THE
SCIENTIFIC REPORTS
OF
THE WHALES RESEARCH INSTITUTE

No. 16

THE WHALES RESEARCH INSTITUTE
TOKYO · JAPAN

MARCH 1962

THE SCIENTIFIC REPORTS OF THE WHALES RESEARCH INSTITUTE

CONTENTS OF NUMBER 16

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

BRYDE'S WHALE OCCURS ON THE COAST OF BRAZIL

HIDEO OMURA

Mr. S. Watase of "Taiyo Gyogyo K. K.", who had been working for some years at the landstation of "Sociedade de Pesca Taiyo Ltda" at Cabo Frio, Brazil, presented us two baleen plates from so-called sei whales taken there for identification of the species. It was clear that one baleen had been taken from a sei whale, *Balaenoptera borealis*, having very fine and white colored bristles. Another baleen, however, is quite different from the other and shows typical features of Bryde's whale, *Balaenoptera edeni* (Fig. 1). Bristles of this plate are coarse and greyish in color, though the plate itself is black. The length of the plate along outer curve measures 51 cm and the width 19 cm. The ratio baleen width to baleen length is 37.3 per cent. The measured length is shorter than the length to gum line, because the baleen has

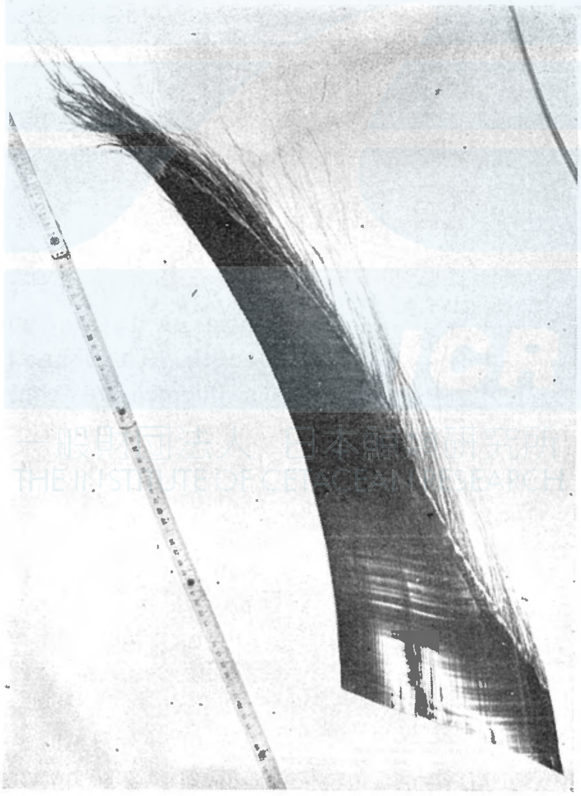


Fig. 1. Baleen plate of a Bryde's whale from the coast of Brazil.

TABLE 1. PARTICULARS OF THE BALEEN PLATE SHOWN IN FIG. 1

Date killed	Sept. 27, 1960
Position	22°56′S, 41°52′W
Sex	Male
Body lengh	41 feet
Baleen length (along outer curve and excludes bristles)	51 cm
Width (inner side broken)	19 cm

been cut above this line. Since the inner side of the baleen was damaged, the width is also shorter than the correct figure. There is a ground, however, to think that the measured length is not differ greatly from the length to gum line and the difference between these two lengths might be within 1 cm and the width should be added 2–3 cm. If we take into account of this correction the ratio baleen width to baleen length will become over 40 per cent and approach to 45 per cent, a mean figure found by Olsen (1913) for this value (four individuals) for the Bryde's whale from the coast of South Africa. Chittleborough (1959) found that the three Bryde's whales taken on the west coast of Australia differ in this respect, having a mean of 73 per cent. The Bryde's whales from the coast of Australia, however, agree quite well in this character to those from the coast of Japan as reported by Omura and Fujino (1954).

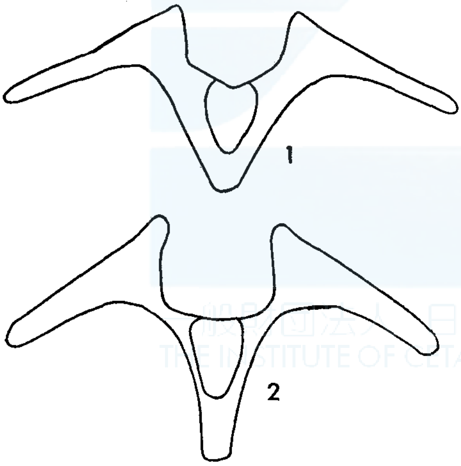


Fig. 2. Cross section of beak, just cranial to blow-holes.
1. *Balaenoptera edeni*
2. *B. borealis*
(Material obtained at Ayukawa, Japan by T. ICHIHARA)

Above will lead to a conclusion that the Bryde's whales from the South Atlantic may differ in this respect from those from other oceans, having longer baleen plates or wide range of variation in the ratio of baleen width to baleen length. The shape of baleen plates is deemed to connect with the shape of the skull, in particular to that of rostrum. One striking feature of the skull of the Bryde's whale is the flat and straight pointing shape of the rostrum than the sei whale (Lönnberg, 1931; Junge, 1950; Omura, 1959). The flat rostrum of the Bryde's whale is clearly shown compared with that of sei whale in Fig. 2. Junge (1950) states, however, that "In *brydei* there is some variation. Lönnberg (1931, p. 2) points to the fact that the rostrum of Bryde's whale (from the coast of South Africa) is flat and straight as compared with skulls of *borealis*. This feature is well shown in the side view of this skull (l. c., plate 1 fig. 1). In the specimen in the British Museum, however, the rostrum is more curved to the rostral side". It is anticipated, therefore, that there is rather a wide range of variation in the ratio of baleen width to baleen length among Bryde's whales from the South Atlantic, whereas such evidence has never been shown so far from those from the other oceans.

Further evidences that the Bryde's whale occurs on the Brazilian coast were supplied by Mr. E. Tanaka of "Taiyo Gyogyo K. K.", who has been working at the landstation at Cabo Frio. He sent us some photographs of the Bryde's whale taken there as well as some informations. These photographs show the characters of the Bryde's whale, i. e. broader palate between rows of baleen plates (Fig. 3), ventral grooves

Fig. 3. Brydes's whale from the coast of Brazil—1.
(Cabo Frio, 1961. Photo. E. TANAKA)

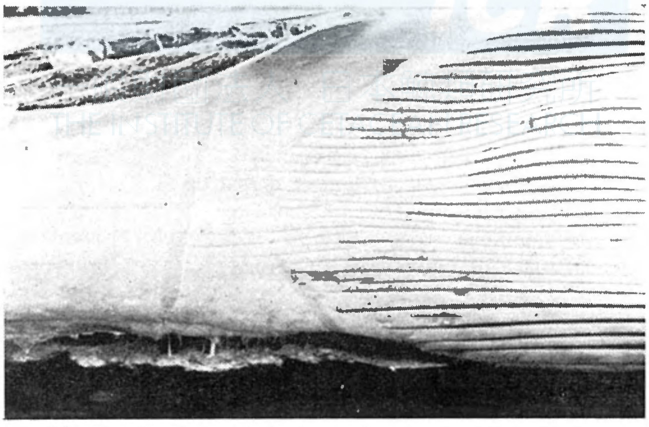


Fig. 4. Bryde's whale from the coast of Brazil—2.
(Cabo Frio, 1961. Photo. E. TANAKA)

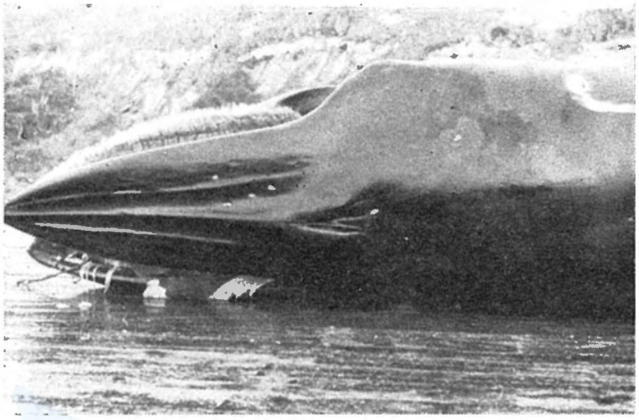


Fig. 5. Bryde's whale from the coast of Brazil—3.
(Cabo Frio, 1961. Photo. E. TANAKA)

extend posterioly beyond umbilicus (Fig. 4), and ridges on the head (Fig. 5, see also Omura 1962).

According to the information a total of 12 Bryde's whales were taken there in 1961 as of 14th September (May 2, June 8, September 2). These include 7 males and 5 females and their body lengths range from 39 feet to 43 feet in both sexes, except one female of 47 feet in length. These whales were taken in an area of Lat. 23°–24°S and Long. 41°–

TABLE 2. BODY PROPORTION OF A BRYDE'S WHALE FROM THE COAST OF BRAZIL (Measured by Mr. E. TANAKA)

Date killed	Sept. 14, 1961
Position	Lat. 23°13′S, Long. 41°53′W
Sex	Male

Measurements	Length in cm	% of length
Total length of body	1,300	100
Lower jaw, projection beyond tip of snout	35	2.7
Tip of snout to angle of gape	250	19.2
Tip of snout to centre of eye	258	19.8
Tip of snout to anterior insertion of flipper	395	30.4
Centre of eye to centre of ear	72	5.5
Notch of flukes to posterior emargination of dorsal fin	365	28.1
Notch of flukes to centre of anus	338	26.0
Notch of flukes to umbilicus	608	46.8
Centre of anus to centre of reproductive aperture	103	7.9
Vertical height of dorsal fin	40	3.1
Length of base of dorsal fin	50	3.8
Flipper, tip to axilla	125	9.6
Flipper, tip to anterior end of lower border	177	13.6
Flipper, greatest width	34	2.6
Gaeatest girth (at a point 110 cm anterior to umbilicus)	600	46.2
Tail flukes, tip to tip (estimated)	290	22.3

42°W.

Mr. E. Tanaka measured body proportions of a Bryde's whale which is shown in Table 2 for reference.

Sincere thanks are due to Messrs. S. Watase and E. Tanaka who presented us valuable material on which this note is based.

REFERENCES

CHITTLEBOROUGH, R. G. (1959). Balaenoptera Brydei Olsen on the west coast of Australia. *Norsk Hvalfangst-Tid.*, 48 (2); 62-6.

JUNGE, G. C. A. (1950). On a specimen of the rare fin whale, *Balaenoptera edeni* Anderson, stranded on Pulu Sugi near Singapore. *Zoologische Verhandelingen*, no. 9: 1-26.

LÖNNBERG, E. (1931). The skeleton of *Balaenoptera brydei* O. Olsen. *Arkiv f. Zoologi*, 23A (1).

OLSEN, ϕ. (1913). On the external characters and biology of Bryde's whale (*Balaenoptera brydei*), a new rorqual from the coast of South Africa. *Proc. Zool. Soc. London*, 1073-90.

OMURA, H. (1959). Bryde's whale from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 14: 1-33: 7-18.

——— (1962). Further information on Bryde's whale from the coast of Japan. *Sci. Rep. Whales Res. Ins.*, no. 16.

OMURA, H. and FUJINO, K. (1954). Sei whles in the adjacent waters of Japan. II. Further studies on the external characters. *Sci. Rep. Whales Res. Inst.*, no. 9: 89-103.

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

FURTHER INFORMATION ON BRYDE'S WHALE FROM THE COAST OF JAPAN

HIDEO OMURA

Very little has been reported on ecological matters of Bryde's whale (*Balaenoptera edeni*) from the coast of Japan. In 1960, however, material was collected from about 120 whales from various landstations at Sanriku and Oshima. The present paper is based on this material as well as on that collected before, together with catch informations.

EXTERNAL CHARACTER

One striking feature in external character of Bryde's whale is the ridges on each side of the head which run just posterior to the tip of the snout to the level of blow-holes, on the mid line between median line and margin of the snout. Since there present another ridge on the median line of the head, from tip of snout to blow-holes, there are 3 similar ridges, which run antero-posteriorly, on the head of the Bryde's whale. The side-ridges, however, sink abruptly at a level of or a little infront of the anterior part of the blow-holes and end with grooves (Fig. 1). Several hairs are present on each side-ridge.

In sei whale (*Balaenoptera borealis*) median ridge is present, but prominent side-ridges are not present (Figs. 2 and 3). This character is, therefore, very useful for identification of the two species at a glance. Such side-ridges are also present on the head of the Bryde's whale from the coast of Brazil as reported by Omura (1962). This character was already reported by Omura (1959) in a Japanese journal.

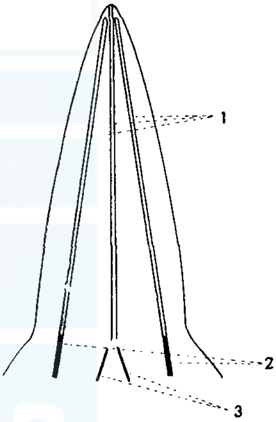


Fig. 1. Schematic drawing of head of *B. edeni* showing ridges.
1. Ridge 2. Groove
3. Blow-holes

MOVEMENTS

Bryde's whale does not follow long distance migration, being only one exceptional species among balaenopterid whales. It is believed that Bryde's whale tends to remain in the same locality throughout the year. Recently Best (1960) reports that the Bryde's whales on the coast of

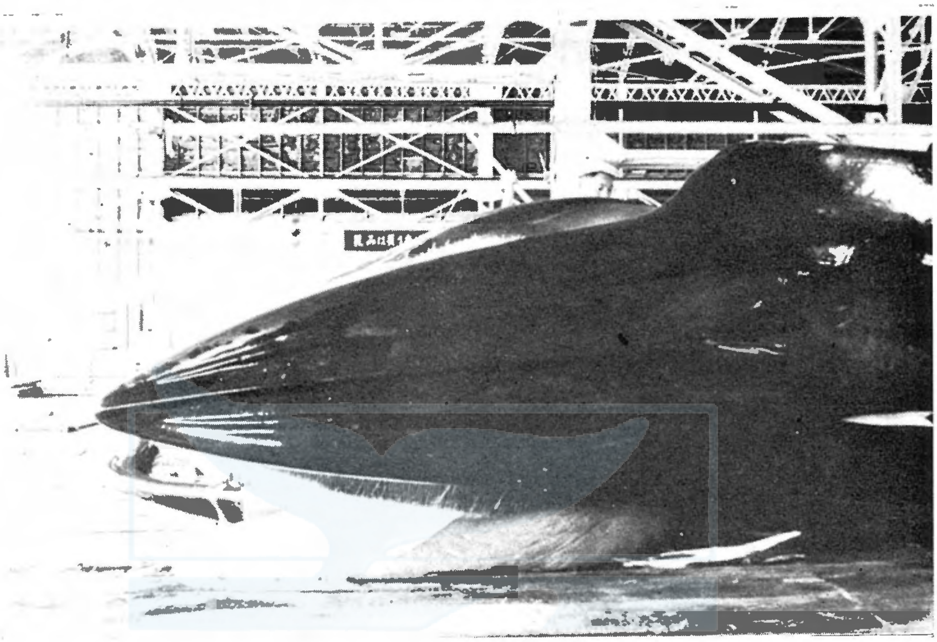


Fig. 2. Dorsal view of head. *B. edeni*. (Onagawa landstation, 1960)

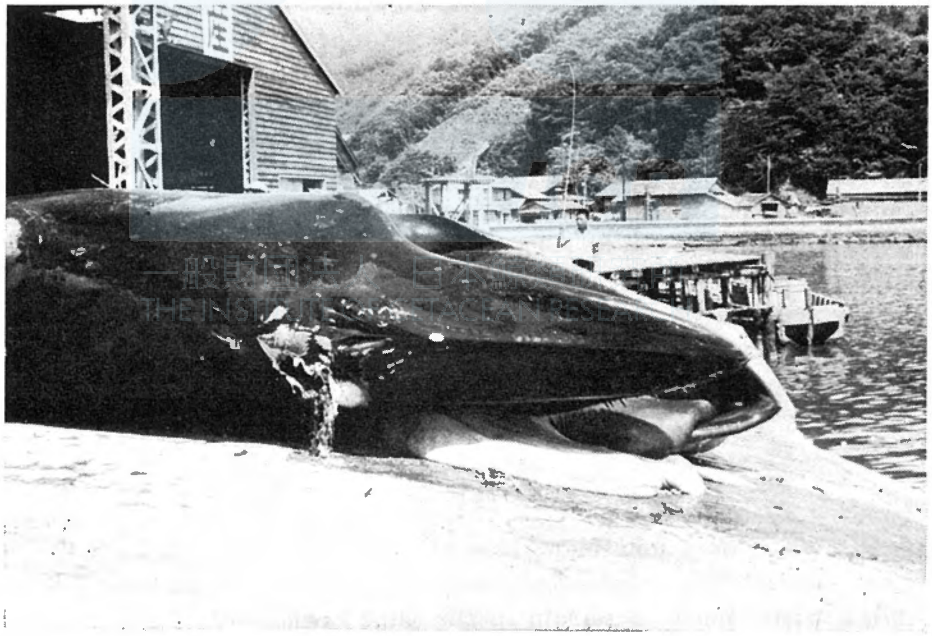


Fig. 3. Dorsal view of head. *B. borealis*. (Onagawa landstation, 1960)

South Africa are participating in either an onshore-offshore or a limited North-South migration and it is possible that they tend to follow the shoals of fish (South African pilchard) on which they feed for most of the year.

On the coast of Japan there are four localities on which Bryde's whales concentrate. These are the seas around Bonin Island, off Sanriku, off Oshima (Wakayama prefecture), and west coast of Kyushu (Fig. 4).

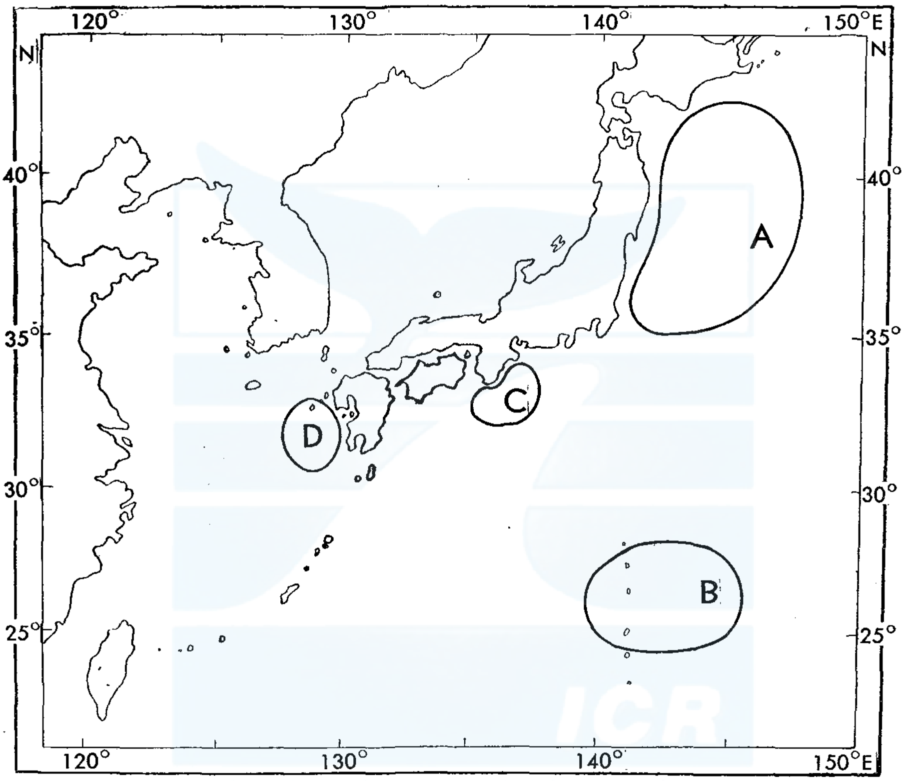


Fig. 4. Main concentrations of Bryde's whales on the coast of Japan.
A. Sanriku B. Bonin Island
C. Oshima D. West coast of Kyushu

It was proved by whale marking that the Bryde's whales in the seas around Bonin Island move to the coast of Sanriku as already reported by Nemoto (1959). Fujino (unpublished) found that there is no practical difference in the frequency occurrence of blood group types between whales from the coast of Sanriku and off Oshima, using the material collected in 1960. It is possible, therefore, that the Bryde's whales in these three localities belong to single group or population. I have no material, except catch information, of the Bryde's whale on the coast of west Kyushu. It is probable, however, that they belong to another group or population of Bryde's whales than those occurring on the former three localities, judged from the size distribution of the catches and from the point of view of the geographical separation. They are shorter than the other by about 3–4 feet (Fig. 5).

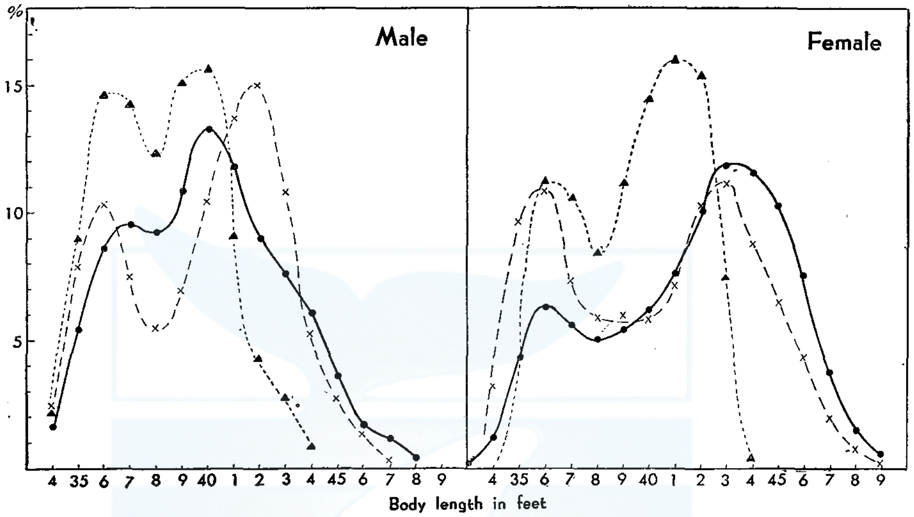


Fig. 5. Size distribution of Bryde's whales. (1955–1960, Smoothed)

●——● Sanriku ×---× Oshima

▲----▲ West coast of Kyushu

At Saldanha Bay, South Africa, Bryde's whales are taken during a period of 6 months from May to end of October (Best, 1960). On the coast of Japan, however, season is shorter than 6 months. On the coast of Sanriku baleen whales are taken from the beginning of May to the end of October yearly, and taking of Bryde's whales last usually about 4 months during this period. At Oshima, Wakayama prefecture, season does not last longer than 3 months. Usually season at Sanriku begins one month later than Oshima. The month when season begins differs yearly, possibly due to the oceanographic condition in that year. In Fig. 6 monthly catches of Bryde's whales are shown according to localities and by months for each year from 1955 to 1960 inclusive. As shown in this figure, at Oshima the peak of the catch is seen in May in 1955 and 1960, while in 1958 and 1959 the peak shifted to June. On the coast of Sanriku the largest catch was attained in June in the years 1955 and 1960 (and also in 1956), but in 1958 and 1959 (and also in 1957) the peak of the catch is observed in August. Fig. 7 shows the percentage of females among the monthly catches in these years. It is clear that at Oshima there is a difference of sex ratio and its tendency

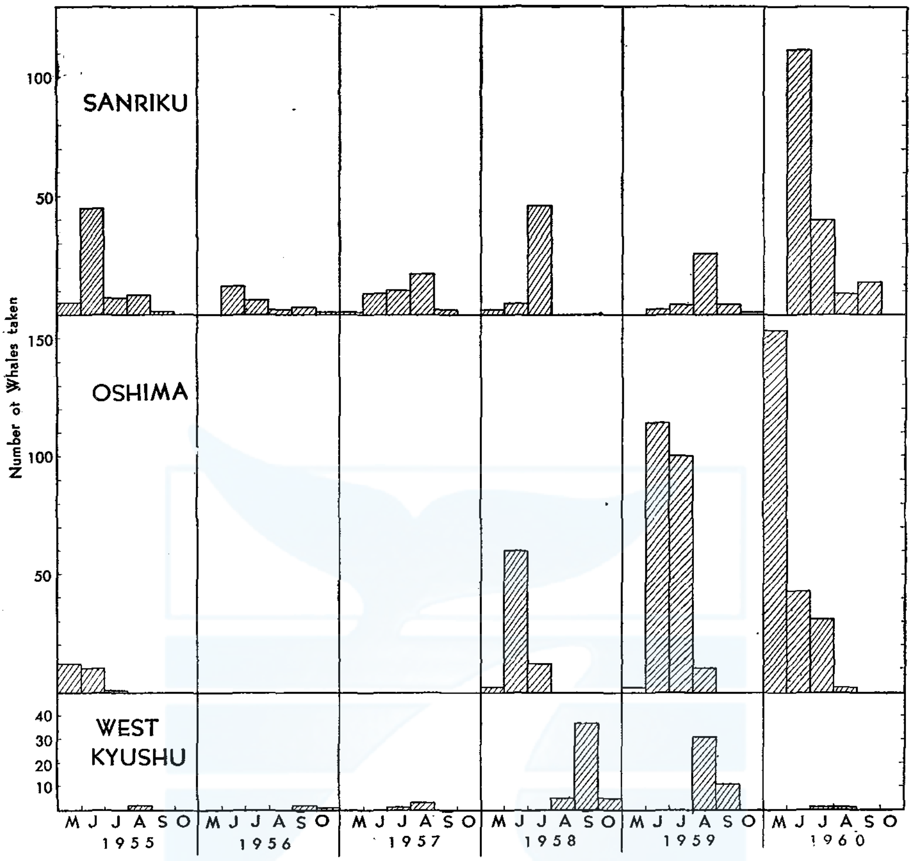


Fig. 6. Monthly catch of Bryde's whales on the coast of Japan. (1955-1960)

according to these groups of years. In 1955 and 1960, when the season started earlier, female is dominant in the catch and increases its ratio with the shifting of the season. In 1958 and 1959, when whaling begun later, a quite different tendency is clearly demonstrated in the figure. Also on the coast of Sanriku a similar tendency is observed, but in this locality female is alway dominant than male and towards the end of the season such tendency is changed abruptly.

I have no corresponding figure of the Bryde's whales around the Bonin Island, since whaling in this region has been ceased since 1953. It is probable, however, from the above that the Bryde's whales on the coast of Japan move from the seas around Bonin Island to the coast of Honshu, the main island of Japan, seasonally and back again to the former region, hence migrating, and a segregation between males and females taken place during this migration.

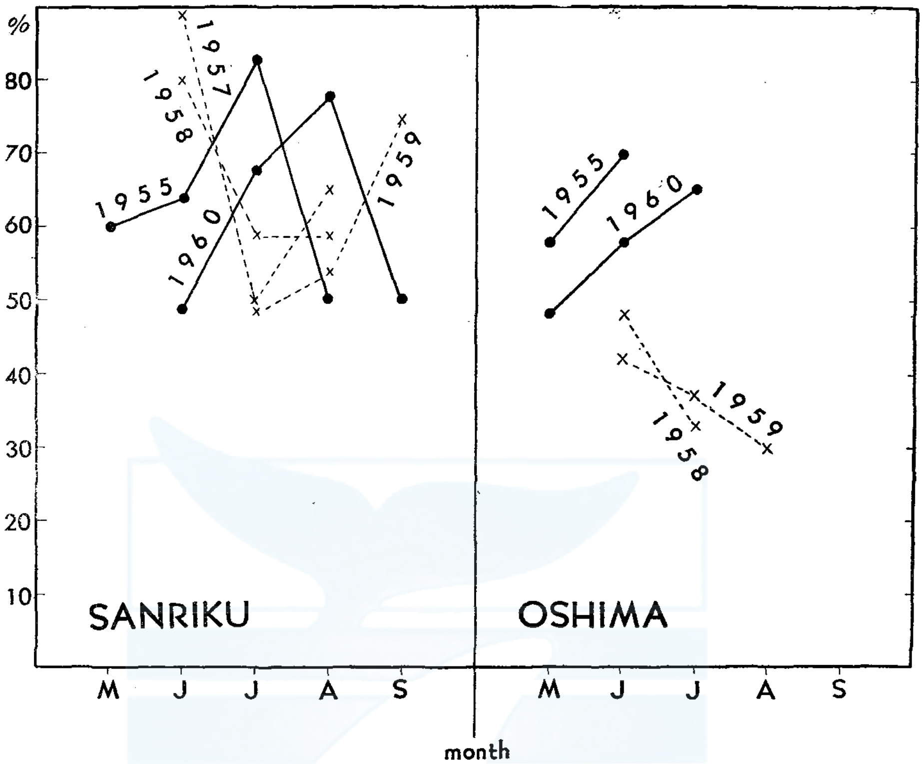


Fig. 7. Monthly change of sex ratio. (% females)

GROWTH OF FETUS

Laws (1959) found that foetal growth in three species of toothed whales can be described by a linear plot of length and larger neonatal sizes are attained by increased rates of growth and by extension of the gestation period, and in the baleen whales the first half of pregnancy follows this law, but thereafter growth can best be described by a logarithmic plot of length or of the cube root of weight. The reason is not known, but he suggests the fact that the baleen whales subject to very discontinuous feeding cycle as compared with the toothed whales. Bryde's whale is presumably different from other species of balaenopterid whales in this habit. According to Best (1960) it seems that there is no restricted breeding season in the Bryde's whales from South Africa and no fetal growth curve can be drawn from his material.

I have no recent record of fetus of the Bryde's whales from the coast of Japan, except one which was obtained at Oshima in June 1960 and measured 1.78 m in length. This is because almost all fetuses are lost during the time of towing whales by catcher to landstation. It is an usual practice on catcher to cut open the belly of a whale, just after taking, and let the internal organs be washed and cooled by sea water in order to keep freshness of whale meat which is consumed as human food. The fetal records from Bonin Island, however, suggests that also in the Bryde's whales from the coast of Japan exist a breeding season, similar to that of other species of balaenopterid whales (Table 1). But these records are limited within two months of May and June and this is not conclusive.

TABLE 1. RECORDS OF FETAL LENGTHS OF BRYDE'S WHALES FROM THE COAST OF BONIN ISLAND, 1950-52

Length (m)	May	June	Total
0.0～0.2	10	—	10
0.2～0.4	6	1	7
0.4～0.6	14	6	20
0.6～0.8	16	2	18
0.8～1.0	19	5	24
1.0～1.2	12	3	15
1.2～1.4	14	4	18
1.4～1.6	7	7	14
1.6～1.8	11	9	20
1.8～2.0	8	6	14
2.0～2.2	6	1	7
2.2～2.4	2	1	3
2.4～2.6	1	1	2
2.6～2.8	—	2	2
2.8～3.0	—	—	—
3.0～3.2	—	—	—
3.2～3.4	—	—	—
3.4～3.6	—	—	—
3.6～3.8	—	1	1
Total	126	49	175
Mean length (m)	1.060	1.447	
2 S. E.	0.105	0.191	

SEXUAL CONDITION OF WHALES TAKEN

In 1960 at landstations at Oshima and Sanriku 81 whales were observed of their reproductive organs during a period from June to middle of September. The material obtained are tabulated in Table 2. Males with a combined testis weight of 1.5 kg. or over were deemed as sexual mature and less immature. In females the criterion for mature is the presence of any corpus luteum or albicans. As stated above only one fetus was obtained at Oshima, but great majority of females with a functional corpus luteum were deemed as pregnant, judged from the condition of their uterine cornua. Sometimes one or both testes or ovaries were lost before dismembering. There were two cases of pregnant

TABLE 2. OBSERVATION OF REPRODUCTIVE ORGANS (1960)

Sexual condition	Females	Males
Immature	16	25
Mature	28	17
Pregnant or ovulating	12	
Resting	6	
Lactating	4	
Unknown[1]	6	

1) Because of one ovary lost

TABLE 3. OCCURRENCE OF NUMBERS OF OVULATIONS IN EACH BODY LENGTH GROUP (Female 1960)

Body length (m)	Numbers of ovulations													
	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
10.6~10.8	7													7
10.9~11.1	5			1*										6
11.2~11.4	2													2
11.5~11.7														—
11.8~12.0	1	1												2
12.1~12.3		1	1		1									3
12.4~12.6			2		1									3
12.7~12.9		1							1					2
13.0~13.2											1		1	2
13.3~13.5	1					1		1						3
13.6~13.8								1						1
13.9~14.1										1				1
14.2~14.4											1			1
Total	16	3	3	1	2	1	—	2	1	1	2	—	1	33

* One ovary lost

(or ovulating) and concurrently recorded as lactating. Table 3 shows the frequency occurrence of each corpora number group against body length. From this table it seems probable that sexual maturity may be attained in average at a body length of around 11.8–12.0 m (39 feet).

AGE

Ear plugs were collected in 1960 from 64 whales, but among them 19 plugs were damaged at the time of taking or in the course of preparation and could not used for determination of age. Thus remaining 45 ear plugs, 13 from males and 32 from females, were used in the present study. The results of ear plug examination are tabulated in Table 4 (males) and Table 5 (females). In Table 4 it is noted that males with up to 9 laminations are all sexually immature and with 13 laminations and more are all mature, except one whose testes had not been examined but apparently mature. In Table 5 it is shown that in females

TABLE 4. OCCURRENCE OF NUMBERS OF LAMINATIONS IN EAR PLUG IN EACH BODY LENGTH GROUP (Male 1960)

Body length (m)	Numbers of laminations in ear plug																				
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	…	33	Total
10.6~10.8	▲ 1	▲ 1	▲ 1	▲ 1																		4
10.9~11.1																						—
11.2~11.4				▲ 1			▲ 1															2
11.5~11.7				▲ 1																		1
11.8~12.0																						—
12.1~12.3																						—
12.4~12.6																						—
12.7~12.9																	○ 1		○ 1			2
13.0~13.2											○ 1					○ 1					× 1	3
13.3~13.5													○ 1									1
Total	1	1	1	3	—	—	1	—	—	—	1	—	1	—	—	1	1	—	1	…	1	13

▲ Immature
○ Mature
× Testes lost

TABLE 5. OCCURRENCE OF NUMBERS OF LAMINATIONS IN EAR PLUG IN EACH BODY LENGTH GROUP (Female 1960)

Body length (m)	Numbers of laminations in ear plug																					
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	…	24	27	28	Total
10.6~10.8					▲ 1																	1
10.9~11.1		▲ 1					○ 1															2
11.2~11.4				▲ 1																		1
11.5~11.7																						—
11.8~12.0					○ 1																	1
12.1~12.3				× 1			○ 2				○ 1											4
12.4~12.6							○ 1	○ 1 × 1	× 1					× 1								5
12.7~12.9	○ 1													○ 1			× 1					3
13.0~13.2									○ 1				○ 1							× 1		3
13.3~13.5						▲ 1			× 1													2
13.6~13.8						○ 1 × 1				× 1		× 1			× 1						× 1	6
13.9~14.1										× 1												1
14.2~14.4												× 1			× 1				○ 1			3
Total	1	1	—	2	2	3	4	2	3	2	1	2	1	2	2	—	1	…	1	1	1	32

▲ Immature
○ Mature
× Both ovaries lost

sexual maturity will probably be attained when 9 or 10 laminations are accumulated in the ear plug. If we assume that two laminations are laid down each year, as in the case of other balaenopterid whales, it is probable that Bryde's whales attain their sexual maturity after five years from birth.

TABLE 6. CORRELATION BETWEEN NUMBERS OF OVULATIONS AND LAMINATIONS (Female 1960)

Numbers of ovulations	Numbers of laminations in ear plug															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	··· 24	Total
0		1		1	1	1										4
1	1				1		1									3
2							1									1
3																—
4								1			1					2
5																—
6																—
7																—
8														1		1
9																—
10													1		1	2
Total	1	1	—	1	2	1	2	1	—	—	1	—	1	1	··· 1	13

In Table 6 is shown the correlation betweeen ovulation numbers and number of laminations. The material is very small, but it is probable that the increment of ovulation can be described by a linear plot of number of laminations in the ear plug.

FOOD

As already stated whales are cut open of their belly just after taking in order to keep freshness of meat. Concurrently stomachs are also cut very often and their contents are washed away during the course of towing, especially in cases stomachs were full of food. Even in these cases, however, it is possible to ascertain the kind of food eaten, by inspection of the second stomach and others. In this way 27 whales were observed of their stomach contents at landstations in Sanriku and 55 whales at Oshima in 1960. The results of observation are shown in Table 7. At Sanriku it is noted that most of the food were consisted of

TABLE 7. STOMACH CONTENTS OF BRYDE'S WHALE (1960)

Locality	Empty	Krill	Anchovy	Anchovy & Mackerel	Sand lance	Saury pike	Small fish	Total
Sanriku	6	2	11	2	1	1	4	27
Oshima	25	17	11	1	—	—	1	55

fish and among them anchovy is very dominant, while at Oshima higher percentage of krill than anchovy is observed.

OTHER INFORMATION

Nearly all Bryde's whales taken on the coast of Japan bear marks caused by the healing of the open pits in the skin, of unknown origin, which are aquired by whales in warmer waters. In addition to these white scars whales treated at Oshima bear very frequently fresh open pits on their skin, which numbers from one to 17 on one side of the body. These open pits were also observed at Bonin Island, but never at Sanriku. If we assame that the whales in the waters off Oshima move to the offing of Sanriku, these open pits are healed during this period of movement, which is supposed as about one month as already stated.

REFERENCES

Best, P. B. (1960). Further information on Bryde's whale (*Balaenoptera edeni* Anderson) from Saldanha Bay, South Africa. *Norsk Hvalfangst-Tid.*, 49 (5): 201-15.

Laws, R. M. (1959). The foetal growth rates of whales with special reference to the fin whale, *Balaenoptera physalus* Linn. *Discovery Rep.*, 29: 281-308.

Nemoto, K. (1959). Food of baleen whales with reference to whale movements. *Sci. Rep. Whales Res. Inst.*, no. 14: 149-290.

Omura, H. (1959). NITARI-KUJIRA NO HANASHI (On Bryde's whales). *GEIKEN TSUSHIN*, no. 99: 787-801. (In Japanese).

——— (1962). Bryde's whale occurs on the coast of Brazil. *Sci. Rep. Whales Res. Inst.*, no. 16: 1-5.

RYUKYUAN WHALING IN 1961

MASAHARU NISHIWAKI

In accordance with the invitation from the United States Civil Administration of the Ryukyu Islands, the author had been engaged in the biological investigation of the Ryukyuan whaling from March 24 to April 4, 1961.

The scientific study of the composition of whales and the survey on the migration routes are reported mainly in this paper.

OUTLINE OF THIS WHALING SEASON

The whaling of this year started in the first week of January, and the catch was started with the sperm whale. Though the humpback whale was caught in the middle of January, this species of whales are very scarce at that time.

Even in February the water volume of 20°–22°C which is the suitable temperature for the humpback whale did not appear in the main whaling ground but existed in the Miyako area. So the smaller type catcher boats caught no whales in February. This phenomenon is considered as follows. According to the weather reports in Far East Asia, the Chinese Continent had some copious rains with deluges in the summer of 1960. The author pointed out in his report of the Ryukyuan humpback whaling in 1959 that the Chinese Continent had brought in the summer of 1958. In that case the decrease of cold water from these Chinese rivers might probably cause a higher temperature around the Ryukyuan Island. The reverse phenomenon occurred this year. There is a fact of some floating ice draft in the Korean Channel to the southward, which the author believes was caused by the Tsushima warm water caurrent that seemed to have weekened this year.

The time of year for the migration of the humpback whale, however, seemed to have made no great difference from the average year. That time was pointed out by author in his report of 1960 i. e. about 10th of January.

There is, so to speak, a marching column in the migration of whales. The order of migration of humpback whale in the Ryukyuan waters is as follws. The first is some groups of immature male, second is immature female. Then the main groups i. e. the mature male and female come. Shortly after there are some lactating females mixed in these main groups. This lactating female delivered a calf this season and was actually lactating at the time. These actually lactating groups are the last to leave these waters. The males which arive after the main groups are almost mature.

There were very small number of immature males caught in the catch of this season. Taking the above mentioned consideration, the immature male migrated away from the Miyako area to the north-east direction in January. The catcher boats found and caught the immature females at the time of their migration in the southern parts of the whaling ground. It is considered that their migration was affected by the colder water mass of the East China Sea. In Fig. 1 the above mentioned facts are shown as average body length, sex ratio and composition of sexual conditions in each month. These figures fit in well with the same figures of the previous years. In May of this season one mature female was caught, but the figure does not include this whale.

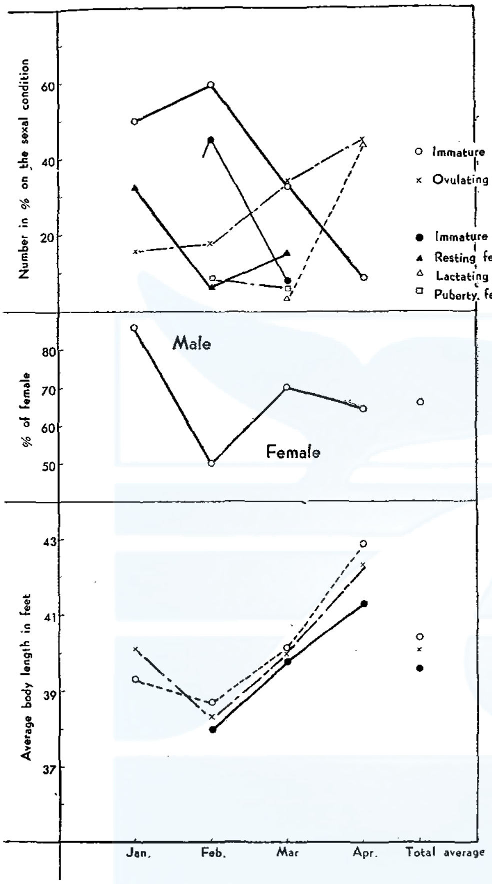


Fig. 1. Average body length, sex ratio and composition of sexual conditions in each month.

Nine sperm whales were caught in the beginning of this whaling season, but in a later period only a small effort was paid to the sperm whale whaling, because efforts were concentrated in the humpback whale whaling.

No other species of whales were caught.

COMPOSITION OF WHALES CAUGHT

In Table 1 is given the size distribution of the humpback whales caught according to their physical condition on 90 whales including 31 males and 59 females.

TABLE 1. SIZE DISTRIBUTION OF HUMPBACK WHALES CAUGHT ACCORDING TO PHYSICAL CONDITIONS

Body length in feet	Male			Female								
	Immature	Mature	Total	Immature	Puberty	Mature					Total	Grand total
						Ovulating		Resting	Lactating	Sum		
						First	Multipola					
34	1		1									1
35	3		3	5							5	8
36	1	1	2	8							8	10
37	1	2	3	4							4	7
38		3	3	3	2	1		1		2	7	10
39		3	3	1	1	1				1	3	6
40		2	2				2		1	3	3	5
41		4	4				3	2	1	6	6	10
42		4	4				1	2	2	5	5	9
43		3	3				1	2		3	3	6
44		1	1				4		1	5	5	6
45		2	2				3			3	3	5
46							1		1	2	2	2
47							3	1		4	4	4
48												
49												
50							1			1	1	1
Total	6	25	31	21	3	2	19	8	6	35	59	90
Average length	35.3	40.6	39.6	36.4	38.3	38.5	44.0	42.1	42.5	43.0	40.4	40.1
						43.5						
Sex ratio			34.4								65.6	100.0
Matulity rate	19.4	80.6	100.0	40.6						59.3		
Rate of ovulating						60.0				100.0		
Rate of lactating									17.1	100.0		

The male whose testis weight on either side is 2.0 kg is defined as mature. The number of immature males is fewer in comparison with the previous years. The reason that the immature males were scarce is as above stated.

The classification of physical conditions in females was the same as in the previous investigations. The female whose ovaries contain neither new nor old corpus luteum is defined as immature. In these immature females whose Graafian follicle was more than 30 mm in diameter was defined as puberty. The mature females are divided into three stages; the ovulation stage where the female has a new corpus luteum (sometimes two or more new corpora lutea were found), the resting stage where the female has some old corpora lutea and her Graafian follicle is less than 30 mm in diameter, and the lactating stage when they are found to be capable of secreting milk in the mammary glands and did not have any new corpus luteum or a Graafian follicle more than 30 mm in diameter.

