FOOD OF BALEEN WHALES COLLECTED IN RECENT JAPANESE ANTARCTIC WHALING EXPEDITIONS

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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

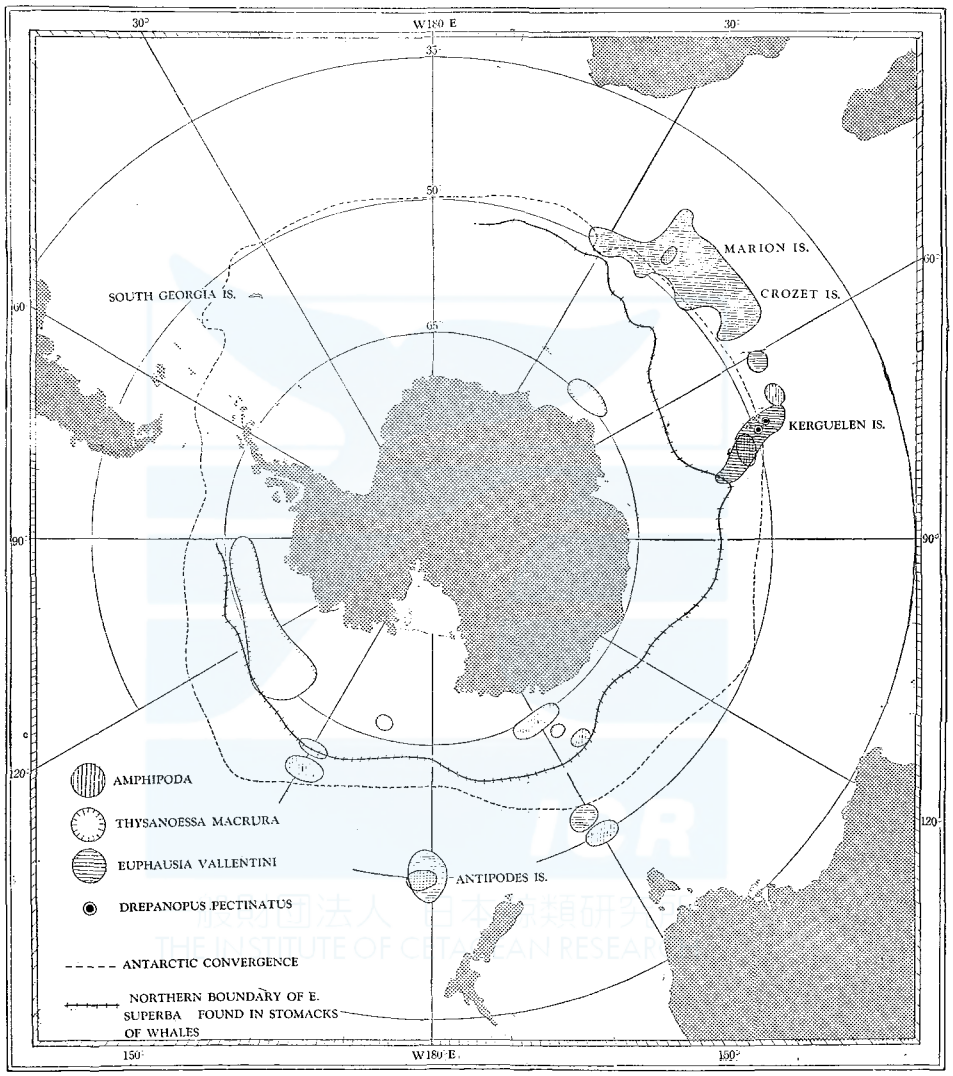

Fig. 1. Distribution of foods of baleen whales in the Antarctic

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

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
50~55	10	1	—	—	11	1	2	14	1	12
55~60	7	—	—	—	11	24	—	—	—	18
60~65	1	—	—	—	—	3	—	—	—	—

A. C.

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.

