HUMPBACK WHALES IN RYUKYUAN WATERS

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INTRODUCTION

The statistical table for the past 50 years shows that the number of humpback whales caught in northern Pacific is much less than in the southern hemisphere.

The table attached in Appendix I, showing the combined catch of humpback whale caught in Alaska, British Columbia, Washington state, California State, Lower California and the coastal waters off Japan since 1910, is based on data already published so far.

According to the table the largest number of catch was made in 1927 amounting to 1144 whales which includes 554, 472 and 95 whales caught in Alaska, Lower California and the adjacent waters of Japan, respectively.

After 1920-30 which was the most prosperous era of whaling, the number of catch has been gradually decreased year after year. The average number of whales killed annually in the North Pacific Ocean is 424, 111 and 73 in 1910-30, 1931-45 and 1946-56 respectively.

The detail statistic of annual catch in the coastal waters of Japan, that is the west side of the North Pacific, is also given in the table attached in Appendix II. During the year of 1910-30, most of the catch was made in both east and west side of Honshu including the waters around Kurile Islands Chain. The whaling operation around Formosa has started since 1920, while that around Bonin Islands started since 1924. Both of Formosa and Bonin whaling ground were closed because of the significant decrease of catch since the start of the operation.

Even the biggest catch in Bonin waters does not exceed 86 whales in a year.

It is easily understood that the decrease of catch, mentioned above, was mainly caused by over-exploitation. Since 1940, however, whaling of this species has hardly been carried out in the North Pacific except in British Columbia, so that the abundance of humpback whale is believed to have been recovered gradually thereafter. In recent years, the average catch in a year was about 300 including the catch off San Francisco which has been established since 1956.

In Ryukyuan waters, fishermen often reported the occurrence of humpback whales for these several years. Nago Fisheries Association started to kill them since 1954, using the 25 mm caliber of valley gun.

They caught 13 whales in 1956 and 23 in 1957. At that time, Japanese whaling industry begun to have interest in Ryukyuan whaling.

In the season of 1958, two new whaling companies are constructed in co-operation with Ryukyuan and Japanese companies. These companies expected to kill 50 humpback whales and 30 sperm whales. Actually, however, no sperm whales was caught. On the other hand, they caught 290 humpback whales throughout the season.

United States Civil Administration of Ryukyu Islands (USCAR) has great concern to the number of catch and stated that this amount of catch of humpback whales would not be favorable. In 1959, it presented a quota of 90 humpback whales for three companies. At that time, the author was requested by Japanese Whaling Industry to take care of Ryukyuan whaling. This is the motive of the examination trip to Ryukyuan Islands.

METHOD OF INVESTIGATION

Methods applied to this investigation are quite similar to those used for whale examination in Antarctic, North Pacific and the coastal waters of Japan. Items to be examined are as follows: sex, body length, the time of killed, the time of commence of treating, location of catch, body color, parasites both external and internal, thickness of blubber, thickness and color of mammary gland, contents of the first stomach, weight of testis, careful examination of ovaries, fetuses if any, and osscification of vartebrae. Special attention was paid to ear plug this time which is a important and effective clue to age determination. Furthermore, blood samples were collected to study the frequency of blood type which may be indicative of intermixture with other group of whales. The details of methods applied are not given in this report, because most of those methods were already published.

OUTLINE OF THE WHALING SEASON IN 1959

The author was invited by the Government of the Ryukyuan Islands to make estimation of the total number of whales migrating to the Ryukyuan waters and determination of optimum number of catch for this season. It was also aimed to develop methods in whale research to train investigators of the Government and finally to make suggestion for the improvement of the Ryukyuan whaling industry.

Before the author arrived at the Ryukyuan Islands, the quota of 90 humpback whales had been extended by USCAR to 190 with a condition to help the research activity by reporting the occurrence of other species of whales. The author recommended to USCAR to make further extention of the quota, because the catch amounting to 190 whales is not sufficient to make reliable study on the migrating whales for a shorter time.

Needless to say, however, the catch should not exceed the optimum level. From the view point of research, a larger sample size is better, but the quota of catch could not be increased limitlessly. So the author tried to estimate the total number of migrating whales basing on the number of observed whales in the last season. According to the data, made by one company, 350 whales were observed during the season in which 120 were actually killed. Since the author considers these figures are reasonable but not exaggerated, this numerical relationship is applied to estimate the migrating whales from the number of catch. Basing on the catch records by three companies, the estimated number is calculated as 850 (350+350+150).

But some individuals would be observed and counted more than once. To eliminate this source of over-estimation, 150 is substracted from the total. Outside of the whaling ground, that is Miyako, Yaeyama and Amami areas, many whales were also observed by other fishing boats than whaling one, therefore, 100 individuals are added to the estimated number within the whaling area. Hence, finally estimated number amounts to 800 whales.

According to the general concept that the number of migrating whales is about 2 or 3 times of the observed number, 1600–2400 individuals may be migrate around Ryukyuan waters.

It is also a general belief that one-tenth of the migrating whales may be caught without harmful influence to a abundance. Basing on these estimation, the author suggested to USCAR 160 as a standard number of an annual catch. The suggested number is unexpectedly quite equal to the standard number made by USCAR.

It is considered that the kill up to 216 whales, that is ninety percent of the maximum number available as mentioned above, may be permissible to be caught this year. Then the author requested 220 whales as a quota this year which includes 60 whales taken for the additional purposes. To this request, USCAR accepted the quota of 220 whales. In such a course of consultation, the quota of this season was settled but the problem of the period of whaling operation was still in question.

Shooting mother whale accompanied with calf is prohibited by a stipulation of the Whaling Convention and the custom of gunners. According to the growth of fetuses the hight of the parturition in the North pacific is probably in November. Ryukyuan waters are certainly considered as a mating and nursing area but may neither parturition nor feeding area. This is based on the evidence that whales in mating were observed at several places in this area for the whaling season, and Ryukyuan whaling had no fetus in the previous seasons. Anyhow, it is desirable to open the whaling season in the time when most of pregnant whales have given birth to culves. One of other reason is that the author had received some opinions on protection of the whales from the American scientists. If the height of the parturition period would be sometime in November, it is quite effective to open the whaling season in a little more later date for protection of calves.

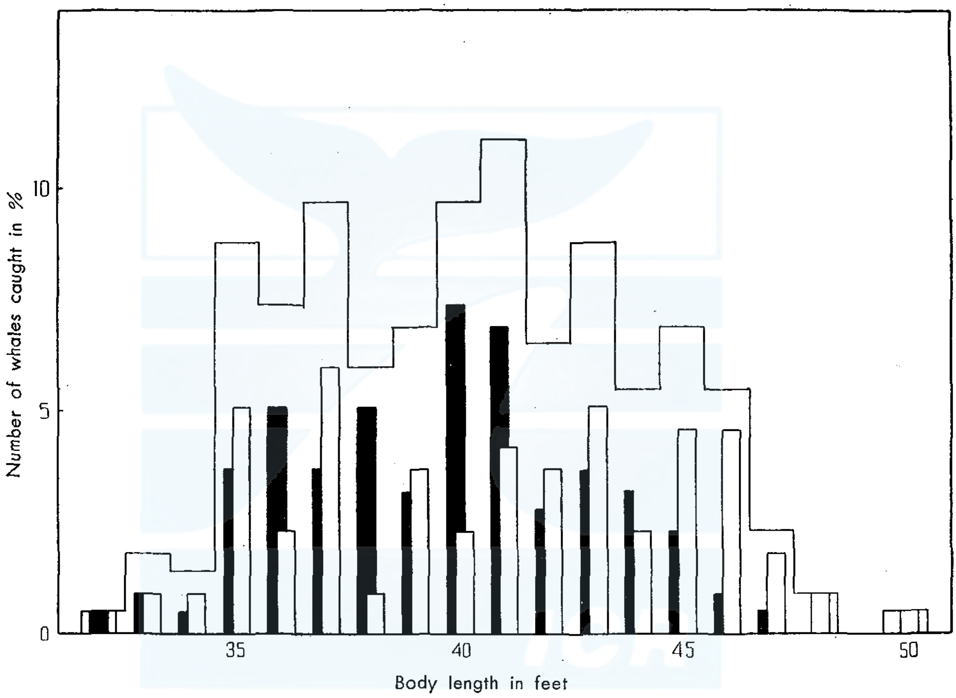


Fig. 1. Size distribution of Ryukyuan humpback whales in this season.

For this reason, the author suggested the Ryukyuan Government to open the whaling season in the middle of January instead of 1st December. So the Government decided 7th January as the date of removal of a ban.

Now, on January 7, catcher boats began to operate for whaling, and some larger boats brought several whales to the whaling stations. The author was surprised in a glance by more fresh, fat and fine whales than those taken in the adjacent waters of Japan. It is general concept that the whales migrating to the warmer waters are more or less thinner than those in colder waters, because of exhaustion of energy for their breeding. Because of smaller boats, Nago Fisheries Association could not catch any whales.

In the middle of January, when air and water temperature went down, the whaling season came to the height. However, the water temperature in February when the temperature were used to be coldest was higher by 2°C–3°C this year than the normal year.

According to the weather reports in Far East Asia, the Chinese Continent had drought in the last summer. By the drought, the water volume of the river flowing to the East China Sea (Yangtze River,

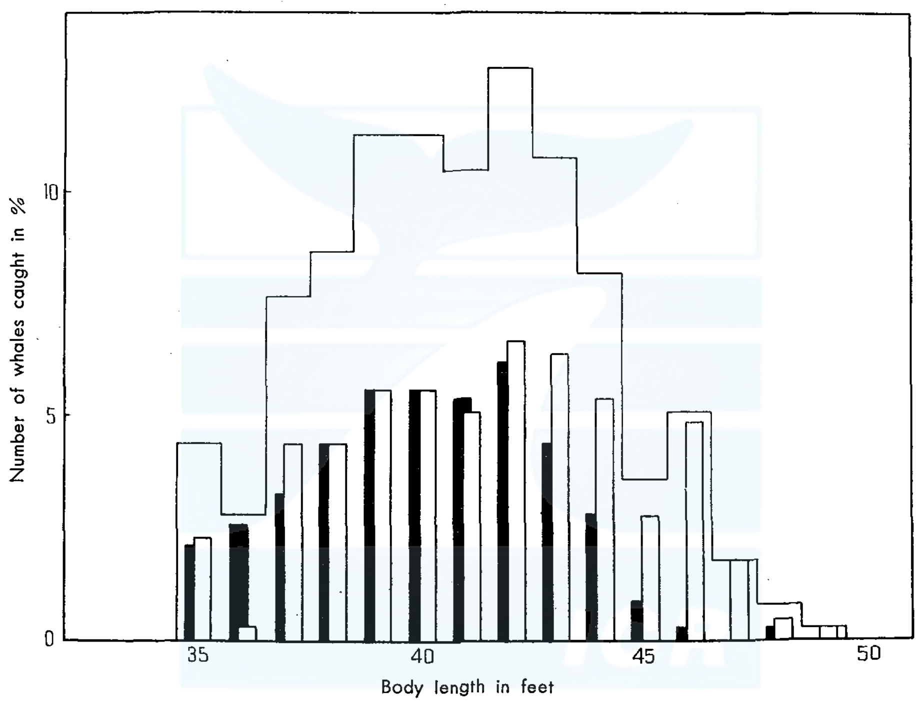


Fig. 2. Size distribution of Aleutian humpback whales in the years 1952–1958.

Yellow River and etc.) might be reduced. The decrease of colder water from rivers might probably cause a higher temperature around Ryukyuan Islands. A higher temperature around there was also noticed by the fishermen for tuna, bonito and mackerels.

The significant change in water temperature may be a decisive factor to the migration of whales. They migrated not only in a earlier time but also in the northern part of the whaling area. For instance, whales are scarcely sighted in Miyako and Yaeyama where many whales were usually observed. On the contrary, a considerable amount of whales were seen around Amami where they had scarcely seen in the normal year.

In spite of the unfavorable condition this year, one whaling company with two larger boats had rather satisfactory catch and quitted the operation on March 19th, Nago Fisheries Association also filled up the quota in the comparatively earlier time. One other whaling company with only one larger boat could not fill up the quota until the middle of April, because of the poor efficiency in scouting whales.

Seven sperm whales were caught for four months from January 7th. This is considered to be a very important clue to the development of the Ryukyuan whaling industry in future. In other words, the profit from the catch of sperm or Bryde's whales should be spent for conservation measures of humpback whales. In the case of this year, one company took two and the other caught five sperm whales. These catch mean the reduction of the number of humpback whales killed. Then, the total catch actually treated amounted to 217 whales.