TABLE 2. OCCURRENCE OF BODY COLOR OBSERVED

Period	Sex	Grade of body color			
		1	2	3	4
January	Male	1	0	0	0
	Female	5	1	0	0
February	Male	11	1	0	0
	Female	10	0	0	0
March	Male	13	0	0	0
	Female	29	1	0	0
April	Male	6	0	0	0
	Female	11	0	0	0
May	Male	0	0	0	0
	Female	1	0	0	0
Total	Male	31	1	0	0
	Female	56	2	0	0
	Animal	87	3	0	0
% of occurrence		96.7	3.3		

It is impossible to classify the ovulation stage into the ovulation and the pregnant stages in these breeding areas, because of the very small embryo. The rate of ovulation is used for the pregnancy rate in this report. The ovulation rate therefore, always shows a higher percentage than the actual pregnancy rate.

On the maturity rate in the female, the higher percentage figure is concerned with the migration time of this season.

Table 2 shows the occurrence of the white pattern distribution on the abdominal side according to four stages in the same standard in the previous investigations. There is no significant difference in comparison with the previous seasons.

In Table 3 is given the frequency of occurrence of blood types. The classification of the blood types was made by investigater Mr. Kazuo Fujino of our Institute as in the case of the last year by using the same serum as in 1960. The occurrence between Type 1 and Type 3 were more similar to the 1959 data than the 1960 data. This matter is also shown in the other results of the biological investigation of this season. It may be suggested that the same groups of the humpback population do not migrate every year to this whaling ground.

TABLE 3. FREQUENCY OF OCCURRENCE OF BLOOD TYPES COMPARED WITH THE DATA IN 1959 AND 1960

Blood type	Occurrence					
	1959		1960		1961	
	Number	%	Number	%	Number	%
1	1	1.0	2	2.35	1	1.7
2	4	4.0	8	9.4	2	3.3
3	7	7.0	2	2.35	5	8.3
4	87	87.0	73	85.9	52	86.7
2 or 3	1	1.0	0	0.0	0	0.0
Total	100		85		60	

No tested samples because of hemolysis	26
Number of samples collected	86
Number of whales caught	90

TABLE 4. SIZE DISTRIBUTION OF SPERM WHALES CAUGHT IN 1959, 1960 AND 1961

Body length in feet	Number of mature male			
	1959	1960	1961	Sum
37	1		1	2
38	2	3	3	8
39	1	3	2	6
40		3	1	4
41	3	3	1	7
42		1		1
43		1		1
44				
45			1	1
Total	7	14	9	30
Average length	39.3	39.9	39.4	39.6

Immature male and female whales were not caught in each season.

Thickness of blubber, stomach contents and parasite, etc. were investigated, but the data giving the effective suggestions on composition of whales or on migration routes were not available.

Composition of the sperm whale caught in this year was made in Table 4 with the same data of previous two years. They were matured young males classified by testis weighing and did not accompanied with females. They are not the main group of this species, but usually the forerunners of their migrating column.

CONSIDERATION FOR THE STOCK OF THE HUMPBACK WHALE

The ear plugs that have the most suitable data on the age determination for baleen whales were collected from 92% of the catch of this year. In Fig. 2 the frequency of the number of ear plug laminations was shown as a survival curve. The same curves of the previous two years are shown in the same figure for comparison. These three curves are very well in accord. Basing on the agreement of these curves the stock of the humpback whales did not suffer heavy damages through the whaling.

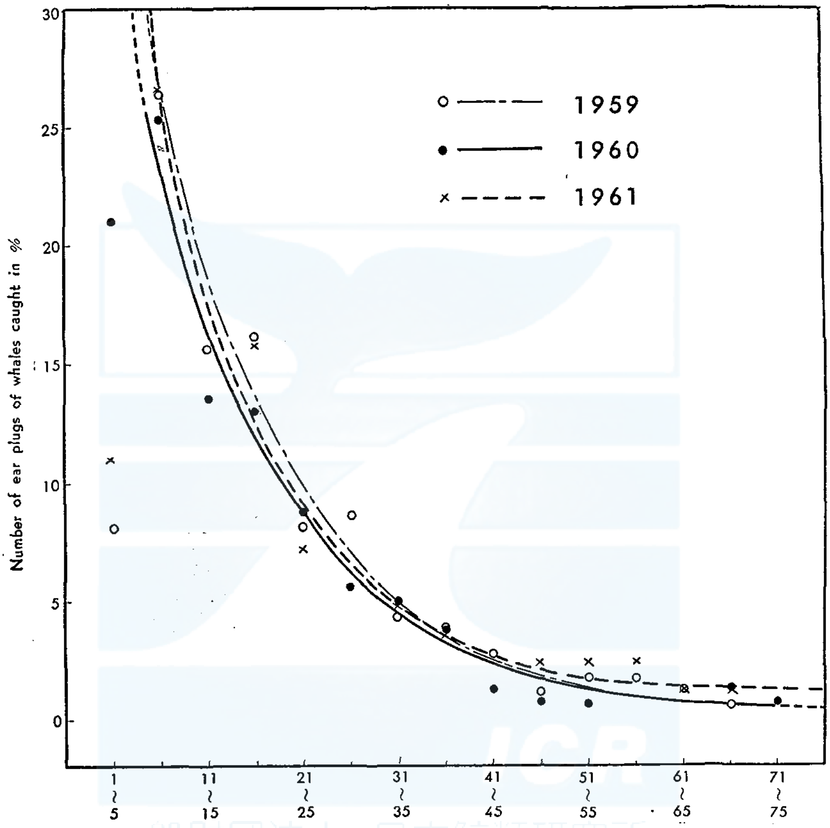


Fig. 2. Survival curve from the ear plug lamination survey of the humpback whales caught in Okinawa 1961.

These curves must be separated into male and female and the gathering of the class of ear plug lamination numbers must be done more carefully, but since the data were scanty this method had to be accepted. These results, however, are enough to study some of the tendencies of the stock. The mortality curve that should be calculated from the survival curve was omitted here.

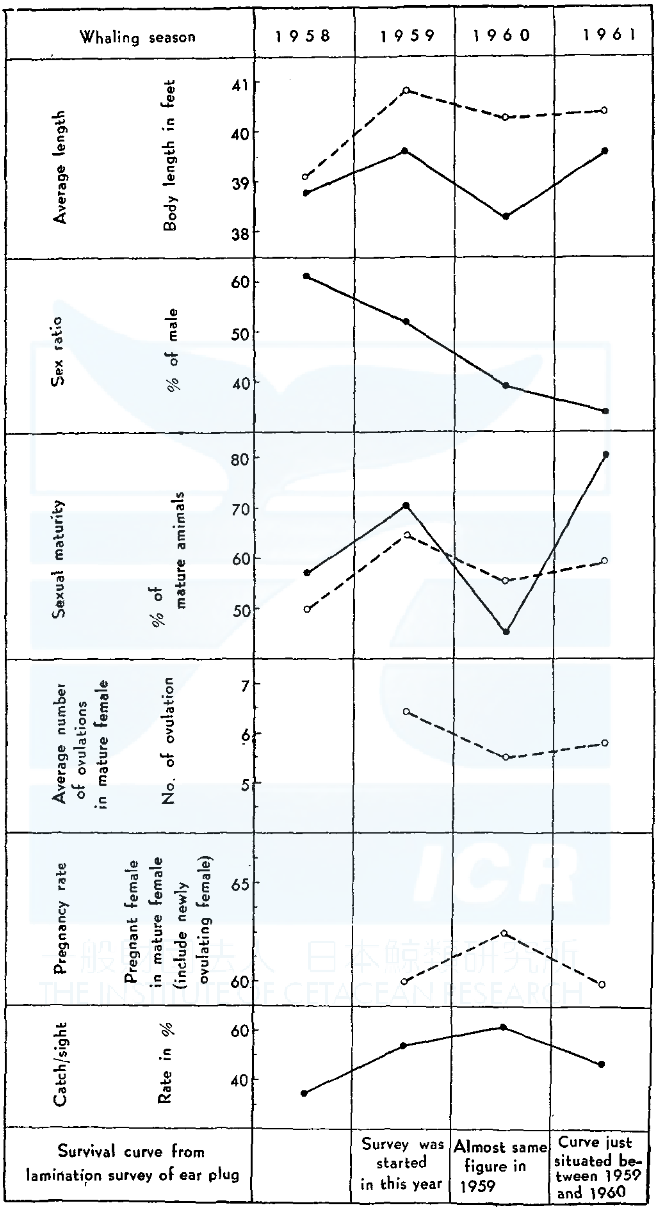


Fig. 3. Data of interpretation on the movement of the humpback whale population.

The annual variations of the above mentioned results are shown in Fig. 3.

In the case of decrease in stock, the following phenomena are observed usually.

1. Decrease of average body length.
2. Decrease of male in sex ratio.
3. Decrease of sexual maturity rate.
4. Decrease of average ovulation number in mature female.
5. Decrease in survival curve.
6. Increase of sight catch ratio.
7. Increase of pregnancy rate in mature female.

According to Fig. 3 the stock of the humpback whale seems to be stable except in the item 2. It is considered that the effect of the present whaling do not cause considerable decrease in the stock.

Also in this season one of the whale marks that were marked in the Aleutian waters was recovered. This fact bear witness to the fact that the humpback whales in the Ryukyuan waters are closely connected with the stock of all North Pacific. By the observation of the Japanese whaling fleet operating in the Aleutian waters more than 300 of the humpback whales are found every season. Nevertheless the catch is decreasing annually. That is caused by the bad weather and the strong winds. The second reason, it must be acknowledged, is that the humpback whales are intelligent enough to change their migration routes because of the increase in the catching intensity.

MIGRATION ROUTES OF THE HUMPBACK WHALES

This is a very difficult problem, and in a word it still remains unexplained. For information, however, the author enumerates some evidences as the following.

1. The whale marks tagged in the Aleutian waters are recovered in the Ryukyuan waters every season and the total number of recoveries reached six marks.
2. Numerous humpback whales are observed between February and March and also in October in the waters of the Midway and the Hawaii Islands.
3. From January to March many humpback whales are observed in the Ogasawara waters (area of Bonin Is.). Whale marking on the humpbrck whales was carried out in March 1961 by the Fisheries Agency of the Japanese Government in the Ogasawara waters.
4. The number of humpback whales caught in the Japanese coastal whaling were very scarce after the World War II.

SUMMARY

Some considerations and results are made hereinafter based on the data already mentioned above.

1. The number humpback whales caught in this year has decreased compared with the last year. The colder waters of the East China Sea, that was caused by the downpour in the summer of 1960, obstructed the migration way of the humpback whales.
2. The number of humpback whales sighted have not decreased in comparison with the last season, but the weather and the strong winds have obstructed the successful catch. The next reason is the factor depended on the catcher boat.
3. Judging from the results of the biological survey the stock of the humpback whales did not suffer heavy damages through whaling. As is shown by the recoveries of the whale marks, the migration groups of the Ryukyuan waters are closely connected with the stock in the Aleutian waters i. e. all the North Pacific stock. It is considered, therefore, that the data of investigation shows the increase and the decrease of the North Pacific stock.
4. It is still unknown where the migration routes of the humpback whales are. Further investigation is necessary to solve this problem. It seems that the whale marking on the humpback whales in the Ogasawara waters by the Japanese Government is a very valuable action.
5. As was mentioned above, the stock of the humpbak whales is considered as a fairly stable condition. It is suitable to give the highest limit of the number of catch as the quota.
6. Though small in number the sperm whales are caught every season. The author does not consider that the actual scouting of this species is carried out. The Ryukyuan Whaling industry should not rely on the catch of the humpback whales only, but try to catch other species of whales also in order to decrease the catch of the humpback whales.
7. The water temperature around the Okinawa Island, the author believes, is dependent on the climatical precipitation on the Chinese Continent. Close study of the weather of the last year on the Chinese Continent will be, therefore, essential in deciding the most suitable time for starting the whaling season and the direction of scouting the whales.

ACKNOWLEDGEMENT

In concluding the report for the Ryukyuan whaling season of 1961, the author wishes to thanks every person concerned for his kindnesses suggestions and assistances. The author must particularly acknowledge

to the appointment for the whaling investigation of this season by the United States Civil Administration of the Ryukyu Islands.

The author is quite indebted to the officials of USCAR, the American Embassy in Tokyo, the Government of the Ryukyu Islands and the Fisheries Agency of the Japanese Government who have given a accomodation on the invitation to the Ryukyu whaling.

Grateful thanks are due to the members of the Ryukyuan Whaling Industry who have always given a big favor.

REFERENCES

NISHIWAKI, M. (1959). Humpback whales in Ryukyuan waters. *Sci. Rept. Whales Res. Inst.*, no. 14.

——— (1960). Ryukyuan humpback whaling in 1960. *Sci. Rept. Whales Res. Inst.*, no. 15.

A SECONDARY SEXUAL CHARACTER OF FIN WHALES

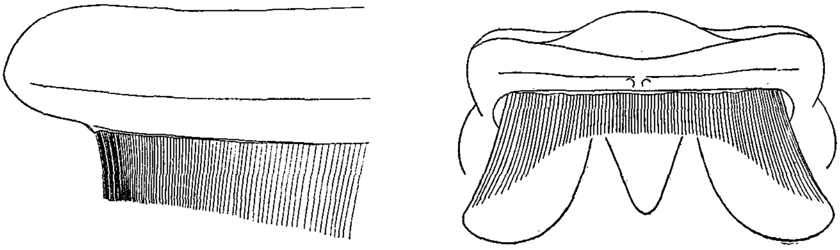
TAKAHISA NEMOTO

Up to these days, the body length of baleen whales is considered as only a secondary sexual external character of baleen whales. Usually female baleen whales are larger than male whales in each species especially after they attained their sexual puberty and maturity, and other external body characters and proportions do not display the sexual dimorphism (Mackintosh & Wheeler, 1929; Ohsumi, 1960). The length between the anus and the genital is the clear distinction of the sex of whales, however, this is already clear in the youngest fin whale, even in the foetal stage in mothers' body.

In the whaling expedition in the North Pacific in 1960 when I was aboard, the protuberance in the tip of the snout of upper jaws of male fin whales was noticed as the secondary sexual character and this character has been examined in the North Pacific expeditions in 1960 (Kataoka 1960) and 1961, by staffs of the Whales Research Institute and inspectors.

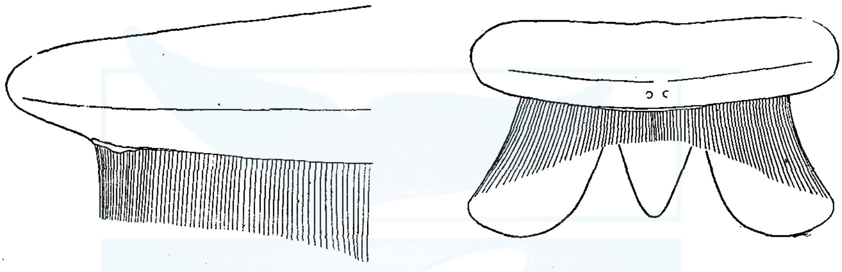
The protuberance in the tip of the snout is easily found by observers from the side or infront of the head part of the body of fin whales on the deck of factory ships. The tip of the snout of a full grown male fin whale becomes thicker and swells like the goose neck along the surface streching about 50 cm long and wide from the very pointed end of the snout as illustrated in Fig. 1. This protuberance varies considerably according to the stage of the sexual maturity of fin whales, and immature males lack the protuberance. Although full grown female fin whales have thicker tips than immature whales, they completely lack this protuberance in the tip of the snout. As younger male fin whales also lack the protuberance, full grown male fin whales are easily distinguished from female and immature fin whales in this point at a glance.

The relation between testicle weight and the presence of the protuberance in the tip of the snout is illustrated in Fig. 3. According to Fig. 3, those fin whales which have testicles heavier than 5.0 kg demonstrate typical protuberance in the tip except two whales. Usually fin whales are considered to attain to their sexual maturity at each testicle weight 1 to 3 kg. And all testicles over 3 kg weight have the sexual mature character when they are examined histrogically (Ohsumi, Nishiwaki & Hibiya, 1958). As illustrated in Fig. 3, the younger males lacking the protuberance are sometimes have a mature testicle when it is examined histrogically, but the weight is far lighter. From the above



A B

Fig. 1. Top protuberance in the tip of the snout of a sexually mature male fin whale. A—From the side; B—From the front.



A B

Fig. 2. Tip of the snout of a sexually mature female fin whale. A—From the side; B—From the front.

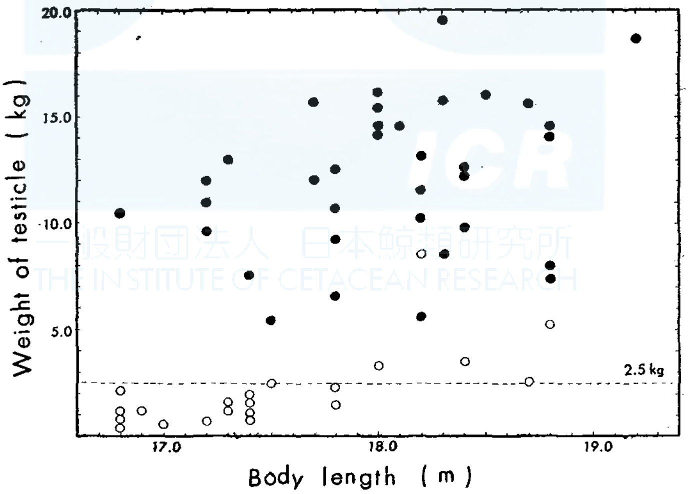


Fig. 3. Testicle weight in fin whales with or without the protuberance in the tip of the snout. Black symbols—The protuberance present; White symbols—The protuberance absent.

fact, it is considered the young fin whales which begin to form spermatozoa in their testicles will not bear the protuberadce at the same time, and the protuberance is gradually formed with the increasing of weight of testicles and the developing of sexual ability after the beginning of spermatozoa formation. If laminations of ear plugs show the age of whales as they have been considered (Purves, 1955, etc.), among the fin whales possessing the protuberance in their tip of snouts, the youngest male fin whale has the ear plug of 10 laminations, but the heavier testicle weight of which is 5.5 kg. This value is far higher for usual fin whales having 10 laminations in their ear plugs. Other whales with the protuberance have ear plugs of 18 laminations or more, and the oldest whale has 82 laminations in its ear plug.

There are three exceptional fin whales without the protuberance shown in Fig. 4, which are considered to be rather older whales as they have many laminated ear plugs. But they have comparatively light testicles respectively. One of these whales has 19 laminations in the ear plug, but the heavier testicles is only 3.6 kg in weight. The heavier testicles of other two fin whales are 5.5 and 8.6 kg respectively. These two values are also not so high among the whales possessing the protuberance although they are mature in the histrogical examination of their testicles.

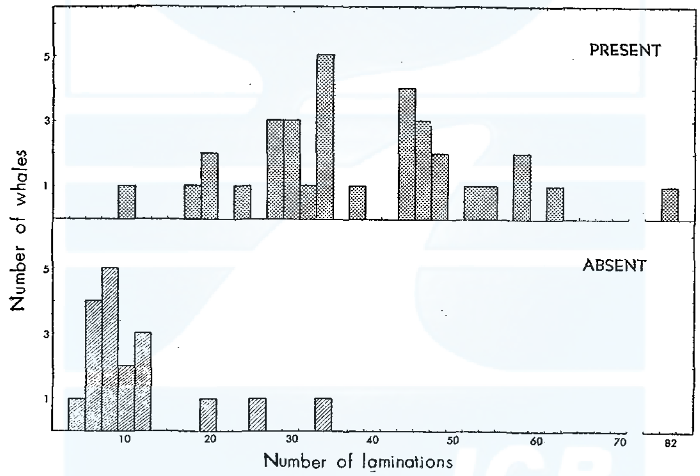


Fig. 4. Number of fin whale in each ear plug lamination. Black—The protuberance present; Oblique—The protuberance absent.

From observations on the *Balaenoptera* whales up to now, only full grown male fin whales possess this distinct secondary sexual character. Full grown male Bryde's whales also have the slight protuberance in the tip of the snout as illustrated in Fig. 5, but this observations are only based on several specimens caught in the adjacent waters to Japan. So, further investigation will prcve the convincible result as to the presence of the tip protuberance in Bryde's whales.

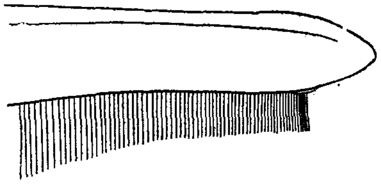


Fig. 5. Top protuberance in the tip of the snout of a sexually mature male Bryde's whale.

Other two baleen whales, blue and sei whales have not been observed to show this sexual dimorphism, and I have no information on humpback and little-piked whales.

In some other aquatic animals, this type of the secondary sexual character in head parts is often observed. Full grown male elephant seals in southern and northern hemisphere have the tremendous sexual character-proboscis, which gradually develops after their sexual maturity (Matthews, 1929). Laws (1960) describes that male elephant seals in southern hemisphere attain to their sexual maturity at an average age of four years by the examination of the testis, but bulls of this stage do not usually play an active part in the social organization of the breeding rookeries until they become six years old. According to Matthews (1929), these younger sexually grown bulls of three or four years old have no typical developed proboscis (Matthews, 1929, pl. 23, Fig. 2). On the other hand, every harem bull has excesively developed proboscis, and it is always inflated when they fight against or frighten other males and human intruders.

Of course fin whals do not form the harem like elephant seals when they are breeding in the warmer waters. But if the protuberance in the tip of the snout of males means the greater activity in sexual behavior than the younger male whales without the protuberance, fin whales play the active part in the breeding after they have heavier testicles more than 5 kg in weight with having the developed protuberance. And the laminations of ear plugs are more than 20 in general. It seems reasonable to consider the younger whales without the protuberance do not take a part in sexual movements. Because usually about the half of mature females are pregnant or lactating in winter, and the number of free adult females is far smaller in number than males if all the sexually mature males are capable of perfect copulating directly after their sperm formation.

Another example of the secondary sexual character of this type is found in fish. In some salmonoid fish, the second sexual character in upper jaw is also very distinct. Male *Oncorhynchus* salmons, Dog salman *O. keta*, pink salmon *O. gorbusha* and Silver salmon *O. kisutch* have strong curved nostrils (Bécarts) when they are breeding in the river (Hikita, 1956). The slight curve is sometimes observed in the sexual mature salmons in the sea, when they are feeding and migrating. The curve becomes the strong second sexual character with going up rivers for breeding. This example also means that there is a delay between the sexual maturity and the completion of a secondary sexual character in the upper jaw.

There is a question still remained, if this secondary sexual character lasts for the life or vanishes with the passing of seasons. The data in figures have been collected in the late of July and August in Bering Sea, when fin whales have swarmed to feed on fish, Alaska pollack (*Theragra chalcogramma*). As fin whales usually come to this northern feeding area from the beginning of summer, May and June, those fin whales have already taken their foods considerably in the sea. This may help the appearance of this sexual character growing for the next breeding season in coming winter.

This secondary sexual character has not been examined about the Antarctic fin whales yet, although some unpublished data have been collected. Not a few examples prove the same tendency observed in fin whales in the North Pacific. And it is said the protuberance in the tip is also a clear mark for the weight of testicles of male fin whales in the Antarctic at a glance, as observations on the size of penis may be useful as a means of deciding whether a fin whale is sexually mature or not (Mackintosh & Wheeler, 1929).

Finally I thank Mr. Seiji Ohsumi of the Whales Research Institute, and Mr. Shokiti Kataoka of the Shimonoseki College of Fisheries, for valuable discussions and collections of materials.

REFERENCES

Hikita, H. (1956). [Pacific salmonoids caught in the adjacent waters to, and in the river in Hokkaido.] *Sci. Rep. Hokkaido Fish. Hatchery*, 11: 25-44.

Kataoka, S. (1960). [Tip protuberance in upper jaws of fin whales] *Geiken Tsushin* no. 109: 22-24.

Laws, R. M. (1960). The southern elephant seal at South Georgia. *Norsk Hvalfangst-Tid.*, 49 (10): 466-76, 49 (11): 520-42.

Mackintosh, N. A. & J. F. G. Wheeler (1929). Southern blue and fin whales. *Discovery Rep.*, 1: 257-540.

Matthews, L. H. (1929). The natural history of the elephant seal with notes on other seals found at South Georgia. *Discovery Rep.*, 1: 233-56.

Ohsumi, S. (1960). Relative growth of the fin whale, *Balaenoptera physalus* (Linn.). *Sci. Rep. Whales Res. Inst.*, no. 15: 17-84.

Ohsumi, S., M. Nishiwaki & T. Hibiya (1958). Growth of fin whales in the northern Pacific. *Sci. Rep. Whales Res. Inst.*, no. 13: 97-133.

Purves, P. E. (1955). The wax plug in the external auditory meatus of the Mysticeti. *Discovery Rep.*, 27: 293-302.

EXPLANATION OF PLATES

PLATE I

Fig. 1. Top protuberance in the tip of a sexually mature male fin whale.
Fig. 2. Tip of the snout of a sexually mature female fin whale.
Fig. 3. Slight protuberance in the tip of the snout of a sexually mature male Bryde's whale.
Fig. 4. Tip of the snout of a sexually mature sei whale.

PLATE II

Fig. 1. Top protuberance of the sexually mature fin whale from the front.
Fig. 2. Tip of the snout of the sexually mature female fin whale.
Fig. 3. Tip of the snout of the sexually mature sei whale.

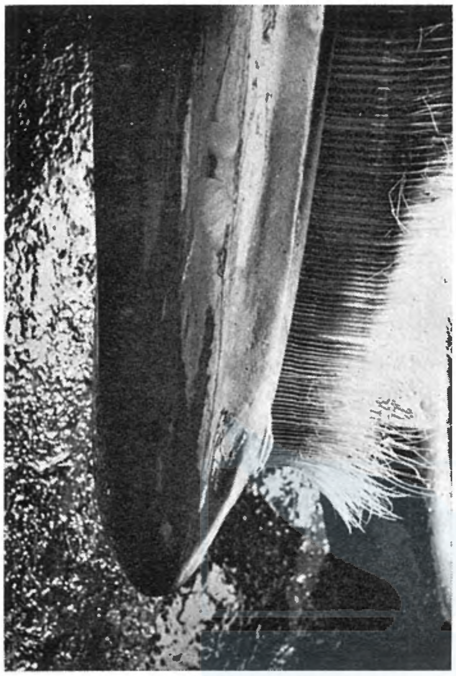


Fig. 2.

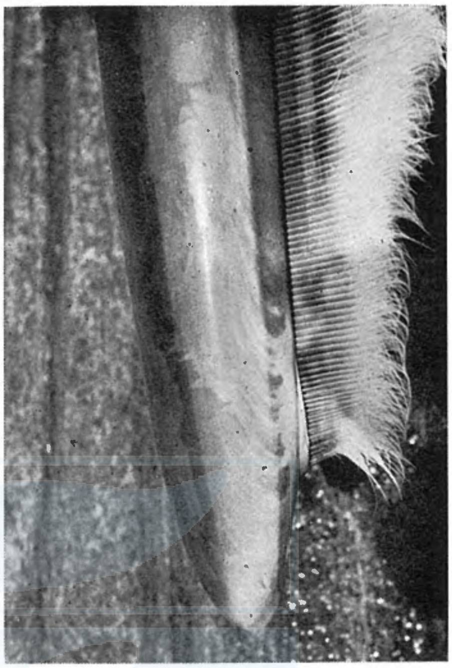


Fig. 4.

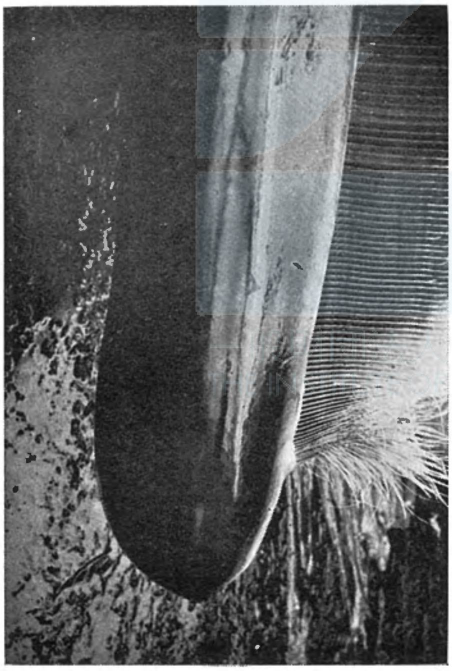


Fig. 1.

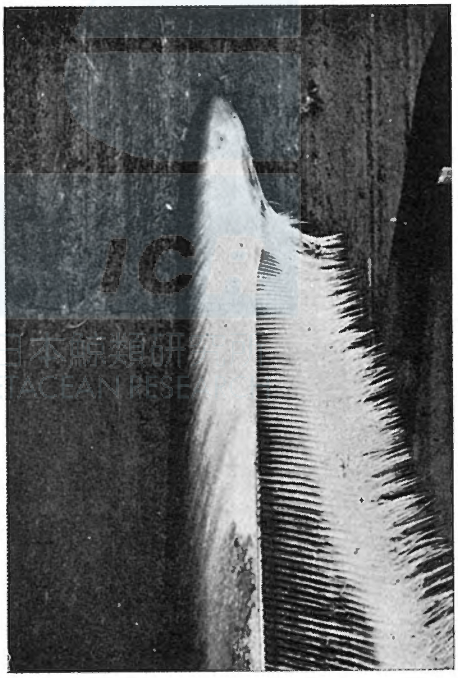


Fig. 3.

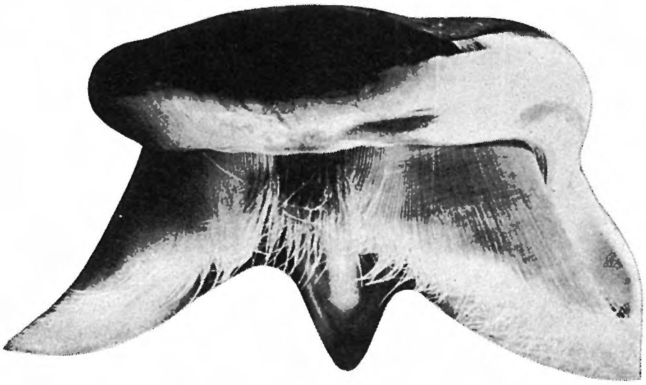


Fig 1

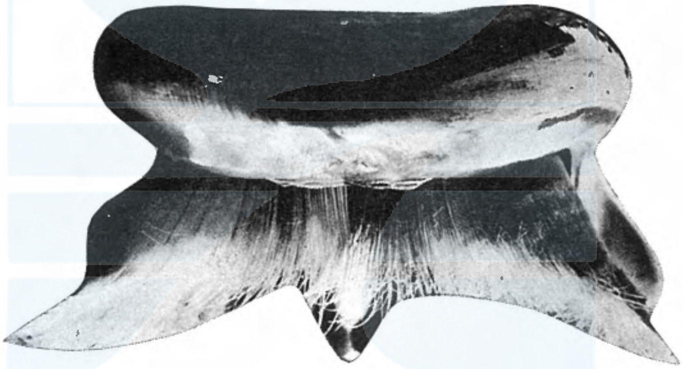


Fig. 2.

Fig. 3.

OSTEOLOGICAL NOTE OF A SPERM WHALE

HIDEO OMURA, MASAHARU NISHIWAKI,
TADAYOSHI ICHIHARA AND TOSHIO KASUYA

Material used in this report is a skeleton of male sperm whale measuring 46 feet in body length, which was collected in request of Staatl. Museum für Naturkunde, Stuttgart, West Germany. The measurements were made soon after cleaning of the skeleton in order to obtain the measurements which do not differ greatly from fresh condition as far as possible. We believe that these measurements may be useful in mounting the skeleton at the Museum. Further we think that it is of some value to publish them, since measurements of the whole skeleton of sperm whale from the coast of Japan have never been reported before.

This sperm whale was caught on 29 August 1960 at 37°17′N, 145°04′E by one of the whaling vessel of Nippon Kinkai Hogei Co. Ltd. and was dissected on the following day. It is very regrettable that no external body proportions were measured owing to some difficulties during the dissecting process. Soon afteer dissection the skeleton was buried in the sand of Kugunari Beach, Ojika Town, and in the case of small bones they were enveloped in a net of chemical fibres in order to prevent from any missing.

The purpose of the present report is only to supply these data and any discussions comparing with others presented by various authors are not included.

The longitudinal section of an upper tooth was made for the age determination and in it 32 laminae were observed.

While measuring this specimen, some interesting or important facts were noted, which are written below.

The skull of sperm whale differs from that of other toothed whales in having a large space which contains spermaceti. We measured it according to the usual way of measurement applied to other species, though it was thought that other items of measurements should be applied to this species. Among the measurements concerning nasal bones some were omitted, because it was rather difficult to distinguish them from other. It is regrettable that nearly all of the maxillary teeth, vestigial teeth, which usually present ten to twenty have been lost during the course of dissection, though they could have been collected without any difficultly and only one has been saved for age determination. All of the mandibular teeth and vertebral bones were collected, and chevron bones were nearly complete. Damage of skeleton caused by grenade and harpoon is very little.

The body length of male sperm whale at the attainment of physical maturity is thought to be between 52 and 53 ft. Several years, during which growth of several feet is attained, might be necessary for this specimen before the attainment of physical maturity, for the epiphyses of vertebrae are not completely ankylosed to their centra. The epiphyses are so thin that they were easily warped in various degree by drying after digging them out from sand and washing, and do not fit *in situ* to their centra, which caused some discrepancies in values of the vertebral measurement No. 1 (length of body at center). The ankylosis of vertebral epiphysis to its centrum is only observed in those posterior to the 14th caudal and in the cervical vertebrae.

Fig. 1. Chevron bone.

Though all the ribs have been collected, 9th and 10th of left rib were broken by the harpoon. The 11th ribs are so small compared with 10th that one may apprehend that the preceeding one was lost in the process of dissection.

The right lamina of the 1st chevron bone has not been collected. We think that possibly it was lost, though a probability that the ossification had not completed yet cannot finally be erased. The shape of the first chevron bone is subject to a considerable sexual difference. In this specimen 13 pairs of chevron bone were collected. But usually there present several more pairs of cartilage in the posterior region.

The hyoid bone is very large and resembles in shape to that of other toothed whales. The dimensions of the hyoid bone are shown in Table 1.

The sternum is very irregular in shape. It may be of some interest to note that the 2nd and 3rd bones seem to show wide individual variation. Sternum is combined with vertebral ribs by means of cartilage. The first rib is connected to sternum at the most anterior joint, 2nd and 3rd at 2nd, and 4th and 5th at 3rd respectively.

The rudimental pelvic bones are slender and in this specimen there is

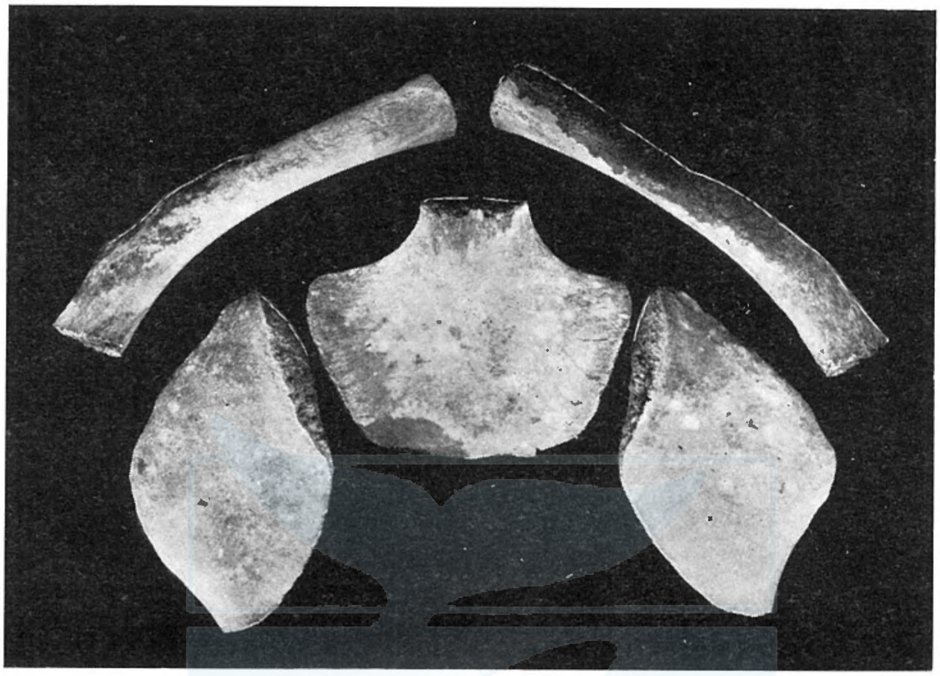
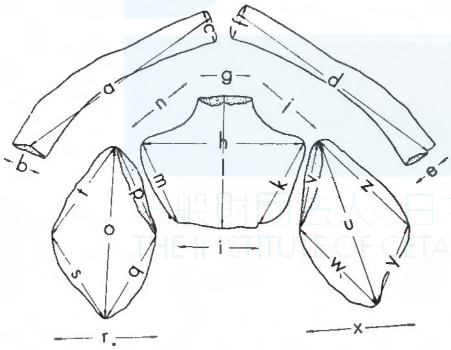


Fig. 2. Hyoid bone.

TABLE 1. DIMENSIONS OF HYOLD BONE (cm)



		L		R
Stylohyals	a	60	d	60
	b	12	e	11
	c	8	f	8
Basihyals	g	13		
	h	43		
	i	20		
	j	22		
	k	25		
	l	35		
	m	25		
	n	20		
Thylohyals		L		R
	o	45	u	45
	p	26	v	27
	q	29	w	26
	r	28	x	27
	s	23	y	27
	t	30	z	28

no bone which represent femur. But in other specimens femur-like bones were found, which ankylosed to pelvic bone or connected to it with joint.

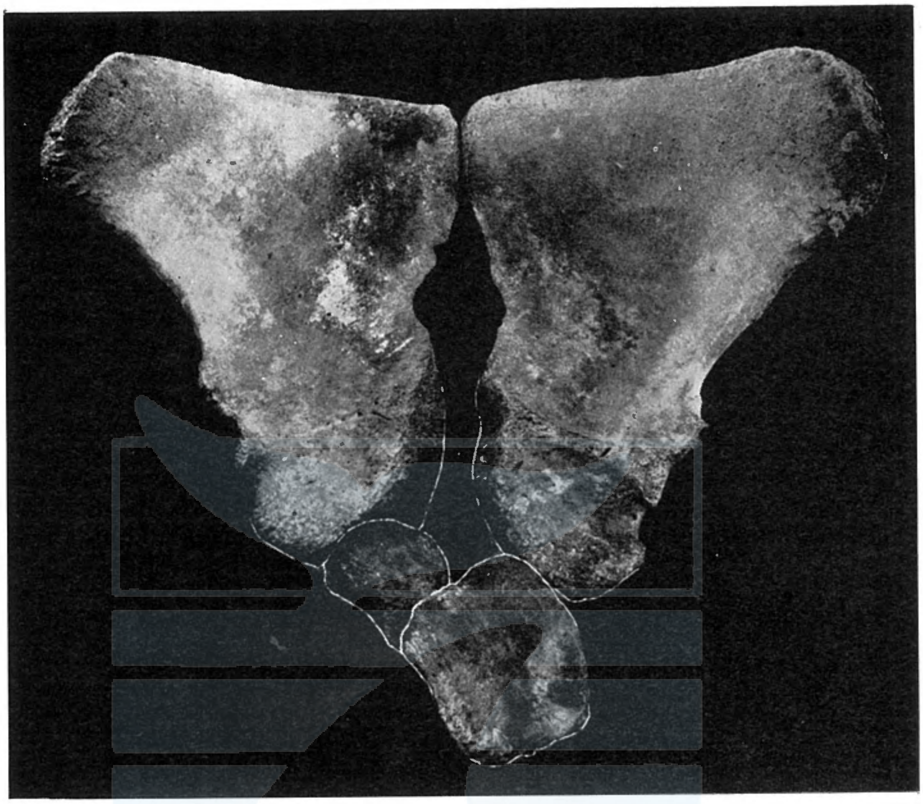
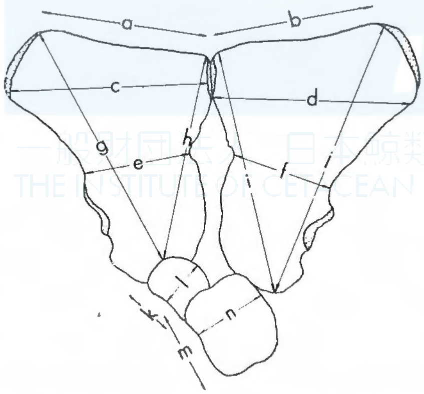


Fig. 3. Sternum.

TABLE 2. DIMENSIONS OF STERUM (cm)



a	45	h	61
b	38	i	65
c	52	j	73
d	52	k	15
e	28	l	12
f	27	m	22
g	68	n	18

Bones in flipper were collected nearly completely. But ulna, radius and some digits of left flipper were broken by the clashing with the side of the catcher boat during the time of towing the whale to the landstation.

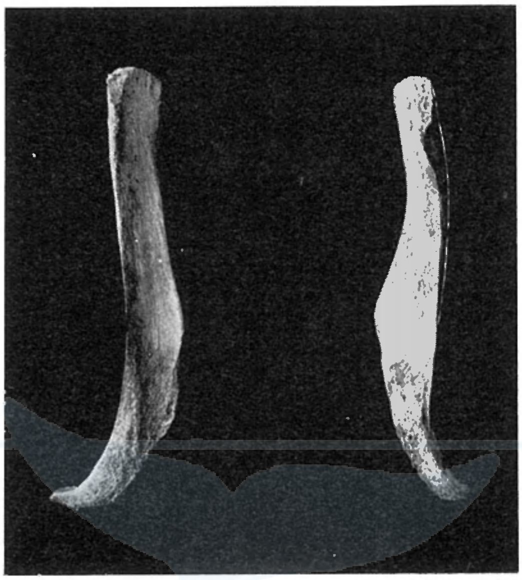
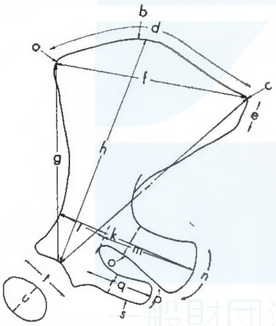


Fig. 4. Pelvic bone.

TABLE 3. DIMENSIONS OF SCAPULA (cm)



	L	R		L	R
a[1]	25	28	l	93	98
b[1]	23	23	m	282	283
c[1]	26	27	n	170	161
d	610	650	o[1]	20	22
e	100	120	p	82	76
f	570	580	q	198	198
g	600	600	r	51	51
h	705	718	s	27	30
i	715	738	t	188	188
j	143	152	u	137	138
k	428	440			

[1] thickness

We are grateful to Mr. Yoshinori Kimura who kindly helped us in various works, e. g. securing of the fresh skeleton, preparation for sample, and in measuring the skeleton. Sincere thanks are due to the staffs of Nippon Kinkai Hogei Co. Ltd., especially to those who worked at Ayukawa whaling landstation. The sperm whale was caught by the catcher of this company and dissected at the landstation.