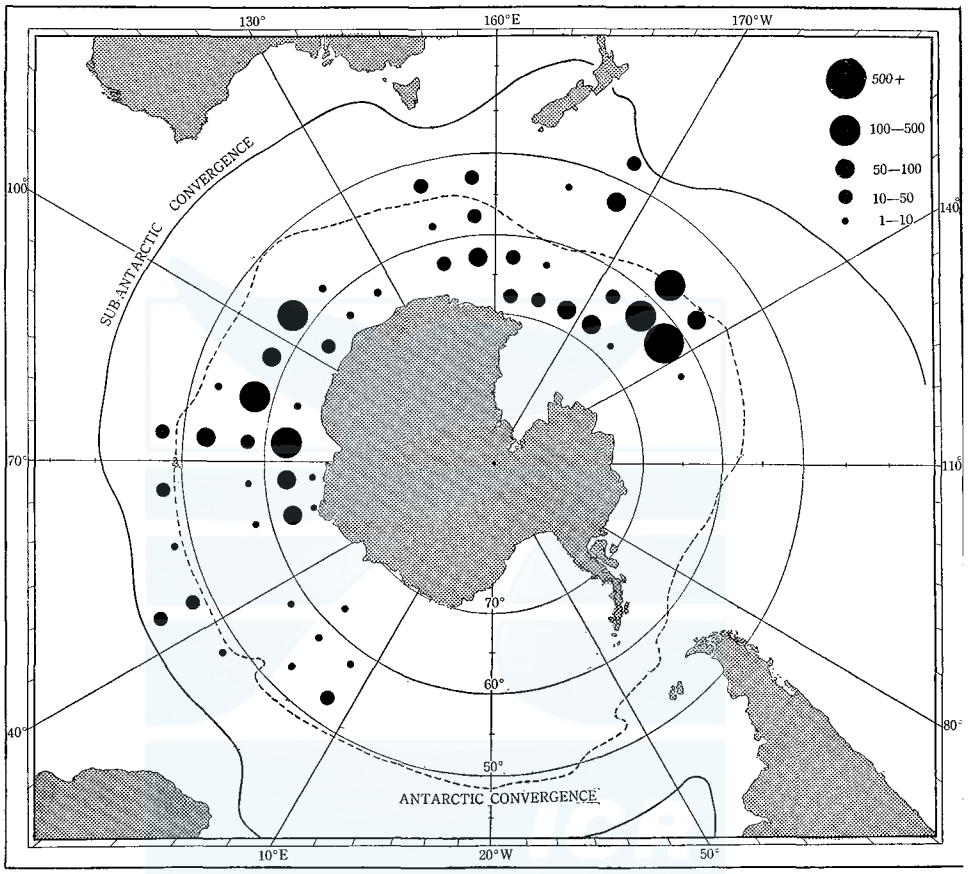

Fig. 2. Distribution of sei whales caught Japanese whaling in 1960 and 1961.

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.