Beside them, four "Dauvhal" were picked up by fishermen. As these were used only as fertilizer, they were not included in the statistic mentioned above.

COMPOSITION OF BODY LENGTH

The number of catch by body length is given in Table 1 and Fig. 1. In Fig. 2 is given the composition by body length of the total catch, amounting to 390 whales, which was taken by Japanese Whaling Fleet in the Aleutian waters from 1952 to 1958.

It is noticed from the figures that these two compositions are quite similar. The similarity might indicate that the stocks in the Ryukyuan waters and the Aleutian waters are of same origin. This is also supported by the results from the recovery of whale making. In the Ryukyuan waters, three and one whales marked in the Aleutian waters were recovered last year and this year respectively. This fact indicates the close relationship between these two waters.

Without accurate calculation, it is easily considered that a high rate of whale marking recovery indicates that the abundance is not so large. It is quite strange that no marked whale has been recovered in the waters off British Columbia and California.

MONTHLY CHANGE OF CATCHES

The monthly change in the average body length of catch is given in Fig. 3. Female is longer than male by two feet in January. But the difference is getting smaller in February and March. According to the

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

Body length in feet	Male whale			Female whale							Grand total
	Immature	Mature	Total	Immature	Mature					Total	
					Ovulating	Pregnant	Lactating	Resting	Sum		
31											
32	1		1								1
33	2		2	2						2	4
34	1		1	2						2	3
35	8		8	11						11	19
36	8	3	11	4	1				1	5	16
37	3	5	8	12	1				1	13	21
38	6	5	11	1			1		1	2	13
39	1	6	7	5	2		1		3	8	15
40	2	14	16	1	2		1	1	4	5	21
41		15	15		5	1	1	2	9	9	24
42		6	6		5	1	2		8	8	14
43		8	8		5		4	2	11	11	19
44		7	7		3		1	1	5	5	12
45		5	5		7		2	1	10	10	15
46		2	2		6		4		10	10	12
47		1	1				3	1	4	4	5
48					2				2	2	2
49											
50					1				1	1	1
Total	32	77	109	38	40	2	20[1)]	8	70	108	217
Average length	36.2	41.0	39.6	36.3	43.3	41.5	43.7	43.0	43.3	40.8	40.2
Sex ratio			50.2							49.8	100.0
Maturity	29.4	70.6	100.0	35.2					64.8	100.0	
rate	Immature male and immature female were 32.3					Mature male and mature female were 67.7					100.0
Rate of					37.0	1.9	for total female			100.0	
pregnancy					57.1	2.9	for matured female		100.0		
Rate of							18.5			100.0	
lactating							28.6		100.0		
Rate of	3.7		100.0	3.7						100.0	
under size	$MS+FS=3.7$										100.0

In this lactating whales, 10 whales are included which had been ovulated in lactating stage also.

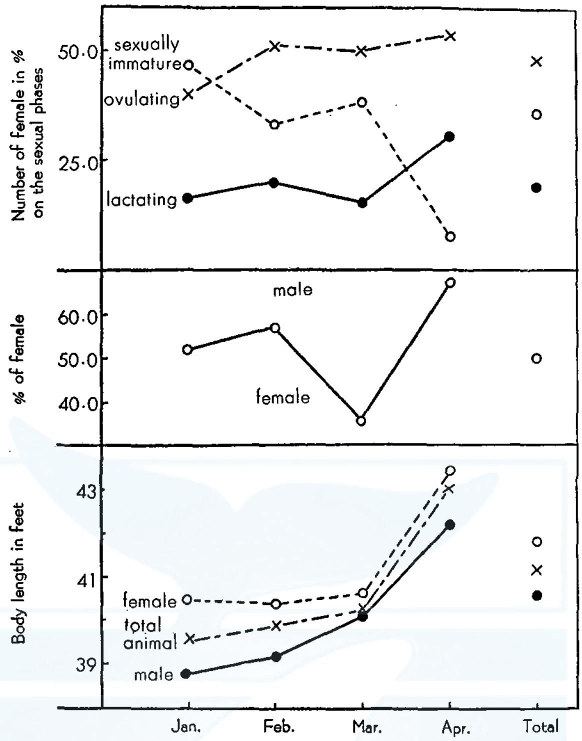


Fig. 3. Monthly average length, sex ratio and percentage of sexual conditions in the females.

Upper; open circle and dotted line: sexually immature,
solid circle and solid line: lactating stage,
cross and broken line: ovulating stage.

Lower; open circle and dotted line: females,
solid circle and solid line: males,
cross and broken line: both sexes.

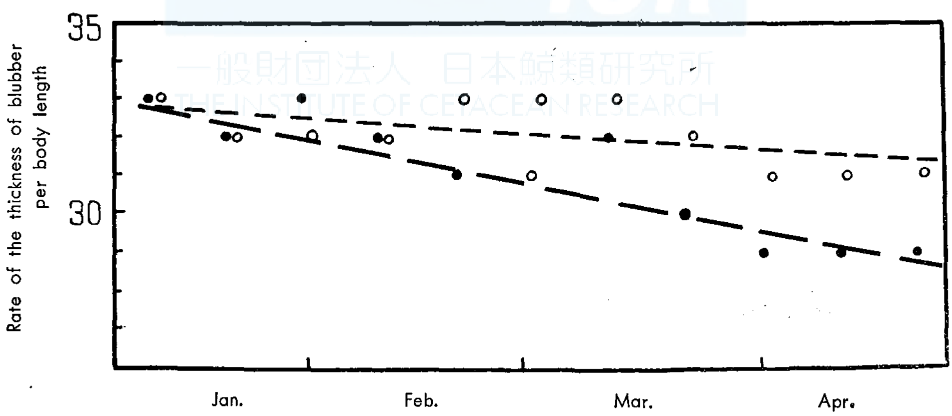


Fig. 4. Monthly decreasing rate of the thickness of blubber.

progress of the season, male is getting longer, compared to female. In April, the body length of catch both male and female is significantly longer, although the number of sample is a few.

These facts reveals that whales migrated to this waters in the beginning of the season are rather small, but gradually they are taken place by the matured group and eventually only the larger whales remain in this waters.

During January and February, the sex ratio is about 1:1. In March the male is slightly more than the female. In April, however, the female is predominant. From the view point of physiological condition of female, more than half of them are immature in January, but the number of the matured whales is increasing through February and March. In April, the number of immature one is very few.

On the contrary, the rate of the ovulating female is more or less lower in January, but after February it is in fairly high level. This may suggest that the ovulation might occur until the end of February. The rate of the lactating whale is rather low during January, February and March, but it becomes higher in April.

In brief, younger and smaller whales migrate in the beginning of the season but later, according to the progress of time, larger and matured whales appear in this waters. From the middle of March, many of the immatured whales move to the northern waters for feeding. Therefore, the whales still remaining in the warmer and nursery waters are mostly of the whales in lactating or mating stage. Since thirty percent of the remainning whales in April is in lactation, there are many mother whales accompanied by their calves being born in this season. These findings, mentioned above, is quite identical to the results on the humpbacks in the Australian waters reported by Chittlebourough.

As is shown in Fig. 4, the thickness of blubber is decreasing in either male or female from January to April. Male is getting thinner from the middle of February more significantly than in female. Infering this fact from behavior of dog in the mating season, male whales become absorbed in chasing female for reproduction.

PHYSIOLOGY OF OVULATION AND LACTATION

Classifing the female whales in more detailed physiological condition, the maximum diameters of Graafian follicles and corpora lutea and the thickness of the mammary glands are given in Fig. 5.

The immatured whales listed in the extremely left side in the figure have no corpus luteum, very small Graafian follicle, about 16 mm in diameter, and the mammary gland up to 35 mm in thickness. Afterwards, the diameters of the Graafian follicles are around 50 mm and the mammary gland is getting thicker when they reach to the pre-puberty stage. In this stage, however, no ovulation has been occurred and no corpus luteum is seen. By the first ovulation, the Graafian follicle changes to a corpus luteum. Immediately after the change, the

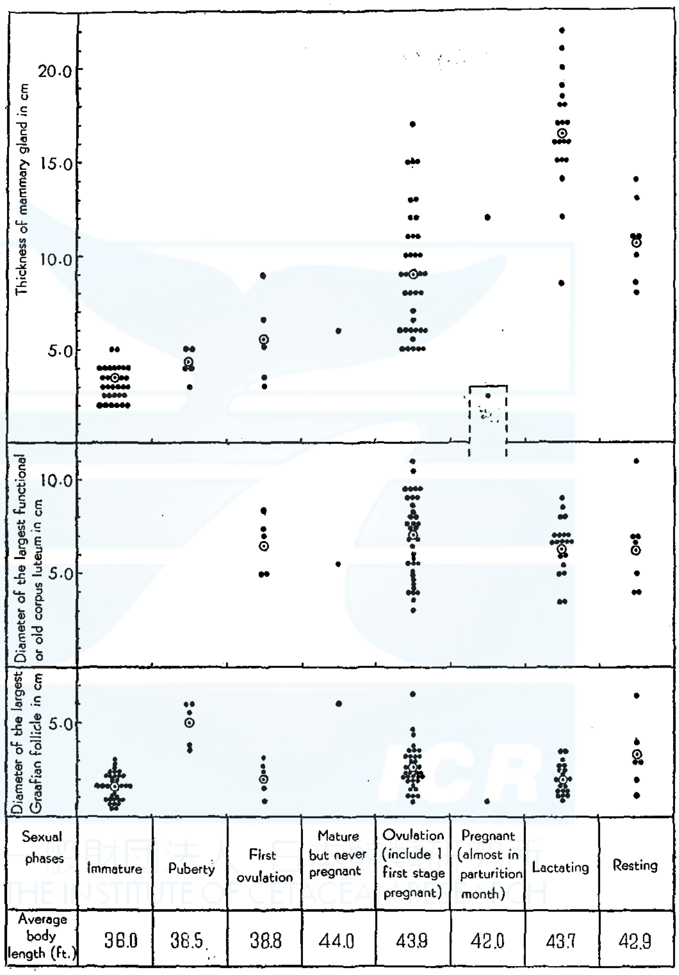
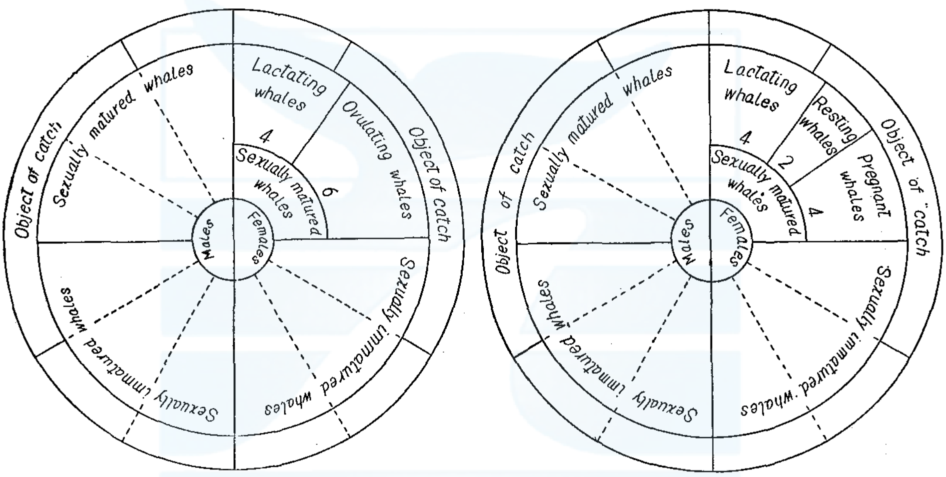


Fig. 5. The largest diameter of the Graafian follicle, functional or old corpus luteum and thickness of mammary gland are showing on the sexual conditions of female whales.

size of a corpus luteum becomes as large as 65 mm in its diameter in average. Other Graafian follicles than that ovulated in the first place and changed to a corpus luteum are rather small in their size, amounting to 20 mm in average diameter. The mammary gland of the lactating whale reaches up to 165 mm in its thickness and the size of the functioning luteum is around 65 mm in diameter. Graafian follicles of the lactating whales are usually shrunk into 20 mm in diameter.