TABLE 4. DIMENSIONS OF SKULL (cm)

			cm	percentage to the length	percentage to the breadth
1.	Total (condylo-basal) length		359	100	221.8
2.	Length of rostrum (median)		251	69.9	151.3
3.	Breadth of rostrum at base		123	34.3	74.2
4.	Breadth of rostrum at middle		83	23.1	50.0
5.	Breadth of rostrum between antorbital notches		124	34.6	74.7
6.	Depth of rostrum at middle		21	5.9	12.6
7.	Breadth of premaxillae at middle of rostrum		37	10.3	22.3
8.	Breadth of premaxillae in front of anterior nares		51	14.2	30.7
9.	Greatest breadth of premaxillae opposit anterior nares		64	17.9	38.6
10.	Least distance between the postero-dorsal margins of the maxillary foramina		89	24.8	53.6
11.	Least distance between the postero-dorsal margins of the premaxillary foramina		29	8.1	17.5
12.	Least distance between the maxillary foramina and premaxillary foramina	L:	37	10.3	22.3
		R:	25	7.0	15.0
13.	Greatest breadth of superior nares		33	9.2	19.9
14.	Distance from tip of rostrum to anterior end of vomer		52	14.5	31.3
15.	From the same to anterior margin of superior nares	L:	289	83.4	174.1
		R:	309	86.2	180.1
16.	From the same to medial suture line of posterior end of pterygoid		277	77.2	166.9
17.	From the same to occipito-frontal vertex		298	83.0	173.5
18.	From the same to posterior median end of maxillae on palate		231	64.4	139.2
19.	From the same to most anterior point of the palatines		231	64.4	139.2
20.	Length of vomer visible on palate		151	42.1	91.0
21.	Breadth across middle of orbits		166	46.3	100
22.	Diameter of orbit (antero-posterior)	L:	16	4.5	9.6
		R:	16	4.5	9.6
23.	Greatest breadth across supra-orbital plates of maxillae		153	42.6	92.2
24.	Greatest breadth across post-orbital processes		166	46.3	100
25.	Greatest breadth of cranium at parietal region in temporal fossae		120	33.4	72.3
26.	Length of temporal fossae	L:	26	7.3	15.7
		R:	27	7.5	16.3
27.	Depth of temporal fossae	L:	25	7.2	15.1
		R:	30	8.4	18.1
28.	Breadth of occipital condyles		51	14.2	30.7
29.	Breadth of foramen magnum		18	5.0	10.7
30.	Length of occipital condyle	L:	31	8.6	18.7
		R:	30	8.4	18.1
31.	Height, vertex to inferior border of pterygoids		126	35.1	75.7
32.	Depth of orbit	L:	16	4.5	9.6
		R:	16	4.5	9.6
33.	Length of mandible (median)		300[1]	83.6	180.7
34.	Length of mandibular ramus	L:	301[1]	83.8	181.3
		R:	305[1]	85.0	183.7
35.	Distance from anterior end of mandible to coronoid process	L:	269[1]	75.0	162.0
		R:	275[1]	76.6	165.6
36.	Length of symphysis	L:	171	47.8	103.0
		R:	161	44.8	97.0

TABLE 4. DIMENSIONS OF SKULL (cm) (continued)

			cm	precentage to the length	percentage to the breadth
37.	Distance from anterior end of mandible to anterior end of alveoli	L:	0	0	0
		R:	0	0	0
38.	Distance from anterior end of mandible to posterior end of alveoli	L:	185[1]	51.6	111.4
		R:	189[1]	52.7	119.9
39.	Depth of mandible at posterior margin of teeth	L:	17	4.7	10.2
		R:	17	4.7	10.2
40.	Depth of mandible at anterior margin of teeth	L:	7	2.0	4.2
		R:	7	2.0	4.2
41.	Depth between angle and coronoid process	L:	50	13.9	30.1
		R:	52	14.9	31.3
42.	Breadth across mandibular condyles	L:	13	3.6	7.8
		R:	13	3.6	7.8
43.	Greatest height of mandible at coronoid process	L:	55	15.3	33.1
		R:	56	16.2	33.7
44.	Distance between mandibular condyles		148	41.2	89.2
45.	Distance between ear bones		70	19.5	42.2
46.	Breadth of posterior end of pterygoids		25	7.0	15.0
47.	Breadth of anterior end of pterygoids		46	12.8	27.7
48.	Length of malar bone	L:	54	15.0	32.5
		R:	54	15.0	32.5

1) 2 cm added for deficit

TABLE 5. DIMENSIONS OF MANDIBULAR TEETH (mm)

Number of teeth[1]	Length		Diameter of cavum dentis (antero-posterior)		Diameter of cavum dentis (transverse)	
	L	R	L	R	L	R
1st	82	80	21	20	19	17
2nd	92	93	29	28	27	26
3rd	100	94	29	29	27	27
4th	98	97	30	29	28	28
5th	94	98	31	32	25	27
6th	92	93	33	35	25	25
7th	91	96	36	38	24	26
8th	90	89	38	37	24	24
9th	93	92	37	41	24	26
10th	97	93	37	41	25	27
11th	99	97	39	40	26	27
12th	95	99	38	41	28	28
13th	100	94	39	38	27	28
14th	100	94	36	38[3]	28	28
15th	102	88	34	37	27	28
16th	99	92	31	33	24	26
17th	89	88	33	30	27	24
18th	81[2]	84	25	26	21	21
19th	78[2]	83	23	25	18	19
20th	83	82[2]	23	21	18	15
21th	60[2]	75	20	17	14	16
22th	73	62	22	23	9	8
23th	67	55	21	19	12	8
24th	60	—	19	—	8	—

1) from anterior to posterior
2) tip broken
3) has some deficit, estimated

TABLE 6. DIMENSIONS OF VERTVRAL COLUMN (mm)

Number of vertebrae	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C 1st	105	125	158	420	730	241	224
2nd	169	336[2]	253	413	750	126[3] 98[4]	192[3] 212[4]
3rd							
4th							
5th							
6th							
7th							
D 1st	104	248	349	425	548	94	215
2nd	113	236	294	446	525	111	202
3rd	113	224	257	482	478	122	184
4th	122	222	234	502	450	130	170
5th	127	226	235	516	442	122	189
6th	122	228	230	526	429	132	149
7th	120	235	232	514	397	104	137
8th	129	240	244	558	375	112	125
9th	138	244	256	567	367	114	114
10th	140	251	272	588	491	118	101
11th	144	265	283	613	640	121	86
L 1st	152	251	275	625	616	126	78
2nd	160	288	275	655	618	120	66
3rd	160	313	291	682	622	117	60
4th[1]	165	331	280	637	623	119	60
5th	172	322	288	632	628	110	60
6th	177	315	284	605	625	81	60
7th	183	315	278	587	640	88	60
8th	195	320	282	574	655	85	63
Ca 1st	203	322	310	588	640	74	58
2nd	204	322	320	595	662	72	58
3rd	205	310	332	576	638	76	44
4th	210	311	332	562	562	66	35
5th	212	315	331	542	535	55	32
6th	207	313	327	495	450	45	38
7th	193	309	313	446	379	45	30
8th	188	306	300	420	323	36	28
9th	182	287	268	390	272	29	25
10th	175	276	252	355	—	26	18
11th	143	260	230	303	—	26	20
12th	100	232	222	250	—	—	13
13th	68	173	207	187	—	—	—
14th	62	140	176	147	—	—	—
15th	56	124	161	128	—	—	—
16th	52	105	162	122	—	—	—
17th	50	99	140	110	—	—	—
18th	50	79	110	88	—	—	—
19th	43	74	90	78	—	—	—
20th	38	62	84	65	—	—	—
21th	40	54	68	55	—	—	—
22th	36	44	46	46	—	—	—
23th	36	33	35	33	—	—	—
24th	20	18	22	18	—	—	—

C 7+D 11+L 8+Ca 24=50

(1) Length of body at center
(2) Height of body at front end
(3) Breadth of body at front end
(4) Total height from anterior bottom
(5) Breadth of transverse processes
(6) Greatest height of neural canal
(7) Greatest breadth of neural canal

1) has some deficit and pathological change at centrum
2) measurment at the posterior end of 7th cervical
3) height at anterior point of the canal
4) height at posterior point of the canal

TABLE 7. DIMENSIONS OF RIB BONE (cm)

Number of rib	Straight length		Curvilinear length[1]		Breadth of head		Breadth at middle		Breadth at distal end		Depth at head		Depth at middle		Depth at distal end	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1st	89	89	140	130	20	21	11	12	28	27	6	6	4	5	8	8
2nd[3]	113	115	192	194	20	20	8	8	16	15	5	5	5	4	9	9
3rd[3]	127	131	211	218	21	21	7	6	15	13	5	5	5	5	10	10
4th[3]	129	131	221	223	20	20	5	5	11	10	4	5	5	5	9	9
5th[3]	126	128	212	214	19	21	4	5	11	12	5	5	5	5	8	7
6th[3]	123	124	200	200	19	20	5	5	10	10	5	5	4	4	7	7
7th[3]	119	113	184	188	19	19	5	5	8	8	5	5	4	4	6	7
8th[3]	121	123	171	171	17	17	4	5	8	8	5	7	4	4	4	5
9th	115	121	145	155	10	14	4	4	7	8	6	4	3	4	3	3
10th	101[2]	102	121[2]	122	11	12	4	4	5[2]	5	6	6	3	3	2[2]	1
11th	28	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1) along the lateral border
2) has some deficit
3) two headed rib

TABLE 8. DIMENSIONS OF CHEVRON BONE (mm)

Number of chevron		Length (antero-posterior)			Breadth (transverse)			Greatest height (supero-inferior)
		proximal	middle	distal	proximal	middle	distal	
1.	L	57	65	—	38	18	15	131
	R[1]	—	—	—	—	—	—	—
2.		130	77	141	74	60	43	382
3.		138	101	195	160	47	39	423
4.		139	128	182	155	30	35	422
5.		162	137	201	152	46	53	332
6.		162	197	156	152	42	39	311
7.		178	201	168	142	34	34	280
8.		171	190	176	145	34	31	225
9.		153	189	183	137	35	26	183
10.		133	—	145	122	26	16	134
11.		118	—	104	116	27	18	85
12.	L	—	78	—	26	9	11	55
	R	—	79	—	26	9	11	56
13.	L	—	45	—	14	8	10	26
	R	—	46	—	15	8	10	27

1) missed

TABLE 9. DIMENSIONS OF PECTORAL LIMB BONE (cm)

	Humerus		Radius		Ulna	
	L	R	L	R	L	R
Length	40	40	30	30	30[1]	30[1]
Breadth at distal end	17	15	19	20	15	15
Breadth at proximal end	19	20	16	17	14	15
Depth at distal end	15	16	8	10	10	10
Depth at proximal end	12	12	5	5	7	7

1) Epiphysis at distal end is lost.

TABLE 10. DIMENSIONS OF CARPARS (mm)

Number of Carpars	Length		Breadth		Depth	
	L	R	L	R	L	R
1.	42	44	51	52	47	41
2.	52	60	66	66	44	43
3.	44	44	56	54	55	48
4.	55	52	62	60	45	43
5.	51	51	62	61	41	38

TABLE 11. DIMENSIONS OF DIGITS (mm)

			I		II		III		IV		V	
			L	R	L	R	L	R	L	R	L	R
1st	Length		66	61	115	114	121	130[1]	109	110[1]	94	92
	Breadth	proximal	45	41	65	69	68	68	68	70	50	51
		middle	18	19	35	40	31	31	32	—	37	38
		distal	20	18	73	73	70	68	67	66	45	45
	Depth	proximal	31	28	65	41	37	35	37	37	32	31
		middle	16	14	22	22	18	20	19	20	15	15
		distal	17	13	41	33	32	31	29	28	20	22
2nd	Length				91	92	96	100[1]	79	82	53	54
	Breadth	preximal			64	—	62	63	55	56	37	39
		middle			36	38	30	30	26	27	27	27
		distal			48	50	47	50	42	41	29	31
	Depth	proximal			32	34	29	30	27	25	12	31
		middle			17	16	16	16	13	14	10	10
		distal			22	21	19	15	19	19	12	13
3rd	Length				68	68	70	69[1]	58	59	24	28
	Breadth	proximal			41	42	41	39	35	32	17	19
		middle			27	26	19	19	20	20	12	12
		distal			35	33	37	37	32	31	10	10
	Depth	proximal			21	19	22	22	17	17	7	9
		middle			11	11	12	12	14	9	4	5
		distal			13	13	14	14	10	10	5	5
4th	Length				45	46	45	44	30	32		
	Breadth	proximal			25	43	27	26	20	17		
		middle			20	19	21	21	13	15		
		distal			22	20	27	24	11	12		
	Depth	proximal			12	11	13	13	7	8		
		middle			6	6	7	12	5	5		
		distal			6	6	7	8	4	4		
5th	Length				22	22	20	21[1]				
	Breadth	proximal			15	14	18	20				
		middle			14	13	17	18				
		distal			12	13	14	16				
	Depth	proximal			5	5	7	7				
		middle			3	3	3	6				
		distal			2	2	3	5				

1) has some deficit

EXPLANATION ON PLATES

PLATE I

Lateral view of the skull with mandible attached; anterior and posterior views of the skull; right (upper) and left (lower) side mandibular tooth (anterior teeth are shown in left).

PATEL II

Lateral, dorsal and ventral views (top to bottom) of the skull.

PLATE III

Lateral, dorsal and reversed lateral views (top to bottom) of mandible.

PLATE IV

Lateral views of vertebral column. Cervicals, thoracics, lumbars, caudals 1-7 and caudals 8-24 (top to bottom). Vertebral formula is C7+D11+L8+Ca24=50.

PLATE V

Lateral, cranial and caudal views of cervical vertebrae. left: lateral views of 1st and from 2nd to 7th cervicals; upper right: cranial (left) and caudal (right) views of 1st cervical; lower right: cranial (left) and caudal (right) views of from 2nd to 7th cervicals (fused).

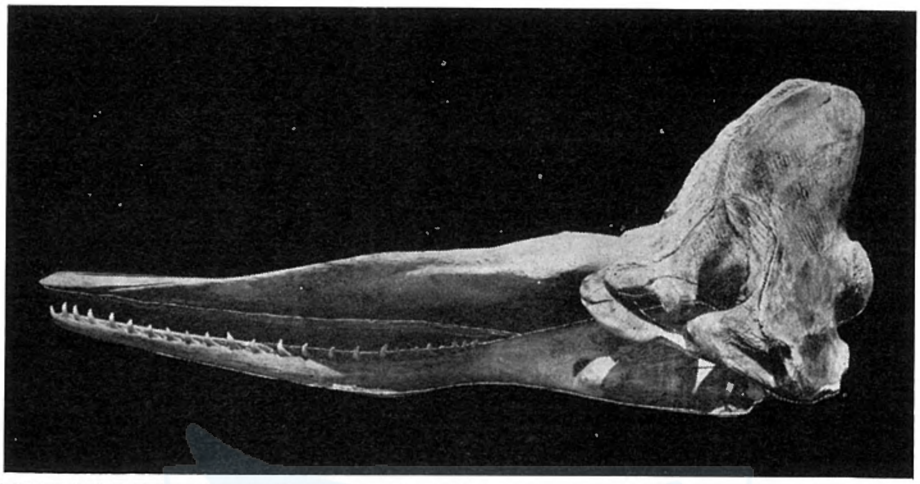
PLATE VI

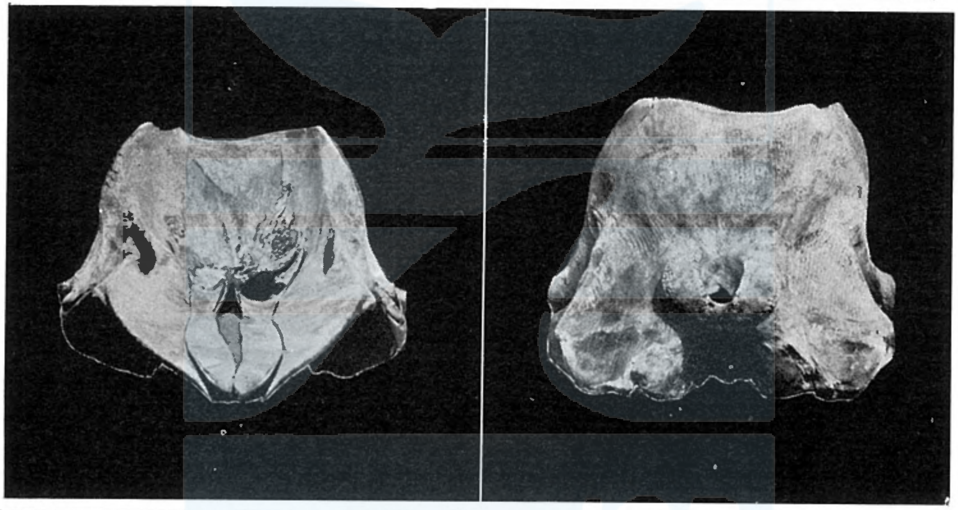
Left and right ribs (top to bottom).

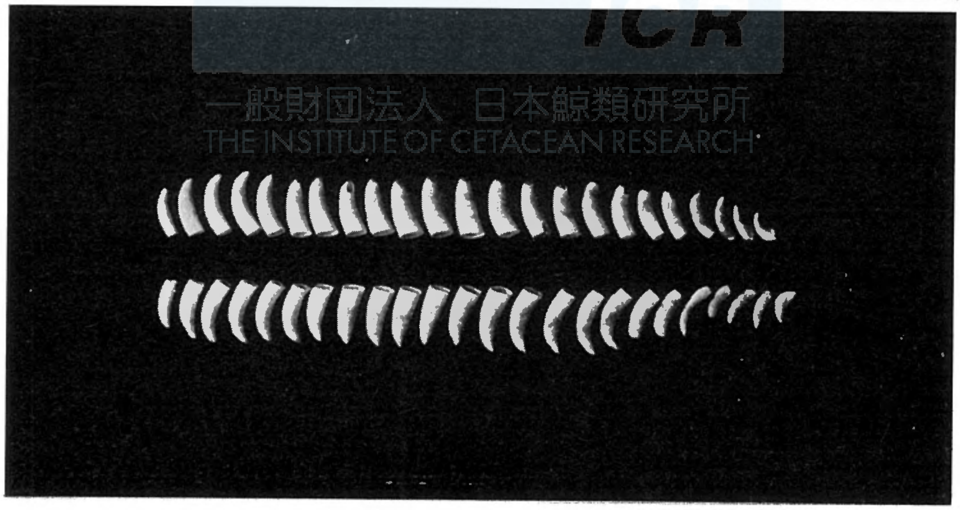
PLATE VII

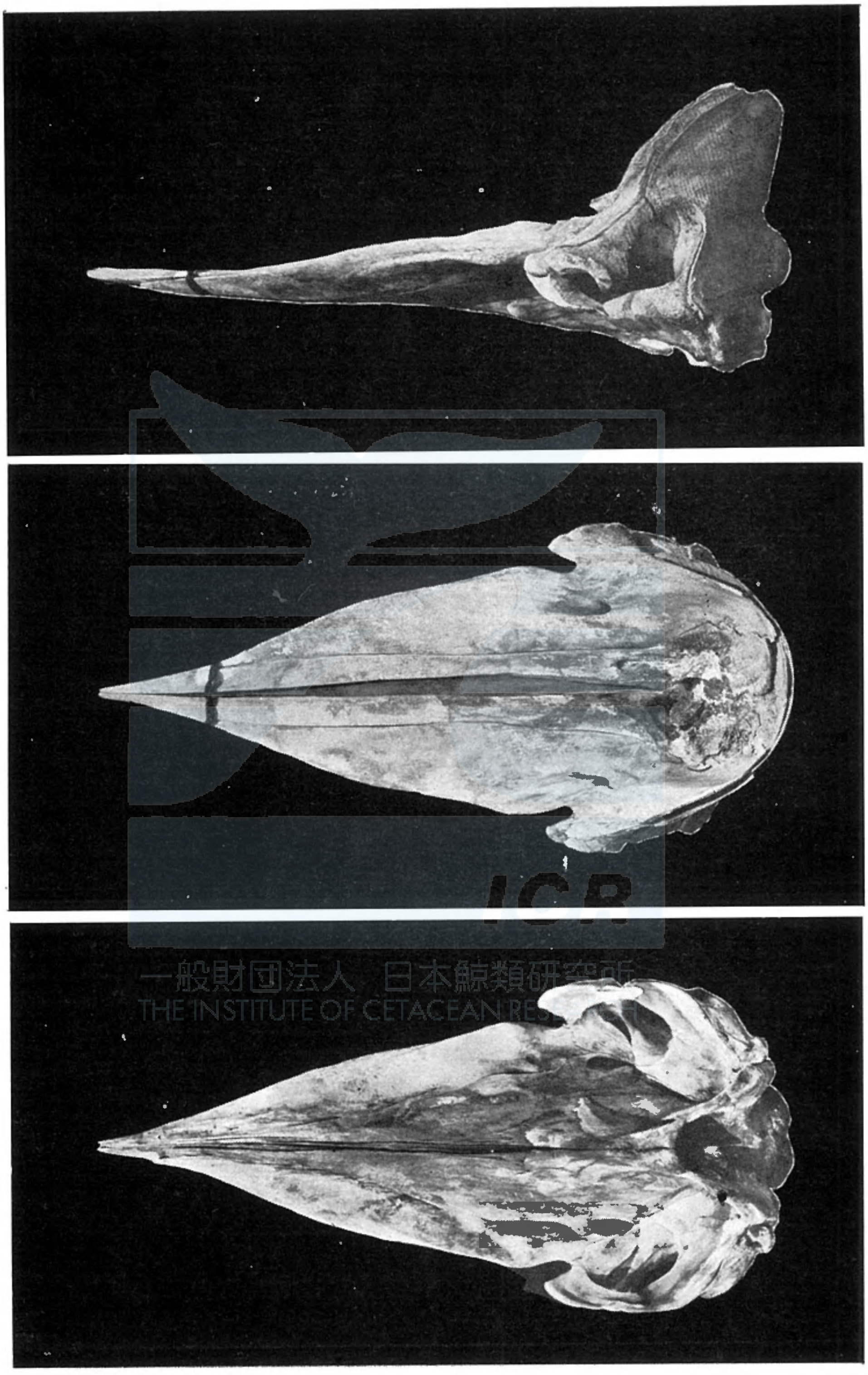
Left and right flipper bones (top to bottom).

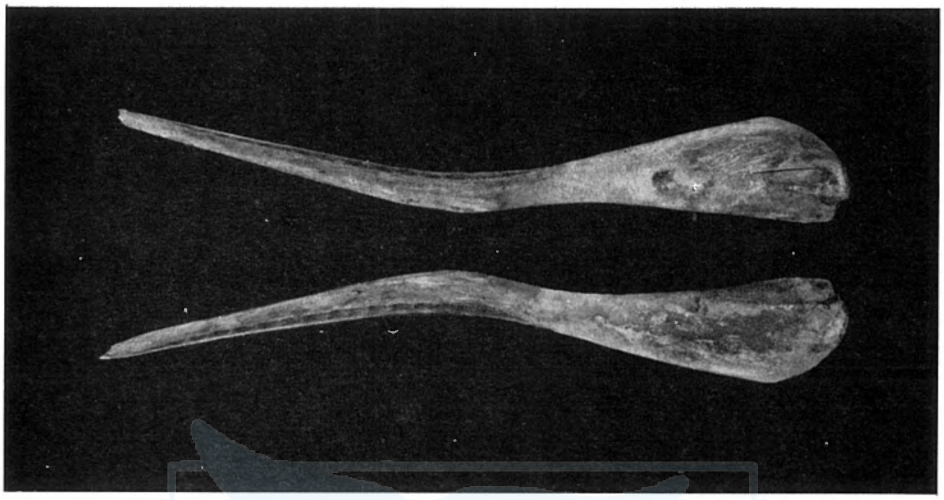
一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

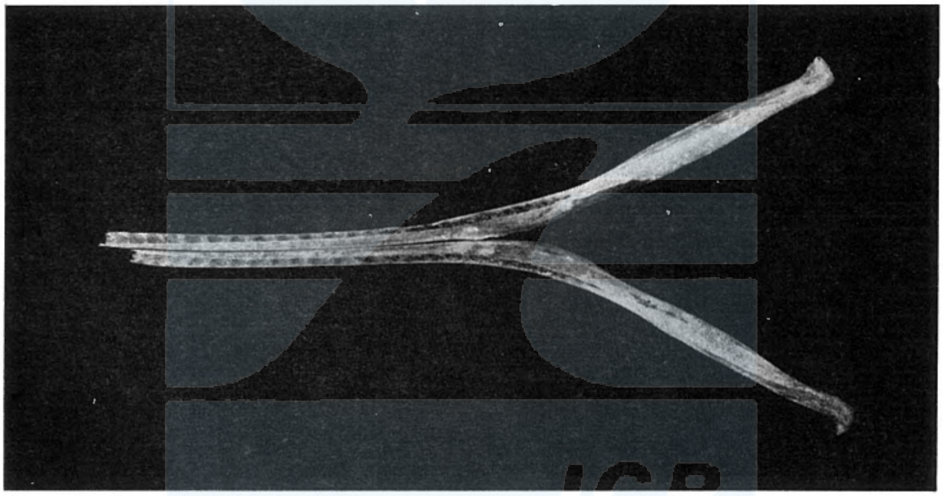


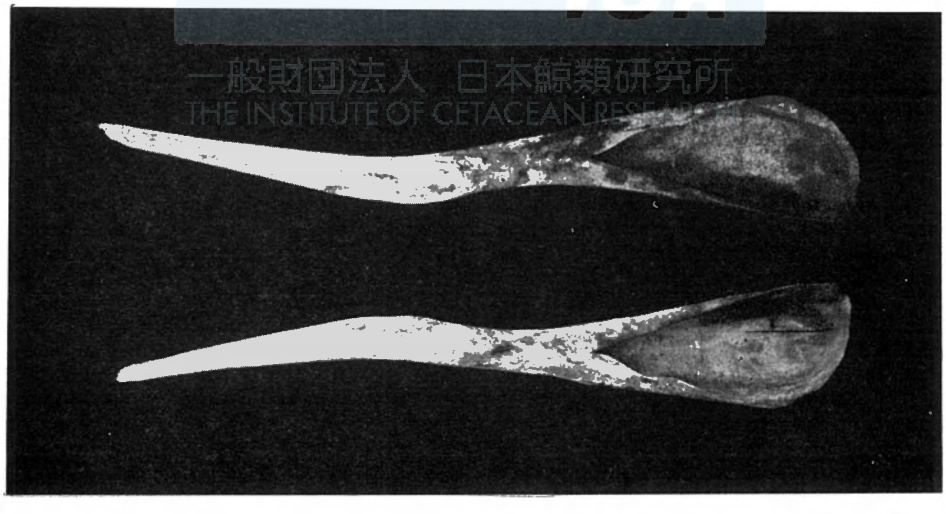


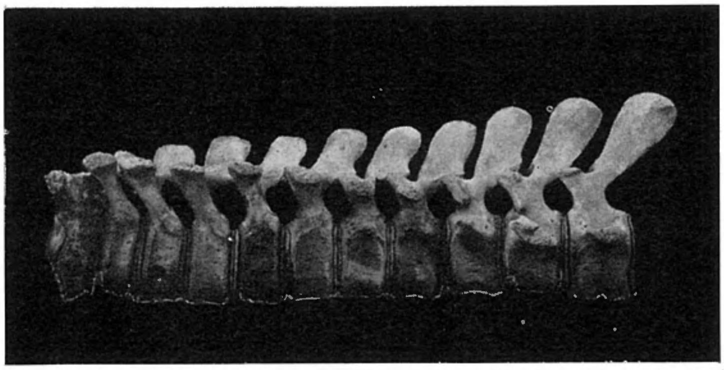


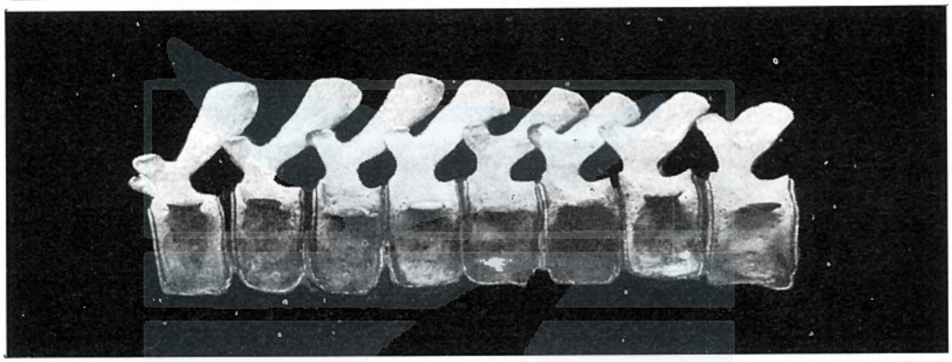


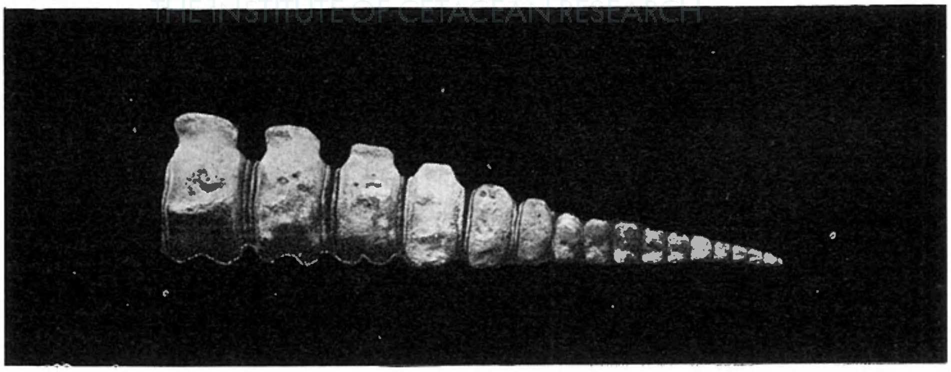


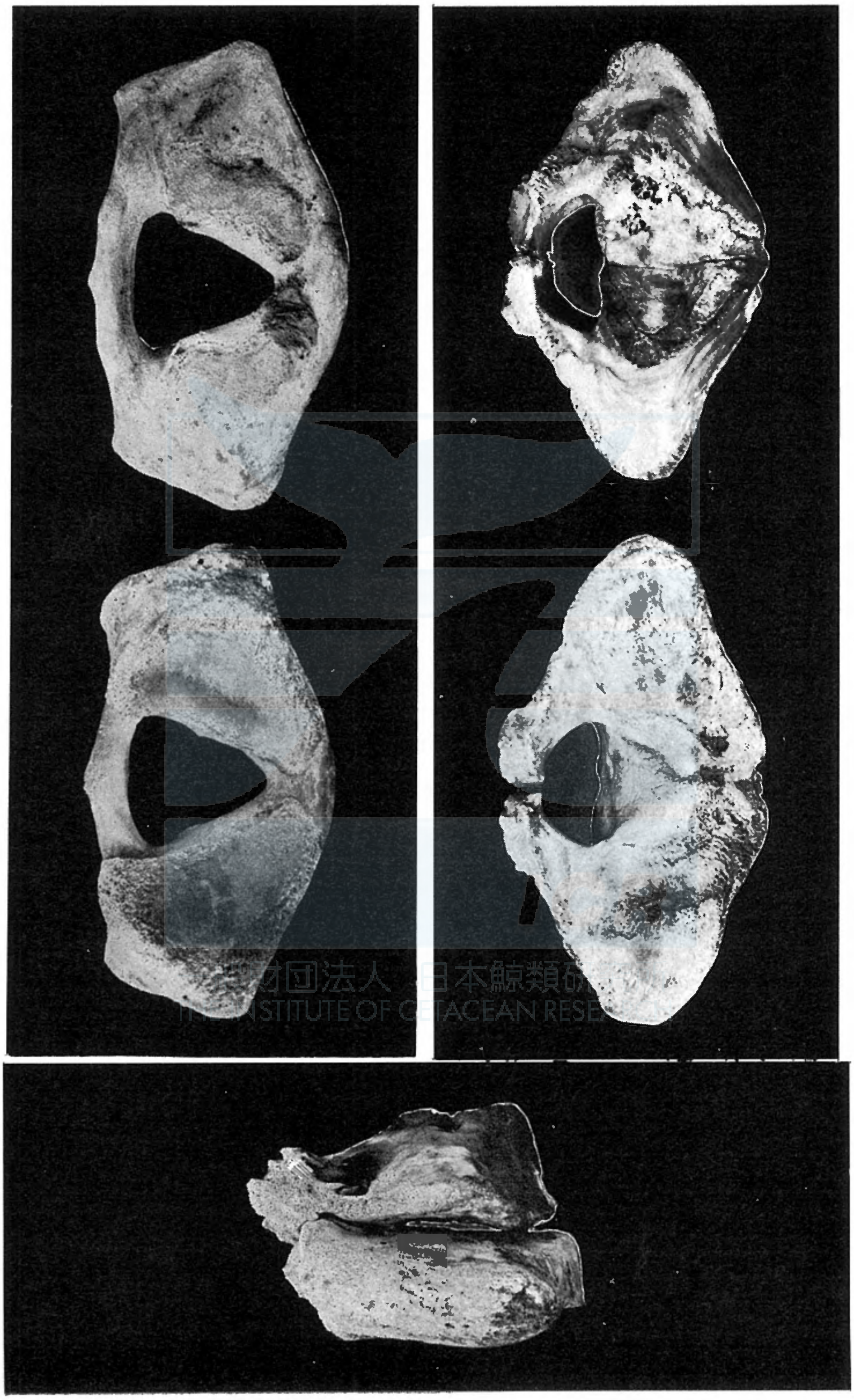


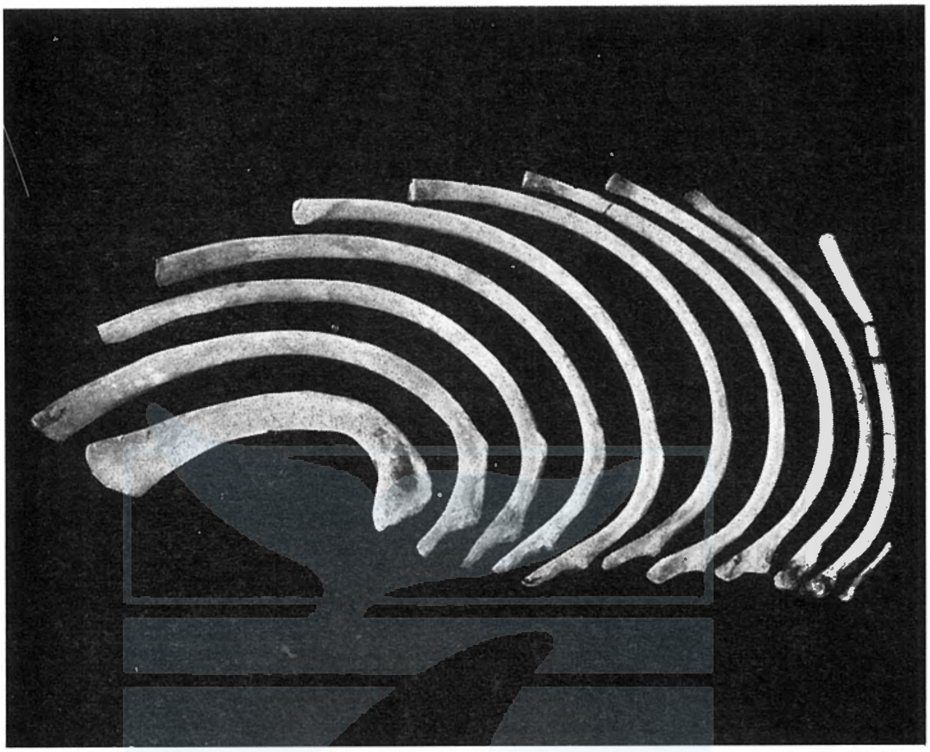


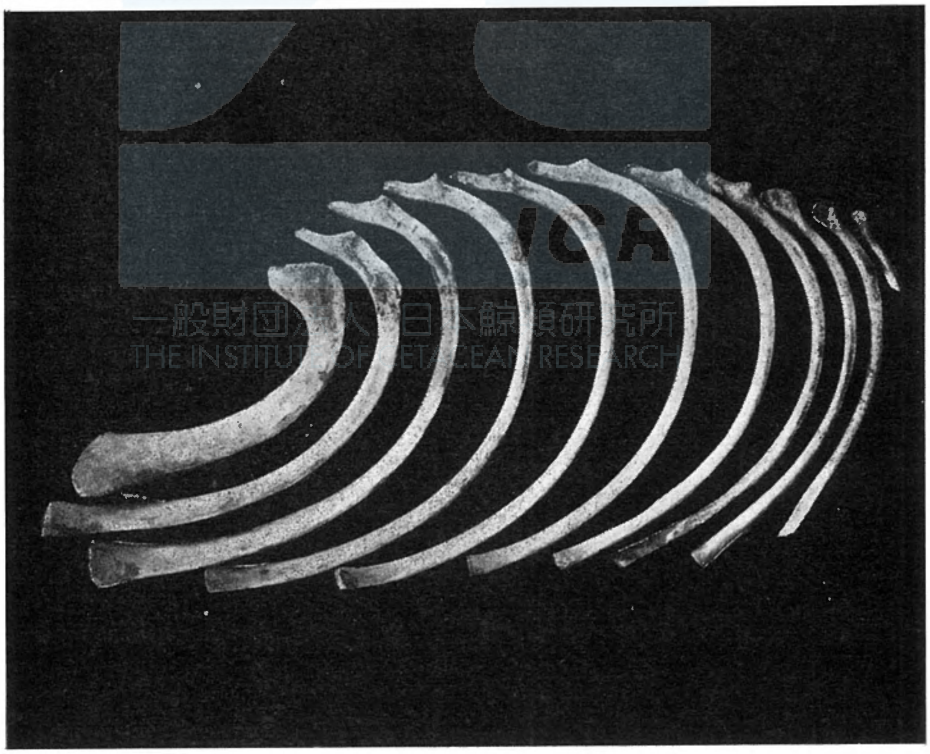


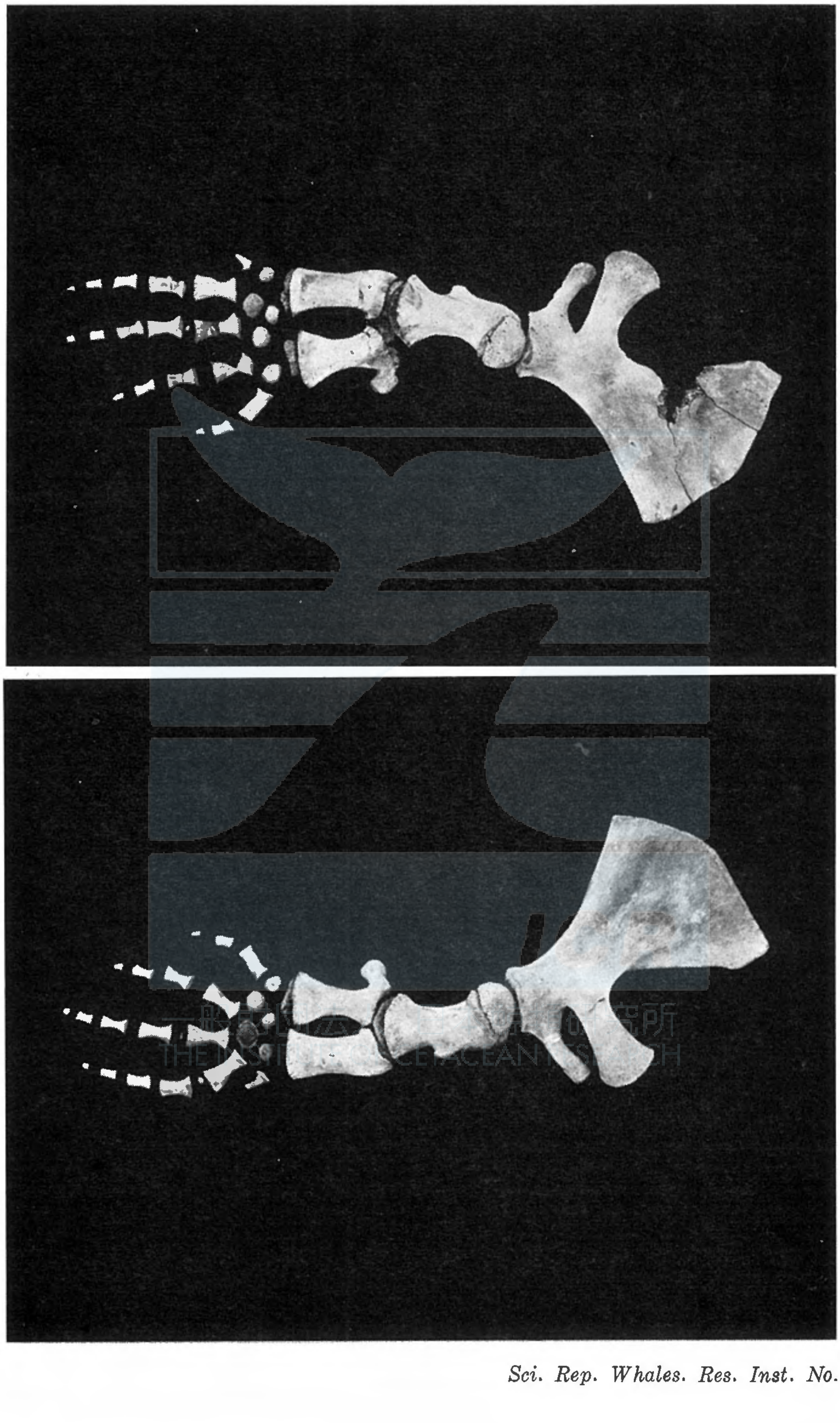












一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

PRENATAL DEAD FOETUS OF BALEEN WHALES

TADAYOSHI ICHIHARA

INTRODUCTION

Little is known about the prenatal death of whale foetus, although it is of importance as a part of total prenatal mortality. The total prenatal mortality in mammals indicates the sum of death rate at each stage from ovulation to partrition, that is, the sum of mortality such as unfertilized ova, the reabsorption and the abortion during the development of embryo. In other meaning, prenatal dead foetus is of particular interest in the study on genetical, physiological, pathological and serological factor causing prenatal death. Understanding of these factors is an indispensable preliminary to the prenatal mortality, for the nature and significance of prenatal dead foetus cannot be assessed without this context. There is, however, no intension in this paper to study these particular factors, but some biological observations and discussion on reabsorption are made for the prenatal dead foetus. The pursuit for factors and mutual relations among them should be made in other field.

In am indebted to the members of the Whales Research Institute and the trained inspectors of the Japanese Government, who recorded the foetuses on the factory ships. Especially, Dr. Ichiyo Asami, the Department of Anatomy, Faculty of Medicine, University of Tokyo, Messrs. Seiji Ohsumi and Keiji Nasu, the Whales Research Institute took the valuable photographs and kindly permitted me to include them in this paper.

RECORD OF PRENATAL DEAD FOETUS

The records on prenatal dead foetuses observed aboard the factory ships in the Antarctic expeditions between 1946/47 and 1960/61 season have been arranged. These foetuses were observed by the biologists and trained inspectors, therefore, they do not seem to represent all dead foetuses to be observed in the Japanese expeditions.

In Table 1, the foetuses for each species are indicated with other biological data, particularly with the corpora count in the mother's ovaries. The records in the North Pacific expeditions from 1952 to 1960 are included in the bottom of Table 1. Most of these foetuses observed in the Antarctic are composed of the fin whale and this trend is explained by the evidence that the main catch in the recent Antarctic expeditions has been the fin whale. In other species, one prenatal dead foetus is observed respectively for the blue, the pigmy blue (Ichihara, 1961) and the sei whale. During the North Pacific expeditions the foetus except the fin whale has not recorded yet. There is no record of prenatal dead foetus in the humpback whale.

TABLE 1. LIST OF DEAD FOETUS

No.	Locality	Positon killed	Species	Mother's length in feet	Date killing mother whale	Dead foetus Sex	Dead foetus Length in feet	Ovaries Corpora luter	Ovaries Corpora albicans
1.	Antarctic	62-16 S 98-06 E	Fin	67	Jan. 24, 1959	?	0-5	1	16
2.	〃	67-18 S 145-39 W	Fin	75	Feb. 10, 1958	?	0-10	1	6
3.	〃	48-33 S 39-44 E	Fin	69	Feb. 22, 1961	M	0-10	1	2
4.	〃	63-01 S 108-34 E	Fin	71	Dec. 22, 1950	? F M F	1-4 4-2 7-11 19-11	0	17
5.	〃	57-00 S 93-36 E	Fin	62	Jan. 8, 1960	?	2-1	1	2
6.	〃	67-16 S 172-30 W	Fin	72	Feb. 1, 1951	M M	11-5 (alive) 4-0	over 8	
7.	〃	42-53 S 38-03 E	Fin	68	Feb. 27, 1961	?	5-2	not counted	
8.	〃	55-47 S 13-48 E	Fin	71	Jan. 15, 1961	F	5-11	not counted	
9.	〃	68-12 S 170-03 W	Fin	74	Jan. 10, 1952	F F M	15-0 19-8 5-2 (alive)	1	25
10.	〃	68-05 S 136-06 W	Fin	73	Feb. 5, 1957	?	20 from 15	0	19
11.	〃	74-07 S 177-57 W	Fin	78	Feb. 11, 1954	?	16-4	not observed	
12.	〃	49-01 S 33-48 E	Fin	74	Feb. 8, 1961	?	17-8	1	14
13.	〃	69-12 S 179-46 W	Fin	75	Feb. 14, 1949	M	18-0	1	22
14.	〃	70-11 S 176-14 E	Blue	85	Feb. 15, 1955	F F	8-6 (alive) 4-2	2	17
15.	〃	46-58 S 39-32 E	Pigmy Blue	77	Feb. 8, 1961	?	not measured	not counted	
16.	〃	59-48 S 150-24 E	Sei	50	Feb. 4, 1960	M M	13-1 10-8 (alive)	1	19
17.	North Pacific	52-50 N 164-12 E	Fin	66	July 3, 1957	F	0-8	1	12
18.	〃	54-35 N 165-35 W	Fin	68	July 18, 1954	F	1-1	1	10
19.	〃	55-24 N 171-07 E	Fin	68	June 15, 1959	?	12-0	1	12

Detail of records on these foetuses should be described to know various case of death. All records do not necessary remain in full forms. Some of them are recorded only as the foetus observed is dead, however, the some details described later and the photographs included help the study on the prenatal death in whales.