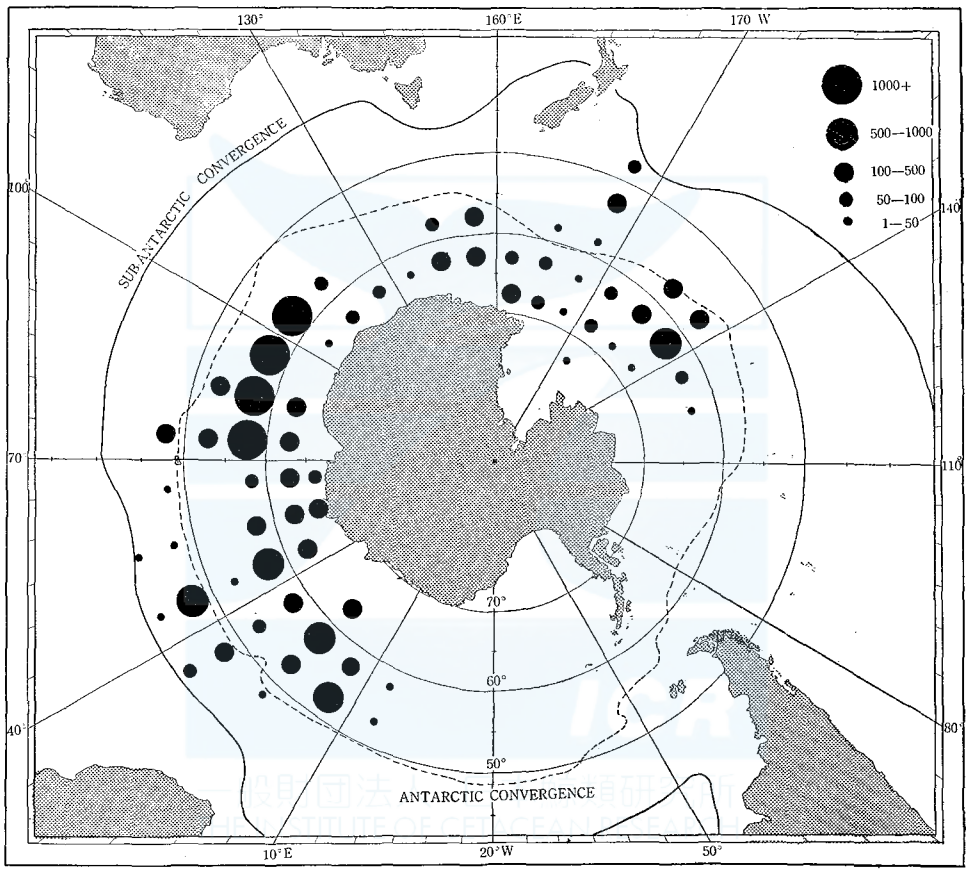

Fig. 3. Distribution of fin whales caught Japanese whaling in 1960 and 1961.

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

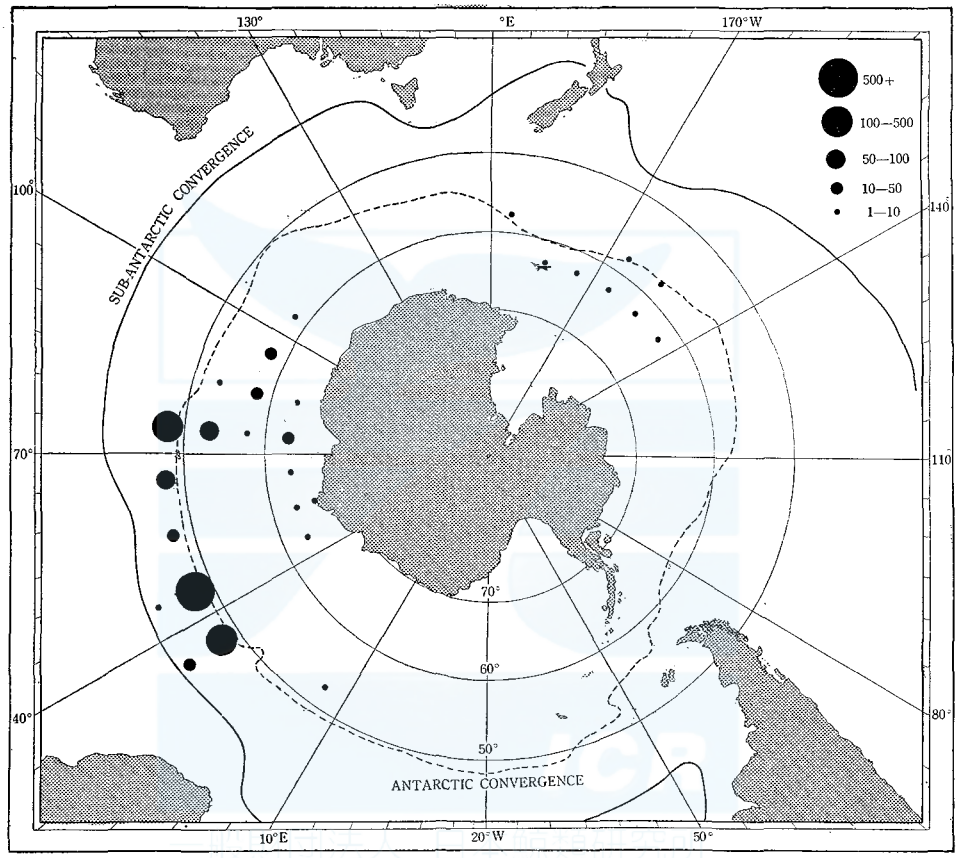

Fig. 4. Distribution of blue whales caught Japanese whaling in 1960 and 1961.

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.

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

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