FOOD OF BALEEN WHALES WITH REFERENCE TO WHALE MOVEMENTS

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The close relationship between foods and whales has long been recognized and many works on the role of foods in the interrelationship between foods and whales have been undertaken in many parts of the world open sea. In the previous report (Nemoto, 1957), I described the short summarized historical reviews on the problem and tried to discuss the foods of baleen whales in the northern part of the North Pacific. In the paper, the main foods of the northern Pacific baleen whales caught by Japanese pelagic expeditions are described. But after the year 1956, Japanese expeditions have covered broader areas in the northern Pacific, and insufficient data in the paper have been complemented by the successive researches. The previous paper of mine, at it was, should be regarded as a preliminary report on this problem, and I would add the more detailed discussions here but some discussion described in my previous paper may be omitted for the convenience for the preparation of the paper.

Japanese investigation of foods of baleen whales are also carried out in the waters adjacent to Japan as well as in the northern part of the North Pacific. Only a few works has been made on the subject, however, the works are not always quite satisfactory. Especially on the taxonomy of food planktons in the adjacent waters to Japan, those works were not so correct still in the very recent investigation, and I point it in the previous paper that the insufficient taxonomy of food planktons has made some confusions among the studies of foods of whales. I have been trying to correct these mistaken species as well as possible except some species still remained to be corrected owing to the lack of materials. As to the Antarctic waters, Japanese investigations on whales have operated in some 14 years after the year 1945. These accumulation of researches have proved the results done by *Discovery Committee* are quite satisfactory, and there are some other reliable informations of the whales in Antarctic that they feed on other euphausiids and planktons than *Euphausia superba*, the famous main food of baleen whales in the water.

Whales Research Institute's investigation on the biology of euphausiids is in process now, but interesting results have been obtained through the course. Unfortunately, Japanese investigations only cover the summer seasons of both high latitudes, and I could not examine the winter samples of both areas at all. So I would like to refer to the *Discovery* works (Bargmann, 1945; Fraser, 1937 etc.) about the biology of euphausiids in the Antarctic in some points, but I would state some new consideration on the problems of the relation between foods and whales in order to add something to the recent knowledge of baleen whales. The distribution of euphausiids is also studied in view of feeding condition for whales in the ocean and local characteristics of euphausiids in growth and morphological points.

With regard to the migration and movement of whales, vast number of researches should be done before the definite conclusion is obtained. But I would try here, to comment the particular tendencies of whale movements related to the food of whales mainly consulting with marking results, catch statistics and oceanographical conditions.

Oceanographical studies on whaling ground do not show so rapid accumulation of materials that I can't fully discuss the migration of whales only from the oceanographical conditions of view. But some baleen whales show clear distribution in accordance with the water temperature of the sea, the shape, the topography of the sea and the abundance of the foods.

For comprehension of the relation between foods and whales, it is desirable to study body characters of whales. I examined these particulars as feeding apparatus in order to add the appropriate consideration to the foods of whales in this paper. Body structure examination of baleen whales show interesting fact that the preference of whales for food are affected by the body structure, external apparatus for feeding. Some ecological classification of whales is given by Eschricht (1846 in Tomilin, 1945) and Kükenthal (1892 in Tomilin, 1945), and Tomilin (1954) states further discussions on the classifications based on morphological and biological characteristics. In this report I also try to classify baleen whales into typical types according to said features of whale bodies and feeding.

This paper is by no means a conclusive information on the foods of whales, because there are many unsolved question of foods of whales remained. And these question will be discussed again after many examination and collection of materials are obtained.

Finally, I think it is of use to summarize the species of foods of whales in many sea regions from many previous works on the problem here in this paper to suffice the present inquiry of knowledge of foods of baleen whales.

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MATERIALS

The following materials are available for the present study throughout the course. These data and samples are collected by biologists and inspectors on board in the North Pacific and in the Antarctic waters.

In the northern part of the North Pacific, Japanese pelagic expeditions have caught following baleen whales which have been examined.

Periods covered	Blue	Fine	Sei	Humpback
1952–1958	569	7505	804	392

Methods of the examination on these baleen whales is already stated in the previous report (Nemoto, 1957). Rough classification on species quantity and freshness are determined on boards, and a part of each stomach contents have been preserved in formalin sea water and brought back to our Institute.

In adjacent waters to Japan, following investigations have made collections of materials, however, those materials and observations are not so sufficient. They are all partial collections of whales caught in the waters adjacent to Japan. These are as follows.

Okhotsk Sea, in 1952, 1953, 1957 and 1958. Stomach samples and observations by T. Nemoto and T. Ichihara.

North east area of Japanese coast, Sanriku and Hokkaido in 1952, 1953, 1956 and 1957. Stomach samples and observations by all staffs of the Whales Research Institute.

South west area of Japan proper, Oshima, Wakayama in 1958. Stomach samples and observation by T. Nemoto.

West Kyushu area or East China sea, in 1955, 1956 and 1957. Stomach samples and observations by K. Mizue, K. Fujino and T. Koga.

Bonin Islands waters, in 1948, 1949, 1950 and 1951. Stomach samples and observations by inspectors and biologists on board.

The Whales Research Institute data on the baleen whales in the Antarctic available up to date are made of following whales.

Period covered	Blue	Fin	Sei	Humpback
1946-1958	5449	28395	1502	975

These observations include the works on the stomach contents, species, quantity, freshness and size of the foods of whales.

The following statistics are also used in this paper so as to get the informations on the catch and seasons of whaling.

International whaling statistics

Japanese shore whaling statistics, seasons in 1910, 1911, 1914, 1919, 1921, 1922, 1926, 1932, 1934, 1940, 1941, 1942, 1943, 1944, 1945, and those after the year 1945.

Japanese whale marking investigations have been carried out from 1949 in the North Pacific and data of discovery of marks are all provided by courtesy of the Fisheries Agency of Japanese Government. A full list of these marks returned from baleen whales from 1949 to 1958 is given in the Appendix. Some interesting informations on the Antractic whale marking carried out by co-operations of International whale marking program are also very useful for the consideration of movements of whales. The note of those prepared by Brown in the Norwegian Whaling Gazette is helpful for consideration of the movement of whales in recent years too.

The materials of body proportion and body characters obtained through the northern Pacific, Bonin Islands and Antarctic waters expeditions and results at the stations are referred to make the illustrations of whales. The skeletons and baleen plates preserved in Japanese museums are measured in needs in order to get the comprehension of feeding mechanisms of baleen whales and body characteristics.

FEEDING APPARATUS

As already well known, all of the baleen whales take their foods with their baleen plates or whalebone. The baleen plates of whales and some other special features about mouth part of whales differ among each species of whales considerably. It is considered that feeding habits and their preference for foods are much affected by the character of baleen plates and other features. Here, I would state the summarized discussion on feeding apparatus of baleen whales. However, the difference among internal organs of baleen whales is omitted in following.

BALEEN

Number of baleen plates. Number of baleen plates of whales is illustrated in Table 1, mainly based on the data by *Discovery* investigations

TABLE 1. AVERAGE NUMBER OF BALEEN PLATES OF BALEEN WHALES IN ONE SIDE IN THE NORTHERN PACIFIC AND THE ANTARCTIC WATERS

	Blue	Fin	Bryde's	Little piked	Sei	Hump-back	Right	Grey
North Pacific								
Range	300–400	300–400	260–370	260–300	320–380	300–370	230–260	130–180
Approximate mean	360	355	300	280	340	330	245	160
Antarctic and Southern hemisphere								
Range	260–400*	260–480*	250–280	—	300–410*	300–370*	220–240*	—
Approximate mean	320	360	—	—	345	—	—	—

* After the data by *Discovery* research since 1929.

and Japanese expeditions. There is no significant difference between the Antarctic and North Pacific whales except Bryde's whales. The data of the North Pacific Bryde's whales are obtained in the Bonin waters (Omura, Nishimoto & Fujino 1952), and those of southern hemisphere may be gotten in Saldana Bay, though it is not certain. Bryde's whales in these two localities are considered really the same species, *Balaenoptera edeni* (Omura, 1959 p. 24), but I have no further information on the number of Baleen plates of Bryde's whales in the southern hemisphere.

Generally speaking, the large whales have more numerous number of baleens, but the number of baleen plates does not bear such a great efficiency for the selection of their food as the morphological characteristics of mouth part or the features of baleen plates and fringes. It is noted, however, that the whales belong to BALAENOPTERIDAE have many baleen plates ranging from 250 to 400, but whales belong to BALAENIDAE from 220 to 260, and whales belong to RHACHIANECTIDAE from 130 to 180. Above results may be due to the fact that whales belong to BALAENIDAE and RHACHIANECTIDAE lack the baleen plates rows at the top of palates in the mouth. Grey whales have the smallest baleen plates in number, which is the half of the number of baleens of BALAENOPTERIDAE whales. Another reason for the fact may be the heavy thickness of baleen plates of grey whales.

Right whales lack the plates row at the top position of palate and the number of baleen plates are comparatively small in number comparing with other whales. Right whales have, however, the longer plates which may enable the whales to filt the micro-planktons successfully by the broad baleen filter. This morphological feature is very important for the feeding habits of right whales which I discuss later.

Shape of baleen plates. The shape of baleen plates also differ very much according to the whale species. It may be classified into following three groups.

Balaena (*Eubalaena*) type
Balaenoptera type
Rachianectus type

Whales belong to BALAENIDAE (*Balaena* and *Eubalaena*) have long elastic baleen plates with fine fringes. On the other hand, BALAENOPTERIDAE whales have comparatively short and less elastic plates. Above distinctions give us very interesting suggestions. Tomilin (1954) considers in his short but very excellent paper, the adaptive type of baleen whales are classified according to the thickness of bristles and flexibilities of the plates. The latter point flexibilities of baleen plates may be very useful for successive filteration in the sea. Generally speaking, the long elastic baleen plates mean convenience to skim the foods in the sea water. Because the baleen plates are filtering foods on the surface of the inner plane consists of fine baleen fringes, and long inner edge of baleen plates is very effective in the successive filtering. Short and wide based plate is on the other hand very useful for filtering their foods in a very short time, with strong stress of flesh tongue to make the water run off through the plates remaining the mass of food in the mouth.

Baleen plates of fin whales belong to *Balaenoptera* type show some ocal difference. Baleen plates of fin whales caught in the northern part of the North Pacific have a strong resemblance to those of the Antarctic waters but those of fin whales caught in the East China Sea are shorter and of more coarse texture. The difference closely related to the one between the baleen plates of sei whales and Bryde's whales. I would also consider this difference means some local stock existence of fin whales in the Pacific Ocean as considered by Omura, Fujino, Ichihara and Kimura (1958) and Ichihara (1957) as well as some different condition of feeding environment in the waters.

Grey whales have very characteristic baleen plates. Tomilin (1954) describes it in following way, semi-elastic thick, short and coarse. The baleen plate of a grey whale sent by courtesy of Mr. G. C. Pike (Canada) bears such distinctions. But to my regret, the plate may be collected in the anterior portion of baleen plates row, so that I can't imagin the

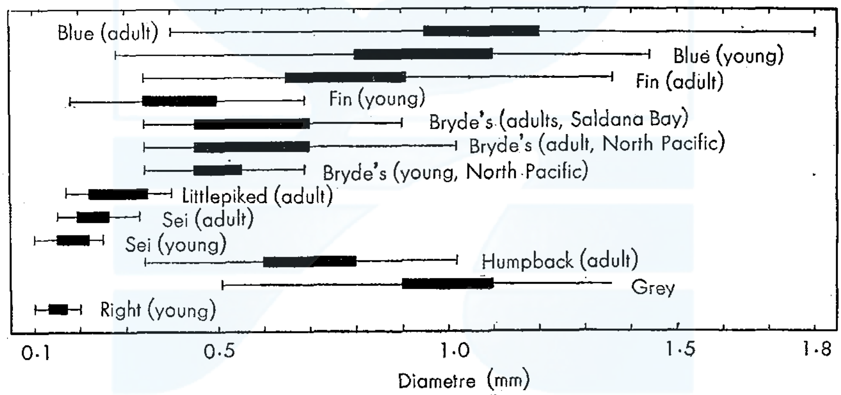


Fig. 1. Diameters of baleen fringes of baleen whales measured at the center position of baleen plates. Black belts show the ranges of dominant sizes of baleen fringes. Adult—whales after the sexual maturity, young—sexual immature and baleen plates are not chipped.

shape of the plates exactly but it is short. Tomilin (1954) considers further that grey whales can dig up and probable even to plow up the silty benthic ground with these short and thick plates. The above function can only be made by such a characteristic baleen plates of grey whales.

Fringes of baleen plates. I would consider that the baleen fringes of baleen plates have comparatively importance for the selection of their food or feeding habits, though I state in the previous report (Nemoto, 1957) that the degree of luxuriancy or thickness of baleen fringes are considered not to be so important to decide food species of whales. The diameters of baleen fringes of each baleen whales are illustrated in Fig. 1. As clearly shown in Fig. 1, fringes of right whales are the finest one ranging from 0.1 to 0.2 mm in diameter, the same result as

Tomilin (1954). My data are, however, based on two young specimens caught in adjacent waters to Japan, and they are all immature adolescent whales, fringes of which may be far finer than old whales. Usually, the baleen fringes of the older whales are more coarse than those of the younger whales. It is very interesting that the baleen fringes of Bryde's whales caught in the adjacent waters to Japan show the same value as those caught in Saldana Bay, South Africa, and Bryde's whales are famous for their selection of fish as their food (Ruud in Peters 1938). As to the species of whales in Bonin water before 1950, it is not certain if all sei whales caught are Bryde's whales, but Bryde's whales caught along the coast of Japan take fish mainly with some occasional occurrence of euphausiids with rough baleen fringes.

Fin and blue whales have comparatively coarse baleen fringes. Of course the younger fin and blue whales have much fine fringes when they are sucking the milk of mother whales. The smallest baleen whale, little piked whale has still more course baleen fringes than sei whales. Sei whales prefer small copepods to euphausiids in the northern Pacific (Nemoto, 1957), and there is no indication that sei whales take small euphausiids or furcilia stage of euphausiids, which is as small as copepods. This fact suggests something to the selection of food by sei whales. Tomilin (1954) simply considers sei whales, by reason of its fine baleen bristles, may also be classified as 'Microplanktonphagi'. But I would consider further the patch of planktons also bears characteristic distinctions, and the selection of food by whales is also much influenced by them because there are many circumstances that can't be explained by simple diagnose of baleen fringes.

Humpback whales have coarse fringes too, but not so coarse as adult blue and fin whales. As to the baleen plates of grey whales, I have only one example of the North Pacific. The baleen is not suitable for my study as it is collected from the anterior position of the baleen plates row. However, it may be concluded by works of some scientists (Andrews, 1914; Tomilin, 1954), that the baleen fringes of grey whales is very coarse when we consider the moderate body size of grey whales. Tomilin (1954) states in the whales feed on benthic and near-benthic organisms (chiefly amphipods), the straining apparatus develops as a very coarse structure consisting of relatively few semi-elastic, thick, short and coarse plates with spine-like bristles. The plate and fringes are quite different from those of BALAENIDAE, but in the feeding method there is a little resembrance considered.

From the Fig. 1, it may be concluded whales having baleen plates with fine fringes ranging 0.1 to 0.3 mm in diameter can take even small copepods of 0.5 mm or less in cephalothorax length in the scattered condition in the sea. Whales having baleen plates with coarse fringes from 0.4 to 1.8 mm can take euphausiids or other macroplanktons favourably. Of course there are some other evidence and observations that whales with coarse fringes take small copepods. The fact is considered to be due to feeding habits of whales and condition of food planktons, on which I should discuss in the latter part of this paper.

Number of baleen fringes along the edge of plates. The luxuriance of baleen fringes also should be investigated. At the center part of inner edge of baleen plates, the number of baleen fringes are counted for 1 cm. Fig. 2 shows the results. It is clear, from Fig. 2, that blue, fin, Bryde's, little piked and humpback whales are classified into the same group. Sei and right whales into another one group, and grey whales is third group. With comparing the diameter of baleen fringes, the number of baleen fringes also shows interesting fact. Little piked whales have baleen plates with fine fringes, but number of baleen fringes are

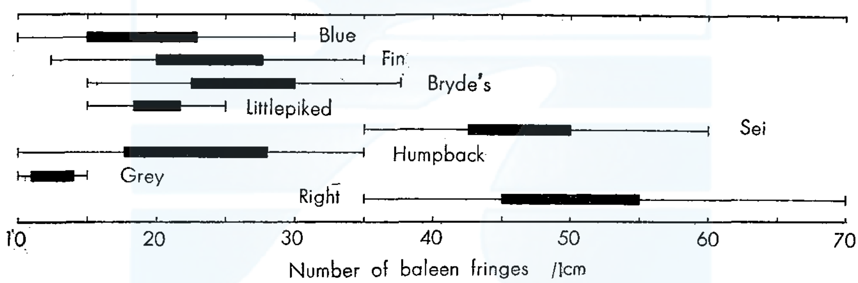


Fig. 2. Number of baleen fringes along the edge of plates of baleen whales caught in the north Pacific. Black belts show the ranges of main range of number. All specimens are collected from sexually mature whale except grey and right whales.

small in number owing to their thin plates. Usually baleen fringes are found in double or more in some part of inner the edge of baleen plates in other whales. Baleen fringes of little piked whales are rarely doubled, thus making a small number of fringes. Little piked whales often take fish in many parts of the world (Omura & Sakiura, 1956). It must be due to the small number of baleen fringes along the inner edge of baleen plates enabling to take fish or larger macroplanktons more often than they feed on smaller copepods. Sei and right whales have many baleen fringes of the finest tissue. This character is very useful for slow filteration for the scattered small planktons. The heavy luxuriance of fine baleen fringes is considered not so effective the instantaneous filteration for big organisms in the sea water.

Gray whale has the fewest number of baleen fringes. The baleen fringe of grey whales also the most coarse one. This mechanism must be very effective for rather rapid and successive filteration of food among mud in the bottom of the sea as considered up to these days (Tomilin, 1954).

Baleen plates row. The baleen plates row of baleen whales on the plates has special peculialities too. As already stated, right and grey whales lack the baleen plates or horny spines at the top of the plates, inner rostrum, that is left and right rows of baleen do not coalesce. So, when they open their mouth in swimming the sea water run into the mouth and is then filtered by baleen plates. Right whales have rather broader space between the tip of the plates rows because of the rows projecting in a certain angle. If we see the head of right whales in front, it's shape resembles to triangle form, each side of which is baleen rows. Among BALAENOPTERIDAE whales, the left and right rows are jointed by means of numerous horny spines located near the tip of the plates (Tomilin, 1954). This type of baleen plates row is observed also in *Megaptera* humpback whales. The projecting angle of baleen plates in these whales are nearly the same, but sei whales' baleen plates are considered projecting in a little like right whales.

As to the spacing of the baleen plates row, Matthews discusses the problem in his paper on sei whales (Matthews, 1938). He compares the space between baleen plates of sei whales with those of blue and fin whales and concludes that the spacing of sei whales are not much less than in fin whales. I also notice as the baleen fringes of all whales are long enough to cover the space between baleen plates, the spacing does not mean the significant difference among the feeding types of whales. There is another evidence that the spacing of young whale are extremly narrow comparing with the older whales, and the baleen fringes of the former are also comparatively shorter than the latter

The filtering area in a right whale formed by baleen plates row is much greater than in the other whales belong to BALAENOPTERIDAE. These shapes of the filtering area exactly show the feeding type of whales. Blue whales represent spindle shape filtering areas, and grey whales too. But as grey whales have arched rostrum, they may be able to use this narrow filtering area also in successive skimming. Right whales have, of course, broadest filtering area as shown in Fig. 3. From this illustration, the more available position is located in about two-third of all rows from the tip of the plates in blue and grey whales, and about half to two-third in right whales.

HEAD, MOUTH AND TONGUE

The head parts of whales are also divided into three types in first stage of investigation according to their structure. Blue whale type, grey whale type and right whale type are them.

Those whales belong to *Balaenoptera* and *Megaptera* have related structures of mouth parts. The head is less than one-fourth of the total body length. The rostrum is pointed, but it is not so narrow as right whales, when the mouth is closed, the rostrum fits in between the two lower jaws. The rostrum of sei whales is pointed as in the blue whales, but from lateral view, the rostrum is slightly curved. Fraser (1949) describes this distinction that it recalls the acurate form of BALAENIDAE, but of course in a much less degree, and other *Balaenoptera* whales are closely related to each other. The distinction of sei whales must bear the meaning of the feeding method, which has a little resemblance to that of right whales. The beak of humpback whales is comparatively short and broad. But mouth part is apparently *Balaenoptera* type and feeding method is also considered more related to blue and fin whales.

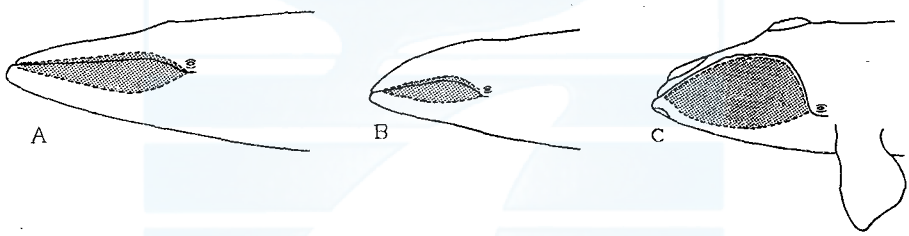


Fig. 3. Heads of baleen whales, A—Blue whale, B—Grey whale, C—Right whale. Shading areas show baleen plates and filtering area of each whale.

The head of right whales is triangular in shape in front of view. The lower edge of the triangle is made of space between two lower jaws, and top of the triangle is the arched head bone. The fore part of the skull is arched. The arching of the skull is not so pronounced as in the Greenland whales, and when the mouth is opend, the water may rush into the mouth because the top of the inner rostrum lack completely whale bones. The lower jaws and sides projected above form an efficient scope for gathering foods as stated in Fraser (1949).

Andrews (1914) states the full description on the body characters of grey whales. The head of *Rachianectes* is very characteristic. Its shape, in some respects, is the intermediate form between that of the BALAENIDAE and the BALAENOPTERIDAE. The rostrum is convex dorsally, narrow and very deep, but it is neither as narrow or curved as in the former, but is much narrower and deeper than in the latter. From the form of skull *Rhachianectes* is the intermediate between of skulls of the *Eubalaena* and *Balaenoptera*.

The lateral section of mouth parts of right and Bryde's whales are illustrated in Fig. 4. Left illustration of Fig. 4 shows the right whale mouth part in scheematic condition. When the mouth is opened, the water rush into the mouth along the tongue and filtered in successive motion. The rather tough tongue may keep the water spread on the inner surface of filterning area of baleen plates row. The narrower base and long extension of baleen plates is very available for running out of waters from cavity of mouth in the slow swimming. As clearly shown in the illustration, to make a successful filteration of foods in swimming, the mouth cavity is widened by opening the mouth, because the sides become U shaped boards from the triangle shape in a closed mouth.

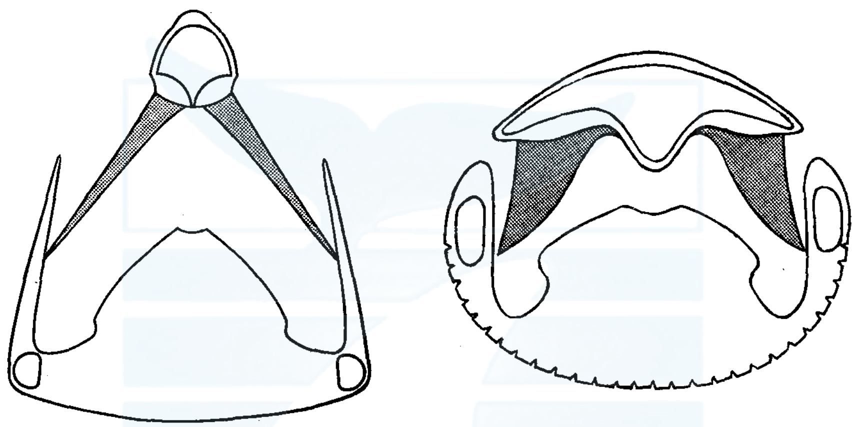


Fig. 4. The lateral sections of mouth parts of baleen whales at the center position of baleen plates rows, Left—Right whale, Right—Bryde's whale.

The section of a Bryde's whale, typical *Balaenoptera* type is shown in the right of Fig 4, the fleshy tongue and ventral grooves expansion make a large cavity to take large volume of water containing the swarms of foods. After the swallowing, the water come out through the space of baleen plates. The left shows the condition of this filtering. The baleen plates in the base keep the baleen very effective in a stong filteration with pressure in a short period. Fleshly tongue is able to scrap all the remaining of food on the surface of coarse baleen fringes successively.

VENTRAL GROOVES

The number of ventral grooves also differ among baleen whale species, and some of baleen whales lack absolutely these ventral grooves. Greenland and right whales have no ventral grooves. Right whales have none of these ventral furrows like grey whales (Omura, 1958). Along the throat and belly part of the body, whales belong to BALAENIDAE have none of throat furrows but grey whales have some thoroat furrows. These throat furrows are comparatively deep and usually two of them are longer than others. And as Andrews (1914) described, the most of grey whales have only two furrows. The function of these furrows is considered to bear some significants to increase the throat capacity in also grey whales, it bears a close connection to take foods or the air (Andrews, 1914).

Humpback whales have fewer ventral grooves than other whales of BALAENOPTERIDAE. And the width of each ventral grooves is wider than the other whales, but the extension of grooves reach the position of 58 percent of the body length from the head in average, and there is no difference from other BALAENOPTERIDAE whales. As shown in Table 2, the number of ventral grooves is the most numerous in blue whales and fin whales come next. According to the data by Omura, Nishimoto

TABLE 2. NUMBER AND EXTENSION OF VENTRAL GROOVES OF BALEEN WHALES IN THE NORTHERN PACIFIC

	Balaenoptera whales					*Megaptera*
	Blue	Fin	Bryde's	Little piked	Sei	Humpback
Ventral groove extension	58%	55%	58%	47%	45%	58%
Approximate no. of ventral grooves	80	64	53	62	52	22
Range of number	64–94	50–86	40–69	—	40–69	18–24

& Fujino (1952) there is little difference in number between Bryde's and sei whales in the north Pacific. The number of ventral grooves has been considered as a taxonomic distinction of Bryde's whales from sei whales, so it needs more examination on the point. I would consider the number of ventral grooves of Bryde's whales is more numerous than those of sei whales according to my recent observation.

The extension of ventral grooves also differ among the each whale species. Table 2 shows these values, and blue and Bryde's whales are considered to have the most long extension of ventral grooves in general. On the other hand, sei and little piked whales have comparatively shorter extension of ventral grooves among whales of *Balaenoptera*. The ventral grooves of sei whales do not reach umbilicus, and sei whales have only such a character in Balaenopterids. The shorter extension of ventral grooves suggests something about the feeding of sei whales. Sei whales which have the shorter extensions of ventral grooves may have less convenience to gulp the water, or less throat and mouth capacity when they are feeding. Sei whales often skim their foods in the surface of the water is partly due to above reason, but I have never noticed if the little piked whales usually take their foods by skimming of the water containing the foods scattered condition.

Above stated discussions are all indicating the 'type' of whales in feeding from the point of view of body structures. I would summarize following the each subject. The Table shows four type of body structures for feeding. Those are, Blue whale, Sei whale, Grey whale and Right whale types.
The most important point may be the type of sei whales. Sei whales are considered a little different from other Blue whale type whales, which I describe before. These feeding apparatus type should be examined again by many stand points, feeding method, selection of food etc.

Whale species	Baleen plates			Head, mouth and tongue	Ventral grooves	Apparatus type
	Shape	Fringe	Row			
Blue	Blue	Blue	Blue	Blue	Blue	Blue
Fin	〃	〃	〃	〃	〃	〃
Bryde's	〃	〃	〃	〃	〃	〃
Little piked	〃	〃	〃	〃	〃	〃
Sei	〃	Sei (Right)	〃	Sei (Blue)	Sei	Sei (Blue)
Humpback	〃	Blue	〃	Blue	Hump.	Blue
Grey	Grey	Grey	Grey	Grey	Grey	Grey
Right	Right	Right	Right	Right	Right	Right

I have no exact information on the body characters of Greenland whales, however, they are apparently considered to belong to Right whale type.

FOOD OF THE BALEEN WHALES IN THE ANTARCTIC WATERS

SPECIES OF FOODS

The reason why so many baleen whales swarm in the Antractic waters in summer of the southern hemisphere is up to now attributed to the vast propagation of *Euphausia superba*, which is the main food for them. Many works of foreign and our own Japanese scientists prove that the almost all baleen whales feed on those krill *E. superba* (Mackintosh & Wheeler, 1929; Mizue & Murata, 1951 etc.). In my first cruise to the Antarctic waters from 1954 to 1955, I found none but *E. superba* in the stomachs of baleen whales in the Antarctic area IV. Recent investigations, however, have collected some other very interesting examples of stomach contents though I lack samples of stomach contents in November and December owing to the whaling regulations. One of those food, *Thysanoëssa macrura* is already described in a previous report (Nemoto & Nasu, 1958). In the Antarctic whaling grounds VI and I, which has been sanctuaries before 1955 whaling operation, *Thysanoëssa macrura*, another kind of euphausiids, is considered to bear significans as a foods of baleen whales (Nemoto & Nasu, 1958).

Besides above two euphausiids, the plankton amphipod, *Parathemisto* *gaudichaudi* is found as a food of sei whales in the Antarctic. There are still other planktons which probably become foods of baleen whales. Peters (1955) describes these planktons.

The recent Japanese collections of stomach samples show following occurrences of *Euphausia superba*, *Thysanoëssa macrura* and *Parathemisto gaudichaudi* in the each Antarctic whaling area. As described in the remark of Table 4, the observations and collection of *P. gaudichaudi* are not sufficient, but it has mainly been found in areas V and IV.

TABLE 3. OCCURRENCE* OF *EUPHAUSIA SUPERBA, THYSANOËSSA MACRURA* AND *PARATHEMISTO GAUDICHAUDI* IN THE COLLECTED SAMPLES OF THE ANTARCTIC BALEEN WHALES CAUGHT BY JAPANESE EXPEDITIONS IN 1955, 1956, 1957 AND 1958

Species of foods	Area				
	I	III	IV	V	VI
Euphausia superba	69	11	311	402	318
Thysanoëssa macrura	15	2	—	2	20
Parathemisto gaudichaudi	—	—	—	14	—

* Samples containing *T. macrura* besides *E. superba* are included in the column of *T. macrura*, and sampling for *P. gaudichaudi* is not sufficient.

TABLE 4. OCCURRENCES OF ONE AND TWO YEARS' GROUPS OF *EUPHAUSIA SUPERBA* IN THE STOMACH OF BLUE, FIN, SEI AND HUMPBACK WHALES CAUGHT BY JAPANESE WHALING EXPEDITION, CHIEFLY IN AREA V AND IV IN 1958

Euphausiids group	January			February			March	
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd
2 years group								
after copulation	29	58	52	7	4	2	29	11
before copulation	—	—	2	—	—	1	7	—
1 year group	—	8	25	26	36	27	3	—
Mixture	—	2*	16*	7	2	4	2*	—

* *Euphausia superba* of two years group not copulated.

From said results and description by Marr (1956), Peters (1955), I may describe following planktons of the foods of Antarctic baleen whales.

Euphausia superba	*Euphausia crystarollophyas*
Thysanoëssa macrura	*Thysanoëssa vicina*
Calanus propinquus	*Calanus acutus*
Parathemisto gaudichaudi	

According to Japanese observation, the Antarctic *Calanus* has never been observed in the stomachs of whales in dominant quantity. But these copepods may play some part of a food for sei whales, because sei whales can skim the scattered food like plankton amphipods in the sea (Nemoto, 1957). *Euphausia crystarollophias* is considered Antarctic species, on which Marr (1956) describes that it becomes a food for blue and little piked whales in the high Antarctic such as Ross Sea. *Thysanoëssa vicina* has not be confidently known as a food of baleen whales in the Antarctic but in the whaling area I, the occurrence in the far off waters from the pack ice is probable from the distribution.

Euphausia superba is the most important food for the Antarctic baleen whales as considered up to the present. *E. superba* is a by-ennial euphausiid, and the investigation usually finds 1 year or 2 years groups in the stomachs of whales. I would use here the term, 0 year group, 1 year group and 2 years group, after the classification by Ruud (1932). In this case, 0 year group means the *E. superba* from egg to adolescent within a year living, 1 year group after 1 year making comparatively rapid growth and 2 years living, 2 years group after 2 years living. I find *E. superba* of 1 year or 2 years group in the stomachs of baleen whales in general, and 0 year group has never been noticed by my investigation. Recent observations of above classifications are shown in Table 4.