Record no. 1: A prenatal dead foetus is observed with the amnion and indicated in Fig. 1. The colour of this is turbid pale green as like as boild horse beans.

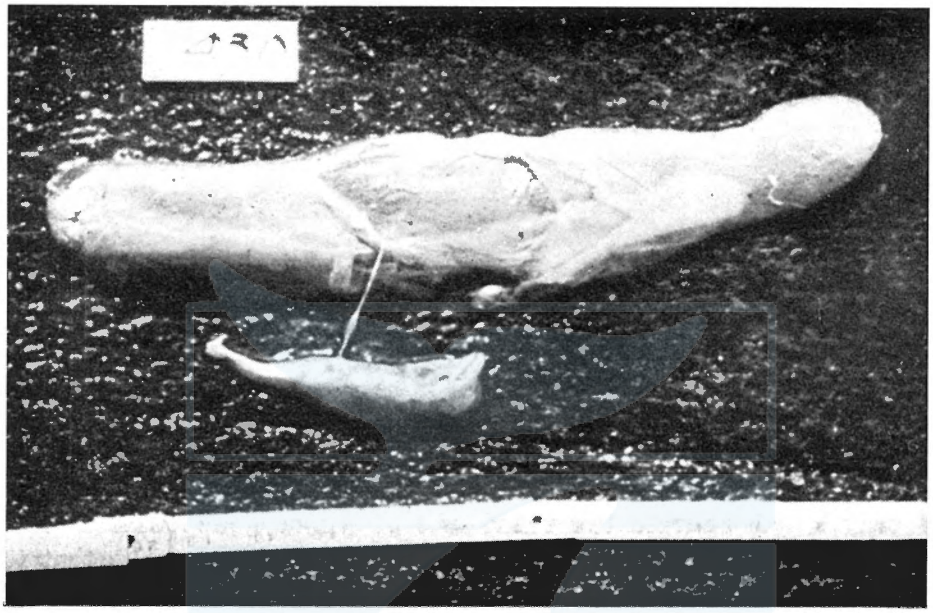


Fig. 1. Prenatal dead foetus of fin whale, recorded as no. 1 in Table 1 (Photo. by Mr. Seiji Ohsumi). The colour of this foetus is turbid pale green as like as boild horse beans.

Record no. 2: A prenatal dead foetus of which sex is unknown is observed. The colour of foetus is dark-green.

Record no. 3: Body of foetus are decomposed but not dissolved.

Record no. 4: Reported by Kimura (1957). Four prenatal dead foetuses are present in both uteri. Since no corpus luteum of pregnancy is present in mother's ovaries, it is impossible to estimate when these foetuses were dead. The most small foetus in 1 foot and 4 inches long is decomposed in the posterior region of body and so sex is unknown. Although the other information is not recorded, it is estimated that these foetuses has resulted neither from the single ovum nor from the multiple ova but each foetus was dead at the respective stage in development and that a fairly long period has been elapsed between the oldest foetus and the recent one. The prenatal death such as record no. 4 is very rare and it may be based on the physiological abnormality in the mother's uterus.

Record no. 5: Abdominal and posterior region of body is dissolved and so sex is unknown.

Record no. 6: Reported already by Kimura (1957). One of two foetuses is alive and the other is a dead male foetus, 4 feet in length. Corpora numbers are counted in one side ovary as no corpus luteum and 8 corpora albicantia. The other side ovary is unfortunately lost. It is not estimated whether the two foetuses have developed either from a single ovum or from different ova.

Record no. 7: A deformed foetus is dead.

Record no. 8: Tail flukes is lost. Dark-blue foetus has an odour of decomposition. Body length, therefore, is not measured accurately and estimated as 180 cm. Real measurement is 160 cm (5 feet 3 inches) in length.

Record no. 9: Reported already by Kimura (1957). One among three foetuses is alive, which is male, 5 feet 2 inches in length. Corpus luteum of 18.0×11.0 cm in diameter is present in the mother's ovary and corresponds to the presence of this foetus. Female prenatal dead foetuses are observed in one uterus. Also judging from the difference of body length between two prenatal dead foetuses, they are supposed to be the monozygotic twins. Kimura (1957) states that the difference of body length between two individuals of monozygotic twins is more than that of dizygotic twins. Fig. 5 in his paper suggests that the difference of 4 feet and 8 inches between body lengths of monozygotc twins in record no. 9 may be expected. At the next oestrus after two female foetuses was dead, the mother whale ovulated one ovum which has resulted in a new embryo. This male embryo has developed to 5 feet 2 inches which corresponds to the foetal length of the late in 6 months after mother whale was conceived. Laws (1959b) indicated that the average duration of gestation is $11^1/_4$ months in the southern fin whale and $10^3/_4$ months in the southern blue. It is concluded that these prenatal dead foetuses have remained in the mother's uterus over 6 months.

Record no. 10: Posterior body is decomposed and tail flukes are dissolved and lost. Therefore, sex is unknown and the accurate body length is not measured. The amnion in the white membraneous thickness sticks on and encircles the anterior body.

Record no. 11: The nearest part to reproductive aperture is particularly decomposed and so sex is unknown.

Record no. 12: The posterior body from the external reproductive aperture to the tail flukes is decomposed and so the sex of the foetus is unknown. Eyes are lost. White amnion sticks on the body and many fissures parallel to the notch of flukes from the tip of snout are present on the surface of body. Accurate body length is not measured but estimated.

Record no. 13: A deformed foetus are dead.

Record no. 14: Two female foetuses are observed in the uterus of the same side. One of them is alive, being 8 feet 5 inches long and the other is dead, 4 feet 5 inches in length. This prenatal dead foetus is yellowish-grey and atrophies in the enervated state, though the external body is not destroyed generally. Two large corpora lutea, 13×12×14 cm and 14×15×13 cm in the respective diametre, are present in the one side ovary where there are 10 corpora albicantia including one comparatively fresh corpora. In the other side ovary, 7 corpora

Fig. 2. Two foetuses of the blue whale, recorded as no. 14 in Table 1. Upper foetus is healthy but below is dead.

Fig. 3. Ovaries of mother including two foetuses indicated in Fig. 2. Large corpora lutea are shown in the right ovary. (Photo. by Dr. Ichiyo Asami).

albicantia including 1–2 fresh corpora are present. There are fairly large cavities in two corpora lutea but they are not measured. Two foetuses and ovaries are indicated in Fig. 2 and 3. The presence of two foetuses in one side uterus suggests that these foetuses are either a monozygotic or a dizygotic twins and the fertilization date is almost the same in either case. As the structure of placenta unfortunately is not observed, it is impossible to examine which two foetuses come from one ovum or two ova.

In relation to this problem, it is necessary to interpret the two corpora lutea in one side ovary. In my examination on multiple ovulations of the baleen whale, there is an evidence that if one fertilized ovum develops, corpora lutea coming from sterilized ova are maintained in ovaries throughout the pregnancy of healthy foetus. This evidence supports the presence of two corpora lutea even if the two foetuses in record no. 14 are the monozygotic twins.

Even if one foetus in the dizygotic twins is dead in the course of development, the two corpora lutea of pregnancy will be maintained throughout pregnancy of the other healthy foetus. This phenominon is very rare in the whale as a monoparous species. In the multiparous species of terrestrial mammals, such phenomina are known well and the total prenatal mortality before and after implantation is estimated by many scientists from the numbers of corpora lutea and of healthy embryos ; pig (Hammond, 1921, etc.), sheep (Henning, 1939, etc.), ferret (Robinson, 1921), stoat (Deanesly, 1935) and wild rabbit (Brambell, 1948 etc.).

Record no. 15 : A foetus is decomposed and dissolved to green fluid. Therefore, body length is not measured and sex is unknown.

Record no. 16 : A prenatal dead foetus is observed in the one side of uterus and a healthy foetus in the other side of uterus. The photograph of a prenatal dead foetus is shown in Fig. 4. The foetus is the full-grown male, 13 feet and 1 inch in length, and near to partrition. Tail flukes bent as indicated in lower left of Fig. 4. The colour of amnion changes whitish-grey and the thickness of it increases. The aminion encircling the foetus body breakes at some parts and on the surface of body there are many fissures parallel to body axis. Dark pigments observed usually on the dorsal region of full-grown foetus vanish and the external body of the foetus appears yellowish-white. Tip of flipper and tip of tail flukes are dissolved and lost as indicated in lower left and right of Fig. 4. Eyes also are lost.

One corpus luteum in the ovary corresponds to the healthy foetus. Since the corpus luteum has regressed to corpus albicans after the death of foetus, it is pointed out that these foetuses have developed from the different ova. 19 corpora albicantia are counted in both ovaries. At the next oestrus after a foetus was dead, the mother whale ovulated a new ovum which has developed to a foetus of 10 feet 8 inches in length. Since the average duration of gestation is about 12 months and the neonatal length is 4.5 metre (14 feet 9 inches) for the southern sei whale (Matthews, 1938; Laws, 1959b), about 10 months and a half have elapsed after conception until the foetus has grown to 10 feet 8 inches. This estimation also supports that the prenatal dead foetus has remained in the mother's uterus over 10 months.

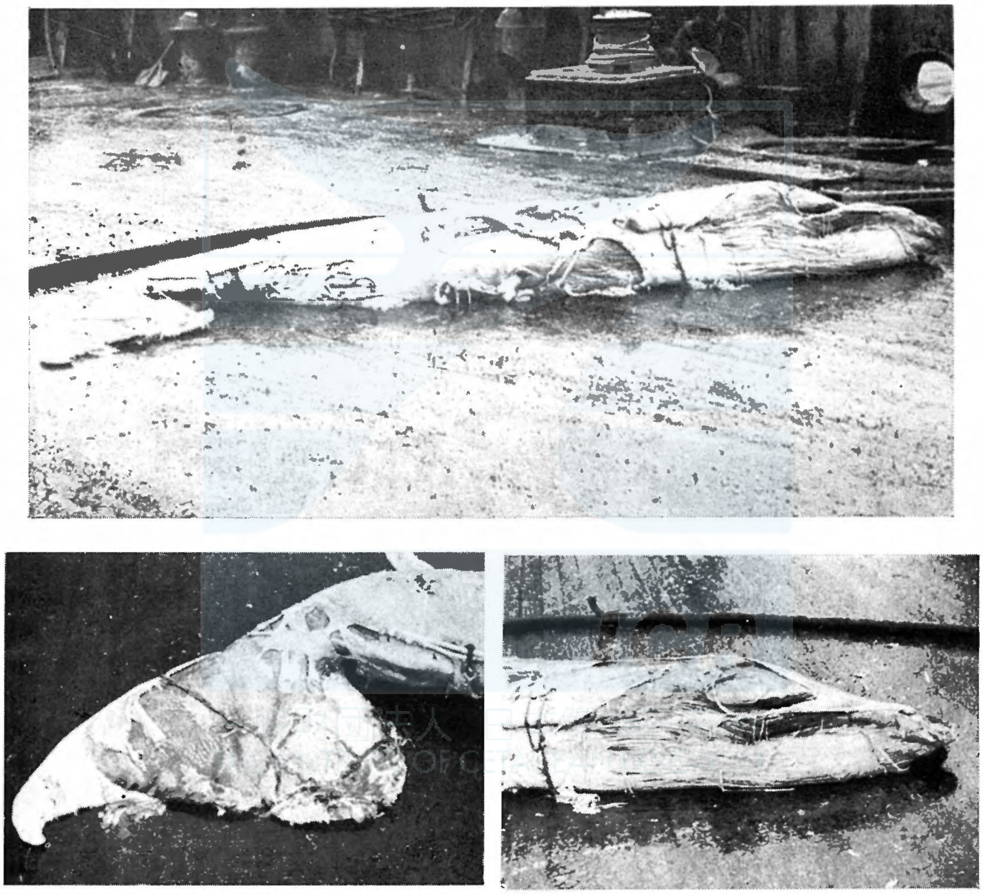


Fig. 4. Prenatal dead foetus of the sei whale, recorded as no. 16 in Table 1.
Lower left: Tail flukes; Lower right: Anterior body part

Record no. 17 and 18: Dark-green foetuses are dead.

Record no. 19: A dead foetus is observed. Some parts of body are decomposed and so sex is not examined. Flippers and tail flukes are dissolved and lost, besides eyes also fall off as shown in Fig. 5. The head of the foetus seems to be deformed. The outside of body appears yellowish-grey. One corpus luteum remains in the corresponding ovary to the uterus including the foetus. 12 corpora albicantia are present in the both ovaries.

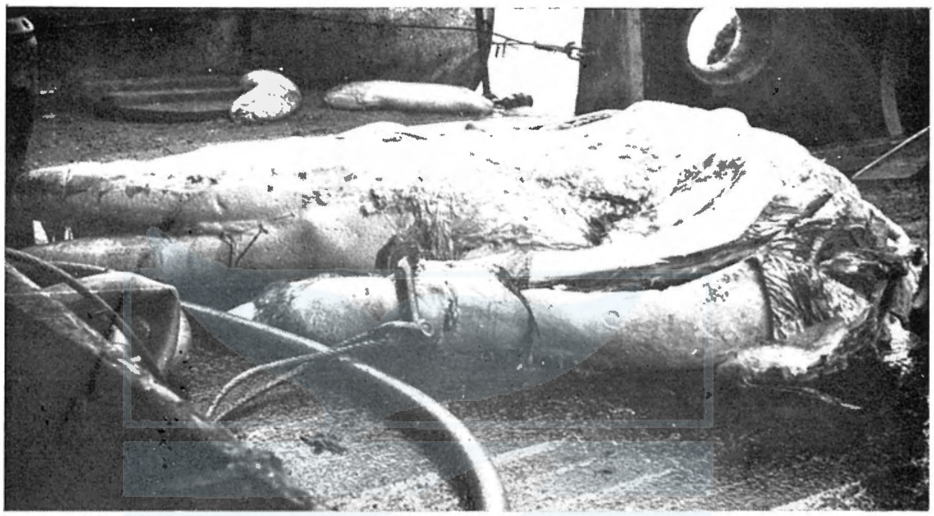


Fig. 5. Prenatal dead foetus of the fin whale, recorded as no. 19 in Table 1. (Photo. by Mr. Keiji Nasu).

DEAD FOETUS AND LIFE OF CORPORA LUTEA

It is pointed out from the records mentioned above that corpus luteum exists in the ovary, although the foetus was dead in the uterus before the mother whale is killed. With regard to whales, corpus luteum remains throughout pregnancy and it regresses gradually to corpus albicans after partrition. In the case that the foetus was dead in the mother's uterus, corpora lutea of pregnancy shrinks in the similar process as partrition from the time of interrupted pregnancy. It is probably accepted that the periods of transformation from corpus luteum to corpus albicans is not always the same in the death of foetus as well as in partrition. It is often observed in the Antarctic whaling season between January and March that corpus luteum of pregnancy regresses to corpus albicans in the ovary of the lactating female. Mackintosh and Wheeler (1929) state that the lactating periods are about 6 months for the southern fin whale. From two evidences mentioned above it seems that corpus luteum of pregnancy regresses to corpus albicans for a few month after partrition. In the case that the dead foetus remains in the uterus, if the placenta is active yet, it is assumed that the corpus luteum of pregnancy is maintained for a fairly long time without regression. In the record nos. 1, 2, 3, 5, 17 and 18, such assumption may be accepted. It is very doubtful however that the corpora lutea of pregnancy corresponding to the prenatal dead foetuses have remained in the ovaries in the record nos. 12, 13 and 19, for these foetuses was dead long before. In fact, there are no corpora lutea of pregnancy in the record nos. 9, 10 and 16 in which large foetuses are dead. Besides, there are similar informations on the prenatal dead foetuses of fin whales between the record nos. 10 and 19. It is estimated that corpora lutea in the record nos. 12, 13 and 19 result from new ova shed after the foetuses was dead, that is, corpora lutea of ovulation. Measurement of diameters of these corpora are not informed.

OCCURRENCE AND PROCESS OF REABSORPTION

From the records indicated in Table 1 informations on the relation between the frequency of the prenatal dead foetus and the maternal age are obtained. With regard to baleen whales, corpora albicantia remain in the ovary throughout the life span and so the total numbers of corpora indicate the relative age of whale (Mackintosh and Wheeler, 1929 ; Laws, 1958). In 13 records of the Antarctic fin whale in Table 1, the examples over 10 corpora counts occupy about two-third of total. In the multiparous species of mammals, the number of ova shed increases with the maternal age and the loss of foetus increases with the number of implanted embryos (Brambell, 1948). This fact suggests that the prenatal mortality increases with the maternal age in the multiparous mammals. This evidence is probably applied to the whales as monoparous species.

In the multizygotic foetuses of whale, it is estimated that the death rate is higher more than in the single foetus. Nutrient supply from the maternal body is probably limited not to breed many foetuses. The death of multizygotic foetuses appears more frequently in the last stage than in the early stage of foetal development. Possibly related to this is the fact in the horse, a species in which only about fifteen twin births per thousand occur (Lauprecht, 1932), more than one-half of the twin pregnancies end in an abortion (Wriedt, 1928).

Dead foetus is observed frequently in the early stage and in the late stage of pregnancy as tabulated in Table 1. Length frequency of foetus observed in the Antarctic is indicated in Fig. 6, based on the material of the International Whaling Statistics in 1959/60 Antarctic whaling season. Examing the foetal lengths of fin whales in the International Whaling Statistics covering 1925–58 and composing many thousands of records, Laws (1959a) concludes that there has been no progressive change in the mean foetal lengths of fin whales from year to year in the Antarctic. In this meaning, the length frequency of fin whale foetus in 1959/60 season seems to represent the foetal length frequency in the Antarctic. In Fig. 6 the length frequency of prenatal dead foetus is plotted at each 3 feet and smoothed with a curve. The section of each gestation month for the fin whale is shown in the bottom of Fig. 6 in order to explain the interrelationship between the periods from conception and the foetal length. Although the percentage frequency of foetal length is skewed positively, there is a peak from 5 to 8 feet of the foetal length. This corresponds from $6^1/_2$ to about 8 months after conception.

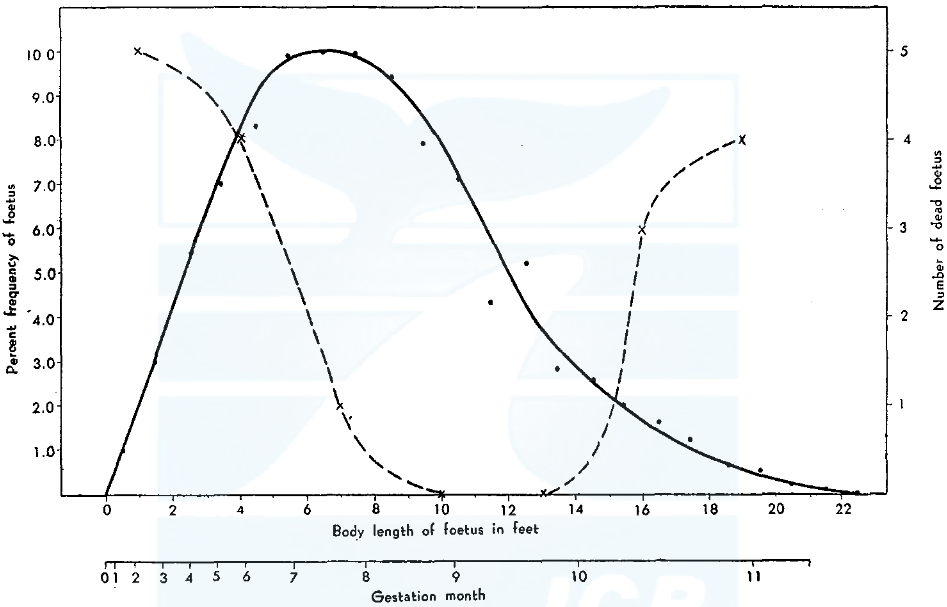


Fig. 6. Relation between length frequency of foetus and length frequency of dead foetus in the Antarctic fin whale.

●——●: Foetus frequency in 1959/60 Antarctic season
×---×: Dead foetus frequency

On the contrary, the prenatal dead foetus occurs frequently both in the early stage and in the late stage of pregnancy. In the curve indicating the length frequency of dead foetus, there is a bottom between 10 and 13 feet which corresponds the foetal length from 9 to 10 gestation months. Fig. 6 suggests why the prenatal dead foetus is not observed frequently in the Antarctic. In order to explain this reason, Fig. 7 is obtained from Fig. 6 by means of dividing the number of prenatal dead foetus by the percent frequency of foetus at the corresponding foetal length. Thus, relative death ratio in the foetal stage is shown against the foetal length at each feet and against the each gestation month in the Antarctic fin whale. The scale of ordinate in Fig. 7 is an arbitrary one. In the late stage of pregnancy, the death rario in fin whales is about three times higher than in the early stage of pregnancy. It is suggestible that the prenatal dead foetus is observed more frequently in the breeding area—subtropical waters—than in the feeding area—the polar waters. The curve of death ratio based on resorption is similar to that of the other terrestrial mammals.

It is impossible to obtain the real death ratio in fin whales, because the prenatal dead foetuses tabulated in Table 1 have been observed only by the biologists and trained inspectors in the Antarctic expeditions, therefore, these do not represent the all prenatal dead foetuses to be recorded as stated before, and because it is moreover difficult to know the abortion rate in fin whales. 17 records on dead foetuses of fin whale corresponds to 0.14% of 9400 foetuses observed by the Japanese expeditions in the Antarctic between 1946/47 and 1960/61 season. This percentage is the minimum value on the death ratio in the foetal stage of the fin whale. Although it is assumed that the death ratio in the foetal stage of fin whale is not very high, the rigid conclusion is not stated from the materials in this paper.

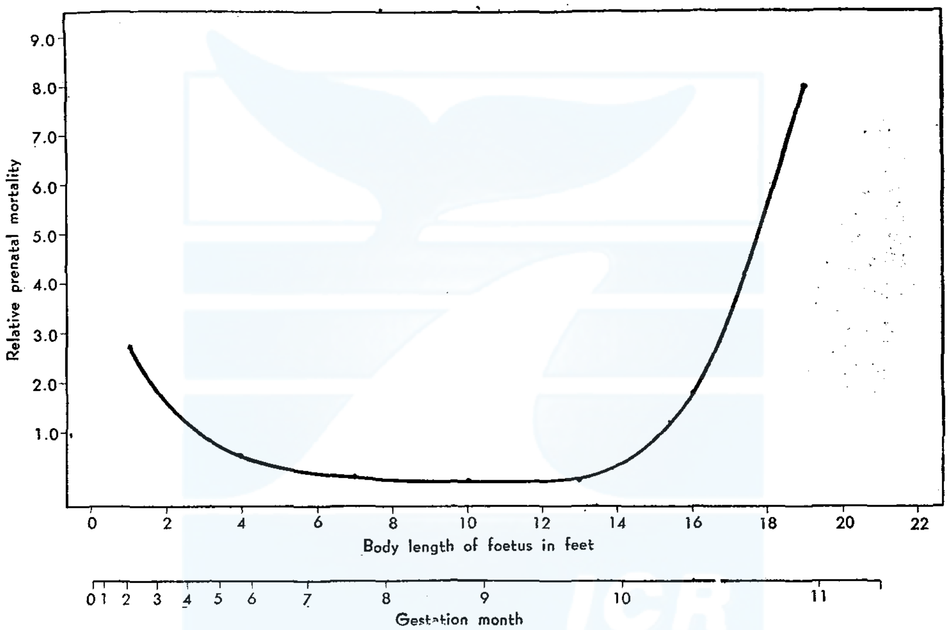


Fig. 7. Relative mortality resulted from reabsorption in the foetal stage of fin whale in the Antarctic.

It is noticeable in Table 1 that 13 female fin whales including prenatal dead foetuses are recorded from 1946/47 to 1960/61 Antarctic season and that particularly dead foetuses from 4 mother whales are observed in only 1960/61 Antarctic season, indicating the more frequent occurrence than in the other seasons. These mother whales were captured at the locality between 10°E and 40°E in the Antarctic Ocean. In the seasons except 1960/61 season, 3 female fin whales including prenatal dead foetuses were captured between 90°E and 110°E, 4 between 170°W and 180°W, 2 between 130°W and 150°W. This evidence suggests that the occurrence of prenatal dead foetus varies among the localities where mother whales migrate and so depends on the difference of hereditary nature among fin whale populations. Lethal genetic factors as confirmed in the other terrestrial mammals is possibly present in whales.

Prenatal dead foetuses and their membranes are removed from the uterus either by being forcibly expelled relatively intact or by being gradually autolysed or mummified. The former process is called abortion and the latter reabsorption or resorption. In relation to both process, Hammond (1914, 1921) states that in those species which produce only one young at birth, abortion of the foetus results from its death, but in those species in which many young are produced the dead and mummified embryos are carried in the uterus to full term and may be found mixed with the cleanings after birth. Brambell (1948) suggests that both process of occur in most, if not all mammals, but whereas abortion is the commoner in monoparous species, reabsorption is the rule in multiparous forms.

In whales as well as in the other mammals, the possibility of detecting prenatal mortality resulting from abortion at autopsy will be slight. Abortion is a muscular process, analogous to partrition, which, if carried to completion, results in the expulsion of the entire conceptus or conceptuses from the tract. A uterus which has aborted is difficult or, it may be, impossible to distinguish from a post-partum uterus. It is necesary to know the abortion ratio to analyse the death ratio in the foetal stage of whales, however, no information on abortion remains. According to Brambell's statement, abortion is the commoner in whales as monoparous species. It is, however, sure that the foetus being gradually autolysed or mummified is present in whales as indicated in this paper.

The process of reabsorption is a gradual one and its duration and result depend on the stage of development attained by the foetus at the time of death as well as upon other factors. In the case that the whale foetus is dead in the early stage of pregnancy, the foetus seems to be autolysed and reabsorbed later. The process of resorption appears in the previous chapter for the fin whale and the pigmy blue whale. Early foetus is rapidly and completely disintegrated and results in the green fluid in the mother's uterus as indicated in the record no. 15 in Table 1. Whereas, the foetuses in the late stage of pregnancy may resist complete maceration and their remains become shrivelled and mummified. Disintegration appears in some parts of foetal body in the course of mummification. Tail flukes, flippers and eyes are often lost or deformed in the mummified whale foetus. The embryonic fluids escape from the dead membrances, which collapse and closely invest the embryonic remains as pointed by Brambell (1948). Brambell's conclusion obtained from the study on prenatal mortality of wild rabbit that these changes are characteristic of foetus dying during the life of the mother and that it is easy to distinguish at autopsy between such foetuses and those which survived to the time of the mother's death, even in uteri in which post-mortem changes are advanced, can be applied to the whale foetus.

SUMMARY

The records of prenatal dead foetuses of whales, examined on boad the Japanese factory ships in the Antarctic whaling season from 1946/47 to 1960/61, were arranged and analysed. They are observed in the uteri of mother whales at autopsy and are composed of 17 fin whales, 1 blue whale, 1 pigmy blue whale and 1 sei whale. 3 prenatal dead foetuses of fin whales were observed by biologists in the North Pacific expeditions from 1952 to 1960. The following conclusion is summarized from the observation on these prenatal dead foetuses.

1. It is easy to discriminate at autopsy between the prenatal dead foetus and that which survived to the time of the mother's death.
2. In the uterus of the mother whale, only the prenatal dead foetus resulting in reabsorption or resorption is observed. It is difficult to obtain the information on abortion from the whale migrating in the high latitude waters.
3. The prenatal dead foetus in the early stage of pregnancy is rapidly disintegrated and reabsorbed. The dead foetus in the late stage of pregnancy is mummified and remains in the mother's uterus for a fairly long time.
4. The ratio of resorption is very low for the fin whale, however, it is estimated to occupy more than 0.14% of the all foetuses. It is the lowest from 9 to 10 gestation months for the fin whale and it is higher both below and over such range of gestation months. The prenatal dead foetus is observed more frequently in the late stage than in the

early stage of pregnancy.

5. The prenatal dead foetus of fin whale occurs in the higher frequency in the locality between 10°E and 40°E in the Antarctic. This evidence suggests that the prenatal mortality is different among fin whale populations.

6. The death of multizygtic foetuses is observed more frequently than that in the single foetus.

7. In whales as well as in the multiparous species of the terrestrial mammals, the prenatal mortality seems to increase with the increment of maternal age.

REFERENCES

BRAMBELL, F. W. R. (1948). Prenatal mortality in mammals. *Biol. Rev.*, 23: 370-407.

DEANESLY, R. (1935). The reproductive processes of certain mammals. IX. Growth and reproduction in the stoat (*Mustela erminea*). *Philos. Trans.*, B, 225: 459-92.

HAMMOND, J. (1914). On some factors controlling fertility in domestic animals. *J. Agric. Sci.*, 6: 203.

——— (1921). Further observations on the factors controlling fertility and foetal atrophy. *J. Agric. Sci.*, 11: 337-66.

——— (1941). Fertility in mammals and birds. *Biol. Rev.*, 16: 165-90.

HENNING, W. L. (1939). Prenatal and postnatal sex ratio in sheep. *J. Agric. Res.*, 58: 565-80.

ICHIHARA, T. (1961). Blue whales in the waters around Kerguelen Island. *Norsk Hvalfangst-Tid.*, 50 (1): 1-20.

KIMURA, S. (1957). The twinning in southern fin whale. *Sci. Rep. Whales Res. Inst.*, no. 12: 103-125.

LAUPRECHT, E. (1932). Über die Fruchtbarkeit und das Geschlechtsverhaltnis beim Trakenker Pferde und ihre Beeinflüssung durch das alter der Eltern. *Landw Jb.*, 75: 389.

LAWS, R. M. (1958). Recent investigations on fin whale ovaries. *Norsk Hvalfangst-Tid.*, 47 (5): 225-54.

——— (1959a). On the breeding season of southern hemishere fin whales, *Balaenoptera physalus* (Linn.). *Norsk Hvalfangst-Tid.*, 48 (7): 229-351.

——— (1959b). The foetal growth rates of whales with special reference to fin whale, *Balaenoptera physalus* Linn. *Discovery Rept.*, 29: 281-308.

MACKINTOSH, N. A. and WHEELER, J. F. G. (1929). Southern blue and fin whales. *Discovery Rept.*, 1: 257-540.

MATSUURA, Y. (1940). [On the multiple pregnancies and multiple ovulations of the baleen whales]. *Jap. J. Zool.*, 52 (11): 407-14. (In Japanese).

MATTHEWS, L. H. (1938). The sei whale, *Balaenoptera borealis*. *Discovery Rept.*, 17: 183-290.

ROBINSON, A. (1921). Prenatal death. *Edinb. Med. J.*, 26: 137-51, 209-31.

THE COMMITTEE FOR WHALING STATISTICS (1961). International Whaling Statistics, 46.

WHEELER, J. F. G. (1930). The age of fin whales at physical maturity with a note on multiple ovulations. *Discovery Rept.*, 2: 403-34.

WRIEDT, C. (1928). Vererbung von Zwillingsgeburten bei Pferden. *Züchtungskunde*, 3: 455.

MESOPLODON BOWDOINI STRANDED AT AKITA BEACH, SEA OF JAPAN

MASAHARU NISHIWAKI

INTRODUCTION

Most of the news on stranded whales or dolphins in the coast of Japan by the Japanese local news papers are customarily sent to the Whales Research Institute. On 28th May, 1960, some cutting from the news paper arrived at the Institute. The author was informed through these cuttings, that a sei whale was found stranded on a beach near Akita City, and the article containd photograph showing the dissection of the whale by some fishermen and teachers to teach about whales to their primary school children. The photograph is shown in Fig. 1.

Seeing the photograph, the author perceived that the whale was not

Fig. 1. The whale was dissected by primary school teachers for practical education. (Photo by "Akita Sakigake News")

a sei whale but belonged to the rare *Mesoplodon* species. The whale had been caught only a few days before (on 22nd May, 1960) so the author telephoned to the Fisheries Section of the Akita Prefectural Office to investigate how the whale had been disposed of and where the bones of the whale had been carried out to. According to the report from the Section, almost all of the bone had been buried in the beach where the whale had been found stranded.

At that time the author was very busy, because he had just returned from Ryukyu and was planning to go to investigate fur seals in Ozuchi, Iwate Prefecture, in about two weeks. The author decided to go to Akita on the way from investigate fur seals.

Fig. 2. The whale and the family of the fisherman, many parallel lines can be seen.

About a month later from the time the author read the news, he went to Akita City. A staff of the Fisheries Section of the Akita Prefectural Office guided him to the exact spot where the whale was found stranded, on the Shimohama Beach which is about 30 minutes by car from Akita City.

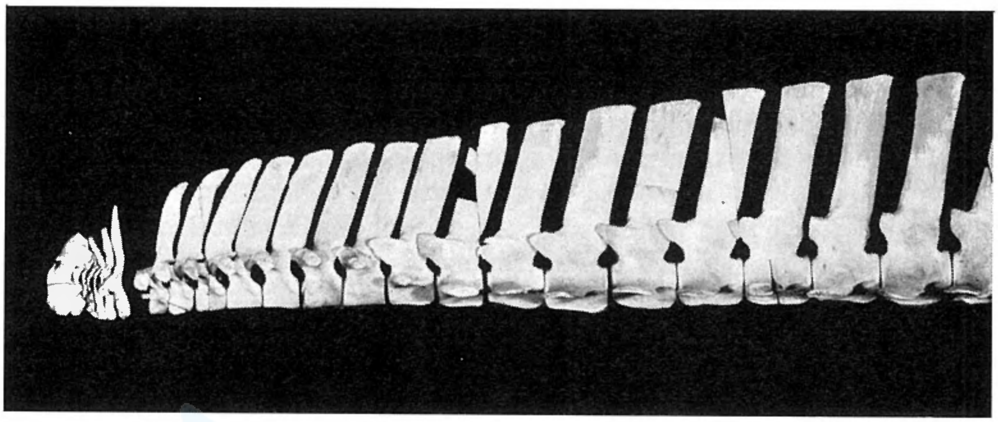
In the morning of 22nd May 1960, a fisherman named Nenosuke Akai who lived near the beach found a small whale kicking and struggling on the beach. He killed the whale and pulled it on to the sand with the help of his son and neighbours. They had never seen such a whale, so they went to the primary school nearby to ask to what species it belonged. The available picture book was not so detailed, and teachers told them that the whale might be a sei whale. They thought it was an unusual chance to teach the children about whales, so they took them to the beach show them the whale.

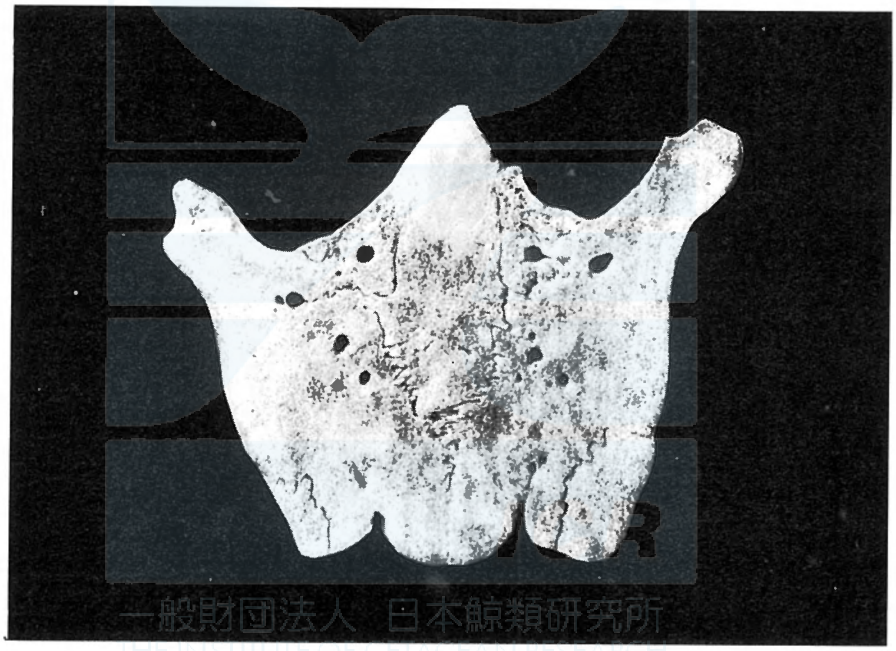
Mr. Akai's family and teachers dissected the whale, after which the meat and blubber were sold in the Akita fish market as human food. The bone was buried in the beach because they thought that the bone might become a specimen of a whale.

Fig. 2 shows the whale with Mr. Akai's family soon after it was taken. As shown in Fig. 2, many parallel lines are drawn on the skin surface of the whale. The author presumes these parallel lines are scars from the teeth of whales of the same *Mesoplodon* species, when they had fought with each other. A white patch is clearly seen on the left side of the body slightly forward from the dorsal fin. It seems to be a group of scars when the whale had incorred from strong rivals. Considering from these scars, the whale might have been defeated by its rivals and was so tired that it got stranded on the beach.

Fig. 3. Tailflukes. (after this photograph was taken, the tailflukes were carried out then thrown away)

The author went to the beach with Mr. Sudo who is a staff of the Fisheries Section of the Akita Prefectural Office and had some labourers to excavate the bones of whale. Fortunately, in spite of its having been buried in the sand, the skeleton was unearthed in a very good condition.





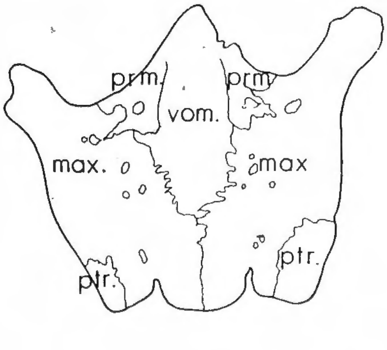
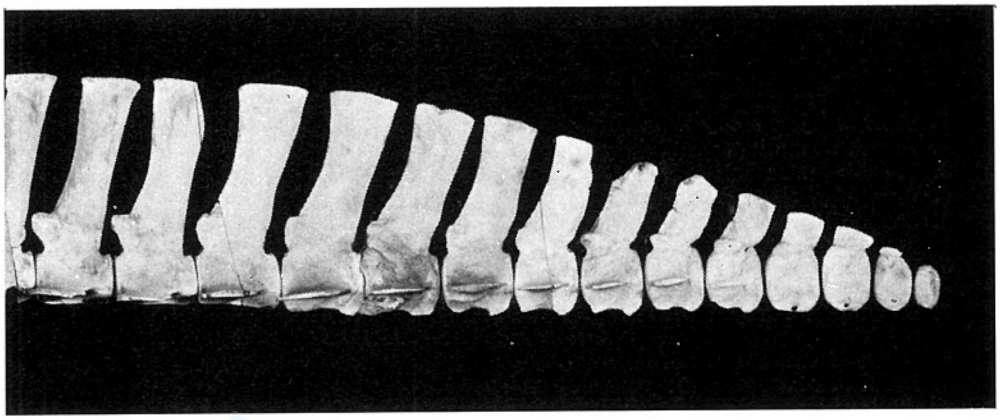


Fig. 5. The cross section of the snout, the vomer is well ankylosed with the premaxillae. (prm. . .premaxilla, vom. . .vomer, max. . .maxilla, ptr. . .pterygoid.)



↖↗ Fig. 4. Lateral view of verteblral column. Caudal vertebrae after 12th are lost. Deduced formula is C 7+D 10+L 10+Ca 19=46.

As shown in Fig. 3, the tail flukes had been cut off at its insertion and it was carried away by a staff of the Akita Fish Market to his house. He intended to make it into an ornament, but was forced to throw it away into a river due to the dirty dripping of the whale oil. Probably, he considered that the tail flukes were same as the caudal fin of a fish. Through this accident some caudal vertebrae contained in the flukes (probably 8 vertebrae) were lost. Also the right pectoral limb had been carried and was thrown away by him. The author regrets them very much that this accident had occurred. Though some of other parts of the skeleton had been cut with a saw at the time of dissection, most of them were preserved in a fairly good condition and be investigated. The left ribs were slightly more complate than the right ribs which were lost except for several number of heads. They probably had been dug out and carried away by stray dogs, for the right ribs had been buried nearer the surface. Though the skinned snout together with the mandibule and the mandibular teeth had been cut off to be made into an ornament, the dripping caused them to be buried in the sand in the original form and were later collected by the author.

Consequently, the cross section of the snout, shown in Fig. 5, was made at the point measuring 363 mm from the tip of the snout along the vomer. The point of cross section coincides to the most anterior part of the pterygoids. As is shown in Plate I the section is made abliquerely to the antero-posterior, infero-superior and lateral axis, which causes the asymmetry of the section.

The unearthed bones were skeletonized unexpectedly well, so they were packed at once in a box and sent to the Whales Research Institute, and were boiled there to make a complete specimen.

