of colouration.

On both counts, physical maturity is more sharply related to the degree of lenticular colouration rather than to the number of corpora lutea. One of the reasons for this seems to lie in the fact that the degree of lenticular colouration changes more regularly with age than the number of corpora lutea, just as the number of corpora lutea changes more regularly with age than the body length.

Fig. 25. Average Body Length of Female Whales According to the Degree of Lenticular Colouration

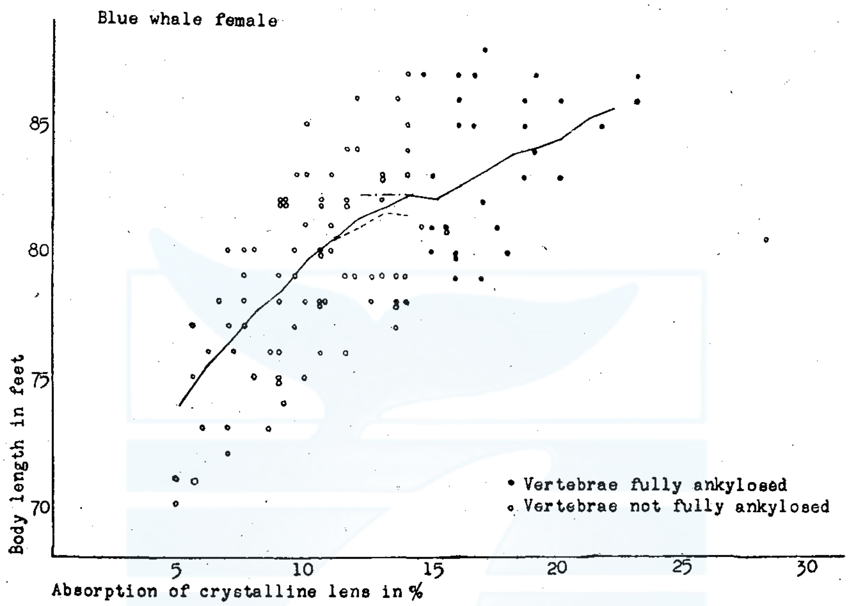
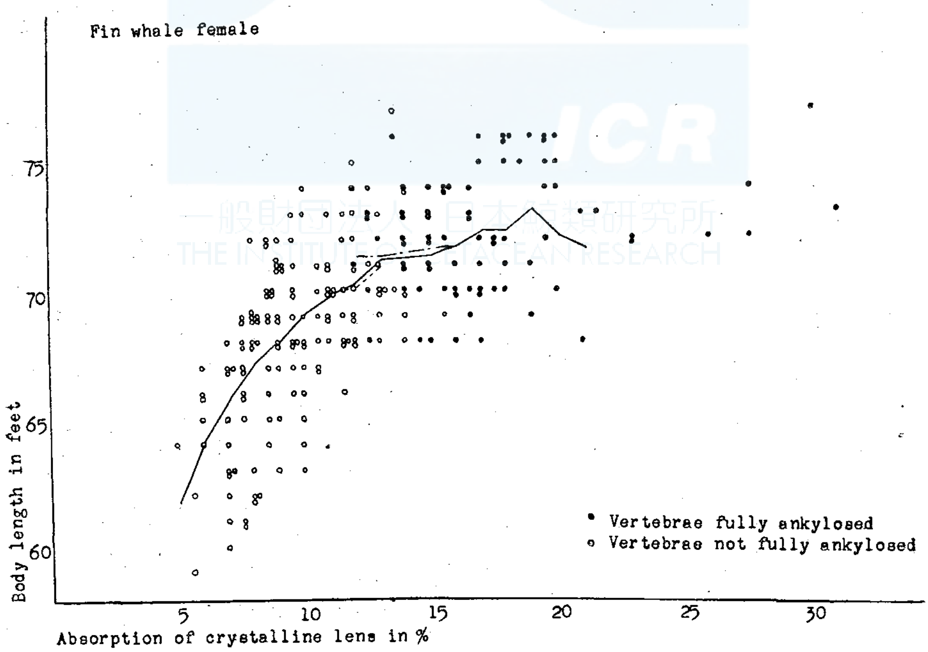


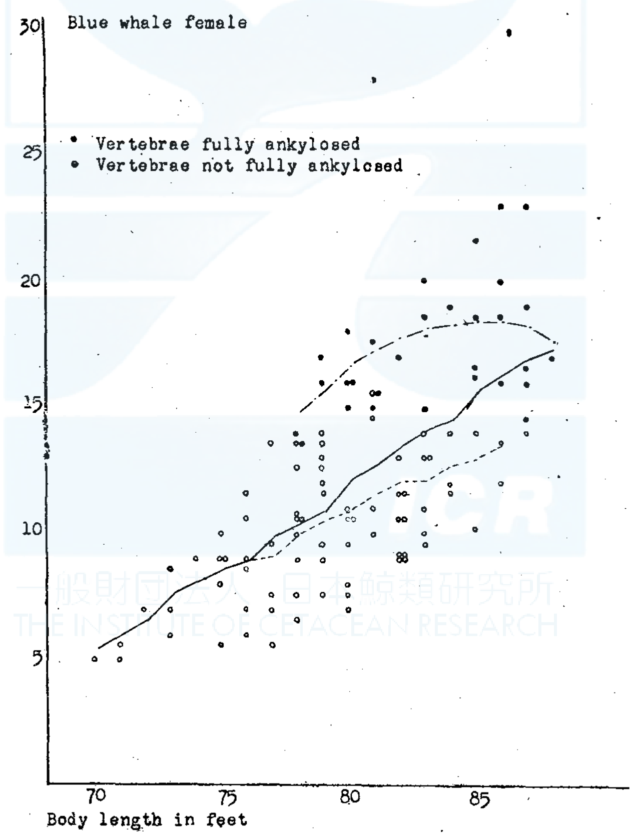
Fig. 26. Average Body Length of Female Whales According to the Degree of Lenticular Colouration



Figs. 25 and 26 show the relationship of sexual maturity to the degree of lenticular colouration and body length in female blue whales and fin whales, respectively.

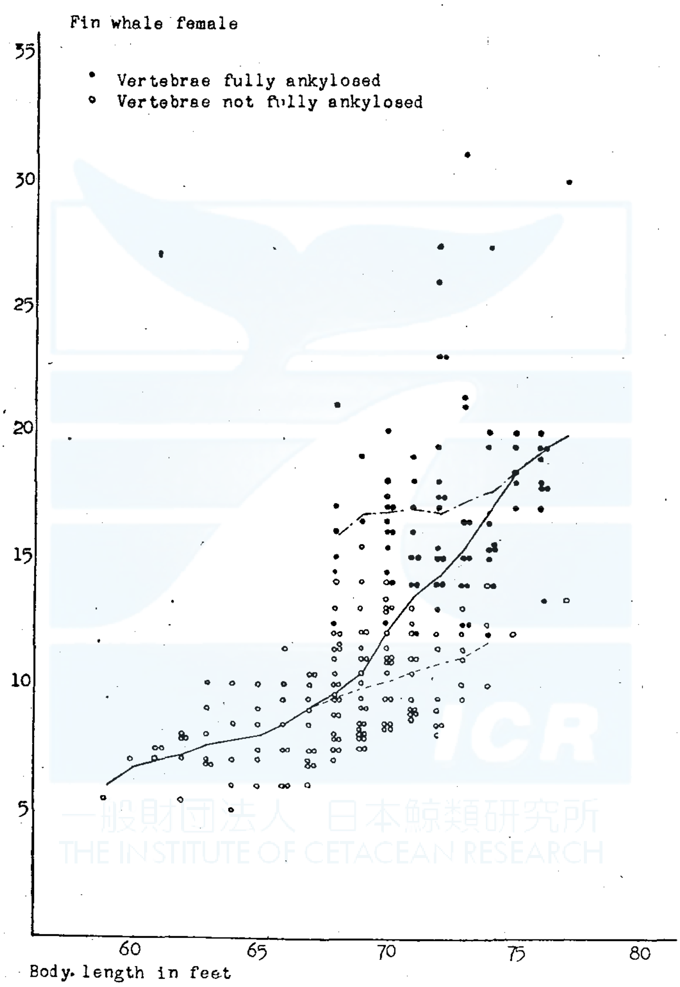
Both graphs clearly show that physical maturity is not related to body length but to the degree of colouration. The boundary between physically mature and immature in blue whales can be drawn at 14 to 14.5% of colouration and in fin whales, at 13 to 13.5%. The overall average curves in these graphs show the increase in body length with age, as explained in Chapter IV.

Fig. 27.. Average Degree of Lenticular Colouration According to Body Lengths in Female Whales



There is not particular features in the average body length curve for physically mature and immature whales. Figs. 27 and 28 show average degree of colouration in blue and fin whales of physically mature and immature stages according to their body lengths. Although it is not as linear as those obtained by combination with the number of corpora lutea, yet the three curves for immature, mature and total whales show linear increase, with good coincidence between the three.

Fig. 28. Average Degree of Lenticular Colouration According to Body Lengths in Female Whales



From these results, it can be said that the physical maturity of female whales is not related to body lengths but to the number of corpora lutea and the degree of lenticular colouration. The boundary between maturity and immaturity lies at 14 to 14.5% of colouration in blue whale females, and at 13 to 13.5% colouration in fin whale females.

Same observations made on male whales from Figs. 17 and 18 give imperssion that, without using the data on the degree of lenticular colouration, it would be very difficult to determine the physical maturity of male whales. Solely from their body length. Calculations had heretofore been made from the percentage curve of physical maturity by body length which is explained in later chapters. However, it has been found that the sexual maturity of male whales was closely related to the degree of lenticular colouration and had little connection with their testicular weight.

In blue whale males, classification of sexual maturity by testicular weight, however well it is made, resulted in an inclusion of about 20% immature whales in the mature group, and about 30% of mature whales in the immature group. The range in which both mature and immature whales appear is usually very wide, being from 22 to 56 kg. of testicular weight.

Classified according to the degree of lenticular colouration, 8 out of 80 whales with less than 13% of colouration were found mature, and only 7 out of 100 heads with over 13.5% of colouration were immature. The range of mixed appearance was between 11.5% to 16% of colouration.

Classification of fin whale males according to their testicular weight resulted in an inclusion of about 20% each of immature in mature groups, and vice versa. The range of mixed appearance was between 8.5 and 29 kg. of testicular weight.

Classifying these according to the degree of lenticular colouration, 6 out of 93 whales with less than 12.5% of colouration is found to be mature, and only 8 out of 106 whales with more than 13% of colouration to be immature. The range of their mixed appearance was between 12 to 14.5% of colouration.

From these results, it can be said that, even in male whales, the physical maturity is more related to the degree of lenticular colouration rather than to their testicular weight.

Relationship between body lengths and the degree of lenticular colouration in male whales is shown in Figs. 29 to 32.

In all these graphs, it can clearly be seen that physical maturity has no relationship to body length but is connected with the degree of lenticular colouration.

Fig. 29. Average Body Length of Blue Whales Males According to the Degree of Lenticular Colouration.

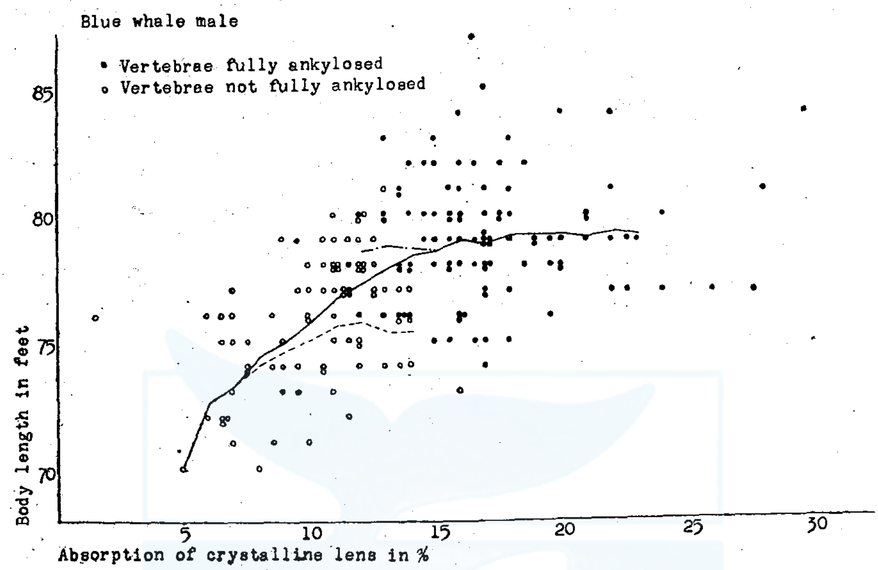


Fig. 30. Average Body Length of Fin Whale Males According to the Degree of Lenticular Colouration.

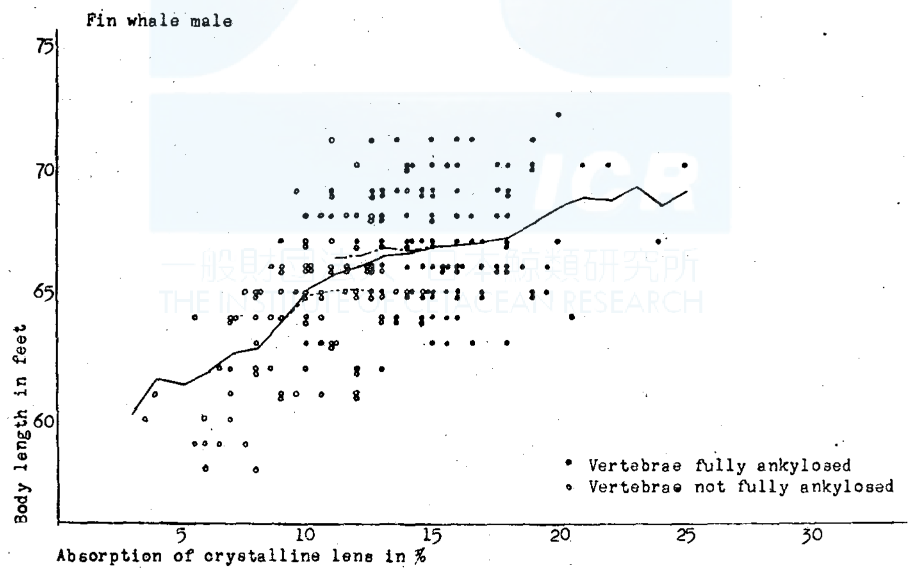
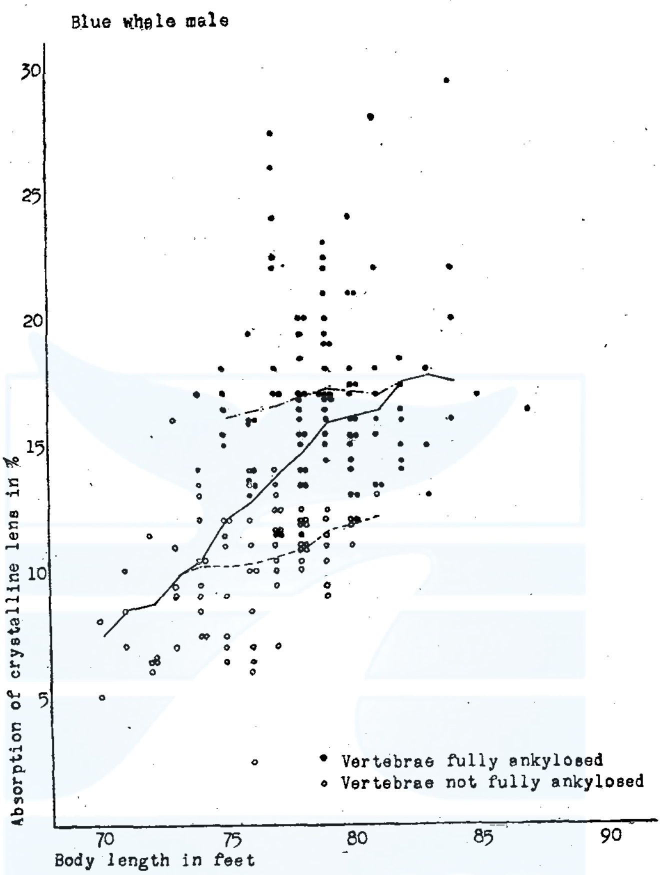


Fig. 31. Average Degree of Lenticular Colouration in Blue Whale Males According to Body Length.

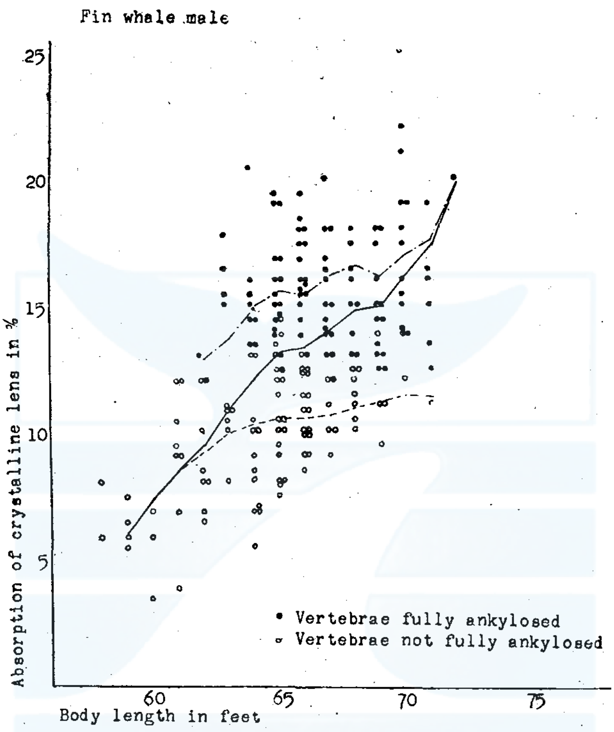


In blue whale males, 8 out of 80 whales with less than 13% of colouration are found to be mature, while only 7 out of 100 whales with more than 13.5% of colouration to be immature. The range of mixed appearance is between 11.5 and 16% of colouration.