TABLE 5. OCCURRENCES OF ONE AND TWO YEARS' GROUP OF *EUPHAUSIA SUPERBA* IN THE COLLECTED SAMPLES OF WHALES' STOMACH IN 1957

Euphausiids group	January			February			March	
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd
2 years group								
after copulation	5	10	14	36	16	25	17	7
before copulation	—	1	—	—	1	—	—	—
1 year group	3	12	6	15	34	57	21	16
Mixture	—	4	4	3	4	5	3	3

I get these observations in whaling area IV and V mainly, but the samples in 1957 had been collected from the whaling area I and VI. It is clear from these Table 4 and 5, that 2 years group is comparatively dominant in the earlier decades and 1 year group in the later decades. Of course as shown in Table 4, I observed many occurrences of 2 years group in the late decades of March in the whaling ground V in 1953, which is also illustrated in the next figure of Fig. 5. Generally speaking, *E. superba* of 2 years group is the better food for baleen whales than 1 year group of euphausiids. This has fewer oil contents than that, and further there are another reasons such as the behavior of the dirnnal migration. The adult 2 years group *E. superba* swarms heavyly in the surface waters to take their foods and copulate. The swarms of these *E. superba* are mainly restricted in the surface waters within the 10 meter depth (Marr, 1957). This condition is very favourable for baleen whales to feed. It is also very interesting that the most of 2 years group of *E. superba* has copuleted. There are, on the other hand, some occurrences of 2 years group *E. superba* in 3rd decade of January in 1958. These 2 years group *E. superba* swarms are, however, found along the pack ice where the growth and spawning of euphausiids are comparatively slower or later than those in the off waters. A example of distribution of 1 year and 2 years group is given in Fig. 5, which is drawn after the observation in 1958. This figure gives exact distribution of the two groups. The detailed explanation should be referred to the

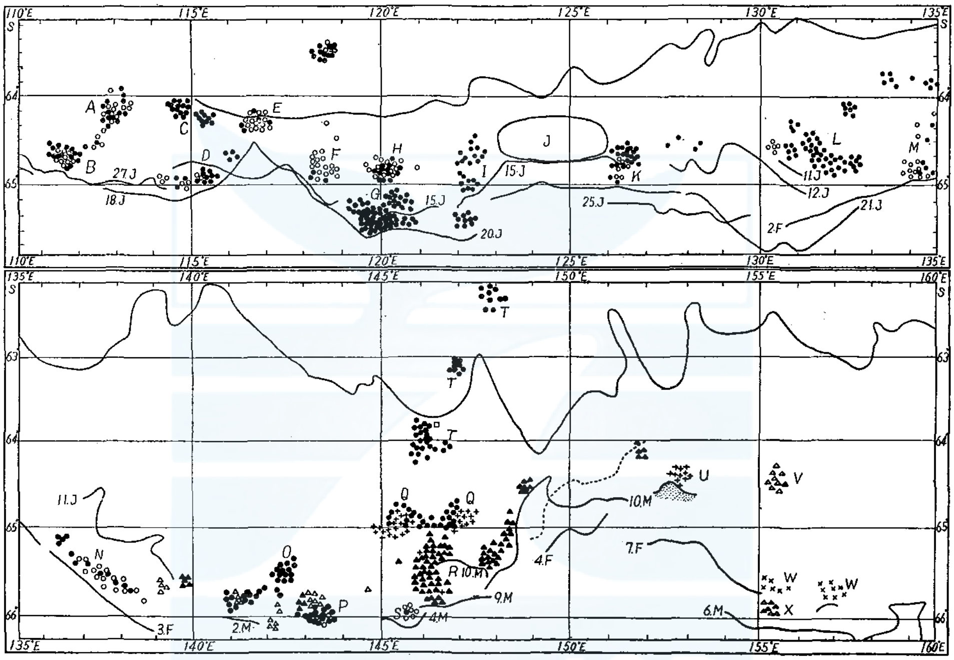


Fig. 5. A example of the distributions of pack ice line and foods of baleen whales in the stomachs of whales caught by Japanese operations in the Antractic in 1958. Open circles—1 year group of *Euphausia superba*. Solid circle—2 years group in January and February. Open triangle—1 year group of *E. superba* in March. Solid triangle—2 years group of *E. superba* in March. Cross—*Parathemisto gaudichaudi*. Open square *Thysanoëssa macrura*. Alphabet show the whaling grounds and number and alphabet show the pack ice line of the date. J—waters where no swarm of *E. superba* is obsered and no whale caught.

explanation, but in short it may summarized as follows. At first in the earlier whaling operation, fin whales feed on the 2 years group *E. superba*, which is copulating, distribute in the off waters 200 miles from the pack ice as shown in Fig. 5. The feeding ground consists of 2 years group of *E. superba* falls down in February which is due to the subsiding of gravid females of *E. superba* to spawn in deeper waters, as Bergmann (1945) discussed in her paper. But the feeding grounds of

1 year group flowerish still in the late of the summer season of the Antarctic. This fact does not deny the another evidence that the 2 years groups of *E. superba* are found throughout the season. But in this case successive appearance of 2 years group of *E. superba* is not due to the same group of *E. superba* occurrence. Different *E. superba* may come up successively into the surface waters with the retreat of the pack ice.

According to Ruud (1932), the Nowegian whalers well know 'Blue whale krill' and 'Fin whale krill' meaning 1 year and 2 years groups of *E. superba* respectively. Peters (1955) states, these early stages of the smaller *E. superba* occur dominantly at the beginning of the whaling season from November to December. But my collections do not show such tendencies. I am not sure which is right, because my collection only started from 1954, before which no available observation and collections of systematic research had been made on the stomach contents. So I lack completely these earlier season samples. But the explanation may be given by local characters of the Antarctic ocean. Except some waters along the Ross sea, Japanese whaling has covered usually the ground along the pack ice. On the other hand, the foreign Antarctic operations sometimes have been conducting in the far off waters from the pack ice, where the drift of the euphausiids from the southern waters is observed. The circulation of Weddle sea current may bring these younger stage euphausiids to the ground, or 2 years group of small size appears in the earlier seasons along the pack ice before retreating to the south. Thus the foreign scientists found the small size euphausiids. According to the Peters (1955, Fig. 3-6), the size of *E. superba* in the off waters are comparatively larger than that in the waters along the ice, or the small size groups, that is 20 to 30 mm in length, are more abundant in the latter areas than the former said waters. On the other hand, he considers the small *E. superba* is dominant in the earlier season. Blue whales, the earlier comer to the Antarctic waters than fin whales, take their foods along the pack ice where the euphausiids of 20 to 30 mm in length are mostly abundant. Fin whales feed, on the other hand, *E. superba* of 30–40 mm in length favorably. In my collections of 1957 and 1958, the dominant size groups belong to the larger body length groups as shown in Fig. 6. From 15 mm to 40 or 45 mm length group is considered to be 1 year group in 1957 and from 45 to 50 mm groups is 2 years group. As above measuring is given by the value from the tip of telson, these value may be a little different from the figures given by Peters (1955). Anyway, the occurrences of 1 year group and 2 years group are about half and half of the total in my collections.

Bargmann (1945) measured the diameter of eggs of gravid female, and get the average of 0.55 mm, and my work also coinside with the result. The heavy gravid female (stage 7 by Bargmann, 1945 p. 115 or Ruud stage 3-4) is found in the collections of stomach samples in January and February. These stage of maturities of *E. superba* also show the half in total in consideration of swarms of euphausiids. Whether the swarms of *E. superba* in the stomach of whales copulated or not is already given in the Tables 4 and 5, and the copulation date is late one or not is shown by the condition of spermatophores in thelycum (Bargmann, 1945). The half of copulated swarms of *E. superba* out of 15 samples show the fact because there still remains the sparm-mass. This discrimination is very interesting in order to examine the condition of swarms of euphausiids as stated above. From the 14 years observations, the copulated females are dominant from January to February suggesting that the pairing of *E. superba* occur mostly in this season of a year. Bargmann (1945) already refers to the point and describes

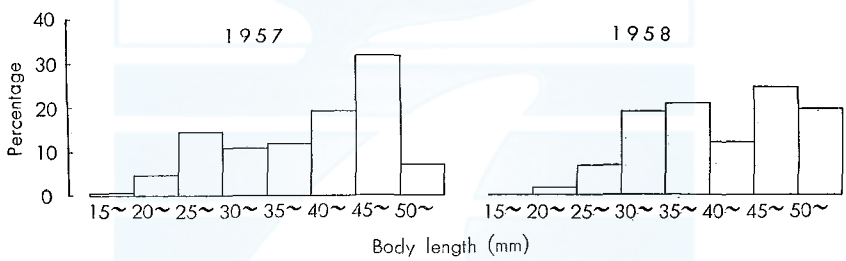


Fig. 6. The size distribution of dominant group of *Euphausia superba* observed and collected by Japanese whaling expeditions is 1957 and 1958 in the Antarctic waters in the whaling area IV, V. VI. and I.

the peak season of pairing comes in February when the greatest number is found, and the gravid females become scarce in the surface waters to spawn in the deeper waters. So before subsiding, the gravid *E. superba* must be the most fovorable food for baleen whales, the peak season of which is the same as the peak of the migration of baleen whales in the Antractic waters. I have also noticed the swarms of *E. superba* consisted of mostly dominant males in 2 stomachs of whales and females with vacant ovary. One may think they are swarms of euphausiids after spawning.

The egg and the younger larva, from nauphi to furcilia, have never been observed in the stomachs of baleen whales. The smallest *E. superba* is about 20 mm adolescent, which is nearly the same length as previous paper on the *E. superba* in the Antarctic (Marr, 1956).

The sex ratio of *E. superba* differs from those of the North Pacific euphausiids. As described in a previous report (Nemoto, 1957), males are less in number among the Northern Pacific *Thysanoëssa*. On the contrary to this fact, male *E. superba* is not less dominant in the swarm collected from the stomach of whales. As to the body length of *E. superba*, males are a little larger than females in general. This fact is also different from that of the North Pacific *Thysanoëssa* euphausiids (Nemoto, 1957, Fig. 20). The female of *Thysanoëssa* euphausiids exceeds the males in body length in the northern Pacific and in the Antarctic.

Thysanoëssa macrura. Next to *Euphausia superba* *T. macrura* is mostly common in the Antarctic waters. It is also described as a staple food of baleen whales in the Antarctic waters (Nemoto & Nasu, 1958). *T. macrura* distributes more abundantly in the whaling area VI and I, only few samples of which are observed in the whaling areas IV and V. In

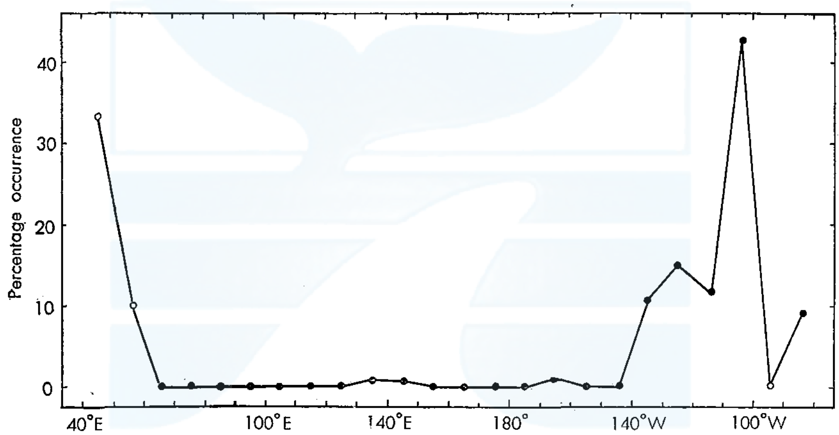


Fig. 7. Occurrences of *Thysanoëssa macrura* in the stomachs of Antarctic baleen whales in 1956, 1957 and 1958. Open circles shows insufficient observations in number.

1958 whaling season, I examined euphausiids in the stomachs of whales chiefly on the samples of whaling areas IV and V, but only 2 samples of *T. macrura* are found in the area V and none in the area IV. From three years investigations from 1955, I get a percentage occurrence of *T. macrura* in the Antarctic whaling area from 40° east to 80° west longitudes. As clearly given in Fig. 7, *T. macrura* shows dominant appearance in the waters from 140° west to 80° west longitudes. Another dominant occurrence is observed in the west waters from 40° east to 60° east longitudes, but it must be due to the insufficiency of collections. *T. macrura* swarms in the warmer waters than *E. superba* and in off waters from the pack ice (Nemoto & Nasu, 1958), their main occurrences are observed in the last decade of January and the first decade of February, and baleen whales are considered to concentrate to take *T. macrura* in the off waters at these periods of the season in the said waters.

T. macrura, showing the dominant appearance in the stomachs of whales, must make large swarms in the sea. In my collections, however, no copulated females appear. It is very difficult to explain if the pairing season of *T. macrura* is earlier or later than that of *E. superba*, because I lack the complete series of *T. macrura* throughout the whaling season. From their distributional occurrences in the whales' stomachs, it is considered that the spawning time and grounds differ a little from those of *E. superba*. Ruud (1931) discusses, however, spawning of *T. macrura* may begun October and continue to February. Rustadt (1930) also finds that the youngest stage of *T. macrura* are more common among or near the ice. Rustadt (1930) and Ruud (1932) suppose from above observations *T. macrura* has the same spawning ground and season as *E. superba*. *T. macrura* is considered to distribute in waters with temperature about 0°C (Ruud, 1932, Nemoto & Nasu, 1958), and the temperature distributes a little apart from the pack ice. So I would consider the distribution and spawning season differ from those of *E. superba* according to above Japanese observation.

As it is pointed by Rustadt (1930) and Baker (1954), in the younger stages, it is difficult to separate *T. macrura* from *T. vicina*. Still collected samples at my hand are considered all *T. macrura* by external characters. But in the far off waters especially in the whaling area I, it is probable that *T. vicina* may be a food for whales.

Besides the dominant appearances of *T. macrura*, the mixed occurrence of *T. macrura* with *E. superba* should be examined. Because the stomach samples of the Antarctic baleen whales have been classified according to the size of euphausiids in the *Discovery* method. 'X' in the classification of stomach contents means the mixture of the larger and smaller sized euphausiids. It may sound strange, I have a evidence that some routine observations might cause mistaken description as to the species of euphausiids. It is probable the small *T. macrura* has not been noticed by routine workers only describing sizes of euphausiids. In this point, to my regret, I can't refer to any former works especially carried out in Japanese investigations.

Euphausia crystallorophias. The Antarctic neritic species, *E. crystallorophias* has not been collected by Japanese investigations. However, Marr (1956, 1957) notes that in the high Antarctic, Ross sea, some blue and little piked whales may take *E. crystallorophias* as their food, and blue and fin whales fed on *E. crystallorophias* in the high Antactic caught by A. Larsen expedition in 1923–24 season because along the Ross sea barrier, the patch of *E. crystallorophias* were observed very often (John, 1936).

Parathemisto gaudichaudi. *P. gaudichaudi* has only been described as a local plankton in the Antarctic waters, and it bears no significance for the baleen whales as their foods (Mackintosh & Wheeler, 1929). Also by Japanese investigations, the dominant occurrence has never been noticed up to recent time. (Mizue & Murate, 1951 etc.). *P. gaudichaudi* has only been found among the euphausiids in the whales' stomach in few number. It has been considered insignificant diet for whales (Mackintosh, 1942). But in 1958, Japanese whaling expeditions have taken considerable number of sei whales in the Pacific sector of the Antarctic, when I was aboard on a factory ship to examine the whales as my second cruise to the Antarctic ocean. Some 1500 sei whales are caught in the late season of March, which is a very interesting phenomena since the Antarctic pelagic whaling opened. Other blue and fin whales become comparatively scarce at that time and sei whales feeding on *P. gaudichaudi* besides *E. superba* are found in the off waters from the

TABLE 6. OCCURRENCE AND QUANTITY OF *E. SUPERBA* AND *PARATHEMISTO GAUDICHAUDI* IN A CERTAIN AREA OF ANTARCTIC AREA V, MARCH IN 1958

Whale species	*E. superba*				*P. gaudichaudi*				None
	R	rrr	rr	r	R	rrr	rr	r	
Blue	—	—	—	—	—	—	—	—	2
Fin	1	5	14	6	—	—	—	—	88
Sei	—	2	1	1	—	5	4	5	24

pack ice. *P. gaudichaudi* is exclusively found in stomachs of 14 sei whales. Many sei whales with vacant stomachs also have darker excrement in their gut, showing that they had fed on *P. gaudichaudi* before their being shot. Because the excrements of *E. superba* origin and *P. gaudichandi* have different colour and remaines respectively. At the sametime, fin whales caught in these areas have no trace of *P. gaudichaudi* but the stomach contents of *E. superba*. This is the first description of *P. gaudichaudi* as a staple food of sei whales in the Antarctic, suggests sei whales skim the water to take scattered patch of *P. gaudichaudi*. Table 8 gives us the same data of feeding condition of whales in a certain period in March in 1958. Only sei whales take *P. gaudichaudi*, and all fin whales feed on *E. superba*. In other time of the season, the occurrence of the amphipoda has not been observed. But I would consider that from the abundance of sei whales it is abundant in the warmer waters of the Antractic. In the near waters of the Antarctic convergence, sei whales must have been feeding on the amphipods or some other organisms scattered in the sea. Foxton (1956) well describes the total volume of zooplanktons from the north to the south crossing the Antarctic convergence. The zooplankton concentration is observed in a region 0-200 miles south of the convergence. Of course, this value is calculated without *E. superba* near the pack line, the former waters must be one of the probable feeding grounds of sei whales consisting of scattered plankton such as *P. gaudichaudi*.

The concentration of Japanese catch of sei whales is located in the waters of 140° east longitude and 140° west to 160° west longitudes. In the former area, the peak of the occurrence of *P. gaudichaudi* is described by Baker (1954).

Fish. Fish in the stomachs of baleen whales in the Antarctic waters are appearently considered incident occurrences. There is no finding of fish in the stomach of baleen whales dominantly but a few specimens along with euphausiids. They bear no significant meaning for whales feeding, only being swallowed by whales with other food planktons. Those fishes also often swallow *E. superba* of ten or more individuals in their stomachs. Only the slender fish *Notolepi coatsi* Dollo has often been observed. Those fish persure krills in the surface of the water, and one can see the fish chasing *E. superba*. The fish is called as 'icy long nose fish' by Japanese whalers. Another fish belonging *Myctophidae* are sometimes observed in the stomachs of baleen whales.

In 1955, I found a curious fish from the stomach of a fin whale in the whaling area IV, which afterwards is named *Xenocyttus nemotoi* by Abe (Abe, 1957). This fish was found along with numerous *E. superba*, but the fish fed exclusively on the copepods, contrary to the expectation.

As a conclusion from 14 years observation, it is safe to say there is no important fish for baleen whales as their food in the Antarctic.

QUANTITY OF STOMACH CONTENTS

As a routine work, the stomach contents are classified into four groups according to their quantities (Nemoto, 1957). It is, however, made by the naked eyes and exact weighing has not been obtained. So it gives us only a comprehension of the feeding condition. Figures 8 and 9 show the stomach quantity of each species. Generally speaking, blue whales show higher feeding percentage than fin and sei whales, and there is no difference between sei and fin whales. Humpback whales take their food usually in their stomach, thus the percentage of vacant stomachs is less in number, or show higher percentage of feeding than blue and fin whales. In other localities, humpback whales also show higher percentage of feeding food. Mackintosh (1942) already describes full stomachs are found in 80% of blue whales, 50–60% of fin whales and 90% of humpback whales according to the observations by Major Spencer. When I compare above figures with Japanese result, the latter shows lower value than the former by Mackintosh. I have some probable explanation to this difference. To begin with, in the modern whaling, the prolong chasing of whales may cause vacant whale's stomachs, because the longer the chasing is done, the more the vacant stomachs of whales caught we find (Nemoto, 1957). Really the diesel motor equipped catcher boat chases whales in higher speed for longer hours in the recent operations. In second, the abundance of euphausiids may differ in each localities

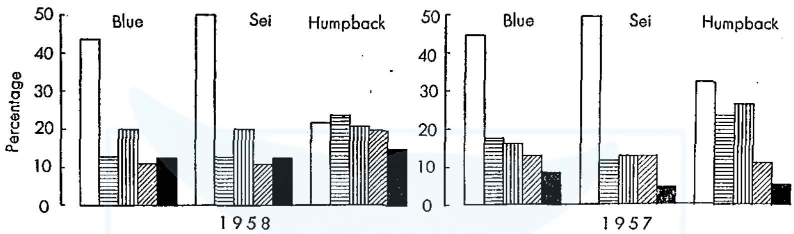


Fig. 8. Quantity of stomach contents of blue, sei and humpback whales in the Antarctic waters in 1957 and 1958. White—vacant, Lateral—few, Straight—moderate, Oblique—rich, Black—full.

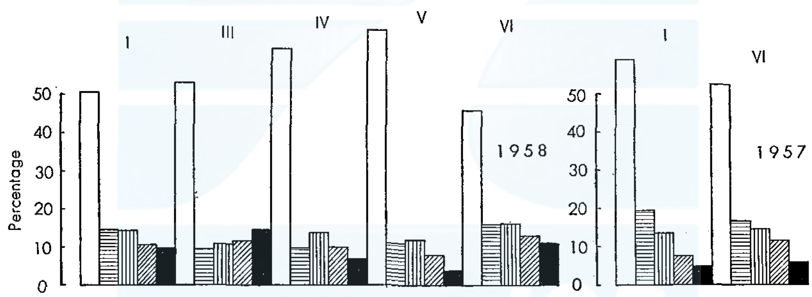


Fig. 9. Quantity of stomach contents of fin whales in the Antarctic waters in 1957 and 1958. Roman numeric shows Antarctic whaling secters. White—vacant, Lateral—few, Straight—moderate, Oblique—rich, Black—full.

of the Antarctic waters or owing to the fluctuations in each year. Japanese investigations carried out in 1940 and 1941 give also higher percentage than recent results.

Based on the results of 1957 and 1958, the feeding percentage of fin whales show the local differences among the whaling sectors of the Antarctic waters. Comparatively many fin whales take their food in the whaling ground VI. On the other hand, over 60% of the stomachs of fin whales are empty in the whaling grounds IV and V. Although no evidence is obtained as to the exact abundance of food in the sea from above figures, the result may be an indication that there are different abundance of euphausiids in each Antarctic area. Peters (1955) also describes that pelagically caught whales had more empty stomachs, as compared with the whales off South Georgia. Mackintosh states (1942), there was some indication that empty stomachs may be found a little more often in the early and late part of the season. I also think it is probable if a certain area is confined to examine, because whales follow the waters where their foods are abundant, but it is rather difficult to get the exact feeding percentage in seasonal comparison. Still, it is evident that the peak of *Euphausia* occurrence is observed in the mid-summer of the Antarctic when the feeding percentage must show the higher value throughout the season.

THE GROWTH OF *EUPHAUSIA SUPERBA*

Ruud (1939) and Bargmann (1945) state full discussions of growth of *E. superba*. By their discussions, *E. superba* attains the sexual maturity

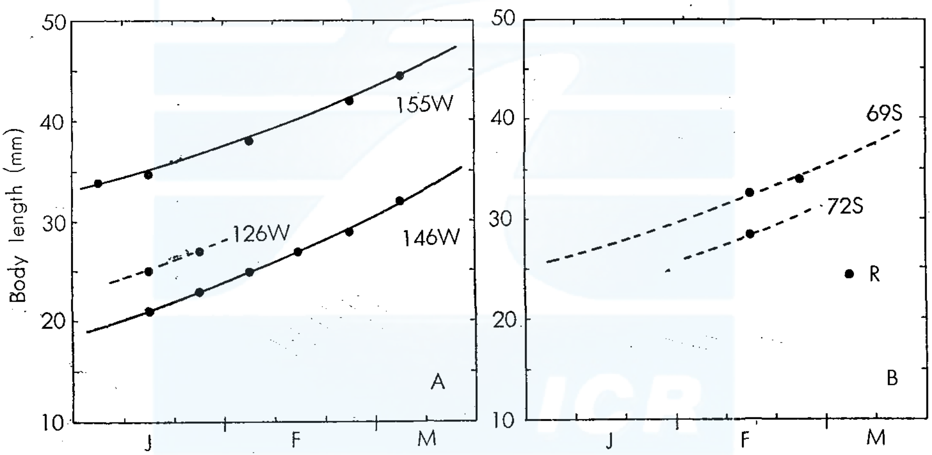


Fig. 10. Growth of *Euphausia superba* of 1 year group along the pack line of the Antarctic. A—The latitudes are nearly the same but the longitudes are different. B—longitudes are the same but latitudes are different. R—see R of Fig. 5.

stage after two years. It makes comparatively rapid progress in earlier and slower progress in later stages in general. The growth of *E. superba* is considered to be different among each locality of the areas of the Antarctic. Bargmann (1954) already describe the very heterogenous population of *E. superba* owing to the prolonged spawning seasons. Generally speaking, *E. superba* in the off waters where the pack ice melt in the earlier date of the Antarctic summer makes more rapid growth at the same season of a year. As shown in Fig. 10, 1 year group of *E. superba* in 155° west longitude area shows an advance of growth in 20 mm, or the group of *E. superba* in 146° west longitude shows smaller body length at the same time of the Antarctic summer. Going more east waters, *E. superba* again recovers its body length in the waters of 126° west longitude. Among the every group of *E. superba*, exact division lines are considered, which is directly considered to be due to the different spawning time in a year.

On the other hand, this fact is partly due to the melting time of pack ice when the rapid propagation of foods of *E. superba* diatoms and some other zoo organisms have begun. The foods of *E. superba* are described by Barkley (1940). According to his work the main food is a diatom *Fragilariopsis antarctica* and my recent investigation supports

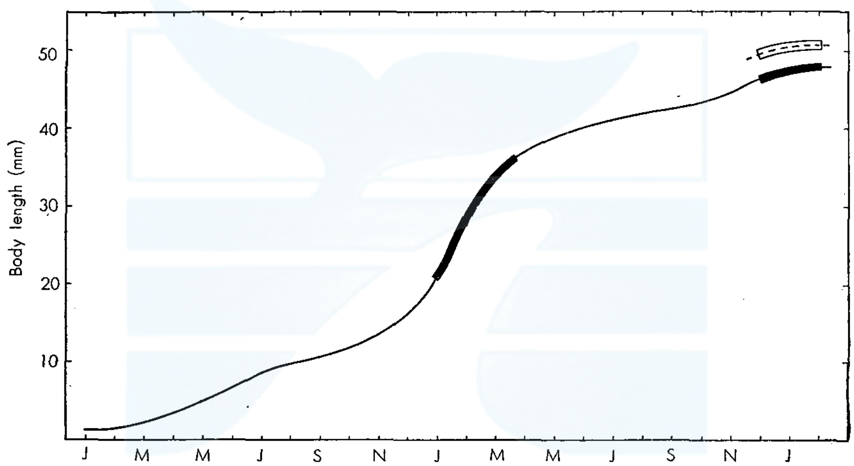


Fig. 11. Growth curve of *Euphausia superba* along the pack ice of the Antarctic waters, Solid line—female, Broken line—male, Shading area shows main Japanese collections.

the fact. And in a favorable condition diatom will propagate so rapidly as to support the vast growth of *E. superba* of 1 year group. From the body length of 20 mm to 45 mm, the body weight of *E. superba* becomes three times as big as the smaller stage of 20 mm. So the different spawning time of each group should be considered as one stable reason of different growth of *E. superba* in each locality. In 1958, I get two groups of *E. superba* which are swallowed by whales at the same longitude but the latitudes of the positions are 69° and 72° south latitude at 151° west longitude.

The pack ice at 69° south latitude melted away in the middle of January, but the pack ice at 72° south latitude melt in 30th of January. There exists 15 days delay in melting of the ice. The body length of

E. superba in the former waters shows about 10 mm advance, the difference of which may be too big for the lapse of 15 days. But the figure gives us evidence of difference in growth of *E. superba* in each locality. If I consider the rather rapid growth curve of *E. superba*, as shown in A of Fig. 10, it is probable that *E. superba* makes 10 mm growth in 15 days. Thus the difference in growth according to the food supply is also evident.

The marked decrease during the winter months (Fraser, 1936) is attributed to scarcity of materials by Bargmann (1945). But I would consider from the growth of 0 and 1 year group of *E. superba*, the winter growth should show more decrease than that by Bargmann, because

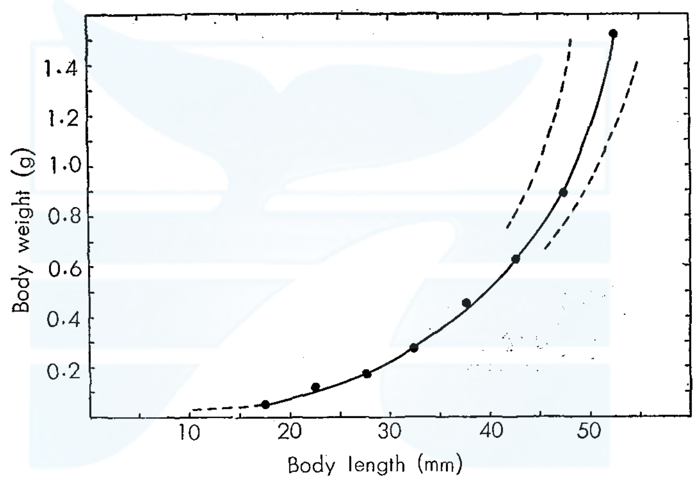


Fig. 12. Body weight and body length relation of *Euphausia superba* in the Antarctic waters along the pack ice, the sudden increase from 45 mm in body weight show a illustration of expansion and growth of ovary of euphausiids.

along the pack ice the growth of *E. superba* is very rapid after the melting of ice covering the surface of swarming area as shown in Fig. 10. As the maximum length of female *E. superba* is about 55 mm, and if they do not stop the rapid growth in the winter season, it goes too far. With considering above points, I draw the growth curve of *E. superba* along the pack ice in Fig. 11, which may have some resemblance to that of Bargmann (1945).

The relation between body length and body weight of *E. superba* is illustrated in Fig. 12. This figure clearly shows the tremendous growth of *E. superba* in the weight in the latter part of its life. Especially after copulating, the ovary of *E. superba* which contains more fat expand remarkably, thus the increasing growth curve is obtained. Peters (1955) also considers the larger whale shrimps (2 years group of *E. superba*) are the better food resource for the baleen whales than the small stage of *E. superba* owing to their fat content. The smallest copulated *E. superba* is about 35 mm in length, which is, however, not real signal of coming maturity. The weight of it is not so heavy that it is considered to be only a external phenomena, because maturity of a female euphausiid can be measured by the body weight of it. The increase of weight in the later stage of *E. superba* is well given by the development of the egg in ovary.

The relation between body length and weight of euphausiids in the different localities in the North Pacific is given by Ponomareva (1954), but with regard to *E. superba* in the Antarctic waters, there is no significant difference among the relation in each locality.

FOOD OF THE BALEEN WHALES IN THE NORTH PACIFIC

NORTHERN PART OF THE NORTH PACIFIC

Stomach contents of whales

The foods of baleen whales in the northern part of the North Pacific based on the observations by the year 1956 are summarized in the previ-

TABLE 7. STOMACH CONTENTS OF BALEEN WHALES CAUGHT BY JAPANESE WHALING FLEETS FROM 1952 TO 1958 IN THE NORTHERN PART OF THE NORTH PACIFIC

Kinds of stomach contents	Whale species			
	Blue	Fin	Sei	Humpback
Euphausiids	266	2222	10	203
Eu. & Copepods	2	137	1	2
Eu. & Squids	—	6	—	1
Eu. & Fish	—	8	—	11
Eu., Fish & Squids	—	1	—	—
Eu., Fish & Co.	—	7	—	—
Copepods	—	965	286	1
Co., & Squids	—	3	5	—
Fish	—	247	8	53
Fish & Squids	—	—	1	—
Squids	—	22	15	1
Empty	298	3868	473	120
No. of Stomachs examined	566	7486	799	392
Not examined	3	19	5	—

ous report (Nemoto, 1957). The successive whaling operations have covered broader areas than the former operations. In 1957 and 1958, the expeditions have covered the off waters of Anadyr gulf, the most northern part of Bering sea, Navarin cape, Anadyr gulf and Olutorskiy

Bay. From the two years' operations, I can get more detailed features of food of baleen whales and distribution of whales. Stomach contents of baleen whales caught during 1952 to 1958 are illustrated in Table 7. It is clear from the Table 7, that blue whales feed on only euphausiids, but 2 occasions. Some 140 blue whales caught in 1957 and 1958 take nothing but euphausiids like the previous report. Fin whales caught in the both years also feed on mainly euphausiids and copepods as previous year. Still considerably many fin whales feed on fish swarms in the years. Some 244 fin whales take fish in the North part of Bering sea, and fish is important as a food of fin whales. In the previous report, I consider

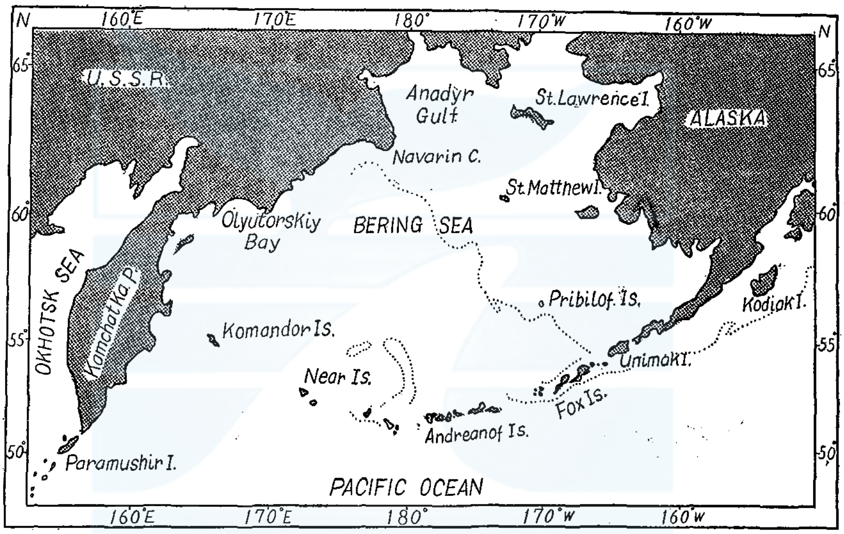


Fig. 13. Whaling ground in the northern part of the North Pacific.

that fish is only a makeshift food for fin whales. But I would think here fish is a main food for fin whales in the north waters of Bering sea above 58° north latitudes where the whaling operation had not operated before 1957. Sei whales show the same tendency as previous investigations. Calanoid copepods are the favourite foods of sei whales with other occurrences of euphausiids, fish and squids. The main food of humpback whales are euphausiids and fish, which is also the same result as the previous investigations.