TABLE 1. DIMENSIONS OF SKULL

	mm	Percentage to the length	Percentage to the breadth
1. Total (condylo-basal) length	682	100.0	200.6
2. Length of rostrum (median)	403	59.1	118.5
3. Breadth of rostrum at base	186	27.3	54 7
4. Breadth of rostrum at middle	52	7.62	15.3
5. Breadth of rostrum at the position just above the teeth	46	6.7	19.7
6. Breadth of rostrum at the highest point of anterior palatin suture	126	18.5	37.1
7. Breadth of rostrum between the antorbital notches	191	28.0	56.2
8. Depth of rostrum at middle	68	10.0	20.0
9. Depth of rostrum at the position just above the teeth	62	9.1	18.2
10. Depth of rostrum at the hfghest point of anterior palatine suture	102	15.0	30.0
11. Length of premaxillae	L: 608 R: 619	89.1 90.8	178.8 182.1
12. Breadth of premaxillae at middle of rostrum	41	6.0	12.1
13. Breadth of premaxillae at expanded proximal end	131	19.2	38.5
14. Breadth of premaxillae at in front of anterior nares	112	16.4	32.9
15. Breadth of pramaxillae opposite premaxillary foramina	70	10.3	20.6
16. Breadth of premaxillae opposite maxillary foramina	65	9.5	19 1
17. Greatest breadth of premaxillae opposite anterior nares	112	16.4	32.9
18. Least breadth of premaxillae opposite anterior nares	107	15.7	31.5
19. Least distance between the postero-dorsal margins of the maxillary foramina	78	11.4	22.9
20. Least distance between the postero-dorsal magins of the premaxillary foramina	48	7.0	14.1
21. Least pistance between the maxillary foramina and premaxillary foramina	L: 23 R: 28	3.4 4.1	6.8 8.2
22. Distance from posterior border of maxillary foramina to anterior extremity of maxillary protuberance	L: 127[1)] R: 134	18.6 19.6	37.4 39.4
23. Length of nasal suture line	66	9.7	19.4
24. Greatest breadth of nasals	45	6.6	13.2
25. Greatest breadth of superior nares	52	7.6	15.3
26. Diameter of orifice of poserior nares immediately behinc pterygoid processes	116	17.0	34.1
27. *Distance from tip of rostrum to* bottom of maxillary notches	L: 401 R: 405	58.8 59.4	117.9 119.1
28. ——anterior end of vomer	422	61.9	124.1
29. ——anterior margin of superior nares	L: 502 R: 504	73.6 73.9	147.6 148.2
30. ——nosal vertex	583	85.5	171.5
31. ——medial sture line of posterior end of pterygoids	560	82.1	164.7
32. ——line joining anterolateral processes of moxillae	571	83.7	167.9
33. ——occipito-forutal vertex	607	89.0	178.5
34. ——posterior menian end of maxillae on palate	429	62.9	126.2

	mm	Percentage to the length	Percentage to the breadth
35. ——botton of tubal notch (median)	376	55.1	110.6
36. ——most anteior port of palatine	L: 363	53.2	106.8
	R: 363	53.2	106.8
37. Length of vomer visible on palate	243	35.6	71.5
38. Breadth across middle of orbits	340	49.9	100.0
39. Diameter of orbit (antero-posterior)	L: 97	14.2	28.5
	R: 95	13.9	27.9
40. Greatest breadth across supra-orbital plates of maxillae	335	49.1	99.7
41. Greates breadth across post-orbital processes	346	50.7	101.7
42. Breadth across zygomatic processes	333+1)	48.8+	97.9+
43. Breadth across posterior margins og temporal fossae	236	34.6	69.4
44. Greatest breadth of cranium at parietal region in temporal fossae	305	44.7	89.7
45. Length of temporal fossae	L: 86	12.6	25.3
	R: 89	13.0	26.2
46. Depth of temporal fossae	L: 62	9.1	18.2
	R: 67	9.8	19.7
47. Length of tympanic bone	L: 45	6.6	13.2
	R: 48	7.0	14.1
48. Greatest breadth of tympanic cone	L: 32	4.7	9.4
	R: 33	4.8	9.7
49. Breadth of occipital condyles	118	17.3	34.7
50. Breadth of foramen magnum	43	6.3	12.6
51. Length of occipital condyle	L: 80	11.7	23.5
	R: 80	11.7	23.5
52. Height vertex to inferior border of pterygoids	303	44.4	89.1
53. Length of wandible (median)	599	87.8	176.2
54. Length of wandibular ramus	L: 610 1)	89.4	179.4
	R: 611	89.6	178.7
55. Distance from anterior end of wandible to coronoid process	L: 589	86.4	173.2
	R: —1)		
56. Length of symphysis	L: 143	21.0	42.1
	R: 142	21.0	41.8
57. Distance from anterior end of mandible to anterior end of alveolus	L: 149	21.8	43.8
	R: 148	21.7	43.5
58. Distance from anterior end of wandible to posterior end of alveolus	L: 260	38.1	76.5
	R: 260	38.1	76.5
59. Depth of wandible at posterior wargin of tooth	L: 89	13.0	26.2
	R: 88	12.9	25.9
60. Depth between angle and coronoid process	L: 126 1)	18.5	37.1
	R: —1)		
61. Minimum depth of wandible between tooth and coronoid process	L: 90	13.2	26.5
	R: 90	13.2	26.5
62. Breadth across wandiblar condyles	287 1)	42.1	84.4
63. Length of tooth	L: 164	24.0	42.9
	R: 158 2)	23.2	46.5
64. Breadth of tooth (antero-posterior at crown)	L: 101	14.8	29.7
	R: 98	14.4	28.8
65. Breadth of tooth (transvers at crown)	L: 24	3.5	7.1
	R: 24	3.5	7.1
66. Length of tooth row	L: 342	50.1	100.6
	R: 340	49.9	100.0
67. Length of alveolus	L: 121	17.7	35.6
	R: 120	17.6	35.3

1) has deficit

2) tip broken

TABLE 2 DIMENSIONS OF VERTEBRAE (mm)

Number of vertebrae		(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	1st	36	43	118	154	193	45	51
	2nd					173	—	—
	3rd					136[1]	34	49
	4th	15	58	71	122	120+[2]	42	39
	5th	15	58	71	147	114+[2]	43	41
	6th	16	58	75	159	100[3]	46	45
	7th	19	62	76	220	147	51	46
D	1st	26	58	66	261	162	59	48
	2nd	41	54	61	285	171	58	46
	3rd	52	50	61	292	175	59	45
	4th	63	51	62	306	165+[2]	60	49
	5th	69	53	64	321	174	60	45
	6th	76	58	68	325	174[4]	58	45
	7th	84	56	74	327	171	51	47
	8th	91	58	79	335	171	49	45
	9th	86+[5]	61	79	365	251	45	42
	10th	103	66	80	377	320[6]	46	38
	11th	111	72	84	396	332	41	38
L	1st	114	76	86	417	316+[2]	47	38
	2nd	120	79	89	426	240+[2]	45	39
	3rd	124	81	91	441	205+[7]	42	39
	4th	129	85	93	457	167+[8]	43	36
	5th	137	90	97	462	319[9]	37	34
	6th	142	95	98	465	307[10]	31	30
	7th	150	95	100	456	321+	27	26
	8th	154	100	101	447	318	19	23
	9th	153	103	104	427	264+[11]	17	20
Ca	1st	150	107	108	424	303[12]	17	17
	2nd	143	109	125	405	282[13]	13	15
	3td	135	108	111	380	217+[14]	11	12
	4th	127	113	108	339	245[15]	8	11
	5th	123	112	118	284+[2]	191	8	10
	6th	111	114	117	253	168	8	8
	7th	108	109	109	220	128	5	7
	8th	100	102	98	136	103	—	5
	9th	89	102	90	155	95	—	3
	10th	69	94	89	114	92	—	—
	11th	62[2]	81	82	81	85	—	—

(1) Length of body at center
(2) Height of body at front end
(3) Breadth of body at front end
(4) Total height from anterior bottom
(5) Breadth of transverse processes
(6) Greatest height of neural canal
(7) Greatest breadth of neural canal

1) has dificit on right transverse process. Approximate.
2) has dificit.
3) deformed.
4) the front end of bods strongly deformed.
5) has deficit on the posterior end of body.
6) has deficit on right transverse process.
7) has large deficit.
8) excluded right transverse process. encluded value 288+.
9) Deformation and deficit on left and right transverse processes respectively.
10) has deficit on sight transverse process. excluding left proeess 165.
11) deficit on both transvearse process.
12) pathological change, dificit on transverse process.
13) dody front greatly pathological change.
14) both transverse process broken, pathological change on the body.
15) right transverse process broken, left side only: 104 mm.

NOTE ON THE EXTERIOR

The external measurements and the morphological observations of the present specimen are very difficult to goage as in the case of the previous specimens in Japan. It is only known that the specimen was a 6 meter long male whale and several photographs of it were taken before dissection. The weight of the soft part is olso unknown.

OSTEOLOGICAL AN TAXONOMICAL DISCUSSION

At the beginning of the study, the author selected some species of *Mesoplodon*, which might coincide with the present specimen from the Table 6 of "A beaked whale *Mesoplodon* stranded at Oiso Beach, Japan" which was published in the Scientific Reports of the Whales Research Institute No. 13, 1958. The present specimen is compared with *M. bidens*, *M. stejnegeri*, *M. bowdoini*, *M. densirostris* and *M. ginkgodens* in the following paragraphs.

Skull: The measurements of the skull are shown in Table 1. The size of the skull is not very different from those of the above species. The author thinks that the age through ossification is at about the same stage as the two specimens that he has reported in his previous papers. But the vomer was markedly developed. The first character of the skull is the relative position of the premaxillary and maxillary foramina.

Moore, J. C. of the American Museum of Natural History has stated that "the relative position of the premaxillary foramina and the maxillary foramina is variable within the sample now known of *Mesoplodon mirus* and, for this species, has no taxonomic worth. In *M. gervaisi* its worth is very doubtful. The proposition may be more constant in some of the other species of *Mesoplodon*, but its advocates have not demonstrated that this is so any more firmly than they have for *gervaisi* and *mirus*", in his study titled "New Records of the Gulf-Stream Beaked Whales, *Mesoplodon gervaisi*, and Some Taxonomic Considerations".

The authors of the report of the *Mesoplodon* stranded at Oise Beach in their wishes to express that the specimen of the Oiso Beach is different from any other previous species, they alluded to *M. mirus* and *M. gervaisi* without sufficient data, and they may have said too much. The authors think that the relative position of the premaxillary foramina and maxillary foramina is a more suitable character in identifying the species than the presence or absence of the lateral basirostral groove in the various other species of *Mesoplodon*.

Moore has explained the 25 distinctions between *M. gervaisi* and *M. mirus*. The work regarding the distinctions is very valuable in the accumulation of knowledge on the *Mesoplodon* study. The author, however, would like to know which is the most fundamental charactor for classifying the various species of *Mesoplodon*. From considerations of the present knowledge, the author cannot help relying on the relative position of the premaxillary foramina and the maxillary foramina in classifying the various species of *Mesoplodon*. The author accepts, of cause, that *M. mirus* or *M. gervaisi* are exceptions, and would like to accumulate more data on this specific subject.

The author was accumulated perhaps a too great a number of dimensions, figures and plates on the specimens, but wishes to make them available as data in determining the species of *Mesoplodon*.

The premaxillary foramina of the present specimen are situated more caudally from the maxillary foramina. From this fact *M. bidens* and *M. ginkgodens* were omitted from the comparison with the present specimen. The middle figure in the Plate II clearly shows this character.

The second character is the existence of the basirostral groove. The basirostral groove of the present specimen could be seen clearly from the tip of the snout to the forepart of the antorbital notch, but it was shallow and inconspicuous. Ravan discribed that this character is absent in *M. stejnegeri* and *M. bowdoini*. The present author, however, already mentioned in his previous paper that the groove is remarkably present in *M. stejnegeri* and *M. bowdoini* (Nishiwaki & Kamiya, 1958, p. 69). In the first and second characters the present specimen can not be classified in the three species, *M. stejnegeri, M. bowdoini* and *M. densirostris*.

The third character is the shape of the teeth and the position where the teeth are situated. All of these three species have very large teeth, but the compressed rate is different. The teeth of *M, stejnegri* are strongly compressed at the rate of Ca. 1/7 between antero-postero length and transverse thickness at crown. And the root of the teeth are directed extremely foreward. The teeth of *M. bowdoini* have the rate of 1/3–1/4, and the teeth of *M. densirostris* have the rate of 1/2–1/3. The teeth of the present specimen have the rate of Ca. 1/4. According to the preceding authors, the lengths of symphysis are short in these species. The length of symphysis of the present specimen is also short. In the present specimen the teeth are situated entirely behind the symphysis.

Other observations made on the skull are as follows. The maxillary protuberance is pronoucedly large, and the distance from the occipital condyle to the premaxillary foramen is much less than the greatest width of the skull.

The author hopes to discuss not only on the measurements of the skull, but also the shape of the skull with the Plate XII–XV of the previous report (Nishiwaki & Kamiya, 1958)

There are considerable differences in dorsal view of the maxillary notch of the various species including the present specimen. The author can not explain this difference now.

In the lateral views of the various species, the skull of *M. bowdoini* (No. 31756 of the American Museum of Natural History) closely resembles that of the present specimen. Furthermore, when compared with the mandibles, especially in the dorsal view, the present specimen strikingly resembles the specimen of *M. bowdoini* (No. 31756 of AMNH).

Length of symphysis and situation of teeth are quite similar, only the bending of the teeth are different. The author thinks that this difference usually occurs in the same species of whales. As in discriptions of the previous authors, the teeth of the present specimen are also very large and imposing. In the frontal edges of the teeth some erosions were seen. The eroded parts on the teeth are where the teeth have grown from the gum, and the teeth have heavier erosion on the inner surfaces of the teeth plates. The intensity of erosions was found to be about the same degree on both sides. From the observation of the skull with the mandible attached, there is a considerably wide speace around the teeth. Caries of teeth were considered, the erosion is too bisymmetrical on the bilateral teeth, and there is no sign of invalid tissue. From these characteristics, this erosion might have occurred simply through rubbing. What has caused this rubbing? The author can think of no other cause than the rubbing of the teeth with the skin of the upper jew. It is a very strange matter.

Vertebral column. The dimensions and the photograph of the lateral view of the vertebral column are shown in Table 2 and Fig. 3 respectively.

Cervicals: Detailed explanations on the cervicals by previous authors are very scarce. The author considers that classifying dolphin species by means of the shape of cervicals simultaneously with the skull dimensions is available.

He has aimed mainly at innatal ankylosis of cervicals. The author had a chance to compare the cervicals of the three specimen; *M. ginkgodens*, *M. stejnegeri* and the present specimen. In the case of *M. ginkgodens*, the first three cervical vertebrae are ankylesed at the bodies as well as at the neural arches. The 4th and the 5th cervical ones are also ankylosed with each other, but it is considered that there is a chance occurred postnatally. On the cervical vertebrae of *M. stejnegeri*, only the atlas and the axis are ankylosed, and other five free. In the present specimen the first three cervicals are ankylosed and the remaining four are free. The characteristics of these fixtures can not be understood by taking the measurements, and the shapes of the cervicals closely resemble each other even in the different species. Precise observations of the real specimens, therefore, are necessary.

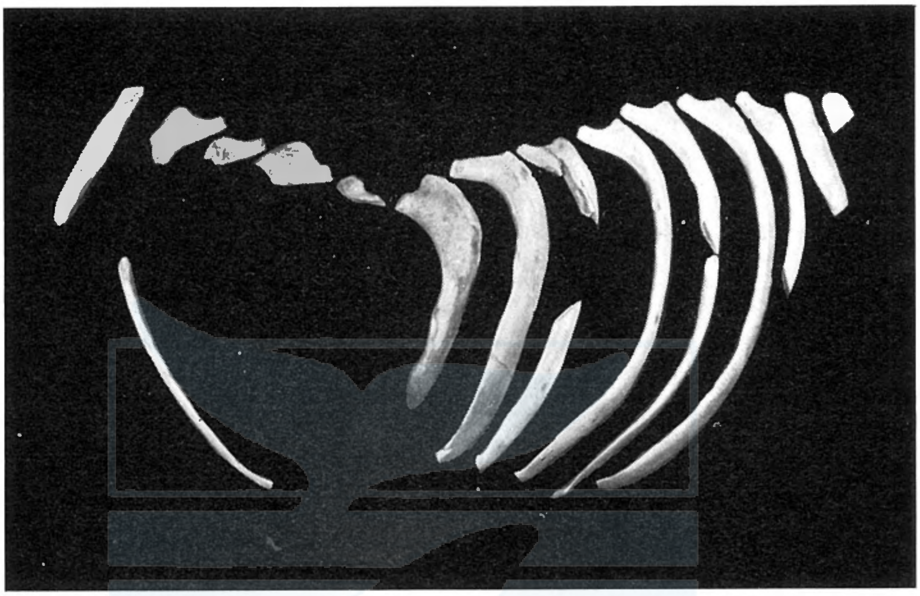


Fig. 6. Medial view of the vertebral ribs, the major parts of the right side were excavated by wild dogs.

TABLE 3 DIMENSIONS OF RIB (mm)

Number of rib	Straigh length		Length along visceral border		Breadth at middle		Depth at middle		Breadth at heads	
	L	R	L	R	L	R	L	R	L	R
1*	342	—	310	—	48	—	23	—	84	—
2*	494 1)	—	523	—	54	—	21	—	— 2)	83
3*	— 2)	—	—	—	—	—	—	—	82	80
4*	586	—	666	—	38	—	18	—	81	82
5*	— 2)	—	—	—	—	—	—	—	81	—
6*	637	—	750	—	42	—	17	—	80	—
7*	—	—	—	—	—	—	—	—	75	—
8	—	—	—	—	—	—	—	—	38	39
9	—	—	—	—	—	—	—	—	38	—
10	—	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—	—

* two headed 1) has deficit 2) broken

These characteristics on the cervical vertebrae are also considered as an important feature.

Dorsal, lumbar and caudal vertebrae: The numbers of dorsal vertebrae are usually determined by the number of the ribs. However, the last rib is difficult to find in many cases. In such a case the discription will be based on an unexactly number. The same can be considered regarding the lumbar or the caudal vertebrae. The author therefore mainly used the shapes of the vertebral bones and the number of the attached bones as supplementaly factors. The present specimen has incomplete number of ribs as shown in Fig. 6. Judging from the above factors and data, the dorsals are determined as ten, 7 two-headed ribs, 2 jointed ribs and a non-jointed rib. The number of two-headed and jointed ribs is the same as other specimens of *Mesoplodon*, but the number of non-jointed rib is a question. The author determined the number of ribs by the shapes of the lateral processes of the vertebrae and the protuberance of the under surface of the centrum vartebrae. The protuberance of centrum on the 18th vertebra is not higher than that of the 19th, but that of the 17th and the frontward vertebrae are very low. Considering this fact, the number of dorsals might be 10, i. e. the number of ribs is presumed to be 10. Observing the first chevron bone is also unavoidable at times. The protuberance of the centrum vertebrae are devided into two lines when the chevron is attached, and those on the under surface of the first caudal is usually Y or V shaped. This fact is shown Fig. 3 of page 43 in the Scientific Reports of the Whales Research Institute No. 14, 1959. In that Fig. 3 the first caudal are shown in the middle.

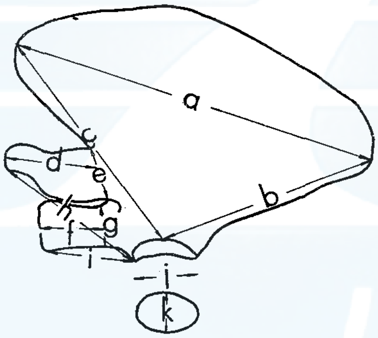
In the Fig. 3 of the present specimen, the 28th bone of the vertebral column is the first caudal vertebra. A half rounded projection can be seen at the rear end of the under surface of the bone, and this is the part to which the chevron is attached. These projections are clearly seen on the following bones. The chevron bones of the present specimen were collected from the sand thoroughly with the caudal vertebrae attached. Only the first chevron is divided two pieces, the other chevrons are fused as a single bone. The caudals after No. 12 are contained in the part of the tailflukes. The tailflukes were cut by a saw at its insertion. Even 1/4 of caudal No. 11 was cut off. Although the exact number of caudals are unknown, the estimated number contained in the tailflukes are usually 8 in the *Mesoplodon* species. The number of caudals that have no neural processes is generally 9. Judging from these hypothesis, the number of caudals in the present specimen are presumed as 19. The vertebral formula of the present specimen therefore is shown as $C\,7+D\,10+L\,10+Ca\,19=46$.

All the epiphyses of the vertebrae were fused to their centrum and the epiphyses of all the other parts of the skeleton were observed as being in the ankylosed condition. For that reason the present specimen is very old, without mentioning its physical maturity.

All cervicals, 2nd, 3rd and 9th dorsals, 3rd 4th, 7th, 9th and 10th lumbars, 4th and 11th caudals of the vertebrae have some incised scar caused by a saw. The first to the 3rd dorsals, the 8th lumbar and tne first and 2nd caudals have some pathological deformity.

Pectoral rimb : The right flipper was not collected as mentioned above. In spite of the careful excavation, some phalangeal bones of the left flipper were lost as shown in Plate VI due to its having been buried naked. The author can not give his opinion on these skeletons. Both the scapulae were collected and observation shows that the shape is similar as in other species of *Mesoplodon.* Measurements are given in Table 4.

TABLE 4 DIMENSIONS OF SCAPURA (mm)

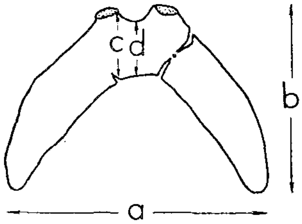


	L	R
a.	386	388
b.	254	250
c.	269	263
d.	107	—
e.	61	—
f.	80	—
g.	48	—
h.	155	—
i.	104	—
j.	72	71
k.	55	56

Sternum and Hyoid bone : The sternum consists of four segments as in the other *Mesoplodon* species. The right side of the bones were lost due to cutting by the saw. Photograph and dimensions of the hyoid bones are shown in Plate VI and Table 5 respectively. The basihyal and thyrohyals are ankylosed. The shape of stylohyals are different from the two previous specimens in Japan.

The bones around the pelvic region could not be found at the excavation. It may have been carried to the market with the fresh. Judging from these osteological and taxonomical discussion, the present specimen is considered as a *Mesoplodon bowdoini.* This is the first record on this species in Japan, especially at the coast of the Sea of Japan.

TABLE 5 DIMENSIONS OF BASIHYAL, THYROHYALS AND STYLOHYALS (mm)



a.	192	The greatest length and breadth of stylohyals		
b.	142			
c.	55	L	155	51
d.	41	R	153	50

TABLE 6 DIMENSIONS OF CHEVRON BONE (mm)

Number of chevron bone	Greatest length (antero.posterior)	Greatest breadth (transverse)	Greatest height (supero-inferior)
1st	69	21	31
	64	18	28
2nd	94	49	73
3rd	94	66	128
4th	113	70	150
5th	90	67	125
6th	84	67	103
7th	85	65	91
8th	82	54	67
9th	60	46	41

SUMMARY

A six meter long male whale had been found stranded at Akita Beach attended to the Sea of Japan.

Almost all of bone had been buried in the beach, but unfortunately, the tail flukes including about eight bones of the caudal vertebrae and the right pectoral limb had been lost, because of these parts were carried out to the fishmarket then thrown away.

Judging from the osteological and taxonomical discussion, the present specimen is considered as a *Mesoplodon bowdoini*. This is the first record on this species in Japan. The referred reasons are as follows.

1. In spite of the kind suggestion of Moore, the author cannot help relying on the relative position of the premaxillary foramina and the maxillary foramina in classifying the various species of *Mesoplodon*. The premaxillary foramina of the present specimen are situated more caudally from the maxillary foramina.

2. The basirostral groove of the present specimen could be seen clearly, but it was shallow and inconspicuous.

3. The teeth of the present specimen have the rate of 1/4 between antero-postero length and transverse thickness at crown. The length of symphysis is short and the teeth are situated entirely behind the symphysis.

4. The vertebral formula of the present specimen is shown as C 7+D 10+L 10+Ca 19=46.

ACKNOWLEDGEMENT

The author would like to express his sincere thanks of Mr. Nenosuke Akai and his family for their kind presentation of the specimen that they have caught. Sincere thanks are also given to Mr. K. Ishiwaka and the staff of the Fisheries Section of the Akita Prefectural Office for their appropriate supervision in preserving the specimen. Particularly to Mr. M. Sudo who had excavate the bones of the whale with the author. The author is deeply grateful for his kindness.

The author is most grateful for the courtesy extended by the Akita Sakigake News who had been so kind as to furnish him with the photographs of the whale.

REFERENCES

ANDREWS, R. C. (1908). Description of a new species of *Mesoplodon* from Canterbury Province, New Zealand. *Bull. Amer. Mus. Nat. Hist.*, 24(13): 203–15.

FLOWER, W. H. (1878). A further contribution to the knowledge of the existing ziphioid whales: genus *Mesoplodon*. *Trans. Zool. Soc. London*, X, part II: 415–37.

HUBBS, C. L. (1946). First records of two beaked whales, *Mesplodon bowdoini* and *Ziphius cavirostris*, from the Pacific coast of the United States. *J. Mammal.*, 27(3): 242–55.

MOORE, J. C. (1958). A beaked whale, from the Bahama Islands, and comments on the distribution of *Mesoplodon densirostris*. *Amer. Mus. Nov.*, 1897: 1–12.

——— (1960). New Records of the Gulf.Stream Beaked Whale, *Mesoplodon gervaisi*, and Some Taxonomic Considerations. *Amer. Mus. Nov.*, 1993:1–35.

MOORE, J. C. & F. G. WOOD (1957). Differences between the Beaked Whales *Mesplodon mirus* and *Mesoplodon gervaisi*, *Amer. Mus. Nov.*, 2813: 1–25.

NISHIWAKI, M. & T. KAMIYA (1958). A beaked whale *Mesoplodon* stranded at Oiso Beach, Japan. *Sci. Rep. Whales Res. Inst.*, no. 13: 53–83.

——— (1959). *Mesoplodon stejnegeri* from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 14: 35–48.

RANKIN, J. J. (1956). The structure of the skull of the Beaked Whale, *Mesoplodon gervaisi* Deslongchamps. *J. Morphol.*, 99(2): 329–57.

RAVEN, H. C. (1937). Notes on the taxonomy and osteology of two species of *Mesoplodon* (M. europaeus Gervais, M. mirus True). *Amer. Mus. Nov.*, 905: 1–30.

——— (1942). On the structure of *Mesoplodon densirostris*, a rare beaked whale. *Bull. Amer. Mus. Nat. Hist.*, 80: 23–50.

TRUE, F. W. (1910). An account of the beaked whales of the family Ziphiidae etc. *Bull. U.S. Nat. Mus.*, 73: 1–89.

EXPLANATION OF THE PLATES

PLATE I

Skull of *Mesoplodon* from Akita Beach with mandible attached; lateral, dorsal, anterior and posterior views (top to bottom).

PLATE II

Lateral, dorsal and ventral views (top to bottom) of skull of *Mesoplodon* from Akita Beach.

PLATE III

Lateral, dorsal and reversed lateral views (top to bottom) of mandible of *Mesoplodon* from Akita Beach.

PLATE IV

Teeth of *Mesoplodon* from Akita Beach. (Left one in figures is right side tooth).

Fig. 1. Reversed lateral view.
Fig. 2. Lateral view.
Fig. 3. Dorsal view.
Fig. 4. Rostral view.

PLATE V

Figs. 1 and 2. Lateral and caudal views of cervical vertebrae of *Mesoplodon* from Akita Beach.

Figs. 3 and 4. Cranial and caudal views of each bones of cervical vertebrae of *Mesoplodon* from Akita Beach.

Fig. 5. Left side lateral views of each chevron bones (from the first to 9th, left to right respectively).

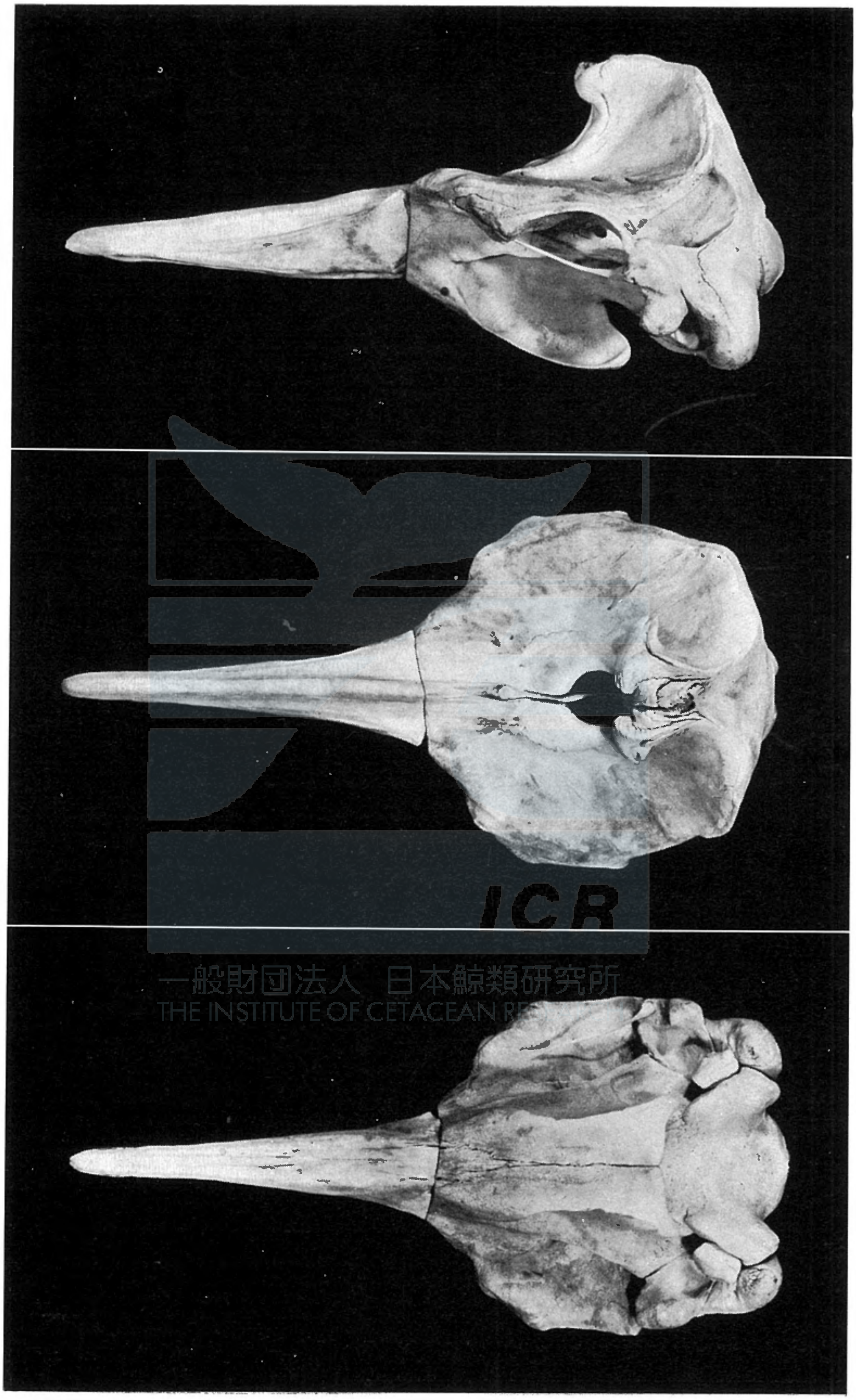
PLATE VI

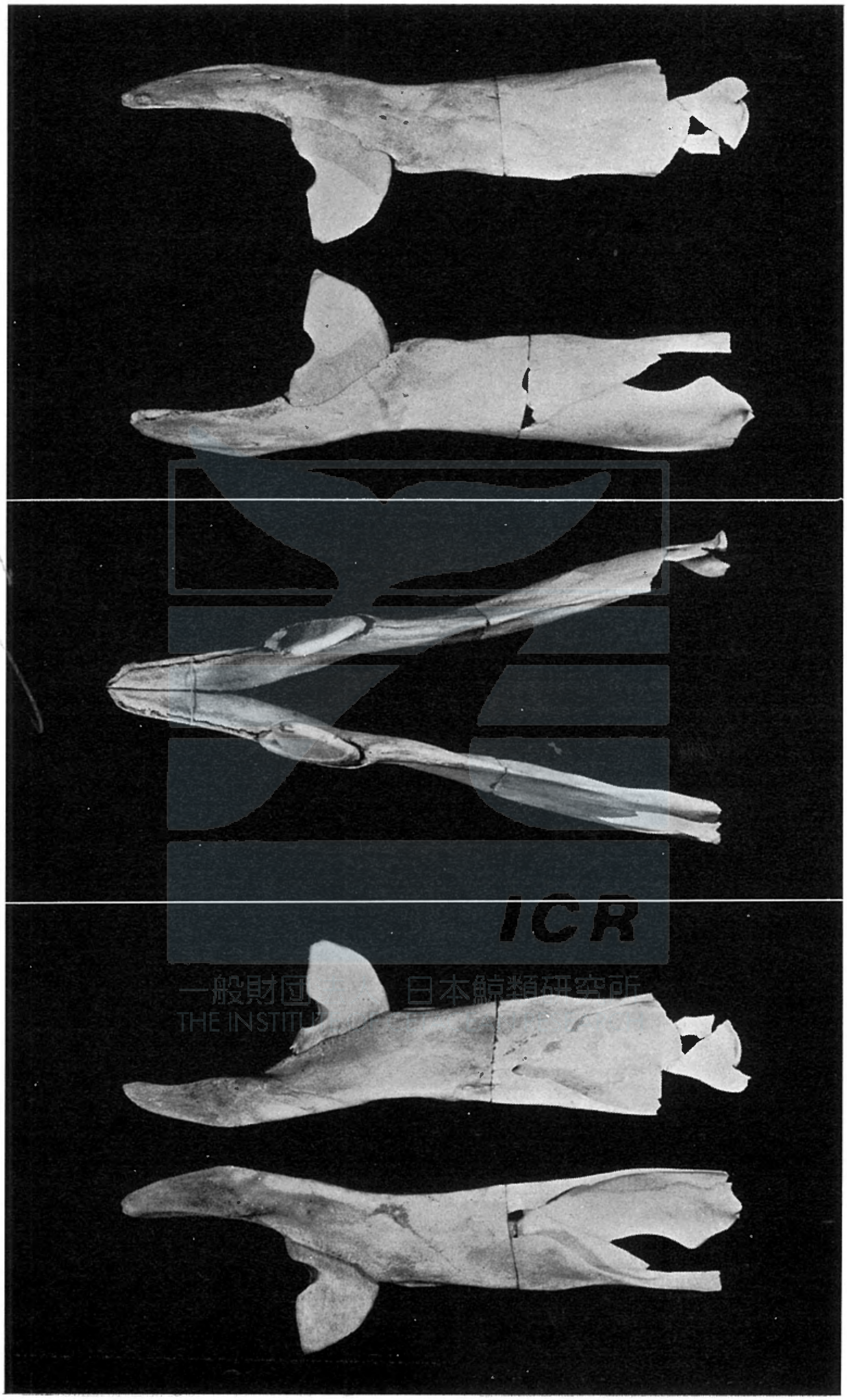
Fig. 1. Dorsal view of left pectoral limb with scapula attached, and right side scapula (dimentions are shown in Table 5).

Fig. 2. Dorsal view of sterum, right sides are cutted away by a saw.

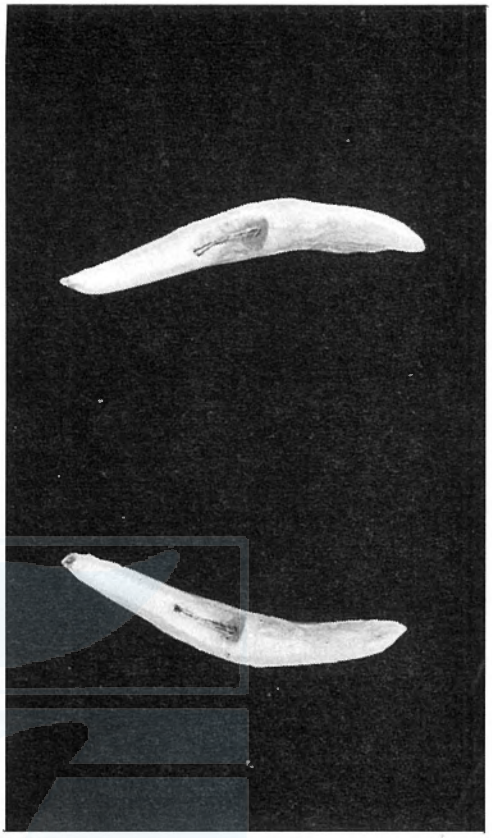
Fig. 3. Dorsal view of hyoid bones (dimentions are shown in Table 6).

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH



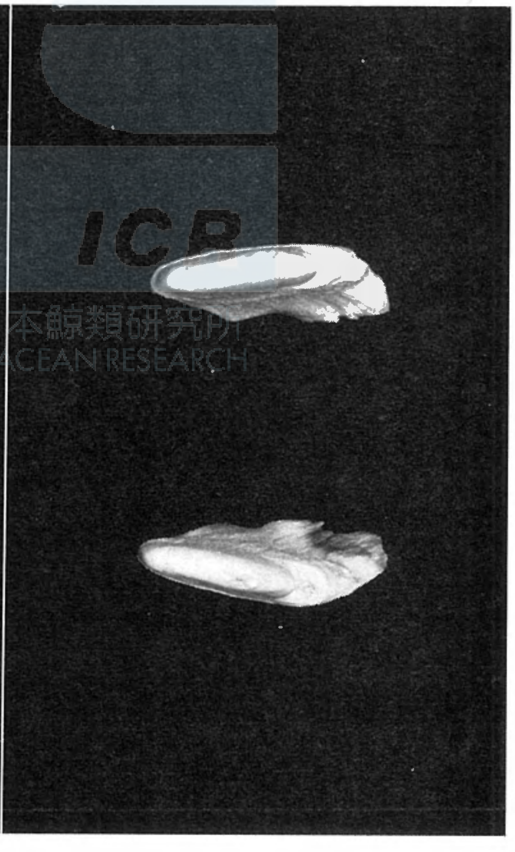


1



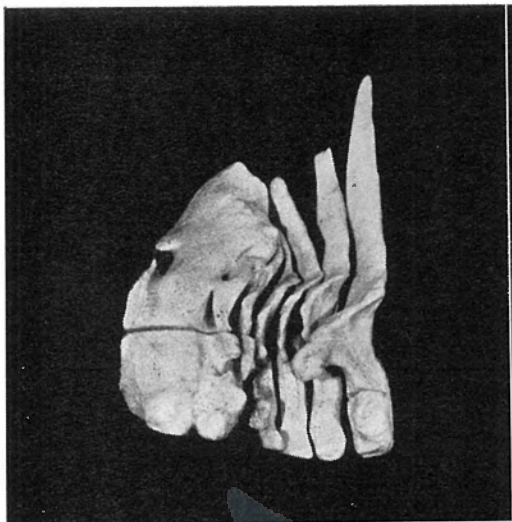
4

2

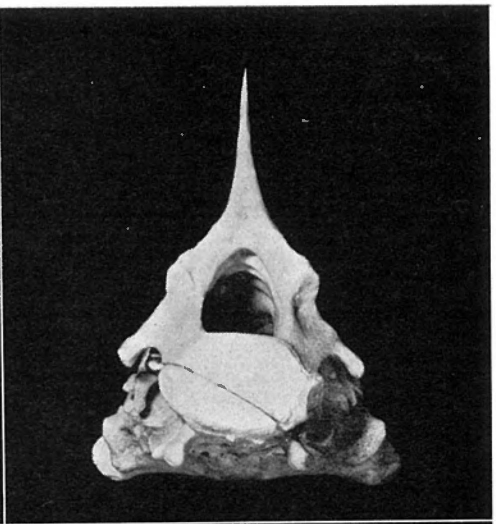


3

1



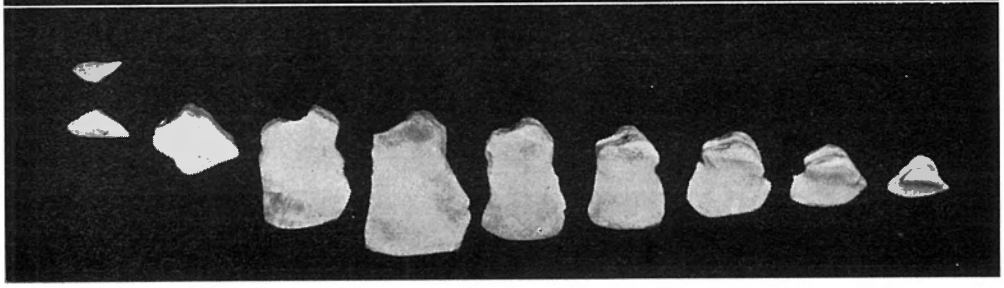
2

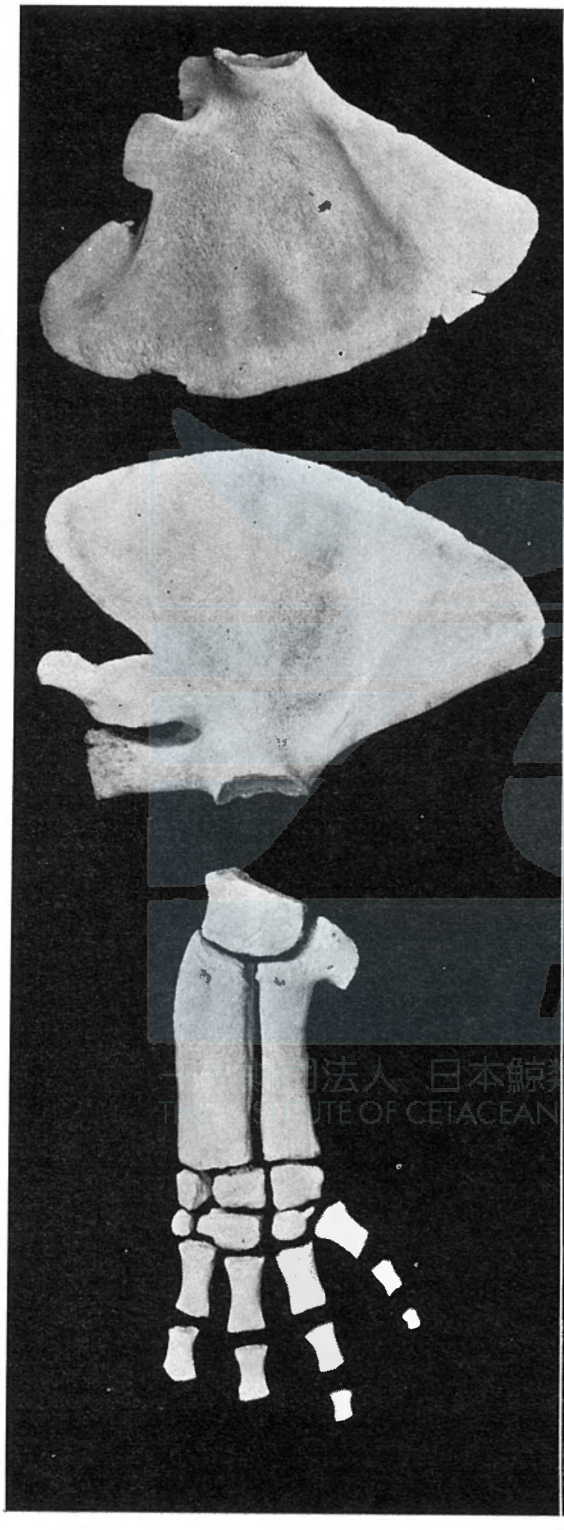


3

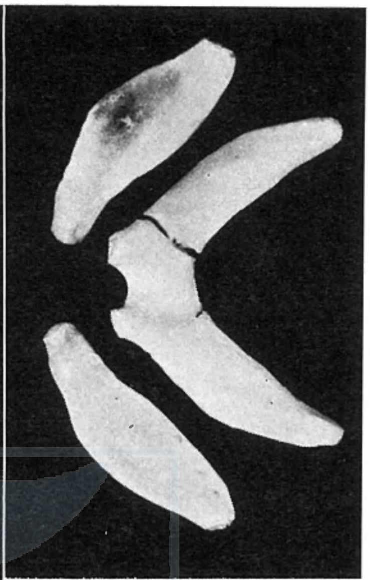
4

5

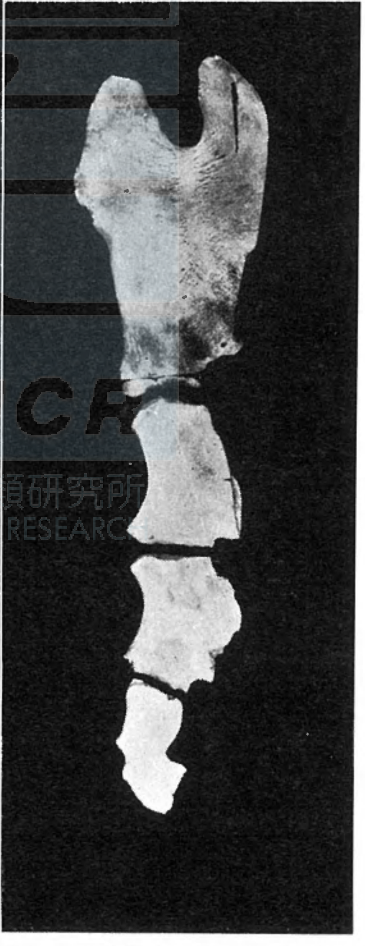




1



2



3

OBSERVATION ON TWO MANDIBLES OF *MESOPLODON*

MASAHARU NISHIWAKI

In 1958 the author reported the *Mesoplodon ginkgodens* as a new species of the Ziphioid whales. Yet not many comments on this report have been received. But some one might consider that, *M. ginkgodens* closely resembles *M. stejnegeri* or *M. bowdoini*. On the other hand some may be of the opinion that a sufficiently adequate series of specimens is not available to determine the limit of variation.

Now, the author has collected some mandibles of young *Mesoplodon*. The collection is very interesting as an accumulation of adequate series of specimens.