In the extremely right column of Fig. 5 are indicated the conditions of the whale ovaries which are in the resting stage, neither pregnant, ovulating nor lactating. Some of the ovaries of the resting whales in the breeding area have much larger Graafian follicles than those in the feeding area. This indicates that the former whales are just about to ovulate in this breeding season. On the other hand, some ovaries of the resting whales in just after the lactation have rather smaller Graafian follicles and thicker mammary glands. The so-called resting whale, therefore, occupies a important part of the whales in the feeding area. In the breeding area, however, they are caught in a very short period, that is just finished the lactation or just before the ovulation. Hence, they are better be included in the stage of ovulation.



Breeding area Feeding area

Fig. 6. Schematic figures of the North Pacific humpback stock.

One pregnant whale having the fetus amounting to 12′10″ in length was caught in the breeding area. This may be considered to be in the lactating stage, because she must begin to lactate very soon.

Taking considerations mentioned above into account, the ratio given in Table 1 should be changed a little. In other words, the ovulating stage includes the stage of pre-puberty, ovulating in lactation and resting with larger Graafian follicles. And the pregnant one may be included in the lactating stage.

By the above mentioned definition, twenty-one whales are in the lactating stage, but less than 10 of these are actually in lactating.

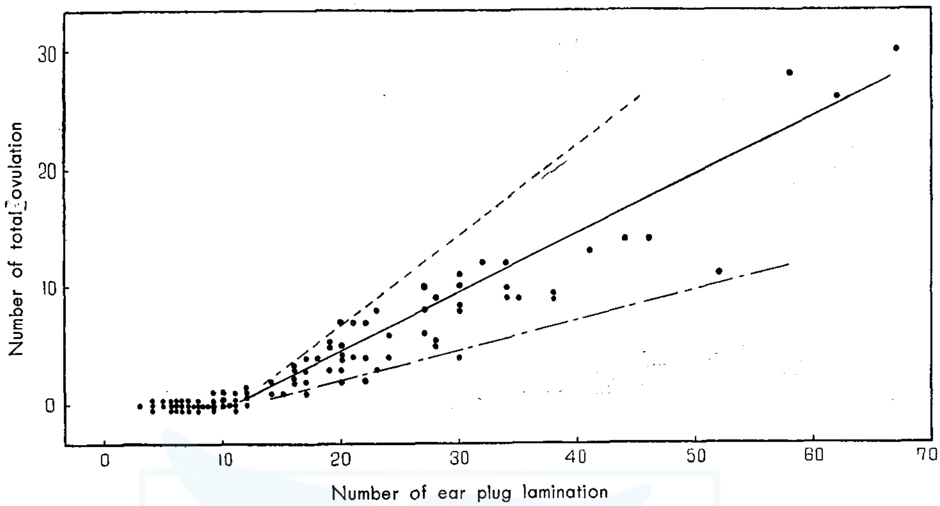


Fig. 7. Relation between number of lamination in ear plug and total ovulation number of the Ryukyuan humpback whales in this season.

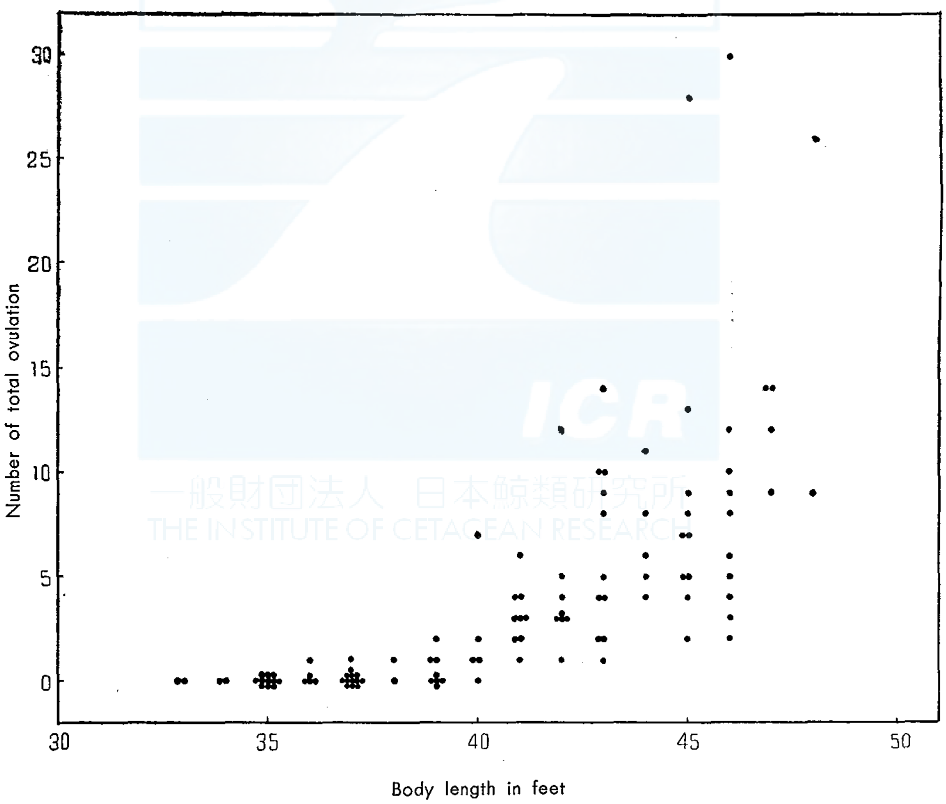


Fig. 8. Relation between body length and total ovulation number of the Ryukyuan humpback whales in this season.

These whale actually in lactating could not be killed because of the international regulation and the custom of gunners. Since these should not be subjected to killing, the whales in lactating must be eliminated from the kill. In that case, other matured whales are mostly in the stage of ovulation. Some of them may conceive in this season.

The pregnancy rate of the whales in the Ryukyuan waters is not known yet, so the pregnant rate in the Aleutian waters, that is feeding area, may be applied. The average pregnancy rate of the matured humpback whales in the Aleutian waters from 1952 to 1958 is estimated to be around 65 percent.

Basing on the age composition of whales determined from the lamination of ear plugs, it is estimated that a half of the whales is immature. As is shown in Fig. 6, the half of a stock is male and the other half is female. Both in male and female, half of them is immature. In the breeding area, 4/10 of the mature females were pregnant in the last season and are now in lactating. The remaining 6/10 of them are in ovulating, 2/3 of the ovulating females may be pregnant this year. In the next season, the whales now in pregnancy would be delivered of a calf and begin to lactate. And the whales now in lactating would be in ovulating stage together with these in the resting whales in the feeding area.

Now, the age when they reach to the sexual maturity after the prepuberty stage is considered. For this purpose, the relation between the total ovulation number and the lamination of ear plug which is considered to be the best index of age is given in Fig. 7. Fig. 8 is shows the relation between the total ovulation number and the body length. According to the figure, it is noticed that the first corpus luteum is seen when the number of the lamination amounts to nine. In the whales with 12 laminations in ear plug, there is only one immatured whale with no corpus luteum in its ovaries. Therefore, it is possibly presumed that the sexual maturity is reached when they are in the stage with 11 laminations in ear plug. Since two laminations are formed in a year, the whale just reaching to the sexual maturity is five years old or slightly old than that.

COMPOSITION OF MALE WHALES AND THE CHANGE IN THE WEIGHT OF TESTIS

All of the testis collected were weighed and some of them were processed and preserved for the histological observation if they are less than 5 kg in their weight. The testis with the closed seminiferous tubules is considered to be immature and with the open one is classified

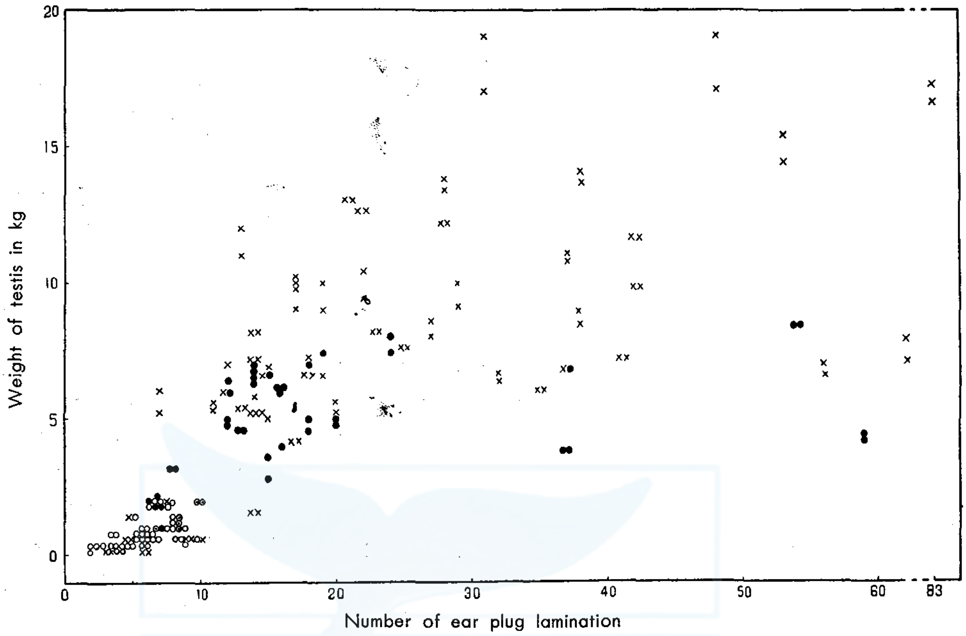


Fig. 9. Relation between number of lamination in ear plug and weight of testis that was examined histologically.

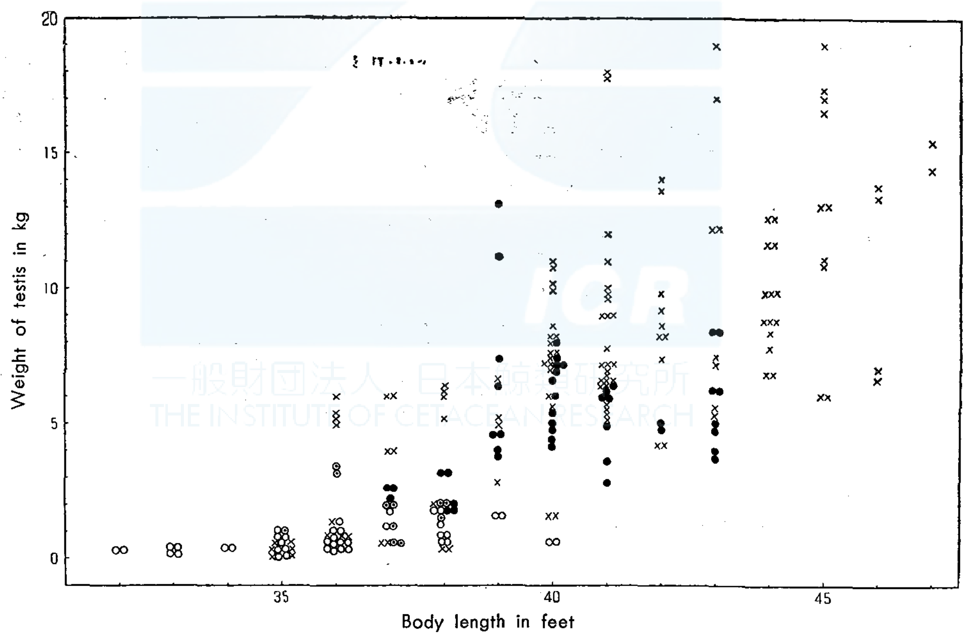


Fig. 10. Relation between body length and weight of testis that was examined histologically.

Explanation of Fig. 9 and Fig. 10.

solid circle: spermatozoa were found,

point in a open circle: some tubules were enlarging with a lumen and few spermatocytes were cited,

open circle: all of tubules were closed,

cross: these were not examined histologically.

to be mature. This classification is similar to that used by Chittleborough (1955), but both results may involve some errors to certain extent, because the identification of the puberty stage is very difficult.