Thus the foods of baleen whales in the northern part of the North Pacific, adjacent waters to Aleutian Islands and Bering sea are described as follows.

Blue whale	euphausiids
Fin whale	euphausiids, copepods, and swarming fish
Sei whale	copepods

Humpback whale euphausiids, and swarming fish

Besides above listed foods, squids are considered a makeshift food for fin and sei whales. From 1952, 22 fin whales and 15 sei whales have fed on squids and 7 fin whales and 6 sei whales have taken the mixture of squid and other organisms. There is a evidence that one main food of sei whales in the adjacent waters to Japan is squids, but it is not so important in the northern part of the North Pacific.

Species of food

Euphausiids. The previous studies on euphausiids are summarized in the report (Nemoto, 1957, p. 44–52), and I add here further knowledge on the problem. Following 5 species belonging to EUPHAUSIACEA have been collected through the investigation. Among them, *Thysanoëssa raschii* is found in 1957 as a first record in the northern part of the Bering sea, and the successive collection in 1958 proves this.

One *Euphausia* and four *Thysanoëssa* observed are follows.

Euphausia pacifica Hansen, *Thysanoëssa inermis* (Krøyer)
Thysanoëssa longipes Brandt, *Thysanoëssa spinifera* Holmes
Thysanoëssa raschii Sars,

The distribution and occurrence of above species in the northern part of the North Pacific are already stated to some extent in the previous paper (Nemoto, 1957).

TABLE 8. OCCURRENCES OF PLANKTONS IN THE COLLECTED SAMPLES OF STOMACH CONTENTS OF WHALES IN THE NORTHERN PART OF THE NORTH PACIFIC SINCE 1954

Species of plankton	Whale species									
	Blue		Fin		Sei		Humpback		Total	
Euphausiids										
E. pacifica	3	(3)*	12	(25)	—	—	1	(1)	16	(29)
T. inermis	8	(8)	95	(123)	9	(9)	8	(10)	114	(150)
T. longipes	5	(7)	86	(121)	1	(3)	1	(3)	93	(134)
T. spinifera	—	(1)	2	(17)	—	—	—	(3)	2	(21)
T. raschii	—	—	7	(7)	—	—	—	—	7	(7)
Copepods										
C. cristatus	—	—	116	(140)	9	(9)	—	—	125	(149)
C. plumchrus	—	(1)	11	(20)	2	(3)	—	(2)	13	(26)
M. lucens	—	—	1	(1)	—	—	—	—	—	(1)

* Number in bracket shows the subordinate and dominant occurrences in the stomachs of whales.

Still, recent investigation reveals very interesting distribution of euphausiids in the northern part of the North Pacific. Since the year 1954, distributions and occurrences of euphausiids and copepods are obtained as shown in Table 8. From the Table 8, it is clear *Thysanoëssa inermis* and *T. longipes* are the most important euphausiids in the waters.

When I compare the Table 8 with the data before 1957, it is evident that *Thysanoëssa longipes* become dominant in the collected sample of 1957 and 1958. One of the reason for the fact is due to the fact that Japanese whaling operation have caught considerably many whales in the

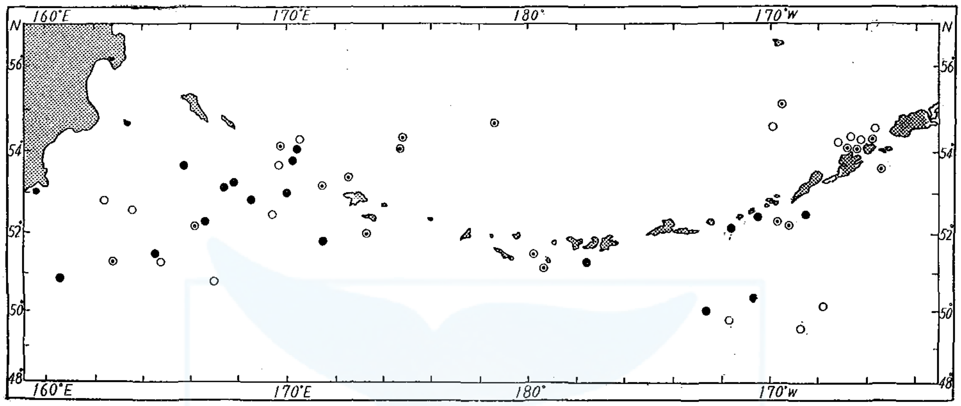


Fig. 14. Occurrences and distributions of *Euphausia pacifica* in the northern part of the North Pacific since 1952. ●—Dominant occurrences in the stomach contents, ○—Subordinate occurrences in the stomach contents, ⊙—Occurrences by net collections.

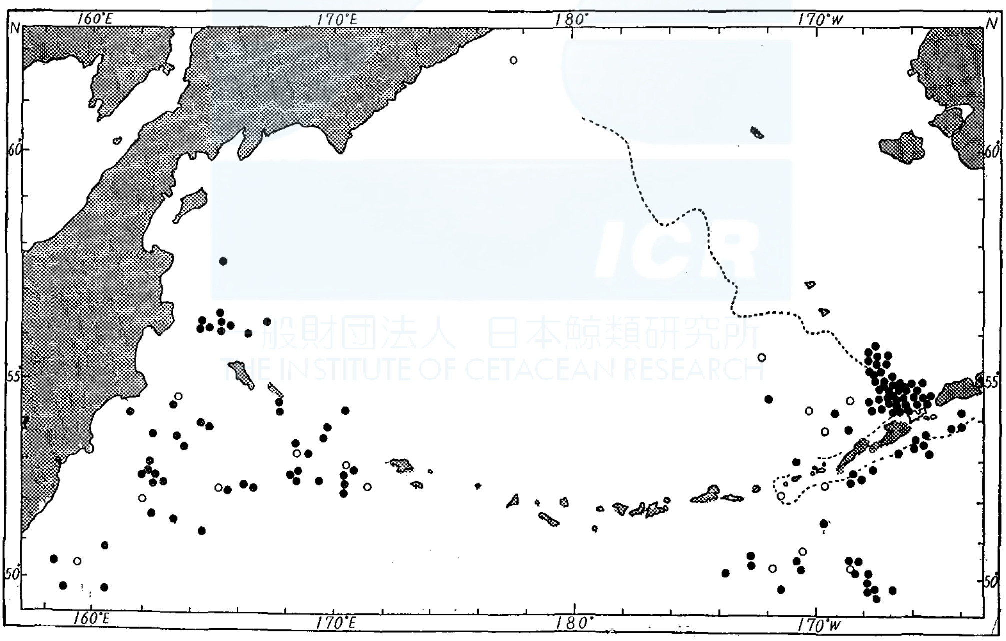


Fig. 15. Occurrences and distributions of *Thysanoëssa inermis* in the northern part of the North Pacific since 1952. ●—Dominant occurrences in the stomachs of whales, ○—Subordinate occurrences in the stomachs of whales.

south water of the eastern Aleutian Islands, Andreanof Islands and Fox Islands where the swarms of *T. longipes* have been mostly observed. Besides above two species *Euphausia pacifica* and *Thysanoëssa spinifera* have been observed and the more detailed knowledge is obtained on the characteristic of distributions.

Euphausia pacifica has been observed comparatively warmer waters in the northern part of the North Pacific. I describe as to the distribution of *E. pacifica* that it vanishes as a dominant food of whales in the north waters of Aleutian Islands (Nemoto, 1957). The recent collections add many occurrences of *E. pacifica* as illustrated in Fig. 14. None of specimen is found in the collected stomach contents of baleen whales north waters of 56° north latitude. The net hall collections also show the same tendency, as no specimen of *E. pacifica* is collected in the north waters. From above result, it is evident that *E. pacifica* plays little role of foods of whales in the north waters of Aleutian Islands and significance of *E. pacifica* is not so heavy as in the southern waters, adjacent waters to Japan (Nemoto 1957).

Thysanoëssa inermis is described one of the dominant foods in the Aleutian waters. Japanese investigation clearly reveals the concentration of *T. inermis* is observed in the north waters of eastern Aleutian Islands, Fox Islands. There are also scattered occurrences in the western part of the North Pacific. In the southern waters of Fox Islands, some occurrences of *T. inermis* are observed. But the number is far smaller if the comparing with the occurrences of *T. longipes* is made. On the contrary to the distribution of *T. inermis, T. longipes* is mostly found in the off waters of eastern Aleutian Islands. Few *T. longipes* distributes along the continental shelf of the eastern Aleutian Islands, but the dominant occurrences are observed in the off pelagic waters from the continental shelf. The relative abundance of *T. longipes* in each side of the North Pacific has not been given yet, however, the data by the year 1958 furnish us that the most dominant area of *T. longipes* is in the south waters of the eastern Aleutian Islands. Before reaching the definite conclusion, the alternation among the euphausiids should be considered. For example in 1954, *T. inermis* was very abundant along the continental shelf of the north waters of the eastern Aleutian Islands. The next year in 1955, *T. longipes* was comparatively abundant in the off waters of the same area along with the dominant patches of *Calanus cristatus*. Along the south edge of continental shelf of the eastern Aleutian Islands, swarms of *T. inermis* was very numerous in 1954, when the considerable number of blue and humpback whales had been caught in the waters. In 1957 and 1958, on the other hand, *T. longipes* has been very abundant in the far south waters from the shelf, and few whales distributed along the shelf. Above alternate occurrences of euphausiids give us the very illustration of annual variation among the euphausiids abundance. This must partly be due to some oceanographical conditions in the sea water which I discuss in the latter part of the paper. *Thysanoëssa spinifera* distributes along the Alaskan continental shelf and is neritic species (Nemoto, 1957). Japanese recent collections add few samples of *T. spinifera* to the Fig. 4 of my previous paper, but all occurrences are found along or within the Alaskan continental shelf. As discussed in the previous report, no swarm of *T. spinifera*

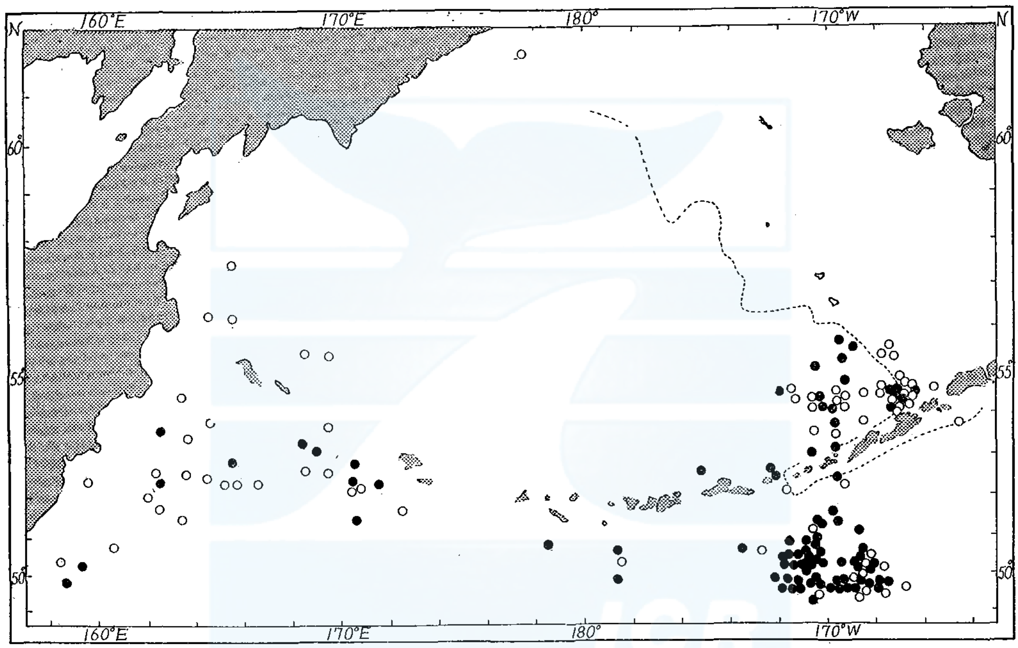


Fig. 16. Occurrences and distributions of *Thysanoëssa longipes* in the northern part of the North Pacific since 1952. ●—Dominant occurrences in the stomach contents. ○—Subordinate occurrences in the stomachs of whales.

is observed in the western part of the North Pacific. As shown in Fig. 18, and Table 8. *Thysanoëssa raschii* is observed in the stomachs of fin whales in the off waters of Anadyr gulf. I am very pleased to have the specimens of *T. raschii* in the waters because I have little expectation that *T. raschii* plays the role of food of baleen whales in the Bering sea. The distribution of *T. raschii* is restricted to the shallow and neritic waters within 50 metre in depth as illustrated in Fig. 18. The water of Anadyr gulf contains less salinity affected by the flesh water by the Anadyr river, and temperature and salinity are lower than that of the southern waters. *T. raschii* can live in such shallow waters so that fin whales in the waters successfully take the euphausiids in the day time, though it may go down to the near bottom depth as it is observed on the another euphausiids *Euphausia pacifica* (Saito & Mishima, 1953). Besides above food euphausiids, a young specimen of deep water living *Gnathophausia gigas* is found in a fin whale in the north waters of the

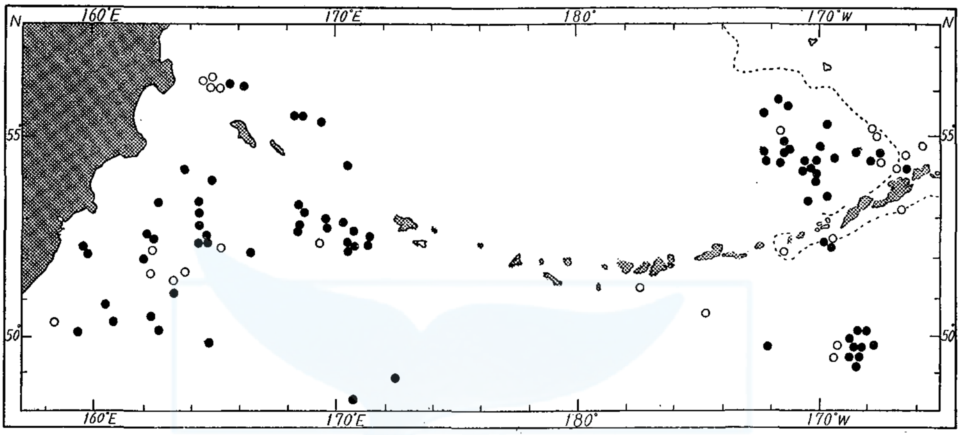


Fig. 17. Occurrences and distribution of *Calanus cristatus* in the collected samples of stomachs of baleen whales since the year 1952. ●—Dominant occurrences in the stomachs of whales, ○—Subordinate occurrences in the stomachs of whales.

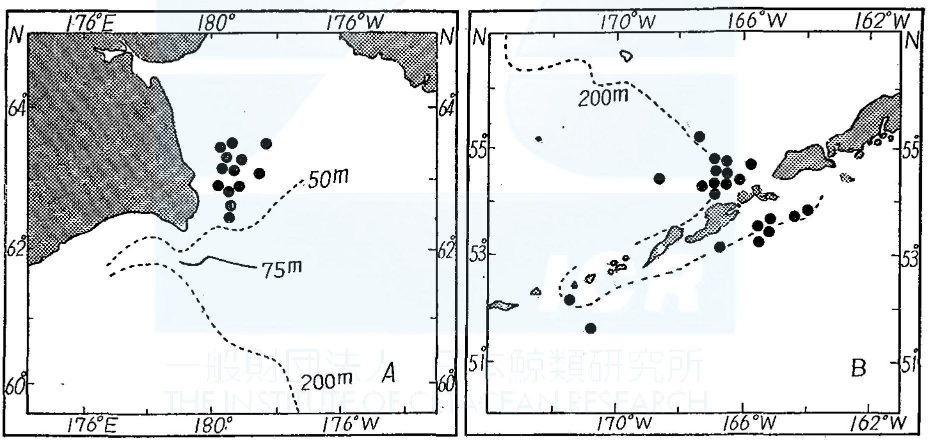


Fig. 18. Occurrences and distribution of euphausiids in the stomach of baleen whales in the northern part of the North Pacific. A—*Thysanoëssa raschii* in the north part of the Bering Sea off Navarin Cape. B—*Thysanoëssa spinifera* in the eastern Aleutian Islands.

eastern Aleutian Island among the swarm of *Thysanoëssa inermis*. I consider the fact is not due to the deep diving of the fin whale but to the coming up of the *Gnathophausia gigas* to the near surface waters.

Copepods. Two important copepods are observed in the previous researches in the northern part of the North Pacific.

Calanus cristatus and *Calanus plumchrus* are the main copepods consisting the food of baleen whales. In my collections *C. cristatus* is more abundant than *C. plumchrus*. But as stated in my former report *C. plumchrus* is very important for right and sei whales. In Japanese routine observations, inspectors do not classify copepods into above two species. Only biologists on board have some chance to do so. According to their reports, *C. cristatus* is dominant in three areas. As shown in Fig. 17, in the western part of the Near Islands, *Calanus cristatus* is usually found in the stomachs of baleen whales swarming there from May. The next whaling ground of *C. cristatus* is the north waters of Fox Islands. I already stated this distribution of *C. cristatus* in the previous report (Nemoto, 1957) that *T. inermis* is dominant along the shelf and *C. cristatus* is in the off water of about 3000 meters depth. As plankton survey shows the adult *C. cristatus* is found in the deeper waters than 500 metres (Nakai, 1954) in the waters adjacent to Aleutian Islands, it is reasonable that *C. cristatus* swarms in the off waters where the sea depth is more than 500 metres.

The third place is the south waters of the eastern Aleutian Islands, where also considerable fin whales feed on *C. cristatus*. According to Japanese collections, the most northern collections are obtained in the waters north of Komandorskiy Islands at about 56° North latitudes. On the other hand, I already cited the work by Brodsky that the main food of fin whales in Olyutorsky Bay, which situated at about 60° North latitude, is *Calanus cristatus* (Brodsky 1955). It seems reasonable to say, further, that *Calanus cristatus* plays a role of food for fin whales in the waters around the Aleutian Islands and Olyutorsky Bay. Along the Alaskan continental shelf, *Calanus cristatus* has not appeared as a dominant food but few cases and of course it vanishes within the shelf. With regard to the quantity of *C. cristatus*, it needs more collections before definite conclusion is obtained. But as illustrate in Tables 7 and 8, *Calanus cristatus* bears the very important part of foods of fin whales in the Aleutian waters.

Another macro copepods *Calanus plumchrus* distributes dominantly in the south waters of the chain of Aleutian Islands and Komandorskiy Islands. The most common occurrences are observed in the south waters of the eastern Aleutian Islands and south waters of Komandorskiy where considerable number of sei whales have been feeding on *Calanus plumchrus*. In the Table 8, only 3 samples of sei whales take *C. plumchrus* in samples owing to the insufficiency of collections. There are evidences, however, that sei whales are mainly feeding on *Calanus plumchrus* by the observations of biologists on board.

Calanus finmarchicus and *Metridia lucens* are described in my former report (Nemoto, 1957, p. 53, 54), but the successive investigations in 1957 and 1958 add no occurrence of these copepods to the previous results.

Fish. As shown in Table 7, swarming fish is considered to be very important in the northern part of the North Pacific, the north part of the Bering sea. Before the year 1957, baleen whales feeding on fish are comparatively small in number (see the table 2 in the previous report, Nemoto, 1957). Only 7 fin whales and 5 sei whales take fish or mixture of fish and plankton, though considerable number of humpback whales take fish. The successive operations, however, find many fin whales feeding on the swarming fish. Table 9, shows the occurrences of fish in these waters. There are some differences among the fish species according to whale species suggesting the difference of feeding habits. Fin whales take mainely herrings and capelin and Alaska pollack, and on the other hand sei whales take only saury. Humpback whales have a particular favourite for Atka mackerel as given in the Table 9. The distribution of the swarming fish also shows interesting tendencies. Generally speaking, capelin, Alaska pollack and herring distribute in the high

TABLE 9. FISH FOUND IN THE STOMACH CONTENTS OF BALEEN WHALE CAUGHT BY JAPANESE WHALING EXPEDITIONS IN THE NORTHERN PACIFIC FROM 1952 TO 1958

Whale species	Fish species						
	Herring	Capelin	Saury	Alaska pollack	Sand lance	Atka mackerel	Unknown
Fin whale	16	172	1	70	—	4	—
Sei whale	—	—	9	—	—	—	—
Humpback whale	—	3	—	2	2	54	3

latitude of 58° north, and capelin is found from the Olutorskiy Bay to Andyr gulf along the Kamchatka Peninsula coast but two occasions. The latter samples are observed in the north waters of Fox Islands of the eastern Aleutian Islands. Main occurrences go as far as the near waters of St Lawerences Is., but the most congregated area in the two years is the waters off Nawarin cape. The water depth there is about within 100 meter and as I described the neritic euphausiid *Thysanoëssa raschii* is the main food for fin whales in the water. Fin whales took sometimes *T. raschii* with capelin, the stomachs of which were often satiated with the former *T. raschii*. The size of capelin is about 15 cm and females are dominant usually in the swarms and stomachs of fin whales. Herrings demonstrate the same distribution as capelin. They are observed along Kamchatka Peninsula, mostly in the waters around Olutorskiy cape and south waters of Nawarin cape. Zenkovich (1934) states considerably many fin whales took herrings and often chase the swarms of herring in the Bering sea. Those occurrence of herring is the next one to the Zenkovich's description in the North Pacific. The largest size of herring is about 25 centimeter. At this stage of growth, herring must migrate in a very congregated swarm which attracts fin whales.

Alaska pollack shows the dominant occurrences among these fish. It is observed those fin whales fed it appear along the Alaskan continental shelf from 58° North to 61° North especially in 1957. The size of Alaska pollack never exceed 30 centimeter in length. This small size Alaska pollack swarms in the shallower waters than the adult Alaska pollack. The larger size Alaska pollack is found in the stomach of humpback whales in two occations (Nemoto, 1957). In this case, it is clear that two

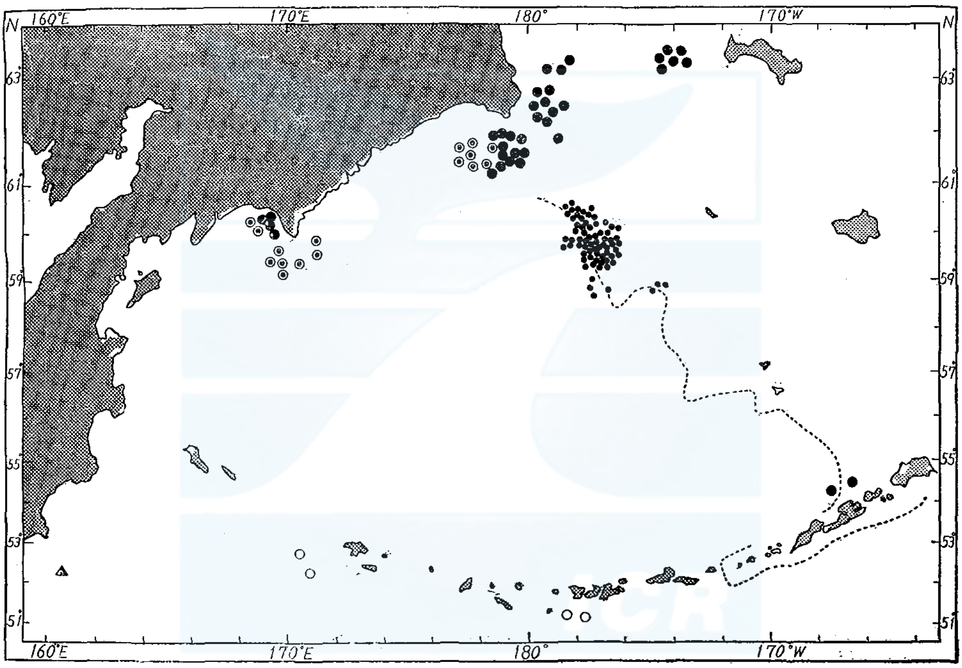


Fig. 19. Occurrences and distributions of fish in the stomachs of fin whales caught from 1952 to 1958 in the northern part of the North Pacific. ●—Capelin, ⊙—Herring, •—Alaska pollack, ○—Atka mackerel, ▲—Saury.

whales have different preference of feeding. From 1952 to 1956, few fin whale was caught in the northern part of the Bering Sea, and Japanese whaling expeditions have mainly covered the southern waters where many euphausiids are abundant. In recent years, however, the transition of the food from euphausiids to fish must be considered. In 1956 and preceding seasons, the scouting boats for whales seek the school of whales in the northern part of Bering sea. But not so many fin whales have been observed and the locality is unfavourable for whaling operation.

In 1957, fin whales swarming in the north waters of the eastern Aleutian water swim further to the north waters of the eastern Aleutian water and swim further to the north part of Bering sea along the continental shelf and feed on Alaska pollack. The relative abundance of euphausiids there is considered not so sufficient as in the preceding seasons. The whaling ground where Alaska pollack is fed shows no single occurrence of euphausiids in the stomachs of whales. In some years, *T. inermis* which is very abundant along the Alaskan continental shelf may propagate to the northern water along the shelf. But I have no specimen of *T. inermis* in 1957. Alaskan pollack fed by fin whales take, in its turn, mainly food of *Calanus plumchrus*. Small pelagic amphipods are also observed in its stomachs in smaller quantities. *Calanus plumchrus* distributes in the northern part of the North Pacific widely. But according to Johnson (1958), *C. plumchrus* (*C. tonsus*) is not so common in the Bering strait and Arctic sea. So, it is considered the main occurrences of *C. plumchrus* are within 61° or 62° North latitudes. The patch of *Calanus plumchrus* may be a food for fin whales sometimes, but fin whales never take favourably *Calanus plumchrus*. On the other hand, to the larval and adolescent form of Alaska pollack, Atka mackerel and adult saury, *Calanus plumchrus* is the most favourable food especially because the usual living depth of *C. plumchrus* is the same as that of the swarming fish.

The swarm of herrings found in the stomachs of fin whales caught in the Olutorskiy cape feed mainly on *Thysanoëssa inermis* and small appearances of *Calanus cristatus* and *C. plumchrus*. As already stated in the part of *Thysanoëssa inermis*, *T. inermis* is found in the north part of the Komandorskiy Islands as far as 58° north latitude and the dominant occurrences are observed 57° north latitudes as shown in Fig. 16. Because within the continental shelf, *T. inermis* is usually found in far smaller number and only herrings from Olutorskiy to Nawarin cape take *T. inermis* as their food.

Humpback whales are famous for their fish feeding. I describe humpback whales are very fond of Atka mackerel, as comparatively many humpback whales take Atka mackerel in the waters near Near Islands and Andreanof Islands. As shown in Table 9, the most favourite food for humpback whales is Atka mackerel of 15 to 30 centimetre. Fin whales never take, the Atka mackerel of the latter body length, 30 centimetre. But humpback whales sometimes take Atka mackerel of 30 centimetre or adult. In the same way, humpback whales feed on adult Alaska pollack in two occasions, and none of fin whale take it. Small Alaska pollack fed by fin whales and Atka mackerel fed by humpback whales contained many specimens of *Thessarabrachion oculatus* besides

Calanus cristatus and *Euphausia pacifica* in their stomachs in the waters of Near Islands. It is a very interesting fact that *T. oculatus* never swarms in so close patches as *Thysanoëssa* euphausiids, and fin and humpback whales of 'swallowing type' whales cannot take them. On the other hand, for the migrating swarm of fish, *T. oculatus* become a food for them.

Sei whales are surface feeders and feed on saury only according to Japanese collections from 1952 to 1958. Of course, other swarming fish may be a food for sei whales in some occasions. In the adjacent waters to Japan, many kinds of fish are favourite food for sei whales. But the limitting facter of foods of sei whales is due to their vertical living layer, that is, the surface swimmer is only considered as a food of sei whales. Sauries distribute largely in the North Pacific (Kasahara & Otsuru, 1956), and by observations on foods of whales, saury is

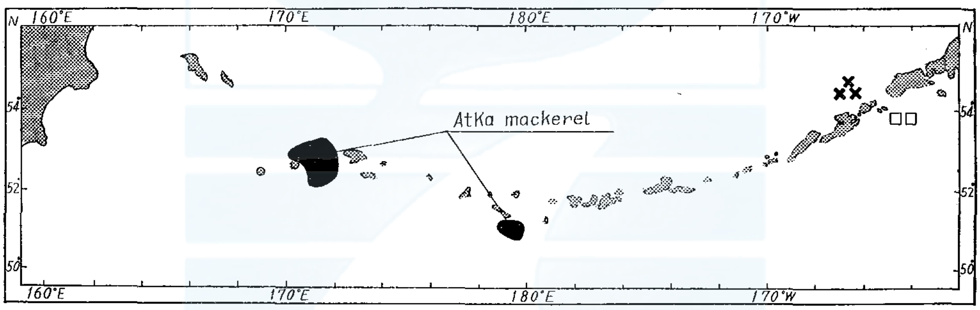


Fig. 20. Occurrences and distributions of fish in the stomach contents of humpback whales in the northern part of the North Pacific. Black shading—Atka mackeral. Open circle—Cod. Cross—Probably Capelin. Square—Capelin.

mainly found in the western part of the Aleutian Islands, where the northern limit of the distribution of saury is considered. The stomachs of saury are often satiated with copepods *Calanus plumchrus*, and the dominant occurrence of saury coincides with the dominant season and place of *Calanus plumchrus* occurrence.

I find no addition to the occurrence of sand lance and capelin in the south waters along the Aleutian Islands since I wrote the previous paper. So it is considered the important fish for baleen whales are followings.

Fin whale	Herring (*Clupea pallasi*)
	Capelin (*Mallotus catervarius*)
	Alaska Pollack (*Theragra chalcogranma*)
Sie whale	Saury (*Cololabis saira*)
Humpback whale	Atka mackerel (*Pleurogrammus monopterygius*)

Besides above species, Cod, whiting, rockfish and sea lamprey are noticed through the observations (Matsura & Maeda, 1942 etc.). Their occurrences are considered to be very incident one, though there is still a possibility that those fish, swarming so heavily, attract whales in some cases. Rock fish (*Sebastodes polyspinis*) and sea lamprey (*Entosphenus tridentatus*) are apparently swallowed with other planktons or incidently because above rock fish take planktons of the same kind as foods of whales and sea lamprey attacks whales (Pike, 1952; Nemoto, 1954).

These swarming fish show some fluctuation of abundance, which affect the distribution and migration of whales very much in the northern part of the North Pacific.

Squids. Squids have been considered not so important as a food for fin whales, because only 0.5 percent of total fin whales have taken them. Sei whales have taken them in 3 percent of all. Humpback whales have never fed on squids before 1956, but 1 humpback whale take

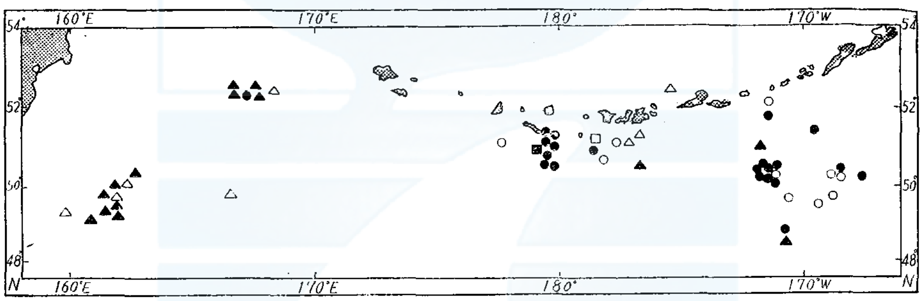


Fig. 21. Occurrences and distributions of squids in the stomachs of baleen whales in the northern part of the North Pacific. ▲—Squids fed by sei whales, △—Squids & others fed by sei whales, ●—Squids fed by fin whales, ○—Squids & others fed by fin whales, ■—Squids fed by humpback whales, □—Squids & others fed by humpback whales.

squids dominantly in 1956. Of course, no blue whale has taken squids.

Ommastrephes sloani pacificus is dominant through the survey. Small squids (*Watasenia scintillans*) and opalescent squid (*Loligo opalescens*) are observed too in less occasions. Especially sei whales often take *Ommastrephes sloani pacificus* in the western part of the Aleutian Islands. Squids come up to the surface waters in dark time of a day, and sei whales fed on squids are mostly found in the night, twilight times and heavey clouded days like fin whales.