In fin whale males, 6 out of 93 whales with less than 12.5% of colouration is found to be mature, while only 8 out of 106 whales with more than 13% of colouration to be immature. The range of mixed appearance is between 12 and 14.5% of colouration.

The average body length curve for physically mature and immature male whales according to the degree of their lenticular colouration, and the average degree of lenticular colouration of mature and immature animals by their body length, show the same tendencies as for female whales and no particular features can be found.

Fig. 32. Average Degree of Lenticular Colouration in Fin Whale Males According to Body Lengths.



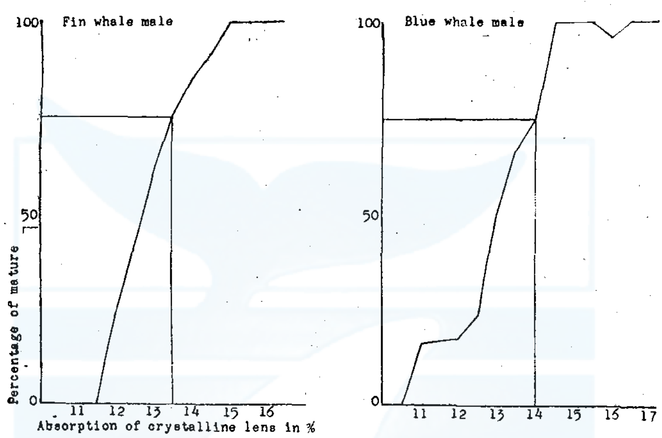
From these results, it can be said that the physical maturity of male whales is more related to the degree of their lenticular colouration and not to either body length or their testicular weight. The boundary between the physically mature and the immature lies at 13.5 to 14% of colouration in blue whale males, and at 12.5 to 13% of colouration in fin whale males.

Percentage of maturity according to the degree of lenticular colouration in whales classified by physical maturity is shown in Fig. 33a for males and in Fig. 34a for females. Percentage of maturity according to body length in whales classified by physical maturity is given in Fig. 33b for male whales, and Fig. 34b for females.

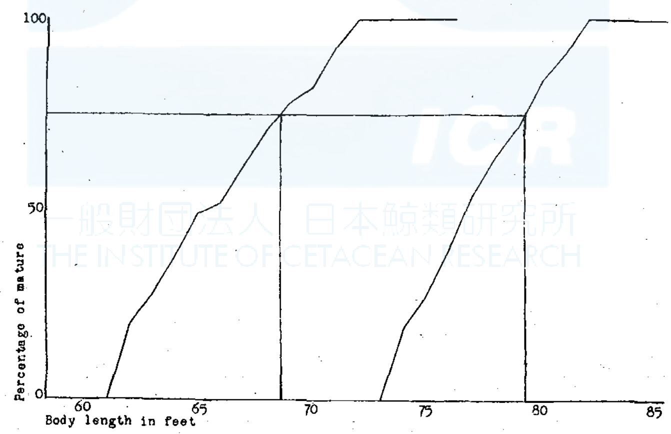
The point at which the maturity is 75% on the maturity curve by the degree of lenticular colouration show lenticular colouration of 14% for blue whale males, 13.5% for fin whale males, 14.8% for blue whale females and 14. 2(14. 15)% for fin whale females. Applying these values to the average body length curves by the degree of lenticular colouration given in Figs. 5 and 6, they correspond to body length of 78 feet in blue whale males, 67 feet in fin whale males, 82 feet in blue whale females and 71 feet in fin whale females.

Fig. 33. Percentage of Physical Maturity.

a) Maturity According to the Degree of Lenticular Colouration.



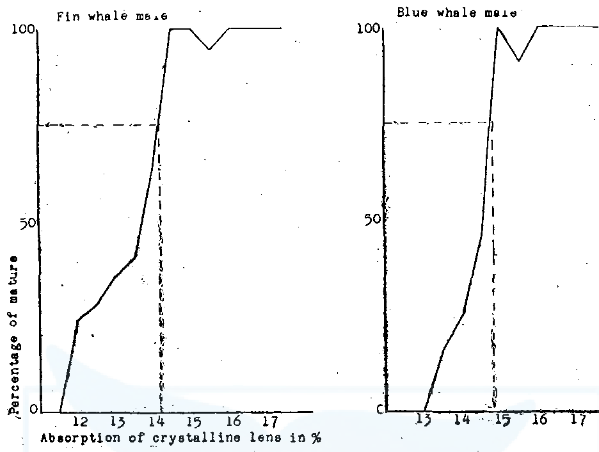
b) Maturity According to Body Lengths.



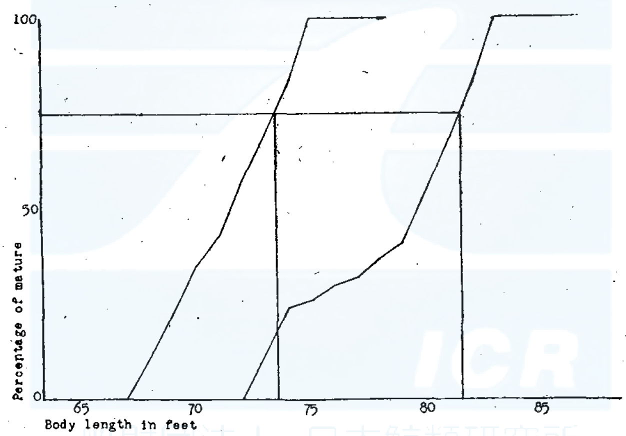
The point at which is 75% on the maturity curve according to body length in Figs. 33b and 34b is at 79 feet for blue whale males, 68. 5 feet for fin whale males, 81. 5 feet for blue whale females and 73. 5 feet for fin whale females, showing good coincidence between the two figures.

Fig. 34. Percentage of Physical Maturity.

a) Maturity According to the Degree of Lenticular Colouration.



b) Maturity According to Body Lengths.



The question now is which figure is more nearer the actual. The values of lenticular colouration from the point of 75% of maturity in the curves in Figs. 33a and 34a, compared with the dividing lines for the range of mixed appearances as described before, give following results:

	(1) 75% on curve	(2) Dividing line	Difference in (1) and (2)
Blue Whale - Male	14.0%	14.0%	none
Female	14.8%	14.5%	none
Fin Whale - Male	13.5%	13.0%	none
Female	14.2%	13.5%	1 inch

The difference in the degree of colouration as obtained from Figs. 5 and 6 correspond to the difference of (1) and (2) above.

These results show that the difference, if at all present, is very small and is in a negligible range. On the other hand, the curves in Figs. 33b and 34b, in which the physically mature body length was directly obtained, offer no data for comparison or examination. These had to be deemed satisfactory up to the present in the absence of other and better methods but it can clearly be seen that the degree of lenticular colouration, or the absorption of light by crystalline lens present values which are more close to actuality.

CHAPTER XI. Conclusion

The foregoing discussions can be summarized as follows:

1) The colouration of crystalline lens increases with passage of time (age) from birth, and the rate of increase in colouration does not change at different stages of life from infancy to old age.
2) Curves showing the change in age and body lengths according to change in the degree of lenticular colouration can be given for both male and female whales at the same time (Figs. 5 & 6), thereby making is possible to compare the body lengths of male and female whales of the same age.
3) Relationship of the degree of lenticular colouration is in direct proportion to the number of corpora lutea which is given by the curve showing increase in the number of corpora lutea according to age. From graphs giving such data (Figs. 13 & 14), the number of ovulations between sexual and physical maturity are found to be 10 in blue whales and 9.5 in fin whales.
4) A relationship exists between the degree of lenticular colouration and testicular weight similar to the one between body length and testicular weight. This can be considered as the curve showing increase in testicular weight according to age.
5) The sexually mature body lengths, as calculated from lenticular colouration ar as follows:

	Lenticular Colour	Body Length	Body Length as calcd. by previous methods
Blue Whale – Male	8.8%	74.9 ft.	74.6 ft.
– Female	9.5%	79.1 ft.	78.2 ft.
Fin Whale – Male	8.2%	63.5 ft.	62.4 ft.
– Femal	8.7%	67.8 ft.	67.3 ft.

6) By consideration of the degree of lenticular colouration, it has become possible for the first time to consider the physically mature body lengths of male whales in the same degree of accuracy as for the female whales. The physically mature body lengths as calculated from lenticular colouration are as follows:

	Lenticular Colouration	Body Length	Body Length as calcd. by previous methods
Blue Whale – Male	14.0%	77.9 ft.	79.3 ft.
– Female	14.8%	82.2 ft.	81.5 ft.
Fin Whale – Male	13.5%	66.6 ft.	68.6 ft.
– Female	14.2%	71.3 ft.	74.5 ft.

These values do not constitute final and decisive factors from the point of the number of whales examined. Some corrections are likely, both theoretically and numerically, by future studies. Only by then, they will become final and decisive.

This paper deals with the change in the degree of lenticular colouration (light absorption by crystalline lens) by passage of time since birth, and changes in colouration during one year will have to wait for future studies.

It is the belief of this author that the change in the colouration of crystalline lens is not only convenient but is far more accurate and reliable than any other data heretofore offered for estimation of age in whales.

(11 February 1950)

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Age Characteristics in Baleen Plates

(Reported on 26 Nov., 1949.)

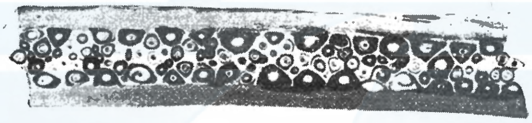
Masaharu Nishiwaki

I. Foreword.

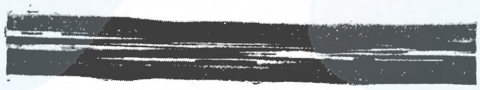
W. Scoresby in 1820 already considered the possibility of a presence of some age factor in the sculptures found on the surface of baleens. Later, E. F. Eschricht, J. Reinhardt and T. Tullberg, studied this matter and showed the structure of baleens as shown in Fig. 1.

Fig. 1. Section of a Baleen Plate
(J. T. Ruud)
a) Cross Section. b) Longitudinal Section.

a



b



As can be seen from the photograph, there are a group of horny tubes in the centre, and nail-like tissues in the outer layer that is called blade-pulp.

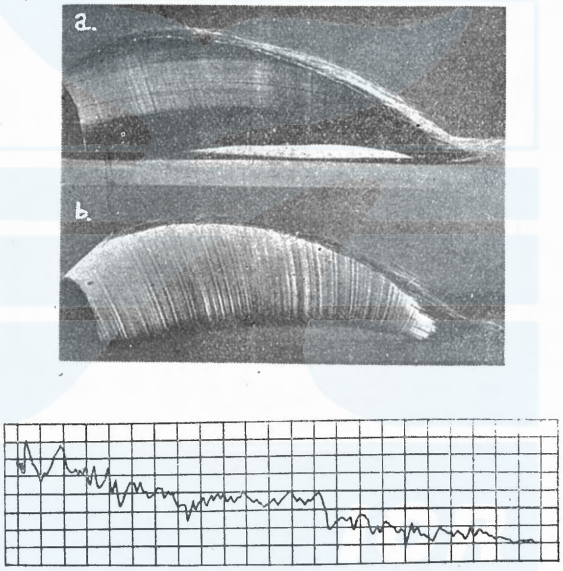
These horny tubes begin at the root of baleen plate, passes through the baleen in parallel lines, and forms what is called the bristle part at the tip of the plate. These tubes form one long tube from the root to tip and contains blood vessels and nerves. These tubular tissues never start from the middle of a baleen plate, one such tube from one end to the other is of fairly uniform size.

On the other hand, the outer layer is formed of pulp-like tissues and contains no blood vessels or nerves. As can be seen from Fig. 1b, this layer varies in thickness.

From these data, it can be seen that the horizontal creases called sculptures on the outer surface of a baleen plate are not due to horny tubular tissues in the centre but to the periodical increases and decreases in the thickness of the outer layer. These periodical changes in thickness are due to the inequality of nutrition by the longitudinal migration of whales. Therefore, this period refers to nutrition period, rather than annual period.

These were the conclusions reached by researchers before J. T. Ruud. J. T. Ruud based on these conclusions, deviced a machine which records the thickness of a baleen plate because he considered that the periodical growth of sculptures could be measured by recording the changes in plate thickness. Such a recording machine is shown in Fig. 2.

Fig. 2. Photograph of a Baleen Plate and a Record of the Baleen (by J. T. Ruud)



In a set of baleens from one whale, the sculptures on their surface are of the same nature, except in the small number of baleens at each end, and a definite number of small sculptures were found to gather together to form one step in growth.

From the results of measurements, three such steps were found in female whales of two years of age (the sexually mature female) as advocated by Mackintosh and Wheeler. Therefore, these females are in the third year, and Ruud claims that his measurements are in agreement with the theory of Mackintosh and Wheeler.

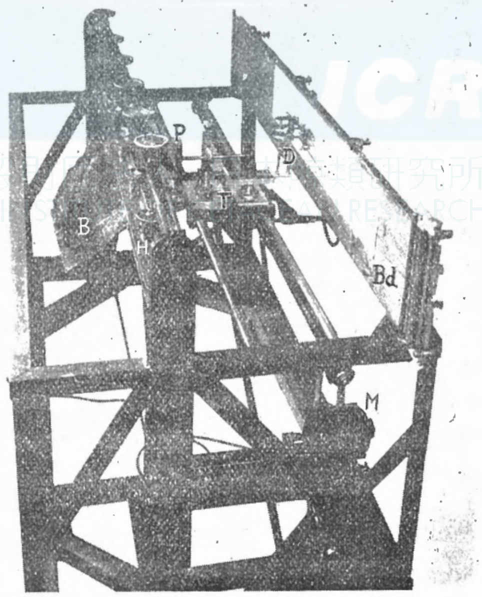
From these facts, it was assumed that each step corresponds to one year. J. T. Ruud made no further reference to it and offered no conclusions but promised further research. (Ruud has published papers on baleens after the war but we have had no chance of seeing the papers.)

Soon after the cessation of the second world war, Japan was again permitted to take part in the Antarctic whaling. We were fortunate in being able to bring back largest baleens on either side for our studies, but those of the first and second expeditions (1946-1947 and 1947-1948 season) were send to the United States and only those of the 1948-1949 season were left in our hands. With these, the sculptures were measured by the methods described later.

II. Measuring Method for Sculptures of Baleen Plates.

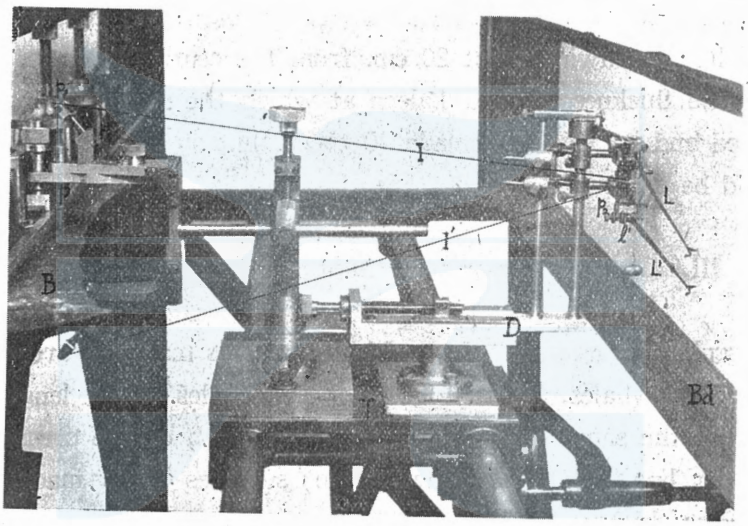
For reasons as described below, plans were made for the measuring of sculptures on baleens obtained from Antarctic whales in the 1948-1949 season, and, with the help of Mr. Hideo Omura of the Marine Products Bureau and Dr. Tsutomu Maruyama, Director of the whale Research Institute, a measuring apparatus as shown in Fig. 3 was manufactured by Mr. Osatake Shibazaki of the University of Tokyo.

Fig. 3. Complete Photograph of Measuring Apparatus of Baleen Sculpture.



This machine has a holder (H) for a baleen (B) which holds the latter under pressure so as to allow least warping. A measuring needle (P) moves on either side of the baleen. The movable table (T) on which are fixed the measuring needle (P) and a drawing needle (D) moves at a rate of 25 cm. per minute by the motor (M) of 1/3 HP, AC. Details of the movable table (T) and the measuring and drawing needles are shown in Fig. 4.

Fig. 4. Miniature Photograph of Measuring Apparatus of Baleen Sculpture.