The relation between weight of testis and lamination of the ear plug which is considered to be the most reliable clue to age determination is plotted in Figs. 9. Fig. 10 is shows the relation between weight of

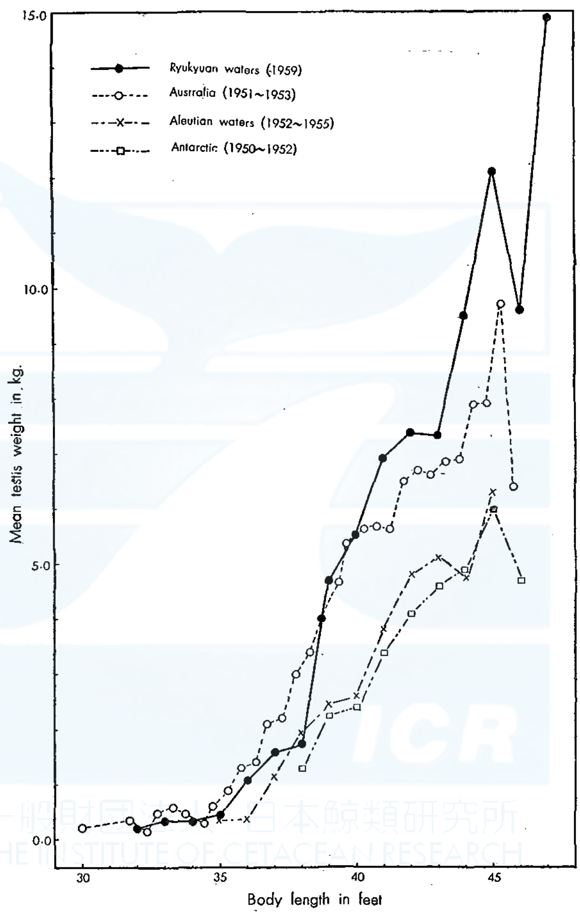


Fig. 11. Geometric means of testis weight according to body length. It is showing the differences between breeding and feeding area.

testis and the body length. Judging from the figure, the whale with testis of about 2 kg in weight, that is of five years old in age, reaches to the sexual maturity.

Fig. 11 shows the average weight of testis by body length in various waters. The result of the present investigation is shown by the solid line. Glancing over these four lines, the relationship in Ryukyuan and Australian waters, both of them are the breeding area, is quite similar, while that in the northern part of the North Pacific and the Antarctic waters being considered as the feeding area is also quite equivalent.

The figure also shows that after the sexual maturity the weight of a testis of a given body length is much heavier in the mating area than in the feeding area. The result by Symons is not referred here, because his finding given in the Norwegian Whaling Gazette No. 2 1958, is quite same to that obtained by Omura.

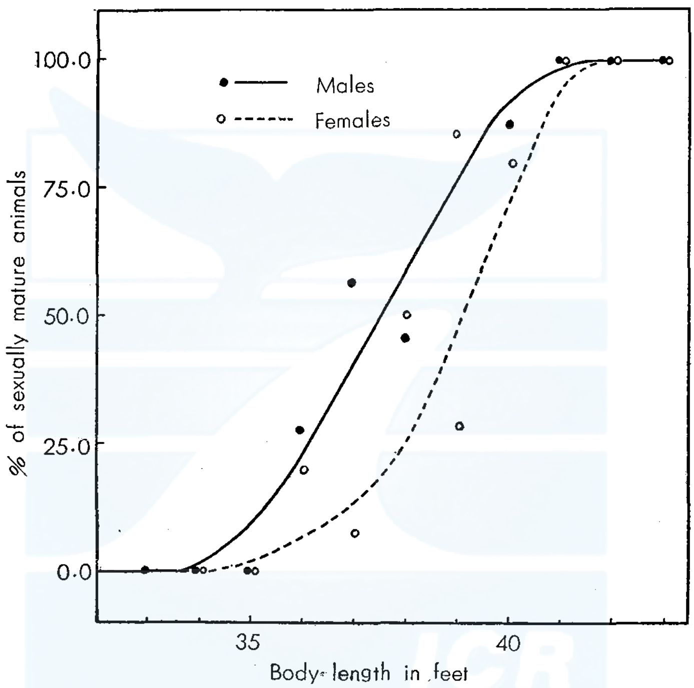


Fig. 12. Percentage of sexually mature animals according to body length.

It is very interesting that the weight of testis differs significantly between in the breeding and the feeding area regardless the hemisphere. Such a finding is made only on humpback whale so far but not realized in any other whale species.

BODY LENGTH IN THE SEXUAL MATURITY

In order to decide the average body length when matured sexually, the frequency distribution of the rate of sexual maturity by body length is shown in Fig. 12 on the basis of the above mentioned classification which defines the male whale with testis less than 2 kg as immature and more than that as mature. In case of female, the whale, with no corpus luteum is defined as immature. As is shown in the figure, whales reach to the sexual maturity when they are about 37–39 feet in body length in case of the male, and 39–40 feet in case of the female. This is quite identical to the result obtained by Chittleborough on the Australian humpback whales in the southern hemisphere. In case of the other whale species such as blue or fin whale, the body length in the sexual maturity is different between the south and the north hemisphere. However, no such a difference is observe in this investigation. This merits more detail study on other aspects of whale biology.

GROWTH OF FETUS

It is believed that the most accurate data on the fetus in the northern hemisphere have been obtained in the Aleutian waters, because these have been collected every year directly by scientists of the Whales Research Institute. In addition to these data, all other data on the growth of fetus obtained so far even in foreign country are plotted in Fig. 13. The cross mark in the figure indicates the average length of fetus by month. Fitting those points, the solid curve is drawn as growth curve of fetus. This curve, however, looks like slightly different from the real growth curve. Hence, the author calculated other growth curve, using the accurate data collected in the Aleutian waters from May to August. As is noticed in the figure, the calculated curve (represented by the dotted line) is different from the fitted one. This discrepancy may be interpreted as follows. The average length observed are longer than the calculated values in September and October. This may be due to looking over some smaller fetuses. On the contrary, the dotted line proceeds the solid line after October. This is because paturition begins from October and the samples observed are more or less limited to the whales being conceived in later time than the normals.

The broken line is the fetal growth curve of humpback whales in the southern hemisphere obtained by Laws this year. In this figure, Laws's curve is drawn as shifted by the time-lag for six months. The author considers that Laws's curve is not appropriate, because it is also based on the biased samples. Judging from the fetal growth of humpback whale in the northern hemisphere, the height of paturition occurred in November and the body length at birth is around 13–14 feet. The gestation period lasts for 10 and half months (or slightly longer than that).

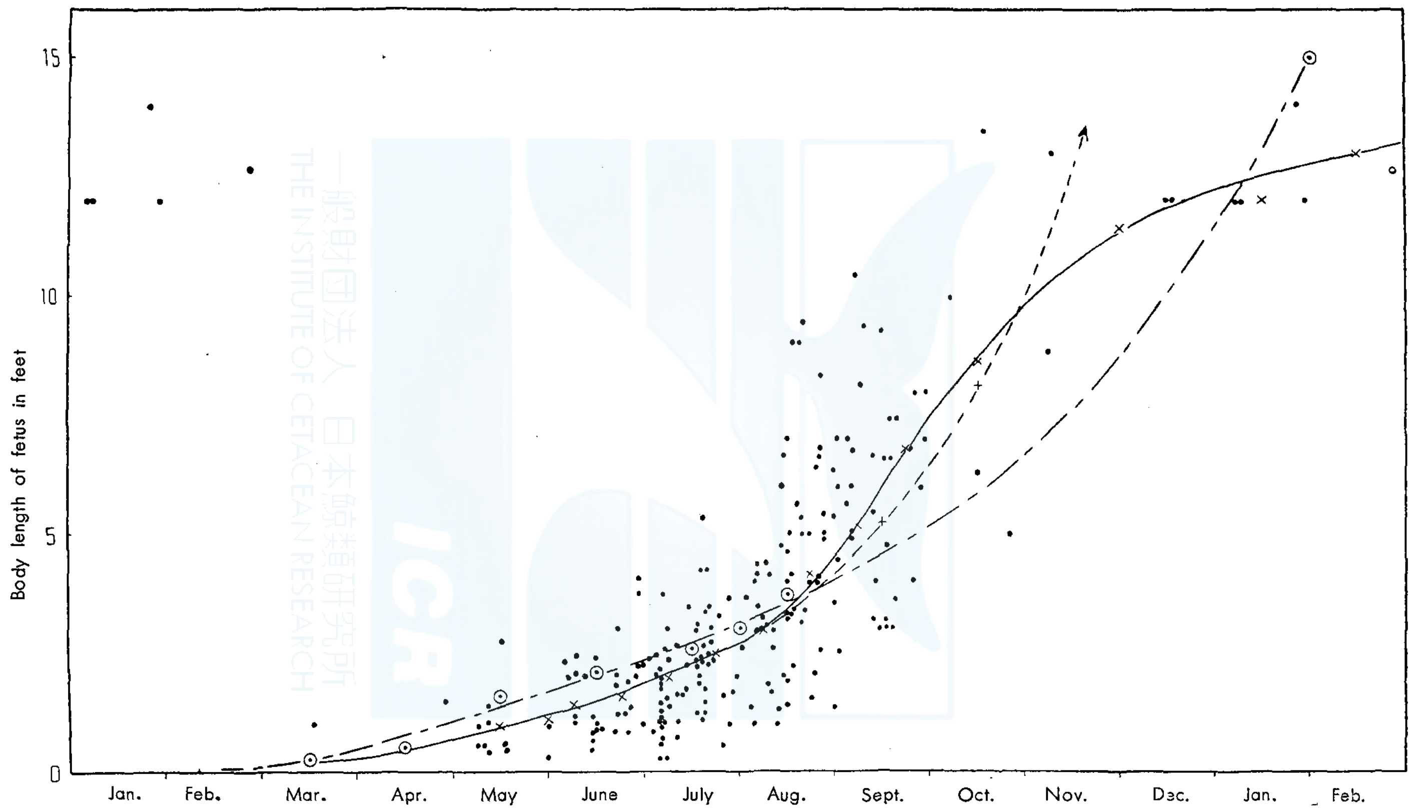


Fig. 13. Fetal growth in length of the North Pacific humpback whale.

Black dots: individuals, open circle: observed in this reason, cross and solid line: mean growth, dotted line: estimated growth curve. Point in open circle and broken line: data after Laws (six months shifted). The individuals that found in Jan. and Feb. are shifted in next year.

GROWTH IN BODY LENGTH

Fig. 14 indicates the growth of body length according to age estimated from the lamination of ear plug.

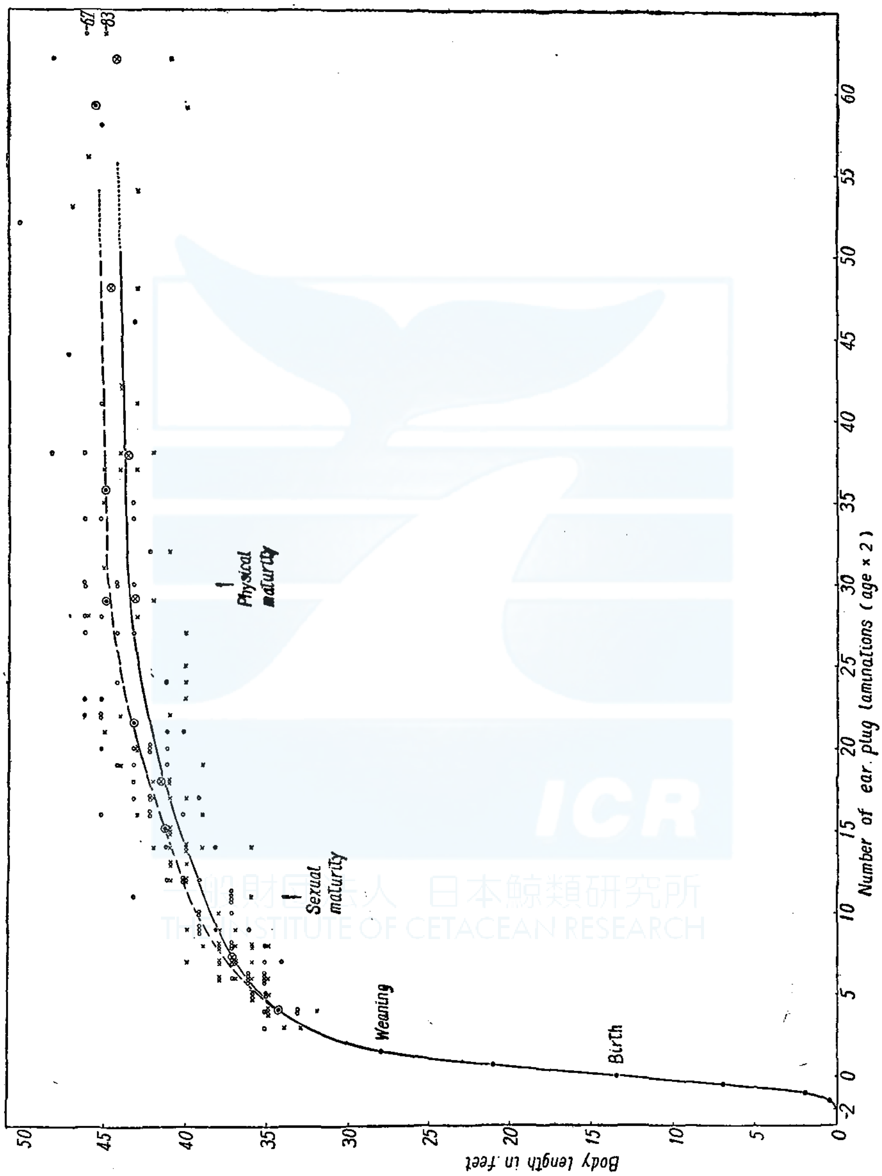


Fig. 14. Growth curve of body length according to the number of laminations in ear plug (age).
Cross and solid line: male, opencircle and broken line: female.