Foods of fin whales in each locality and year

As described in the former part, blue whales feed only on euphausiids, humpback whales on euphausiids and fish and sei whales on copepods mainly. These three species show no typical change among their foods in the northern part of the North Pacific. But foods of fin whales bear some local characteristics as partly considered from the illustrations of Tables 10 to 12. In the south waters of Komandorskiy Islands, east of Kamtchatka and west of Near Islands, the foods of fin whales from 1952 to 1958 are illustrated in Table 10. From the Table 10, the main foods are euphausiids and copepods. The former consists of *Euphausia*

TABLE 10. STOMACH CONTENTS OF FIN WHALES CAUGHT IN THE OFF WATERS OF KAMTCHATKA PENINSULA, THE SOUTH WATERS OFF KOMANDOR ISLANDS AND THE WEST OF NEAR ISLANDS

Contents	Year						
	1952	1953	1954	1955	1956	1957	1958
Euphausiids	79	83	182	32	149	57	64
Eu. & Copepods	4	15	18	1	17	8	1
Eu. & Squids	—	—	—	—	1	—	—
Eu. & Fish	—	1	—	—	—	—	—
Calanoid	19	105	92	48	47	69	37
Ca. & Squids	—	—	—	—	1	3	—
Fish	—	1	—	—	1	—	—
Squids	1	—	—	—	7	—	—
Empty	110	252	272	67	114	143	166
Total	213	457	564	148	337	280	268
Not examined	—	13	—	—	—	—	1

TABLE 11. STOMACH CONTENTS OF FIN WHALES CAUGHT IN THE ADJACENT WATERS TO THE EASTERN ALEUTIAN ISLANDS FROM 1954 TO 1958

Contents	South waters					North waters				
	1954	1955	1956	1957	1958	1954	1955	1956	1957	1958
Euphausiids	66	7	8	171	75	306	421	264	45	70
Eu. & Copepods	4	—	—	13	2	—	22	13	2	9
Eu., Co. & Squids	—	—	—	3	—	—	—	—	1	—
Eu. & Fish	—	—	—	—	—	2	—	—	—	—
Eu. & Squids	1	—	—	—	4	—	—	—	—	—
Co. & Squids	—	—	—	—	2	—	—	—	—	—
Fish	1	—	—	—	—	—	—	—	—	—
Fish & Squids	1	—	—	—	—	—	—	—	—	—
Squids	—	—	1	2	12	—	—	—	—	—
Copepods	23	1	—	26	56	4	137	172	42	63
Unknown	—	—	—	—	—	3	—	1	—	1
Empty	71	27	37	285	290	269	597	323	196	155

pacifica, *Thysanoëssa longipes* and *T. inermis*, and the latter of *Calanus cristatus* mainly and a few occurrence of *C. plumchrus*. The annual change among foods is also observed, suggesting there are '*Calanus* year' and '*Euphausiid* year' (Nemoto, 1957), which I describe in next part. Euphausiids are a little more important in this waters as a conclusion. In the south waters of the eastern Aleutian Islands euphausiids also play considerable part of the foods of fin whales. In 1954, the most of the euphausiids are *Thysanoëssa inermis* along the continental shelf along the Islands. Fin whales swarm on *T. inermis* exclusively in the areas. On the other hand, *Thysanoëssa longipes* take the position of *T. inermis* among the food euphausiids in 1957 and 1958 as I describe in the part of foods in the north Pacific. In 1957, *Thysanoëssa longipes* was very dominant and numbers of fin whales taking *Calanus cristatus* were comparatively less in number. But *T. longipes* becomes rather less than the preceding season, and number of copepods are more dominant in 1958. From the above number of euphausiids occurrences and empty stomachs of fin whales, the feeding condition in 1958 is considered not so favourable for fin whales as in 1957. As other occurrences of stomach contents, 56 fin whales feed on copepods mainly *Calanus cristatus* and 12 fin whales on squids, also suggesting the above scarcity of euphausiids in 1958.

TABLE 12. STOMACH CONTENTS OF FIN WHALES CAUGHT IN THE NORTHERN PART OF THE NORTH PACIFIC IN 1957 AND 1958

Locality		Stomach content					
		Capelin	Alaskan pollack	Herring	*Thysanoëssa raschii*	Copepod	Empty
Alaskan continental shelf 58°–61°N	1957	—	70	—	—	2	86
Anadyr gulf & Navarin Cape	1957	6	—	8	47	—	113
	1958	141	—	—	11	—	120
Off Olutorskiy cape	1957	—	—	5	—	—	1
	1958	23	—	3	—	—	21

In 1954, almost all fin whales take euphausiids (mainly *Thysanoëssa inermis*) along the Alaskan continental shelf. But successive operations show the considerable occurrences of copepods in the off waters. Especially copepods are important for fin whales in 1956. Fish and Squids are rather scarce in the waters north of the eastern Aleutian Islands. In 1956, Japanese pelagic whaling covered the north waters of Komandorskiy Islands. Fin whales caught in the waters were feeding on euphausiids mainly and on *Calanus cristatus* resembling to the constitution of the south waters of the Islands.

In successive operations in 1957 and 1958, the waters north of 58°N latitudes have been covered, where many fin whales were feeding on fish, Alaska pollack, capelin and herring. In 1957, along the Alaskan continental shelf from 58° to 61° North latitudes, some 158 fin whales were caught by the Japanese operation. These whales were feeding on Alaska pollack (*Theragra chalcogramma*) exclusively but 2 whales on copepods. Fin whales caught a little northern waters of Anadyr gulf and off Navarin cape waters, mainly take a euphausiid *Thysanoëssa raschii*, and the rest of about 20 percent of the total feed on capelin and herrings. The 6 fin whales caught in the off waters of Olutorskiy feed on herring only. The aspect of feeding in 1958 is a little defferent from above preceding year. In 1958, capelin (*Mollotus catervarius*) is so dominant that almost all fin whales take it in the waters off Navarin cape, and no fin whales feed on Alaska pollack. This fact apparently suggests that there are annual fluctuations of swarming fish, and the feeding condition of fin whales is very much influenced by the fluctuation. In the preceding season before 1957, the swarming fish, capelin and Aaska pollak were not so abundant that fin whales did not migrate to the northern water of the Bering sea. It was probable almost all fin whales remained in the southern waters of the adjacent waters to Aleutian Islands in those years.

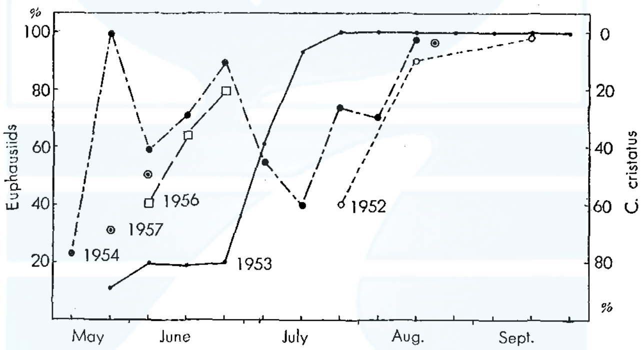


Fig. 22. Occurrences of euphausiids and *Calanus cristatus* in the west part off waters of the Kamtchatka Peninsula from 1952 to 1957.

Euphausiid year and calanus year

I describe in the former report there are ' *Calanus* year ' when copepods (mainly *Calanus cristatus*) is abundant and ' euphausiid year ' when euphausiids are abundant (Nemoto, 1957). As a example, I would refer again to the stomach contents of fin whales in the west part of the northern Pacific from 1952 to 1958. In 1952, the occurrence of *Calanus cristatus* is not so many as compared with the number of euphausiids, and the year 1952 is considered euphausiid year. In 1953, 1955 and 1957, the number of fin whales fed on copepods are dominant in number. These years are considered to be *Calanus* year. Especially in 1953, fin whales took *Calanus cristatus* mainly or 80 percent of total catch fed on *C. cristatus* at the beginning of the operation. To discuss the problem more clearly, the seasonal change between euphausiids and copepods should be considered. Generally speaking, Copepods are dominant at the beginning of the season in May and June, and euphausiids become dominat from July to September as it is seen in 1953. This is the typical change which '*Calanus* year' demonstrates. In euphausiid year in 1954, both euphausiids and *Calanus* are observed in stomachs of whales, and there is no typical change from May to July. In the latter part in July, however, euphausiids become dominant and copepods are vanished. The latter part of this curve is rather related to the curve of 1952 as shown in Fig. 22. It may be safe to say in some euphausiid year, though the complete transition from *Calanus* to euphausiids is finished in August, from May to August euphausiids are abundant through the seasons. Anyway, in the late decade of August and September, almost all whales feed on euphausiids or *Calanus cristatus* disappear from the surface waters of the area in August and September (Nemoto, 1957). This affects the migration of blue whales, euphausiids feeder,

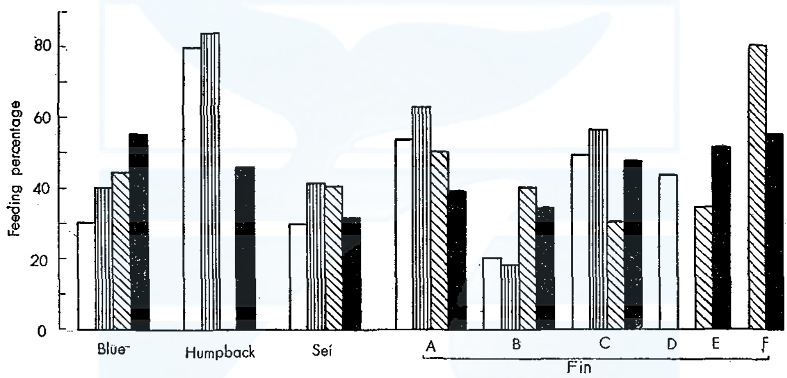


Fig. 23. Feeding percentage of baleen whales in the northern part of the North Pacific waters from 1955 to 1958. White—1955, Straight—1956, Oblique—1957, Black—1958. A—West waters of North Pacific, B—South waters of the eastern Aleutian Islands, C—North waters of the eastern Aleutian Islands, D—North waters of Komandorskiy Islands, E—Waters along the Alaskan continental shelf, F—North waters of the Bering sea.

very clearly. In '*Calanus* year' the migration of blue whales to the waters becomes later, and earlier in 'euphausiid year' (Nemoto, 1957, p. 77).

From the Table, the years 1952, 1954 and 1956 are considered euphausiid years, and the year 1953 *Calanus* year. The both years come alternately about every 4 years by rough examinations on the net samples of planktons.

This phenomena must have some relations to the variation of strength of 'Kuroshiwo' current, but the present data are so scarce that I would wait further investigation and refrain from the conclusion.

Quantity of stomach contents

The quantity of stomach contents of baleen whales also has been examined in the North Pacific. The recent result of the routine works is illustrated in Fig. 23. As a general tendency humpback whales take more foods than other whales like those in the Antarctic. But blue whales indicate comparatively low feeding percentage in the northern part of the North Pacific. The feeding percentages of above two species show yearly changes as illustrated in Fig. 23. These yearly changes may suggest the feeding condition of each year to some extent which I describe in the later part.

The feeding percentage of fin whales domonstrates local differences as well as the yearly changes. In the whaling grounds, in the off waters of Kamtchatka (A in Fig. 23), it indicates the higher value than that of the south waters of the eastern Aleutian Islands (B in Fig. 23). As fin whales in these two waters mainly feed on planktons of euphausiids and copepods of the nearly same species, the difference of feeding percentage is considered to be due to some reason of whaling season or abundance of foods. In 1955 and 1956, the number of fin whales caught in the south waters of the east Aleutian Islands were comparatively small in number suggesting the scarcity of the foods with the low percentage of feeding. But the successive operation in 1957 and 1958, many fin whales have been caught in the same waters but a little more southern position and the feeding percentage in both years increase. Still, they are lower than those of western waters (A in Fig. 23). One explanation for this is the season of whaling. Japanese whaling usually begins its operation from the western waters when the dark hour of a day is longer which may cause the higher feeding percentage as this make the less diurnal migration of food planktons of whales.

Fin whales in the northern part of the Bering sea (F. Fig. 23) show the highest feeding percentage, which is apparently due to partly the sea depth and food species in the waters. Fish and a euphausiid, *Thysanoëssa raschii* are eaten by fin whales in also daytime in the shallow waters of the northern part of Bering sea, and this makes that high feeding percentage of fin whales.

Sei whales only show 30 to 40 percent feeding percentage of all whales, and there is no significant yearly change. The fact will suggest that the favourite food of sei whale, the crop of *Calanus plumchrus*, has been constant in the described years.

KURIL ISLANDS

In the pre-war seasons, Japanese shore whaling from the landstations of Kuril Islands had caught many baleen whales, but only few observation on foods of whales in the waters is remained. 'Krill' and fish were described as their foods.

Recent investigations by a Russian scientist (Betesheva, 1954, 1955) gives us the fairly good comprehension on the problem. Two *Thysanoëssa* species, *T. longipes* and *T. raschii* are the main euphausiids in the waters according to his description in 1954. Besides above euphausiids, *Calanus cristatus* and *C. plumchrus* (*tonsus*) are described from the copepods as food planktons. Squid, *Ommastrephes sloani pacificus*, anchovy, *Engraulis japonica*, Alaska pollack, *Theragra chalcogramma*

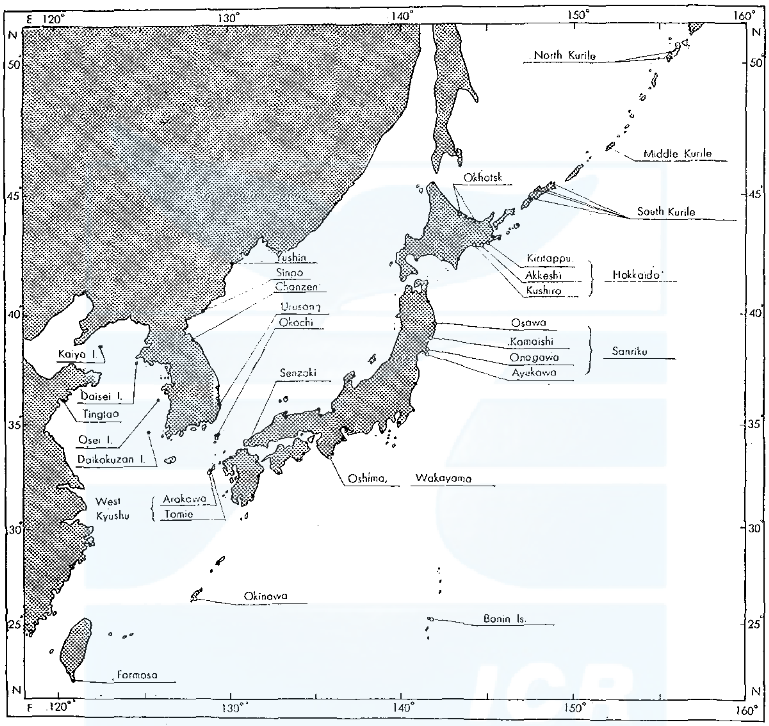


Fig. 24. Whaling centres around the Japan proper. Solid circles—whaling landstations only before 1945. Open circles—whaling landstations which have been operated after the year 1945 too. The name of the landstation before 1945 is referred to the old Japanese name.

are also found in the stomachs of fin whales. The 42 percent of fin whales of the total, take euphausiids and 20 percent is occupied by copepods (Betesheva, 1954). Though examined number is few, sei whales feed on mainly squid, *Ommastrephes sloani pacificus* and a copepod *Calanus plumchrus* (*tonsus*). Only one case, they feed on the mixture of *Calanus* and a euphausiid, *Thysanoëssa raschii*.

The results on little piked whale obtained in Kuril waters in 1951 is very interesting (Betesheva, 1954). Little piked whales are feeding on fish, Alaska pollack. And euphausiid species is all *Thysanoëssa raschii*. This neritic species has not been observed in the stomachs of baleen whales in the off waters of Kamtchatka Islands. As *T. raschii* play a subordinate food of fin whales in the shallow Okhotsk sea, it must also distribute in the very coastal waters to Kuril Islands where the coastal form little piked whales are feeding. The following data in 1953 give somewhat different data on foods of baleen whales caught in the adjacent waters to Kuril Islands (Betesheva, 1955). *Thysanoëssa inermis* is also observed in the investigation. Fish *Cololabis saira* and *Podonema*

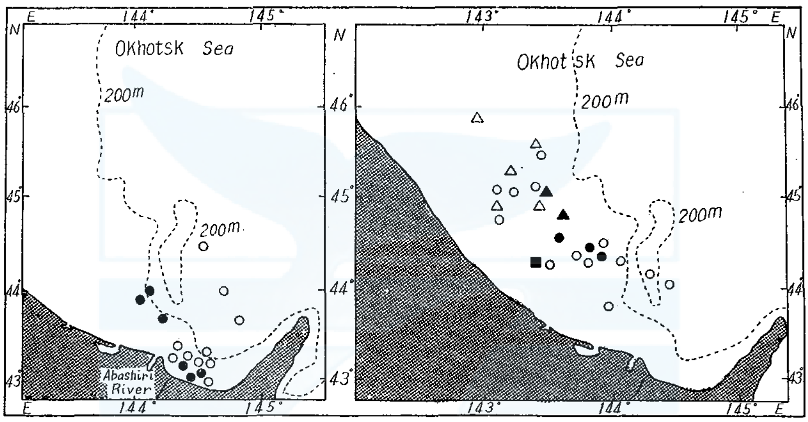


Fig. 25. Occurrences and distributions of foods of fin and little piked whales in the northern part of the North Pacific. △—*Euphausiids*, ▲—*Thysanoëssa inermis*, ●—*Euphausia pacifica*, ○—Vacant stomachs, ■—*Thysanoëssa longipes* and *T. raschii*. Left—little piked whales, Right—fin whales.

longipes are added to the list of previous season in 1951. Fin whales also feed on euphausiids, *Euphausia pacifica*, but no *Thysanoëssa raschii* is described. With other occurrences of fish, *Podonema longipes* and *Cololalis saira*, some annual changes among the foods may be considered. Though sei whales show no typical change of constitutions among the foods between 1951 and 1953, little piked whales feed only Alaska pollack in 1953. It is desiable that the further accumulation of observations on stomach contents will be obtained to explain above annual changes and feeding habits of baleen whales in the waters adjacent to Kuril Islands.

OKHOTSK SEA

In the Okhotsk sea, fin whales have been caught mostly, and a few catch of sei and humpback whales are observed. Baleen whales in the area mainly feed on euphausiids. From 1946–48, the biological observations had been carried out, summary of which was already described by Mizue (1951).

According to his descriptions, the main food for baleen whales is Krill and no other food is described. In recent operations, the number of whales caught has been decreasing considerably. Owing to those small number of the catch, examinations on the stomach contents have been carried out are not so satisfactory. I have 13 samples of stomach contents from fin and little piked whales from the Okhotsk sea. *Euphausia pacifica* and *Thysanoëssa inermis* have been observed as a dominant food and *Thysanoëssa longipes* and *T. raschii* are also found among above two species. The distribution of food euphausiids are not certain owing to

TABLE 13. STOMACH CONTENTS OF FIN WHALES CAUGHT IN THE OKHOTSK SEA IN 1955 AND 1956

		1955			1956			
		Euphausiids	None	Unknown	Euphausiids	Squids	None	Unknown
June	1st	10	5	—	—	—	—	3
〃	2nd	9	4	4	1	—	1	6
〃	3rd	6	3	4	6	1	2	—
Aug.	1st	—	—	—	2	—	2	—

TABLE 14. FOOD EUPHAUSIIDS OF BALEEN WHALES CAUGHT IN THE OKHOTSK SEA COLLECTED FROM 1953 TO 1956

Occurrences	Euphausiids			
	E. pacifica	*T. inermis*	*T. longipes*	*T. raschii*
Fin whale dominant	3	4	—	—
subordinate	—	—	2	2
Little piked whale dominant	7	—	—	—
Humpback whale subordinate*	—	1	1	1

* Dominant species is unknown, because the whale is flensed the day before my arrival at the landstation.

the scarcity of collections yet. But I would think that ' Krill ' contains in this case only euphausiids though I can't insist on the staple food is only euphausiids in the Okhotsk sea.

Euphausia pacifica distributes in shore waters and *Thysanoëssa inermis* in off waters. Fig. 25 shows little piked whales take mainly *Euphausia pacifica* in the shore waters. There is the Abashiri river running into the sea. The shore waters along the coast has less salinity than the off waters. *Euphausia pacifica* is more neritic species in the Okhotsk sea than *Thysanoëssa inermis* or *E. pacifica* may be more tolerable in the less salinity waters. On the other hand, the main currents in this part of the Okhotsk sea may be divided into two origins. One of the warm current from Tsushima current, and the other is the cold current of Sahalin current. From the distribution of water temperatures, *E. pacifica* appear in the warmer waters, and *T. inermis* in the colder waters. *Thysanoëssa raschii* is also observed with *T. longipes* and *T. inermis* in the colder waters. As it has been considered as a arctic neritic species I have found none of *T. raschii* in the oceanic whaling ground of the North Pacific but the waters of Anadyr gulf (see p. 181). The fact that *T. raschii* is found in the stomach of fin whales is apparently due to the shallow waters of the Okhotsk sea. As in the neritic waters along the Kuril Island, *T. raschii* is already noticed by Russian scientists, as a food of baleen whales (Betesheva, 1954, 1955). *T. raschii* and *T. longipes* are not so abundant as *E. pacifica* or *T. inermis* in the Okhotsk sea, considering the occurrence in the stomachs of baleen whales. Above occurrences and distributions are quite the same as some previous paper on the subject (Iizuka, Kurohagi, Ikuta & Imai, 1954). These euphausiids must play the role of food for fish too. Squid (may be *Ommastrephes sloani pacificus*) is found once in 1956 as a food.

As to humpback whales in this waters, I have no exact information on about their food. But I have a chance to examine the scattered euphausiids on a flensing deck of the landstation. The whale is considered feeding on *Thysanoëssa* species, *T. longipes, T. raschii* and *T. inermis*. There is a evidence that baleen whales in the Okhotsk sea are sometimes feeding on swarming fish. From 1943 to 1945, 3 occurrences of fish in the stomachs of fin whales, and in 1945, 9 little piked whales are observed as fish feeding occurrences. The species of fish is following.

Fin whales	Sand lance (*Ammodytes personatus*)
	Herring (*Clupea pallasi*)
	Cod (*Gadus macrocephaus*)
Little piked whales	Sand lance (*Ammodytes personatus*)
	Alaska pollack (*Theragra chalcogramma*)

Regarding to the foods of little piked whales, Omura (1956) summarized them. In his report, plankton organisms are described as 'Krill' containing copepods. But it is certain to consider 'Krill' means usually euphausiids only in the Okhotsk sea owing to the shallow sea and the warm current habitats. According to his report, saury and sardin like fish are described besides above species as foods of little piked whales. It is probable that saury is found in the stomachs of whales in the Okhotsk water along the coast, but I am not sure the sardin occurrence in the Okhotsk sea.

SANRIKU AND HOKKAIDO

Along the Pacific coast of north east part of the Japan proper, many baleen whales have been caught and examined until now. Omura (1950) and Mizue (1950) state the summarized consideration on the foods of

TABLE 15. STOMACH CONTENTS OF SEI WHALES IN THE ADJACENT WATERS TO JAPAN IN THE NORTH EAST AREA FROM 1955 TO 1957

Stomach Contents	May		June		July		Aug.		Sept.		Oct.	
	S*	N**	S	N	S	N	S	N	S	N	S	N
Euphausiids	13	1	14	3	13	24	3	7	—	6	1	10
(Anchory)	—	—	21	2	6	11	2	6	8	9	3	7
Anchory	10	—	7	—	—	4	—	6	—	5	7	2
Mackerel	1	—	—	1	1	3	—	1	—	11	—	1
Mackerel & Anchory	—	—	—	—	1	—	—	—	—	—	—	—
Saury	—	—	—	—	—	3	—	—	—	25	—	9
Saury & Anchory	—	—	—	—	—	1	—	—	—	—	—	1
Saury & Mackerel	—	—	—	—	—	—	—	—	—	1	—	—
Horse mackerel	—	—	1	—	—	—	—	—	—	—	—	—
Squids	6	—	11	—	1	27	—	4	—	21	—	38
Squids & Saury	—	—	—	—	—	1	—	—	—	4	—	3
Squids & Anchory	—	—	1	—	—	—	—	—	—	—	—	—
Squids & Euphausiids	—	—	—	—	—	2	—	—	—	—	—	—
Fish sp.	—	—	—	—	1	—	—	—	—	—	—	—
None	36	5	103	7	25	164	15	34	3	92	13	23
Unknown	65	1	104	8	16	122	21	20	6	106	3	89

* S—Southern waters of 40°N latitude. ** N—Northern waters of 40°N latitude.

TABLE 16. FOODS OF WHALEBONE WHALES IN THE ADJACENT WATERS TO JAPAN OF SANRIKU AND HOKKAIDO AREAS COMPILED AFTER THE DATA BY MIZUE (1951)

	Blue		Fin		Sei*		Humpback	
	S	H	S	H	S	H	S	H
Krill	16	34	43	90	253	103	2	—
Sardin	1	—	1	1	103	32	—	1
Saury	—	—	—	1	25	16	—	—
Mackerel	—	—	1	—	1	10	—	—
Rock fish	—	—	—	—	2	—	—	—
Squids	—	1	—	2	10	135	—	—
Octopus	—	—	—	—	1	1	—	—
Empty	11	23	41	34	547	145	4	6

* Apparently include Bryde's whales in Sanriku waters.

whales in those waters. Their descriptions, however, are not so satisfactory, because the identifications of foods comprise many mistakes as I discussed in a previous report (Nemoto, 1957, p. 45). To my great regret, the recent investigations have added few observation and collections of the stomach contents owing to the cutting of whales' body to preserve the meat fresh. Especially very little knowledge has been obtained after the paper by Mizue on the stomach contents of blue, fin and humpback whales which have been caught also in few number in recent operations. With regard to sei whales, comparatively many results show the same tendencies as that illustrated by Mizue (1951), though there are many unknown and empty (considerable part is considered broken stomachs) stomachs.

Sei whales in the Sanriku and Hokkaido areas feed mainly on euphausiids, anchovy saury and squids. Euphausiids consist of *Euphausia pacifica, Thysanoëssa longipes* and *T. inermis* in the northern region of the water off Hokkaido. But latter two species are observed in only a few occasion. In the southern waters from 35° to 40° north of the off waters of Sanriku, *Euphausia pacifica* play a role of foods of baleen whales. *E. pacifica* is considered rather abundant from spring to the summer season in the southern waters and little piked whales migrating to those areas from May to June also feed on *Euphausia pacifica* too. Sei and little piked whales also feed on it, and fin, blue and humpback whales caught in pre-war seasons must have fed on *E. pacifica* along the coast of these areas. Among the fish, anchovy (*Engraulis japonica*) sardin (*Sadinops melanosticta*) and saury (*Colorabis saira*) are the most important species. As shown in Table 15, anchovy occurrs throughout the season, but saury becomes dominant in the later part in September and October. It coincides with the height of saury in these areas. Besides above two species, mackerel (*Scomber japonicus*) is found in a considerable number in September. The size of mackerel is not so large, ranging about 7 to 20 cm in length.

Squids is also important for sei whales, especially in the northern area. Mizue describes further that all the species of whales eat, besides " Krill ", squids, the proper food for sperm whales in this sea area (Mizue, 1951, p. 88). But his consideration should be corrected. Because the species of squids on which sperm and sei whales feed are quite different. Sperm whales feed on mainly *Onychoteuthis* squid, *Onychoteuthis banksii*, and sei whales seldom or never feed on it. Sei whales on the other hand feed on large squids, *Ommastrephes sloani pacificus* which is very abundant in the Sanriku and Hokkaido waters. There is some reliable evidence that the former squids distributes in so deeper sea waters that sei whales, shallow water divers, can't take it.

As to the food of blue, fin and humpback whales, I would refer to the results by Mizue (1951) as summarized in Table 16. These three species mainly feed on ' Krill '. Though the species contain two kinds of planktons, *Calanus* copepods and euphausiids, it must be *Euphausia pacifica* from its abundance in these waters. The 10 stomach samples of planktons collected from these areas are all *E. pacifica, Thysanoëssa inermis* and *T. longipes*. Although the main food plankton is *Euphausia pacifica*, there are another evidence that sei whales are feeding on micro-copepods *Calanus helgolandicus* too. I have 3 occurrences of it in 1953 and also 3 occurrences in 1956 in the northern area of Hokkaido region. Other copepods, *Calanus cristatus* and *C. plumchrus* have not been observed definitly, but it is probable that the whalebone whales take above two copepods in the northern Hokkaido waters where the cold current planktons dominate abundantly. Food of Bryde's whales in the Sanriku waters are mainly euphausiids and anchovy (*Engraulis japonica*), and some Bryde's whales also take the larva of anchovy (Shirasu in Japanese) squids and mackerel.

TABLE 17. FOODS OF BRYDE'S WHALES IN THE OFF WATERS OF OSHIMA, WAKAYAMA PREFECTURE IN 1955 AND 1958

	Stomach contents	May			June		
		1st	2nd	3rd	1st	2nd	3rd
1955	Euphausiids	1	—	14	3	—	—
	Anchory	—	—	—	—	3	—
	Empty	—	—	1	2	—	2

	Stomach contents	May	June			July	
		3rd	1st	2nd	3rd	1st	2nd
1958	Euphausiids	1	2	—	—	—	—
	Anchory	1	—	8	—	6	3
	Post larva of fish	—	—	1	7	—	—
	Unknown & Empty	—	1	18	23	3	—

Two right whales caught in the adjacent waters of Sanriku and Hokkaido in 1956 show the trace of the feeding *Calanus plumchrus* mainly as the scraps collected from the stomachs are mostly of remains of *C. plumchrus* (Omura, 1958). A little fragments of *Calanus cristatus, C. finmarchicus* and *Euphausia pacifica* are mixed in *C. plumchrus*. The size of *Euphausia pacifica* is considered only 10 mm or less and these *Euphausia pacifica* must have not swarmed so mackedly but in the scattered in the sea along with copepods. The quantity of foods for baleen whales in Sanriku and Hokkaido waters was considered very abundant. The feeding percentage given by Mizue (1951) shows very high value, and in the pre-war season many baleen whales with full stomachs had been caught along the coast of Sanriku and Hokkaido. As I said, recent operation prove no such tendency owing to the lack of the complete remaining of stomachs and internal organs.

WAKAYAMA, OSHIMA

At the Oshima landstation in the Wakayama prefecture, comparatively many Bryde's whales have been caught by recent operations. Of course, sei and other baleen whales had been described (Andrews, 1916; Omura, 1950 etc.) in the seasons before 1945 and earlier season after 1945, very little is known about the foods of whales in the waters.

Bryde's whales in the waters feed on euphausiids and anchovy (*Engraulis japonica*). A euphausiid *Euphausia similis* is considered as a role in the earlier season of May, and anchovy play a greater part in the later season of June and July. Bryde's whales also feed on anchovy (*Engraulis australis*) in the south western waters of Australia (Chitterborough, 1959). These facts prove the feeding ground of Bryde's whales lies in the warmer waters as considered up to this time (Rund, 1952; Omura & Nemoto, 1955), because anchovy generally distribute within the warm current in the northern and southern hemisphere.

BONIN ISLANDS

In the adjacent waters to Bonin Islands, the pelagic whaling had been carried out, and caught comparatively many Sei and Bryde's whales. The investigations on those whales, however, were not sufficient to discuss the problem completely. I am very sad that there has been remaining only few samples of stomach contents of baleen whales in the Bonin waters. They are all incomplete collections. Especially I noticed there are many notes about copepods as foods of Sei whales in the Bonin waters at the earlier date of pelagic whaling (Mizue, 1950). But to my regret, the species is not certain because I have none of the collections owing to the insufficiency of the preserving. I would only expect future chance to study.

Some of euphausiid and fish samples of the stomach samples are found in my laboratory, which are of use for considering the main foods in these waters. The euphausiids examined are *Euphausia similis* and *E. recurva*, both of which distribute from subtropical to warm waters in the north Pacific. Nishimoto, Tozawa & Kawakami (1952) describe the food of sei whales in the adjacent water to Bonin Islands in our scientific report No. 7. In the report, the euphausiids is named *Thysanoëssa gregaria* with the illustration of Fig. 1. I would think it is a serious mistake. The illustration clearly shows the distinctions of *Euphausia similis*. I would consider it is *Euphausia similis* which appears dominantly among the remained collections of Bonin Islands waters. *Thysanoëssa gregaria* is also found in considerable number by net collections in these waters (Nakai & Honjo, 1953). But *Thysanoëssa gre-*

garia never swarms so markedly as *Euphausia similis*, and the relative abundance of *E. similis* is far greater.

Fish swallowed by sei or Bryde's whales are all Myctophyid and Gonostomid fish. *Yarrella* sp described by Nishimoto, Tozawa & Kawakami, (1952), is *Yarrella microcephala* which is commonly found from the subtropical warm waters. *Myctophum asperum* is another fish found mainly in the stomachs of whales but in a smaller number. *Myctophum asperum* is not found alone in the stomachs of whales, it is found among the *Euphausia* occurrences. There is another question as to the species of sei or Bryde's whales in the waters from feeding of view. Because Mizue's data based on the catch from February to early May. On the other hand, the distinct Bryde's whales cited by Omura,

TABLE 18. STOMACH CONTENTS OF SEI AND BRYDE'S WHALES CAUGHT IN THE ADJACENT WATERS TO BONIN ISLANDS IN 1947, 1948 AND 1949

		Feb.	March			April			May		Total
		3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	
1947	Plankton	1	1	42	16	20	24	7	10	7	128
	Fish	—	—	—	5	5	4	—	—	1	15
	empty	—	—	3	—	—	1	—	—	3	7
1948	Plankton	3	13	1	3	1	15	3	10	—	49
	Fish	—	—	3	5	6	1	4	1	—	20
	empty	1	2	5	7	2	10	8	—	—	35
1949	Plankton	—	—	—	7	2	5	2	5	4	25
	Fish	—	1	3	3	5	14	9	16	6	57
	Decapoda	—	—	—	1	—	—	—	—	—	1
	empty	2	2	2	1	6	4	2	6	7	32

Nishimoto & Fujino (1952) were taken from the early May to June. So the catch from February to the early May may contain real sei whales as suggested by Omura & Fujino (1954). So it is probable that some baleen whales described as sei whales in the former investigations from 1946 to 1949 take copepads (Mizue 1950). As sei whales can take the scattered copepods in the sea with fine fringes and in skimming feeding, Mizue's description should be examined again with regard to above suggestions.