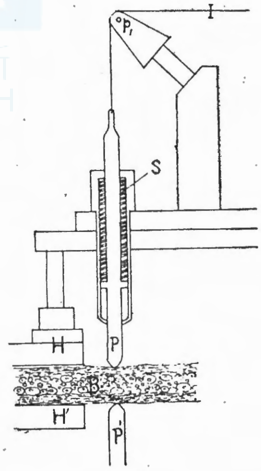


The measuring needle (P), Fig. 5, is pressed onto the baleen (B) by a spring (S). The needle transmits the sculpture on the baleen by the up and down movement which is transmitted to leading lever (l) through induction wire (I) and two pulleys (p_1 and p_2). The leading lever for induction wire (I) and drawing lever (L) are completely parallel.

The drawing lever (L) writes directly on a piece of paper pinned on a cardboard paper (Bd) the shape and form of the sculptures on a baleen surface.

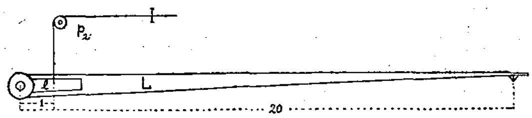
The magnification, as shown in Fig. 6, is determined by the sculptures, i. e. its height and

Fig. 5.



depth from the ordinary surface, by the drawing lever (L). The length of the baleen itself is as in the original.

Fig. 6.



In the present studies, the magnification were made 20 times on both surfaces. As can be seen from the Fig. 6, the induction wire is fixed at a point one cm. from the central fulcrum of leading lever, and the drawing lever (L) has a drawing point 20 cm. from the central fulcrum. By this means, if the thickness of the baleen at which the measuring needle rests is measured and its thickness made 40 times that amount, the whole thickness would be transmitted as 40 times larger.

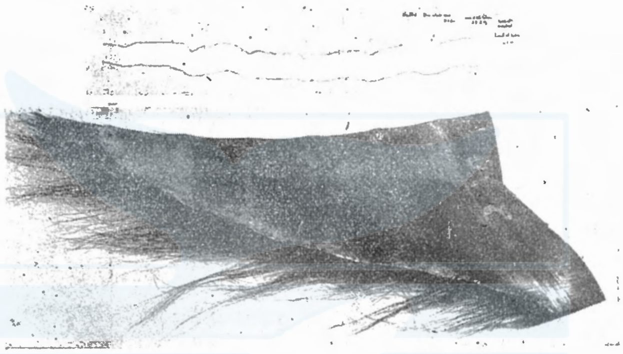
III. The Nature of the Sculptures of Baleen Plates.

The sculptures as depicted graphically by this machine are shown in Fig. 7 for blue whales. and in Fig. 8 for fin whales. The length of the baleens were the same in both cases and the depth of the creases on the upper (upper line) and lower (lower line) surfaces were made 20 times greater. The thickness of the baleen, if made also to 20 times its actual size, would result in too far a space between the upper and lower lines so that the distance has been suitably reduced. This graph is different from that of Ruud, both in the mode of expression and in the method of measurement, but there is not a great difference in showing the tendencies. In short, it shows the periodic cycle of growth well. Disregarding small ups and downs, one cycle was taken as that period from the thin part (malnutritious) to the next thin part through a thick part (nutritious). The spot marked with a round is where the thin part exists. Although not very discernible in the photograph, there were some that had many small holes in this thin place. Measurements were made as to how many of these thin places were present on one baleen.

Studies of a pair of baleens from one animal showed that, not only in the number of cycles but also in the shapes and forms of up and down trends, the pair showed the same tendencies. This seemed to prove the theory that these sculptures show the state of nutrition of the whale and that the periodic cycle is a nutrition cycle. Since there were no evidence of a pair showing different cycles on each baleen out of 100 cases studied, the measurements were then made only with the baleen taken from the right side. Observations were made on its periodic cycle, together with other representative data for age estimation.

Fig. 7. Photographs of Baleen Plates and their Recordings.

a) Blue Whale Male



b) Blue Whale Female

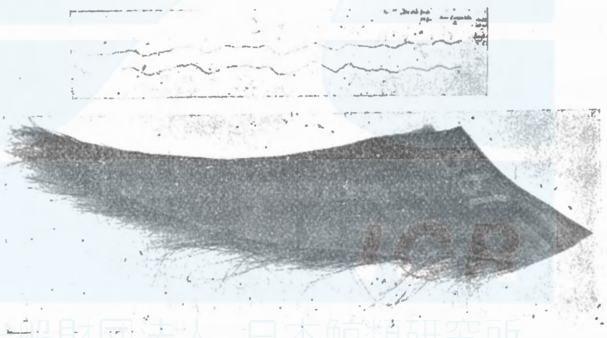
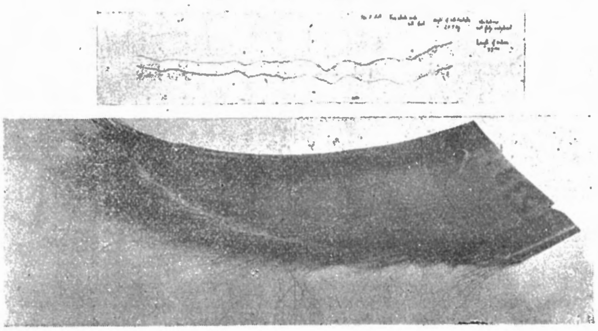
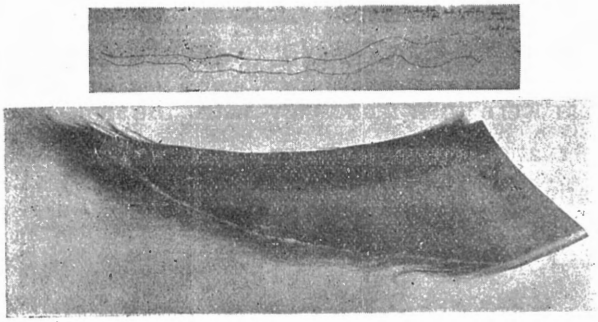


Fig. 8. Photographs of Baleen Plates and their Recordings.

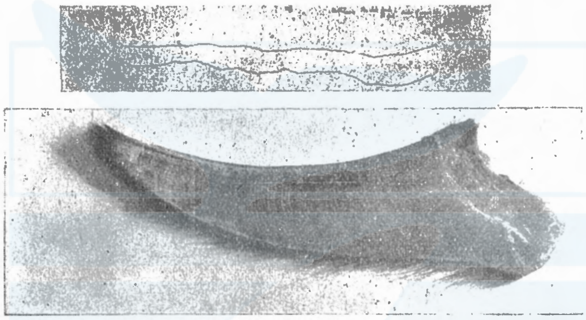
a) Fin Whale Male



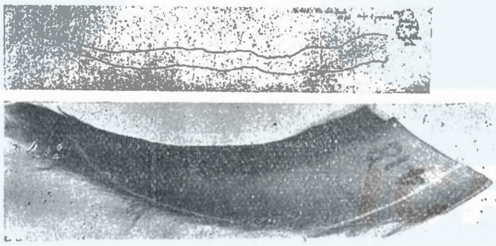
b) Fin Whale Female



c) Fin Whale Female



d) Fin Whale Female



IV. Relationship between Periodic Cycles on Baleen Plates and Number of Corpora Lutea.

The number of corpora lutea in the ovary has been studied by many investigators and are considered the most reliable data on estimation of age in female whales. The maturity or immaturity of a female whale can be judged very simply by the presence or absence of corpus luteum. Both blue and fin whales are known to become mature two years after the birth.

The sculpture of baleens were measured of whales having no corpus luteum, i. e. on sexually immature whales. Of 24 heads of blue whales measured, 1 was found to be in its fourth cycle, 10 in fifth cycle, and 13 in sixth cycle. Of 33 heads of fin whales examined, 27 were in the fourth cycle and 6 in the fifth cycle.

If sexually immature whales are taken as those under two years since birth, then the cycle we have been considering does not mean one year.

It was also considered that the cycle we have been using and that of Ruud's are the same, but, if the cycle does mean one year, then the period necessary for sexual maturity is between five and six years in blue whales and four years in fin whales. This is contrary to the conventional theory that female whales become sexually mature two years after their birth.

At any rate, period necessary to attain sexual maturity seems to be different in blue and fin whales. This is an important point on which our investigation rests. However, we shall let these points rest a while and arrange the results of measurements made on all of the female whales.

In Fig. 9, the black dots (physically mature whales) and white circles (physically immature whales) represent individual data, and the solid line is the average cycle curve according to the number of corpora lutea. The broken line is the average number of corpora lutea according to the number of cycles.

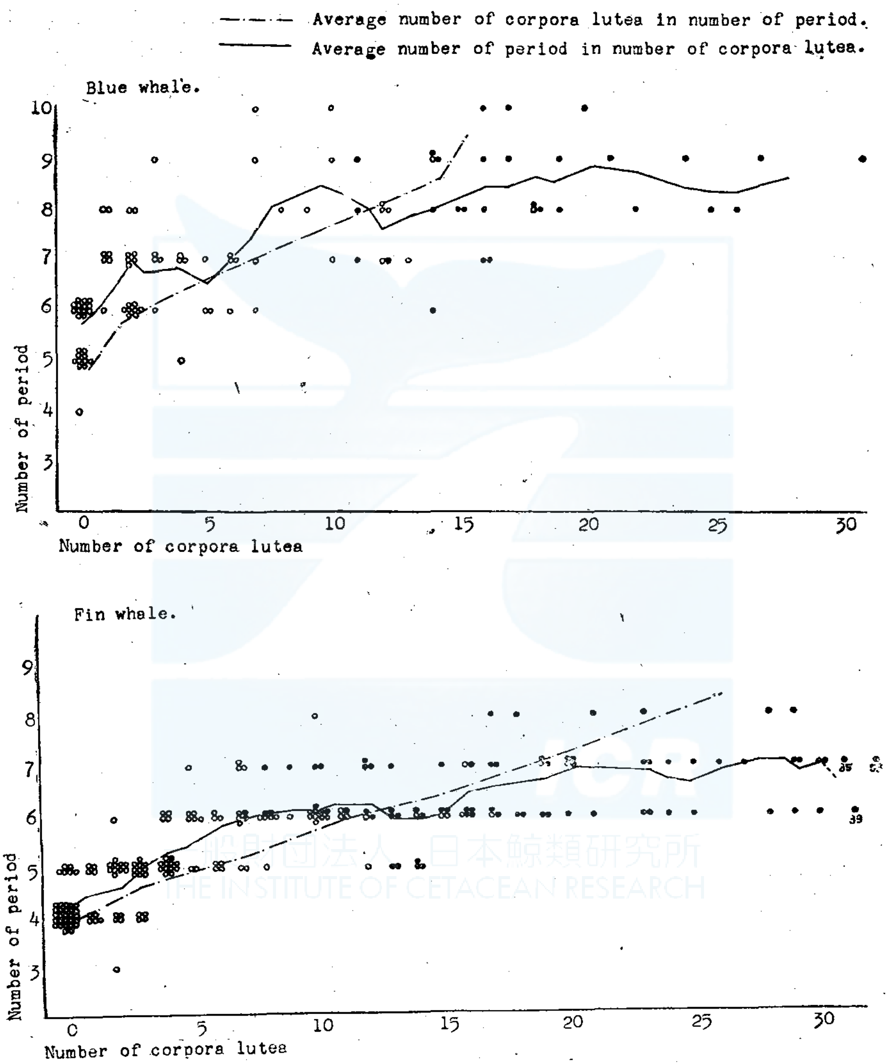
If baleens are not replaced since birth, the growth rate must differ at the tip and at the root. The number of cycle must also change at a certain proportion, and an increaes in the number of corpora lutea must have the same increase in the number of cycles. Also, the aforementioned two curves must show approximately the same results. However, the curve showing average mumber of cycles according to the number of corpora lutea levels off after a certain number of cycles, i. e. eight to nine cycles in blue whales, seven cycles in fin whales.

As can be seen from Figs. 7 and 8, the space between each cycle, though differring slightly between whales, is almost the same in each individual.

These facts seem to point out that baleens, like human hair or nails, grow from their roots all the time and, after a lapes of certain time (the length of this time being different in each individual) bigin to chip off from the tips.

The curves for number of cycles according to the number of corpora lutea stabilizes already at seventh cycle in blue whales and at sixth cycle in fin whales. Even with varieties of ups and downs, curves finally level off at the above period which give the impression that, even at that early period, chipping off starts in some individuals.

Fig. 9. Number of Periodic Cycles on Baleen Plates and Number of Corpora Lutea.

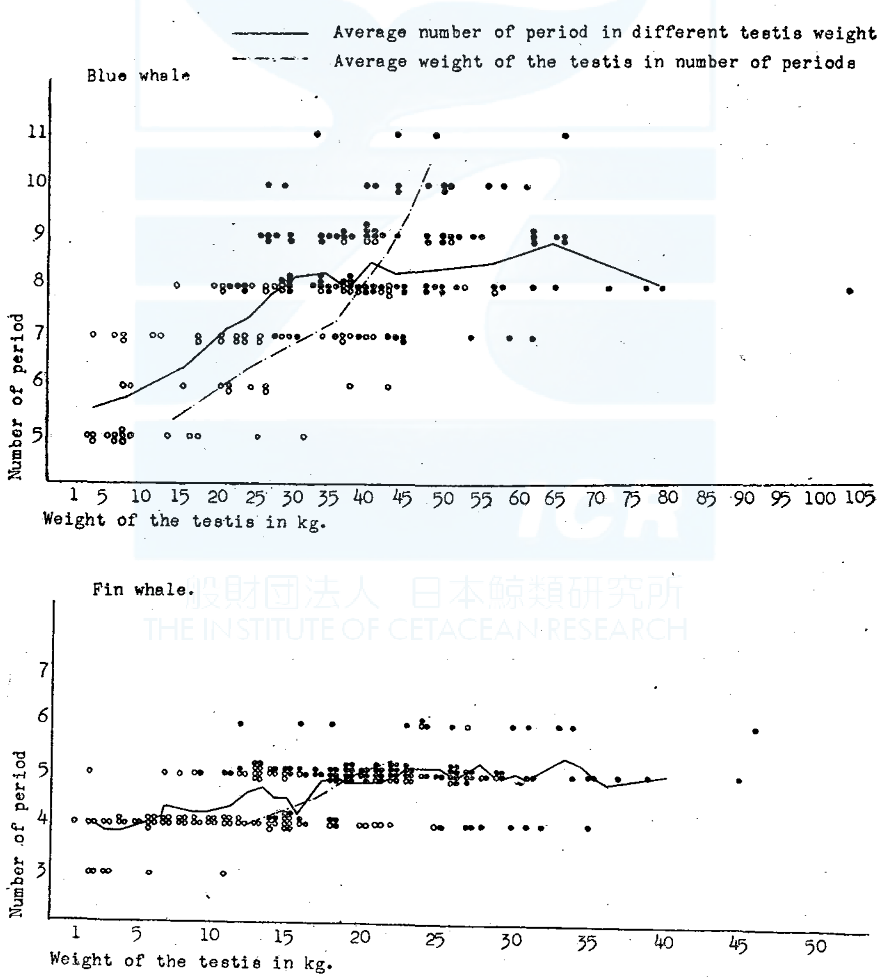


V. Relationship between the Periodic Cycles on Baleens and the Weight of Testes.

Combination of the periodic cycles appearing on baleens and age data in male whales, i. e. weight of testes, is given in Fig. 10. Black dots show individual data for physically mature whales, and white circles, those for physically immature whales. The solid lines represent average number of periodic cycles according to weights of testes. Where only a few heads of whales were available, an average of that group has been taken up. The broken lines show the average weight curve of testes according to the number of cycles.

In this case also, the same idea applies as to the female whales. The chipping of baleen seems to start at seventh to eighth period in blue whales, and at fourth to fifth period in fin whales.

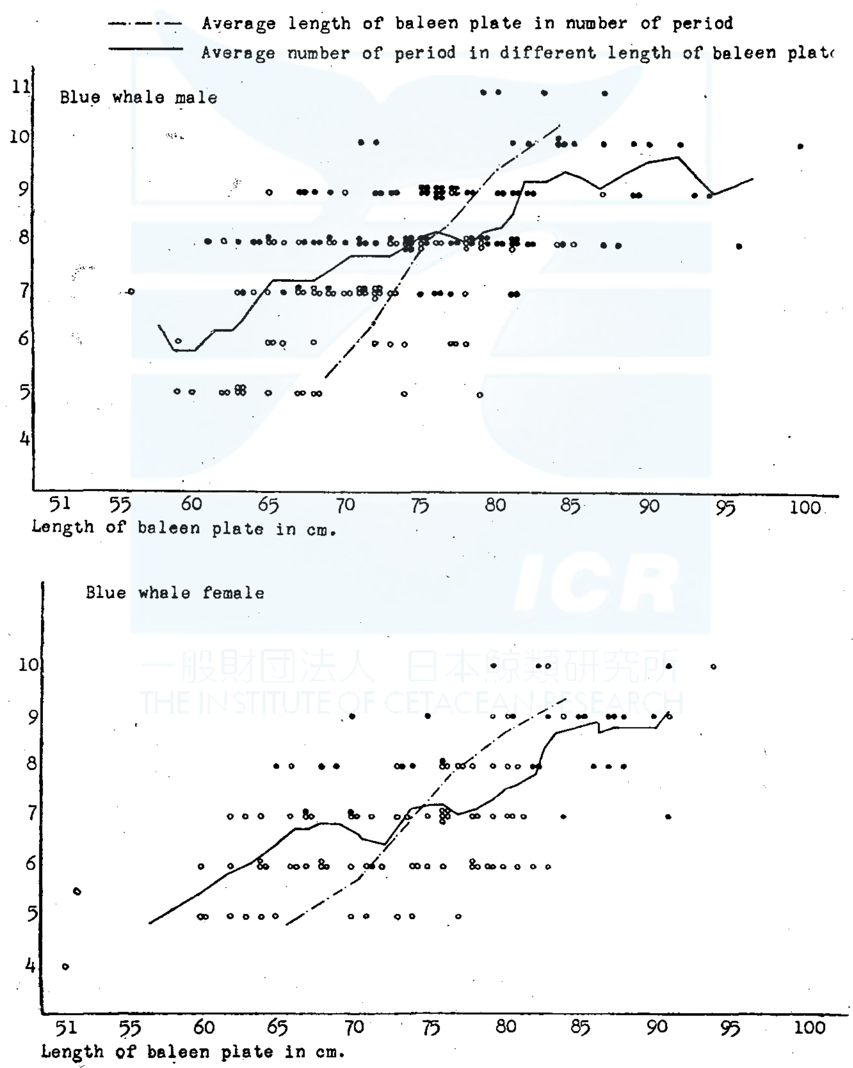
Fig. 10. Number of Periodic Cycles on Baleen Plates and Weight of Testes.