It is estimated that the body length at birth is about 13–14 feet and the gestation period is 10–11 months. However, since no data has been obtained from birth to the stage of 30 feet in length, the curve during this period is drawn by free hand. According to the fitted curve, a suckling calf, 21 feet in length, found accidentally on the coral reef in Miyako Island on 31st March this year, is estimated to be about 4 months old.

It is noticed that the female is longer than the male by $1^1/_3$ feet in a given age class of the adult stage. This species of whale reaches to

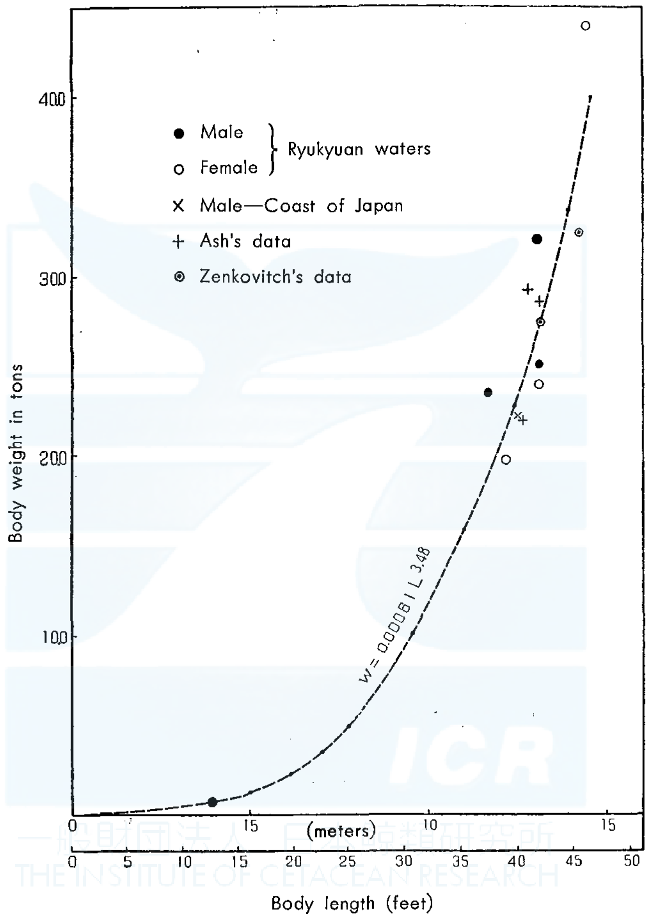


Fig. 15. Increase of body weight according to growth of body length.

the physical maturity about ten years after the sexual maturity. A growth curve usually comes down to certain extent from sometime at the older stage, but no such a tendency is observed in this case.

BODY WEIGHT

Informations of body weight bring us many essential knowledges concerning the growth of whale as well as informations for regulation and the commercial value. This most voluminous work even been done on the body weight study of humpback whale is Ash's which considered the oil content of this species in the Antarctic waters.

All data concerning length weight relationship are plotted in Fig. 15, in which the data by Ash are the mean value only, because no individual value was given in his report. Six whales and one fetus were weighed for this investigation by the same method to others already reported so far. These results together with weight of separate part of the body are given in the Appendix VI. As is shown in Fig. 15, the dots plotted are scattered rather widely. This wide variation can be easily understood by the fact already mentioned in this report that the thickness of blubber is getting thinner from the middle of February.

Basing on the data given in the figure, the following equation is obtained in the relationship between body length and weight,

$$W = 0.00061\, L^{3.48}$$

where W is in the unit of tons and L in feet.

Although adequate data is not available yet, the length-weight relationship of this species may be represented by the above equation either in the northern or the southern hemisphere.

OTHER OBSERVATIONS

Other observations and their results than those mentioned above are considered here.

Basing on the lamination of ear plug, the mortality and survical curves are given in Figs. 16 and 17. The detailed data used for these figures are recorded in Appendix VII. On the other hand, data of the age composition based on the total ovulation number are tabulated in Appendix VIII.

Eleven humpback whales were measured on detail part of the body. These results, however, could not be compared to those already measured on 9 humpback whales caught in the Aleutian waters, because the number of samples is too few for such a comparison. The growth pattern of each part measured, represented by proportional rate to body length, is shown in Fig. 18. The detailed data is tabulated in Appendix IX.

As to the body color, many scientists reported on humpback whales caught in the various waters. Since the standard applied to those study, is rather complex and confusable, the author classified the color of whales, into four categories is illustrated in Fig. 19, and its result is shown in Table 2. 92 percent of the total catch belongs to the Grade

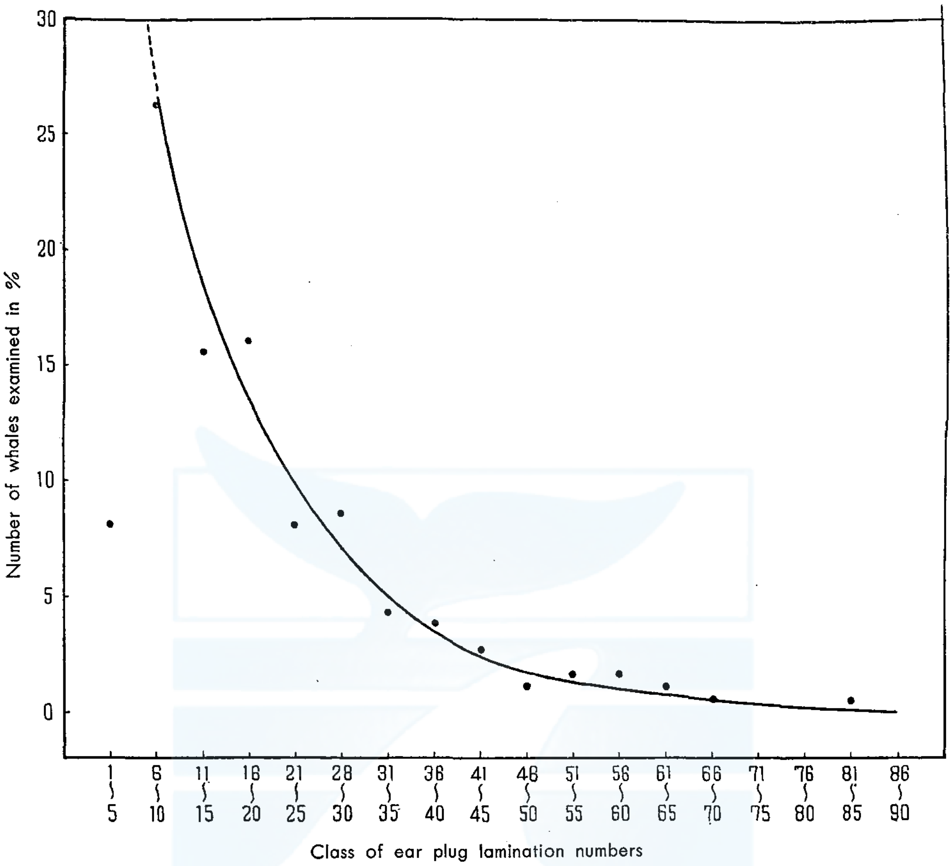


Fig. 16. Frequency curve of whales caught according to ear plug lamination

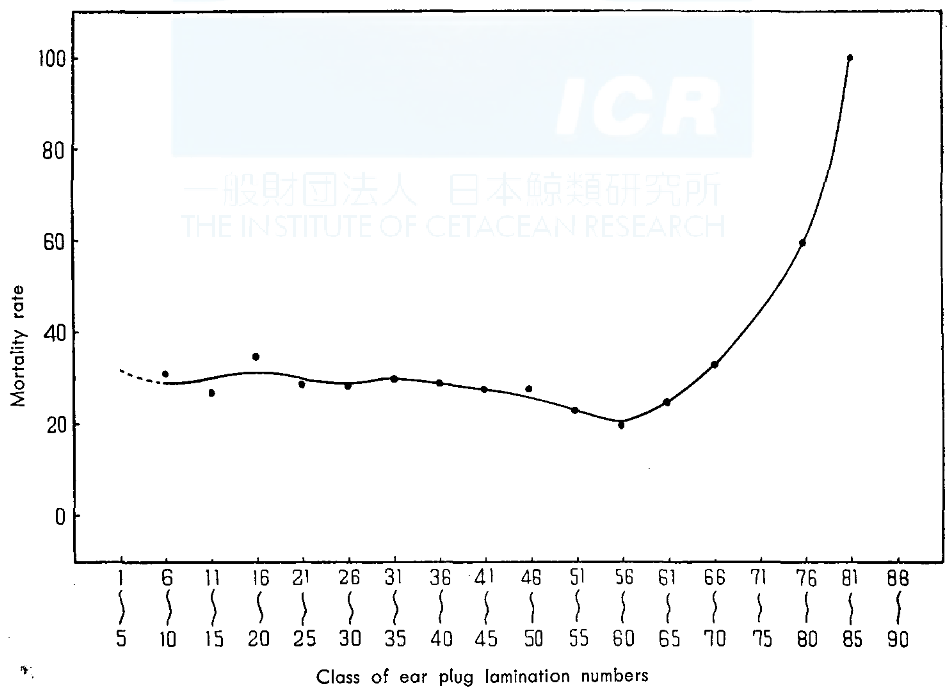


Fig. 17. Mortality curve according to ear plug lamination

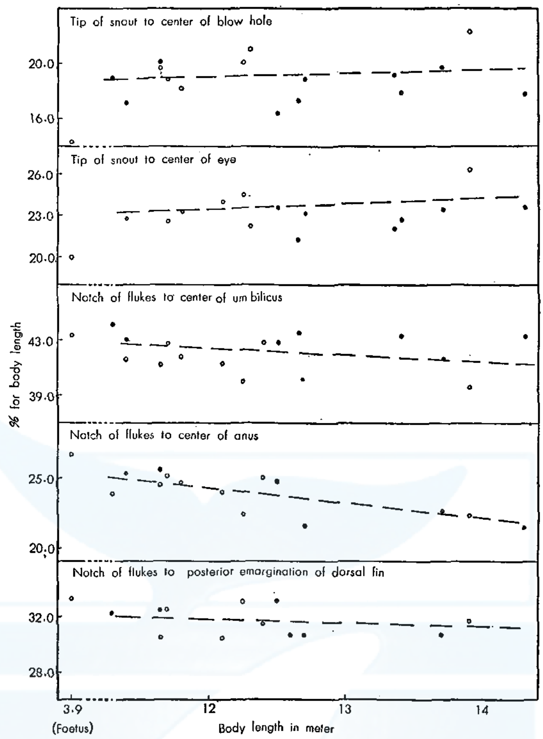


Fig. 18. Increase or decrease tendencies according to the growth of length in body proportions.

Grade of body colo

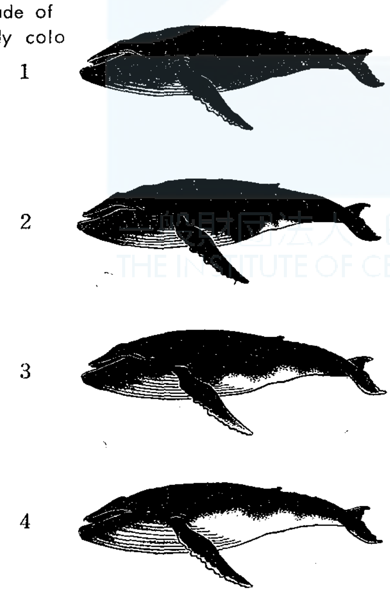


TABLE 2. OCCURRENCE OF BODY COLOR OBSERVED

Month	Sex	Grade of body color 1	2	3	4
Jan.	Male	25	3	0	0
	Female	26	3	1	0
Feb.	Male	27	2	0	0
	Female	34	4	1	0
Mar.	Male	44	2	0	0
	Female	25	0	1	0
Apr.	Male	6	0	0	0
	Female	13	0	0	0
Total	Male	102	7	0	0
	Female	98	7	3	0
Percentage of occurrence		200	14	3	0
		92.2	6.4	1.4	0.0

← Fig. 19. Grade of color pattern. (almost same as Lillie's pattern types in Matthews' report, 1938)

1, but none to the Grade 4. The whale of the Grade 4, however, is not rare in the Antarctic waters.