Late in June, 1960, after the author send the specimen of *Mesoplodon* stranded at the Akita Beach to the Whales Research Institute, he went to Ayukawa for his routine work on whale investigation. Mr. Y. Kimura was waiting for him in Ayukawa, and he regreted that the two whales perhaps belonging to *Mesoplodon* which were caught in several days ago, had not been preserved. When he went to the whaling station, however, one pair of the mandibles of the whale (Ayukawa Mesoplodon No. 2) and a left side mandible of the other whale (Ayukawa Mesoplodon No. 3) were found, but most of the bones had been already treated in the cooker. These whales were caught by " Hachiryu-maru ", which is a catcher boat for small species whaling, at a point about 30 miles southeast of Kinka-san within a few days. The whaling company reported on both individuals as being a 15 feet long male Cuvier's beaked whale (*Ziphius cavirostris*). Measurements of these mandibles are shown in Table 1.

The body lengths of the whales as well as the mandibles have certain similarities in sizes. However the shape of the teeth and the position where the teeth are situated give an impresion that they belong to a different species. Ayukawa Mesoplodon No. 3 has a tooth that closely resembles that of the Ogawa specimen of *M. ginkgodens* (Nishiwaki & Kamiya, 1958). This tooth was under growth and the root is not completed as shown in Fig. 2 of Plate II.

The teeth of the Ayukawa Mesoplodon No. 2 are snaped at the part where the teeth are inserted into the alveolae. This was caused by perhaps a worker trying to take out the teeth with a rod. The upper half of the teeth were placed near the cooker for a few days. When the author went to the factory with Mr. Kimura, these pieces of the teeth had been already lost. Observation of the lower half of the teeth showed that the roots were almost finished with the pulp cavity slightly showing. From this point of view the specimen No. 2 may be considered as slightly older than the specimen No. 3.

The author can not say whether the teeth have appeared from the gum or not. It seems that in the case of Physeter the teeth cut the gum when they reach sexual maturity, and in the most of the species of Delphinidae the teeth grown up from the gum when they reach the weaning period. It seems that in case these two individuals reach the same age at about the same time, many differences on the teeth and mandibular characteristics may appear. The author concludes that these two specimens do not belong to the same species. The author received the impression that the specimen No. 2 belongs to *M. stejnegeri* and the specimen No. 3 is presumed as *M. ginkgodons*, though the available data were scanty.

TABLE 1. MEASUREMENT OF THE MANDIBLES

Serial No. of specimen	Ayukawa No. 2 (M. stejnegeri)		Ayukawa No. 3 (M. ginkgodens)
	Left	Right	Left
Length of mandible	702 mm	709 mm	666+ mm (700)
Distance from anterior end of mandible to coronoid process	685	687	648+ (682)
Length of symphysis	191	191	136+ (172)
Distance from anterior end of mandible to anterior end of alveolus	152	150	92+ (130)
Distance from anterior end of mandible to posterior end of alveolus	242	243	126+ (158)
Depth of mandible at posterior margin of tooth	76	74	67
Minimum depth of mandible between tooth and coronoid process	63	63	61
Breath across mandiblar condyles	345		
Distance from coronoid process to angle	116+, (138)	112+, (132)	124
Vertical length of tooth	—	—	52
Horizontal length of tooth	72	69	75
Breath of tooth (transverse)	8	7	7

As result of the foregoing observations, it seems that some Ziphioid whales, that belong to Mesoplodon, were caught as *Ziphius cavirostris* in the past days at Ayukawa. The parties concerned in whaling should observe the Ziphioid whales more carefully in the future in order to avoid the repetition of similar oversights.

The author is much indebted to Mr. Yoshinori Kimura for his constant kindness and support.

REFERENCES

FLOWER, W. H. (1878). A further contribution to the knowledge of the existing ziphioid whales: genus *Mesoplodon*. *Trans. Zool. Soc. London,* X. part 11: 415–37.

MOORE, J. C. (1960). New Records of the Gulf-Stream Beaked Whale, *Mesoplodon gervaisi,* and Some Taxonomical Considerations. *Amer. Mus. Nov.* 1993.

NISHIWAKI, M. & T. KAMIYA (1958). A beaked whale *Mesoplodon* stranded at Oiso beach, Japan. *Sci. Rep. Whales Res. Inst.*, no. 13: 53–83.

——— (1959). *Mesoplodon stejnegeri* from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 14: 35–48.

RAVEN, H. C. (1937). Notes on the taxonomy and osteology of two species of Mesoplodon (M. europaeus Gervais, M. mirus True). *Amer, Mus. Nov.* 905: 1–30.

EXPLANATION OF PLATES

PLATE I

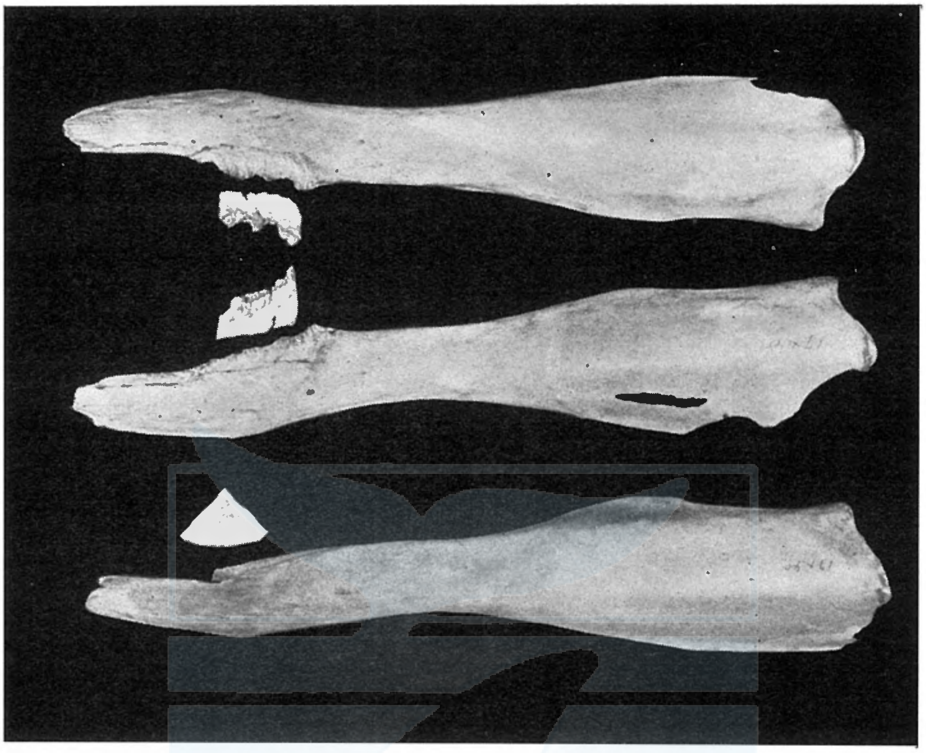
Fig. 1 (Upper). Lateral views of mandibles. Upper two are *Mesoplodon stejnegeri* of Ayukawa specimen No. 2, and lower one is *Mesoplodon ginkgodens* of Ayukawa specimen No. 3.

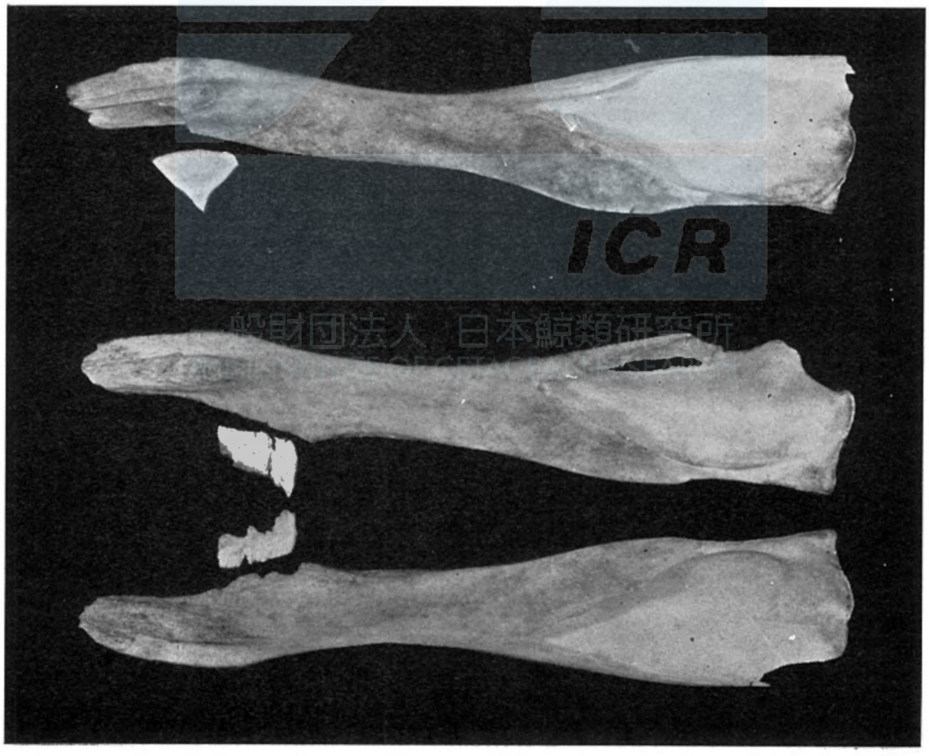
Fig. 2 (Lower). Reversed lateral views of mandibles. Upper one is *Mesoplonon ginkgodens* of Ayukawa specimen No. 3, and lower two are *Mesoplodon stejnegeri* of Ayukawa specimen No. 2.

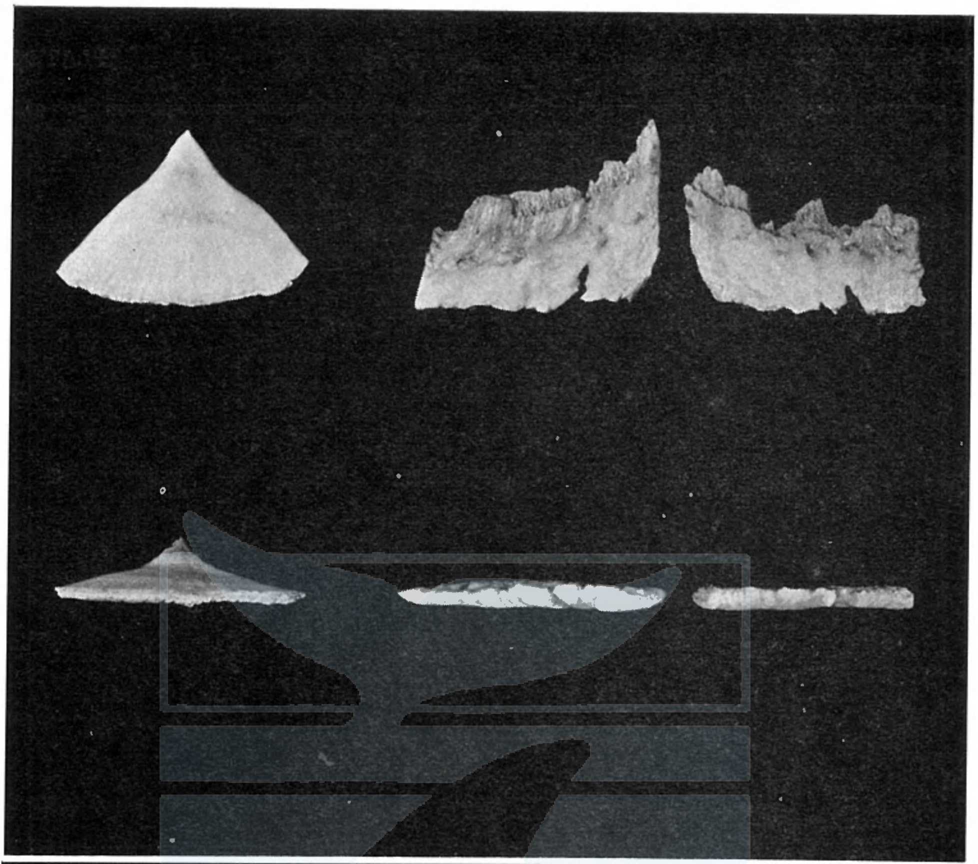
PLATE II

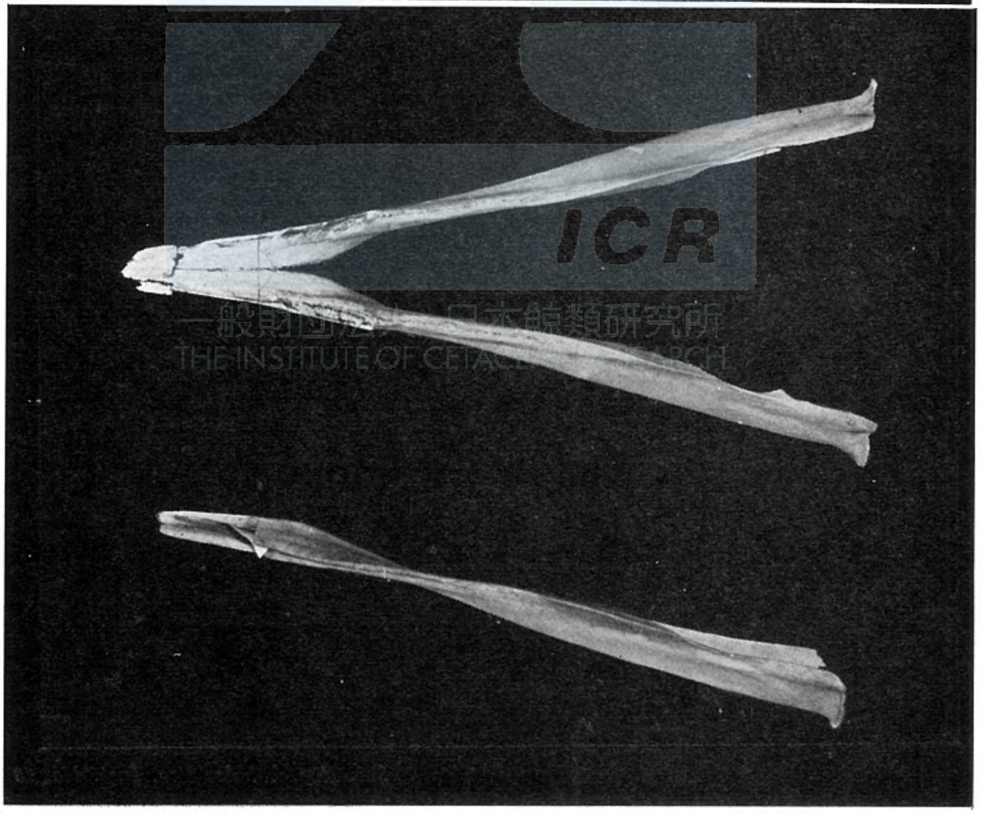
Fig. 1. Dorsal views of mandibles. Left side one is left mandible of *Mesoplodon ginkgodens* of Ayukawa specimen No. 3, and right side one that both side bones are attached is *Mesoplodon stejnegeri* of Ayukawa specimen No. 2.

Fig. 2. Lateral and ventral views of teeth are shown in upper and lower lines respectively. Left one is *Mesoplodon ginkgodens* of Ayukawa specimen No. 3 and right side two are *Mesoplodon stejnegeri* of Ayukawa specimen No. 2 in both lines.









AN EARLY DOLPHIN EMBRYO (STENELLA COERULEOALBUS) IN SERIAL SECTIONS

JOHN G. SINCLAIR *

This 4.2 mm. dolphin embryo is probably the youngest to be completely described. A 12 mm. embryo was described by H. Hosokawa in 1955 in complete serial sections (1). Embryos of the humpback whale were studied and described by Stump, Robins and Garde (2). The present embryo was taken at Kawana on Izu peninsula Japan, Dec. 7, 1960. The dolphin drive which takes place twice a year was rather light yielding 300 animals whereas some drives reach 1000. Of dolphins killed in this drive approximately half were females. Several species were included but Stenella predominated. Females were of all ages but about twenty younger ones were examined and, using the corpora lutea as indicators, ten uteri were removed. Three of the ten contained blood due to rough handling in killing and the remainder yielded only one embryo. The others apparently had aborted.

This result together with the fact that only one embryo could be secured in a second drive a month later, from approximately fifty females in a catch of 600 dolphins, leads one to think that the rate of reproduction in this cetacean is extremely low. Dr. T. Ogawa of Tokyo University had insisted that young embryos could be secured only in early December because the period of breeding is probably late October or early November. The size of the present embryo indicates an age of about one month and confirms his estimate. A second embryo of 26 mm. taken Jan. 20, 1961 is about 2·1/2 months old and again confirms his judgement of the breeding period. This data also fits the second of the breeding periods for the Fin Whale deduced from International statistics (3). According to Stump, Robins and Garde (2) the mating is at a maximum for the humpbacked whales in August in the eastern and western Australian waters.

The external features of the embryo are remarkable. Fig. 1. The external appearance of a whale embryo of the same dimensions was given by Dr. Nishiwaki in 1957 (4). In our dolphin embryo the whole trunk is a helix of one full turn about the body stalk as an axis.

---

* The author is in Japan under Research Grant NONR-3355(00) between the Office of Naval Research and the University of Texas. Dr. M. Nishiwaki of the Whales Research Institute, Tokyo, secured the embryo. The Department of Anatomy, Tokyo University Faculty of Medicine provided the facilities for preparation of sections and photography. I am endebted to both institutions.

Various degrees of spiralling may be seen in many mammal embryos and the author has two human embryos of the same dimensions and equal amount of torsion.

The embryo was removed from a gestation sac 65 mm. in length. Fig. 2. The placenta is extremely simple like that of the pig and separated from the uterus under a small stream of water. A detail of corpus luteum of the maternal ovary is seen in Fig. 3. Its dimensions were 32 × 36 mm. The gross cut surface of this corpus luteum is homogeneous. Those taken from uteri suspected of recent abortion showed a more cordlike structure.

These serial sections were cut from celloidin at 10 microns and were stained with hematoxylin and eosin. Standard orientation presents the midbrain first. Section 14, Fig. 4, shows the germinal zone of the brain and surrounding marginal zone. No mantle zone is discernable. By section 20, Fig. 5, the narrow cleft opening into the third ventricle and expansion of the fourth ventricle are distinguishable. The roof of the hindbrain (metencephalon) is already folded although it is thick. Small extensions of the cerebral plexus foreshadow the carotid and cardinal systems. Section 31, Fig. 6, shows the forbrain and hindbrain separated by the cephalic flexure. Neural crest may be distinguished in the region which becomes the trigeminal ganglion. Note the skin depression and its adherence to the neural mass. An interesting detail Fig. 7, is from the angle between forebrain and optic vesicle. Here may be seen a stream of basophil cells still attached at the angle and stretching down into the mandibular arch. They are said to take an important part in the structure of that arch.

In section 38 Fig. 8 the optic vesicles are seen to be narrow extensions of the forebrain barely contacting the epidermis. There is no lenticular thickening and no terminal expansion of the vesicle. Basophil cells are seen both cranial and caudal to it. The infundibulum of the third ventricle does not contact the notochord any longer. The latter is fused to the roof of the preoral gut. The hindbrain has developed neuromeres between the potential origins of fifth and seventh nerves. Note that the seventh ganglionic aggregate also contacts the epidermis closely.

By section 43 Fig. 9 we reach the middle of the open octocyst. Asymmetry due to torsion begins to appear. By section 52 Fig. 10 the otocysts are cut ventrally and the ganglionic primordia of nerves VIII-IX are indicated. The anterior cardinal vein becomes a prominent landmark. First and second aortic arches and their dorsal connections are present. The preoral gut (Seessel's pouch) between the first arches ends on the pharyngeal membrane. Cranial to that are two diverticula of Rathke's stomodeal pouch lateral to the infundibulum. The anterior neuropore is still open over the telencephalon.

By section 57 Fig. 11 the stomodeum opens upon the left side and the unruptured membrane is suspended between mandibular arches. First and second arches are seen in cross section together with their associated fifth and seventh ganglionic primordia. The first pouch reaches its closing plate and the first furrow does the same. The last trace of otocyst is seen. Any occipital somites between this and the first cervical are already fused into one mass. Note the small size of the brain and the thin terminal lamina. The tip of the head is in section 65 Fig. 12. The second branchial furrow is on the left together with an unexplained endodermal microvesicle. The first somite to show a definite dermamyotome is present. Ganglion X is indicated.

Section 78 Fig. 13 shows the margin of the second somite on the left and the cervical opercular bulge candal to three well defined arches of nearly equal size. The descending aorta is present. The spinal cord shows no differentiation of mantle layer and there is no evidence of spinal ganglia. Thick endodermal epithelium indicates future developments. Most of the medial surface of the first arch is ectodemal reaching back to the deep phayngeal membrane. By section 83 we see the floor of the pharynx and note the ventral aorta reaching the first arch. Second and third pouches reach closing plates without perforation. Somite three begins to show on the left.

By section 96 Fig. 14 the bulbus arteriosus shows at the base of the second arch and a section of truncus arteriosus lies in the pericardial cavity. Mandibular arches have not yet closed into a symphysis. The pharynx is broad at the fourth pouches. Descending aortae lie just ventral to the third somite. The spinal cord is thick and the lumen narrow. It shows no distinction into basal and alar plates. By section 102 Fig. 15 the pharynx narrows and the thickened pulmonary ridges develop just lateral to the thick endoderm foreshadowing lung buds. The truncus arteriosus and part of the ventricle show a suspended endocardial tube and many extravascular erythroblasts.

In section 106 Fig. 16 the ventricular loop gives way to the central atrium. Pulmonary ridges are prominent but the pharynx narrows. Neither glottis nor trachea is present. Somite four appears on the left. Lateral mesocardia containing common cardinal veins appear in section 120 and are more symmetrically developed in section 126 Fig. 17. This results in forming a pair of pleuroperitoneal canals. Between these just ventral to the gut are the cordlike diverticula of the liver and gall bladder. The latter does not get beyond a rudimentary stage. Pancreatic diverticula also are present but difficult to demonstrate.

Somite five is present. Still in the segment of five in section 142 Fig. 18 the liver cords extend profusely and lateral diverticula of the duodenum are evident. The face of the liver lining the pericardial cavity is the septum transversum. Liver extends to the lateral walls and incorporates vitelline and allantoic veins into hepatic sinusoids.

Section 159 shows the intestinal portal as the gut opens up opposite somite six and the liver is separated into lobes containing paired vitelline or omphalomesenteric veins. The epithelial and vascular structure of the yolk sac wall are well displayed in folded membranes. Blood making functions have already been largely transferred to the general circulation. In section 168 Fig. 19 the right vitelline vein passes upward toward the liver. Heavy parietal walls indicate the future limb buds.

In section 174 the coelom opens laterally to the extraembryonic coelom. At somite seven there is the first appearance of mesonephric duct cranial to any tubules. Limb primordia are still just parietal thickenings.

Section 186 Fig. 20. The spiral torsion of the trunk is evident in somites 7–8. The coelom on both sides is open. Aortae remain double. Mesonephric tubules appear in the nephric ridge. The gut is again closed by the folded yolk sac. By section 193 the whole border of the loop is cut in a half circle. The wall of the yolk sac is central to the loop. Ten mesonephric tubules appear. By section 198 Fig. 21 a ninth somite is added and the coelom is seen extending to the caudal end. Section 207 Fig. 22 cuts the full line of somites from nine through twenty-nine. The last somite ends in the unsegemental lateral mesodermal plate. The whole remaining mesonephros is displayed with its duct. There are approximately 2·1/2 tubules per somite but neither glomeruli nor cloacal connection to permit function.

Shifting caudally to section 220 Fig. 23 the spiral is cut through the open posterior neuropore. Dermatome, myotome and sclerotome of each somite are distinct and the dorsal intersomitic invasion by somatopleure is in process.

By section 223 Fig. 24 the notochord terminates in the primitive knot and the cloacal plate is indicated. The superior mesenteric artery descends and the gut is defined back to the rectum. Section 235 Fig. 25 shows the cloacal expansion to the anal plate and proctodeum on the one hand and the dorsal wing leading to the mesonephric duct on the other. These features are further expanded in section 248 Fig. 26. This sectiton passes through the urachus (allantoic duct) into the thick walled allantois. Note that at this stage it is much less vascular than the yolk sac. The urethral plate is better shown in section 251. Finally section 275 Fig. 27 shows the expanding end of the allantois extending caudally through the gut loop.

REFERENCES

1) Hosokwa H. (1955). Cross sections of a 12 mm dolphin embryo. Scientific Reports Whales Research Institute, 10; 1-73.
2) Stump C. W., J. P. Robins and M. L. Garde (1960). The development of the embryo and membranes of the humpback whale, megaptera nodosa (Bonnaterre). Austr. J. Marine and Freshwater Research 11; 365-368.
3) Naktgebornen C., E. J. Slijper and W. L. Van Utrecht (1960). Remarks on the period of conception, duration of gestation and growth of the fetus of the fin whale based on data from International Whale Statistics. Norsk. Hvalfangst Tidende, 1960 ♯3; 313-319.
4) Nishiwaki M. (1957). Very smal lembryo of cetacea. Scient. Rep. Whales Res. Institute 12; 191-2.


ICR
一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

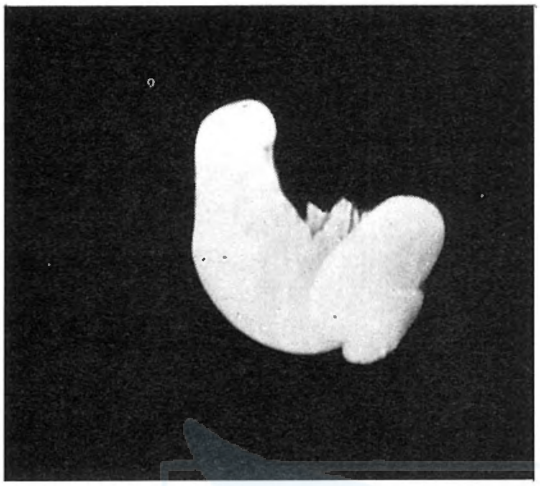


Fig. 1. 4.2 mm dolphin embryo. The trunk shows a spiral of one full turn about the allantois and yolk sac.

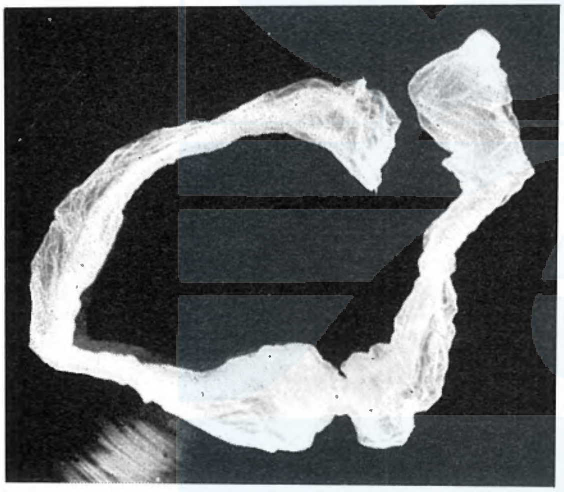


Fig. 2. Gestation sac of 65mm containing a 4.2 mm embryo dolphin.

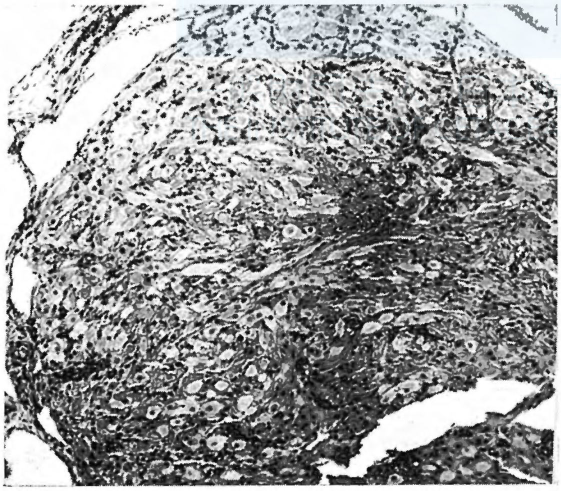


Fig. 3. Corpus luteum of the dolphin of one month gestation.

This is a small segment of the 32×36 mm corpus luteum.

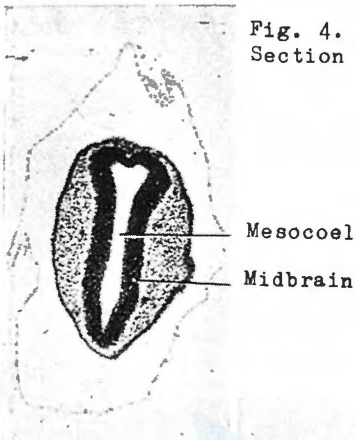


Fig. 4.
Section 14.

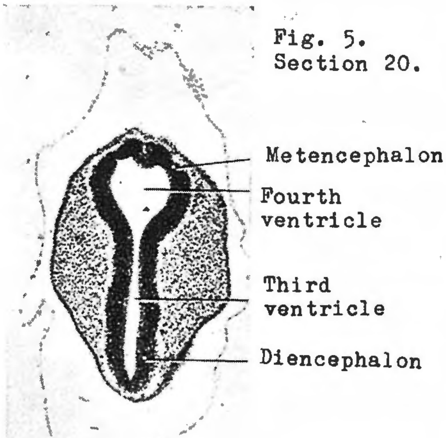
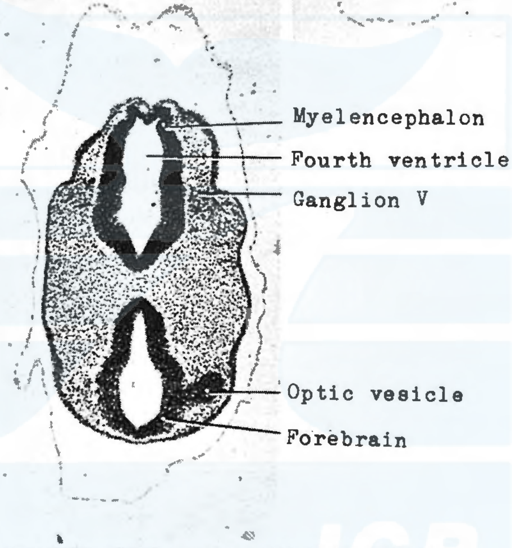


Fig. 5.
Section 20.

Fig. 6.
Section 31.



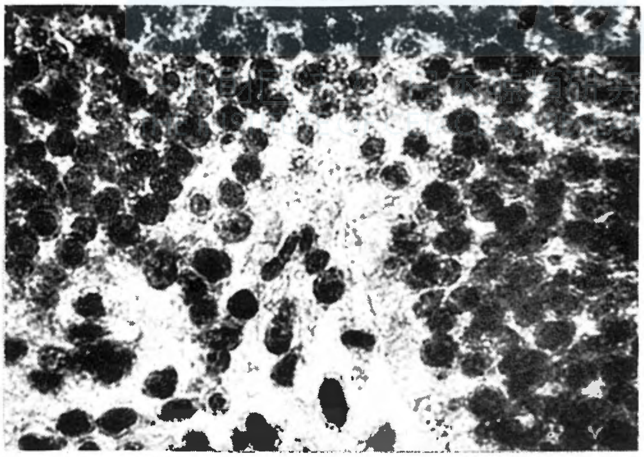


Fig. 7. Detail from section 31 showing descending neural crest in the angle between forebrain and optic vesicle.

Fig. 8.
Section 38.

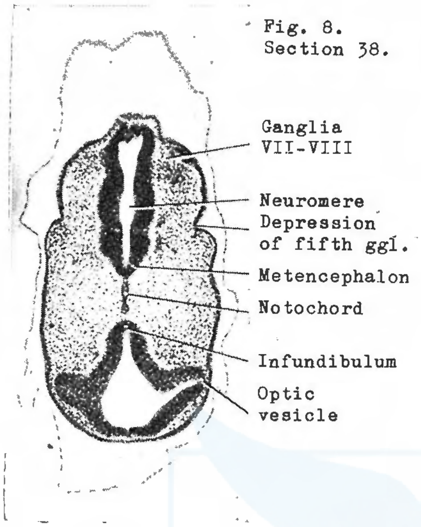


Fig. 9.
Section 43.

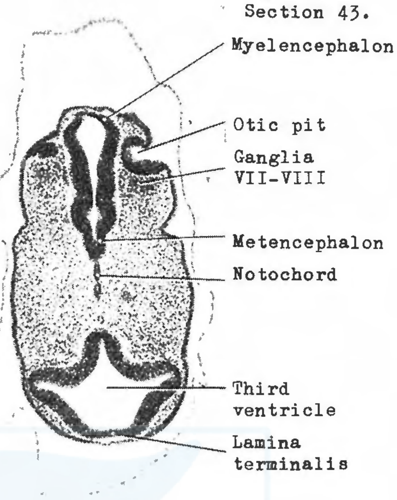


Fig. 10
Section 52.

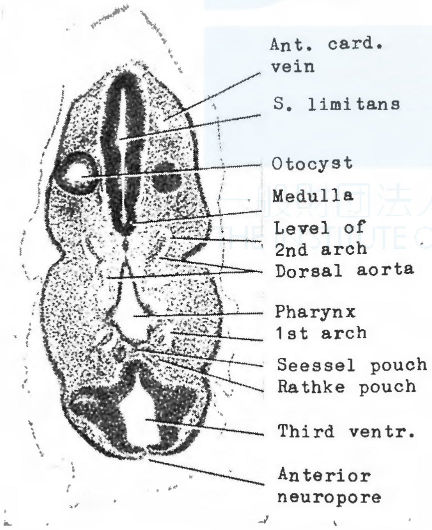


Fig. 11
Section 57.

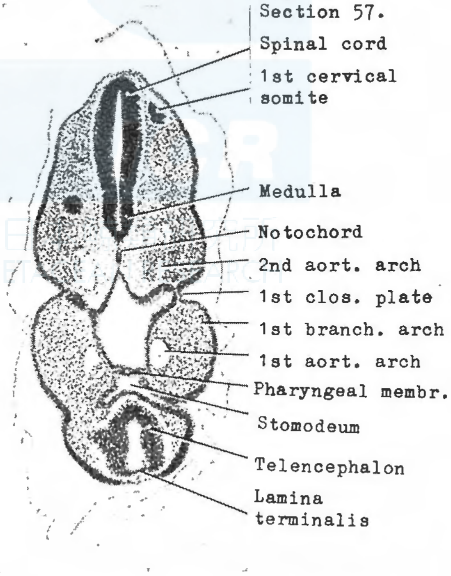


Fig. 12.
Section 65.

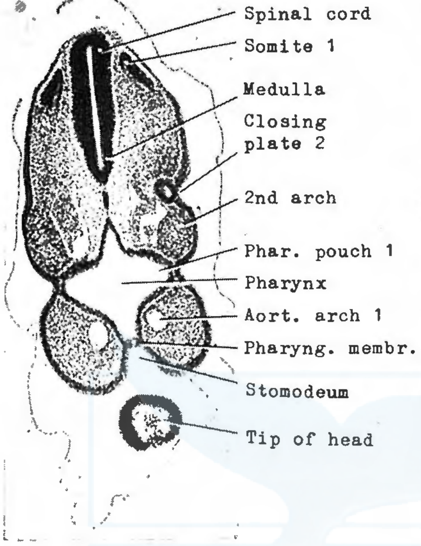


Fig. 13.
Section 78.

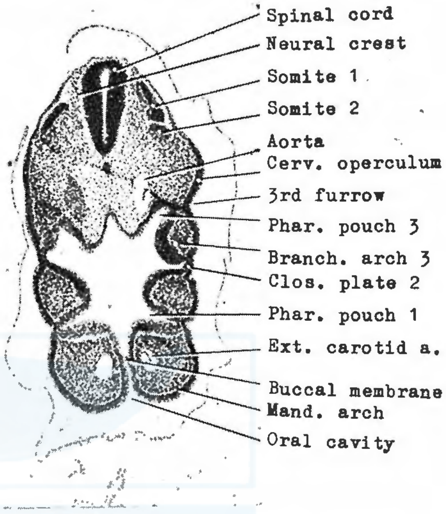


Fig. 14.
Section 96.

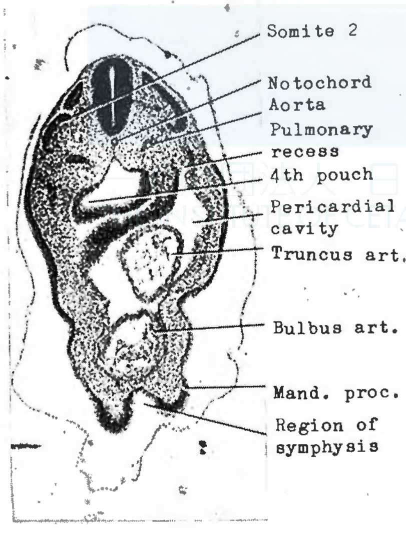


Fig. 15.
Section 102.

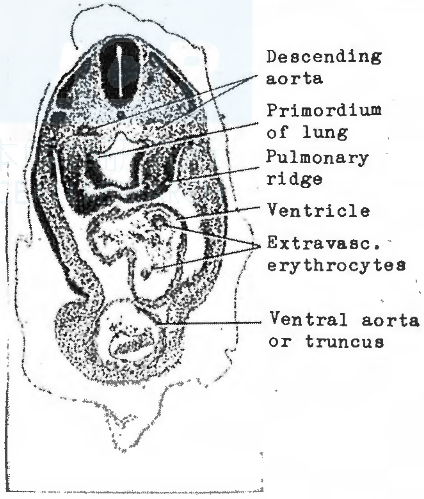


Fig. 16. (Section 106)

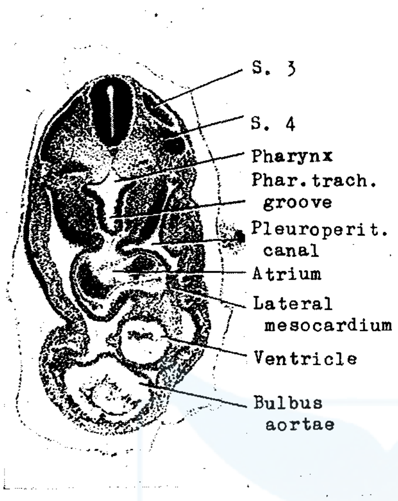


Fig. 17. (Section 126)

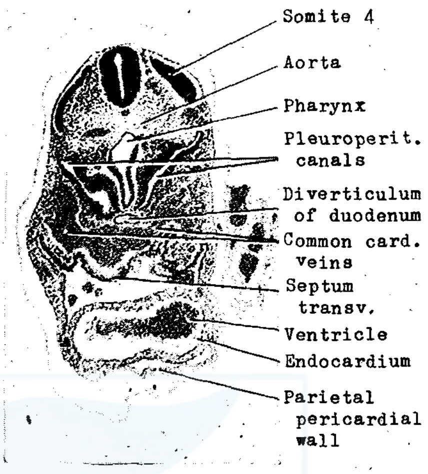


Fig. 18. (Section 142)

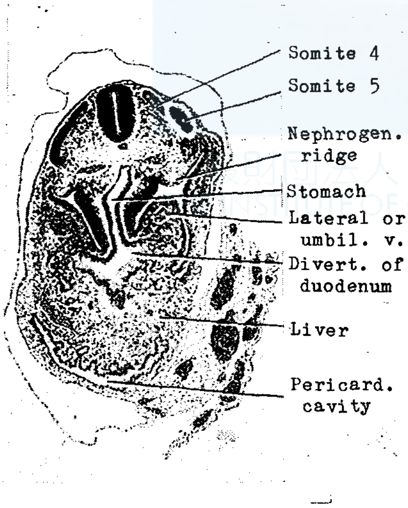


Fig. 19. (Section 168)

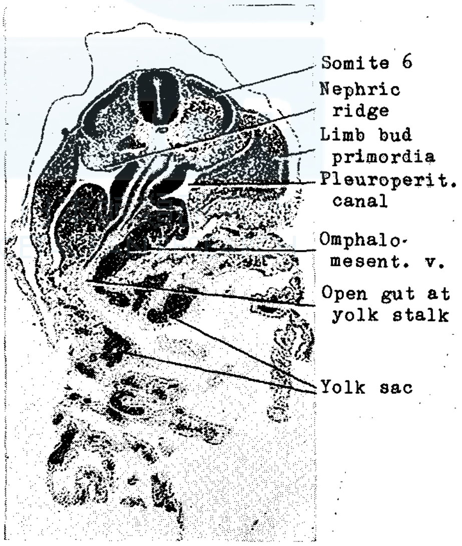


Fig. 20. (Section 186)

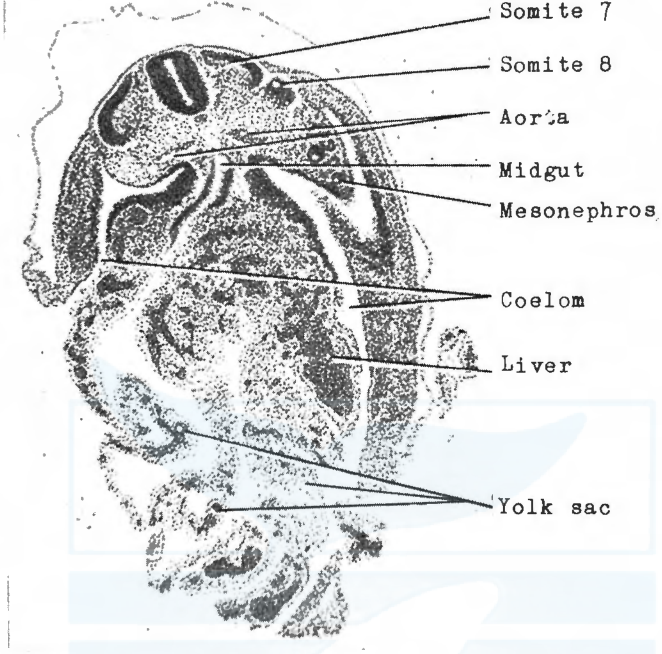
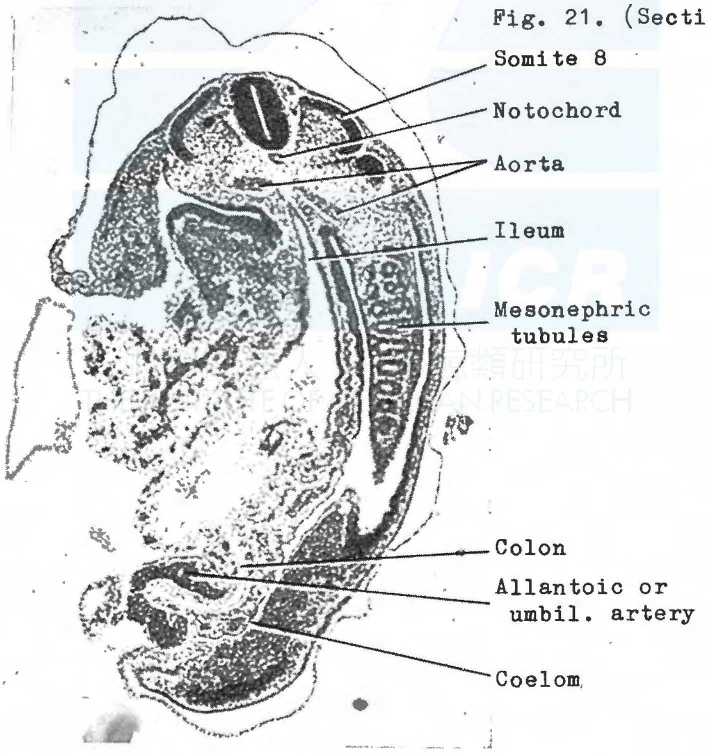


Fig. 21. (Section 198)



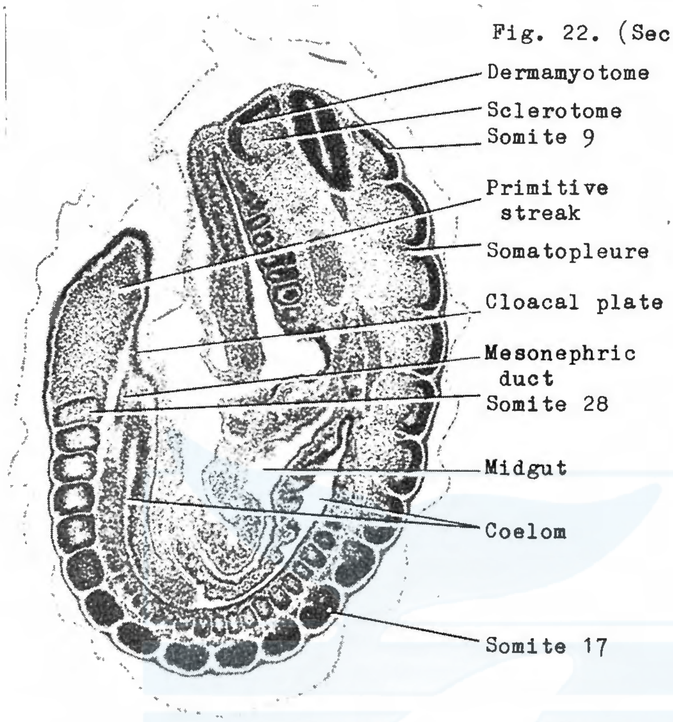


Fig. 22. (Section 207)