As I stated in the former part, copepods are found in the stomachs of sei whales (Mizue, 1950) in the earlier seasons. According to his description, 13 whales take euphausiids, 34 *Calanus* and 17 young serdines. The last species, young sardines should be corrected as *Yarrella microchephala*. These species show single occurrences of each species in the stomach of whale. From 1947 to 1949, the rough classification of stomach contents of sei whale including some Bryde's whale are illustrated in Table 18. The most dominant occurrences are observed in planktons' part containing different two species, euphausiids and copepods, but in 1949. Fish is twice as many as planktons in 1951 according to the data by Nishimoto, Tozawa & Kawakami (1952), and the whales species at the whaling periods are considered to be Bryde whales considered from the season. Thus no *Calanus* copepods are found in those whales. Generally speaking whales with vacant stomach show comparatively few number when we consider the locality of Bonin Islands waters in 25° to 28° North latitudes, the southern unreproductive area. The fact that so many whales fed, on the other hand, clearly suggests that the waters around Bonin Islands is very productive though it located in the south waters. Subtropical convergence run through laterally the Bonin Islands waters and especially in the seasons between winter and spring (Uda, 1954). I find out many small pelagic Copepods in the stomachs of *Yarrella microchephala* which has generally the small month part. The most dominant species are *Candacia* species living in the subtropical to boreal warm waters. None of euphausiids has been found in the stomachs of *Yarrella microchephala*. On the contrary to this, *Myctophum asperum*, which have comparatively large mouth part, take euphausiids. Each of *Myctophum asperum* feeds on *Euphausia similis* of about 10 specimens. *Candacia* species are not so congregated into swarms of plankton, and they will not become a food for baleen whales in themselves. But if it is fed by *Yarrella* species as a favourite food, *Yarrella* species may become food of Bryde's whales in the waters.

EAST CHINA SEA AND WEST KYUSHU AREA

In the seasons before 1945, Japanese whaling had covered broad area of the Yellow sea and adjacent waters to Korea. These whaling grounds had not been operated after the war as we lost the landstation of all. In 1955, Japanese whaling have commenced the operation in the East China sea from the landstation of a little southern waters of the Yellow sea and adjacent waters to Korea. The baleen whales caught in this area are mainly fin and Bryde's whales. The latter species are, however, descriminated only after the year 1955. Before 1955 and pre-war seasons, comparatively many sei whales (may be Bryde's whales) had been caught along the western coast of Kyushu. The main grounds for sei whales (Bryde's whales) in these area is described in Fig. 26, and season of pre-war seasons before 1945 are between June to September. The whaling ground of Bryde's whales in recent years is also the same as the preceding seasons.

Fin whales, the main object in these waters have been caught in the off waters from the landstations, where no whaling operation had been carried out. The whaling grounds range from 30° to 32°50′ North latitudes and 125°30′ to 128°56′ East longitudes. The water temperature in the area is comparatively high ranging from 21°C to 29°C and differs much from other whaling grounds of the feeding type (Nemoto, 1957) in

TABLE 19. STOMACH CONTENTS OF FIN WHALES CAUGHT FROM THE LAND STATIONS OF WEST KYUSHU, GOTO ISLANDS IN THE EAST CHINA SEA IN 1955 AND 1956

		July		Aug.			Sept.			Oct.	
		2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd
1955	Euphausiids	—	6	3	3	16	7	10	1	—	—
	Empty	—	4	20	26	19	24	35	17	6	1
	Unknown	—	—	2	—	1	2	2	6	9	5
1956	Euphausiids	—	2	12	5	3	5	—	—	—	—
	Flying fish*	—	—	1	—	—	—	—	—	—	—
	Blind eel*	—	—	—	—	—	—	—	1	—	—
	Empty	—	3	7	2	17	14	10	1	—	—
	Unknown	2	47	25	38	16	10	16	21	17	2

The quantity is not so large

TABLE 20. QUANTITY OF EUPHAUSIIDS IN THE STOMACHS OF FIN WHALES CAUGHT IN THE EAST CHINA SEA IN 1955 BASING ON THE DATA OF REMAINED STOMACH

Quantity	July	Aug.			Sept.			Total
	3rd	1st	2nd	3rd	1st	2nd	3rd	
Full	1	—	—	1	—	—	—	2
Rich	1	—	1	1	—	3	—	6
Moderate	1	1	—	2	2	3	1	10
Few	3	2	2	12	5	4	—	28

TABLE 21. STOMACH CONTENTS OF BRYDE'S WHALES CAUGHT IN THE WEST KYUSHU AREA IN 1957 AND 1958

		July	Aug.	Sept.			Oct.	
		3rd	3rd	1st	2nd	3rd	1st	2nd
1957	Anchory	1	2	—	—	—	—	—
	Horse mackerel	—	1	—	—	—	—	—
1958	Anchory	—	—	4	1	—	—	—
	Horse mackerel	—	—	3	—	—	—	—
	Empty	—	—	4	2	1	—	1
	Unknown	—	5	11	9	2	—	4

the North Pacific. Fin whales in this area feed on euphausiids mainly except two occasion of fish and 1956. The quantity of euphausiids in these waters is not so abundant as in the northern part of the North Pacific. Illustrated tables show, that the whales with vacant stomachs are found more. Owing to the long draging from the whaling grounds to the land stations, whales are cut at the belly portion of the body to preserve the meats flesh. As the result, stomachs are often damaged or swollen and contents are washed away by the sea water. Thus the unknown stomachs, thus amount to a considerably number. It is difficult to decide the quantities of euphausiids exactly because of said reason, but as described in Table 20, the euphausiids' occurrences are clearly less than the quantities of the North Pacific whaling areas.

I have got some 20 stomach samples of fin whales caught in the area from 1955. These euphausiid are all *Euphausia pacifica* which is considered dominant in the East China sea and the Yellow sea. *Euphausia pacifica* is commonly found in the waters from adjacent waters to

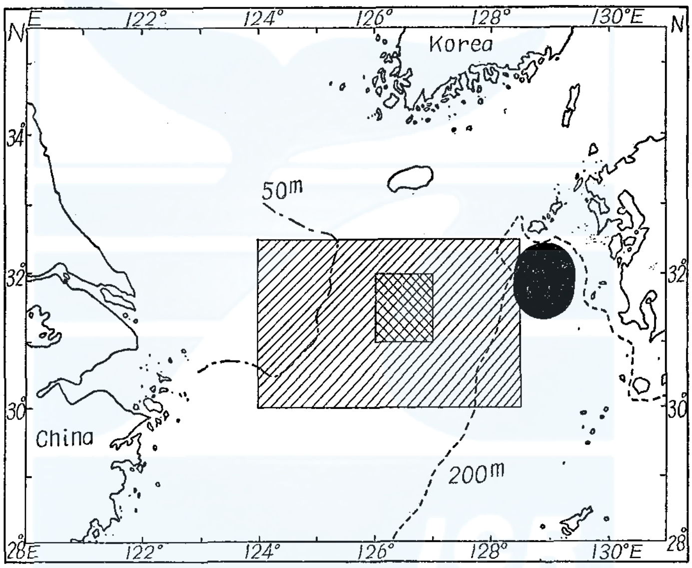


Fig. 26. Whaling grounds showing sea depth in the east China sea. Shading area—whaling ground of fin whales. Double shading—main ground of fin whales. Black area—whaling ground of Bryde's whales.

Japan, but I think this is the first description that *E. pacifica* play the role of foods of fin whales in these waters. Of course, *E. pacifica* is already a famous food for mackerel in the Yellow sea up to these days (Nakai, 1942). The relative abundance of euphausiids is not certain, but the fed fin whales are exceedingly small in number comparing with the northern Pacific water regarding the long pulling and lost stomachs by waves. There are still some fin whales fed abundand euphausiids, however, *Euphausia pacifica* is not so abundant considering the occurrences of fin whales with few stomach contents. Besides *Euphausia pacifica*, blind eel (*Eptatretus burgeri*) and flying fish (definite species name is unknown) are observed in the stomachs of fin whales. They are considered not so important as the foods of fin whales because only one occasion of each species is observed. The blind eel lives coastal and neritic shallow waters of south part of Japan. It is also found in the south waters of Korea (Matsubara, 1955). The name of flying fish is not certain, but some flying fish swim in swarms in the surface of the warm sea, it may be probable that they attract the fin whales in the warm waters.

Another occurrence of very particular organism has been observed in the stomachs of fin whales in the East China sea. So many MONOSTOMATRIDAE parasitic worm are found that one may consider them as a food of fin whales. This worm is determined as *Ogmogaster plicata* Crepl. or the related form by courtesy of Dr. J. Senoo of the Tokyo University of Fisheries. This is found in the caecum of *Balaenoptera* whales by Jagerskiold (Senoo, 1958), but I have never noticed in the stomachs of fin and other whales in other part of the sea. Further information on the parasitic worm is desirable to get the definite cycle of the parasitic worm. Bryde's whales in the adjacent waters to Kyushu are confirmed since the year 1955. These Bryde's whales have been caught in the coastal waters as illustrated in Fig. 26. They are mainly feeding on fish. In 1955, 2 Bryde's whales fed on small sardins (*Sadinops melanosticta*) which distribute widely and abundantly in the summer season in these waters. In next year's operation, 3 Bryde's whales with vacant stomach content are caught. In 1957 and 1958, 3 and 47 Bryde's whales have been caught respectively, foods of which are summarized in Table 21. These Bryde's whales are feeding on anchovy (*Engraulis japonica* (Houttuyn)) and horse mackerels. Horse mackerels in these waters are classified into three species, *Trachurus japonicus* (Temminck et Schlegel) *T. argenteus* Wakiya and *T. declivis* (Jenyno), and it is not certain that how horse mackerels found in the stomachs of Bryde's whales belong to above each species, but *T. japonicus* and *T. declivis* are considered mostly common in the waters. From the observations in 1958, 5 whales take anchovy abundantly and 3 whales take horse mackerels moderately, suggesting that the swarming fish such as anchovy and horse mackerels are abundant in the waters and the waters are very favourable for Bryde's whales. In 1944, the provisional investigation has operated on the stomachs of whales, that is 25 sei* (Bryde's) whales feed on big sardin, 37 whales feed on sardins (may consist of sardin and anchovy) and 38 whales with vacant stomachs in the same whaling grounds as the recent seasons. Big sardins were

* In 1944, Bryde's whales had not been discriminated from sei whales.

mostly found in July, but I am not sure if the observations were satisfactory in taxonomy.

ADJACENT WATERS TO KOREA

In the pre-war seasons, Japanese whaling had operated from the land-station of the both sides of Korea, in the Yellow sea and the Japan sea. The rough observations on the fin whales caught in the areas were made from 1940 to 1945. The food found in the fin whales stomachs are all 'Krill' but one occurrence of squids. Above two categories of foods are not identified to belong to any species. There is a evidence, however, that *Euphausia pacifica* is very abundant in the Yellow sea and the Japan sea (Nakai, 1942), Especially it plays the role of foods for serdin and mackerels adjacent waters to Korea. He also found that fin whales and little piked whales in the off waters of south Korea mainly took *Euphausia pacifica* as their foods. Considering the dominance of *Euphausia pacifica* in these waters by previous works, above stated 'Krill' is on the whole considered to be *Euphausia pacifica*. The

TABLE 22. FOODS OF FIN WHALES CAUGHT IN THE OFF WATERS OF CHANZEN IN KOREA BY AVAILABLE DATA FROM 1940 TO 1945

	Jan.	Feb.	Mar.	April	May	Nov.	Dec.
Krill	10	9	5	17	4	14	6
Squids	—	—	—	1	—	—	—
Empty	—	2	13	7	1	—	—

fact that fin whales in these water feed on 'Krill' in winter and in summer, suggests *Euphausia pacifica* is occurring throughout the year, though the cycle of *Euphausia pacifica* in the waters is not certain yet. According to Nakai (1942), a copepod *Calanus plumchrus* is the most dominant plankton in the surface water of the Japan sea. As it is found in the stomachs of fin whales in the northern part of the North Pacific, it may also bear a little significance for fin whales in the Japan sea.

A swarming fish *Clupanodon punctatus* is once found in a stomachs of fin whales in the Yellow sea at about 38°N latitudes and 124°E longitudes. This is only occurrence of fish in the stomach of a fin whales described in the pre-war investigations in the waters adjacent to Korea.

OKINAWA (RYUKYU)

Many humpback whales have been caught by recent whaling operation in 1958 and 1959. These humpback whales take nothing in their stomach

(Nishiwaki, 1959). A humpback whale take few fragment of *Euphausia similis* in its stomach, but none of humpback whale takes the bulk of euphausiids according to the observations carried in 1959. There is another observation on a occurrence of euphausiids in 1958, the size of which suggests that the euphausiids may be *Pseudoeuphausia latifrons* distributing in the neritic subtropical waters (Nishiwaki, 1959). Other foods such as bentholiving sea slug are considered to be fed by whales according to whalers. But it has been not certain if humpback whales are feeding actively in the warm waters of reproduction and rearing.

JAPAN SEA

Very few observation has been obtained as to the food of baleen whales in the sea of Japan. Only data on little piked whales are followings. Little piked whales in Wakasa Bay (whaling ground II in Omura & Sakiura, 1956, Fig. 17) take *Calanus finmarchicus* and fish, sand lance, The whales in the Hokkaido of the Japan sea side also take sand lance mainly with other occurrences of Alaska pollack and euphausiids (probably *Thysanoëssa inermis*).

BRITISH COLUMBIA

Pike (1952) describes the foods of baleen whales in the off waters of British Columbia in his progress report. *Thysanoëssa spinifera* and *Euphausia pacifica* are observed in the stomachs of fin, blue and humpback whales. To my regret, the name of copepods is not suggested by his descriptions, but one occurrence of it is described in a fin whale stomach.

CALIFORNIA

The foods of humpback and grey whales in the waters of California are given by Howell & Huey (1930). Humpback whales take shrimps (*Euphausia pacifica*) and sardins. *Euphausia pacifica* also play some part of foods of grey, fin and humpback whales in these waters.

NOTE ON THE FOOD IN OTHER WATERS

AUSTRALIAN WATERS

In some Australian waters, humpback whales feed on euphausiids or other shrimps though the food quantity is extremly few. Dawbin (1954) says in his letter, the whaler sometimes observes semi-transparent "shrimps" smaller than *Munida gregaria* in the stomach of humpback whales in the Australian and New Zealand seas. Generally speaking, the foods in the Australian and New Zealand waters are considered to be not so abundant as in the adjacent waters to Japan. He notes further, there has been also a few fragments macerated fish bone too far digested for identification, and very finely digested crustacean materials. The latter remains mean certain euphausiids may play parts of humpback whales. Dall and

Dunstan (1957) describe the fragmental occurrence of *E. superba* in the stomach of a humpback whale treated at Tangalooma whaling station. They describe this is the first record of the food in the stomachs of 2,000 humpback whales examined at the station during 1952 to 1955 seasons. This observation causes some enthusiasm discussion by Jonsgård (1957) and Marr (1957). They consider the occurrence must have been due to the remaining of digested *E. superba* from the Antarctic waters. On the other hand Dall & Dunstan think it is probable that *E. superba* is not confined to Antarctic regions, and that it may be found as a bathypelagic inhabitant of Antarctic waters in lower latitudes. I would also consider the explanation of Jonsgård (1957) and Marr (1957) is the most probable case.

Besides the incident occurrence of *E. superba, Euphausia hemigibba* and *Pseudoeuphausia latifrons* were identified from a whale caught in September at Point Cloates of western Australia (Dall & Dunstan, 1957). Sheard and Chittleborough report *Euphausia spinifera* from a whale at Albany (unpublished report cited Dall & Dunstan, 1957). Above many tropical and sub-tropical species of euphausiids, as they are, are comparatively little in quantity in the adjacent waters to Australia, and their swarmmings are not sufficient for humpback whales feeding.

Grimothea stage of crustacean has also been considered in the warmer waters in the southern hemisphere. Mathews (1932) compiled (1932) the previous knowledge on *Grimothea* larva of *Munida gregaria* and he stresses on its importance bearing the migration of the humpback whale in the New Zealand seas. Around the New Zealand coast, Ommanney (1933) describes the south bound whales have a greater or lesser quantity of food in the stomach, while the stomachs of the north bound whales are nearly always empty. But satisfactory expalanation for the fact has not been obtained.

Recently, Chittleborough (1959) reports the food of Bryde's whales that they were feeding on anchovy (*Engraulis australis* Shaw) along with young mackerels.

NORTH ATLANTIC

With regard to the food of baleen whales in the North Atlantic, many previous works referred to the problem as I described in the former report and Mackintosh (1946) states well summarized comment on then. Blue whales feed on euphausiids exclusively as in the North Pacific (Einarsson, 1945). *Thysanoëssa inermis* and *Meganyctiphanes norwegica* have great importance for blue whales in Norwegian and Irish waters. Fin whales feed on mainly planktons and occasionaly on swarming fish too. In the winter seasons from January to April, fin whales feed on *Thysanoëssa inermis* and herrings, and in 'Summer fishing' from the middle of May to the end of seasons fin whales live on the large Krill *Meganyctiphanes norwegica* (Hjort & Ruud, 1929). Between above two winter and summer seasons *Calanus* copepods are observed in April after the figures illustrated by Hjort & Ruud (1929). The whaling grounds of both two periods stand on the different geographical areas. During winter season, fin whales are caught and inside of bank, on the other hand, they are taken on the slope of the continental shelf and slope of the bank in summer.

Sei whales feed on *Calanus* copepods exclusively along the Norwegian coasts (Hjort & Ruud, 1929), but in the waters off Finmark *T. inermis* play a role of food for sei whales (Collett, 1886). Euphausiid, *Thysanoëssa inermis* is also important for right whales and humpback whales in the North Atlantic as summarized by Einarsson (1945).

These observations and investigations are rather old, and I would consider, the study on foods of whales in the Northern Hemisphere of Atlantic requires further investigation. Still, there is another important result that distinct parallel between the catch of sei whales and abundance of *Calanus finmarchicus* is obtained by Hjort & Ruud (1929, p. 51, Fig. 31). The preceding of *Calanus finmarchicus* by a short time (about 10 days after the illustration) should be noted as a general character showing the relation between food and baleen whales. Japanese investigations also endorse the fact but preceding is considered by 7 days or a week.

SOUTH AFRICA

Mackintosh & Wheeler (1929) describe some comments on the food of whales caught to the adjacent waters to South Africa. These species of euphausiids *Euphausia recurva*, *E. lucens* and *Nyctiphnes africans* were included in the stomach contents according to their descriptions. And it seems reasonable that they consider all species of *Euphausian* occurring in the locality are consumed without discrimination when they are congregated into swarms. Besides above euphausiids, fish are found in the stomachs of some humpback and fin whales examined at Saldanha Bay, however, the names of which are not described. In general, the quantities of stomach contents appear to be empty or contain a very small quantity of food. This apparently means, as well published by Mackintosh (1942), baleen whales in warmer regions in winter are feeding little organism but a very meagre diet of certain small euphausiid, some lobster krill and perhaps an occasional meal of fish (Mackintosh, 1942, p. 212). Many species of euphausiids in the warmer waters are considered not so congregated into swarms as in the North Pacific but scattered in the sea. This condition is unfavourable for the swallowing type of baleen whales.

SOUTH AMERICA AND MEXICO

Matthews (1932) states *Munida gregaria* and its Grimothea stage form the food of the sei whale according to Captain Fagerli. Many sei whales were feeding *M. gregaria* or its larva at the surface or near the surface waters. In 1926 at Magdalena Bay on the Pacific coast of Mexico, sei, humpback and Pacific grey whales were found to be feeding on these crustacea shoals, *Pleuroncodes planipes* (Matthews, 1932).

FEEDING HABITS

METHODS

The skrilful collecter of plankton and some other organisms in the sea, baleen whales have two kinds of method to take their foods. Ingebrigtsen (1929) and I (Nemoto, 1957, p. 57) described Skimming and swallowing (gulping) as methods of their feeding. The swallowing by fin and humpback whales is described by Andrews (1909). When feeding, fin whales turn on the side, the water spouting from between the baleen plates as the mouth is closed, and they often turn of rolling their body at the surface of the water, Humpback whales also show the roll on the side (Andrews, 1909, p. 221), and Ingebrigtsen (1929) describe the skimming of sei whales. From the feeding apparatus and food of whales, baleen whales are classified into the above two groups as follows.

Swallowing (gulping) type
- Blue whale
- Fin whale
- Bryde's whale
- Little piked whale
- Humpback whale

Skimming type	{ Right whale Greenland whale
Swallowing and Skimming type	Sei whale

As discussed in the former part of feeding apparatus, baleen whales belong to blue whale type whales take their foods by swallowing. The main food for swallowing type of whales is euphausiids as discussed in the former part on Antarctic and North Pacific whales. But in some cases, swallowing type whales feed on swarming fish and copepods as fin, whales Bryde's whales, little piked whales and humpback whales do sometimes. Swallowing type whales have generally thick and coarse baleen fringes, and are fitted to take macro-planktons and fish. Tomilin (1954) simply considers those whales belong to the family BALAENOPTERIDAE are classified into macro-planktonophagi, with short and less elastic plates, thick setous bristles and other peculiarities described in the previous section. Tomilin also refers to the fine baleen fringes of sei whales, and states sei whales may also be classified as " microplanktonophagi ". Rearlly they feed mainly on copepods, *Calanus finmachicus* (Hjort & Ruud, 1929) in the Atlantic and *C. plumchrus* in the northern part of the North Pacific (Nemoto, 1957). Of course, those *Calanus* copepods are smaller than the euphausiids in general, but there is a important result which should be examined. I would point out that Tomilin has never considered the pecurialities of patch or swarms of planktons. It is evident that baleen whales with fine baleen fringes can take the small planktons, and the smaller *Calanus* copepods may escape the capture by some species of whalebone whales (Marshall & Orr, 1955). On the other hand, there are considerably many illustrations that fin whales sometimes take small copepods *Calanus plumchrus* with rough baleen fringes, and blue whales feed on the small euphausiids smaller than *Calanus* copepods in volume, weight and size. Accordingly, I would discuss the size and volume of each food planktons to understand the relative volume for the baleen fringes of plates. These values are nearly the same as those by Nakai (1942) on the materials collected in the Japan sea. As illustrated in Table 23, *Calanus finmarchicus* is considered to be the most small size, and it seems reasonable only those baleen whales with fine fringes can take them. *Calanus plumchrus* comes next position to *C. finmarchicus* and may be fed by sei and right whales most favourably. *Thysanoëssa longipes* of 6 mm size is, however, smaller than *C. plumchrus* both in size and volume. This stage should be classified as ' microplankton ' according to its size and volume, but blue whales sometimes feed on it. A blue whale caught in 1954 in the south waters of the eastern Aleution Island fed on *Thysanoëssa longipes* of this size which is far smaller than *Calanus plumchrus*.

The next indication is the case of *Parathemisto gaudichandi* in the Antarctic waters. I found *P. gaudichaudi* in the stomachs of sei whales and no occurrence is given in the stomachs of blue and fin whales as discussed in the part of the Antarctic food. The stretched length of *P. gaudichaudi* is about 16 mm and from 8 to 15 specimens may be contained in 1 cc. As these values are higher than the *Calanus finmarchicus* and small copepods, *P. gaudichaudi* should be considered as a macroplankton in the sense. To make clear the above two cases, the swarming condition of planktons in the sea must be examined. The special water noise caused by planktons (Cushing & Richardson, 1956) also should be considered as a factor to attract the baleen whales in the sea water.

TABLE 23. SIZE, VOLUME AND WEIGHT OF FOOD PLANKTONS OF BALEEN WHALES IN THE NORTH PACIFIC AND IN THE ANTARCTIC

Species of plankton	No. of individuals contained 1 cc	Approximate average length
*Calanus finmarchicus**	300–500	3 mm
*Calanus plumchrus**	50–110	5 〃
*Calanus cristatus**	8–25	9 〃
Thysanoëssa longipes	180–220	6 〃
〃	13–18	12 〃
Thysanoëssa inermis	3–6	28 〃
Euphausia pacifica	10–15	15 〃
Parathemisto gaudichaudi	8–15	16 〃

* All copepodite V stage.

I consider those swallowing type baleen whales feed on euphausiids or copepods according to the state of congregated swarms of them. If the swarms of planktons are not so heavy, swallowing type of baleen whales pay little attention to the patch. On the other hand, skimming type whales take sparse patch of planktons. In my previous report (Nemoto, 1957, p. 53), I discussed the case of *Calanus plumchrus* in the northern part of the North Pacific. With consideration on the point it seems reasonable that if the patch of *Calanus* copepods congregated so heavily, fin whales can take the patch such as *Calanus cristatus*.

Swallowing type whales prefer euphausiids, swarming fish and swarming copepods *Calanus cristatus* to scattered foods in the sea. Among them, fin, Bryde's and little piked whales are rather polyphagous animals. (I would not consider 'polyphagous' is suitable for the whales in a strict sence as I described in my former report p. 56. Here I use the term only in comparing meaning). But blue and humpback whales are considered to be monophagous and biphagous whales. As described in Table 7, blue whale feed on only euphausiids. The two cases of blue whale feeding on the mixture of euphausiids and copepods suggest that the patch of the mixture bear both characteristics of euphausiids and copepods, and blue whales take them as a euphausiids' swarm (Nemoto, 1957). Humpback whales are also euphausiid feeder and fish feeder, and only very few of them take squids and copepods in their stomach in the North Pacific. Of course the fact that humpback whales congregate to the shore waters and copepods *Calanus cristatus* and *C. plumchrus* distribute mainly in the off waters may cause such tendency. But as a whole, humpback whales never prefer squids and copepods as their food, they can't take scattered planktons in the sea. Fin, Bryde's and little piked whales are rather polyphagous animals according to the recent investigations. They take euphausiids favourably if there is a sufficient swarm for whales in the sea. In the case of wanting euphausiids, they take fish, squids and copepods too, but they never feed on single swimming fish or scattered copepods in the sea. In the northern part of the North Pacific, a fin whale take *Metridia lucens* in one occasion (Nemoto, 1957, p. 54). *Metridia lucens*, as it is very abundant in the surface waters in the North Pacific, swarms not so heavily as *Calanus cristatus*, and usually is considered unfavourable for fin whales of swallowing type as a food. So above case means the very rare occasion that *Metridia lucens* swarms heavily so that fin whales feed on it. Right and Greenland whales take their food by skimming the water with the foods. This method enables whales to take scattered micro planktons in the sea, but fine baleen fringes and long elastic baleen plates may not be effective for swallowing the foods in a short time with the gulp of water mass containing foods.

In the North Pacific, Greenland and right whales had been caught in the shallow waters of the Okhotsk sea and the Bering strait within the Alaskan continental shelf where the swarming euphausiids and copepod such as *Calanus cristatus* are comparatively scarce (Townsend, 1935). Only *Thysanoëssa raschii*, the neritic shallow water species, and scattered copepods such as *Metridia* species are considered as dominant planktons. Right and Greenland whales must have taken there scattered copepods or other planktons by skimming.

It is very difficult to explain the feeding method of grey whales because few investigation has been carried out up to now. I can refer to only one or two foreign observations on the foods of grey whales. First, it should be noted that grey whales feed the bottom living amphipods (Zenkovich, 1937; Tomilin, 1954). In this case, grey whales may skim the amphipods in the the bottom of the sea with rough baleen fringes and tough baleen plates. On the other band, Howell and Huey

(1930) write the evidence that some grey whales feed on *Euphausia pacifica* along the California coasts. Swallowing methods is considered effective for the swarms of euphausiids, however, it is probable *E. pacifica* comes down to the bottom of the sea and is caught by grey whales. From the narrower space of baleen plates row the shape of the plate and structure of skull and shorter baleen plates, it is probable that grey whales also take their foods by swallowing like *Balaenoptera* whales.

When feeding, these swallowing type baleen whales are considered to open the mouth and take in quantities of the foods, then turn on the side (Andrews, 1909; Gunther, 1948). But as to the skimming type whales, they swim with considerable or moderate velocity below the surface of the sea, with their jaws widely open, and the micro-planktons are filtered to remain in the cavity of mouth (Scoresby, 1820; Nemoto, 1957).

FEEDING TYPES

Preceding a paper by Tomilin (1954), Eschricht (1849) and Kükenthal discuss the ecological or feeding classification of CETACEA. By those authors, whales are divided into five groups, "Ichthyophgi", "Planktophagi", "Sarcophogi", "Teuthophagi" and "Phytophagi". Tomilin (1954) states, however, these classifications are based on foods only, and do not consider the adaptive morphological characteristics of the organs used to obtain the food. According to his conclusion, among whalebone whales, three adaptive types can be distinguished. Those are microplanktophagi, macroplanktophagi and benthophagi. I would consider further his classifications are inadequate in some means. As I state in the former part, the euphausiids smaller than copepods (apparently microplankton) are sometimes fed by blue and fin whales which have coarse baleen plates fringes and classified as "Macroplanktophagi" by Tomilin. I would explain that the case must be due to the swarms of euphausiids which are congregated so heavyly that blue and fin whales pay attention to the patch. Blue whales is considered to have special preference for euphausiids to other planktons in nature as I discuss in many parts, and they are not 'Macroplanktophagi' in a strict sense but 'euphausiid shrimp feeder' in general. 'Microplanktophagi' described by Tomilin (1954) must mean nothing but the skimming type whales, and the latter whales can take scattered planktons which are generally small and do not offer attention to swallowing type whales. As to the food of Greenland whales, one of the skimming type whales or 'Microplanktophagi', very little is known up to these days. But copepods are also favourite food for right whales, another skimming type whale, and right whales are considered as a copepods feeder in the North Pacific (Nemoto, 1957; Omura, 1958).

Humpback whales are generally euphausiids feeder as well as fish feeder, and they are anything but copepods feeder or squids feeder as discussed in the previous part. These words, euphausiids feeder etc. may sound too common. But the words 'Macroplanktophagi' and 'Microplanktophagi' are not so satisfactory to explain the delicate feeding types of baleen whales. To make summarized comprehension on the problem, the latter detailed classification may be helpful for the purpose.

In the northern part of the North Pacific where the relative abundance of food for whales are dominant, following feeding types are considered.

Euphausiids feeder	Blue whale, fin whale, Bryde's whale, little piked whale and humpback whale
Copepods feeder	macro-copepods feeder Fin whale
	moderate and micro-copepods feeder Sei whale and right wnale
Fish feeder	small swarming fish feeder Fin whale, Bryde's whale and little piked whale
	moderate and small swarming fish feeder Humpback whale
Squids feeder	Fin whale, sei whale

From above classifications, it is evident that there are selections by whales for their food and if there are sufficient foods above listed found in the sea water, whales follows their food selection orders as follows. Arrows show the order and lines show equivalent order

Blue whale	Euphausiids
Fin whale	Euphausiids—macro-copepods—Swarming fish→micro-copepods→Squids
Bryde's whale	Euphausiids—Swarming fish→Copepods
Little piked whale	Euphausiids—Swarming fish→Copepods
Sei whale	Copepods→Euphausiids—Swarming fish—Squids
Humpback whale	Euphausiids—Swarming fish
Right whale	Micro and macro-copepods→Euphausiids

In the adjacent waters to Japan, the aspects of the feeding types may be a little different from those in the northern part of the North Pacific where the planktons are abundant. Only *Euphausia pacifica* is available for the baleen whales among euphausiids as a dominant food, and only some occurrences of *Calanus finmarchicus* are considered. But anchovy (*Engraulis japonica*) and saury (*Colorabis saira*) are so abundant that comparatively many sei whales feed on above fish as often as on planktons. One may think that sei whales in the adjacent waters to Japan proper are fish feeder. But other blue, fin and humpback whales do not show such difference in their feeding from data of the northern waters. The above difference of sei whales must be due to the feeding of methods, taking fish and squids by swallowing as well as microplanktons by skimming. As illustrated in Table 7, blue and fin whales were feeding on "Krill", but many sei whales were feeding on fish and squids too. Thus, the feeding type of baleen whales in the adjacent waters to Japan may be described as follows.

Euphausiids feeder	blue whale, fin whale
Fish feeder	sei whale
Squids feeder	sei whale

In the Antarctic waters, the large euphausiid, *Euphausia superba* is available for baleen whales, (Mackintosh & Wheeler, 1929). With Japanese recent investigations, the southern baleen whales take also *Thysanoëssa macrura* and *Parathemisto gaudichaudi*. In the warmer waters, *Munida gregaria* and some other euphausiids are described in the previous parts of this paper. Accordingly the feeding method and type of the baleen whales in the southern hemisphere are given as follows by these recent observations.

Swallowing type	blue whale, fin whale, Bryde's whale, and humpback whale
Skimming & Swallowing type	sei whale

Very little is known as to the feeding of right and little piked whales, and their feeding type is also unknown. The swallowing type whales in the southern hemisphere feed mainly on euphausiids, but there is another evidence that Bryde's whales in the adjacent waters to west Australian waters feed on anchovy (Chittleborough, 1959), humpback whales on *Munida gregaria*, and sei whales on *Munida gregaria* too. But as the data on the foods of whales in the southern warm hemisphere is not sufficient except those of the Antarctic, it seems reasonable, therefore, to refrain from any conclusion. Tomilin (1954) proposed food preferences of baleen whales developed in the northern hemisphere and not in the southern hemisphere. His explanation may be reasonable to some extent because the main food of the Antarctic waters is *Euphausia superba*, and right and sei whales also feed on *E. superba* in the Antarctic (Matthews, 1938, a, c). With the compliments to his explanation the feeding type in the southern hemisphere is as follows.