VI. Relationship between Periodic Cycle on Baleens and Baleen Length.

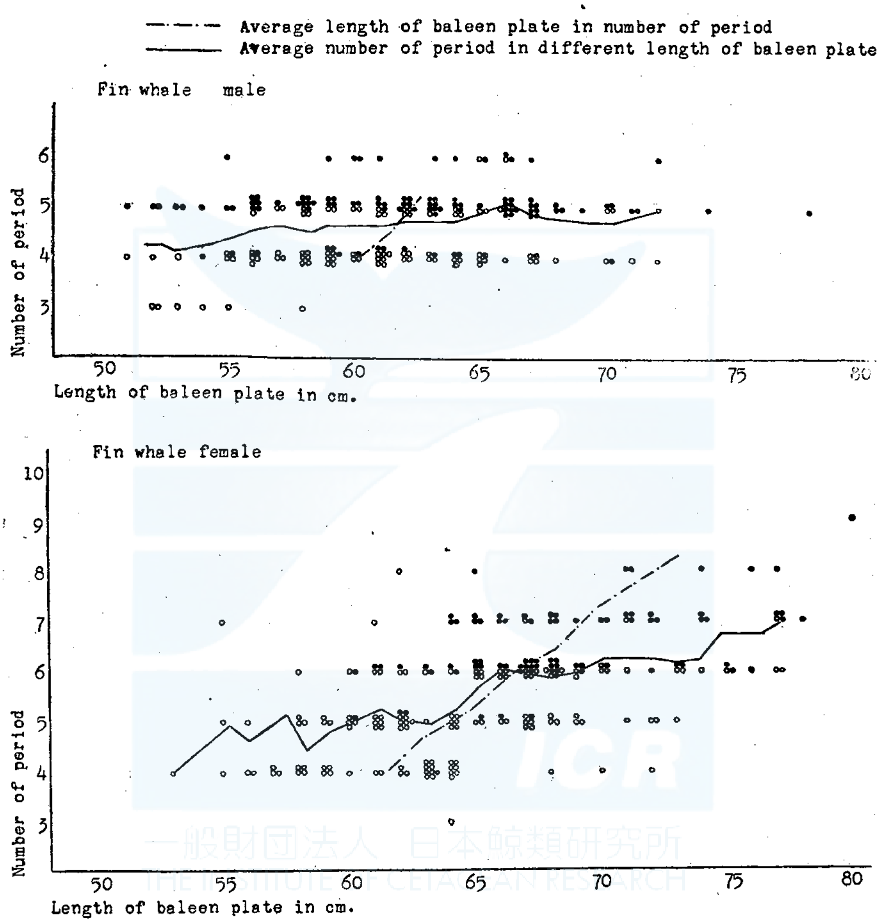
In accordance with the ideas formulated in the foregoing chapters, long baleens should have larger number of periodic cycles, although a slight difference may exist between individuals. In other words, in two whales of similar nature, one possessing less chipped baleens would possess

Fig. 11. Number of Periodic Cycles on Baleen Plates and Length of Baleen Plate in Blue Whales.



longer baleens. Figs. 11 and 12 show the combination of baleen length and the periodic cycles appearing on the baleens for blue and fin whales, respectively.

Fig. 12. Number of Periodic Cycles on Baleen Plates and Length of Baleen Plate in Fin Whales.



Black dots show individual data for physically mature, and white circles, those for physically immature whales. The solid lines represent average curve for number of periods according to baleen length, and the broken lines, average curve for baleen length according to the number of periods.

In both graphs, the positions of individual data, i. e. black dots and white circles, are different from foregoing data. Although there are various small movements, the curves as a whole have no relationship to the number of corpora lutea or to the weight of testicles, and short baleens have fewer number of cycles, the longer ones, more. This proves authenticity of the hypothesis that baleens begin chipping off at the tips.

The curves for fin whale males are all without much variation which seem to show that no great difference in periodic cycles exists between individuals, the majority showing four to five cycles. Hewever, variation between these two periods are not small, compared to others.

The rate of growth of baleen plates in one periodic cycle, calculated from Figs. 11 and 12, give the values of 7 to 10 cm. in blue whales, and 9 to 15 cm. in fin whales. These values coincide well with actual measurements.

VII. Relationship between Periodic Cycles on Baleen Plates and Body Length.

Combination of the body length and number of periodic cycles in blue and fin whales are shown in Figs. 13 and 14, respectively.

Black dots signify data for physically mature whales and white circles, those of the physically immature. The solid lines represent average curve of the number of periods according to body length, and the broken lines, that of body length according to the number of periods. In these graphs, as in the others, the curves level off after eight to nine cycles in blue whales, and five to six cycles in fin whales, showing that baleen plates start chipping off after these periods. This period seems to be late in fin whale males but, compared with curve for baleen plates, it shows that they have strong tendency to chip off.

Figs. 15 and 16 show the combination of body length and baleen length in blue and fin whales, respectively. They both show similarity to the curve for periodic cycle and body length. As a whole, the increase in body length is accompanied by increase in the length of baleen plates. This shows that the baleen plates increase, not only in proportion to passage of time but also with the increase in body length, i. e. increase in the size of the mouth. The change in the length of baleen plates differ greatly in individuals of the same body length and not so much between whales of similar body length, which makes this factor unsuitable as age determination datum. However, this fact also proves the explanations given regarding relationships between the body length and the number of periodic cycles, or that between the length of baleen plates and the number of periods.

Fig. 13. Number of Periodic Cycles on Baleen Plates and Body Length in Blue Whales.

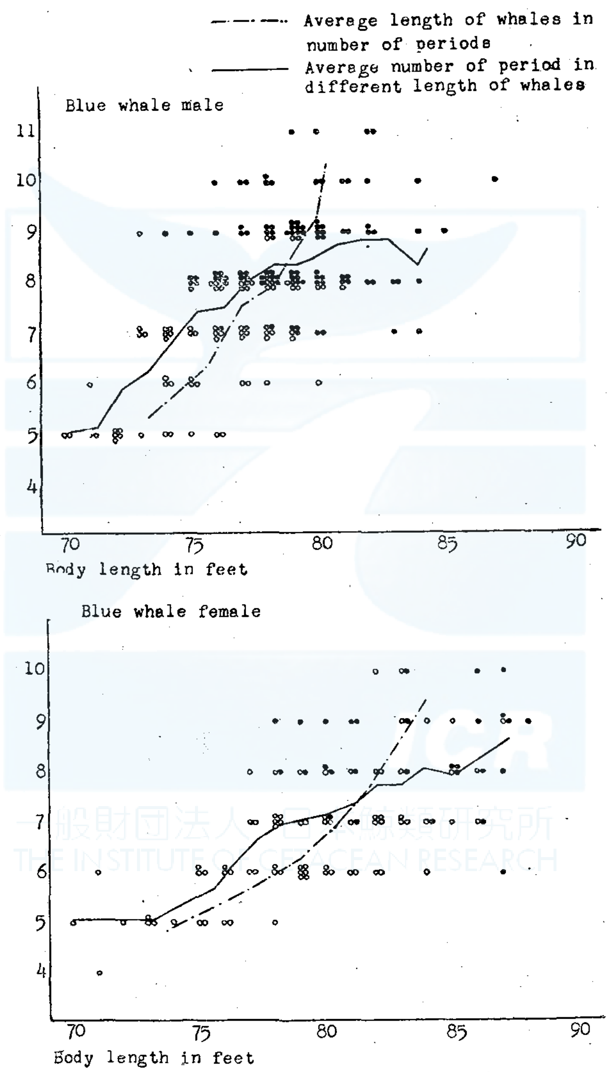
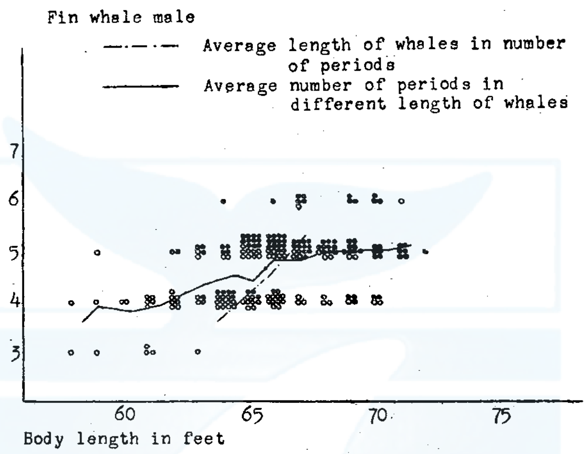


Fig. 14. Number of Periodic Cycles on Baleen Plates and Body Length in Fin Whales.



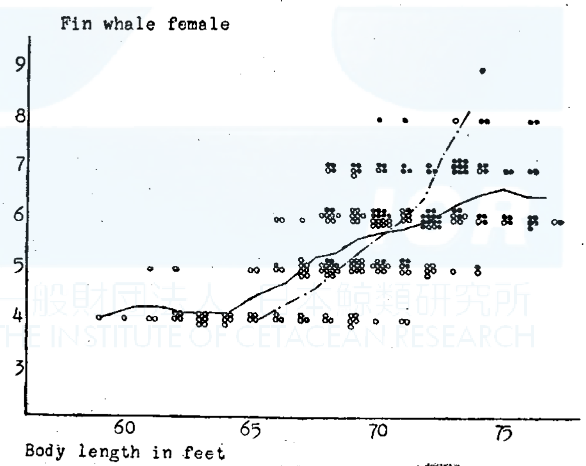


Fig. 15. Length of Baleen Plates at different Body Lengths in Blue Whales.

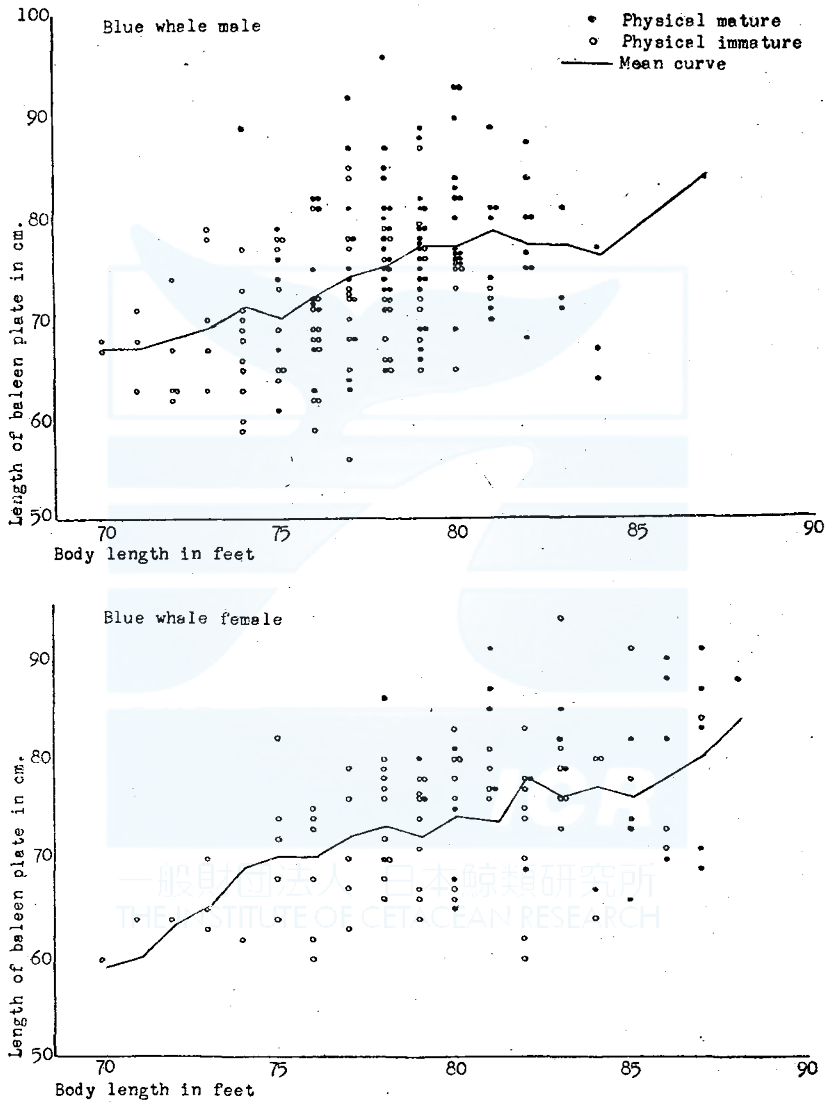
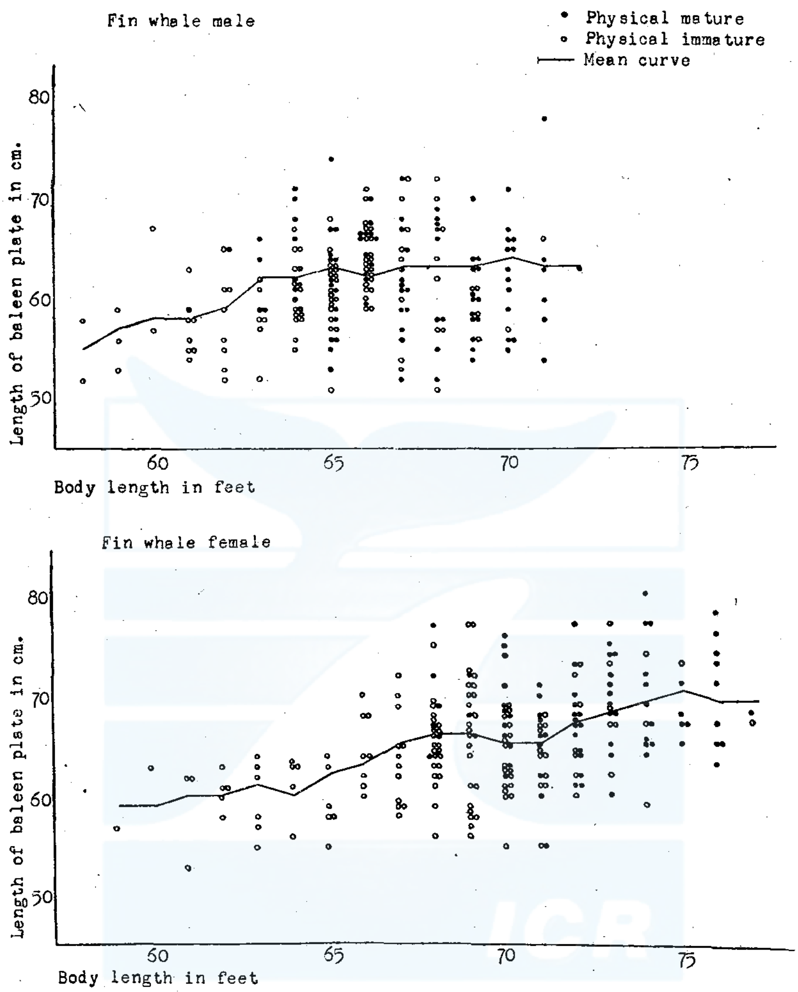


Fig. 16. Length of Baleen Plates at different Body Length in Fin Whales.



VIII. Relationship between Periodic Cycles on Baleen Plates and Sexual Maturity.

Judging from the various curves obtained in the foregoing chapters, following conclusions may be drawn, although in some instances where two curves show coincidence or approximate coincidence such conclusion would be dangerous.

The number of corpora lutea according to periodic cycles seems to be about four corpora per cycle.

Number of corpora lutea	Blue whales	Fin whales
0—— 2	up to 6th cycle	up to 4th cycle
3—— 6	6——7 〃	4——5 〃
7——10	7——8 〃	5——6 〃
11——14	8——9 〃	6——7 〃

According to Wheeler's theory, the whales are divided into groups having five corpora lutea each, from the curve of the number of corpora lutea.

The sexual maturity of female whales, i. e. those having one corpus luteum, is at the seventh period in blue whales, and at the fourth to fifth period in fin whales, according to Fig. 9. The body length at that period, from Figs. 13 and 14, is 78 feet for blue whales and 66 feet for fin whales. These values coincide well with other theoretic data.