As to the external parasite observed for this investigation, no special finding is obtained. Pennella attached to the whale in the feeding area has the shape like a writing brush. But in the Ryukyuan waters their shape is just like a thin string. Therefore, some of them must be over looked.

At the field station, the author collected some of diatom film, but later he realized that they are not diatom, but just rust come from catcher boat. So no diatom infection was observed this time.

Special survey for barnacles, which has been observed on their species, numbers and diameters of the shells, was made on six whales. These results would be reported in other paper co-operate with Dr. Joe Connel of the California University.

TABLE 3. INFECTION RATE OF EXTERNAL PARASITES

Sex		Male				Female				Total	Rate of infection
Month		Jan.	Feb.	Mar.	Apr.	Jan.	Feb.	Mar.	Apr.		
No. of whales caught		28	29	46	6	30	39	26	13	217	
No. of whales examined		26	29	45	6	29	38	26	13	212	
White scar	not infected										100.0%
Cyamus sp.	not infected			1						1	99.5%
Coronula sp.	not infected			1						1	99.5%
Conchoderma sp.	not infected		1	1						2	99.1%
Pennella sp.	infected	1	2	1	1	2			1	8	3.8%
Diatom film	infected										0.0%

In the report of the last season, neither stomach content nor fetus was found in the whales caught in the Ryukyuan waters. People around there could not understand this phenomena. From the scientific common sence of whales, this is not curious at all, because the foods are not abundant in the breeding waters and whales are not active in feeding there.

There could not be obtained any evidence that the foods for humpback whale in this waters is abundant. One individual of *Euphausia similis* could be identified in a small mass of the stomach content, and some piece of looks like *Euphausian* carapace was found in the intestine contents.

They say a whale with small *Euphausia* in its stomach was contained in the catch made by a company in 1958 season. Judging from its size, Mr. T. Nemoto of our Institute considers they are *Pseudoeuphausia latifrons* which distributes in the sub-tropical coast. They also say that one whale with stomach being full of small squid and one other being full of small mackerel were observed in the catch made in 1957 season.

To identify the breeding populations of the North Pacific humpback whales, blood samples of 105 individuals were collected with glycerol-freezing technique and were sent by air to our Institute for the successive analysis. After dialysing against 1.5 percent saline and washing several times centrifugally with saline, cells enough to tests were successfully recovered in 100 bottles, but were not obtained in other 5 bottles because of complete hemolysis. Possible causes of hemolysis have not yet been studied at present, but these results show that the glycerol-freezing technique has a potential value in the large scale of blood typing investigation on whales from broad geographical areas.

TABLE 4. TEMPORARY CLASSIFICATION OF BLOOD TYPES OF HUMPBACK WHALES CLASSIFIED BY ABSORPTION TEST OF ANTI-FINBACK JU_2 SERUM

	Cells of:			
Observed with cells of:	Type-1	Type-2	Type-3	Type-4
Type-1	−	−	−	−
Type-2	+	−	−	−
Type-3	+	+	−	−
Type-4	+	+	+	−

TABLE 5. FREQUENCY OF OCCURRENCE OF BLOOD TYPES OF HUMPBACK WHALES FROM RYUKYUAN WATERS IN THE YEAR 1959

Blood Type	1	2	3	4	2 or 3	No. of whales exam.
Occurrence	1	4	6	88	1	100

Isohemagglutinins were detected in the supernatant parts recovered from frozen materials. Natural antibodies were also found in the sera from several kinds of domestic animals. Absorption tests were undertaken by using anti-finback "Ju" immune sera. Results of these experiments show that the erythrocytes of humpback whales have the antigenic individual differences which are like to finback "Ju" antigens and can be classified temporarily into the four types (Table 4). Individuals of these four types occurred in the Ryukyuan waters in 1959 as shown in Table 5. Detail descriptions on the present study are reported by Cushing, Fujino and Takahashi (1959) in this issue.

RESULTS AND CONSIDERATIONS

Some considerations and results are made hereinafter basing on the data already described above.

In the first place problems concerning to a quota is considered. As was cleary described above, a quota was calculated from the estimated number of the migration whales which is figured out from number of whales observed. The number of observed whales amounted to about 800 last year but 500 this year. This decrease in the number of observed whales is not due to the exploitation in the last season but to a remarkable change in the oceanographic condition in this area. Therefore, 800 is much more reliable than 500 as the factor of calculation.

In general, 2 to 3 times of the number observed is considered to be number of the migrating whales. However, since the whales in the breeding area may stay longer there than in the feeding area, a factor, 1.5 to 2 times would be applied for the calculation instead of 2 to 3. Hence, the numbers of the migrating whales this year is estimated to be around 1,200-1,600 individuals.

Another approach to this problem is to estimate the total abundance which maintains the annual recruitment, being equivalent to a catch in a year. Although 220 whales were caught this year. The number of whales actually killed, however, must be slightly more than that. Taking the number of calves accompanied by the lactating whales and the wounded and lost one into account, the actual kill may amount to about 250 individuals. Therefore, neglecting the natural mortality, 250 individuals should be recruited in a year in order to maintain abundance at the present level. Half of the total are the female whales, half of which are the matured. 1/3 of the matured whales are in the lactating stage, 2/3 of the rest are in the ovulating stage. 2/3 of the ovulating whales are pregnant. Assuming that the number of the pregnant whales is 250, the total abundance amount to 2,250 individuals. According to the assumption mentioned above, catch of this year exceeds the optimum level. 1,600, the optimum level of this year is calculated to be about 180 whales.

However, the estimation of the total abundance as 1,600 whales is made on a condition that the whale stock in this waters is independent to other populations. Whale marking experiments clearly indicate that the whales in this area are more or less intermingled with those in the Aleutian waters. The optimum catch, therefore, should be calculated from the total stock in the North Pacific. Since the author estimated that the total number of humpback whales in the North Pacific is about 5,000-6,000, the catchable number amounts to about 600 whales, if applied the above-mentioned way of calculation.

The number of landed humpback whales in these years in the North Pacific amounts to about 370-390 individuals, of which 200 are caught in U.S.A. (San Francisco), 80 in Canada (British Columbia), 60 in the

Aleutian waters and 30–50 in U.S.S.R. region. Apart from the considerations on which foreign countries decide their catch, the catchable number in Ryukyuan waters is the difference between the estimated total catchable number in the North Pacific, that is 600, and the overall catch made in other areas. This is figured out as 210–230 individuals. This figure is quite equivalent to the quota permitted this year in this area for this year. Same amount of quota, therefore, would be applicable in the coming season.

The author considers it is quite favorable that the average body length of landed whales this year is 40.2 feet which is significantly longer than that of the previous season. This is partly due to the fact that each companies tried to catch larger whales because of the limitation by quota. Main reason, however, is by the migration pattern.

TABLE 6. NUMBER OF WHALES CAUGHT AND AVERAGE SIZE OF WHALES IN FEET

Season	Total number of catch	Average body length	Remarks	
1954	4	?		
1955	11	?		
1956	13	41.7	Male	2 : 40.5
			Female	11 : 41.9
1957	23	40.2	Male	14 : 40.5
			Female	9 : 39.7
1958	290	38.9	Male	176 : 38.8
			Female	114 : 39.1
1959	217	40.2	Male	109 : 39.6
			Female	108 : 40.8

Judging from the fact that in the early time of a season smaller whales migrate first to this waters, following by larger one according to the progress of a season, larger whales were mostly killed this year because of the later migration of whales, due to the change of oceanographic condition. One of other reason is that the author, considering some opinions of the American scientists, recommended to delay the whaling season.

The author suggests to open the whaling season of the coming year on 1st December, because many female whales, accompanied by calves, must be killed in the later part of the season, if the opening day is delayed. In December and January, the price of whale meat in Japan rises up because of the shortage of the Antarctic whale meat. Commercially speaking, therefore, the whale industry may pay off even if the quota is not so large. This is also a reason. Fatness of whales is also an important reason. Thickness of blubber is getting thinner from the middle of February.

Compared to the older time, abundance of whales has been decreasing in any waters in the world. The whaling industry comes to a standstill in the direction to expect more catch. The possible way to develop the whaling industry is to increase the profit by rationalization of administration with consideration on conserving whale resource. For this purpose, several important aspects should be studied further. First is the way to supply whale meat to market in more fresh condition. Second is the most favorable way for processing meat. Third is the most efficient proportion of the total catch by whale species. In case of the Ryukyuan whaling, industry should not rely on the catch of humpback whale but try to catch other whale species in order to decrease the catch of humpback whale. Although there is an opinion that it is much better to catch as many whales as possible than to leave them to the unregulated operation by U.S.S.R. whaling industry, the author believes that U.S.S.R. would not deplete the whale stock on which her industry is depended. It is quite desirable to exploit within the level which is figured out in the basis of scientific research.

As is described in the introduction of this report, the humpback whale stock is liable to be depleted. Therefore, any country having concern to whaling should co-operate for conserving the stock, although the abundance of this whale species seems to increase a little after the World War II. For this purpose, all countries having interest in the humpback whale stock of the North Pacific should decide the optimum catch, basing on scientific data and information from countries concerned. In this sence, it is great regret that no investigation was carried out despite that 290 whales was caught last year. The author believes that the thorough research for coming several seasons basing on the results obtained for this season, must be very helpful to the international negotiation in future. Expense required for such a research is only a small part of the total income by the whaling.

ACKNOWLEDGEMENT

The author shows his respect to the enthusiastic and intelligent instructions made by officials of the United States Civil Administration of Ryukyu Islands and the Government of Ryukyu in order to establish the Ryukyuan whaling as more promising and stabilized industry. Especially, grateful acknowledgement is extended to the aircraft of U.S. Armed Forces for the capable help in the survey.

Grateful thanks are due to the members of the whaling inspection group of the fisheries agency of the Ryukyuan Government and the members of the Ryukyuan Whaling Association for their co-operation to this research.

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APPENDIX I NUMBER OF HUMPBACK WHALES CAUGHT IN THE NORTH PACIFIC (1910~1957)

Year \ Area	Alaska	British Columbia	Washington State	California State	Lower California	Japan	Total
1910	—	—	—	—	—	18	18
11	—	—	—	—	—	59	59
12	—	—	—	—	—	—	—
13	28	—	—	—	—	—	28
14	131	—	—	—	—	160	291
15	153	—	—	—	—	28	181
16	121	—	—	—	—	22	143
17	44	—	—	—	—	16	60
18	—	—	—	—	—	15	15
19	132	65	122	223	—	52	594
20	75	98	138	383	—	35	729
21	75	—	—	124	—	101	300
22	95	50	124	600	—	89	958
23	155	78	99	392	—	70	794
24	71	47	98	197	—	158	571
25	208	40	21	43	403	158	873
26	388	25	—	21	498	109	1041
27	554	21	—	2	472	95	1144
28	220	21	—	10	179	91	521
29	214	9	—	—	23	74	320
30	191	12	—	—	—	62	265
31	—	—	—	—	—	70	70
32	—	—	—	—	—	89	89
33	—	—	—	—	—	92	92
34	166	14	—	—	—	57	237
35	141	1	—	—	6	78	226
36	118	14	—	—	—	79	211
37	104	7	—	3	—	73	187
38	12	4	—	—	—	67	83
39	26	—	—	59	—	80	165
40	—	2	—	19	—	2	23
41	—	27	—	16	—	40	83
42	—	7	—	12	—	30	49
43	—	7	—	5	—	69	81
44	—	—	—	1	—	64	65
45	—	—	—	—	—	11	11
46	—	—	—	—	—	20	20
47	—	—	—	13	—	9	22
48	—	115	—	16	—	11	142
49	—	76	—	11	—	4	91
50	—	95	—	—	—	5	100
51	—	51	—	4	—	4	59
52	—	61	—	—	—	3	64
53	—	47	—	—	—	7	54
54	—	106	—	—	—	12	118
55	—	37	—	—	—	20	57
56	—	28	—	113	—	27	168
57	—	49	—	199	—	32	280
Average number of whales caught during the years							
1910 ~ 1930	179	42	100	200	315	74	424
1931 ~ 1945	94	9		16	6	60	111
1946 ~ 1956		68		31		9	73