Euphausiid feeder	blue whale, fin whale, humpback whale, sei whale
Fish feeder	Bryde's whale
Amphipods feeder	sei whale

Referring to the possibilities of feeding, right and sei whales may be Copepods feeder as well as Euphausiids and Amphipods feeder, because some copepods are abundant in the southern hemisphere in a scattered condition but they attract the attension of skimming type whales.

FEEDING TIME

I already discussed the details of feeding activity of the baleen whales in a day in a previous report (Nemoto, 1957, p. 56, Fig. 11–14), and successive investigations have proved the same result. These conclusions are followings. In the pelagic whaling grounds (meaning the whaling ground with deep sea bottom), the feeding percentage is higher in the morning and in the evening, and it shows decrease in daytimes. This

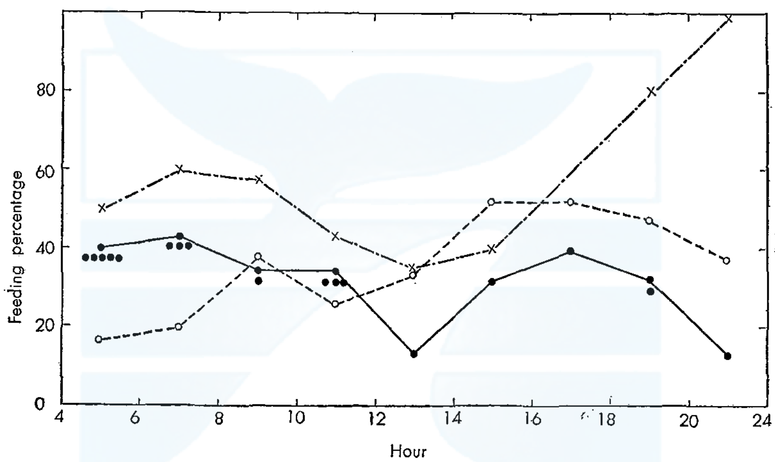


Fig. 27. Feeding percentage of baleen whales in the northern part of the North Pacific in the south waters of the eastern Aleutian Islands in 1958. Solid line—fin whales, Chain line—blue whale, Dotted line—Sei whales. Black dot indicate the occurrences of squids.

fact is considered to be due to the feeding activity of whales and partly diurnal migration of zooplanktons, fish and squids (Nemoto, 1957). Another marine mammal, northern fur-seals also show the same feeding activity according to the diurnal migrations of their main food, *Myctophidae* lantern fish (Taylor, Fujinaga & Wilke, 1955).

There are also some differences of feeding percentage according to the food species and the environment such as sea depth. In the pelagic whaling ground, where the sea depth is over 500 m or more, whales feeding on euphausiid show the said tendency that they feed dominantly in the morning and in the evening. On the other hand, in the coastal or shallow waters such as Andyr gulf in the northern part of the North Pacific where the sea depth is less than 50 m, fin whales take a euphausiid (*Thysanoëssa raschii*) in daytimes. *Thysanoëssa raschii* also follow the general habit of the diurnal migration in the sea, and it is considered to stay in the bottom waters of the shallow waters. The fact suggests the feeding of whales may attain to the bottom layer of the coastal waters of shallow depth less than 50 m. Capelin (*Mollotus catervarius*) is also heavily fed by fin whales in daytimes in the Anadyr waters. These facts give us a comprehension that whales usually feed on their food as much and often as possible to nourish them in their feeding season. If it is possible to take food, they feed also in daytimes and the many vacant stomach directly mean the some unfavorable condition for their feeding in general.

The interesting feeding percentage of baleen whales in the south waters of the eastern Aleutian Islands is illustrated in Fig. 27. Blue and fin whales take their foods mostly in the morning and evening as discussed in the former report (Nemoto, 1957), but the percentage of blue whales is higher than fin whales as a general tendency. As the most favorite food of blue and fin whales is considered to be euphausiids, this difference of feeding percentage between blue and fin whales is partly due to the feeding habit of each whale such as diving depth or the extent of feeding activity. The feeding percentage of sei whales show a little difference of the feeding percentage. The main food of sei whales in the waters is *Calanus plumchrus* which has been considered not to show the more typical diurnal migration. This directly may mean the higher percentage in the daytime as given by the illustration. As to the squids, fin and sei whales take them as a food in the waters. Those squids are fed only in the morning from 6 to 12 by fin whales and no squid has been fed in the afternoon from 12 to 18. Squids are also migrating rapidly according to the diurnal change of light intensity. These squids occurrences in the stomachs of fin whales are described by single marks in the Fig. 27.

WEIGHT OF STOMACH CONTENTS

As the quantity of stomach contents of whales decreases in accordance with the polongation of chasing by catcher boats (Nemoto, 1957, p. 65), and the exact weighing of stomach contents is so difficult that few reliable information has been described. The old description shows that a blue whale take more than 1000 liter of euphausiids in the Atlantic (Collett, 1912), and the full stomach of large rorquals has been considered to contains about 1000 kg of planktons or fish.

The recent investigations by Nishimoto, Tozawa & Kawakami (1952) and Betesheva (1954, 1955) treat the problem, and their data well demonstrate the quantity of stomach contents of whales. The stomach contents of Bryde's whales in the Bonin Islands waters weighed by Nishimoto, Tozawa & Kawakami are ranging from about 100 to 200 kg in the case of full stomach condition. The contents are all considered to be *Euphausia similis*, and its freshness indicates that it is swallowed in the short duration of feeding. Thus the amount of stomach content of 200 kg is directly mean the heaviest food taking of Bryde's whales. The stomach quantity of sei whales has been measured by Betesheva (1954), and he describes the full stomach of a sei whale containes 600 kg of squids (*Ommastrephes sloani pacificus*). Other sei whales in the Kurile waters have also 50 to 370 kg of *Calanus plumchrus* (*tonsus*).

Fin whales take more abundant food usually in their stomachs according to his observation. They take more than 100 kg of foods in 65 percent of all observations. The most abundant volumes are 560 kg of

TABLE 24. WEIGHT OF THE FOODS OF FIN WHALES CONTAINED IN THE FIRST STOMACH OF CAUGHT WHALES IN THE NORTHERN PART OF THE NORTH PACIFIC*

Body length	Sex	Food species	Relative quantity	Weight (kg)
57	Male	Alaska pollack	R	759.0
62	〃	Euphausiids	R	112.5
65	Female	〃	R	100.0
62	Male	*Calanus* copepods	R	81.0
64	Male	*Calanus* copepods	rr	30.0
58	Male	*Calanus* copepods	rr	30.0
60	Male	*Calanus* copepods	rr	26.0
64	Female	Euphausiids	r	10.0

Measured by the courtesy of Mr K. Nasu.

squids, 464 kg of saury and 425 kg of the mixture, *Calanus* copepods and euphausiids.

The exact weight of the stomach contents of fin whales are measured in the northern part of the North Pacific on contents of both euphausiids and copepods. The full stomach contains about 100 kg of stomach contents of euphausiids and *Calanus* which is less than those given by Betesheva (1954, 1955) in the Kurile Islands waters. The fact may partly be due to the food species contained in the stomach. These Japanese data are only based on the planktons, euphausiids and *Calanus* copepods, but the heaviest stomachs of fin whales in the Kurile Islands waters containes squids and saury. The one example of a rather small sized fin whale also take vast volume of fish food (Alaska pollack), which show the heaviest weight of the stomach content of fin whales in the northern part of the North Pacific. The fish is generally digested slower than the said planktons and the weight of stomach contents of fish is heavier than plankton contents, and the specific gravity of fish is apparently heavier than that of the plankton. These reason may cause such results. The former whaling ground in the high latitudes of the North Pacific is considered to generally produce more abundant food planktons, so it is strange that fin whales in the northern part of the North Pacific take only 100 kg of planktons at most. It is desirable to weigh more examples in the water to get exact measurements of stomach contents. But it is evident that fin whales take foods from about 100 to 700 kg in weight in their stomach in the Northern part of the North Pacific. The grade of the quantity decided by routine works on whales also shows the typical degree of the quantity as given in the Table 24, which well indicates the relative quantity of stomach contents of the fin whales.

DISTRIBUTION OF FOOD PLANKTON

Euphausiid

As I have described in the previous chapters, vast number of food euphausiids' distributions are examined. Considering from the stomach contents of baleen whales and net collections, each euphausiid has been observed following locality as illustrated in Fig. 28. These euphausiids distribute in relation to the two main facters in general. One is the oceanographical condition which is illustrated by the water temperature, the other is the shape of the sea which is mainly connected with the depth of the sea. I would treat the distribution of euphausiids mainly from the abundance of them in the sea considered by their occurrence in the stomachs of whales and fish with other net collections. So, the zoo-geographical grouping may be a little different from previous works by other scientists mainly according to net collections.

Ruunstrφm (1927, 1930) and Einarsson (1945) make the three grouping, arctic boreal, boreal and Mediterranean boreal forms. According to Einarsson's excellent discussions, *Thysanoëssa raschii* and *T. inermis* bear the arctic-boreal or rather low-arctic-boreal character. This is the same in the North Pacific waters. By recent years investigations, Ponomareva (1957) writes the account for the distribution of main euphausiids in the north-west Pacific, and she also classifies euphausiids into three distributional groups. Arctic boreal, boreal and tropical groups are her classifications. The latter groups by Ponomareva is apparently following to the works by Ruunstrφm (1930) and Einarsson (1945). Arctic and Cold boreal group contain, *Thysanoëssa raschii*, *T. inermis* and *T. longipes* by the grouping of Ponomareva (1945). *T. longipes* is somewhat warmer water specimens, and it recalls *Thysanoëssa longicaudata* in the Atlantic in this point. As considered in the paper by Einarsson on *T. longicaudata*, *T. longipes* in the North Pacific belong to the higher temperature group. The next species, *Thysanoëssa raschii* has been found in the stomachs of whales in the most northern part of the Bering sea, adjacent waters to Kuril Islands, and the Okhotsk sea. With other observations, *Thysanoëssa raschii* in the North Pacific distributes in the waters lower than 16°C by the surface water distribution described by Fleming (1955). This value 16°C is the higher limit of surface temperature which is nearly the same value 15°C described by Einarsson (1945). The most northern occurrence in the north Bering sea is covered by ice in winter, and the dominant occurrences are considered to be as south as the middle Kurill waters. The water temperature in the area do not exceed 13°C in August. This value also coincides with 12°C of vigorous spawning area by Einarsson. *T. inermis* inhabits in somewhat higher temperature waters than *T. raschii*, as I find the dominant occurrence of *T. inermis* in the stomach of a fin whale in the waters 42° north latitude and 143° East longitude in the adjacent waters to Japan.

The range of distributional water temperature of *T. inermis* is about the same as *T. raschii*. The former, however, distributes in more colder waters, because I have found no dominant occurrences in the stomachs of whales but a few individuals in the stomachs of capelin in the northern part of the Bering sea. By the fact that, *T. raschii* distributes as far north as the edge of pack ice, it is probable that *T. raschii* is found dominantly in the neritic arctic sea.

With regard to *Thysanoëssa longipes*, the dominant occurrences are considered not to exceed as far as 60° north latitudes. Japanese investigation shows that the most north collection of *T. longipes* are made in the waters north of Komandorskiy Islands. *T. longipes* is also found in the sea of Okhotsk and the south east waters of Hokkaido a little more south than *T. inermis*. In the sea of Japan, Komaki & Matsue (1958) also describe the occurrence of *T. longipes*. The water temperature in the sea of Japan is higher than the waters along the Pacific coast by the 'Tsushima' warm current. Perhaps *T. longipes* in the Japan sea shows the distribution of the most high limit of water temperature. The spineless form of *Thysanoëssa longipes* is considered to distribute in somewhat different way. Namely the spineless form distributes a little more southern waters than the original spined forms (Boden, Johnson & Brinton, 1955). The spineless *T. longipes* is observed in three occasions in the stomach contents of whales dominantly in the western waters of the northern Pacific. Other single or subordinate occurrences are more found in the western part than the east as illustrated in Fig. 29.

According to my collections, and Japanese observations the spineless form has not been observed in Okhotsk sea though the original form is

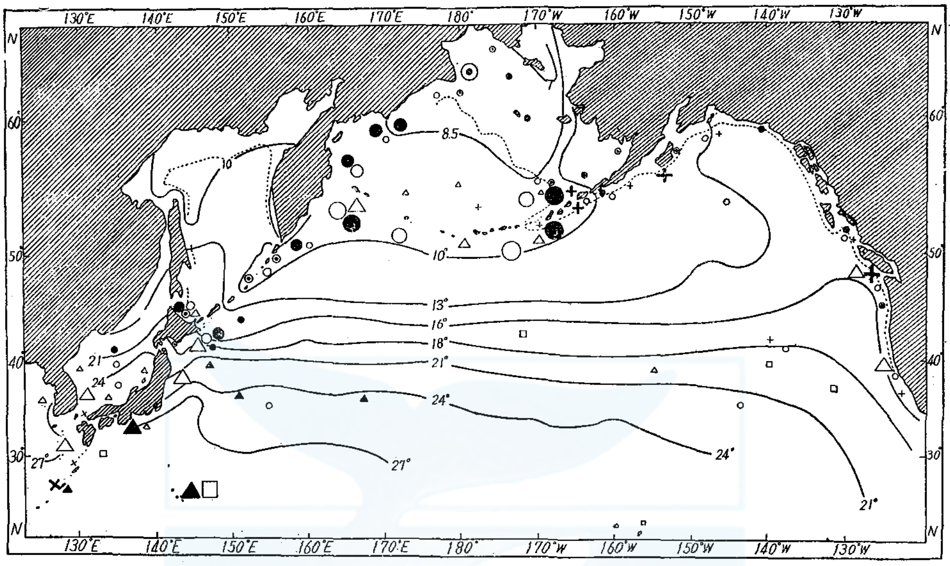


Fig. 28. Schematic illustration of the distribution of euphausiids of foods of whales in the North Pacific. ○—*Thysanoëssa longipes*, ●—*Thysanoëssa inermis*, ⊙—*Thysanoëssa raschii*, +—*Thysanoëssa spinifera*, △—*Euphausia pacifica*, □—*Euphausia recurva*, ▲—*Euphausia similis*, ×—*Pseudoeuphausia latifrons*. The large symbols show the dominant, moderate symbols show usual occurrences and small symbols show the subordinate occurrences as whales' foods.

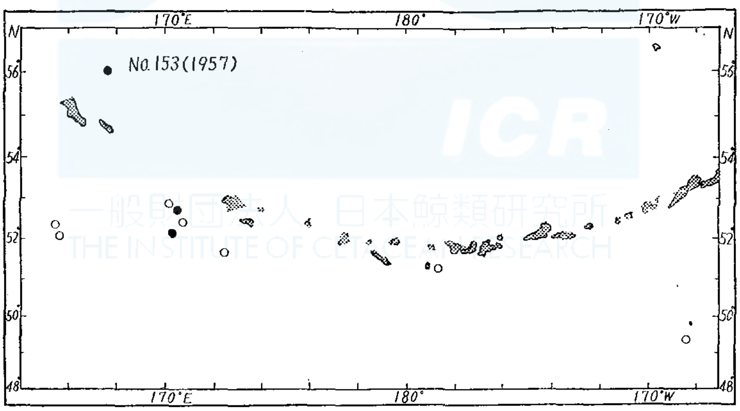


Fig. 29. Occurrence and distribution of spineless form of *Thysanoëssa longipes*. Open circle—subordinate occurrences and net collections, Black circle—Dominant occurrences in the stomachs of whales.

found in the waters by net collections and stomachs of whales. The another different evidence that the spineless forms found in the south waters of the Japan sea is stated by Ponomareva (1957), however, the number of the spineless form of *Thysanoëssa longipes* is considered very scarce or nil by Japanese investigations (Komaki & Matsue, 1958).

Thysanoëssa inermis is considered to show the distribution between *T. raschii* and *T. longipes* from Japanese investigations. It is observed in the stomach of fin whales dominantly in the off waters of Olyutorskiy cape where *T. longipes* is not observed as a dominant occurrence. The most north collection is also obtained from the stomach of capelin found in a fin whale stomach in the water near St. Lourence Islands, but I found none of *T. longipes* in the stomachs of capelin and other fish in the northern waters of the Bering sea. In the Japan sea *T. inermis* also distributes in the more northern waters than *T. longipes* (Komaki & Matsue, 1958). *Thysanoëssa inermis* has two forms according to the classification of the presence of spines at the 6 and 5 abdominal segments (Nemoto, 1957, p. 46). The one spine form is found exclusively in the Atlantic. But the two spines form is dominant in the North Pacific. It distributes mainly in the adjacent waters to Aleutian Islands, but I have found none of the two spine form in the Okhotsk sea. Also in the Japan sea, Komaki & Matsue (1958) illustrate one spine form only, suggesting that one spine form of *Thysanoëssa inermis* preserved in the Okhotsk sea and Japan sea in the North Pacific.

Above three species of *Thysanoëssa* do not distribute in the Yellow sea and mainly inhabit in cold boreal waters. From the consideration of spawning area and its temperature, these *Thysanoëssa* species are classified as Arctic boreal group or low-arctic boreal group as described by Einarsson (1945, p. 130).

The distribution of *Thysanoëssa spinifera* is also very interesting. As I stated in the previous report (Nemoto, 1957), it is mainly found along the west coast of American side, and it plays a role of foods for whales at British Columbia (Pike, 1950). *T. spinifera* has never been found along the Asian side, in the Okhotsk, Japan and Yellow sea, but it distributes as south as La Jolla of California (Boden, Johnson & Brinton, 1955) in American side. This species may be also classified as Arctic boreal group though it is considered a little warm water living species. *Euphausia pacifica* is considered to distribute a little different from above four species. Ponomareva (1957) already states that *Euphausia pacifica* belong to the boreal group in its distribution, a warmer water form than four *Thysanoëssa* group. I would also classify it into the boreal group. Though Einarsson (1945, p. 130) prefers to call the temperate group to the Mediterranean-boreal group described by Ruunstrφm (1927), but this cold temperate group is also the same meaning as the boreal group by Ponomareva (1957, Fig. 1), I would use the term to make contrast to the other *Euphausia*, *Euphausia similis*. *Euphausia similis* mainly distribute in the subtropical waters and it belong to the warm temperate group. Its dominant occurrences are restricted from subtropical waters to the warm temperate zone of 35° North latitude. *Pseudoeuphausia latifrons* is considered to play a role of foods for whales in the tropical and subtropical waters in the North Pacific, a little south waters from the warm temperate group. It belong to the tropical group as it is described by Ponomareva (1957). The excellent schematic illustrations of latitudal distribution of the euphausiids species are given by John (1936) and Einarsson (1945). Here I would repeat it on the North Pacific species. The main food euphausiids in the antarctic are oceanic pelagic forms (Einarsson, 1945, p. 136). On the other hand

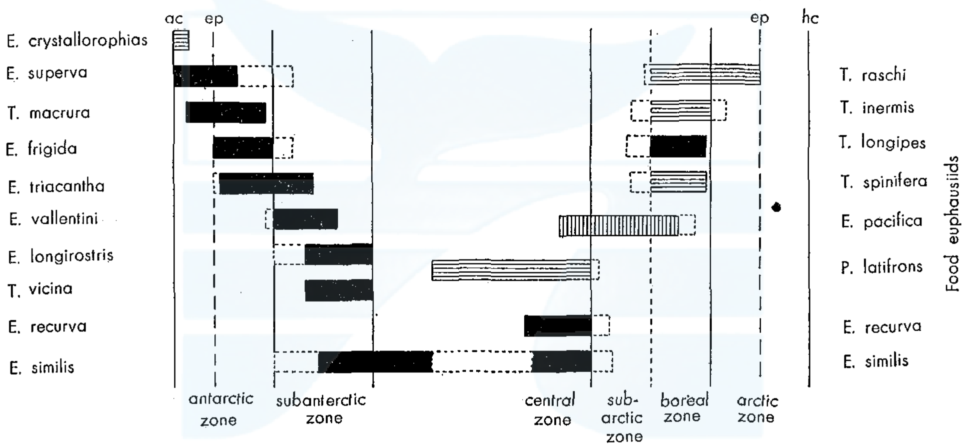


Fig. 30. Schematic illustration of euphausiid fauna of the North Pacific and the Antarctic basing on the data by Einarsson (1945), Johne (1936) and foods of whales. hc—high arctic, ac—Antarctic coast line, ep—edge of pack ice, horizontal shading—neritic species, vertical shading—neritic but some sometimes found in ocean, Black—surface species.

four main food euphausiids are rather neritic coastal species, which is apparently due to the nature of the sea in the North Pacific. Only one, *Thysanoëssa longipes* is considered as a probable pelagic form, because it has been mainly observed in the oceanic water mass and not been confined to the coastal waters. *T. longipes* may take the position of *T. longicaudata* of the Atlantic in the Pacific. *Euphausia pacifica* mainly distributes along the coastal waters, but another *Euphausia similis* and *E. recurva* are considered as the oceanic form. Sometimes *E. pacifica* drifts to the off waters where many baleen whales feed on it especially in Sanriku waters, and it is more oceanic than *Thysanoëssa raschii*, *T. inermis* and *T. spinifera*, Those five main northern species have not been found in the southern hemisphere, but *Euphausia recurva*, *E. similis* and *Pseudoeuphausia latifrons* play some parts of foods also in the southern hemisphere according to the previous investigations (Mackintosh, 1942; Chittleborough, 1959 etc.).

Distribution of food copepods of whales in the north pacific

Four species of copepods have been found dominantly in the stomachs of baleen whales in the North Pacific. *Calanus cristatus*, *C. plumchrus*, *C. finmarchicus* (*helgolandicus*) and *Metridia lucens* are them. There is another occurrence of *Calanus* copepods described by Mizue (1950), but the species is still remained unknown. It is considered to be a subtropical copepod not to belong *Calanus* copepods of boreal waters.

The representatives of Pacific boreal communities of Copepods, *Calanus cristatus*, *C. plumchrus* are considered not to distribute so abundantly in the arctic region, and will not be favorite food of baleen whales. According to the observation on stomach contents of baleen whales, *Calanus plumchrus* and *C. cristatus* have not been described in the northern part of the Bering sea and within the Alaskan continental shelf. As I said in the former report, *Calanus cristatus* need deep waters to be mature, it distributes mostly in the off waters of the adjacent waters to Aleutian Islands and the shelf. Johnson (1956) describes only one specimens of *Calanus cristatus* in the collection of the plankton in the Beaufort and Chucchi sea areas, suggesting that it does not distribute abundantly in the arctic sea. Body length of *C. cristatus* is generally considered to be large in the cold waters. The size of *C. cristatus* in the North waters of Aleutian Islands is larger than that in the south waters. From these size distribution of *C. cristatus*, there are some main local groups in the North Pacific near Aleutian Islands.

Calanus cristatus has not been observed stomachs of whales in the adjacent waters to Japan, and it is also observed in few occasion in the Kurile waters (Betesheva, 1954 & 1955), the bio-mass of *C. cristatus* is considered to be only sufficient in north water from about 45°N latitudes. *Calanus plumchrus* is considered a little warmer water form and the southern range as a food of baleen whales may come down to 40°N latitudes in the western part of the Pacific. *Calanus finmarchicus* (*helgolandicus*) is considered more warmer water form, but the *helgolandicus* form distribute more southern waters. The small Copepoda collected from the stomachs of whales caught in the adjacent waters to Japan of Pacific side are all *Calanus helgolandicus*, and its southern range as a food of whales may attain to 35°N latitude in summer season of the North Pacific.

MOVEMENT AND MIGRATION OF BALEEN WHALES

DISTRIBUTION OF BALEEN WHALES IN THE NORTH PACIFIC

Whaling centers

With regard to migration and distribution of baleen whales, Mackintosh made very important consideration on the problems (Mackintosh, 1942). His summarized Table (p. 229, Tab. 9) gives us clear comprehension on the distribution of baleen whales in the southern hemisphere except some Bryde's whales' occurrences. After the example of Mackintosh's table, the northern Pacific whaling centres and catch may be described as Table 25. Table 25 shows that there are clear distribution of baleen

TABLE 25. NORTH PACIFIC WHALING CENTERS AND CATCH ACCORDING TO THE SOME AVAILABLE DATA FROM 1910 TO 1945

Whaling centre in Pacific	Approximate latitude N	No. of seasons	Whale species						
			Blue	Fin	Bryde's	Sei	Hump-back	Grey	Right
Arctic pelagic	North of 65°	1	—	74	—	—	101	56	1
Eastern side									
Alaskan coast	53°-60°	7	318	1176	—	2	1115	1	3
British Columbia	50°	7	59	634	—	100	183	—	—
Washington	47°	2	2	53	—	5	246	—	—
California	35°-45°	9	—	145	—	31	1181	7	—
Lower California pelagic	20°-35°	1	239	—	34	—	498	42	—
Maxico Gorgona		1	85	1	—	4#	565	19	—
Western side									
Kamtchatka pelagic	Ca 50°-65°	2	74	591	—	9	13	2	3
North Kurile	50°	3	7	104	—	18	5	—	12
Middle Kurile	45°	12	2	293	—	727	2	—	18
Japan coast	40°-45°	14	70	1683	—	1226	79	1	14
〃	35°-40°	15	186	737	—	2661*	34	—	2
〃	30°-35°	14	429	98	—	480**	89	—	9
Okinawa	28°	5	5	7	—	1**	131	—	1
Bonin Islands	27°	8	9	2	—	180*	288	—	4
Formosa	22°	8	—	—	—	3**	206	—	—

Probably Bryde's whale. * Including Bryde's whale.
** Probably almost Bryde's whale.

whales in each latitude according to summer and winter seasons of whaling.

Arctic sea. As to the Arctic ocean, Japanese pelagic whaling covered Chukchee sea in 1941, and fin, humpback and grey whales were caught along the Siberian coast. No other baleen whales was caught though some Russian scientists consider the migration of blue whales reach to the Arctic sea (Sleptsov, 1955). Another observations made by Nikulin (1946) endorse the Japanese result. According to the data by Nikulin fin, little piked, humpback, grey and Greenland whales had been observed, and no blue and sei whales are described in the adjacent waters to Chukchee Peninsula. From 1937 to 1943, following number of baleen whales, 1051 fin, 1904 grey, 687 humpback, 118 little piked and 12 Greenland whales had been observed. Thus fin, humpback, grey, right and Greenland whales distribute in the Arctic sea as a conclusion. The evidence if Greenland whale exists has not been given and I would not state further comment on Greenland whales' distribution and occurrence here. *Kamchatka pelagic* (*western side*). In the off and adjacent waters to Kamtchatka peninsula in Pacific side, many whales has been caught by Japanese and Russian pelagic whaling. Fin whales are considered to be most dominant in the waters with blue, sei and humpback whales. Among them, blue whales has been caught only in the southern waters of Komandor Islands (about 55° North). Grey whales' occurrences are apparently considered as a illustration that some grey whales may migrate along the coast of Kamtchatka peninsula from north to south in the north waters of Bering sea. Though there is no evidence in the old statistics that Bryde's whales have not appeared, the recent investigation on Bryde's whales affirms that Bryde's whales never migrate to the cold waters of Kamtchatka coasts.

Kurile Island. The catch of Kurile Islands situated between Japan proper and Kamtchatka bears the intermediate character between above two localities. In the Noth Kurile waters, the catch is the same as that of Kamtchatka waters. Fin whales are the main catch of the waters, but number of sei whales are not so dominant. The catch in the middle Kuril water region shows a little difference from the northern Kurile waters. Sei whales become dominant in number and form the main catch of the waters.

Japan coast. Along the Pacific side of Japanese coasts, many baleen whales have been caught both in the pre-war seasons and after the year 1945. From those statistics, the differences among the catch in the each landstations are observed. Fin and sei whales make the main part of the catch in the northern coasts from 40° to 45° North whereas sei whales become more dominant in the south waters from 35° to 40° North. Among the catches of sei whales in the waters, however, some considerable number of Bryde's whales should be considered. As Omura & Fujino (1954) and Omura & Nemoto (1955) state, Bryde's whales have been caught in the summer season in the waters along the Pacific coasts of Japan from 35° to 40° North. Along the southern coasts of Japan from 30° to 35° North, the considerable catch of blue whales had been described from 1910 to 1923 in winter seasons at the Wakayama prefecture landstations. But after 1923, blue whales decreased in number and scarcely caught by recent operations. The recent investigations have proved that sei whales caught in summer season are all Bryde's whales. But among the catches, before 1945 some occurrences of sei whales also should be considered according to the paper by Andrews (1914), but above catches were obtained rather in earlier seasons of the year when the migration of sei whales was probable.

Okinawa. Humpback whales are the main catch in winter seasons. Number of blue and fin whales are extremly scarce in number in the waters, suggesting that these whales do not come down to the subtropical water or do not approach the Islands. Sei whales caught in subtropical waters of Okinawa may apparently be Bryde's whales.

Bonin Islands. Humpback whales had been caught dominantly in the earlier seasons, but Bryde's whales become dominant in recent catches. Few blue and fin whales have been caught as in the Okinawa waters.

TABLE 26. BALEEN WHALE OCCURRENCES IN THE PACIFIC OCEAN AND ADJACENT SEAS

	Blue	Fin	Bryde's	Little piked	Sei	Hump-back	Right	Grey
Arctic sea	−	+++	−	+	−	+++	+	+++
Bering sea	+	+++	−	+	+	+++	+++	+++
Sea of Okhotsk	+	+++	−	+++	+	+	+++	+
Sea of Japan	+	+++	−	+++	−	+	+++	+++
Yellow sea	+	+++	?	++	?	+	+	+
East China sea	−	+++	+	+	−	+	++	−
South China sea	−	−	+	?	−	+	+	−
California Bay	−	−	−	−	−	+	−	++
Pacific coast	+++	+++	+++	+++	+++	+++	+++	+++*

* Only along the American coast of the Pacific ocean. +++—whaling operated, ++—Considerable occurrences, +—occurrence observed.

Formosa. Only humpback whales are the main catch. Still, there are some captures of blue, fin and sei (Bryde's) whales, but they never consists the important catch of the warmer waters of Formosa.

American side of the pacific. Along the western coasts of American side of the Pacific, the same catch tendencies have been observed as illustrated in Table 25. In the northern waters, fin whales occur in considerable number, and humpback whales in the southern waters. Blue whales were caught in the off waters of Lower California by the winter pelagic operations in a fairly many number with humpback and grey whales. As a general observations, the distribution of baleen whales and the catch in both sides of the Pacific are not different except the local distribution and the migration of some whales which I would discuss in the next part.

THE SHAPE OF THE SEA AND DISTRIBUTION OF BALEEN WHALES

The baleen whales migrate in the sea, following their foods and to complete their reproducting purpose. The catch and observations up to these days give us the general tendencies about the distribution according to the shape of the sea and submarine topography. Krümmel (1907) and Kuenen (1950) describe the seas, and I would summarize the subject following above authors. The seas are distinguished first as *Oceans* and *Adjacent seas*. Adjacent seas (Dependent seas) are also divided into *Marginal seas* (Fringing sea) and *Mediterranean seas*, which are divided into *in-continental* sea and *inter-continental sea*. When above classifications are used, the seas around the North Pacific may be summarized as follows.

Ocean—The Pacific

Marginal sea—Bering sea, Okhotsk sea, Japan sea, East China sea, South China sea, California Bay

Mediterranean sea—Arctic sea.

Baleen whales distribute in each sea locality as illustrated in Table 26. With regard to the distribution of blue whales, they are mostly caught and found along the Pacific coasts (or the Oceanic coasts) of the eastern and western sides. Number of blue whales have been caught in *Marginal seas* or *Mediterranean seas* is extremly limited numbers. As it is shown by the catch statistics, no blue whale has been caught and only few blue whales observed in the Bering sea, and no record of blue whales in the Arctic waters through the Bering strait. In other marginal seas, blue whales have been scarcely caught as described in Table 26. The same tendency is also considered as to sei whales. Sei whales (some occurrences of Bryde's whales must have been included) have never been caught so markedly in the Yellow sea, the Japan sea and the Okhotsk sea. Some 44 sei whales illustrated in the Table 27 were obtained from the catch of the landstations situated near the Kuril Islands, where some visitors of sei whales from the Pacific side through Kurile Islands were probable. Right whales show very little occurrences in Table 27, but it should be considered to be due to the decrease of the stock. By American whaling in 19th century, right whales had been mostly caught in the Okhotsk sea and the sea of Japan (Townsend, 1935). A right whale also occurred in the Mediterranean seas, at Taranto in Italy, (Capellini, 1877) suggesting that right whales occur in the Inter-continental sea. Thus right whales are considered not oceanic denizen only.

The coastal forms, humpback and grey whales are commoner than above BALAENOPTERIDAE whales, however, when the catch of other localities are referred, the former species are not so abundant in the

Marginal seas. Humpback whales usually congregate along the coastal waters of the continent, around islands in the ocean and the archipelago between the *ocean* and the *Marginal seas*. In winter seasons of the North Pacific, they swarm in the waters of Formosa, Marshal Islands, Bonin Islands, and Okinawa Islands in the western side according to the catch statistics. From California to Lower California and Mexico, the winter catch of humpback whales has been demonstrated in the eastern side of the Pacific. Considering the catch in above districts, humpback whales are rather oceanic coastal form and their occurrences in the marginal sea and the mediterranean sea observed are temporary one, though comparatively many humpback whales had been caught in the Arctic sea region by Japanese operations in 1940.