In male whales, there is no state in which the two curves in Fig. 10 show the same tendencies. This shows that not only the chipping of baleen plates but also the relationship between growth rate (e. g. body length) and testicular weight must be very irregular. However, the average curve for testicular weight according to the number of periodic cycle stabilizes at about the seventh period showing that there is no remarkable increase in weight after that period. This period is about fourth to fifth in fin whales. The testicular weight at these periods is 35 kg. in blue whales and 17. 5 kg. in fin whales. From the curve of testicular weight according to body length, no great change occurs after blue whales reach the length of 75 feet with 32 kg. testicular weight, and at 65 feet with 32 kg. testicular weight in fin whales.

The increase in testicular weight during one periodic cycle at sexual maturity is about 10 kg. in blue whales and about 7. 5 kg. in fin whales.

The rate of body growth during one periodic cycle, as calculated from Figs. 13 and 14, is about 2. 5 feet in blue whale males at fifth to seventh period, and 3. 5 feet in blue whale females at the same period. In fin whale males, this is 6 feet at fourth to fifth period, and in females, 4 feet at fourth to sixth period. From these data, it seems that fin whales gain more in body length than blue whales during one periodic cycle. The growth rate is especially high in fin whale males. This may offer somewhat baffling idea but multiplication of these rate of body length increase by the number of periods give values equal to the increase in body length from infancy to the sexually mature stage.

The increase in body length during the young stage should be much greater than at or near the sexual maturity. Although not among my own data (J. T. Ruud's data), one young fin whale caught during its suckling period possessed a baleen plate 42 cm. long, yet it could not be even one year old.

If the increase in the length of baleen plate during one periodic cycle is taken as 12 cm., and the increase in body length during the same period as 4 feet, then 42 cm. would mean the increase in body length of 14 feet. Based upon these assumptions, values obtained are coincidental with the actual measurement of body length from birth to sexual maturity.

From foregoing ideas, it seems that one periodic cycle on baleen plates mean one solar year. According to this assumption, several years elapse between birth until attainment of sexual maturity, and the length of time differs between blue and fin whales. However, according to existing theories, both blue and fin whales reach sexual maturity in about two years, and there have been no data to disprove this theory.

IX. Relationship between the Periodic Cycle on Baleen Plates and Physical Maturity.

In all the graphs shown in the foregoing chapters, black dots denote physically mature whales, i. e. those in which the vertebrae are fully ankylosed, both in thoracic and lumbar series, and white circles, the immature.

In female whales, as shown in Fig. 9, the physical maturity is related to the number of corpora lutea but the relationship between the number of corpora lutea and the number of periodic cycles on baleen plates is very obscure. The number of heads examined, as a whole, is very small but no physically mature whales were found in blue whales of less than the fifth period, and fin whales of less than the fourth period. The number of mature whales increases as the number of periodic cycles increase, but in both species of whales, physically immature whales can be found in those having the maximum number of periodic cycles.

In male whales, as shown in Fig. 10, the physical maturity is not related either to testicular weight or to the number of periodic cycles on baleen plates.

Its relation to the lengths of baleens is also doubtful since, from Figs.

11 and 12, the longer the baleen plates does not always mean a mature whale, or vice versa.

Figs. 13 and 14 show that physical maturity is not at all related to body length or to the number of periodic cycles found on baleen plates. Of course, the ratio of maturity is greater in whales of larger body length, or in those having larger number of cycles on baleen plates since the latter means a longer time passed from birth.

However, no clear line can be drawn as was possible with the number of corpora lutea between the physically mature and immature whales.

These facts seem to indicate that baleen plates, when it has reached a certain length (differing in each individual), begins to chip off irrespective of physical maturity, i. e. the age.

X. Conclusion.

As can be seen from the foregoing, baleen plates begin to chip off after reaching a certain period. This period is at a stage when the rate of increase in the mouth volume becomes smaller than the rate of increase in length of baleen plates and seems to differ by the growth rate of each individual.

In other words, the inner volume of the mouth becomes larger as whales grow, similar to body length, but the growth rate becomes smaller after a certain period of time. However, baleen plates go on growing as before without any regard for growth rate, so that, at one time or another, it begins to get in the way. This is the period referred to above, which naturally differs in each individual. Some whales show chipping at the fourth period, while some show no chipping even at the seventh period.

J. T. Ruud gives a graph for a young fin whale (still in suckling stage) of 42 feet of body length, among his data. He sites the fact that the sculptures on the baleen plate from this whale is remarkable smooth compared to those of mature whales, and explains the phenomena by saying that the young whale does not receive any nutritional effect other than periodic drinking of milk.

In examing many baleen plates, several were found to have these phenomena towards the tips. These must be plates in which the chipping had not started. Generally, the surface towards the tip is more smoother than at the root of a plate, but this must be a different phenomenon. These baleen plates, as shown in Fig. 17, show more sharper point than the one that has began chipping.

Fig. 17. Baleen Plates with Chipped and Unchipped points.
a) Unchipped plate b) Chipped plate

a b

During measurements, it was found that some blue whales showed chipped plates as early as the fifth period but generally, this chipping seem to take place from the seventh period. In fin whales, this phenomenon was found from the fourth to fifth period in males, and from fifth to sixth period in females.

This poses a question of whether these results are entirely negative and that the chipping of plates would give no data as to the total number of periodic cycles since birth and consequently no determination as to the age of whales.

It is true that whales with whole plates offer enough data for age estimation but in those having chipped baleen plates, only the life history during the recent several periods can be learned and there is nothing to tell the passage of time since birth.

The investigations were made more difficult by the fact that it was very hard to determine whether the tip of baleen plate was chipped or not. It was generally easy enough to tell whether a certain baleen had began to chipped off, but it was very difficult to say that a plate was not chipped off at all.

In short, further investigations are necessary to determine whether these sculptures on the surface of baleen plates represent one solar year per one periodic cycle, or whether several periods constitute a one solar year. However, there is no doubt that a certain relationship does exist between baleen plates and age determination data.

(October 20, 1949)

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On the Body Weight of Whales

Masaharu Nishiwaki

(23 Jan., 1950)

1. Introduction

As for body weight of whales, hitherto some conceptional figures have been known in relation to the percentage of products for materials. But as biological literatures, there are only the following figures by A. H. Laurie (on the base of Capt. Sörlle and Dr. Lukas) and N. Peters (on the base of Zenkovic). They weighed very few whales and that did not weighed for themselves, only making public what was reported. On the base of these few figures, however , the formula was proposed for calculating and the graph showing body weight for body length was made.

species	sex	body length	body weight	remarks
blue whale	?	27.18 m	122.0 tons	located in South Georgea (by Capt. Sorlle)
	?	20.30	48.9	
	?	23.72	63.0	this whale found in the Arctic (by Dr. Lukas)
fin whale	F.	20.80	53.8	located in the North Pacific. (by Zenkovic)
	F.	19.90	48.6	
	M.	18.85	34.0	
humpback	F.	13.9	32.4	
	F.	12.9	27.4	
sperm	M.	13.45	22.7	
	M.	18.0	53.4	
grey	F.	13.35	31.5	

In the Antarctic whaling season 1947/48, under the supervision of Mr. Terry and Col. Winston, representative of G. H. Q., 30 blue whales (*Balaenoptera musculus*) (11 males and 19 females) and 16 fin whales (*Balaenoptera physalus*) (6 males and 10 females) which were caught by the Nisshin-maru and the Hashidate-maru, were weighed with the following method. Yet, even they were so insufficient as data that in the season 1948/49, 2 blue whales (1 male and 1 female) and 13 fin whales (4 males and 9 females) were weighed on board the Japanese fleets.

Thus, data of 32 blue whales (12 males and 20 females) and 29 fin whales (10 males and 19 females) were collected. Here, the author makes public these data with some observation. Indeed, what a hard job the whale body weighing was. It was carried out in the frigid Antarctic O-cean with storming snow and piercing winds for some hours.

The author is very grateful to General manager and his staffs and workers for their endeavour contributing much to the whaling field.

2. Method of work.

When a whale was ascending on the slip way, the former whale had been thrown into the boiler, without a part of it left on the flensing deck of the factory ship. As soon as the whale stopped on the deck and finish-ed to be measured its length, rough dissecting began and at the same time, whale carcass which had been classified in each part was further dissected into easy blocks for weighing. Bones were cut into about 50 to 60 cms cube and weighed with a 200 kg. platform scale. Of course great care was paid not to double weigh and add the same block. Thus dissected and weighed blocks were added in each part of them (e. g. blubber muscle, large intestine, kidney, etc.) to be proposed as data. Sawdusts and scraps were collected into the item "others" but blood left flowing was unable to be weighed, Stomach and intestine contents, urine and show were excluded.

The classification is shown in the table at the end of this report. There are five parts roughly divided, blubber, muscle, internal organs, bones and others. Individual figures, for instance, on pancreas, oesophagus, blub-ber of lower jaw etc., are not always accurate, but what is collected as in-ternal organs or blubber is reliable to be correct. This is due to the dif-ference of dissecting methods between the Hashidate-maru and the Nisshin-maru and to attachment to other parts by times and manners. For instance, pancreas was weighed with stomach or intestines; or oesophagus was mea-sured with trachea, or blubber was classified in different ways by each whale.

In the appendaged table, there are some whales with oil yield, which was not always obtained from the one whale only but was calculated out. After scrutinizing the calculating standard, however, it was considered so reliable that they were similarly treated.

3. Body weight and length.

With the close relation between body weight and length, the more the latter increases, the more the former increases. If whales were of quite same shape, theoretically doubled body length should increase the body weight cubicly.

Fig. 1. Weight of Whales According to Body Length (Blue Whale)

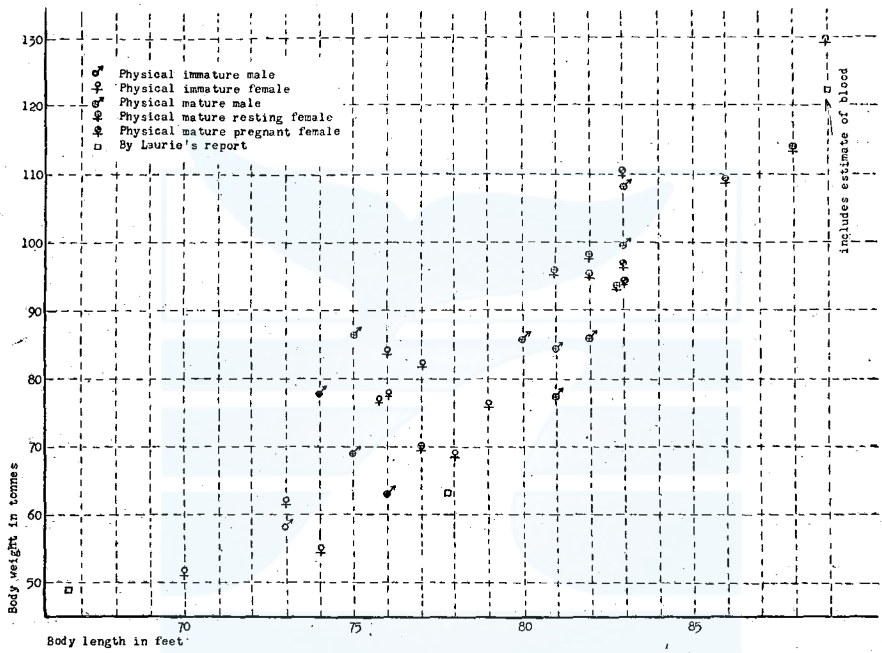


Fig. 1 shows body weight of blue and fin whales in the ordinate and body length in the abscissa.

Observation of Fig. 1 gives clear trend of body weight increase in proportion to body length increase. Difference of body weight between male and female scarcely seems to change. For whales of the same length, rather speaking, male seems a little heavier.

The remarkable difference of weight in individuals of the same length probably means the seasonal variation. For instance, a male of 74 feet and 77 tons, a male of 75 feet and 86 tons, a male of 77 feet and 98 tons, a male of 83 feet and 107 tons, 3 females of 76 feet, a female of 81 feet and 69 tons etc. were captured after the middle of January. On the contrary, a male of 76 feet and 63 tons, a male of 81 feet and 77 tons, a female of 78 feet and 69 tons etc. were caught before the middle of January. Previously the author reported on the seasonal variation of thickness of blubber that it became after fatter the middle of January. Of course, this fact has a close relation with whales migration, showing that there are many whales newly arriving at the Antarctic till the middle of January. As stated below, first of all, muscle begins to grow fat and blubber is influenced by it, perhaps after the middle of January. The body weight too seems to show the same trend.

In the table, Laurie's values were indicated with the mark □. They distribute near the author's values. Though in this measurement no blood was added, Laurie added the presumed 8 tons to 1 instance among three instances. But the figure was not revised. Laurie showed the increasing curve of body weight for these three instances but it is too small in number of whales investigated to calculated the average body weight by body length or vice versa and if the seasonal or the sexual variation is taken into consideration, it would be more difficult. So it will be reported elsewhere. Here, the author quotes only Laurie's figures in Fig. 2 (A. H. Laurie : Some aspects of respiration in Blue whales : Discovery Reports Vol. XV p. 405. 1933).

Fig. 3 shows fin whales in the same way. Those which were indicated with marks ♂ or ♀, based on Peter's Report. These whales were found in the Arctic and seemed different from those in the Antarctic, though they were described anyhow. Among them, a male of 65 ft. and 48 tons, a female of 70 ft. and 60 tons, and a female of 74 ft. and 68 tons were all caught after the middle of January but a female captured on 25 February was of 76 feet and 57 tons. So whales which were caught after the middle of January were not always fatter and heavier than other whales of the same length.

Fig. 1 and Fig. 3 are of the same scale but fin whales are more regular than blue whales. In other words, there is a little fluctuation of body weight by body length. And the body weight curves by body length are so similar that the prolonged curve of fin whales joins with that of blue whales. Few values on short female and long male in body length don't give the clear difference of body weight between male and female. But the author thinks body weight by body length shows nearly complete coincidence.

4. Weight of each part of whale carcass.

From the above mentioned result, the author showed weight of each part, (blubber, muscle, internal organs and bones) by body length. Among Figs. 4 to 19, the half shows the real weight and another half, percentage for total body weight. These 16 figures are of the same scale.

Fig. 2. Calculated Relation between the Length and Weight of Blue Whales. (by A. H. Laurie)

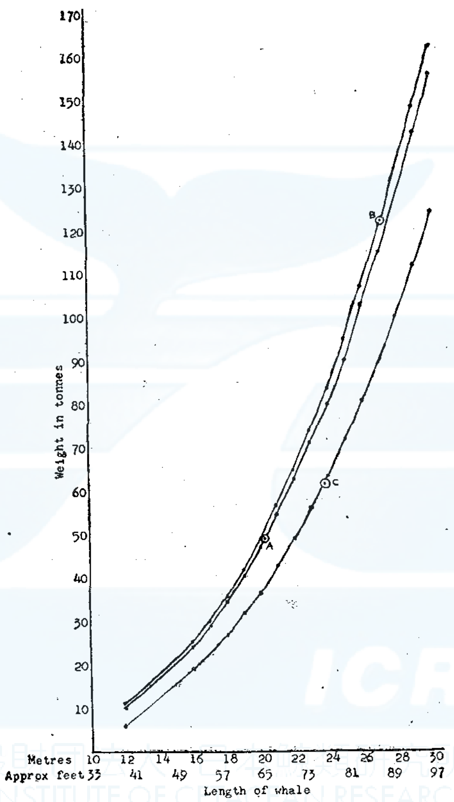


Fig. 3. Weight of Whales According to Body Length (Fin Whale).