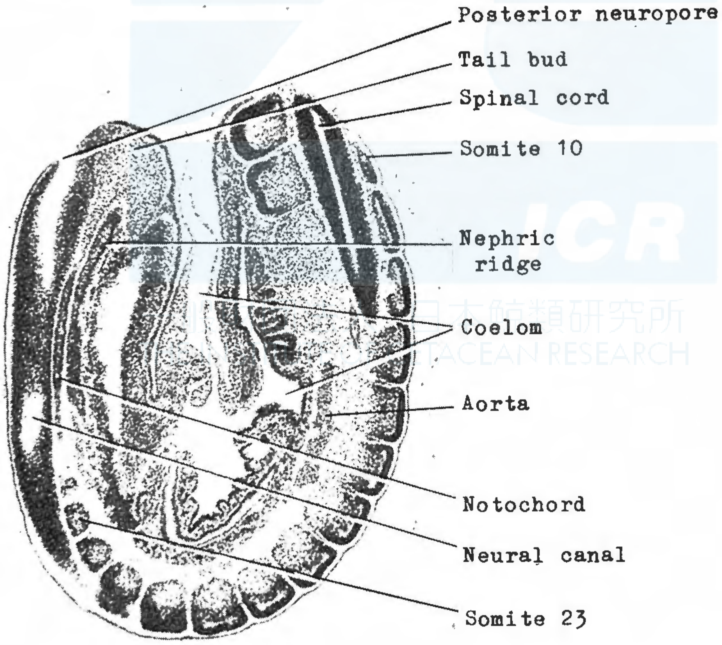


Fig. 23. (Section 220)

Fig. 24. (Section 223)

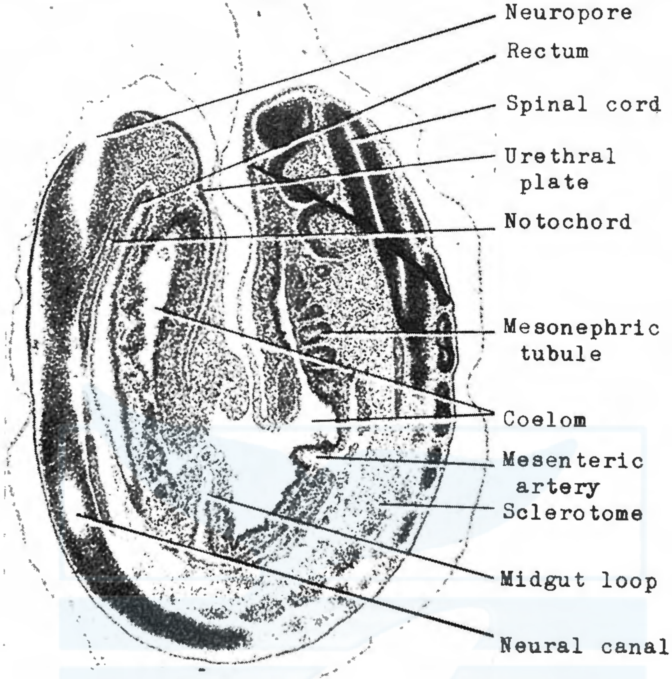


Fig. 25. (Section 235)

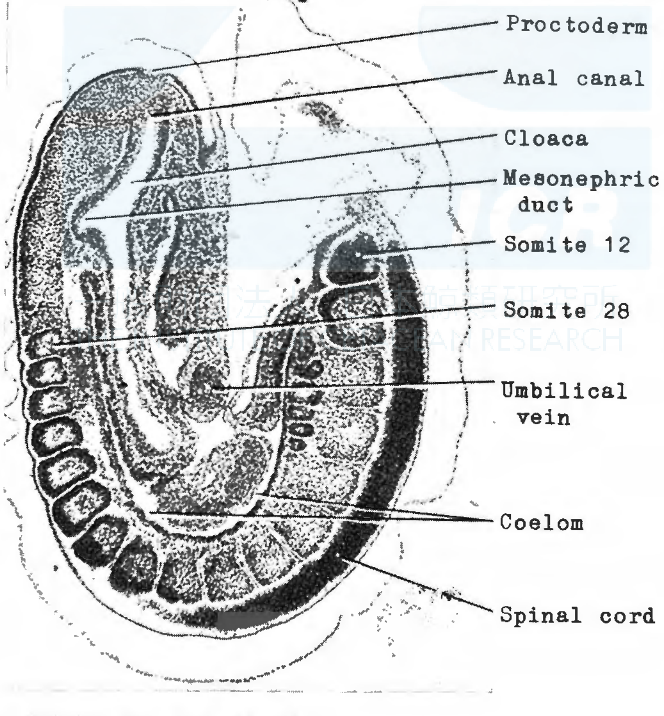


Fig. 26. (Section 248)

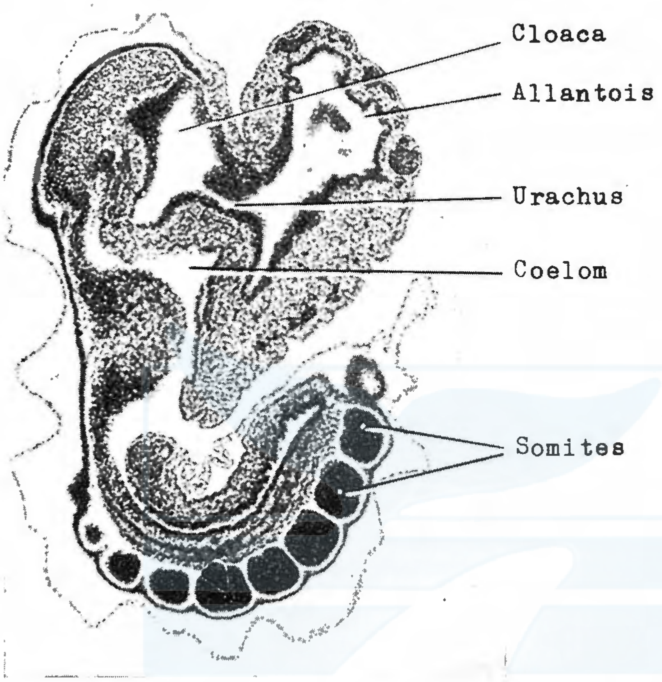


Fig. 27. (Section 275)

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

FOOD OF BALEEN WHALES COLLECTED IN RECENT JAPANESE ANTARCTIC WHALING EXPEDITIONS

TAKAHISA NEMOTO

The research on foods of baleen whales in the Antarctic Ocean has been established by Mackintosh & Wheeler (1929), Hardy & Gunther (1935), Peters (1955), Marr (1956) and Nemoto (1959). In a former report (Nemoto, 1959), I have described two species of food planktons other than *Euphausia superba* Dana as the staple foods for the Antarctic baleen whales. These are a small krill, *Thysanoessa macrura* G. O. Sars for blue and fin whales and a pelagic amphipod *Parathemisto gaudichaudi* (Guér.) for sei whales respectively. The materials on foods of baleen whales which have been collected during the successive Japanese investigations will be analysed in due course. But it is thought convenient to summarize here the peculiar feature of the food of baleen whales observed in recent operations, since it needs some time before the report can be compiled as the second report.

DISCUSSION

Japanese pelagic whaling expeditions have covered all the Antarctic Ocean except the whaling area II after the year 1946, and recent expeditions have been operating comparatively lower southern latitudes in 1960 and 1961. Before the year 1958, the most whales had been caught within the Antarctic convergence excluding some sperm whales being caught in the outward or homeward routes to and from the Antarctic. Those whaling operations are usually called 'the pack-ice operation' by Japanese whalers.

In 1959–60 whaling season, many fin whales were captured in the whaling area IV from 55° to 60° south latitude, and some Japanese whaling fleets caught comparatively many blue whales (what we call pigmy blue whales) around the waters of Kerguelen Is. in March, the late of the season. In this boundary waters between the Antarctic Ocean and the Indian Ocean, fin whales also appeared in the catch. Further, considerable number of fin and sei whales were caught in the lower latitudes of the area V in the Antarctic, ranging from 175° east to 175° west longitude and 47° to 53° south latitude in that season.

This whaling ground was also situated at the far north waters of the Antarctic convergence as illustrated in Figs. 2 and 3.

In 1960–61 whaling season, the whaling ground in the lower latitudes of the Antarctic Ocean expands further. Many blue, fin and sei whales have been caught in the adjacent waters not only to Kerguelen Is. but also Prince Edward Is. and Crozet Is., in the north zone of the Antarctic convergence. The most northern position extends to the latitudes of 42° south in South Madagascar ridge. On the other hand, the usual pack-ice operation has conducted in the whaling area V and VI in the first and the middle of the whaling season, but whaling ships come up from 65° to 55° latitude in 150° W near the Antarctic convergence, which runs along comparatively higher latitudes in that region. As illustrated in Figs. 2 and 3, many sei and fin whales have been caught in the waters just south of the Antarctic convergence. From the observations in the whaling ships and the research on the materials collected on those whales, a map showing the distribution of food species of southern baleen whales is compiled here as a preliminary report.

As a staple food of blue (pigmy blue) whales in the waters around Kerguelen Is., a krill *Euphausia vallentini* Stebbing was found in 1959–60 season (Nemoto, 1961). Those blue (pigmy blue) whales captured in the neighbouring waters from Kerguelen to Heard Island between March 17 and March 26 in 1960 (Ichihara, 1961), took considerable amounts of krill *Euphausia vallentini*. *E. vallentini* is a moderate euphausiid mainly distributing throughout the sub-Antarctic zone between the Antarctic convergence and sub-Antarctic convergence (John, 1936), but it is stated the southern range of the main group of *E. vallentini* extends to the south a little way through the Antarctic convergence (Mackintosh, 1960). John describes that *E. vallentini* is found a little way south of the Antarctic convergence in winter only. He considers that the flow of Antarctic surface waters to the north, strongest in summer when snow and ice are melting in the south is reduced in winter, and the slowing up of the current leads to a southern movement of sub-Antarctic waters at the surface. The fact that waters of the Antarctic ocean south of the Antarctic convergence is mixed with sub-Antarctic water in winter may causes the south extending of *E. vallentini*. As it is described in John's figure and a discussion by Mackintosh (1960), *E. vallentini* occurs in circumpolar waters, and it should be noted it occurs especially in the stations where the ridge of the sea bottom is prominent. The waters around Pacific-Antarctic ridge, Atlantic-Antarctic ridge, Falkland shelf, Aukland shelf and Antipodes

Is. shelf fairly coincide with the main occurrences of *E. vallentini* in John's report.

Perhaps the most southern occurrence of the main group of *E. vallentini* revealed by this study to which I would first draw attention is found along the Kerguelen-Gaussberg ridge streching south-eastery from Kerguelen Is. through MacDonald Is., Heard Is. and Banzare Sea Mount. In this waters along the ridge, *E. vallentini* penetrates into the Antarctic Ocean as far as 54° South latitude through the Antarctic convergence in the summer season. Although the standing crop of *E. vallentini* has not been examined successfully in the southern seas yet, the real amount of the *E. vallentini* is abundant from the consideration on stomach contents of baleen whales caught in these waters. This fact may be proved by the distribution and number of blue and fin whales feeding on *E. vallentini*.

I suggest that, from the above facts, the waters around Crozet Is. and near islands possess the possibility of being feeding ground of blue (pigmy blue) whales (Nemoto, 1961), and many blue (pigmy blue) and fin whales have been captured in the waters around Prince Edward Is. and Crozet Is. as well as in Kerguelen waters in 1960–61 season, the main food of which is also *Euphausia vallentini* as expected. Usually blue whales are feeding on *Euphausia superba* or *Thysanoessa macrura* in the waters of the pack-ice in the Antarctic, and they are not so common in the off waters off the pack-ice. Those blue (pigmy blue) whales are now considered as a distinct population from the usual blue whales in the high Antarctic (Ichihara, 1961), but the reason why the population of those blue (pigmy blue) whales is made in the lower latitudes of southern sea is unsolved. This problem will be discussed again in the following part of this paper.

If *Euphausia vallentini* is very abundant in the shallower waters of sea mounts or the shelf of islands along the Antarctic convergence and sub-Antarctic zone, it may be foods of other baleen whales in the waters around Tristan da Cuhna Gr., Falkland shelf, Campell Is., Aukland Is., Antipodes Is., and Tasmanian shelf as well as Prince Edward Is. and Kerguelen Is. waters. As a matter of fact, *E. vallentini* is found in stomachs of fin and sei whales in the waters of Antipodes Is. and Campell Is. bank, south of New Zealand.

The case that one blue (pigmy blue) whale fed on *Parathemisto gaudichaudi* in Kerguelen Is. waters is also a notable finding in recent investigation in the southern ocean.

Fin whales had been captured mainly from the whaling area III to the area IV in 1958–59 season. These fin whales were feeding on

Euphausia superba in the pack-ice waters, some of which were feeding on *Thysanoessa macrura* in the area VI as before. All whales captured in the years distributed in the waters south of 60° south latitude toward the pack-ice. In the following season in 1959–60, the catch of fin whales in the high Antarctic waters decreased considerably, but some 5900 fin whales were captured in the whaling area IV from 55°to 60° south latitude. The main whaling ground situated at the Kerguelen Gaussberg ridge and the east of Banzare sea mount. *Euphausia superba* is the dominant food in the waters. Although the further collection of

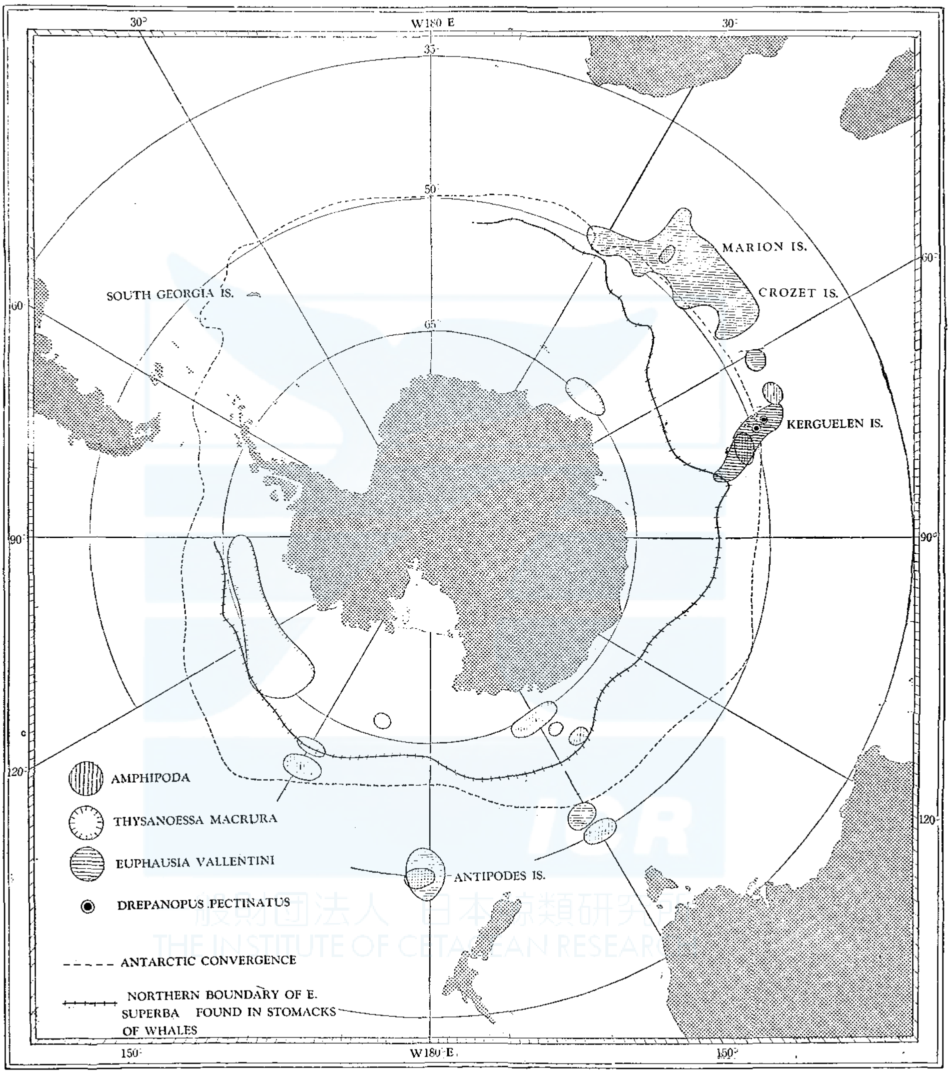


Fig. 1. Distribution of foods of baleen whales in the Antarctic

material is in need, 1 year group and immature 2 years group are dominant, and the full grown 2 years group is scarce in collections. Since the boundary of *Euphausia superba* may be shown in Fig. 1, it is protruding to the north in this region. When I compare with the Fig. 1 to the figure of Marr (Marr, 1956 Fig. 1), the figure of Marr lacks the project distribution of *E. superba*. However, Marr notes a instance that the deflection of East wind drift associated with the Kerguelen Gaussberg Ridge brings forth the northward distribution of larval forms of *E. superba*.

From the distribution of temperature, salinity and oxygen content, the northward current makes result of the transference of water from East wind Drift to West Wind Drift in the east of Kerguelen Gaussberg ridge (Deacon, 1937).

Recently Baker has added the unpublished data on the distribution of adolescent and adult *E. superba* to the figure of Marr (Baker, 1956, Fig. 6). From the comparison between the Baker's figure and Marr's one, it is clear that a considerable occurrence of *E. superba* is added in the region of Kerguelen-Gaussberg ridge. So, it is reasonable to consider the concentration of *E. superba* in the middle Antarctic in 1959–61 seasons is due to the drift of adlescent forms of *E. superba* from the East Wind Drift region. If this assumption is true, the suitch of the main concentration of *E. superba* from the east to the west in this region in 1960 and 1961 is apparently originated from the change of the northern encroachment of cold water from East Wind Drift bringing *E. superba*. The fact that the number of baleen whales feeding on *E. superba* decreases entirely in the west waters of Kerguelen Gaussberg ridge where the West Wind Drift is strong may also prove above consideration.

In any case, it should be noted that the excessive concentration of *E. superba* has occurred in the West Wind Drift region. These waters are, as Beklemishev describes (Beklemishev, 1960), situated at the route of the cyclones of the Indian ocean polar front and those of the Atlantic polar front, and may cause the upwelling of the adlescent form of *Euphausia superba*, which is brought in the strongest current of lower stratum of the surface current along the Kerguelen Gaussberg ridge (Marr, 1956).

The northern limit of the distribution of *Euphausia superba* is discussed by Marr (Marr, 1956). He consideres the northern boundary of maximum abundance of *E. superba* coincides with the boundary of the East Wind and the West Wind drifts, and the single occurrence is far to the south of the Antarctic Convergence except the neighbourhood of South Georgia. But recent investigations on food of whales reveals that the abundant occurrences of *E. superba* should be added in the three sea regions in the middle Antarctic at least.

As shown in Fig. 1, in the lower Antarctic waters from 0° to 30° east longitude, where the effect of Weddel Drift current is observed, *E. superba* is very important for fin whales just within the Antarctic convergence. This tendency of the concentration of *E. superba* is already described in the figure by Baker (Baker, 1956, Fig. 6). The second region is Kerguelen-Gaussberg waters, and the third in 150° west waters. It may be interesting to mention that the two currents Weddell and Ross currents bring the adolescent forms of *E. superba* to the north as far as the boundary of the Antarctic convergence.

In the Antarctic and southern waters, following species of euphausiids have been described in the published papers (John, 1936; Mackintosh, 1960, etc.).

Euphausia crystallorophias Holt & Tattersall
E. superba Dana
E. frigida Hansen
E. triacantha Holt & Tattersal
E. vallentini Stebbing
E. longirostris Hansen
E. lucens Hansen
E. similis Sars
E. similis var. *armata* Hansen
Thysanoessa macrura Sars
T. vicina Hansen

Among those euphausiids, only *E. vallentini, E. superba, E. crystallorophias* and *Thysanoessa macrura* have been described as foods of southern baleen whales (Mackintosh, 1942; John, 1936; Nemoto, 1959 etc.). All those food euphausiids display the shoaling habit clearly, which is very important for the swallowing feeding type whales, blue, fin and humpback whales (Nemoto, 1959). Two moderate sized euphausiid *Euphausia frigida* and *E. triacantha* also distribute in the Antarctic zone (John, 1936; Baker, 1956). But they do not demonstrate typical shoaling habit especially in the latter (Baker, 1956) in the surface of the waters.

From the point, *E. similis* may be a food for baleen whales in the lower sub-Antarctic zone because it makes the heavy shoal sometimes.

Owing to the scarcity of the catch, there was much less certainty about the staple food of sei whales in the southern hemisphere before a report was published. In the report (Nemoto, 1959), I studied sei whales recently increased in the Antarctic summer, and described pelagic Amphipoda, *Parathemisto gaudichaudi* as a principal food of sei whales in the southern hemisphere besides *E. superba*, and suggested the southern sei whales distribute from the sub-antarctic zone to the lower Antarctic zone feeding on the scattering zooplanktons such as pelagic amphipods and copepods.

After the year 1957, comparatively many sei whales have been caught, the considerable part of which have been feeding on *Parathemisto gaudichaudi*. Especially in 1959–60 season, sei whales captured in the subantarctic waters between 170° east and 170° west longitude have taken the amphipods. The complete taxonomic studies on those amphipods is still not solved owing to the scacity of the materials, however, the most of them are considered *Parathemisto gaudichaudi*. As Barnard describes (Barnard, 1932), it occurs everywhere in the south Atlantic and the southern Indian Ocean. The circumpolar occurrence of *P. gaudichaudi* is also described by Baker (Baker, 1954).

TABLE 1. FOOD SPECIES FOUND IN STOMACHS OF SEI WHALES IN THE INDIAN OCEAN SECTOR OF THE ANTARCTIC IN 1961

Latitude Range (South)	0° ~ 70°E					70°E ~ 130°E					
	E. superba	*E. vallentini*	Amphipoda	*D. pectinatus*	None	*E. superba*	*E. vallentini*	*P. gaudichaudi*	*D. pectinatus*	None	
40~45	—	—	—	—	14	—	—	—	—	—	
45~50	—	6	5	1	49	—	2	3	1	22	A. C.
50~55	10	1	—	—	11	1	2	14	1	12	
55~60	7	—	—	—	11	24	—	—	—	18	
60~65	1	—	—	—	—	3	—	—	—	—	

Parathemisto gaudichaudi performs distinct vertical migration in the waters around South Georgia (Hardy & Gunther, 1935), but it does not display the distinct vertical migration in the higher latitudes of the southern ocean (Mackintosh, 1934). This is no doubt partly connected with the reduction or the absence of darkness in summer in the high latitudes (Mackintosh, 1934). The feeding percentage of sei whales, as the correspondence, is higher in the morning or in the evening in the lower latitudes of the Antarctic.

The most northern position of the capture in sei whales in 1960–61 season extends to 42° south in 40° east, where all sei whales have vacant stomachs, but fin whales in these lower sub-Antarctic region take *Euphausia vallentini*. Sei whales in the high Antarctic take *E. superba* as before in the whaling area IV. But many sei whales caught in the whaling area VI take amphipoda including *Parathemisto gaudichaudi* heavily along with *E. superba*.

There are three cases of sei whales feeding on a small copepod *Drepanopus pectinatus* Brady. This may be the first description of a copepod found in the stomach of baleen whales except the description by Peteres (1955). Two sei whales take exclusively *Drepanopus pectinatus* in the waters adjacent to Kerguelen Is., and another sei whale caught in the Crozet Is. waters with the mixture of *Euphausia vallentini*.

Although these cases are the first observations of dominant occurrences in the southern hemisphere, sei whales are usually feeding on copepods in the northern hemisphere, as they have baleen plates of the fine baleen fringe.

TABLE 2. PELAGIC WHALING CATCH IN RECENT 10 YEARS.

Years	Species of whales caught			
	Blue	Fin	Hump-back	Sei
1951~52	5,124	20,520	1,546	32
1952~53	3,866	21,197	954	123
1953~54	2,684	24,986	594	251
1954~55	2,163	25,878	493	146
1955~56	1,611	25,289	1,432	276
1956~57	1,505	25,700	679	712
1957~58	1,684	25,222	396	2,385
1958~59	1,191	25,837	2,394	1,402
1959~60	1,230*	26,415	1,338	3,234
1960~61	1,739*	27,299	709	4,280

Including what we call pigmy blue whales

Drepanopus pectinatus is firstly described from the Kerguelen Is. waters (Brady, 1883). Hardy & Gunther (1935) discuss the ecology of it in the waters of South Georgia and Vervoort (1957) describes it from the bays or inlet of Kerguelen Is. Vervoort states further *D. pectinatus* is found exclusively in a tow of plankton net. In the southern ocean of the Antarctic, *D. pectinatus* has not been observed (Mackintosh, 1934), and Tanaka (1960) also do not observes it in the west waters of Crozet Is. From above descriptions and observations, *D. pictinatus* is considered as a coastal form in the circumpolar high sub-Antarctic and lower Antarctic zone. Subsequently, *D. pectinatus* is not important for the oceanic forms and schools of baleen whales as their foods. Many southern right whales which swarmed in Kerguelen, Prince Edward and Crozet Is. waters in 19 century (Townsend, 1935) might take the copepod with their fine baleen fringes.

It is not certain if other micro copepods in the southern ocean may be foods for sei whales, however, sei whales feed in the waters where the standing crop of copepods and other micro zooplanktons demonstrate the maximum abundance (Foxton, 1956). These areas are observed a little south of the Antarctic convergence, and some other micro organisms will be found as their foods in future investigations.

DISTRIBUTION OF BALEEN WHALES

From the observations in recent 5 years in the Antarctic and the southern ocean, it should be recognized that the pattern of the whale distribution and foods of baleen whales are changing to some extent. The most striking points, which are very interesting for the biology of baleen whales may be summarized as followings.

1. Sei whales—Usually sei whales had been only observed by pelagic expeditions in the latter part of the whaling season in small number in the Antarctic. Recent catch statistics prove that many sei whales have been caught in the Antarctic zone in summer suggesting that they enter the Antarctic in many schools to feed.

Of course, this may partly due to the decrease of another valuable baleen whales, blue, fin and humpback whales, but it is said that sei whales are realy increasing in the Antarctic by whalers.

As the age groups of sei whales caught in recent expeditions are considerably older, sei whales are considered to have been migrating in the lower Antarctic or the high sub-Antarctic areas before recent seasons.

The reason why so many sei whales come to feed in the Antarctic is still unsettled yet, however, three suppositions are given here. One reason is that the increase of the number of sei whales causes the population pressure among sei whales and they seek the feeding ground in the Antarctic. The second is the decrease of the number of southern fin and blue whales which have been feeding in the Antarctic zone. This also means the turned chasing to sei whales instead of blue and fin whales. In a formar report (Nemoto, 1959), I note the 'Balance' among each baleen whale species in the feeding ground as a condition of whale migration to feeding areas. The decrease of blue and fin whales may bring about the spread of the feeding range of sei whales in the southern ocean, as sei whales sometimes share the food *E. superba* with blue and fin whales in the southern latitudes. The third is the change of oceanographic condition in the Antarctic. The surface temperature and other surroundings, and fluctuations in the abundance of standing crop of food planktons have the important control for the migration of sei whales.

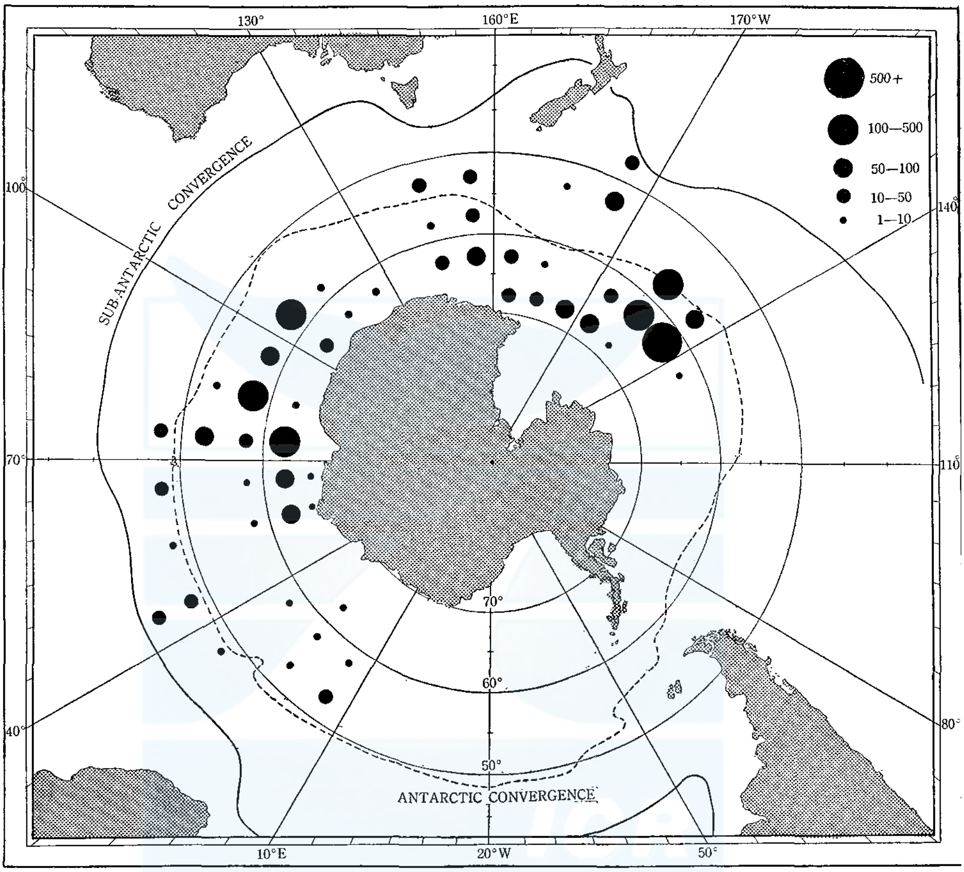


Fig. 2. Distribution of sei whales caught Japanese whaling in 1960 and 1961.

2. Blue whale—The second striking feature in the recent operation is the catch of blue (pigmy blue) whales in the lower waters of the Antarctic zone and high sub-Antarctic zone. Blue whales caught in the lower waters of Kerguelen Is. are considered to belong to a distinct population apart from the usual Antarctic blue whales and may be called pigmy blue whales (Ichihara, 1961). Blue whales which possess the same character have also been caught in the adjacent waters to Prince Edward Is. and Crozet Is. Although the process of the segregation in these blue (pigmy blue) whales in those region is still remained unsolved, the reduction of body length in the blue (pigmy blue) whales

may be due to the water temperature and abundance of foods as well as the population pressure among the population. The three explanations considered in relation to the number of blue whales for the process of the segregation are followings.

The one is that blue (pigmy blue) whales in the lower waters were separated by the population pressure from the usual blue whales in the high Antarctic already in the time when the pack-ice waters were occupied by many usual blue whales.

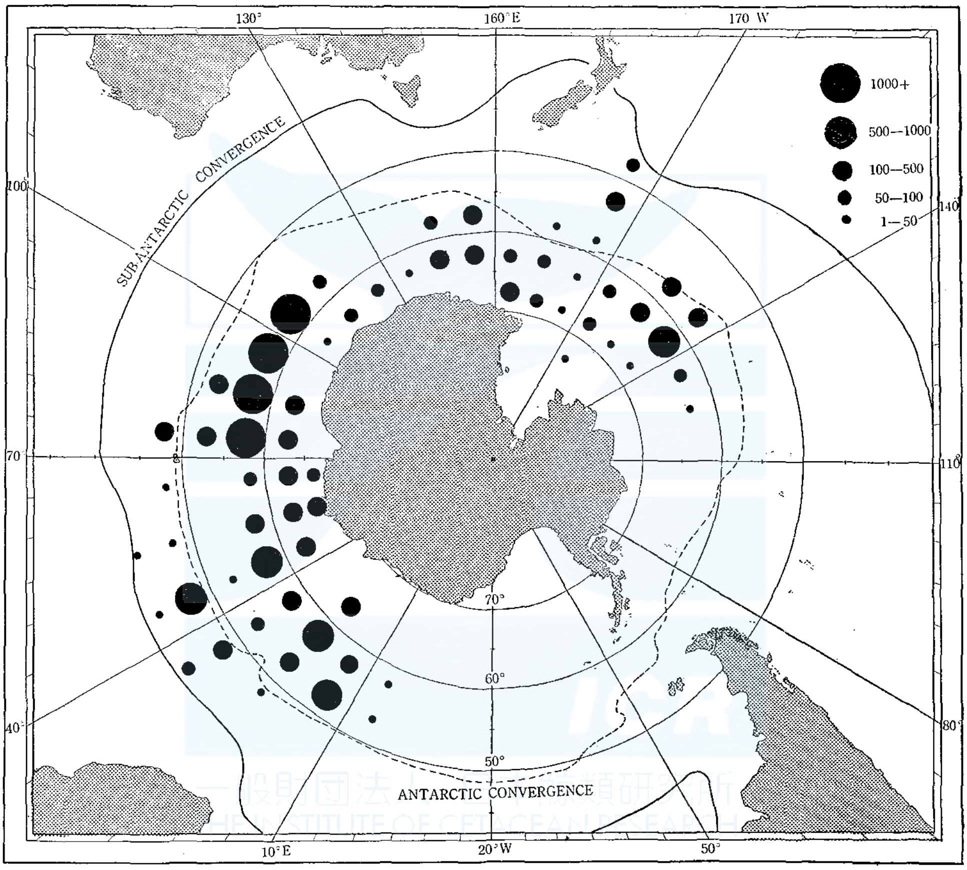


Fig. 3. Distribution of fin whales caught Japanese whaling in 1960 and 1961.

That blue (pigmy blue) whales have come to feed in the lower latitudes owing to the decrease of blue whales by whaling is the other explanation. This example is found in a land animal Buffalo (*Bubalis caffer*) in South Africa. They were living in the plain when their number is numerous. But after the decrease of the number of animals by the rinderpest, they were feeding in the bush along the river.

The isolation owing a mutation is third assumption.

To consider the migration of blue fin and sei whales in the lower Antarctic in summer, the observations on baleen whales in Indian Ocean is very important. In the lower latitudes of the Indian Ocean, considerable number of rorquals are found according to the observation carried out by ships (Brown, 1957). The direct evidence that baleen whales observed in Indian Ocean may have relation to those whales is not obtained yet, however, there may be some relations between the observations from St. Paul ridge to Amsterdam St. Paul Plateau from December to May, and the baleen whales in Kerguelen, Crozet and Prince Edward Is. waters.

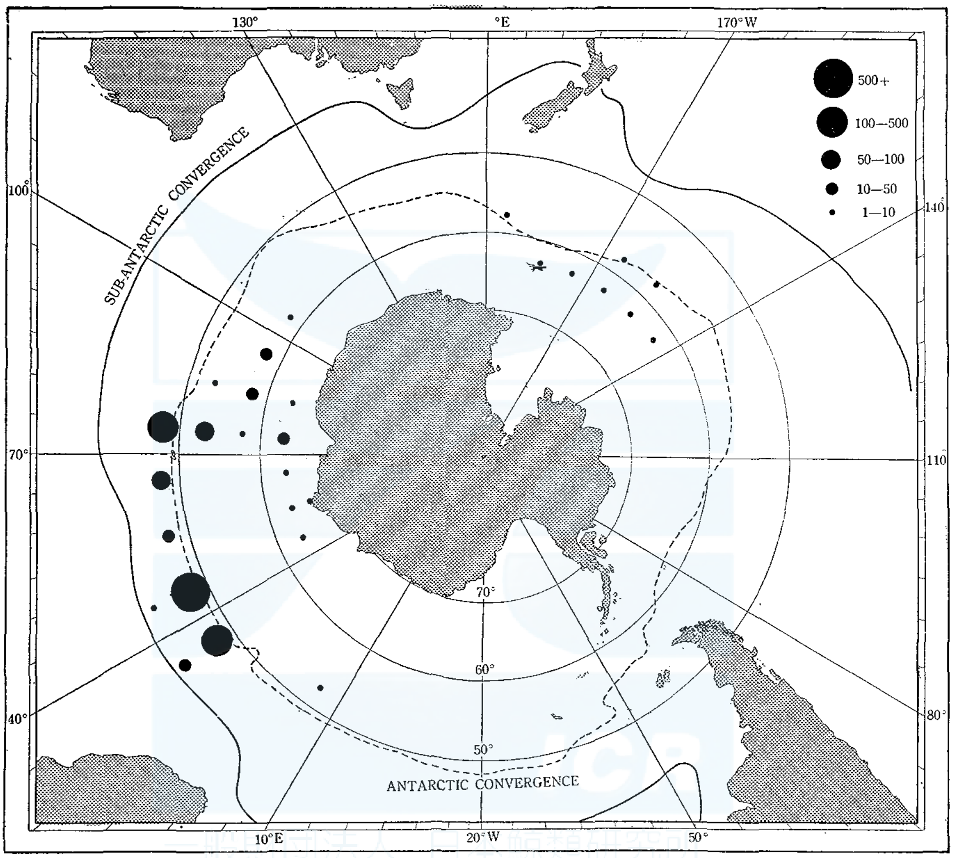


Fig. 4. Distribution of blue whales caught Japanese whaling in 1960 and 1961.

The provisional report compiled by Zenkonich (1960) clearly shows the obsevation of blue and fin whales in the waters of Prince Edward and Crozet Is. If these blue (pigmy blue) whales come up to the north in winter season of the southern hemisphere leaving the feeding ground, two routes in St. Paul ridge and Madagascar ridge are drawn. The observations in these routes are comparatively scarce, and there still remains the possibility of the stay of blue whales in the waters as the ice limit in these areas are far in the south.

3. Fin whales—The fact that so many fin whales have been caught in the lower latitudes of the Antarctic also suggests the fluctuation in the standing crop of euphausiids in the Antarctic. As disscussed in the former part, *Euphausia superba* in the waters of Kerguelen Gaussberg ridge is apparently originated in the East Wind Drift waters. And the scarcity of findings of fin whales in the pack-ice waters in 1959–60 season may prove the lean crop of *E. superba* in the pack ice waters. *Euphausia vallentini* has not described in the published report on food of whales in the lower latitudes of southern whaling grounds (Mackintosh & Wheeler 1929, Dall & Dunstan, 1957), but its abundance in recent years is proved by the numerous fin whales feeding it. If these fluctuations in the crop of euphausiids realy exist, they must be originated in some ecological conditions such as the outburst according to the change of oceanographical conditions, and must have the important role for the feeding migration of baleen whales in general.

SUMMARY

1. In recent Japanese whaling expeditions in the Antarctic, *Euphausia superba* Dana has distributed along the Kerguelen Gaussberg ridge waters as far as 55° south latitude from the pack-ice as a main food of baleen whales. Including other observation in Boubet Is. waters and Ross Sea, the northern boundary of the dominant occurrence in *Euphausia superba* as whales' food is considered a little north against the result hitherto established.

2. Blue and fin whales in the waters of the lower latitudes around Prince Edward Is., Crozet Is. and Kerguelen Is. are feeding exclusively on *Euphausia vallentini* Sttebing. A few sei whales in above waters also feed on *E. vallentini*. *E. vallentini* is observed also in the shelf of Antipodes Is. Aukland Is. and Campbell Is.

3. Including *Parathemisto gaudichandi* (Guér.), pelagic amphipods are important as a food of sei whales in the southern ocean. *P. gaudichandi* occurs most abundantly in the waters along the Antarctic convergence. A copepod *Drepanopus pectinatus* Brady is taken by three sei whales in the coastal waters of islands in the sub-Antarctic zone in Indian Ocean in 1960 and 1961.

4. The distribution of blue, fin and sei whales is studied especially in relation to the fluctuation of foods abundance and individual number of whales in the population as a preliminary report. This problem will be very important theme in the future research.

ACKNOWLEDGEMENT

I would like to express my sincere thanks to Dr. Yoshiyuki Matsue of the University of Tokyo for his kind criticism on euphausiids, and Dr. Otohiko Tanaka of the Kyushu University kindly comments a copepod *Drepanopus pectinatus* Brady, upon which part of this study is based.

REFERENCES

Baker, A de C. (1954) The circumpolar continuity of Antarctic Plankton species. *Discovery Rep.*, 27: 201-18.

——— (1956). The distribution and life history of *Euphausia triacantha* Holt & Tattersal. *Discovery Rep.*, 29: 309-40.

Barnard, K. H. (1932). Amphipoda. *Discovery Rep.*, 5: 1-326.

Beklemishev, C. W. (1960). Southern atomospheric cyclones and the whale feeding grounds in the Antarctic. *Nature*, 187: 530-1.

Brady, G. S. (1883) Report on the copepods collected by H. M. S. Challenger during the years 1873-76. *Challenger Rep.*, 8, part 23:

Dall, W. & D. Dunstan (1957). *Euphausia superba* Dana from a humpback whale *Megaptera nodosa* (Bonnaterre) caught off Southern Queensland. *Norsk Hvalfangst-Tid.*, 46 (1): 6-12.

Deacon, G. E. R. (1937). The hydrology of the southern ocean. *Discovery Rep.*, 15: 1-124.

Foxton, P. (1956). The distribution of the standing crop of zooplankton in the southern ocean. *Discovery Rep.*, 28: 191-236.

Hardy, A. C. & E. R. Gunther (1935). The plankton of the South Georgia whaling ground and adjacent waters, 1926-27. *Discovery Rep.*, 11: 1-377.

Ichihara, T. (1961). Blue whales in the waters around Kerguelen Island. *Norsk Hvalfangst-Tid.*, 50 (1): 1-20.

John, D. D. (1936). The southern species of the genus *Euphausia*. *Discovery Rep.*, 14: 193-324.

Mackintosh, N. A. (1934). Distribution of macro-planktons in the Atlantic sector of the Antarctic. *Discovery Rep.*, 9: 67-158.

——— (1937). The seasonal circulation of the Antarctic macro-plankton. *Discovery Rep.*, 16: 365-412.

——— (1942). The southern stock of baleen whales. *Discovery Rep.*, 22: 197-300.

——— (1946). The Antarctic convergence and the distribution of surface temperature in Antarctic waters. *Discovery Rep.*, 23: 177-217.

——— (1960). The pattern of distribution of the Antarctic fauna. *Proc. Roy. Soc. Lond.*, B, 152: 624-31.

Mackintosh, N. A. & J. F. G. Wheeler (1929). The southern blue and fin whales. *Discovery Rep.*, 1:

Marr, J. W. S. (1956). *Euphausia superba* and the Antarctic surface current. *Norsk Hvalfangst-Tid.*, 45 (3): 127-34.

Nemoto, T. (1959). Foods of baleen whales with special reference to whale movements. *Sci. Rep. Whales Res. Inst.*, no. 14: 149-290

——— (1961). [Tow records of Euphausia as foods of baleen whales]. *Geiken Tsushin*, no. 113: 22 (In Japanese).

NEMOTO, T. & K. NASU (1958). *Thysanoessa macrura* as a food of Antarctic baleen whales. *Sci. Rep. Whales Res. Inst.* no. 13: 193-199

PERCIVAL, A. B. (1924). *A game ranger's note book.* London,

PETERS, H. (1955). Uber das Vorkommen des Walkrehschens *Euphausia superba* Dana und seine Bedeutung für die Ernährung der südlichen Bartenwale. *Arch. Fischereiw.*, 6: 288-304.

TANAKA, O. (1960). Pelagic copepods. *Biol. Res. Jap. Ant. Res. Exp. Spec. Publ. Seto Mar. Biol. Lab., Biol. Res. Jap. Ant. Res. Exped.* 10.

TOWNSEND, C. H. (1935). The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica*, 19 (1): 1-50.

ZENKOVICH, B. A. (1960). Sea mammals as observed by the round-the-world expedition of-the academy of science of the U. S. S. R. in 1957-1958. Data submitted I. W. C. in 1960 by U. S. S. R.