TABLE 27. NUMBER OF BALEEN WHALES CAUGHT IN SOME MARGINAL SEAS OF THE PACIFIC FROM 1916 TO 1949 BY JAPANESE SHORE WHALING OPERATIONS

Seas	Whale species					
	Blue	Fin	Sei	Hump-back	Right	Grey
Okhotsk sea	—	1149	44	58	8	2
East coast of Korea	4	1977	2	47	—	606
Yellow sea	13	3137	2	63	2	7

Grey whales have been only observed and caught along the coast of the land, and continents at the oceanic side and in the adjacent seas and the mediterranean sea. Of course, there still remain some questions about the migration routes of grey whales. In some migration course, they may swim in the far off waters from the American continent (Gilmore, 1955), but they are apparently coastal form and never regarded as a oceanic form. The migration course should be examined by further examination. Fin whales have been caught not only in the oceanic sides, but also in the marginal seas and the mediterranean sea. In the Arctic sea, Okhotsk sea, Bering sea, Yellow sea, East China sea, and sea of Japan fin whales demonstrate the highest catch among baleen whales by whaling operations. Bryde's whales, on the other hand, have been caught and observed mainly along the Pacific sides of Japan and California. Recently the sei whales caught along the western side of Kyushu prefecture (the southern main Island of Japan) and in the eastern part of the East China sea in summer seasons are proved to be all Bryde's whales (Omura & Fujino, 1954; Mizue, 1956). And another evidence gives us the occurrences of Bryde's whales in the adjacent waters to Borneo (Harnisson & Jamuh, 1958) and Singapore (Anderson, 1878). These apparently suggest that Bryde's whales migrate to the south waters of the South China sea, the *Marginal sea*. But if the number of whales will be considered, Bryde's whales are rather oceanic form as a conclusion. With regard to little piked whales, they are described as a coastal form by Tomilin (1954). Really the Japanese investigations prove (Omura & Sakiura, 1956) that little piked whales migrate along the coasts of Japan proper in both sides, the Pacific side and Japan sea side. Many little piked whales have been caught in the Okhotsk sea and along the Japan sea coast and Korea (see Fig. 17 by Omura & Sakiura, 1956). Further in the Antarctic and other parts of the seas, they penetrate into the gulf, bay and straits even into the pack ice crevice. From above occurrences, little piked whales are not a oceanic form, and they inhabit also in the *Marginal* and the *Mediterranean seas*.

Besides above baleen whales, Greenland whales had been caught in

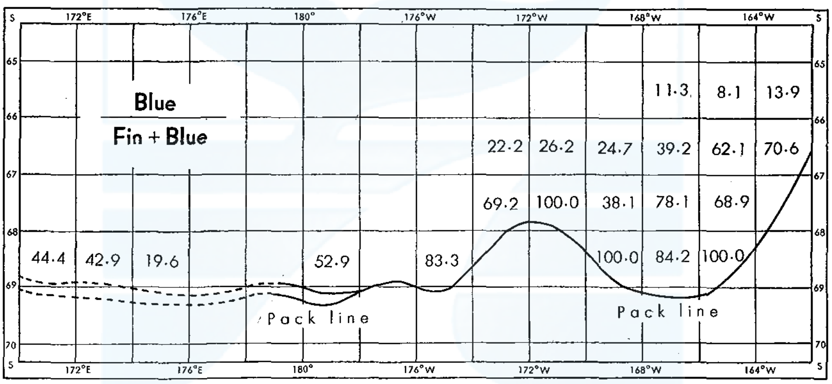


Fig. 31. Catch distribution of blue and fin whales by Japanese pelagic whaling operations along the pack ice line in the Antarctic waters from 1949 to 1950. High value show the domination of blue whales.

19th century in the Okhotsk sea and the northern part of the Bering sea, Bering strait and Arctic sea. Especially in the shallower waters of the Bering sea and the Okhotsk sea, the most dominant catch was observed (Townsend, 1935). Greenland whales are considered shallow *marginal sea* form and not a oceanic form. Thus I would conclude following distributional type of baleen whales in the northern part of the North Pacific.

Ocean denizen	Blue whale, sei whale, Bryde's whale
Ocean and marginal sea denizen	Pelagic form fin whale, right whale Coastal form little piked whale, grey whale, humpback whale
Marginal sea denizen	Greenland whale

Tomilin (1954) consideres the Antarctic whales are considered to be recent emigrants from the Northern Hemisphere, because the close relationship between structure of the baleen and the nature of the food of whalebone whales is disturbed in the Southern Hemisphere. The distribution of whalebone whales in the Antarctic is also very interesting to study. General aspects of the southern Ocean are rather simple in view of the shape of the sea when the comparing with the North Pacific is made. The Antarctic continent is surrounded by the ocean and only two Ross and Weddle seas make incisions along the coast of the continent. Whalebone whales come to the Antarctic waters generally from September to February and return to the North from March to July (Mackintosh & Brown, 1956), and the height is observed in February in the summer season of the Antarctic. From the observations by whaling operations which cover the adjacent waters to the pack ice edge, blue whales have been mainly observed along the pack ice and fin whales have been observed in the off waters. Whalers usually say, they hunt blue whales in the pack ice and chase fin whales in the off waters. By Japanese whaling operation from 1949 to 1950, Japanese operations have caught blue and fin whales in the Ross sea area as illustrated in Fig. 31. It is clear from the figure that blue whales were caught mainly along the pack ice and fin whales were caught in the off waters. Sometimes whalers have noticed the big herds of fin whales in the off waters more than 200 miles from the pack ice. This fact bears some connection with the distribution of food euphausiids. 'Blue whale krill' distributes mainly along the pack ice, and 'Fin whale Krill' mainly in the off waters, the fact of which suggests their distributions are restricted also by the distribution of euphausiids.

As I stated before, little piked whales are often observed among the pack ice. They penetrate into the high Antarctic such as Ross sea in the neighbouring waters of the Barrier of the Ross sea (see John, p. 223). In this case, little piked whales are considered to show the *Marginal sea type* of the distribution. Taylor (1957) and others also show the evidence that little piked whale are sometimes restricted to pools of sea ice near the land in the Antarctic. With regard to the distribution of humpback whales, I have little data as to the distributional characteristics of them in connection with the shape of the pack ice line, and the concentration of humpback whales in some special sea condition in the Antarctic has not been observed. It is a evident fact, however, they are divided into five more or less self-contained stocks of humpback whales in the Southern Ocean (Mackintosh, 1942). The charts by Omura (1953, p. 1 to 102) and recent recovery of whale marks also furnish us the general comprehension about the distribution of humpback whales in the Antarctic areas in summer season of the southern hemisphere.

OCEANOGRAPHIC CONDITIONS

Surface water temperature

As the first step, the water temperature is often considered as a limiting facter to decide the distribution and the migration of whales. In fact, the distribution of some baleen whales such as Bryde's whales has close relation with the distribution of surface water temperatures (Omura & Nemoto, 1955). Here I would discuss the problem so as to consider the aspects of the whales' distribution according to the oceanographic conditions.

With consideration on the catch and observation of the whalebone whales, the range of temperature in the North Pacific in which each whalebone whale mainly inhabits, may be summarized as follows.

Blue whale	25°C– 8°C	in August from Sanriku to the southern waters of Aleutian Islands
Fin whale	30°C– 5°C	from the east China sea to the Arctic sea
Bryde's whale	30°C–20°C	up to Sanriku waters
Sei whale	25°C– 8°C	from Sanriku to the southern waters of Aleutian Islands*
Humpback whale	25°C– 5°C	from Sanriku to the Arctic sea

Of course, some wanderers call warmer or colder waters, and there must be above remainder in the subtropical or the tropical waters. But it is evident that Bryde's whales inhabit in the warmest waters, and fin whales show the broader range of the distribution as a conclusion. The details will be discussed in the special part of each whalebone whales.

Profile of water temperature

The profile of water temperature is considered to clearly show the whaling grounds. Each whaling ground has peculial profile type, and the profile of the North Pacific differs very much from that of the Antarctic area, about which my colleague Mr. Nasu will discuss in his paper. Here I illustrate the examples in the Sanriku waters. As it is clear from the distribution of surface water, sei whales congregate in the waters a little apart from the sub cold current of 'Oyashio', and sei and Bryde's whales are scanty in the waters where the gradient of the profile of the water temperature is not sharply, or the gradient is very smooth. These profiles of the water temperature also indicate that sei and Bryde's whales congregate into the waters of high plankton production.

* Japanese whaling expedition in 1958 found some 60 sei whales in the middle part of the Bering sea, but the water temperature was little different from 8°C.

Whaling ground

The whaling grounds of baleen whales are divided into feeding area type whaling ground and breeding area type (Nemoto, 1957). The former grounds consist of many planktons and their patches or swarms of fish and squids, and the latter is generally located in the warm tropical or subtropical waters. The feeding area type whaling grounds have following main oceanographical surroundings.

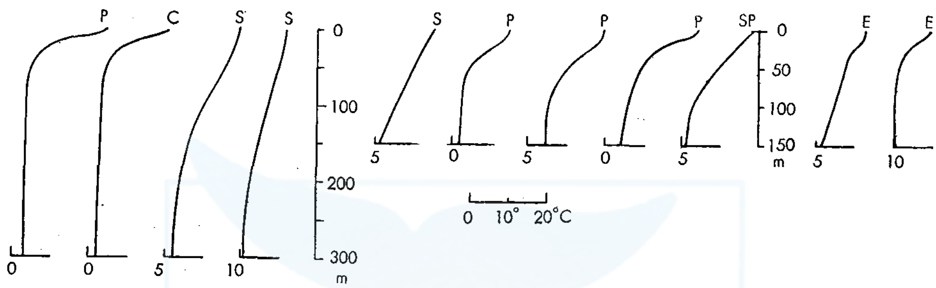


Fig. 32. The profiles of temperature, at stations in the off waters of Sanriku whaling grounds in 1952 and 1955. P—Sei whales congregated and plenty area, C—Above the cold water subcurrent, S—Sei whales scanty, SP—Sperm whales congregated and plenty area, E—East stations of 160°E and 180°E in 1955 through 40°N.

1. *Continental shelf waters and its adjacent waters.* As I described in the previous report (Nemoto, 1957, p. 80, 86), waters along the Alaskan continental shelf produce a large amount of *Thysanoëssa inermis* distributing and form a very favorable condition for whales. *T. inermis* also spawn vigorously above the coastal bank, bottom layer, which is directly suggest the horizontal cycle from the bottom layer to the surface strata where the lavae develop. Einarsson describe the *inermis* type of distribution of euphausiids, and *Thysanoëssa inermis* and *T. raschii* are considered belong to this type. These *inermis* type euphausiids propagate along the continental shelf or within the shelf, and fin whales congregate to feed on them. As I described in the previous report, with the upwelling current and vertical oscillations by wind blowing toward the continental slope, the adjacent waters to the continental shelf become a very productive area. The most typical whaling ground of this type in the North Pacific situated along the continental shelf is the north waters of the eastern Aleutian Islands, and Alaskan continental shelf. I can find further this type of the whaling ground along the shelf, situated the Yamato Bank in the Okhotsk sea and in the East China sea along the China continental shelf.

2. *Boundaries of water-mass and water convergence.* Along the boundary of different water masses, the whales are usually feeding and migrating. In this waters of convergence, the vertical mixing of water and accumulation of food planktons bring very favorable condition for baleen whales. The most typical illustration is observed in the off water of Sanriku in the adjacent waters to Japan (Uda, 1954). The cold current 'Oyashio' meets 'Kuroshio' the warm current in the area. One example of these water convergence in the Sanriku water in summer in 1952 may be illustrated in Fig. 33. The Fig. 33 demonstrates the clear parallel between the water convergence and concentration of whales. There are those heavy water convergences (Fig. 33 middle A, B, C) where many sei or Bryde's whales had been observed. Swarm of birds and bonitoes are also so congregated to the waters that whalers and fisherman can find whales from birds and bonitoes in the waters.

The boundaries of different water masses or currents make the cyclonic water movements, in the center of which the most heavy concentration of foods is observed.

3. *Upwelling and thermal Anticline.* Upwelling occurrs in the high latitude of the earth as well as in the tropical and temperate waters. Upwelling carries nutrient fertilizers into the sulighted zone. Cromwell (1956) describes the mechanism of tuna fishing grounds

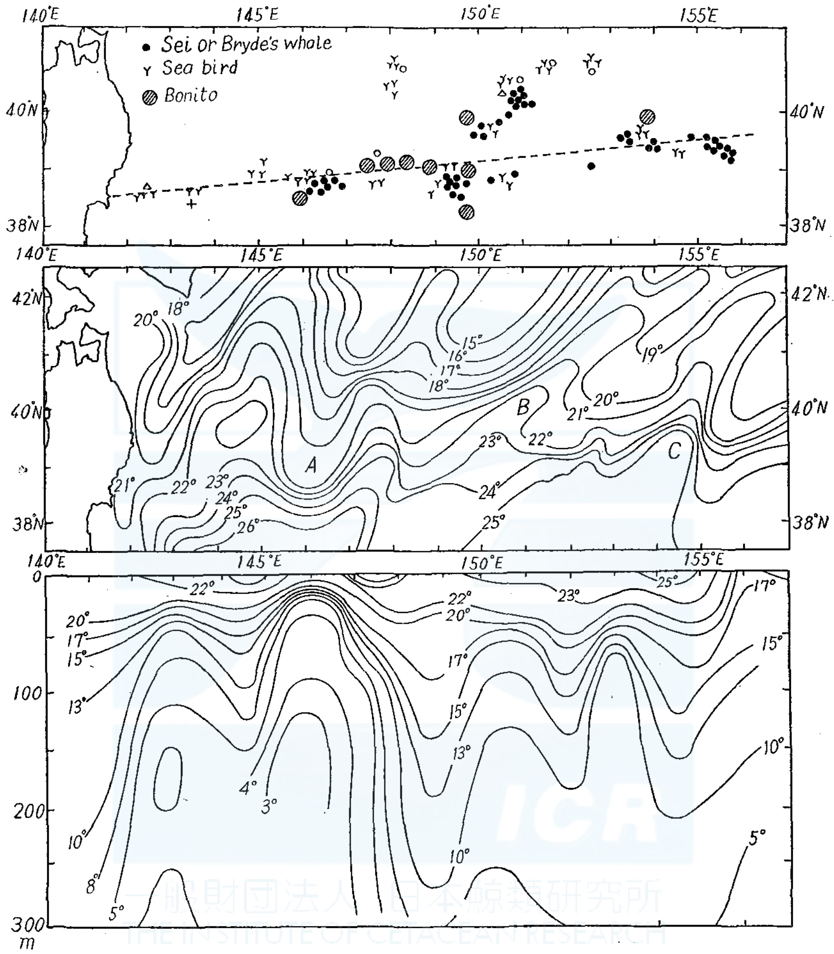


Fig. 33. The distribution of sei and Bryde's whales, surface water temperature and vertical section of whaling grounds in the Sanriku waters in summer in 1952. Upper—Observation of whales, sea birds and fish, Middle—Distribution of surface water temperature distribution, Under—Vertical section along the dotted line in the upper figure from surface to the depth of 300 m. (based on data mainly Miyazaki Otsuru & Watase, 1953).

and that it takes time for biological products to develop after waters has upwelled, so that planktons are found displaced in down stream from the center of upwelling. This caption and his illustration (Fig. 2, a, b) are very important and satisfactory as to the general comprehension of whaling ground consists of the upwelling. Because the whaling ground is also situated a little apart from the center of the upwelling in the sea in general.

As the whaling ground due to the upwelling is often made by affection of the shape of sea bottom, and the ridge or Islands situated in the sea current often produce the upwelling such as the waters around South Georgia Islands.

Thermal anticlines also bring the nutrient rich waters to the surface sunlight zone allowing plankton to develop (Cromwell, 1956).

4. *Back waters and the center of the cyclonic movements.* The food plankton, fish and squids are also concentrated by currents into the center of the cyclonic movement or backwaters (Ruud, 1932). These conditions are formed by two causes. One is made by the current and the other is made by the shape of the land, gulf, bank, ridge, islands, and cape etc. The backwaters or the center of the cyclonic movement are found in the off waters as often as in the adjacent waters to the land, but the former whaling ground are not so stable as the grounds made by the shape of land islands etc. in the adjacent waters to the land, and the center of the plankton concentration move or is transported by current strength along the boundary in the off waters.

5. *Whaling ground in the pelagic waters.* Ruud (1932) describes there are large quantity of Krill among the ice far away from land or any known banks like the waters along the slope of the continental shelf and banks. The Antarctic whaling grounds belong to this type of whaling ground, which have the close connection with the ice melting in the summer season. Of course the cyclonic systems round the coasts of the Antarctic continent bear the possible making of whaling ground in some waters (Ruud, 1932), this type of whaling ground is mainly due to the sun shine into the waters in the summer melting of ice and the supply of the nutrient rich waters from the deep by currents. It brings forth the vast propagation of plyto-planktons and successive congregation and growth of *Euphausia superba* in the surface waters.

MOVEMENT AND MIGRATION OF WHALEBONE WHALES

Movement and migration of the whalebone whales are so vast problems that they need many accumulations of investigation and observations before any definite conclusion is obtained. Still there are many evidence for believing that the whales undertake regular annual migrations, or temporary movements and migrations both in northern and southern hemispheres. As to terms 'migration' and 'movement' in this part, I would refer again to the work by Mackintosh (1942, p. 237). The term 'migration' is also used here to imply long annual journeys between the cold feeding grounds and temperate or tropical waters. 'Movement' means, I would consider, regular or irregular local movement or journey according to some oceanographical conditions, feeding and breeding conditions. The relationship between foods of the whalebone whales and movement or migration of whales should be discussed to get the reasonable explanation for the subject as a first step. Next, the result of the marking of whales gives us also the direct evidence about the movement and the migration of whales. The marking investigations carried out in the Antarctic waters has been examined by Rayner (1940) and Brown (1955). These works show some clear characteristics as to the migration of the whalebone whales in the Antarctic.

Distribution and migration of Sei and Bryde's whales

Kellogg (1929) well describes the migration and movement of sei whales in his paper, but that Bryde's whales were included in the sei whale in his description. So, I would discuss again it carefully here mainly on the data of the North Pacific by Japanese investigation.

Sei and Bryde's whales have been caught in the adjacent waters to Japan by shore whaling and other sei whales have been caught in the northern part of the North Pacific by Japanese pelagic whaling. About these whales, many investigations and marking examinations are made, and some results are already published (Omura, 1950; Omura, Nishimoto & Fujino, 1952; Omura & Nemoto, 1955 etc.).

Generally speaking water temperature seems to be important in limiting the migrations of the sei whale (Clarke, 1957). Sei whales are considered usually never to call the Antarctic high and cold waters as far as the waters along the pack ice before 1954 seasons by Japanese Antarctic observations. After the year 1955, sei whales have been caught and observed in a considerable number as reported by the International Whaling Statistics. In the 1955 and 1956 season, only 6 sei whales were caught by Japanese whaling operations, while comparatively many schools of sei whales had been observed on these days though these sei whales had not been caught.

In the years 1957 and 1958, 133 and 1466 sei whales have beee caught respectively by Japanese whaling expedition. The higher water temperature in these years than previous seasons, and the abundant crop of *Parathemisto gaudichaudi* (p. 164) might have caused such migrations of sei whales, while the further investigation oceanographically is now under examination by Mr. Nasu of my colleague. The surface water temperature shows a little higher value in the waters where sei whales caught than the waters where other blue and fin whales caught, and sei whales have never been among the pack ice. There is another evidence, however, the surface temperature is going down a little in the late of February to March in the waters of Antarctic convergence, when the almost all sei whales have been captured. This tendency is clearly given by Mackintosh in his figures (Mackintosh, 1946, b, Fig. A–E). The surface water temperature in the waters along the pack ice also declines in March, still it is not so cold as in April. Sei whales have been mostly found along the warm water current from the north, and not in the colder current originated in melting of ice from the pack ice. So, sei whales migrate to the high antarctic waters in the height of the surface water temperature in general.

Sei whales have been caught in a considerable number by recent Japanese pelagic whaling expeditions in the northern part of the North Pacific too, because they produce the high production of whale meats in each blue whale unit. The dominant catch of sei whales in recent years is observed in two areas, south east off waters of Kamtchatka Peninsula and the south waters of the eastern Aleutian Islands. The latter waters range from 49° to 53° North latitudes and 165° to 175° west longitudes. These catches of sei whales are all limited in the south waters of Aleutian Islands. The observation of sei whales in the Bering sea has been few, and directly it is considered that sei whales never migrate in the high latitudes and the Arctic sea like the Antarctic. The most northern record of the reliable observation on sei whales in Bering sea

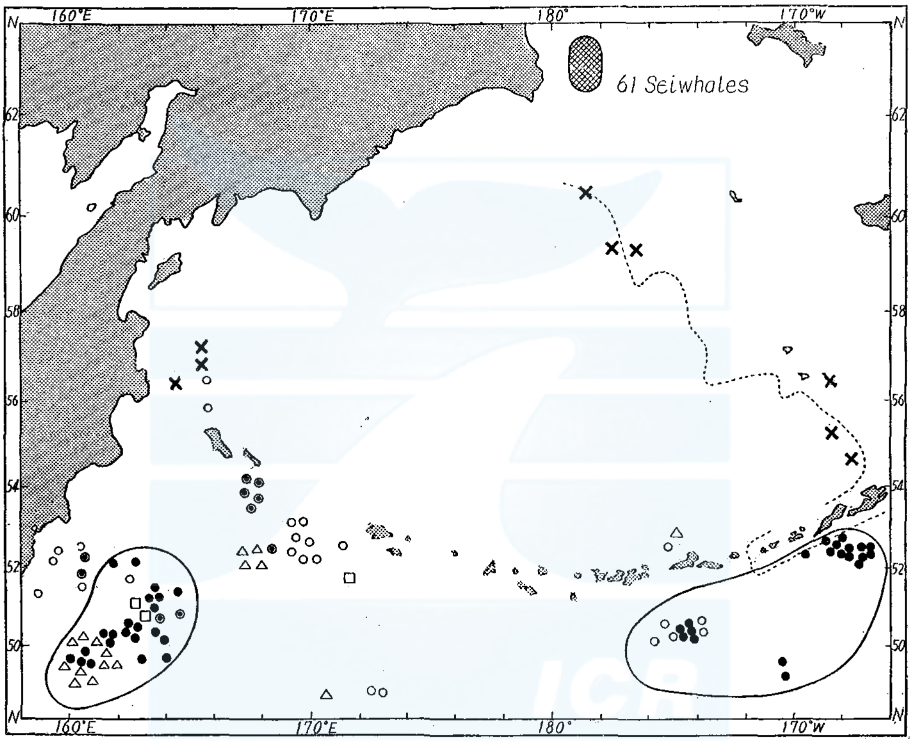


Fig. 34. Distribution of foods of sei whales in the northern part of the North Pacific and the observation of sei whales. × Single observations of sei whale, ● *Calanus plumchrus*, ○ *Calanus cristatus*, ⊙ Saury, △ Squids, □ Euphausiids. The surrounded area shows the waters where *Calanus plumchrus* is dominant.

is obtained in 1958. Some 54 sei whales are feeding in the Andyr gulf, off water of Navarin cape on 4th August. Other 3 and 4 sei whales also described in the near waters in the same ranges as described in Fig. 34. I have 8 other single observations in the Bering sea which contain less than 5 sei whales at each position. Above recent reliable informations also endorse the tendency that few sei whale migrates to the marginal sea as I state in the part of distribution of whales according to the shape of the sea. The migrating season of sei whales in the waters is considered a little earlier in the eastern waters than in the western waters. In the former waters of southern waters of the eastern Aleutian Islands, the main sei whales migrate in the middle of June to feed the vast amount of *Calanus plumchrus* and *C. cristatus*.

As the favourite food for fin whales, *Calanus cristatus* also becomes dominant a little earlier than *Calanus plumchrus* and the height of *C. plumchrus* later in general (Vinogradov, 1956), fin whales are considered

TABLE 28. CATCH AND STOMACH CONTENTS OF SEI WHALES IN THE WEST WATERS OF THE NORTHERN PART OF THE NORTH PACIFIC IN 1953

Stomach contents	June		July		Aug.			Sept.		
	1st	3rd	1st	3rd	1st	2nd	3rd	1st	2nd	3rd
C. plumchrus	—	—	—	—	2	—	11	—	3	—
C. pl. & Squids	—	—	—	—	—	—	3	—	—	—
Euphausiids	—	—	—	—	—	—	2	—	—	—
Saury	—	—	—	—	—	—	2	—	1	—
Squids	—	—	—	—	—	—	8	—	—	—
Empty	7	1	1	1	1	1	42	1	4	3
Uuknown	—	—	—	—	—	—	2	—	2	—

TABLE 29. CATCH AND STOMACH CONTENTS OF SEI WHALES IN THE EAST AND WEST AREA OF THE NORTHERN PART OF NORTH PACIFIC IN 1954

Stomach contents	West								East			
	May		June		July			Aug.	May	June		
	2nd	3rd	1st	2nd	1st	2nd	3rd	1st	3rd	1st	2nd	3rd
C. cristatus	2	—	—	—	—	—	—	—	—	3	—	2
C. plumchrus	—	—	—	—	—	—	—	—	—	—	—	13
C. cri. & Squids	—	—	—	—	—	—	—	—	—	1	—	—
C. sp.	—	—	2*	1*	9*	10*	20*	2*	—	—	—	—
Euphausiids	—	—	—	—	—	—	—	—	1	—		—
Squids	1	—	—	—	—	—	—	—	—	—	—	—
Empty	3	1	—	1	8	—	—	—	—	1	1	19

* These species are considered *Calanus plumchrus* from some collected samples, but no exact observation on board is available.

to migrate to the said area earlier than sei whales. Sei whales also distribute in a little apart from the waters where other fin and blue whales' school are feeding. This suggest the segregation of each species in the feeding grounds, which is partly due to the different distribution of their favourite foods directly. Another explanation for the above fact is ' balance ' or distributional power among the whales.

Above migrational season is well illustrated in Table 28 and 29. Many sei whales were caught in 3rd decade of August, but few number was caught in preceding decades in 1953 in the west areas, off waters of Kamtchatka peninsula.

In 1954, sei whales were caught from the 2nd decade of May feeding on *Calanus cristatus* and squids, and from the 1st decade of June sei whales are considered feeding on another *Calanus plumchrus*. Sei whales become abundant in July in the west waters, on the other hand, considerable number of sei whales are caught in the 3rd decade of June in the east waters. These sei whales are feeding on *Calanus plumchrus* as I described in previous report (Nemoto, 1957, p. 53).

Sei whales are feeding on squids (*Ommastrephes sloani pacificus*) and saury (*Cololabis seira*) besides copepods. This fed positions are illustrated in Fig. 34. The squid distributes mainly in the Kamtchatka side and saury too. As saury also distributes in the American side (Schaefer & Reintjes, 1950), and sei whales' feeding on saury in the eastern parts is

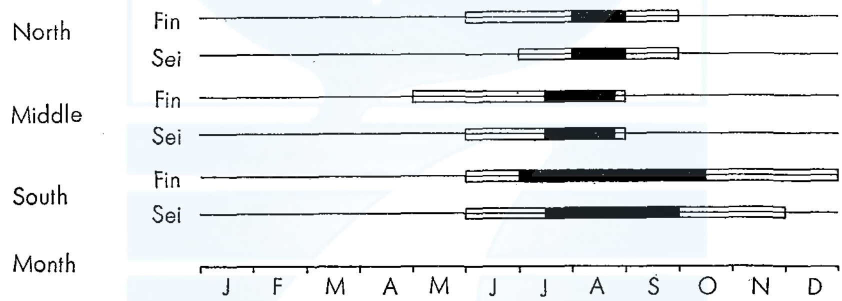


Fig. 35. The whaling seasons of fin and sei whales along the coasts of Kurile Islands by Japanese and Russian operations including the seasons before 1945. Black—main season, White—range of the whaling season.

also probable. Squids and saury in their turn feed on *Calanus plumchrus*. The stomachs of squids and saury in the waters are satiated with *Calanus plumchrus*. The following relations are obtained by above discussions.

$$\text{Sei whale} \xrightarrow{\text{Close}} \text{Calanus plumchrus}$$
$$\xrightarrow{\text{Subordinate}} \text{Saury \& Squids} \quad (\uparrow \text{ Close})$$

The *Calanus year* and *Euphausiid year* make some delay and the early migration of blue and fin whales as I said in the preceding part. But the *Calanus cristatus* and euphausiid are not so favourable for sei whales in the northern part of the North Pacific, sei whales never migrate so early in *Calanus* year.

Sei whales in the northern part of the North Pacific must have close relation to those of Kuril waters, Hokkaido and Sanriku waters. But no mark hit in the adjacent waters to Japan has been recovered in the northern part of the North Pacific and vice versa. The facts that the comparatively many marked sei whales in the adjacent waters to Japan have been caught in the water suggest that they migrate to the waters regularly to feed on foods, and the group may be different from those in the northern part of the North Pacific (the term group is not used in a strict sense).

The catch of sei whales in the Kuril waters which lies between Japan and the northern part of the North Pacific, vary in each localities of the North and South Aleutian waters. In the northern part of the Kurile waters at about 50° North latitude, number of sei whales caught were not so large that the typical migration of the whales to the waters has not been obtained. From the catch of pre-war seasons before 1945 by Japanese and after the war by Russian operations, the height is observed only in August and of short duration, and very few sei whales have been caught in July and September. Along the coast of Middle Kurile Islands, sei whales are also scarce, but they migrate to the waters a little earlier than the north waters of Kurile Islands. Still from July to the middle and the late of August the south Kurile Islands show nearly the same tendency as the Hokkaido waters. Sei whales migrate to the waters from June, and main herds come between the middle of July and the middle of September. Some sei whales also had been taken still in November in the pre-war seasons. Among the sei whales swarming in the South Kurile Islands, some sei whales pass through the straits between Kurile Islands to the Okhotsk sea. Though in the pre-war seasons before 1945, Bryde's whales had not been distinguished from sei whales by Japanese investigations, it is safe to say that all sei whales in the waters are real sei whales (*Balaenoptera borealis*), and they never include Bryde's whales (*Balaenoptera breidei*) or include very few of them. Because Bryde's whales are warm water living whales, and they are considered never to migrate to the north and middle Kurile waters or mainly distribute within the range of surface temperature more than 20°C (Omura & Nemoto, 1955; Omura 1959). Recent Russian investigations also report the occurrence of Bryde's whales in the Kurile waters (Kleinenberg & Makarov, 1955), but it is considered to be restricted to the south waters of Kurile Islands according to recent Japanese investigations.

In the adjacent waters to the north east part of Japan proper Sanriku and Hokkaido waters, Bryde's and sei whales have been examined from the year 1952 at the landstations by the investigation mainly on baleen plates and ventral grooves of whales. The result in 1953 is discussed by Omura & Nemoto (1954), and the fact that considerably many

Bryde's whales are caught in the off waters of Sanriku suggest that the result obtained by the year 1951 were all unreliable to get the comprehension of the migration and the distribution of sei whales in the waters.

In the seasons before 1945 some whale already noticed the occurrence of Bryde's whales, as they called 'Nitarsi' the vague sei whales (apparently Bryde's whales) and 'Triangle sei whale'. The baleen of the whales are coarse and it was never bought so much high price as real sei whales in the Sanriku landstations.

As the catch of baleen whales in the Japanese waters is permitted from May to October, sei and Bryde's whales have been caught by recent operation in the adjacent waters as described in Tables 30 and 31.

TABLE 30. NUMBER OF SEI WHALES CAUGHT IN THE ADJACENT WATERS TO THE SOUTH EAST JAPAN PROPER FROM 1956 TO 1958

		May			June			July			Aug.			Sept.			Oct.		
1956	40 S	5	20	36	70	43	19	3	2	41	13	5	4	7	5	—	1	—	3
	40 N	—	—	6	6	—	5	169	43	13	22	20	23	33	37	32	23	18	28
1957	40 S	—	3	43	51	36	15	1	2	4	6	14	15	4	—	3	7	11	—
	40 N	—	—	—	—	1	1	2	38	18	11	9	13	46	14	18	31	3	11
1958	40 S	2	3	49	42	26	37	20	3	2	4	—	38	21	67	1	4	11	2
	40 N	5	6	6	—	—	—	1	2	1	7	9	31	59	46	12	32	9	22

TABLE 31. NUMBER OF BRYDE'S WHALES CAUGHT IN THE ADJACENT WATERS TO THE SOUTH EAST JAPAN PROPER FROM 1956 TO 1958

		May			June			July			Aug.			Sept.			Oct.		
1956	40 S	—	—	—	3	1	8	2	—	1	—	1	1	2	—	—	1	—	—
	40 N	—	—	—	—	—	—	3	—	—	—	—	—	—	1	—	—	—	—
1957	40 S	—	1	—	—	1	8	6	5	1	—	5	12	2	—	—	—	—	—
1958	40 S	—	—	2	2	—	2	18	19	9	74	48	5	—	—	—	—	—	—

40S means the South waters of 40°N latitude and 40N the North waters of 40°N latitude.