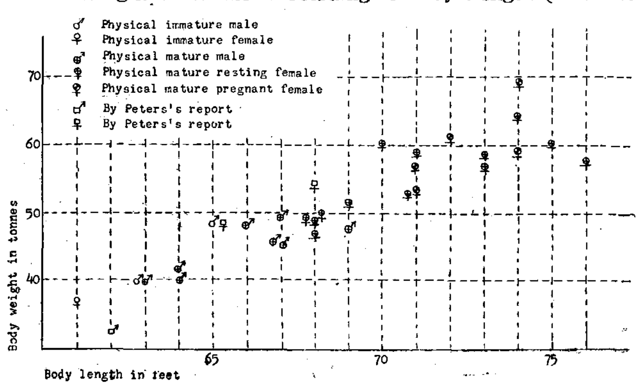


Fig. 4. Weight of Blubber in Different Length of Whale (Blue Whale)

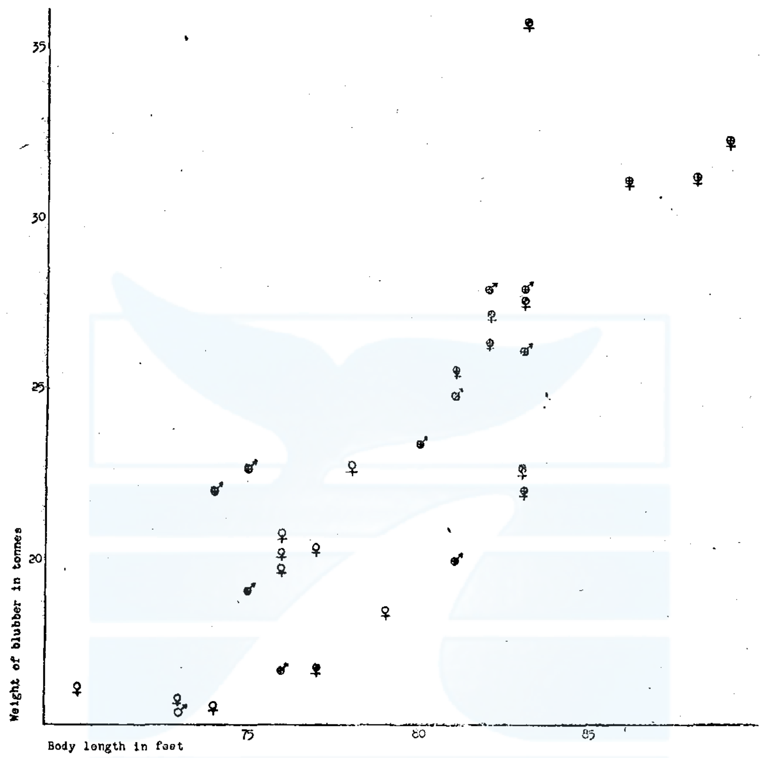


Fig. 5. Percentage of Weight of Blubber to Total Weight of Whale (Blue Whale)

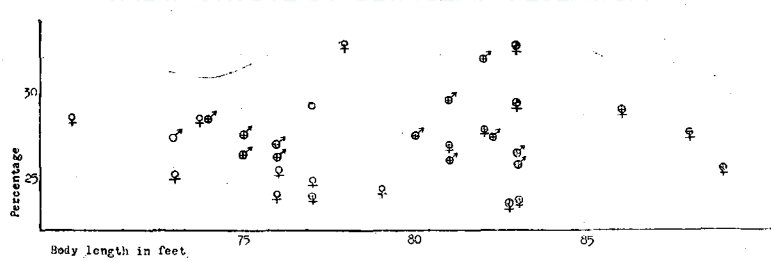


Fig. 6. Weight of Muscles in Different Length of Whale (Blue Whale)

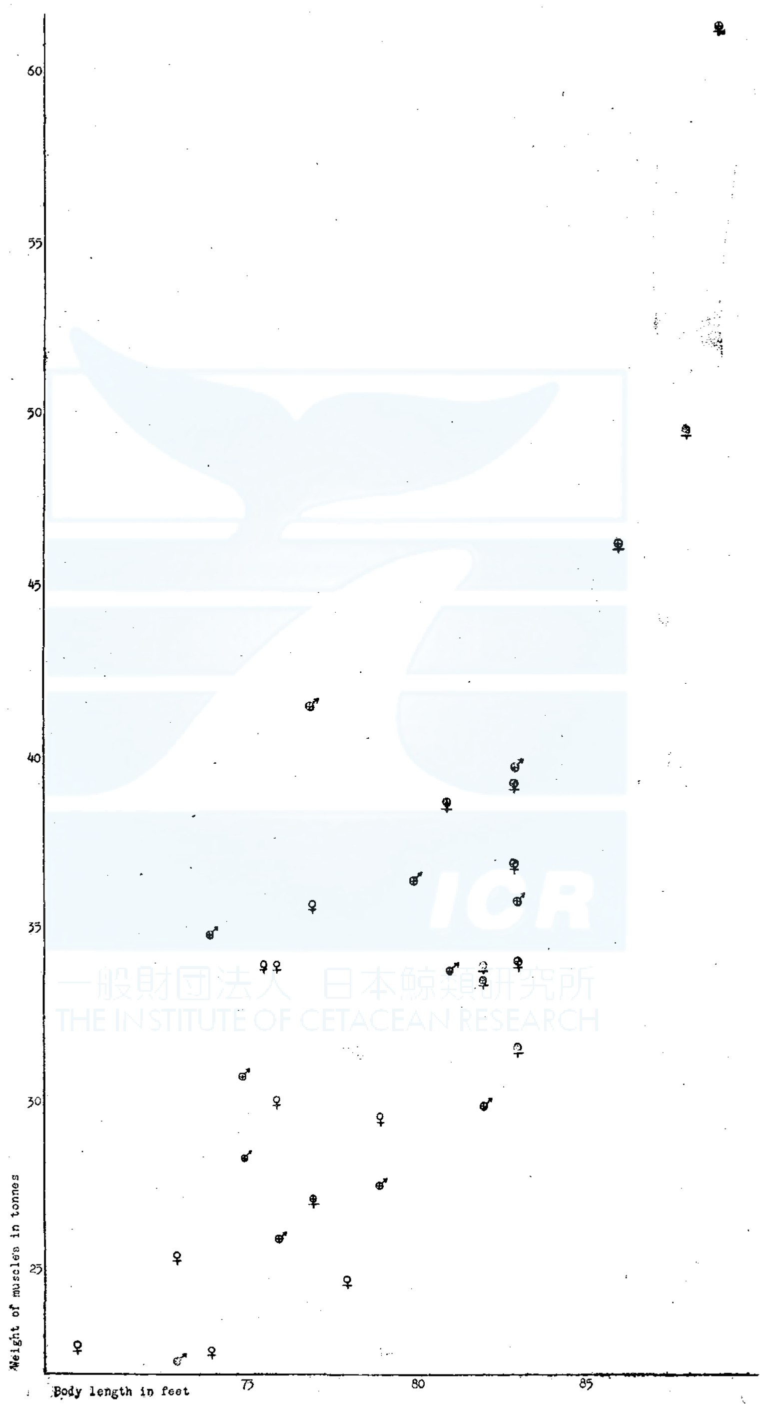


Fig. 7. Percentage of Weight of Muscles to Total Weight of Whale (Blue Whale)

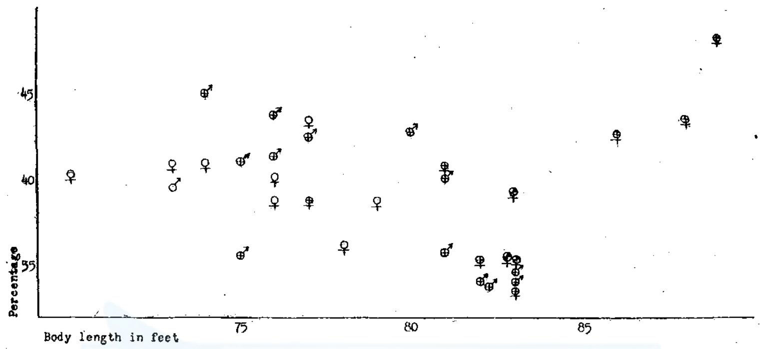


Fig. 8. Weight of Internal Organs in Different Length of Whale (Blue Whale)

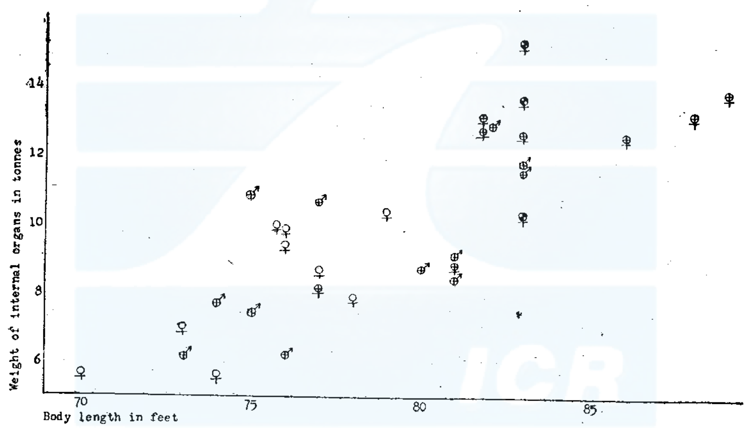


Fig. 9. Percentage of Weight of Internal Organs to Total Weight of Whale (Blue Whale)

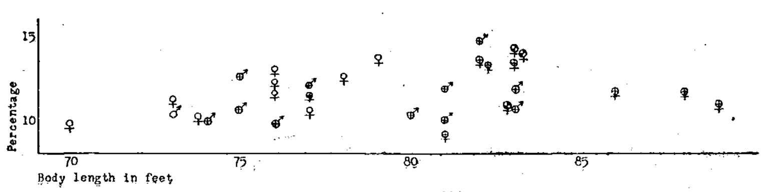


Fig. 10. Weight of Bones in Different Length of Whale (Blue Whale)

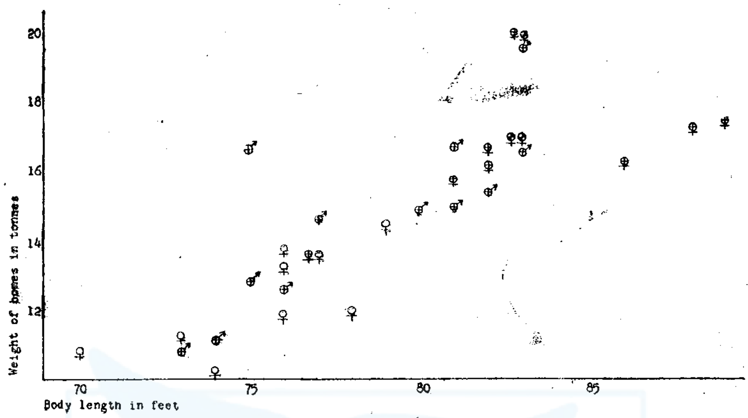


Fig. 11. Percentage of Weight of Bones to Total Weight of Whale (Blue Whale)

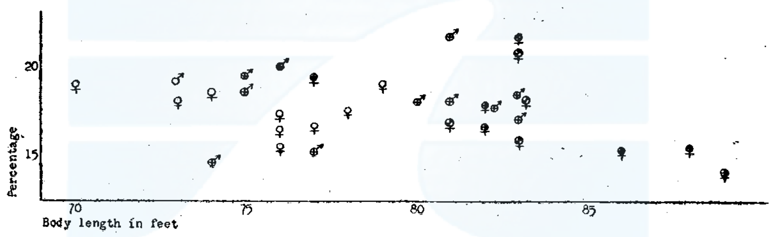


Fig. 12. Weight of Blubber in Different Length of Whale (Fin Whale)

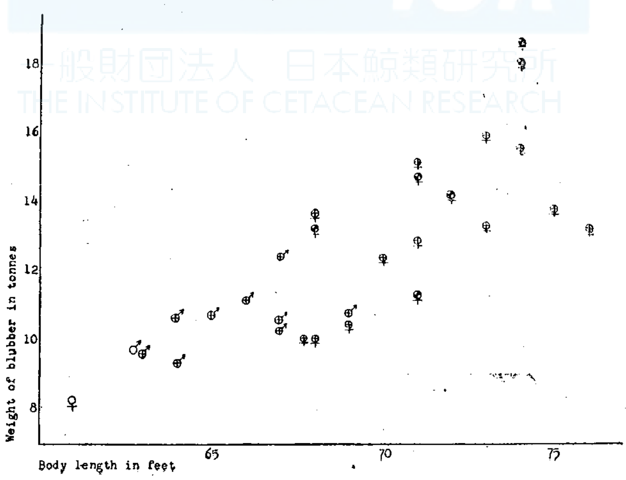


Fig. 13. Percentage of Weight of Blubber to Total Weight of Whale (Fin Whale)

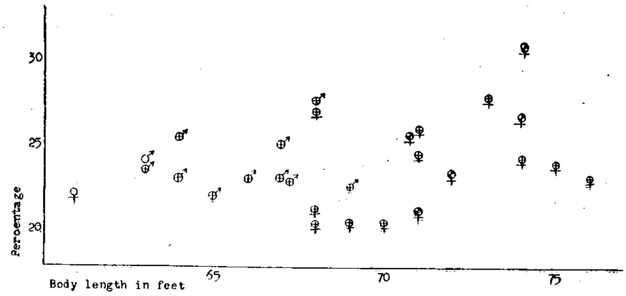


Fig. 14. Weight of Muscles in Different Length of Whale (Fin Whale)

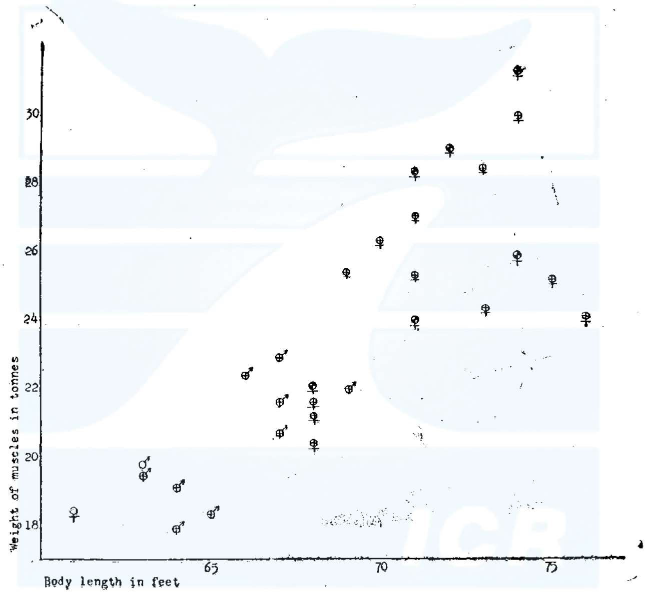


Fig. 15. Percentage of Weight of Muscles to Total Weight of Whale (Fin Whale)

Fig. 16. Weight of Internal Organs in Different Length of Whale (Fin Whale)

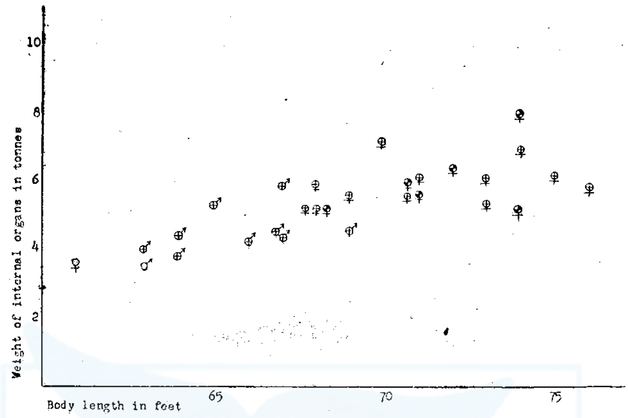


Fig. 17. Percentage of Weight of Internal Organs to Total Weight of Whale (Fin Whale)

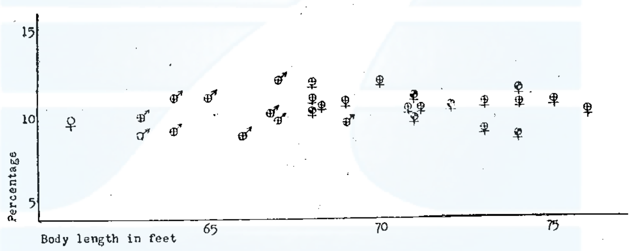


Fig. 18. Weight of Bones in Different Length of Whale (Fin Whale)

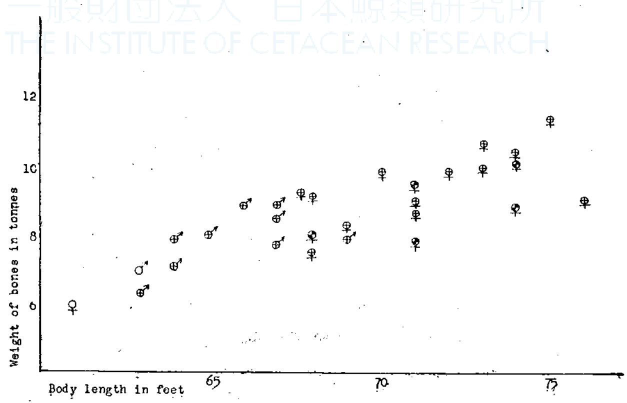
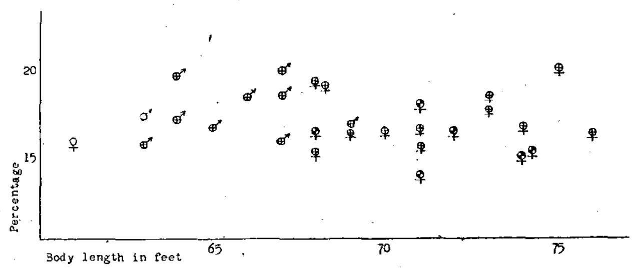


Fig. 19. Percentage of Weight of Bones to total Weight of Whale (Fin Whale)



First of all, as for the real body weight, weight of muscle shows the remarkable change for body length and that of blubber follows it. Both of them show the comparatively large value even in small body length. On the contrary, change of weight of internal organs and bones for body length is not remarkable, showing little unevenness on the average body weight curve. These make us consider that as for body weight or fatness, muscle part shows the most no table change and next blubber part, from the point of view of both age (body length) and whaling season. Bones and internal organs have been little influenced. Three whales which are found far above others both in Figs. 8 and 10 are good examples. All of them were fat and caught after the middle of January.

5. Percentage of the weight af each part for the total weight.

Each part of the above mentioned fat whales, if shown in percentage for total body weight, shows averaged and nearly same value, without unevenness in the figure showing real weight. Especially, internal organs give only a small fluctuation. This means the weight without the relation to the body length. Though instances are few, perhaps naturally the weight of internal organs of pregnant whales (excluding foetus) depends upon the pregnant period and yet is heavier than those of other whales.

The same observation on bones gives us the result that male is larger than female in percentage of weight of bones. This means male is socalled more "large boned" and has more sturdy constitution than female. Generally on mammals like human being their growth does not follow the development of muscles till a certain age. In this investigation, short whales, young whales, show the bigger percentage of weight of bones, this is probably due to the fact that whales too are a mammal.