APPENDIX II NUMBER OF OF HUMPBACK WHALES CAUGHT IN THE COASTAL WATERS OF JAPAN (1910–1957)

Area / Year	Okhotsk sea	Pacific coast of Japan 31°～50°N	Japan sea and Yellow sea	Bonin waters	Ryukyuan waters 24°～31°N	Formosan waters	Total
1910	—	15	3	—	—	—	18
11	3	37	19	—	—	—	59
12	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—
14	—	47	23		90	—	160
15	—	19	9	—	—	—	28
16	—	8	14	—	—	—	22
17	—	3	13	—	—	—	16
18	—	4	11	—	—	—	15
19	—	16	10	—	26	—	52
20	—	3	4	—	—	28	35
21	13	31	7	—	8	42	101
22	11	15	17	—	3	43	89
23	8	11	9	—	—	42	70
24	—	15	4	86	—	53	158
25	8	14	7	86	—	43	158
26	3	6	2	52	—	46	109
27	3	15	8	14	—	55	95
28	2	3	5	25	—	56	91
29	—	7	2	5	—	60	74
30	—	6	14	2	—	40	62
31	—	3	3	27	—	37	70
32	—	7	9	34	—	39	89
33	1	7	8	48	—	28	92
34	—	6	4	28	4	15	57
35	1	6	8	34	—	29	78
36	1	5	2	53	—	18	79
38	—	7	—	50	—	16	73
38	—	4	3	44	—	16	67
39	—	4	8	60	—	8	80
40	—	1	1	—	—	—	2
41	—	12	4	19	—	5	40
42	—	7	4	14	—	5	30
43	—	4	8	57	—	—	69
44	—	3	2	59	—	—	64
45	2	2	7	—	—	—	11
46	2	3	3	12	—	—	20
47	—	6	2	1	—	—	9
48	2	5	1	3	—	—	11
49	—	—	—	4	—	—	4
50	3	2	—	—	—	—	5
51	1	3	—	—	—	—	4
52	—	3	—	—	—	—	3
53	—	7	—	—	—	—	7
54	3	5	—	—	4	—	12
55	2	7	—	—	11	—	20
56	—	12	2	—	13	—	27
57	—	5	—	—	23	4	32
Average number of caught during the years							
1910 ～ 1924	9	17	10	86	32	42	63
1925 ～ 1939	3	7	6	37	4	34	85
1940 ～ 1957	2	5	3	21	13	5	21

APPENDIX III SIZE DISTRIBUTION OF HUMPBACK WHALES CAUGHT IN THE COASTAL WATERS OF JAPAN (1910~1922)

Body length in feet	Okhotsk sea	Pacific coast of Japan 31°-50	Japan sea and Yellow sea	Bonin waters	Ryukyuan waters 24°-31°N	Formosan waters	Total
22	—	1	—	—	—	—	1
24	—	1	—	—	—	—	1
23	—	1	—	—	—	—	1
25	—	2	—	—	1	—	3
26	—	1	1	—	—	—	2
27	—	1	—	—	—	—	1
28	—	5	1	—	—	—	6
29	—	—	1	—	—	—	1
30	1	14	3	—	3	—	21
31	—	9	—	—	3	1	13
32	2	8	4	—	6	2	22
33	—	7	2	—	3	2	14
34	—	6	—	—	3	—	9
35	1	13	7	—	5	5	31
36	—	10	4	—	5	4	23
37	1	6	3	—	2	4	16
38	—	7	7	—	4	6	24
39	—	1	—	—	3	3	7
40	2	10	6	—	3	8	29
41	—	6	3	—	7	4	20
42	1	6	3	—	14	12	36
43	2	4	—	—	3	9	18
44	—	6	2	—	13	3	24
45	3	5	3	—	19	9	39
46	—	8	5	—	13	8	34
47	3	8	5	—	9	3	28
48	2	2	6	—	3	1	14
49	—	2	1	—	3	1	7
50	1	6	8	—	2	—	17
51	—	2	2	—	—	—	4
52	1	—	1	—	—	—	2
53	—	—	1	—	—	—	1
54	—	1	—	—	—	—	1
55	—	—	—	—	—	—	—
56	—	—	—	—	—	—	—
57	—	—	—	—	—	—	—
58	—	—	—	—	—	—	—
59	—	1	—	—	—	—	1
60	—	1	—	—	—	—	1
Total	20	161	79		127	85	472
Average length	42.4	38.0	41.2		41.4	41.1	40.2

APPENDIX IV SIZE DISTRIBUTION OF HUMPBACK WHALES CAUGHT IN THE COASTAL WATERS OF JAPAN (1940~1956)

Body length in feet	Okhotsk sea	Pacific coast of Japan 31°-50°N	Japan sea and Yellow sea	Bonin waters	Ryukyuan waters 24°-31°N	Formosan waters	Total
30	1	—	—	1	—	—	2
31	—	—	—	—	—	—	—
32	—	—	—	—	—	—	—
33	—	—	—	—	—	—	—
34	—	—	—	—	—	—	—
35	2	22	2	16	—	1	43
36	1	13	3	6	—	1	24
37	3	4	—	10	—	3	20
38	—	2	2	7	—	—	11
39	—	3	2	5	—	—	10
40	—	7	3	13	—	2	25
41	1	1	5	10	—	3	20
42	1	5	5	21	—	2	34
43	1	6	1	11	—	—	19
44	1	4	1	6	—	—	12
45	2	11	4	19	—	1	37
46	—	3	3	7	—	—	13
47	—	4	1	7	—	—	12
48	2	1	—	3	—	1	7
49	—	—	—	—	—	—	—
50	—	1	1	5	—	—	7
51	—	—	1	—	—	—	1
52	—	—	—	1	—	—	1
53	—	—	—	1	—	—	1
Total	15	87	34	149		14	299
Average length	40.2	39.8	41.8	41.6		40.1	40.9

APPENDIX V SIZE DISTRIBUTIONS OF HUMPBACK WHALES CAUGHT IN THE RYUKYUAN WATERS DURING THE SEASON (1956~1958)

Body length in feet	1956			1957			1958		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
31	—	—	—	—	—	—	—	—	—
32	—	—	—	—	—	—	—	—	—
33	—	1	1	—	—	—	—	—	—
34	—	—	—	—	—	—	—	—	—
35	—	1	1	—	3	3	16	12	28
36	—	1	1	1	—	1	30	21	51
37	—	—	—	1	—	1	22	13	35
38	1	1	2	3	1	4	19	11	30
39	—	—	—	1	—	1	25	7	32
40	—	—	—	1	2	3	17	10	27
41	—	1	1	1	—	1	16	11	27
42	—	—	—	4	—	4	10	11	21
43	1	1	2	—	1	1	13	8	21
44	—	—	—	1	—	1	6	4	10
45	—	1	1	—	1	1	2	4	6
46	—	1	1	—	1	1	—	2	2
47	—	1	1	—	—	—	—	—	—
48	—	1	1	1	—	1	—	—	—
49	—	1	1	—	—	—	—	—	—
50	—	—	—	—	—	—	—	—	—
Total	2	11	13	14	9	23	176	114	290
Average length	40.5	41.9	41.7	40.5	39.7	40.2	38.8	39.1	38.9
Sex ratio	15.4	84.6		60.9	39.1		60.7	39.3	

APPENDIX VI BODY WEIGHTS OF NORTH PACIFIC HUMPBACK WHALES CAUGHT IN RYUKYUAN WATERS

Serial number	K57	K92	R82	R85	N38	R94	Fetus of R43	—
Date of killed	23, Feb. 1959	26, Mar. '59	3, Apr. '59	9, Apr. '59	14, Apr. '59	24, Apr. '59	27, Feb. '59	2, June '57
Position of killed	26°-09′N 127°-14′E	26°-06′N 127°-11′E	26°-53′N 127°-35′E	26°-21′N 127°-31′E	26°-41′N 127°-59′E	26°-41′N 127°-21′E	26°-00′N 129°-29′E	Off Kinkasan
Body color	1	1	1	1	1	1		
Weight of testis in kg.	1.8 1.8	— —	— —	6.0 6.0	4.5 4.5	— —	— —	} 9.0
Number of ovulations	—	30	1	—	—	1	—	—
Thickness of blubber in cm.	12.0	14.5	11.5	13.0	13.0	11.5	—	—
Fatness	Fat	Fat	Thin	Fat	Normal	Normal	—	Normal
Sex	M	F	F	M	M	F	M	M
Body length in feet	38′	46′	42′	42′	42′	39′	12′-10″	40′
Weight of blubbers	6428.6	11563.8	8711.5	12456.5	6385.4	8592.5	228.0	4871.6
%	**27.3**	**26.3**	**37.9**	**38.9**	**26.0**	**43.5**	**31.0**	**21.9**
〃 meats	9711.4	18125.2	7460.0	10818.0	11041.0	5778.0	123.0	7785.2
%	**41.3**	**41.3**	**32.5**	**33.8**	**45.0**	**29.3**	**16.7**	**35.1**
〃 bones	3309.0	5849.0	3422.5	4487.5	3636.5	2620.0	242.0	3362.5
%	**14.1**	**13.3**	**14.9**	**14.0**	**14.8**	**13.3**	**32.9**	**15.1**
〃 internal organs	2190.6	5848.0	2457.0	3243.0	2719.5	2031.0	118.3	1864.0
%	**9.3**	**13.3**	**10.7**	**10.1**	**11.1**	**10.3**	**16.1**	**8.4**
〃 others	1874.0	2541.0	904.5	977.0	752.6	717.0	24.0	4318.3
%	**8.0**	**5.8**	**3.9**	**3.1**	**3.1**	**3.6**	**3.3**	**19.5**
Total weight of body parts in kg.	23513.6	43927.0	22955.5	31982.0	24535.0	19738.5	735.3	22201.6

APPENDIX VII CALCULATION OF MORTALITY RATE ACCORDING TO EAR PLUG LAMINATIONS (RYUKYUAN WATERS 1959)

Number of ear plug lamination	Male: Number of whales examined	Male: Number of whales examined in %	Male: Number of whales from smoothed curve (×10)	Male: Number of whales dead (×10)	Male: Mortality rate	Female: Number of whales examined	Female: Number of whales examined in %	Female: Number of whales from smoothed curve (×10)	Female: Number of whales dead (×10)	Female: Mortality rate	Total animals: Nubmer of whales examined	Total animals: Number of whales examined in %	Total animals: Number of whales from smoothed curve (×10)	Total animals: Number of whales dead (×10)	Total animals: Mortality rate
1∼ 5	9	9.9	340	80	23.6	6	6.3	340	80	23.6	15	8.1			
6∼10	24	26.4	260	73	28.1	25	26.3	260	73	28.1	49	26.3	270	83	30.7
11∼15	17	18.7	187	55	29.4	12	12.6	187	49	26.2	29	15.6	187	51	27.3
16∼20	12	13.2	132	34	25.8	18	18.9	138	36	26.1	30	16.1	136	47	34.6
21∼25	6	6.6	98	27	27.6	9	9.5	102	30	29.4	15	8.1	99	29	29.3
26∼30	5	5.5	71	21	29.6	11	11.6	72	23	31.9	16	8.6	70	20	28.6
31∼35	3	3.3	50	15	30.0	5	5.3	49	17	34.7	8	4.3	50	15	30.0
36∼40	5	5.5	35	10	28.6	2	2.1	32	12	37.5	7	3.8	35	10	28.6
41∼45	3	3.3	25	5	20.0	2	2.1	20	6	30.0	5	2.7	25	7	28.0
46∼50	1	1.1	20	4	20.0	1	1.1	14	3	21.4	2	1.1	18	5	27.8
51∼55	2	2.2	16	3	18.8	1	1.1	11	2	18.2	3	1.6	13	3	23.1
56∼60	2	2.2	13	2	15.4	1	1.1	9	2	22.2	3	1.6	10	2	20.0
61∼65	1	1.1	11	3	23.3	1	1.1	7	2.5	35.7	2	1.1	8	2	25.0
66∼70	—	—	8	3	37.5	1	1.1	4.5	2.5	55.6	1	0.5	6	2	33.3
71∼75	—	—	5	2	40.0	—	—	2.5	2.5	100.0	—	—	4	1.5	37.5
76∼80	—	—	3	2	66.7	—	—	0	—	—	—	—	2.5	1.5	60.0
81∼85	1	1.1	1	1	100.0	—	—	—	—	—	1	0.5	1	1	100.0
86∼90	—	—	0	0	—	—	—	—	—	—	—	—	—	0	