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

SUBARCTIC OCEANOGRAPHY IN RELATION TO WHALING AND SALMON FISHERIES

MICHITAKA UDA*

INTRODUCTION

Since the year 1952 after the World War II the Japanese High Sea Whaling and Salmon Fisheries were again undertaken with the oceanographic surveys every year and particularly since the NORPAC Project in 1955 the oceanographic surveys covering the whole areas of Subarctic North Pacific Waters from west to east were carried out during the years of 1955–1960.

The present paper is a summary of oceanographic structure in the subarctic waters of North Pacific Ocean (Uda, 1960, 1962) and the results of studies concerning hydrographic conditions in relation to the Whaling and Salmon Fisheries with the purpose to give some useful prediction indices for them.

SUBMARINE TOPOGRAPHY IN RELATION TO WHALING GROUNDS

The shaded steepest zone of continental slope is shown in Fig. 1 which corresponds to the counterclockwise circulatory migration route of whales and consequently contributes to some of the favourable whaling grounds.

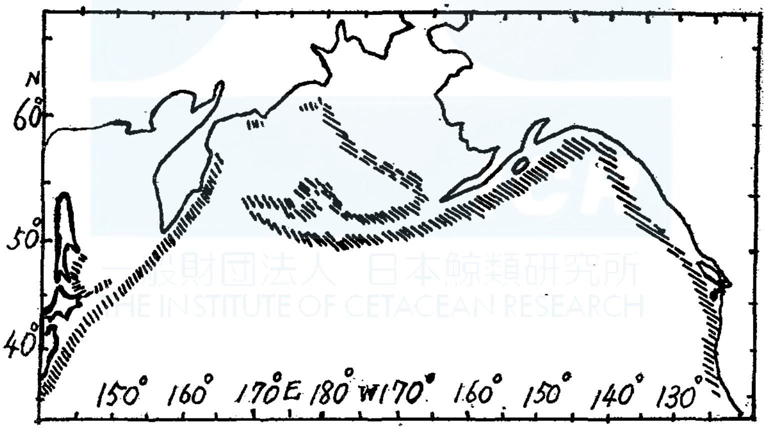


Fig. 1. Zone of maximum bathymetric gradient

Localities of maximum curvature of isobathymetrical lines (Fleming,

---

* Tokyo University of Fisheries.

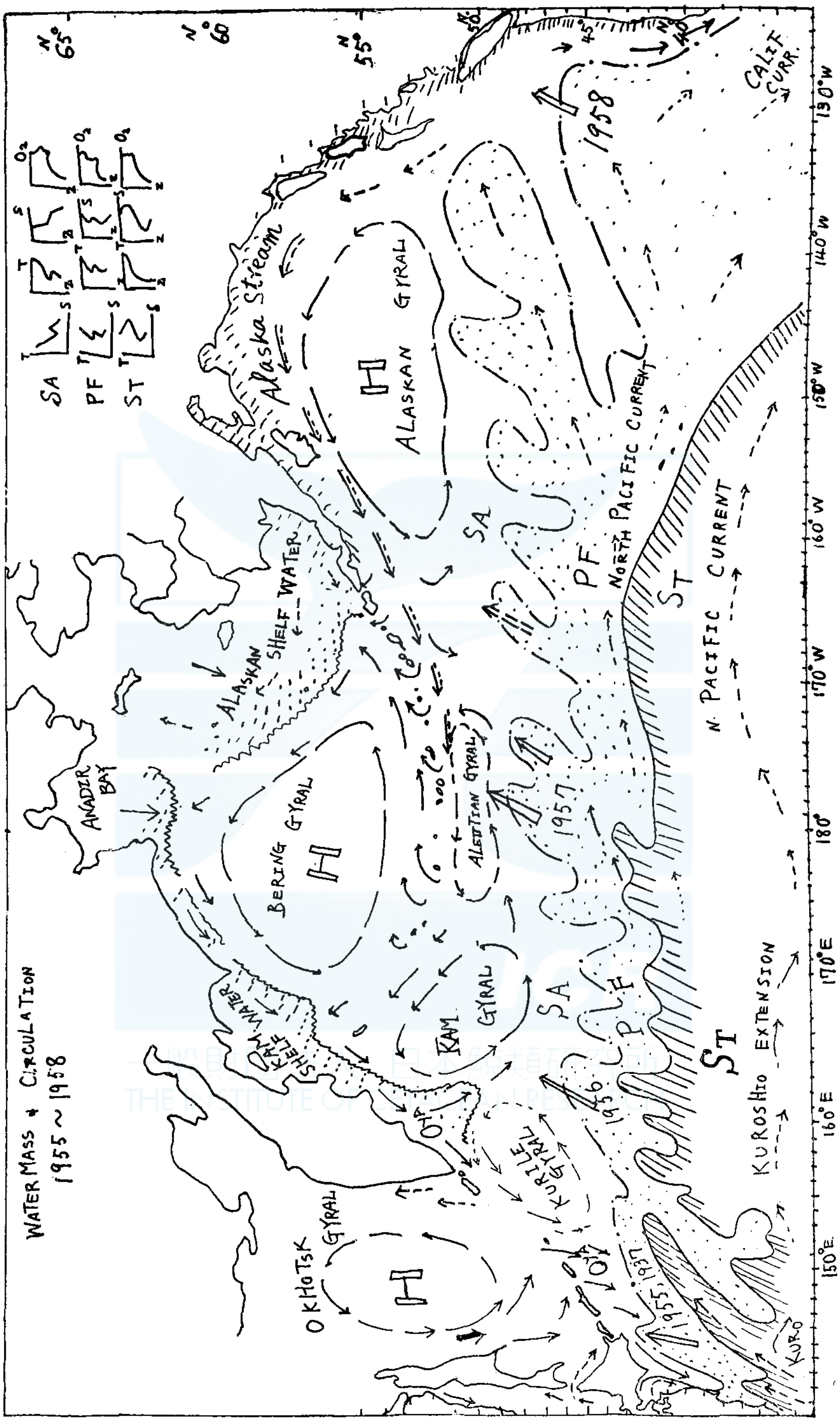


Fig. 2. Schematic map of watermasses and circulation in the Subarctic Pacific (1955-'58).

1955) appear to correspond to the particulary favourable whaling grounds α, β, γ, δ as shown in Figs. 2, 3 compared to Fig. 1., probably due to the concentration of whales and abundant food organisms.

CURRENTS AND WATERMASSES IN RELATION TO WHALING AND SALMON FISHING GROUNDS

Analysis of available hydrographic data collected in the North Pacific (north to 30°N) down to the 1000 m. depth or more for the years 1955–'59, proved the principal three types of watermasses i. e. Subarctic, Polar Frontal (including three subtypes) and Subtropical watermasses with several characteristic gyres and currents as shown in Fig. 2.

The watermasses, gyres and circulations are corresponded to the distribution, migration and conjectured stocks of salmons and whales in general, as suggested by the results of tagging or marking experiments and fishing grounds as the results of fishing exploition.

1. The averaged pattern of *geostrophic circulation* during the years 1955–'59 is shown in Fig. 3, based on the dynamic topography for dynamic anomaly (0 db./1000 db.). The basic pattern referred to 500 db. or even 300 db. as reference level is roughly the same to the above in the Subarctic waters.

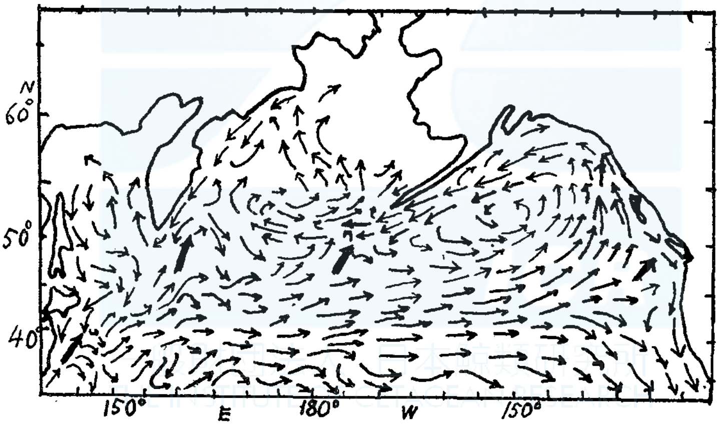


Fig. 3. Circulation based on geopotential topography. Summer (1955–'58) ΔD (0/1000 db.)

2. As a good indicator of Subarctic Watermass and a measure of winter temperature, the extent of *dichothermal water* (intercooled water, mainly produced in winter by convectional cooling and persists its trend to summer) with its core depth was studied (Fig. 4.). Salmon is very scarce in the domain of temperature less than 1–2°C and very abundant in the domain of 4–7°C near the frontal zone of dichothermal cold core

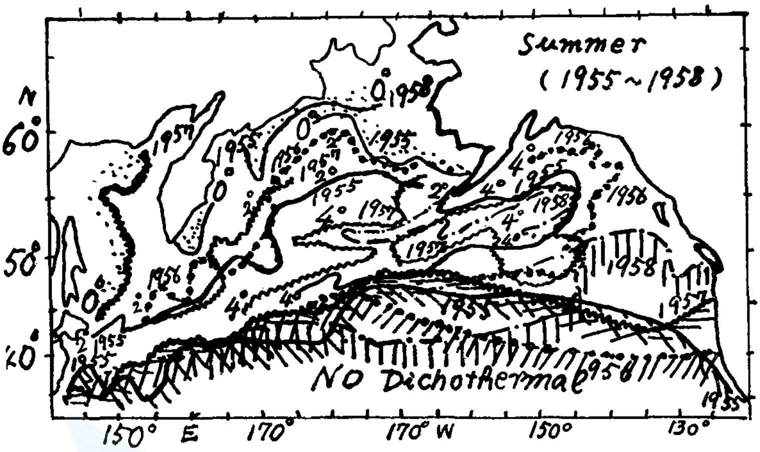


Fig. 4. Dichothermal topography (Summer, 1955~'58)

and again very scarce in the warmer (subtropical) water above 12–13°C.

Salmon wintering grounds are roughly specified by the dichothermal topography in the south of Aleutian and Kurile Chains.

Dichothermal structure in the western Subartic Waters is shallower and well developed in contrast to the eastern waters which is deeper and feeble. Those correspond to the densely concentrated salmons in the upper shallower layer in the western waters of Subarctic high sea compared to the deeply scattered fishes in the eastern waters.

The southern limit of distribution of dichothermal water and the northern limit of the intermediate (salinity minimum) water define the location of Polar Frontal Zone in which favourable fishing or whaling grounds are found in general.

3. *Surface salinity*

The distribution of salinity in each year from 1955 to 1958 are shown in Figs. 5, 6, 7, 8. Fig. 9 indicates the map of oceanic fronts based on the distribution of surface salinity during the summer season in the above years (1955–'58).

The whaling grounds seem to avoid the saline core lying at the Okhotsk Gyre, Bering Gyre and Alaskan Gyre (as well as Subtropical water) and to prefer the fringing zones around those cores of Gyres.

Salinity boundary looks to have more important meaning for the location of whaling grounds than water temperature, at least in the Subarctic waters does.

4. *Transparency of Sea Water or Clarity*

The distribution maps of transparency measured by Secchi's disk are shown in Figs. 10, 11, 12, 13 for each year during 1955–'58. Fig. 14 is the averaged distribution of transparency of them. The shaded turbid zones of less than 10 m. correspond to the several coastal watermasses and the Polar Frontal Watermass.

Eventually salmon stocks belong to each mother-river system and its associated coastal watermass. So, currents, eddies or gyres and the influenced extents of coastal waters in characteristic property (smell)

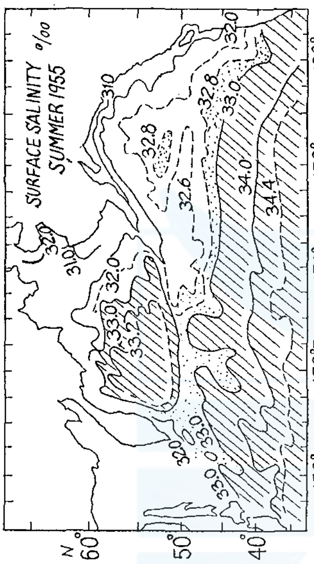


Fig. 5. Surface salinity in Summer of 1955.

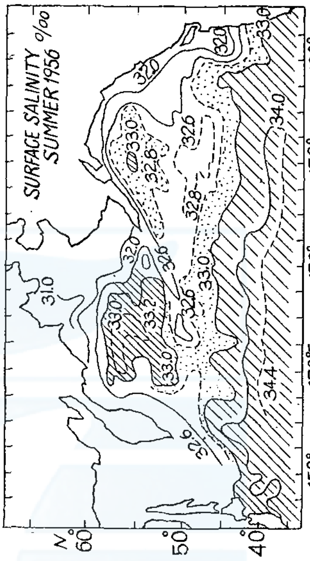


Fig. 6. Surface salinity in Summer of 1956.

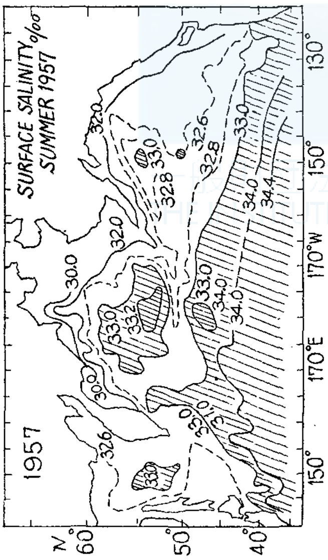


Fig. 7. Surface salinity in Summer of 1957.

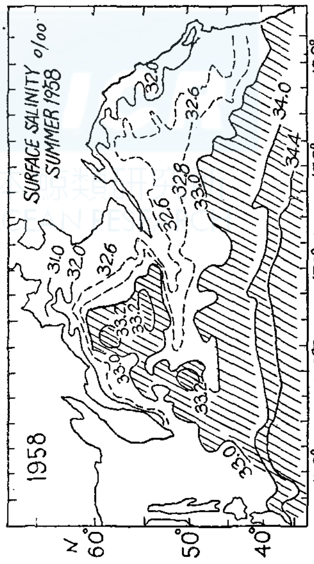


Fig. 8. Surface salinity in Summer of 1958.

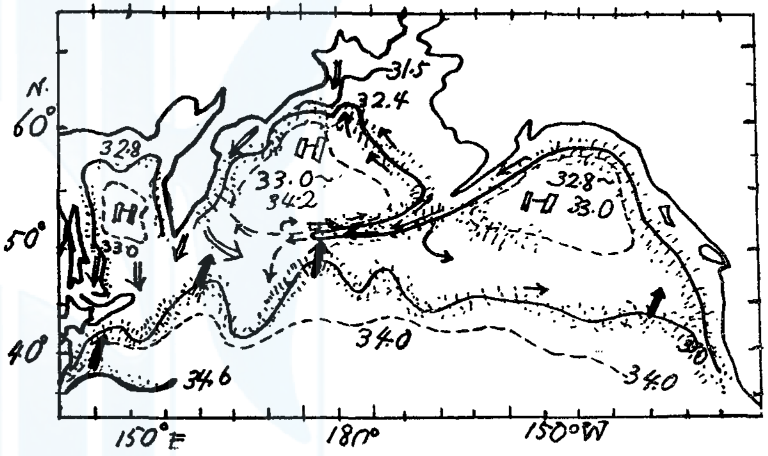


Fig. 9. Oceanic fronts of watrmasses based on surface salinity (‰), Summer (1955-'58).

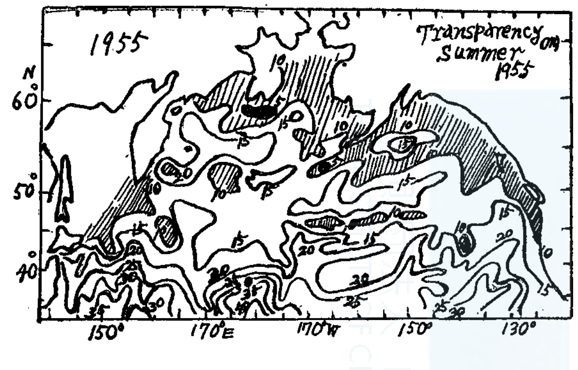


Fig. 10. Transparency in Summer of 1955.

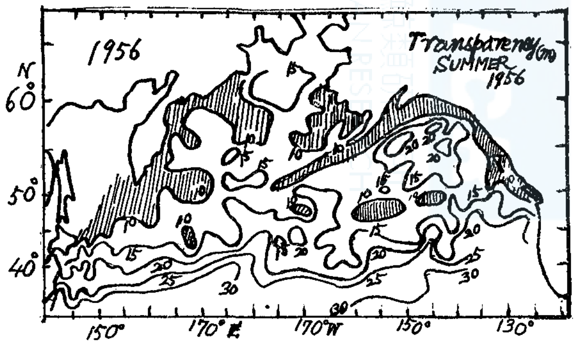


Fig. 11. Transparency in Summer of 1956.

correspond to the migratory routes, concentrated areas and segregated populations of salmons and whales. Turbidity is mainly composed of inorganic (mainly mud particles) and of organic (mainly planktonic origin) matters.

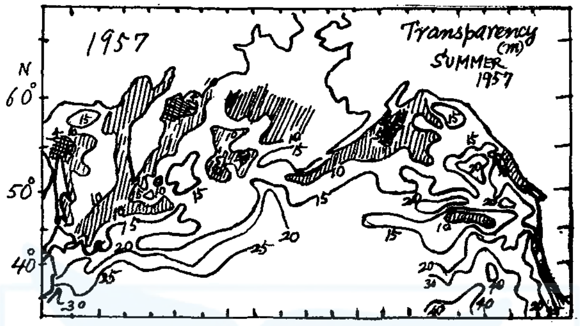


Fig. 12. Transparency in Summer of 1957.

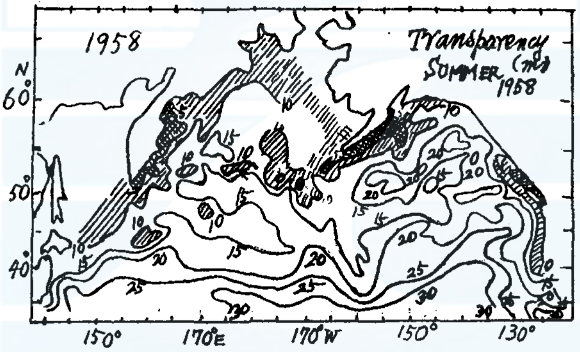


Fig. 13. Transparency in Summer of 1958.

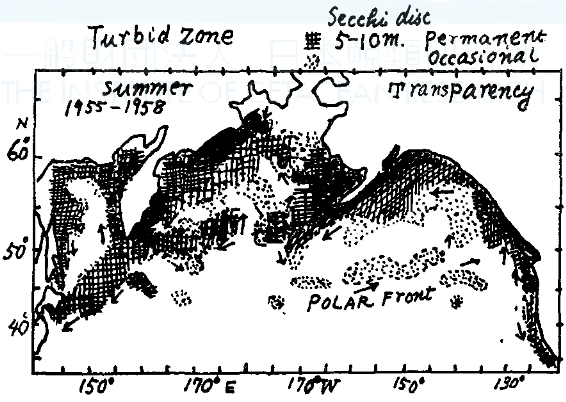


Fig. 14. Distr. of transparency in Summer of 1955~'58.

5. *Favourable whaling grounds at meridional sections*

Several meridional sections illustrate in Figs. 16–22 the oceanic frontal zone nearwhere the mode of whale catch (sperm whale and fin whal) are shown e. g. at the meridional sections across the Aleutian Ridge Fig. 15.

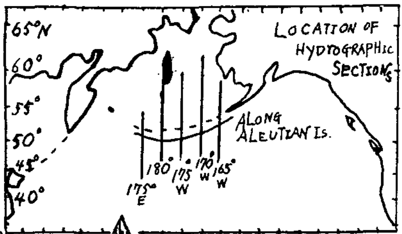


Fig. 15. Hydr. sections.

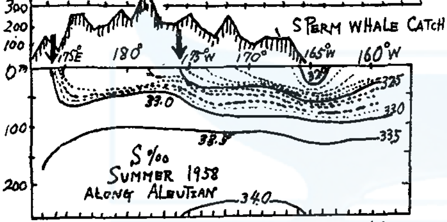


Fig. 16.

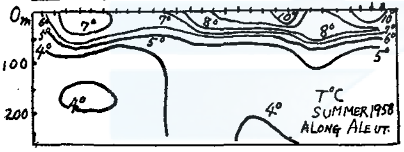


Fig. 17.

Temp. and saltinity sections along Aleutian Islands in contrast to the distr. of sperm whale catch.

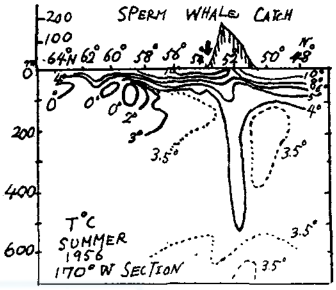


Fig. 19.

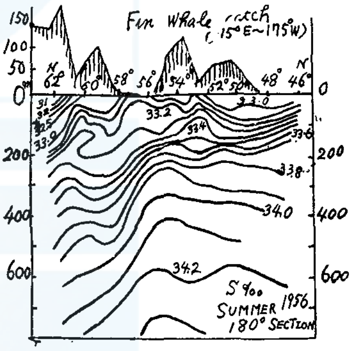


Fig. 20.

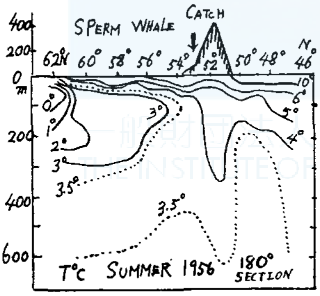


Fig. 18.

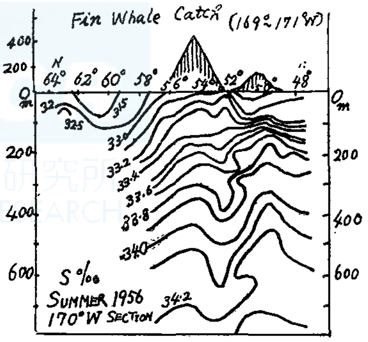


Fig. 21.

VERTICAL CIRCULATION AND WHALING GROUNDS

1. *Vertical mixing and convection in winter*

Table 1 suggests us the influencial depth of convectional mixing in the northern subarctic water from winter and spring to summer within the 200–300 m. depths from sea surface in winter almost completely and

TABLE 1 VALUES OF TEMPERATURE, SALINITY, σ_t, O_2, SATURATION DEGREE OF O_2 AND PHOSPHATE IN THE OKHOTSK SEA

ODOMARI*)									RYOFU-MARU*)						SOYO-MARU*)					
1939, 2, March Winter 45°-41′ N 145°-10′ E			1939, 26, April Winter 46°-27′ N 144°-45′ E			1939, 13, May Winter-Spring 50°-47′ N 145°-09′E			1942, 14, July Summer 50°-21′ N 148°-24′ E						1935, 21, Aug. Summer 40°-38′ N Bottom 146°-32′ E 3385 m					
Depth m	Temp. °C	S ‰	Depth m	Temp. °C	S ‰	Depth m	Temp. °C	S ‰	Depth m	Temp. °C	S ‰	σ_t	O_2 cc	O_2 %	Depth m	Temp. °C	S ‰	O_2 cc	O_2 %	P mg/m³
0	−1.38	32.75	0	−1.19	32.25	0	−0.55	32.07	0	8.44	32.18	25.02	8.01	119	0	12.80	32.45	6.55	106	25
10	−1.49	32.77	10	−1.29	32.30	10	−1.31	32.39	10	7.68	32.16	25.10	8.53	124	10	12.67	32.45	6.68	108	50
25	−1.61	32.75	25	−1.33	32.30	25	−1.47	32.68	25	1.32	32.38	25.92	9.49	119	25	4.56	32.83	8.45	115	35
50	−1.54	32.75	50	−1.48	32.92	50	−1.45	33.04	50	−1.42	32.70	26.41	8.10	85	50	4.12	33.22	6.94	94	75
100	−0.87	32.94	94	−1.59	33.01	100	−1.01	33.22	75	−1.54	32.83	26.42	7.92	93	100	1.41	33.22	6.94	88	90
150	−0.25	33.10	143	−0.62	33.19	146	−1.03	33.24	100	−0.71	33.08	26.60	7.46	90	146	0.84	33.24	6.90	86	100
200	0.43	33.28	196	0.71	—	195	−0.85	33.30	125	0.40	33.17	26.58	6.50	80	195	0.03	33.24	6.72	82	100
292	0.57	33.44	279	0.88	33.48	287	0.32	33.37	150	0.70	33.26	26.67	5.90	74	292	0.65	33.24	6.87	86	85
390	1.22	33.64	376	0.81	33.53	350	0.75	33.44	200	0.60	33.37	26.77	5.02	62	377	1.11	33.51	5.24	66	108
									300	0.75	33.48	26.85	4.08	51	472	1.26	33.44	4.75	60	114
									400	1.24	33.59	26.90	3.75	48	566	1.64	33.74	3.29	—	—
									500	1.60	33.80	27.04	2.95	38	768	1.82	33.96	2.36	30	173
									600	2.00	34.02	27.19	2.10	27	960	2.18	34.13	1.41	18	173
									800	2.36	34.18	27.29	1.17	15	1440	2.22	34.43	1.38	18	150
									1000	2.29	34.36	27.46	0.96	13	1929	2.01	34.54	1.48	19	156
									1199	2.23	34.38	27.47	1.09	14	2893	1.88	34.54	2.04	26	160

*) Research vessel

gradually to the lower depths unto 500–600 m. incompletely with delayed phase lag in which saturation degree of dissolved oxygen is above 60% in the Okhotsk Sea. Contrary to the deep water below the 800 m. depth having 15–30%, the upper water of lower saline and richer oxygen is flowing out through the Middle Kurile Straits into the water of Pacific Ocean of different water type. Stronger convectional mixing continues in the Okhotsk and Bering Seas to the end of May in the upper layer.

2. The schematic pattern of watermasses and currents in the meridional section are shown in Fig. 22.

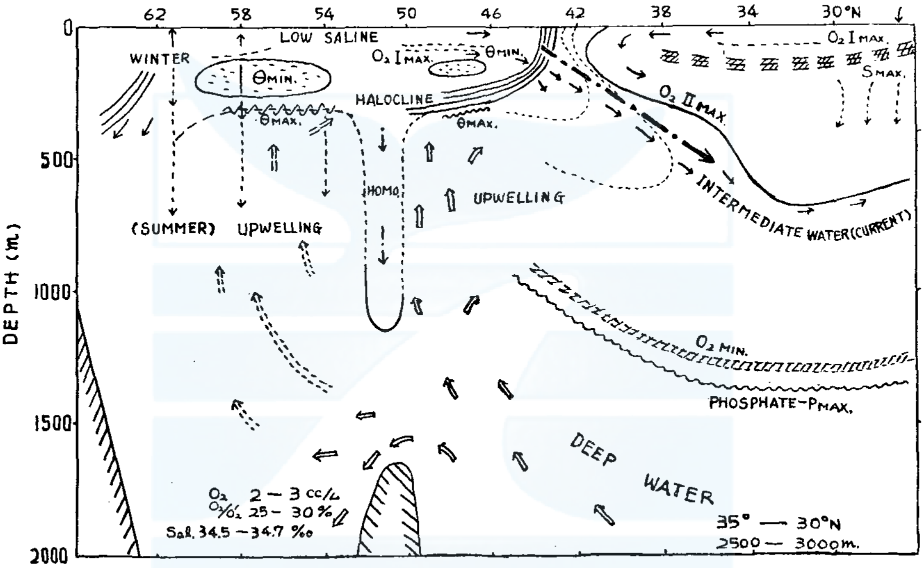


Fig. 22. Schematic circulation pattern in meridional section of North Pacific.

The inflow of Pacific Deep Water having salinity of 34.0–34.7‰ invades in the bottom layers of Bering Sea and Okhotsk Sea, overflowing the Aleutian and Kurile Ridges northwards which is basically different from the oceanographic structure in the North Atlantic Ocean.

3. In summer time the whaling grounds in the North Pacific Ocean cover the area of Subarctic Watermass lying in the zone of 48–64° N as their center.

The pattern of deep circulation in the North Pacific indicates also the general ascending current or upwelling in the higher latitudes. As favourable feeding grounds they depend on the higher productivity aroused by the general upwelling area which is similar to the Antarctic whaling grounds of fertilized waters by the prosperous upwelling process (Uda, 1961a). (Fig. 16–21)

4. We recognize the evidence of the Intermediate Current of Subarctic origin showing the second maximum of dissolved oxygen along the isopycnals of 26.20–26.80 and salinity minimum layer in the Polar Frontal Zone between the latitudes of 38 and 42° N.

WHALING GROUNDS IN RELATION TO HYROGRAPHY

The whaling grounds for each species in the Aleutian waters and Bering Sea north to 48° N during the years from 1955 to 1959 are shown in Figs. 23, 24, 25, 26, 27.

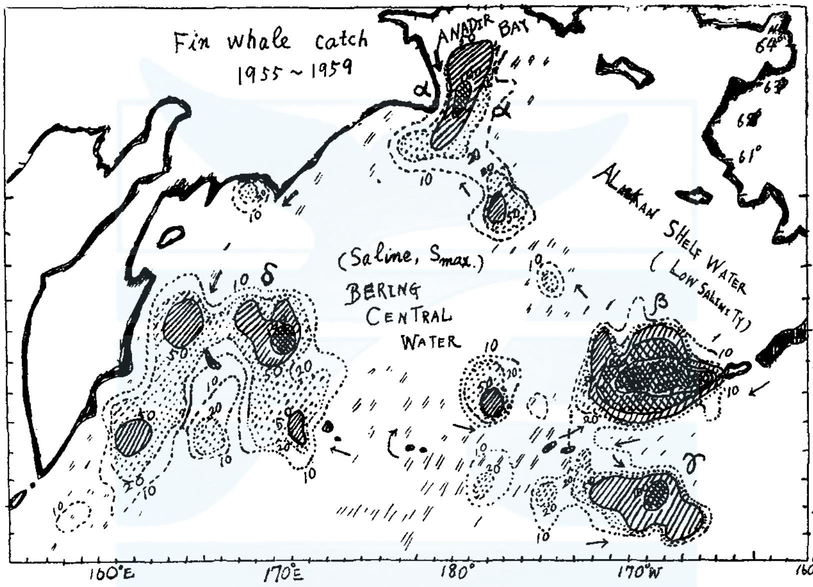


Fig. 23. Distribution of fin whale catch (1955–1959 accumulated).

1. We can not find fin whale grounds (Fig. 23) in the areas of the Bering Shelf Water of low salinity in the eastern part in the Bering Central Saline Water and also in the warm Alaskan Stream, probably due to the poor food-organisms.

Their grounds are located along the several oceanic fronts probably due to the plenty food-organisms concentrated by the vertical trains;

(α)....Anadir Front off the entrance of Anadir Bay,
(β)....Along the continental shelf edge particularly northwest to the southern tip of shelf edge north off Alaskan Peninsula,
(γ)....At the front of the warm South Aleutian Current and the cold Alaskan Gyre,
(δ)....Eddies east off Kamchatka Penninsula covering the water of Kamchatka—Komandorskii Islands—Attu Island.

As for example, sections at longitudes 180° and 170° W concerning water temperature and salinity indicate the relationship between the prosperous whaling grounds and the oceanic fronts, located between the cold, low saline and turbid water and the warm, saline and transparent water.

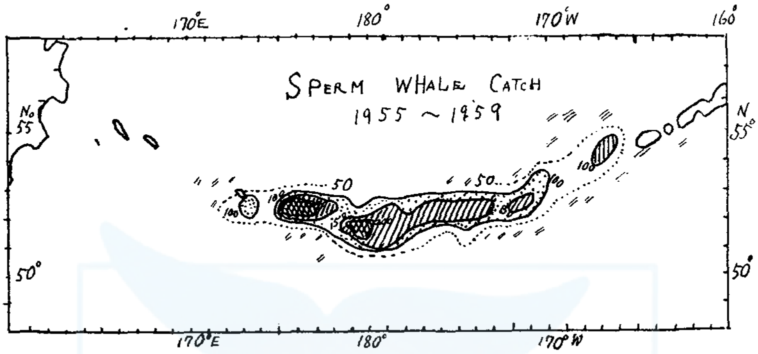


Fig. 24. Distribution of sperm whale catch (1955-1959 accumulated).

2. The sperm whaling grounds (Fig. 24) extend mostly around the Aleutian Islands, especially on the northern side where the upper and lower waters mixed well, almost showing homogeneous water temperature and salinity in the vertical and disappearance of dichothermal water, presumably due to the stronger turbulent mixing by tidal current and convectional mixing on the Aleutian Ridge and also suggesting the plenty food of squids around the Aleutian Islands Chain.

In the western part of the Subarctic Waters the dichothermal topography shows a shallower core depth of temperature minimum which may correspond the lower boundary surface of sperm whale migration.

3. The sei whale grounds during 1955-'59 (Fig. 25) developes mainly in the south of Aleutian Islands and concentrated to the top of the

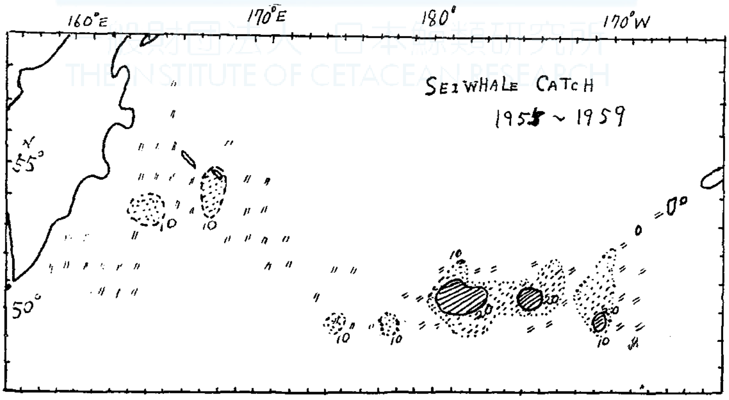


Fig. 25. Distribution of sei whale catch (1955-1959 accumulated).

South Aleutian Current in the south of Middle Aleutian (170° W–180°, 49°–52° N).

4. The humpback whale grounds during 1955–'59 (Fig. 26) also lie nearly along the south of Aleutian Chain.

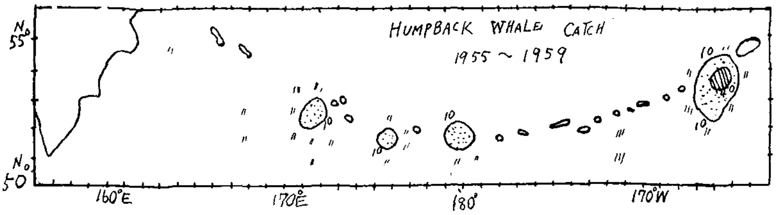


Fig. 26. Distributian of humpback whale catch (1955–1959 accumulated).

5. The blue whale grounds during 1955–'59 (Fig. 27) lie along the south of the Western Aleutian (165° W–180°).

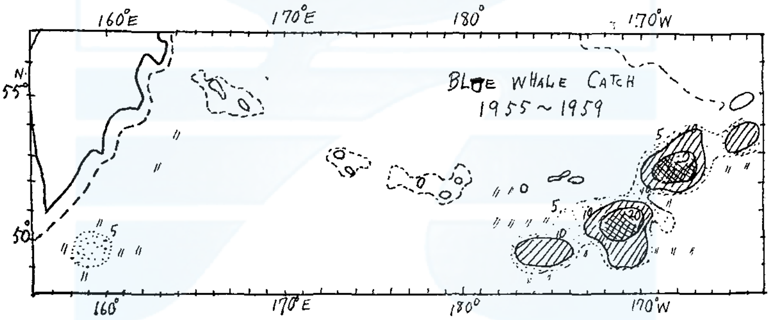


Fig. 27. Distribution of blue whale catch (1955–1959 accumulated).

CYCLIC CHANGE AND SEASONAL VARIATION

1. Seasonal or monthly variation of the distributed extents of water types or oceanographic elements (temperature, salinity etc.) shows rapid changing state of environmental conditions of salmon etc. from winter through spring to summer decade by decade, particularly in the Aleutian waters.

2. By his recent study (Uda, 1960, 1961b, 1962) (Fig. 2, 9) the author convinced that the pulsational cycle travels across the Pacific Ocean in the higher latitudes of prevalent westerlies flow west to east and come back from east to west in the lower latitudes of the prevalent Northeast Trade Wind (Rodewald 1959). The warm water intrusion in the western pacific occurs just concurrently with the cold water intrusion in the eastern pacific and vice versa (according to the past records of half a century).

3. The changing pattern of intruding shift from west to east appears to occur with the cycle of several years.

The superposed isolines of geostrophic flow in one map during 1955–'59 illustrates the above stated pattern of pulsation. Favourable catch year of salmon and whale corresponds to the warm intrusion in that area.

The head of warm water intrusion located in the waters, south of Hokkaido (in 1955), south of Kamchatka (in 1956), south of Aleutian Islands (in 1957) and off British Columbia—Northwest of U. S. A. (in 1958 and less in 1959) successively suggests us the migration pattern of pulsating Polar Front in easterly direction with the transpacific time interval of 3–4 years which is expected to reflect on the fisheries conditions of salmon, whale etc.

4. Temperature rise and fall in the ocean along Japan side occurs almost conversely to that along American side in the pacific during the fifty years 1910–'59. The intermediate pattern between those extrema on west and east coasts of pacific indicates the displacement of warmer or cooler waters in succession in the higher and middle latitudes and lower latitudes from east to west during the cycle years.

The anomaly chart of water temperature for each year during 1910–1941 and 1952–1959 indicates transpacific travelling pattern from west to east in the zone north to 30° N, on the contrary from east to west in tne zone of 30° N to 0° (equator) still in question though conceivably.

5. The core atomospheric pressure difference between the great high and low depressions in winter i. e. those between the Siberian High, the Aleutian Low and North Pacific High increased in the years from 1955 to 1959 in correspondence with the temperature rise in the east and temperature drop in the west during that period.

The increase of above pressure difference suggests us the accelerated geostrophic flow, and the intensified gyres with heat transport of warm watermass from west to east (refer to Fofonof, 1960–'61).

6. Cyclic change in the North Pacific Circulation composed of Subarctic (Cold Water) Circulation and Subtropical with Tropical Warm Water Circulation occurs with the period of 5–11 (in average 7–9) years.

7. Fluctuations of Kuroshio, California Current, North Equatorial Current and Peru Current (El Niño) might be correlated with the prediction indices from one to another.

REFERENCES

Fleming, R. H. (1955): Review of the Oceanography of the Northern Pacific. pp. 1–43. Bull. No. 2. International North Pacific Fisheries Commission.

RODEWALD, M. (1959): Beiträge zur Klimaschwankung im Meere (11), Die Ostpazifische "Wärmewelle" von 1957/58, Deutsches Hydr. ZS. R. (5).

UDA, M. (1960): On the fluctuation and prediction of ocean temperature in the North Pacific. The Memoirs of the Kobe Marine Meteorological Observatory. Vol. 14. 1-16.

——— (1961a): Deep Circulation in the Antarctic Ocean. The Antarctic Record No. 11. pp. 831-835. Ministry of Education. Japan.

——— (1961b): Cyclical fluctuation of the pacific tuna fisheries in response to cold and warm water intrusions. M. S. distr. Pacific Tnna Biology Conference, Honolulu, Aug. 1961.

——— (1962): Oceanography of the Subarctic Pacific. Journal of the Fisheries Research Board of Canada (in press).

Fofonof, N. P. (1960, '61): Transport Computation for the North Pacific Ocean. 1955, '56, '57, '58, '59, '60. Fisheries Research Board of Canada. MS. Rept. Ser. (Oceanographic and Limnological). No. 77, 78, 79, 80, 85, 93.

一般財団法人　日本鯨類研究所
THE INSTITUTE OF CETACEAN RESEARCH

THE SCIENTIFIC REPORTS OF THE WHALES RESEARCH INSTITUTE, TOKYO, JAPAN

NUMBER 1, JUNE 1948

NUMBER 2, DECEMBER 1948

NUMBER 3, FEBRUARY 1950

NUMBER 4, AUGUST 1950

NUMBER 5, JUNE 1951

NUMBER 6, DECEMBER 1951

Kojima, T. On the Brain of the Sperm Whale (*Physeter catodon L.*). 49-72

Mizue, K. and Murata, T. Biological Investigation on the Whales Caught by the Japanese Antarctic Whaling Fleets Season 1949-50. 73-131

Nishiwaki, M. On the Periodic Mark on the Baleen Plates as the Sign of Annual Growth. 133-152

Nishiwaki, M. and Hibiya, T. On the Sexual Maturity of the Sperm Whales (*Physeter catodon*) found in the Adjacent Waters of Japan (I). 153-165

Nakai, T. Chemical Studies on Freshness of Whale Meat. IV. Some informations of *Achromobacter ubiquitum* isolated from Whale Carcass. 167-176

Nakai, T. and Ono, H. The Effects of Electric Shock and Fatigue on Post-mortem Changes in Muscle. 177-185

Omote, Y. Complete Recovery of Vitamin A from Molecular Distillation Residue of Whale-liver Oil. 187-191

Omote, Y. Chemical Structure of Kitol (I). Double Bonds and Hydroxyl Groups. 193-198

Hirata, M. Experimental Investigation on Flattened Head Harpoon an Attempt for Restraining Ricochet. 199-207

NUMBER 7, JULY 1952

Ogawa, T. On the Cardiac Nerves of Some Cetacea, with Special Reference to those of *Berardius Bairdii* Stejneger. 1-22

Akiya, S., Hoshino, O. and Motohashi, N. On an Attempt to Preserve Whale Meat Freshness with 5-Nitrofurfuriden Aminoguanidine from Decay. 23-30

Akiya, S. and Sawamura, R. Colorimetric Determination of 5-Nitro-2 furfuridene Aminoguanidine. 31-36

Tomiyama, S. and Takao, M. Studies on Utilization of Higher Fatty Alcohol from Sperm Whale Oil. 37-46

Omote, Y. A Rapid Method for the Separate Determination of Vitamin A and Kitol in the Whale-liver Oil. 47-50

Arai, Y. and Sakai, S. Whale Meat in Nutrition. 51-67

Yamaguchi, K. and Fujino, K. On the Serological Constitution of Striped Dolphin (*Prodelphinus caeruleo-albus* (Meyen)) (I). 69-77

Nishimoto, S., Tozawa, M. and Kawakami, T. Food of Sei Whales (*Balaenoptera borealis*) Caught in the Bonin Island Waters. 79-85

Nishiwaki, M. On the Age-Determination of Mystacoceti, Chiefly Blue and Fin Whales. 87-119

Nishiwaki, M. and Hibiya, T. On the Sexual Maturity of the Sperm Whales (*Physeter catodon*) Found in the Adjacent Waters of Japan (II). 121-124

Ohno, M. and Fujino, K. Biological Investigation on the Whales Caught by the Japanese Antarctic Whaling Fleets, Season 1950/51. 125-188

NUMBER 8, JUNE 1953

Yamada, M. Contribution to the Anatomy of the Organ of Hearing of Whales. 1-79

Omura, H. Biological Study on Humpback Whales in the Antarctic Whaling Areas IV and V. 81-102

Fujino, K. On the Serological Constitution of the Sei-, Fin-, Blue- and Humpback-Whales (I). 103-125

Ogawa, T. On the Presence and Disappearance of the Hind Limb in the Cetacean Embryos. 127-132

NUMBER 9, JUNE 1954

NUMBER 10, JUNE 1955

NUMBER, 11, JUNE 1956

NUMBER 12, JUNE 1957

NUMBER 13, SEPTEMBER 1958

NUMBER 14, SEPTEMBER 1959

NUMBER 15, NOVEMBER 1960

昭和37年3月15日 印刷
昭和37年3月30日 発行

編輯者 財団法人 日本捕鯨協会
鯨類研究所
東京都中央区月島西河岸通12丁目4番地

編輯責任者 大村秀雄

印刷者 笠井康頼
東京都新宿区山吹町184番地

印刷所 株式会社 国際文献印刷社
東京都新宿区山吹町184番地

Printed at
Kokusai Bunken Insatsusha
Shinjuku-ku, Tokyo