The percentages of weight of muscle and blubber show larger individual fluctuation for they are much influenced by seasonal fatness as stated in paragraph 4. Generally speaking, male seems to show larger percentage in the weight of muscle and female so in the weight of blubber.

The quite same thing can be said on fin whales too. Male is superior in bone and muscle and female in blubber and internal organs. Individual fluctuation of body weight depends much upon muscle and blubber such as blue whales.

6. The relation between weight and maturity sexual and physical.

Male whales of which testic's weight reached 10 kgs. for blue whales and 5 kgs. for fin whales were regarded as mature. Female whales, of which the presence of more than 1 corpora lutea was found were regarded as mature. (This classification by weight of testic shall be explained elsewhere)

Whales with epiphyses of vertebrae ankylosed to contrum were regarded as mature. Even if they had ankylosed lumbar whales with thoracic region not ankylosed were regarded as immature. (Pregnant blue and resting fin whale contain one whale like this respectively)

According to the above maturity classification, percentage of weight of blubber, muscle, internal organs and bones for the total body weight and average body weight and length are shown in the following table.

TABLE 1.

Average body length and weight and percentage of weight of each part of bodies for total body weight.

1. By sexual maturity

a. Blue Whales

name of part	male immature	male mature	male total	female immature	female mature pregnant	female mature resting	female subtotal	total
blubber	27.32%	27.69%	27.66%	26.64%	28.41%	26.35%	26.91%	26.79%
muscle	39.62	39.20	39.24	40.39	36.76	39.66	38.87	39.55
internal organs	10.75	11.24	11.20	11.55	13.02	11.91	12.21	11.91
bones	19.18	17.88	17.99	17.49	18.07	16.90	17.22	17.35
average body weight	56.48 tons	84.95	82.58	71.26	100.31	100.45	100.41	87.29
average body length	73.0 ft.	78.8	78.3	75.4	83.0	83.5	83.4	79.80
number of whales investigated	1	11	12	9	3	8	11	20

b. Fin Whales

name of part	male immature	male mature	male total	female immature	female mature pregnant	female resting	female subtotal	total
blubber	23.95%	23.44%	23.49%	22.13%	25.77%	23.54%	24.28%	24.17%
muscle	48.69	45.47	45.77	49.21	45.88	45.01	45.30	45.50
internal organs	8.75	10.09	9.96	9.76	10.37	10.73	10.61	10.56
bones	17.34	17.49	17.47	15.81	15.59	17.08	16.59	16.55
average body weight	40.39 tons	45.17	44.68	37.37	58.34	55.34	56.34	55.36
average body length	63.0 ft	65.8	65.5	61.0	71.7	71.3	71.4	70.9
number of whales investigated	1	9	10	1	6	12	18	19

2. By physical maturity

a. Blue Whales

Name of parts	male			female						
	immature	mature	total	immature pregnant	resting	sub total	mature pregnant	resting	sub-total	total
blubber	28.08%	27.23	27.66	30.89	26.63	27.17	23.44	25.90	25.29	26.79
muscle	41.61	36.85	39.24	37.46	39.71	39.48	35.37	41.59	40.03	39.53
internal organs	10.38	12.01	11.20	12.45	11.65	11.75	14.16	12.03	12.56	11.91
bones	17.47	18.50	17.99	16.79	17.32	17.26	20.63	16.73	17.71	17.35
average body weight	74.60 tons	90.55	82.58	102.22	79.65	81.81	96.49	109.56	106.54	87.29
average body length	76.0 ft.	80.7	78.3	83.0	77.8	78.4	83.0	86.0	85.3	79.8
number of whales investigated	6	6	12	2	14	16	1	3	4	20

b. Fin Whales

Name of parts	male			female						
	immature	mature	total	immature pregnant	resting	sub total	mature pregnant	resting	sub-total	total
blubber	23.53%	23.43	23.49	23.37	22.77	22.95	28.17	24.61	25.53	24.17
muscle	45.20	46.63	45.77	47.30	45.67	46.16	44.46	44.94	44.79	45.50
internal organs	9.89	10.06	9.96	10.51	10.84	10.74	10.23	10.44	10.37	10.56
bones	17.65	17.21	17.47	15.87	16.37	16.22	15.31	17.71	16.91	16.55
average body weight	42.6 tons	47.66	44.68	57.29	51.00	52.89	59.38	57.42	58.08	55.35
average body length	64.3 ft.	67.3	65.5	71.3	69.0	69.7	72.0	72.2	72.2	70.9
number of whales investigated	6	4	10	3	7	10	3	6	9	19

The author would like to call attention to the fear that a few number of sexually immature whales measured might make the special circumstances (for instance, seasonal variation) magnify.

According to this table, as thought hitherto, physically mature whales gave larger percentage of weight of bones than immature. And it is especially interesting that sexually immature blue whales show larger percentage. Perhaps naturally as explained above, male whales have always the larger percentage of bones, whatever maturiry they may be in. The percentage of weight of internal organs is reversely larger in female whales. And it is larger in mature than immature whales. Pregnant whales always show large percentage of weight of internal organs blubber, and muscles. In natural, the percentage of weight of bones becomes smaller with the increase of other parts. But their real weights are increased, though the increasing ratio is small.

7. Different weight of each part of whale body by species.

The percentage of weight of blubber is about 26 % for blue whales and about 24 % for fin whales. On the contrary, the percentage of weight of muscle is about 39 % for blue whales and more than 45 % for fin whales. But the weight of bones and internal organs are both by about 1 % larger in blue whales, which is not a larger difference.

The raw material for oil was roughly calculated with the above data as follows. Fin whale of 69 ft. and 51.7 tons (average of 29 male and female whales) gives about 21 ton material and blue whale of 80 ft. and 87.3 tons (average of 32 male and female whales) gives only 39 ton material. If they are conversed into blue whale unit, the latter is 39 tons and the former, 42 tons. So, the conclusion is that; it is more profitable to catch fin whales over 70 feet than blue whales under 80 feet.

TABLE. 2. Comparative Table of Weight and Length by Whale Species.

	Blue whales	Fin whales
average body length	79.55 ft.	69.06 ft
average body weight	87.29 tons	51.67 tons
muscle	39.43 %	45.54 %
internal organs	11.64 %	10.35 %
blubber	27.12 %	23.93 %
bones	17.69 %	16.86 %
material for oil (body weight multiplied by percentage of blubber and bones)	39.11 tons	21.09 tons

8. Conclusion

As mentioned above, number of whales measured is about 30, each blue and fin. Though further investigations are necessary for the observation, by sex, and sexual or physical condition, the author could get the above result anyhow. He quite owed it to all member of whaling fleets.

Resumé

1. Body weight increased with body length. Its increasing ratio was nearly same for blue and fin whales.
2. Seasonal increase of body weight was remarkable in muscle part, next blubber part and not so in bones and internal organs.
3. The notable increase of body weight was found after the middle of January in the Antarctic.
4. Males had more developed muscle and bones than females. Blubber and internal organs were heavier in females than in males.
5. From the point of view of oil material, fin whales is superior (of course it depends upon body length also).

The above is a part of author's observation and he eagerly hopes to study these data from all points of view, for the main purpose of this report is to make public data of whale carcass weighing.

As for body weight, he would like to study on the relation between foetus and adult and on variation of weight of important internal organs such as liver. They are so late for this report that he wants to make it his preliminary report.

References

A. H. Laurie: Some aspects of respiration in Blue and Fin whale, appendix, A note on the weight of some Blue whales. Discovery Reports Vol. XV p. 405, 1933.

H. Ohmura, Y. Matsuura and I. Miyazaki: Whales, their science and real whaling. 1942.

Explanation for table of measurement on each whale.

No of whale treated.

N No. ....means No. of whales treated aboard the Nisshin-maru, Taiyo Gyogyo K. K.

H No. ....means No. of whale treated aboard the Hashidate-maru, Nihon Suisan K. K.

Sex and species

Blue whale...............B

Fin whale................F

Male whale..............M

Female whale............ F

Time and Data when whales were captured.

The first 4 figures mean time in 24 hour system.

The following 2 figures mean date and the next English letters mean November for N, December for D, January for J, February for F, March for M, and April for A.

Body length was expressed in feet.

Weight of testis or overies.

right and left one totalled in Kgs.

Diameter of testis or number of corpora lutea.

Three dimensions of testis were measured in cms, separately right and left.

Number of corpora lutea in ovaries was expressed, totalled functional and old, right and left.

Ankylosis of vertebrae.

\+ means ankylosed and − means not ankylosed on whales measured in the season 1947/48.

A means ankylosed (indistinct border between centrum and epiphysis).

a means ankylosed (distinct border).

n means not ankylosed (thin cartilage between centrum and epiphysis).

N means not ankylosed (thick cartilage).

The first (right) letter means the thoracic region and the second (left) letter, lumbet region.

Degree of white scars.

The left figures mean degree of white scars as following classes.

No scar.....................0

Rare scars 1

a few scars 2

many scars..................3

extremely many scars 4

The right letter, a means older scars than last year's. b means older scars as many as last year's. c means fewer old scars than last year's.

Thickness and colour of mammary gland.

It is expressed in cms. Its colour is shown as follows.

white........................W
peach........................P
yellowish brown...............Y
brown........................B
reddish yellow................Ry
dark yellow..................Dy
red..........................R

Sex of foetus and its body length.

male.........................M
female.......................F

Body length is expressed in feet.

Yield of oil is expressed in Barrels. After page 13, in the items the left figures mean weight in tons and the right ones show its % for the total body weight. (1 Barrel=1/6 ton, 1 ton=1,016 kgs)

year	1947 ～ 1948															
Serial number & Sex	N.No.113.B.M.		N.No.148.B.F.		H.No.271.B.F.		H.No.281.B.F.		N.No.207.B.F.		N.No.210.B.F.		H.No.325.B.F.		N.No.223.B.M.	
Date & Time, Killed	12.50.24. D		17.20.29. D.		16.10.30. D.		09.55. 2. J.		09.00. 7. J.		67.20. 8. J.		16.25. 9. J.		12.00. 11. J.	
Body length in feet	82		83		83		79		83		70		77		81	
Weight of Testes or Ovaries in kg.	34.3		8.3		7.0		2.0		2.8		0.8		1.5		33.0	
Size of Testes or Number of Corpora lutea	73×26×12 80×23×11		13		16		0		2		0		1		80×22×13 82×22×10	
Ankylose of Vertebrae	+ +		− +		+ +		− −		− −		− −		− −		− −	
White scars	3		4		4.a		1.a		2		3		1.a		3	
Thickness & Colour of Mammary gland			5		8.ry		8.y		4		3		3.p			
Sex & Body length of Foetus			M. 10−7		F. 4−2				F. 6−7							
Oil yield in Brl.	133.63		179.68		143.04		114.6		150.93		92.59		86.88		143.84	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Blubber	27.90	31.83	35.868	32.55	22.615	23.44	18.439	24.18	27.55	29.24	16.11	28.41	16.708	23.85	24.81	29.52
Meat	29.77	33.97	39.294	35.65	34.142	35.37	29.504	38.69	37.01	39.27	22.91	40.40	27.146	38.74	33.84	40.26
Internal organs	12.91	14.73	15.388	13.96	13.660	14.16	10.416	13.65	10.30	10.93	5.55	9.79	8.196	11.70	8.46	10.06
Heart	0.56		0.615		0.522		0.464		0.30		0.23		0.178		0.31	
Lung & Bronchus	0.86		0.555		0.691		0.591		0.39		0.34		0.597		0.68	
Stomach	0.26		0.543		0.400		0.299		0.29		0.21		0.248		0.19	
Intestine	1.12		1.371		1.621		1.184		0.95		0.60		1.270		0.91	
Kidney	6.31		0.367		0.460		0.272		0.25		0.19		0.285		0.29	
Liver	0.90		0.937		1.153		0.990		0.75		0.56		0.704		0.60	
Others	8.90		11.000		81.813		6.616		7.37		3.42		4.914		5.48	
Bone	15.38	17.55	17.16	15.57	19.906	20.63	14.450	18.94	16.98	18.02	10.79	19.02	13.614	19.43	15.01	17.86
Skull	4.32		4.55		5.026		3.756		4.06		3.50		3.566		3.31	
Vertebrae	6.46		7.27		9.326		6.152		8.12		4.84		5.800		8.15	
Ribs	1.18		1.74		2.117		1.846		1.58		1.13		1.723		1.52	
Jaw bone	2.02		2.26		2.103		1.796		1.82		1.34		1.645		1.13	
Others	1.46		1.34		1.334		0.900		1.40		0.98		6.880		0.90	
Others	1.68	1.92	2.499	2.27	6.171	6.40	3.468	4.54	2.39	2.54	1.35	2.38	4.397	6.28	1.93	2.30
Total weight	87.64		110.209		96.494		76.277		94.23		56.71		70.061		84.05	

Year	1947 ~ 1948															
Serial number & Sex	N. No.230. B.F.		H. No.367.B.M.		N. No.239.B.M.		N. No.247.B.M.		N. No.279. B.F.		H. No.435. B.F.		N. No.280.B.M.		H. No.438.B.M.	
Date & Time, Killed	12.35. 12. J.		13.20. 14. J.		03.40. 15. J.		11.15. 16. J.		06.50. 21. J.		12.55. 21. J.		13.15. 21. J.		15.50. 22. J.	
Body length in feet	78		76		73		75		76		83		74		83	
Weight of Testes or Ovaries in kg.	0.5		22.5		4.6		13.3		0.9		3.9		38.5		31	
Size of Testes or Number of Corpora lutea	0.		61×19×13 60×18×13		38×11×8 36×12×7		40×17×10 43×16×11		0		31		59×23×18 66×25×16		62×26×15 65×24×14	
Ankylosis of Vertebrae	− −		− −		− −		− −		− −		+ +		− −		+ +	
White scars	2		3c		2		2		3		4a		3		42	
Thickness & Colour of Mammary gland	2								3		10dy					
Sex & Body length of Foetus																
Oil yield in Brl.	103.16		75.54		74.22		110.31		113.13		92.16		107.94		122.76	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Blubber	22.69	32.92	16.556	26.25	15.43	27.32	19.02	27.58	20.68	26.64	22.034	23.57	22.000	28.42	27.891	25.87
Meat	24.83	36.03	25.879	41.04	22.38	39.62	28.33	41.07	34.04	43.85	31.605	33.80	34.93	45.12	39.838	36.95
Internal organs	7.941	11.52	6.172	9.79	6.07	10.75	7.373	10.69	9.491	12.22	12.683	13.56	7.739	9.99	11.573	10.74
Heart	0.30		0.257		0.11		0.18		0.33		0.320		0.23		0.344	
Lung & Bronchus	0.68		0.461		0.53		0.46		0.68		0.927		0.47		0.889	
Stomach	0.25		0.260		0.25		0.30		0.30		0.492		0.28		0.280	
Intestine	1.13		0.765		0.86		1.02		1.11		1.647		0.95		1.374	
Kidney	0.20		0.208		0.16		0.24		0.25		0.343		0.18		0.400	
Liver	0.70		0.688		0.56		0.75		0.94		1.085		0.75		1.347	
Others	4.681		3.533		3.60		4.423		5.881		7.869		4.879		6.939	
Bone	11.98	17.38	12.595	19.97	10.83	19.18	12.75	18.49	11.93	15.37	20.080	21.48	11.10	14.34	19.607	18.19
Skull	2.92		3.515		2.78		3.06		3.05		5.570		3.05		5.484	
Vertebrae	5.84		5.478		4.77		5.75		4.58		8.681		4.31		8.440	
Ribs	1.08		1.402		1.04		1.29		1.50		2.154		1.40		2.335	
Jaw bone	1.12		1.397		1.19		1.51		1.67		2.434		1.40		2.182	
Others	1.02		0.803		1.05		1.14		1.13		1.241		0.94		1.166	
Others	1.49	2.16	1.860	2.95	1.77	3.13	1.50	2.17	1.49	1.92	7.100	7.59	1.65	2.13	8.895	8.25

