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	〃

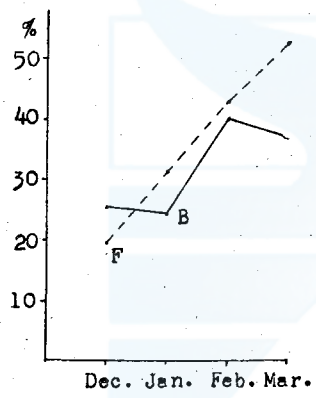
Observation for diatom infection was made on each whale with the naked eye as soon as it was hauled on to the deck of the factory ship for processing. The measure of diatom infection was recorded according to the following four classes; 0 where no infection could be observed with the naked eye; + where 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

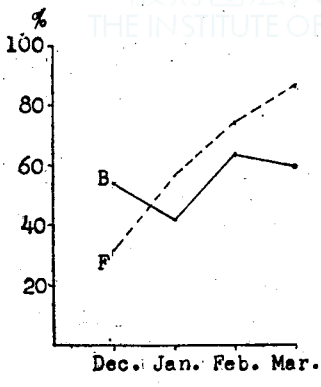
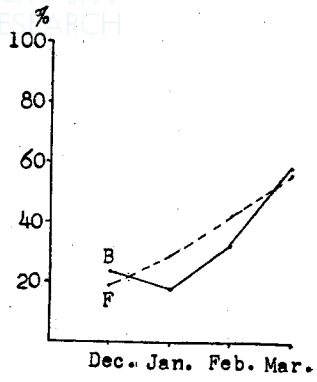
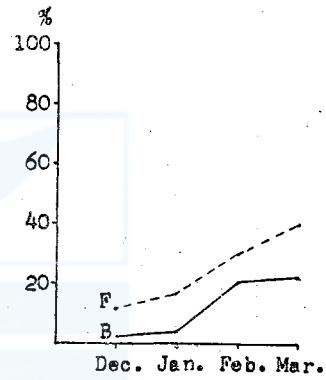


Fig. 3. Diatom infection in the season 1947/48
B : Blue Whale
F : Fin Whale



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

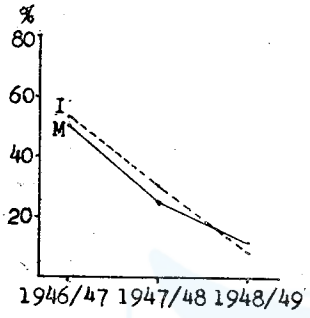
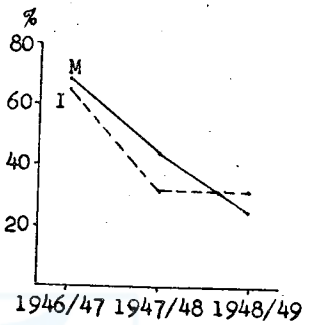


Fig. 6. Difference of infection by maturity Fin Whale
M : Mature
I : Immature



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

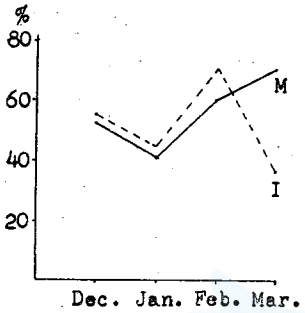


Fig. 8. Diatom infection on mature and immature whale
Blue whale 1947/48
M : Mature
I : Immature

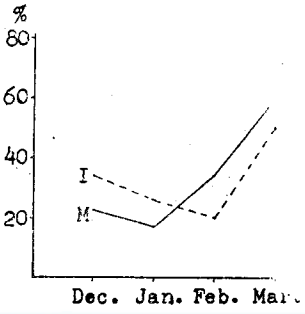


Fig. 9. Diatom infection on mature and immature whale
Blue whale 1948/49
M : Mature
I : Immature

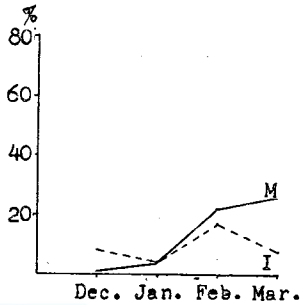


Fig. 10. Diatom infection on mature and immature whale
Fin whale 1946/47

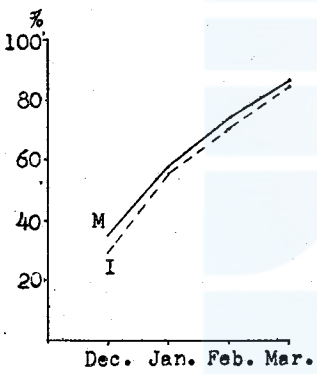


Fig. 11. Diatom infection on mature and immature whale
Fin whale 1947/48

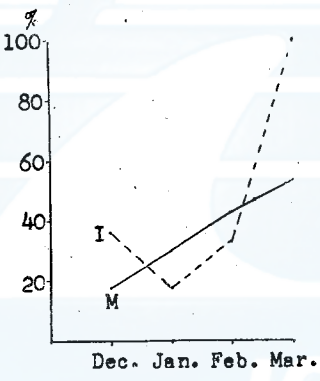
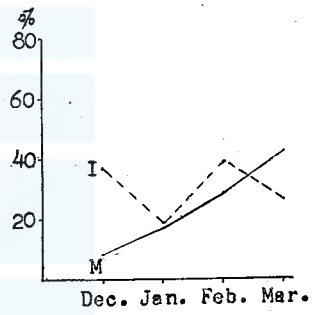