APPEDIX VIII CALCULATION OF MORTALITY RATE ACCORDING TO TOTAL OVULATION NUMBER

Number of total ovulation	Ryukyuan waters (1959) Number of whales	Number of whales in % of matured female	Number of whales from smoothed curve (×10)	Number of whales dead (×10)	Mortality rate	Aleutian waters (1952–1958) Number of whales	Number of whales in % of matured female	Number of whales from smoothed curve (×10)	Number of whales dead (×10)	Mortality vate
0	38									
1	10	14.3	176	36	20.6	18	12.5	260	40	15.4
2	8	11.4	140	24	17.1	19	13.2	220	39	17.7
3	8	11.4	116	19	16.4	29	20.1	181	38	21.5
4	8	11.4	97	15	15.5	22	15.3	143	32	22.4
5	6	8.6	82	13	15.9	15	10.4	112	27	24.1
6	3	4.3	69	10	14.5	14	9.7	85	25	29.4
7	3	4.3	59	9	15.3	6	4.2	60	17	28.3
8	4	5.7	50	7	14.0	4	2.8	43	11	25.6
9	5	7.1	43	5	11.6	7	4.9	32	7	21.9
10	3	4.3	38	4	10.5	1	0.7	25	5	20.0
11	2	2.9	34	3	8.8	—	—	20	3	15.0
12	3	4.3	31	2.5	8.3	3	2.1	17	2.5	14.7
13	1	1.4	28.5	2.5	8.8	2	1.4	14.5	2.5	17.2
14	3	4.3	26.0	2.0	7.7	1	0.7	12.0	1.5	12.5
15	—	—	24.0	1.5	6.3	1	0.7	10.5	1.0	9.5
16	—	—	22.5	1.5	6.7	—	—	9.5	0.75	7.9
17	—	—	21.0	1.5	7.2	—	—	8.75	0.75	8.6
18	—	—	19.5	1.5	7.7	—	—	8.0	0.75	9.4
19	—	—	18.0	1.5	8.3	—	—	7.25	0.75	10.3
20	—	—	16.5	1.5	9.1	1	0.7	6.5	0.5	7.7
21	—	—	15.0	1.25	8.3	—	—	6.0	0.5	8.3
22	—	—	13.75	1.25	9.1	—	—	5.5	0.5	9.1
23	—	—	12.5	1.25	10.0	—	—	5.0	0.5	10.0
24	—	—	11.25	1.25	11.1	—	—	4.5	0.5	11.1
25	—	—	10.0	1.25	12.5	—	—	4.0	0.5	12.5
26	1	1.4	8.75	1.25	14.3	—	—	3.5	0.5	14.3
27	—	—	7.5	1.25	16.7	—	—	3.0	0.5	16.7
28	1	1.4	6.25	1.25	20.0	—	—	2.5	0.5	20.0
29	—	—	5.0	1.25	25.0	—	—	2.0	0.5	25.0
30	1	1.4	3.75	1.25	33.3	—	—	1.5	0.5	33.3
31	—	—	2.5	1.25	50.0	—	—	1.0	0.5	50.0
32	—	—	1.25	1.25	100.0	1	0.7	0.5	0.5	100.0
33	—	—	0	—	—	—	—	0	—	—

EXPLANATION OF APPENDIX IX

Number of measurement	Name of measured part of the body
1	Total length.
2	Lower jaw, projection beyond tip of snout.
3	Tip of snout to blowhole.
4	Tip of snout to angle of gape.
5	Tip of snout to centre of eye.
6	Tip of snout to tip of flipper.
6′	Tip of snout to anterior insertion of flipper.
7	Eye to ear, centres.
8	Notch of flukes to posterior emargination of dorsal fin.
10	Notch of flukes to anus.
11	Notch of flukes to umbilicus.
12	Notch of flukes to end of ventral grooves.
13	Anus to reproductive aperture, centres.
14	Dorsal fin, vertical height.
15	Dorsal fin, length of base.
16	Flipper, tip to axilla.
17	Flipper, tip to anterior end of lower border.
18	Flipper, length along curve of lower border.
19	Flipper,. greatest width.
21	Skull, greatest width.
22	Skull, length, condyle to tip of premaxilla.
24	Tail, depth at dorsal fin.
24′	Tail, dorsal fin to anus.
24″	Tail, depth at insertion of flukes.
25	Flukes, notch to tip.
25′	Flukes, notch to tip. Left.
25″	Flukes, notch to tip. Right.
26	Flukes, total spread.
27	Flukes, shortest length of notch to anterior border.
31	Length of lower jaw bone.
32	Skull, tip of premaxilla to tip of pterygoid.
33	Skull, distance between tips of both pterygoid.
34	Skull, length of rostrum.
35	Skull, width of base of rostrum.

APPENDIX IX BODY PROPORTIONS OF NORTH PACIFIC HUMPBACK WHALES CAUGHT IN RYUKYUAN AND ALEUTIAN WATERS

Serial number	Caught in	Date of killed	Sex	Number of measurement 1	2	3	4	5	6	6'	7	8	10	11	12
R 4	Ryukyuan waters	9, Jan. 1959	F	1340	14 1.0	240 17.9	300 22.4	305 22.8		420 31.3	57 4.3		260 19.4	580 43.3	580 43.3
K10	〃	18, Jan. 1959	F	1140	15 1.3	195 17.1	245 21.5	260 22.8		390 34.2	52 4.6	360 28.3	290 25.4	310 27.2	490 43.0
K31	〃	31, Jan. 1959	F	1370	20 1.5	270 19.7	310 22.6	315 23.0		405 29.6	62 4.5	420 30.7	310 22.6	570 41.6	530 38.7
K37	〃	4, Feb. 1959	F	1265	15 1.9	220 17.4	270 21.3	270 21.3		325 25.7	56 4.4	390 30.8	335 26.5	550 43.5	565 44.7
K43	〃	15, Feb. 1959	M	1130	13 1.2	215 19.0	265 23.5	265 23.5		340 30.1	52 4.6	365 32.3	330 29.2	500 44.2	480 42.5
K54	〃	19, Feb. 1959	F	1250	15 1.2	205 16.4	280 22.4	295 23.6		400 32.0	53 4.2	415 33.2	310 24.8	535 42.8	560 44.8
K57	〃	23, Feb. 1959	M	1165	13 1.2	220 20.1	280 25.6	280 25.6		365 33.4	49 4.5	355 32.5	280 25.6	520 47.5	520 47.5
R84	〃	7, Apr. 1959	F	1333	17 1.3	256 19.2	294 22.1	294 22.1			58 4.4				
R88	〃	11, Apr. 1959	F	1430	17 1.9	255 17.8	340 23.8	339 23.7		422 29.5	62 4.3	440 30.7	308 21.5	580 43.3	550 41.2
N38	〃	14, Apr. 1959	M	1270	15 1.2	240 18.9	300 23.6	295 23.2		390 30.7	58 4.6	390 30.7	275 21.6	530 41.7	510 40.2
Fetus of R43	〃	27, Feb. 1959	M	390	5 1.3	55 14.1	70 17.9	74 20.0		113 5.0	22 5.6	130 33.3	104 26.7	169 43.3	173 44.4
28	Aleutian waters	26, July 1952	M	1238 41 feet		260 21.0		275 22.2			45 3.6	390 31.5	310 25.0	530 42.8	510 41.2
96	〃	24, July 1952	M	1170 38 feet		220 18.8		265 22.6	410 35.0		50 4.3	380 32.5	295 25.2	500 42.7	500 42.7
133	〃	19, Aug. 1952	M	1129 37 feet				290 25.7			40 3.5	300 26.6	270 23.9	470 41.6	460 40.7
570	〃	3, Sept. 1953	M	1225 40 feet		245 20.0		300 24.5	445 36.3		55 4.5	405 33.1	275 22.4	490 40.0	490 40.0
594	〃	6, Sept. 1953	F	1390 46 feet		310 22.3		365 26.3	595 42.8		50 3.6	440 31.7	310 22.3	550 39.6	525 37.8
661	〃	24, Sept. 1953	F	1210 40 feet		270 22.3		290 24.0	360 29.8		45 3.7	370 30.6	290 24.0	500 41.3	500 41.3
674	〃	25, Sept. 1953	M	1165 38 feet		230 19.7		300 25.8	385 33.0		55 4.7	355 30.5	285 24.5	470 40.3	480 41.2
676	〃	25, Sept. 1953	F	1180 39 feet		215 18.2		275 23.3	400 33.9		55 4.7	380 32.2	290 24.6	505 42.8	515 43.6
Fetus of 676	〃	25, Sept. 1953	M	245 8 feet		32 13.1		45 18.4			15 6.1	77 31.4	58 23.7	95 38.8	118 48.2

Serial number	13	14	15	16	17	18	19	21	22	24'	24''	25'	25''	26	27	31	32	33	31	35
R 4	60 4.5	15 1.1	70 5.2	314 23.4	387 28.9		100 7.5								103 7.7					
K10	40 3.5	25 2.2	110 9.6	288 25.3	350 30.7	370 32.5	95 8.3			245 21.5	70 6.1	200 17.5	195 17.1		90 7.9					
K31	43 3.1	25 1.8	130 9.5							290 21.2	90 6.6	250 18.3		500 36.4	110 8.0					
K37	37 2.9	28 2.2	95 7.5	310 24.5	380 30.0	400 31.6	95 7.5			240 20.0	80 6.3	210 16.6		385 30.4	100 7.9					
K43	100 8.8	25 2.2	90 8.0	285 25.2	340 30.0	365 32.3	90 8.0			215 19.0	75 6.6	210 18.6		390 34.5	88 7.8					
K54	50 4.0	23 1.8	95 7.6	320 25.6	390 31.2	415 33.2	95 7.6			265 21.2	90 7.2	220 17.6		420 33.6	95 7.6					
K57	110 10.0	25 2.3	115 10.5	370 33.8	300 27.4	405 37.0	100 9.1			250 22.8	85 7.8				90 8.2					
R84																				
R88	43 3.0	35 2.4	150 10.5	360 25.2	430 30.1	456 31.9									103 7.2					
N38	90 7.1	25 2.0	130 10.2	335 26.4	415 32.7	460 36.2	110 8.7			240 18.9	95 7.5	235 18.5			110 8.7					
Fetus of R43	35 9.0	12 3.1	42 10.8	103 26.4	127 32.6	140 35.9	33 8.5			75 19.2	35 9.0	60 15.4		100 25.6	41 10.5					
28	100 8.1	25 2.0	60 4.8		410 33.1		110 8.9	195 15.8	350 28.3							335 27.1	345 27.9	150 12.1	235 19.0	98 7.9
96	85 7.3	22 1.9	95 8.1		355 30.3		86 7.4	200 17.1	330 28.2							330 28.2	325 27.8	150 12.8	240 20.5	100 8.5
133	40 3.5	16 1.4	83 7.4		370 32.8		90 8.0	207 18.3	345 30.6							352 31.2	330 29.2	149 13.2	220 19.5	103 9.1
570	105 8.6	23 1.9	85 6.9		355 29.0		100 8.2	205 16.7	350 28.6							355 29.0	355 29.0	185 15.1	250 20.4	105 8.6
594	45 3.2	21 1.5	100 7.2		440 31.7		110 7.9	235 16.9	430 30.9							435 31.3	430 30.9	190 13.7	315 22.7	125 9.0
661	50 4.1	28 2.3	115 9.5		380 31.4		100 8.3	170 14.0	345 28.5							360 29.8	350 28.9	145 12.0	250 20.7	100 8.3
674	110 9.4	23 2.0	110 9.4		355 30.5		100 8.6	195 16.7	345 29.6							365 31.3	345 29.6	145 12.4	245 21.0	100 8.6
676	50 4.2	27 2.3	105 8.9		375 31.8		89 7.5	180 15.3	335 28.4							345 29.2	335 28.4	145 12.3	240 20.3	90 7.6
Fetus of 676	19 7.8	6 2.5	17 6.9		75 30.6															

Data from Aleution waters were measured by Messrs. K. Fujino and T. Nemoto of the Whales Research Institute.