Year	1947 ～ 1948															
Serial number & Sex	N. No.319. B.F.		N. No.337. B.F.		H. No.631. B.F.		N. No.411. B.F.		N. No.415. B.M.		H. No.734. B.M.		H. No.736. B.F.		H. No.742. B.F.	
Date & Time, Killed	16.10. 27. J.		12.35. 2. F.		19.35. 7. F.		22.40. 14. F.		17.00. 15. F.		09.30. 20. F.		18.30. 20. F.		21.30. 21. F.	
Body length in feet	89		74		76		86		77		75		73		77	
Weight of Testes or Ovaries in kg.	4.1		0.6		1.4		9.6		30.5		30.5		1.2		1.1	
Size of Testes or Number of Corpora lutea	19		0		0		30		58×22×14 58×22×15		62×22×15 70×22×13		0		0	
Ankylosis of Vertebrae	+ +		− −		− −		+ +		− −		+ +		− −		− −	
White scars	4		2		3a		4		4		4a		1a		1a	
Thickness & Colour of Mammary gland	8		3		5dy		9						2p		2p	
Sex & Body length of Foetus																
Oil yield in Brl.	159.25		76.41		101.16		159.08		152.93		110.70		76.98		100.62	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Blubber	32.36	25.37	15.58	28.16	19.698	25.44	31.24	28.76	28.70	29.40	22.659	26.26	15.753	25.27	20.333	24.70
Meat	61.51	48.23	22.67	40.97	30.062	38.83	46.41	42.73	41.61	42.62	30.730	35.62	25.495	40.92	35.797	43.50
Internal organs	13.944	10.93	5.6406	10.20	10.030	12.96	12.60	11.60	10.74	11.00	10.848	12.59	7.033	11.27	8.701	10.58
Heart	0.43		0.16		0.371		0.59		0.21		0.333		0.297		0.215	
Lung & Bronchus	1.09		0.48		0.466		0.70		0.59		0.644		0.481		0.590	
Stomach	0.47		0.25		0.243		0.54		0.53		0.321		0.183		0.231	
Intestine	1.49		0.71		1.193		1.59		1.13		1.021		1.004		0.945	
Kidney	0.36		0.13		0.278		0.49		0.33		0.283		0.167		0.200	
Liver	1.00		0.56		0.827		1.30		1.16		0.958		0.601		0.700	
Others	9.104		3.3506		6.652		7.39		6.79		7.288		4.300		5.820	
Bone	17.54	13.75	10.21	18.45	13.299	17.18	16.26	14.97	14.64	14.99	16.734	19.40	11.261	18.07	13.671	16.62
Skull	4.88		2.54		3.485		4.80		3.58		5.014		3.035		3.480	
Vertebrae	7.32		4.19		6.170		6.39		6.35		6.736		5.164		6.194	
Ribs	1.47		1.16		1.358		1.64		1.67		1.916		1.094		1.498	
Jaw bone	1.99		1.12		1.398		2.07		1.76		2.044		1.257		1.544	
Others	1.88		1.20		0.888		1.36		1.28		1.024		0.711		0.955	
Others	2.19	1.72	1.23	2.22	4.336	5.59	2.11	1.94	1.94	1.99	5.296	6.13	2.786	4.47	3.787	4.60
Total Weight	127.544		55.3306		77.425		108.62		97.63		86.267		62.328		82.289	

Year	1947 ~ 1948												1948 ~ 1949			
Serial number & Sex	RN.No.462.B.F.		H. No.745. B.F.		N. No.471.B.M.		H. No.819. B.F.		H. No.827.B.M.		H. No.831. B.F.		H. No.79. B.M.		H. No.831. B.F.	
Date & Time. Killed	07.30. 23.F.		18.25. 23.F.		00.40. 25.F.		19.20. 3.M.		15.25. 5.M.		18.20. 7.M.		11.20. 26.D.		19.50. 2.M.	
Body length in feet	88		76		80		82		83		81		81		82	
Weight of Testes or Ovaries in kg.	5.6		1.3		29.0		2.4		32.5		5.8		44.6		4.8	
Size of Testes or Number of Corpora lutea	13		0		71 × 27 × 12 64 × 27 × 12		2		79 × 23 × 12 84 × 23 × 12		6		77 × 24 × 16 75 × 25 × 18		4	
Ankylosis of Vertebrae	− −		− −		+ +		− −		+ +		− −		a a		n n	
White scars	4		2a		4		1a		1a		4a		4c		3c	
Thickness & Colour of Mammary gland	9		5p				6p				5Ry				3p	
Sex & Body length of Foetus																
Oil yield in Brl.	179.51		104.28		142.07		154.92		140.40		159.06		118.63		159.66	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Blubber	31.28	27.50	20.271	24.05	23.31	27.31	26.307	27.70	26.068	26.24	25.526	26.75	19.916	25.89	27.201	27.28
Meat	49.64	43.64	33.964	40.30	36.47	42.73	33.523	35.30	35.893	36.13	38.847	40.71	27.454	35.70	33.995	34.09
Internal organs	13.176	11.58	9.949	11.80	8.709	10.21	12.815	13.50	11.823	11.91	8.792	9.21	9.135	11.88	13.1228	13.16
Heart	0.42		0.738		0.25		0.520		0.176		0.227		0.439		0.297	
Lung & Bronchus	0.98		0.545		0.67		0.456		0.407		0.561		0.437		0.556	
Stomach	0.45		0.336		0.25		0.450		0.305		0.304		0.284		0.379	
Intestine	1.35		1.183		1.09		1.395		1.357		0.937		1.299		1.148	
Kidney	0.35		0.308		0.26		0.350		0.317		0.300		0.235		0.299	
Liver	0.95		0.805		0.70		0.827		1.235		0.666		0.763		0.938	
Others	8.676		6.034		5.489		8.816		8.025		5.767		5.678		9.5058	
Bone	17.31	15.22	13.832	16.42	14.87	17.42	16.665	17.55	16.644	16.76	15.800	16.55	16.691	21.70	16.235	16.28
Skull	4.91		3.569		3.78		4.660		4.205		2.806		4.773		4.480	
Vertebrae	7.63		6.716		6.49		7.600		7.465		7.509		7.264		7.230	
Ribs	1.42		1.239		1.84		1.595		2.021		2.590		1.758		1.731	
Jaw bone	2.00		1.440		1.35		1.786		2.030		1.892		1.767		1.754	
Others	1.35		0.868		1.41		1.025		0.923		1.003		1.029		1.040	
Others	2.34	2.06	6.264	7.43	1.99	2.33	5.646	5.95	8.900	8,96	6.463	6.78	3.716	4.83	9.159	9.19

Year																
Serial number & Sex	H. No.152.F.M.		N. No.152.F.M.		H. No.284.F.F.		H. No.314.F.M.		N. No.211.F.M.		N. No.224.F.F.		N. No.225.F.F.		N. No.236.F.F.	
Date & Time, Killed	09.25. 30.D.		10.15. 30.D.		06.50. 3.J.		16.45. 7.J.		11.40. 8.J.		15.35. 11.J.		17.15. 11.J.		14.30. 13.J.	
Body length in feet	64		67		69		66		63		74		75		74	
Weight of Testes or Ovaries in kg.	12.7		21.6		0.4		24.4		10.2		2.4		2.7		2.1	
Size of Testes or Number of Corpora lutea	56×13×12 56×17×9		56×24×12 61×20×11		1		65×21×13 58×23×13		56×17×7 57×16×7		21		20		14	
Ankylosis of Vertebrae	− −		− −		− −		+ +		− −		+ +		+ +		+ +	
White scars	4		4		1a		4a				4				4	
Thickness & Colour of Mammary gland					3b						7		8		6	
Sex & Body length of Foetus															M. 9−1	
Oil yield in Brl.	54.73		57.57		46.80		47.28		49,48		68.26		60.23		77.76	
	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Blubber	9.27	23.00	10.341	22.86	10.533	20.39	11.091	23.07	9.57	23.80	15.60	24.28	13.78	23.92	18.56	26.69
Meat	17.891	44.40	20.747	45.86	25.358	49.08	22.391	46.56	19.50	48.50	29.93	46.57	25.22	43.78	31.17	44.82
Internal organs	4.411	10.95	4.398	9.72	5.583	10.78	4.226	8.79	3.96	9.85	6.972	10.85	6.212	10.79	7.982	11.48
Heart	0.150		0.131		0.239		0.136		0.13		0.18		0.13		0.30	
Lung & Bronchus	0.25		0.248		0.401		0.379		0.29		0.42		0.54		0.41	
Stomach	0.139		0.12		0.293		0.120		0.12		0.25		0.20		0.10	
Intestine	0.563		0.60		0.960		0.825		0.49		1.21		1.04		0.76	
Kidney	0.150		0.15		0.198		0.179		0.22		0.20		0.23		0.17	
Liver	0.560		0.464		0.592		0.617		0.35		0.49		0.56		0.40	
Others	2.599		7.685		2.900		1.970		2.36		4.222		3.512		5.842	
Bone	7.90	19.60	8.938	19.76	8.338	16.16	8.792	18.28	6.27	15.59	10.49	16.32	11.42	19.83	10.20	14.67
Skull	2.27		2.555		2.288		2.490		0.98		2.35		2.62		2.63	
Vertebrae	3.62		4.07		3.724		3.958		3.47		4.50		4.76		4.56	
Ribs	0.79		1.038		0.966		0.842		0.67		1.69		1.89		1.20	
Jaw bone	0.71		0.72		0.909		0.978		0.72		1.20		1.25		1.25	
Others	0.51		0.555		0.451		0.524		0.43		0.75		0.90		0.56	
Others	0.826	2.05	0.814	1.80	1.855	3.59	1.587	3.30	0.91	2.26	1.27	1.98	0.97	1.68	1.63	2.34
Total Weight	40.298		45.238		51.667		48.087		40.21		64.262		57.602		69.542	

Year	1947 ~ 1948															
Serial number & Sex	N. No. 254. F. F.		N. No. 262. F. M.		N. No. 325. F. F.		N. No. 357. F. F.		H. No. 617. F. M.		H. No. 702. F. F.		H. No. 816. F. F.		N. No. 487. F. F.	
Date & Time, Killed	20.40. 17. J.		19.35. 18. J.		17.10. 29. J.		01.20. 5. F.		21.35. 6. F.		21.15. 12. F.		10.30. 2. M.		11.15. 7. M.	
Body length in feet	72		64		71		71		69		68		68		68	
Weight of Testes or Ovaries in kg.	3.1		7.5		2.4		2.1		26.9		1.8		2.3		2.0	
Size of Testes or Number of Corpora lutea	5		45×13×10 44×12×9		7		16		72×21×11 72×21×11		1		6		15	
Ankylosis of Vertebrae	− −		− −		− −		+ +		+ +		− −		+ +		− −	
White scars	3		3		4		2		4a		4a		4a		4	
Thickness & Colour of Mammary gland	4				5		7				5dy		5dy		6	
Sex & Body length or Foetus	F. 7−10				M. 9−6											
Oil yield in Brl.	74.10		51.19		74.28		66.60		42.72		44.16		46.8		59.34	
	t	%	t	%	t	%	t	%	t	%	t	%	t	%	t	%
Blubber	14.19	23.37	10.59	25.43	14.75	25.57	15.18	25.94	10.778	22.66	10.028	21.17	9.966	20.55	13.70	27.57
Meat	29.09	47.91	19.11	45.88	28.30	49.06	27.02	46.18	21.963	46.16	21.181	44.72	20.436	42.14	26.65	43.57
Internal organs	6.399	10.54	3.778	9.07	5.692	9.87	6.062	10.36	4.535	9.54	5.162	10.89	5.168	10.65	5.885	11.84
Heart	0.16		0.13		0.14		0.18		0.220		0.205		0.142		0.17	
Lung & Bronchus	0.40		0.20		0.30		0.45		0.285		0.335		0.303		0.29	
Stomach	0.27		0.15		0.23		0.17		0.240		0.233		0.266		0.22	
Intestine	0.74		0.58		0.73		0.80		0.793		0.755		0.992		0.62	
Kidney	0.14		0.11		0.16		0.21		0.165		0.180		0.145		0.25	
Liver	0.56		0.38		0.54		0.53		0.475		0.448		0.517		0.50	
Others	4.129		2.228		3.592		3.722		2.357		3.006		2.803		3.835	
Bone	9.87	16.25	7.08	17.00	7.82	13.56	8.96	15.31	7.883	16.56	9.067	19.15	9.227	19.03	7.45	14.99
Skull	2.47		1.85		2.28		2.46		1.910		2.334		1.922		1.63	
Vertebrae	4.38		2.85		3.05		3.50		3.820		4.228		4.357		3.59	
Ribs	1.20		1.06		0.90		1.08		0.972		1.013		1.281		0.77	
Jaw bone	1.17		0.81		1.10		1.26		0.761		0.958		1.085		0.96	
Others	0.65		0.51		0.49		0.66		0.420		0.534		0.582		0.50	
Others	1.174	1.93	1.09	2.62	1.12	1.94	1.29	2.21	2.417	5.08	1.929	4.07	3.701	7.63	1.01	2.03
Total Weight	60.723		41.648		57.682		58.512		47.576		47.367		48.498		49.695	

Year	1948 ~ 1949															
Serial number & Sex	r/N. No.15. F.F.		N. No21. F.F.		N. No.25. F.M.		H. No.85. F.F.		H. No.86. F.F.		N. No.68. F.F.		N. No.105. F.F.		N. No.127. F.M.	
Date & Time, Killed	16.45. 17. D.		15.40. 18. D.		10.45. 19. D.		18.30. 27. D.		20.45. 28. D.		15.40. 30. D.		20.45. 6. J.		09.10. 10. J.	
Body length in feet	68		73		63		61		71		73		74		67	
Weight of Testes or Ovaries in kg.	3.5		2.8		4.0		0.6		2.0		1.8		4.1		13.3	
Size of Testes or Number of Corpora lutea	14		24		40 × 9 × 5 38 × 10 × 6		0		6		19		12		65 × 17 × 8 63 × 14 × 8	
Ankylosis of Vertebrae	a a		A A		n n		N N		n n		A A		a a		A A	
White scars	2c		3c		2b		3c		2c		3c		3c		2c	
Thickness & Colour of Mammary gland	7y		7y				3p		3.5Ry		6Dy		5y			
Sex & Body length of Foetus	F. 2–7								F. 5–4				M. 7–3			
Oil yield in Brl.	41.4		45.6		30.8		37.7		56.1				69.0		37.8	
	t	%	t	%	t	%	t	%	t	%	t	%	t	%	t	%
Blubber	13.337	27.00	15.862	27.76	9.673	23.95	8.270	22.13	11.324	21.18	13.335	22.78	18.249	30.81	10.460	22.93
Meat	22.124	44.80	24.287	42.51	19.665	48.69	18.391	49.21	24.019	44.93	28.365	48.46	25.419	43.76	21.614	47.39
Internal organs	5.1195	10.37	6.1728	10.81	3.532	8.75	3.646	9.76	5.951	11.13	5.364	9.17	5.230	8.83	4.540	9.96
Heart	0.233		0.320		0.100		0.133		0.182		0.238		0.252		0.500	
Lung & Bronchus	0.375		0.580		0.340		0.247		0.419		0.340		0.334		0.420	
Stomach	0.263		0.240		0.150		0.197		2.256		0.230		0.375		0.190	
Intestine	1.004		0.920		0.630		0.477		0.646		0.695		0.708		0.610	
Kidney	0.188		0.215		0.100		0.136		0.175		0.210		0.188		0.170	
Liver	0.450		0.645		0.360		0.344		0.515		0.500		0.512		0.370	
Others	2.6065		3.2528		1.852		2.112		3.758		3.151		2.861		2.280	
Bone	8.012	16.22	10.012	17.52	7.002	17.34	5.910	15.81	9.514	17.80	10.675	18.24	8.911	15.05	8.401	18.42
Skull	2.149		3.646		1.837		1.520		2.623		2.630		3.578		2.484	
Vertebrae	3.634		4.529		3.232		2.803		4.144		4.967		3.876		3.391	
Ribs	0.833		1.344		0.750		0.605		0.976		1.158		0.918		1.071	
Jaw bone	0.859		—		0.795		0.605		1.114		1.333		—		0.945	
Others	0.537		0.493		0.388		0.373		0.657		0.587		0.539		0.510	
Others	0.7934	1.61	0.800	1.40	0.514	1.27	1.154	3.09	2.651	4.96	0.790	1.35	0.918	1.55	0.594	1.30
Total weight	49.3859		57.1338		40.386		37.371		53.459		58.529		58.222		45.609	

Year	1948 ～ 1949									
Serial number & Sex	N. No.219.F.M.		N. No.540. F.F.		H. No.783. F.F.		H. No.795. F.F.		H. No.927.F.M.	
Date & Time, Killed	09.25. 21.J.		05.45. 26.F.		09.30. 25.F.		14.10. 26.F.		19.10. 14.M.	
Body length in feet	67		71		76		70		65	
Weight of Testes or Ovaries in kg.	30.8		1.2		1.2		1.7		19	
Size of Testes or Number of Corpora lutea	68 × 27 × 12 68 × 22 × 13		1		5		7		70 × 15 × 10 62 × 17 × 9	
Ankylosis of Vertebrae	A A		N N		N N		n a		n n	
White scars	4c		2b		1c		3c		3c	
Thickness & Colour of Mammary gland			4Ry		4.0p		6.5Ry			
Sex & Body length of Foetus										
Oil yild in Brl.	43.8						64.2		66.3	
	T	%	T	%	T	%	T	%	T	%
Blubber	12.375	25.07	12.948	24.39	13.319	23.17	12.385	20.53	10.695	22.11
Meat	22.915	46.42	25.240	47.54	24.093	41.91	26.322	43.63	18.311	37.86
Internal organs	5.896	11.95	5.515	10.39	5.9116	10.28	7.2047	11.94	5.323	11.00
Heart	0.245		0.260		0.287		0.251		0.189	
Lung & Bronchus	0.435		0.330		0.358		0.420		0.429	
Stomach	0.230		0.300		0.396		0.267		0.241	
Intestine	0.790		0.671		0.944		0.940		0.682	
Kidney	0.230		0.215		0.201		0.330		0.138	
Liver	0.600		0.500		0.657		0.757		0.659	
Others	3.356		3.239		3.0686		4.2397		2.985	
Bone	7.636	15.57	8.669	16.33	9.132	15.89	9.800	16.24	8.027	16.60
Skull	2.030		2.283		2.583		2.693		2.195	
Vertebrae	3.381		3.542		4.478		4.289		3.417	
Ribs	0.865		1.020		0.686		1.122		1.097	
Jaw bone	0.940		1.330		1.058		1.205		0.794	
Others	0.470		0.494		0.327		0.491		0.524	
Others	0.489	0.99	0.716	1.35	5.032	8.75	4.619	7.66	6.010	12.43
Total Weight	[illegible]		[illegible]		57.4876		60.3307		48.366	