Fig. 12. Diatom infection on mature and immature whale
Fin whale 1948/49



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

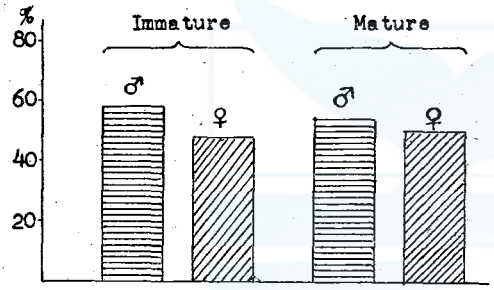


Fig. 14. Difference of diatom infection by sex
Blue whale 1947/38

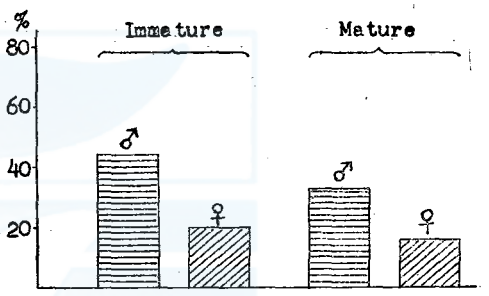


Fig. 15. Difference of diatom infection by sex
Blue whale 1948/49

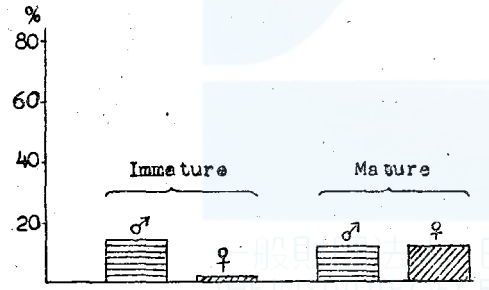


Fig. 16. Difference of diatom infection by sex
Fin whale 1946/47

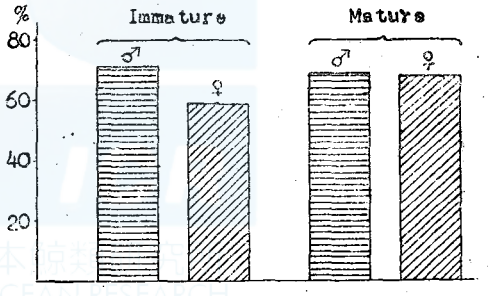


Fig. 17. Difference of diatom infection by sex
Fin whale 1947/48

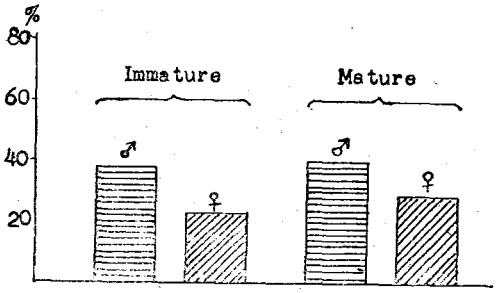
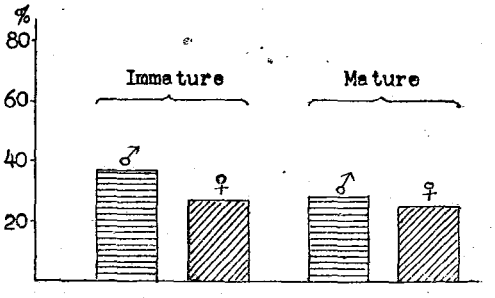


Fig. 18. Difference of diatom infection by sex
Fin whale 1948/49



IIV. Diatom infection in the Ross Sea.

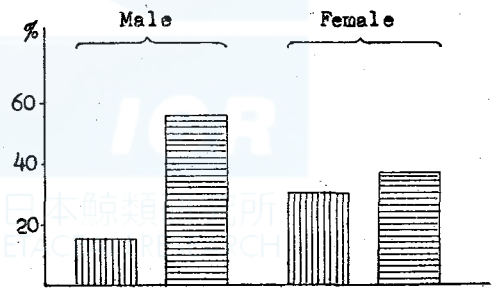
In the season of 1947/48, the "Hashidate-maru" operated in the narrow area near Long. 175°W. Lat. 75°S. in the Ross Sea Area from 12 February to 26 February 1948.

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

Fig. 19. Difference of diatom infection by sex



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.

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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