From the Tables, Bryde's whales have been mostly caught in the south waters of 40° north latitude, and sei whales are more abundant in the latter part of the seasons, some sei whales are captured in the first decade of May in the south waters. But generally speaking sei whales become dominant in the late of May to the late of June in the south water, but few Bryde's whales have been caught in May. Only 1 Bryde's whale is caught in 1957 and 2 Bryde's whales are caught in May in 1958 (see Table 31) which show the early migration of Bryde's whales to the Sanriku waters. The main herd of Bryde's whales migrate to the Sanriku waters from the late of June, and the height is observed in July and August though there are some annual variations of migrations among the years (see Omura & Nemoto, 1955, Table 1) as illustrated in Table 32.

Of course, the annual change of the way of whaling operation is probable and the number of Bryde's whales in each local waters also varies annualy. The catch of Bryde's whales in 1955 shows some 85 Bryde's whales which is comparatively high value from 1953 to 1957. The catch of Bryde's whales in 1958 demonstrates the tremendous number of 298 whales, 179 of which are caught in the Sanriku waters. Another catch of Bryde's whales in the adjacent waters is observed in the waters of Oshima, Wakayama prefecture, and the catch of Bryde's whales in each decades in the Oshima waters may be referred to the preceding Tables 17 and 18. Bryde's whales in recent years have been

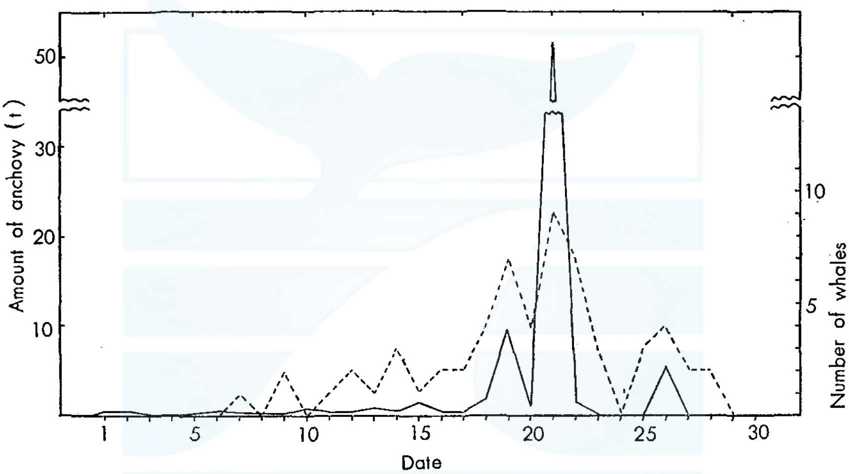


Fig. 36. The relation between the catch of Bryde's whales and the amount of anchovy fished at the landstation of Wakayama prefecture along the Pacific coast in June in 1958.

caught mainly from the late decade of May to June. This migration of Bryde's whales bears close relation with the abundance of anchovy (*Engraulis japonica*) in the off waters of Wakayama. In the earlier season, Bryde's whale are feeding on a euphausiid (*Euphausia similis*) which distributes in the off waters of 20 miles from the land in general (Honjo, 1957). Later the main herds of Bryde's whales in the Wakayama waters are feeding anchovy. The relation between the amount of the anchovy captured and the catch of sei whales is illustrated in Fig. 36, which indicates that anchovy has the close bearing on the migration of Bryde's whales. Anchovy is fished in the waters mainly from April to November, and comparatively scarce from December to March. The most abundant catch of anchovy does not always coincide with the height of the migration of Bryde's whales, however, the catch of Bryde's whales is increasing with the increase of anchovy. The amount of anchovy fished in April and May in 1958 is very scarce, but the shoals of anchovy come from the early of June and become very abundant in the middle of June considered from the catch of anchovy fishing. Although the amount of anchovy shows only the part of anchovy in the waters, there is a close parallel between the catch of anchovy and Bryde's whales. Anchovy in the waters, in its turn, is feeding on the warm water living copepods, belonging to the *Eucalanus*, *Sapphirina*, *Oncaea*, *Candacia* and *Calanus*. These copepods are considered to distribute in the scattered condition, not to aggregate into swarms or patch in the sea. Bryde's whales are swollowing type whales and can not take the scattered copepods in the natural sea condition. If the copepods are fed by swarming anchovy, the latter make growth and become the

TABLE 32. NUMBER OF BRYDE'S WHALES CAUGHT AND IDENTIFIED ALONG THE ADJACENT WATERS TO THE JAPAN PRORER

Locality	1955	1956	1957	1958
Sanriku & Hokkaido	57	24	41	179
Oshima (Wakayama)	26	—	—	72
Goto (West Kyushu)	2	2	3	47
Total	85	26	44	298

favorite foods of Bryde's whales. Especially *Sapphirina* species are very famous as a indicater of 'Kuroshio' current and Japanese fishermen sometimes seek their fishing ground of bonito (*Katsuwonns pelamis* (Linné)) by the water colour containing these *Sapphirina* species. It is reasonable that the whaling ground of Bryde's whales lies in the near waters of bonito fisheries in these Wakayama waters, because Bonito also feed on anchovy very often in the adjacent waters to Japan (Hotta & Ogawa, 1955).

Bryde's whale ⟶ Anchovy ⟶ Calanus spp.
↗ Candacia spp.
Bonito Sapphirina spp.
Oncaea spp.
etc. } Warm water living copepods

Above relation is observed in the off waters of Oshima, Wakayama prefecture, and this tendency will be maintained to Sanriku waters too. At Oshima in 1958, I noticed about 10 new open pits on the surface of body of the whale besides many healed scars. The open pits are not so fresh as they are observed in Bonin waters (see Fig. 6 in Omura, Nishimoto & Fujino, 1952). But the open pits are all more fresh than those observed in the northern Pacific waters of Sanriku waters. This healing stage of the scars is considered to closely resemble to Fig. 7, Plate 36 illustrated in the paper by Mackintosh & Wheeler (1929). This is the very initial stage of healing from the open pits which is usually found in the Bonin and South African waters. The fact clearly indicates the new coming of Bryde's whales to the Wakayama waters from the southern subtropical waters at that time.

From the catch statistics of the seasons before 1945, sei whales (apparently including Bryde's whales in summer seasons) had been caught as illustrated in Fig. 37. Though there are some vague catch in the early spring season and winter the main catch is divided into two heights from winter to spring and from spring to summer. Kasahara (1950) deemes the fact very simply, and summarizes them into one figure, which does not demonstrate the two peaks of the catch.

The former height of the catch is very interest, but the species is not certain, however, it is probable that sei whales (*Balaenoptera borealis*) come to the waters in winter season, and the latter height is undoubtedly

TABLE 33. SURFACE WATER TEMPERATURE RANGE OF THE CATCH POSITION OF BRYDE'S WHALES IN THE SANRIKU AND HOKKAIDO WATERS

	Water temperature range, C						
Year	14–16	16–18	18–20	20–22	22–24	24–26	26–28
1953	1	1	6	27	14	7	—
1956	3	1	7	6	5	—	—
1957	—	—	1	5	19	9	7

the catch of Bryde's whales. One of the explanation for above fact is that sei and Bryde's whales are considered to migrate to the Bonin waters also separately. According to Omura & Fujino (1954) sei whales are taken from November to April in the Bonin Island waters, and the catch is mainly composed of Bryde's whales in May and June. Omura & Fujino (1954) and Omura & Nemoto (1955) already state the occurrences of Bryde's whales only in summer. Their northern migration must be different from sei whales. On the other hand, there is one contradiction to the assumption. Andrews (1916) examined sei whales at the landstation of Oshima in April in 1910, and his descriptions are apparently those of sei whales (*Balaenoptera borealis*). To my regret, there is no explanation as to the ventral grooves of sei whales caught at the Oshima landstation. But he examined carefully the distinguishing points between sei and Bryde's whales in the latter part of his paper, and he further consideres Bryde's whales is distinct from sei whales, so it is probably safe to say that the sei whales described in April at Oshima, Wakayama prefecture, are real sei whales, and the occurrence in 1910 in Fig. 37, also shows the separation of the migration of sei whales in winter seasons. As illustrated in Fig. 37, there are clear two heights of the catch in 1911, 1919 and 1921, which are probably due to the above migrational segregation of sei and Bryde's whales in the off waters of Wakayama.

In 1921, the vague catch of sei whales is described as shown in Fig. 37, but no sei whales had been caught in the winter season from January to March after the year 1926 except some whales caught from October to December. The water temperature still remains 20°C in winter season in the off water of Oshima, so the catch of Bryde's whales in the winter seasons can not be neglected perfectly. As a conclusion, the summer catch of sei whales in the waters are apparently considered

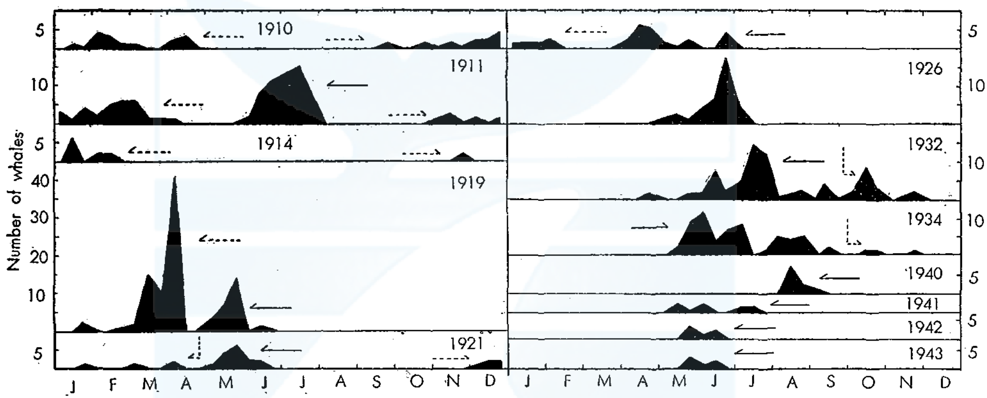


Fig. 37. The catch of sei whales (including Bryde's whales) in the adjacent waters to Oshima, Wakayama prefecture from 1910 to 1943. Solid lines indicate the probable catch of Bryde's whales and dotted lines indicate the probable catch of sei whales. The upper right shows the catch in 1922.

to be Bryde's whales, though the whales were described as sei whales.

In the seasons before 1945, some sei whales had been captured at the landstations of west Kyushu waters from June to September. Also these sei whales have been caught after the year 1945, but recent investigations prove that these whales are all Bryde's whales. Omura & Fujino (1954) state the sei whales measured at Okochi landstation in Tsushima before the year 1945 season are all Bryde's whales considering the extension of ventral grooves on the body. Along the west coast of Kyushu, Bryde's whales are migrating to feed on sardin and anchovy in the summer season, and the northern limit in the west waters of Japan is considered to be 35° North. Bryde's whales are considered never to penetrate into the Japan sea.

In winter, as the west Kyushu waters is still warm by the 'Tsushima' current and their favorite food anchovy is abundant in some waters, some Bryde's whales may pass the winter in the waters though there is no evidence if the sei whale in the winter season is Bryde's whales or not. Some whaler said 'Sendai iwashi' meaning 'Sendai sei whale' had been caught in the west Kyushu areas. This whale may be sei whale (*Balaenoptera borealis*), because Sendai is the city of Sanriku prefecture where many sei whales (*Balaenoptera borealis*) have been caught by whaling operations.

As a conclusion the water temperature range is important for the warm water living Bryde's whales. As I discussed in the previous column, Bryde's whales have been caught mostly in the surface water temperatures more than 20°C. Of course, some yearly change among the dominant occurrences of Bryde's whales in the water temperatures range is observed as illustrated in Table 33. The catch of the year 1956 does not show the typical high water temperature range, but the number of Bryde's whales show the smallest number when the comparison is made with recent other years. It is evident, however, that Bryde's whales are migrating in the water temperature more than 18°C, and never to call the colder waters under 15°C in general.

The whale marking on sei whales began in the spring of 1949 in the Bonin Islands and in the Sanriku and Hokkaido waters, and has been conducted every year in the North Pacific. Recent marking also has covered the northern part of the North Pacific and the recovered marks are listed in the appendix. I would classify these marking data with consideration of marked and captured season, marked and captured whaling grounds and lapse of the year. The whale marking in the Bonin Islands waters had been carried out between 1949 and 1952 and 92 sei Bryde's whales had been marked and 6 of them captured. Three marks were recovered in the same Bonin waters. The two marks were found somewhat west waters of marked position after the lapse of 1 day, and the last mark was recovered from the waters about 20 miles north waters of the marked position after the lapse of 12 days. With the consideration of the swimming direction and the catch of whales in the Bonin Island waters, Bryde's whales stay in the waters from the early of May to July and gradually migrate to the northern waters from the late of May.

Other 3 marks hit in the Bonin Island waters have been recovered from the whales caught in the adjacent waters to Japan Sanriku waters. One mark was recovered in the same year of marking. The whale was marked on 8th May, 1950 at 26°-43'N and 142°-40'E, and captured in the off waters of Sanriku at 37°02'N and 143°02'E after 69 days lapse. The other mark is recovered from a sei whale (The baleen plate is examined, but they say the plate is a sei whale, *Balaenoptera borealis*. The species should be corrected to be Bryde's whale by the recent investigation of a whale of the same school. The baleen plate must be mistaken), and the third is recovered from a Bryde's whale caught at 38°10′N and 145°20′E after the lapse of 8 years. These 3 marks prove directly the migration of Bryde's whales from Bonin Island waters to the Sanriku waters. The Bryde's whales usually call on the Bonin Island waters from the late of April to July and one part of Bryde's whales go north as far as off Sanriku waters, but one part remains longer in the Bonin waters (Omura & Fujino, 1954, p. 101) according to the observation by marking cruises between the late of June and the early of July in 1952

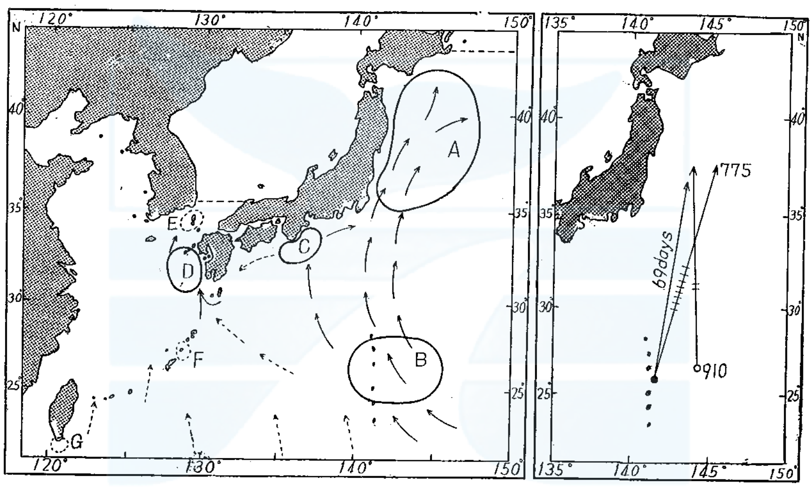


Fig. 38. Left, Schematic illustration of migration course of Bryde's whales in the adjacent waters to Japan. A, B, C, D—Recent whaling grounds of Bryde's whales, E—Catch position of Bryde's whales before 1945, F, G—Probable whaling grounds of Bryde's whales in the seasons before 1945. Dotted lines show the northern range of the distribution of Bryde's whales in the adjacent waters to Japan. Right, The recovery of whale marks bit in the Bonin Island waters and recovered in the Sanriku waters.

when some 74 sei whales (evidently Bryde's whale) had been observed. The comparatively many Bryde's whales were observed swimming to southern direction suggesting some of them may be feeding around the Bonin waters still in summer. The water temperature was very high showing from 28°C to 29°C in the waters at that time. There is some data of swimming school of Bryde's whales obtained in the Bonin Island waters. The single Bryde's whale predominated and the largest school consisted of 5 Bryde's whales. The single occurrences of whales mean to some extent the migrational special feature that they are due to the initial stage of the migration.

In the northern part of the North Pacific, the number of sei whales in a school have been observed in 1954 as shown in Table 35. Though the observations number is not so sufficient, the sei whale school in the earlier time of the season consists of single swimmer, on the other hand the observation in July prove that more schools consist of two sei whales. This fact suggests that some sei whales make rendezvous in the feeding ground and it is probable they return to the south for mating.

The summarized data of whale marking in the Sanriku and Hokkaido are given in Fig. 39. The 0 year group has three individuals, which demonstrates the westward movement from the off waters to the rather

TABLE 34. NUMBER OF SEI WHALES* IN EACH SCHOOL IN THE BONIN WATERS IN 1952

No. of whales	1	2	3	4	5
No. of school	12	4	3	1	2

The whales are described as sei whales by lack of observation.
* These sei whales are considered to be Bryde's whales.

TABLE 35. NUMBER OF SEI WHALES IN A SCHOOL OBSERVED BY JAPANESE INVESTIGATION IN THE NORTHERN PART OF THE NORTH PACIFIC IN 1954

	Number of whale in a school					
Month	1	2	3	4	5	6
May	4	1	1	—	—	—
June	12	3	—	1	—	—
July	19	41	14	6	1	1
Aug.	9	6	4	—	—	—

coastal waters. The mark (No. 3782) hit on 7th July of 1953 at about 42°N latitude is recovered on 12th September at 39°N latitude, and another mark No. 2675 hit on 2nd September is recovered on 21st October. These two marks show some case that sei whales (in some cases, occurrences of Bryde's whales are probable) are feeding in the off waters in summer, and then go to the coastal waters in autumn. From the 1, 2 and 3 year groups, two sei whales marked in July and August are captured in a little more south waters in the early date July, and two sei whales marked in September are caught also in the more coastal adjacent waters, than the position they were marked. Two sei whales marked in September are also caught in the near waters of the marking position in September. The tendency that whales come back to the same water in the same season of the year is partly demonstrated by these 1 to 3 years groups of sei whales.

4 years group or more elapsed group also endorse above tendency as shown in C of Fig. 39. Two September groups are recovered in the

near water after the lapse of 5 years. But another three marks marked in September are recovered in the far coastal waters. The marks, No. 2819 and No. 86 marked in July and September respectively are caught in June after 4 and 6 years. Two 5 and 6 years group cross the waters to the west coastal waters too. These marks all prove the general tendency that sei whales are feeding in the boundary of water mass between 'Kuroshio' and 'Oyashio' in the Sanriku and Hokkaido waters. If the heavy 'Siome' (Current rip) moves by some oceanographic surroundings affecting the sea condition of the whaling ground, sei whales also move very rapidly to the next favorable feeding area where the heavy 'Siome' is occurred. A good example is obtained in 1956. From May to June, comparatively many sei whales had been caught in the off waters of Sanriku, but the center of catch goes to the north and few sei whales are caught in the Sanriku waters

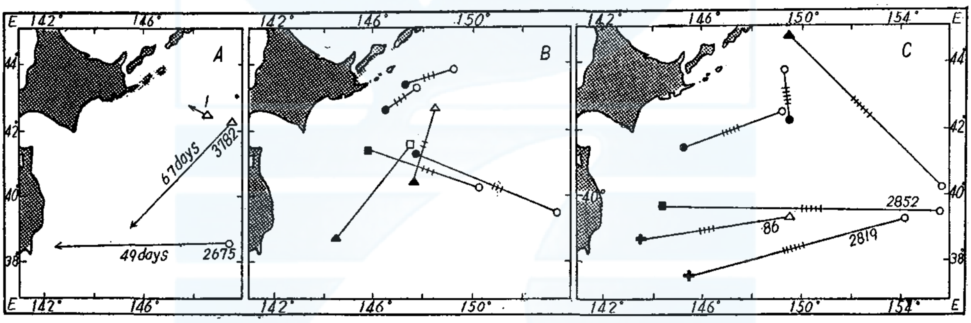


Fig. 39. Marking results of sei whales in the Sanriku and Hokkaido waters by Japanese investigations. Black symbols show the recovered positions. Open symbols show the marked positions. Crosses cutting arrows show the elapsed years. Cross—June, Triangle—July, Square—August, Circle—September, A—0 year group, B—2 and 3 years groups, C—groups more than 3 years.

in July. The typical moving of 'Shiome' is observed between June and July. The catch of sei whales decreases in number in the late of June when the 'Shiome' declines, and sei whales may scatter to feed their food. The sei whales are heavily feeding on *Euphausia pacifica*, *Ommastrephes sloani pacificus* in the 'Shiome' in the Hokkaido waters in the first of July. Again, the developed 'Shiome' down declines in the late of July and the center of the catch of sei whales go to the south in the late of July. These movements of the whaling ground can be explained by the intensity of Oyashio and Kuroshio current and their movements as a conclusion.

In the northern part of the North Pacific, two marks are recovered from sei whales (*Balaenoptera borealis*) after the lapse of 4 years. The sei whales are marked in June along the continental shelf south of

Unimak Islands. When they are marked, they apparently were considered to feeding *Calanus plumchrus* from the observation of other caught sei whales. The sei whales taken in July in 1958 are also feeding on *Calanus plumchrus* but in the more off and western waters. Though there has been no satisfactory explanation for the removal of the whaling ground for sei whales consists of *Calanus plumchrus*, the extention and strength of warm current from the south and the colder shore and northern waters make such a feeding grounds.

There are two evident peculiar features in the catch of sei whales in the Antarctic. That the female is always dominant at the high rate is one, and the catch of mature whales are exceedingly dominant is the

TABLE 37. CATCH OF SEI WHALES IN THE NORTHERN PART OF THE NORTH PACIFIC IN THE EAST AND WEST SIDE IN 1957

Decades	West		East	
	Male	Female	Male	Female
May late	5	7	—	—
June early	9	10	—	—
June middle	—	—	16	20
June late	—	—	5	2
July early	—	—	33	26
Aug. middle*	22	10	—	—

* Including 1 male caught in late August.

TABLE 36. CATCH OF SEI WHALES CAUGHT IN THE ANTARCTIC WATERS BY JAPANESE WHALING OPERATIONS IN 1958

Sex	Antarctic area										Total
	I		IV		V			VI			
	Mature	Immature	Mature	Immature	Mature	Immature	Unknown	Mature	Immature	Unknown	
Male	10	1	16	1	114	1	6	234	2	—	385
Female	19	—	50	1	257	9	8	714	18	—	1076

other. Among the Japanese catch in the Antarctic in 1957 and 1958, females and mature sei whales are very dominant. In 1957, only 4 immature males and 21 mature males, 5 immature females and 103 mature females of sei whales were captured by Japanese expedition. Matthews (1938a) already noticed the female predominated tendency and thinks one reason for the fact is due to the selection of large sei whales for capture. Kasahara (1950) also subscribes his opinion. But the sexual segregation in the migration course also should be considered to explain the fact successfully, because from the sex ratio of foetus does not show such female predominated tendency. As there is another interesting tendency like above segregation in the North Pacific, I would refer to the results in the North Pacific here. Omura (1950) illustrates the sex ratio of sei whales caught in the Kurile and Hokkaido areas in past 18 years. Of course, there must be some trespassers of Bryde's whales in the statistics, but the number is considered very few in above two local waters (Omura & Nemoto, 1955). Males of sei whales are predominated in the Kurile waters, on the other hand, females are more numerous than males in the Hokkaido waters (see Table 36, Omura, 1950). Kasahara (1950) also consideres there is the segregation of migration between male and female of sei whales, and males go to the further northern waters if it is simply considered. In the northern part of the North Pacific, males are always predominated in the western part, off Kamtchatka and south of the Komandorskiy Islands. I would consider these facts are mainly due to the later season of whaling. This illustration is given in Table 37, which show the tendency of male predominating in the latter half season of July and August.

Fin whales

Northern part of the North Pacific. Fin whales have been considered to be a long migratory whale. The recovery of whales' marks in the southern hemisphere proves the long migration between the Antarctic cold waters and subtropical waters of Brazil and South Africa (Brown, 1954). Like the case that the sword of a sword-fish (*Xiphias gladius*) was found in the dorsal flesh of a blue whale in the Antarctic (Ruud, 1952), a sword of a sword-fish was found in the meat of a fin whale caught on 19th July in 1954 in the adjacent waters to Aleutian Island. The fin whale was caught at 54–35N, 165–35W longitude, where the Pacific sword-fish also never inhabit in such cold waters as Aleutian region. This indicates the migration of a fin whale between the northern part of the North Pacific and the subtropical waters of the Pacific.

In the northern part of the North Pacific near Aleutian Islands, fin whales have been caught from May to September by Japanese and Russian expeditions. The catch has been observed along the Aleutian Islands, along the Alaskan continental shelf and Kamtchatka coast. Generally speaking, fin whales come from the southern waters already in May in the west part of the North Pacific. The height of *Calanus cristatus* and euphaussiids, *Thysanoëssa inermis* change their roll in the middle of the season, and the fin whales usually migrate to the north or the east waters to seek the food from July in 'Calanus year' (Nemoto, 1957, p. 79). The catch height in the west waters of off Kamtchatka is considered to be in June (see Fig. 23 Nemoto, 1957) and fin whales become scarce in August owing to the scanty supply of foods in the waters. The height of *Calanus cristatus* shows some local differences according to the latitudal locality in the northern part of the North Pacific as stated in the former part.

In the southern waters of Aleutian Islands, *Calanus cristatus* become dominant already from May, but in the northern waters, it become a little later than May. Fin whales follow the height of their food, and if the food is sufficient they stay there for comparatively long time.

This cause surely the delay of migration (in this case movement is more suitable) of fin whales to the north waters of the Bering sea, especially in the North waters of Kamandorskiy Islands and in the off waters of Anadyr gulf. The temporaly prosperity of swarming fish such as capelin and Alaska pollack also attract many fin whales, the examples of which are observed in 1957 and 1958. The waters where Alaska pollack was abundant in 1957, does not attract fin whales in 1958 owing to the scarcity of Alaska pollack. But comparatively many fin whales go to far north to feed on abundant foods of capelin in 1958. Still, other fin whales feed on planktons in southern waters near Aleutian Islands. This will partly demonstrate that number of fin whales are restricted to the waters according to the abundance of foods in the waters, and excessive number of fin whales may call other waters to feed on their food.

Marking results in the North Pacific. The whale marking research commenced in 1953 in the northern part of the North Pacific, and has been succeeded since then.

With regard to the result of marking investigations on the fin whales in the northern part of the North Pacific, the periodical report and summarized reports (Omura & Kawakami, 1956; Kawakami & Ichihara, 1958 etc) discuss the problem to some extent. Here, I would make the discussion mainly considering the seasonal migration and the movement of fin whales.

The recovered marks are classified into year and seasonal groups as illustrated in Fig. 40. In the earlier season, the whaling operation has been conducted mainly in the southern waters, and gradually covered the North waters. As this directly indicates the early finding of marks only in the southern waters, no marks has been recovered in the north waters in the earlier season of whaling when no fin whales has been caught in the north waters. It should be considered that fin whales not always go to the north from the spring season to the summer season because many fin whales have been caught in the southern waters of the Aleutian Islands in the high summer season of the North Pacific.

My preliminary discussion based on the seasonal movement is as follows.

1. From May and June, the general tendency of fin whales migrating north is observed. Fin whales come to the western waters of the south

waters of Aleutian Islands, near waters of Komandorskiy Islands from May. These two marks hit on fin whales in the north waters of the east Aleutian Islands in August and September have been recovered in May, suggesting that these fin whales may migrate to the east and north waters again. The marks connect the east and west groups of fin whales in the northern part of the North Pacific in appearance. Two marks (J. 6042 and J. 6834) are recovered as the May group, but the Mark (3213) hit in May in the middle south waters of the Aleutian Islands is recovered in July in the said waters.

The Mark (J. 6060) in Fig. D. hit in September in the northern waters of Aleutian Islands is found in the western waters of the Near Islands in June, which indicates the same tendency as May group in Fig. A.

2. The marks hit in the north waters of the eastern Alutian Islands in September and August, the rather late season, are recovered in the south waters of the eastern Aleutian Islands. This also indicates the northward movement from the early season to the middle and late season of whaling demonstrated by three marks (J 6799, JS 6987, J 5998) in Fig. D.

3. After the lapse of the time more than 8 months or in the next year after the hit, the same month group show the capture position situating the very near position of marking position. For example, the marks hit in August, rather in the late season, are recovered in September in the near position of markings (Fig. C). The marking and recovering in July and in August respectively also show the same tendency (Fig. B).

Above results endorse the consideration that fin whales migrate to the same waters in the same season of the year as a rough conclusion. The main reason for the tendency is due to the general plankton crop in the same time of every year though there are some yearly change is observed. If there are any changes of oceanographical condition, or amounts of planktons organisms, the different migration of fin whales will be obtained.

4. The 'dispersal' of the whales also should be considered. The term 'dispersal' is used to describe the ultimate movement of whales east or west from the position in which they are marked by Brown (1954, p. 358–359). He made very excellent consideration on the problem in the Antractic on the dispersal of whales. Here I would state some different conditions between the Antractic and the North Pacific whaling ground at first as regards the dispersal of whales. The whaling ground in the Antractic is situated along the pack ice surrounding the Antractic continent. Of course, the currents of the Weddle sea, Ross sea and South Shetland sea etc, make the drift of euphausiids into the off waters (Ruud, 1932) or bring forth the constant crop of plankton in the off waters and show the strong latitudal distribution of baleen whales as

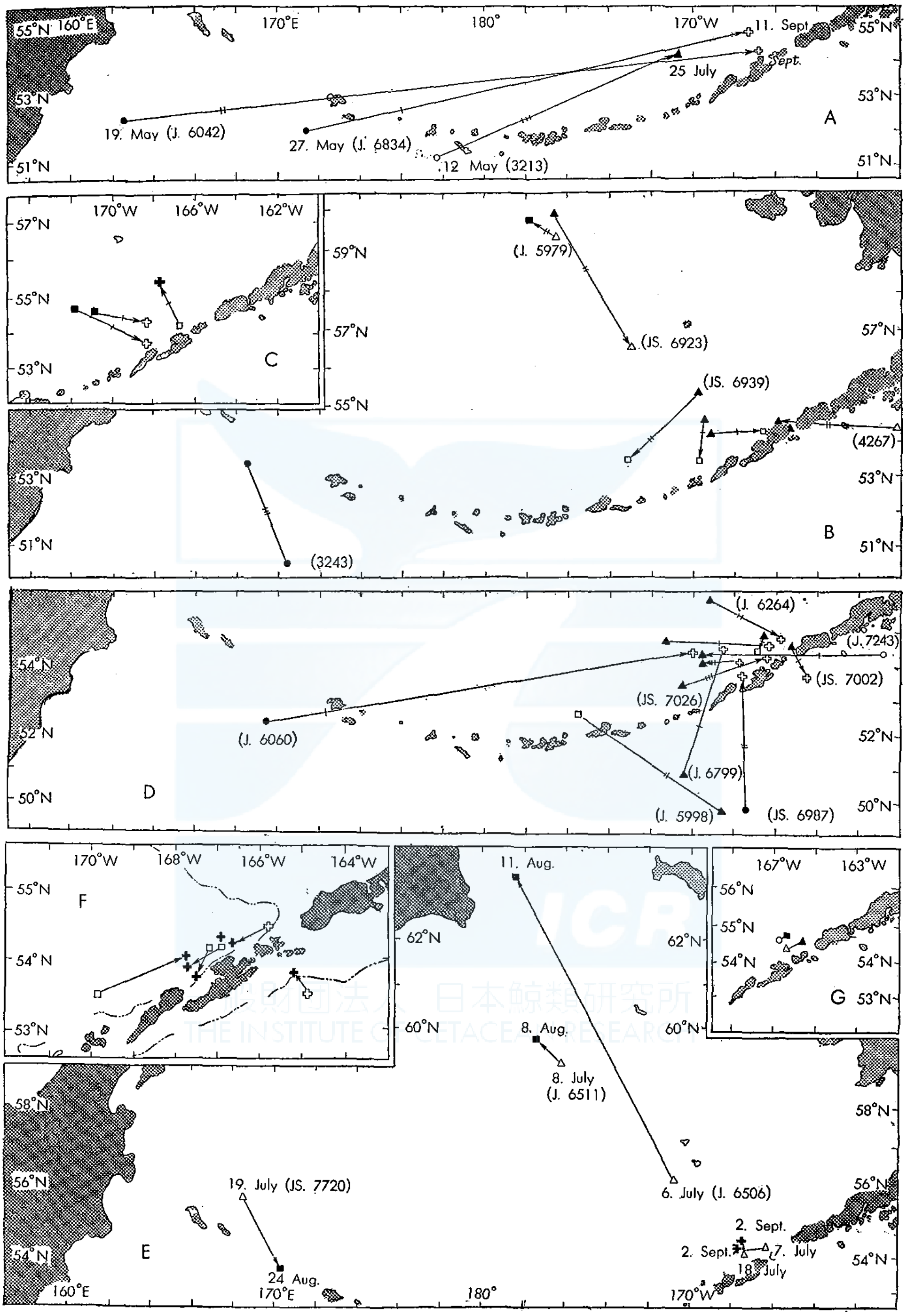


Fig. 40. Marking results by Japanese marking research in the nothern part of the North Pacific: A—May group after the lapse of time more than one year. B & D—June and July group after the lapse of time more than one year. C—August and September group after the lapse of time more than one year. E—July group within the same year of marking, 0 year group. F—August & September group within the same year of marking, 0 year group: Open symbols show the marking position and Solid Symbols show the recovering position. The short crossing lines show the elapsed year. Circle—May & June, Triangle—July, Square—August, Cross—September.

described by Arseniev (1957) in the Weddle sea. But generally speaking in recent times comparatively short whaling periods indicate the following lateral movement more frequently than the longitudinal movement in the whaling grounds of the Antarctic.

Thus the east and west-ward movements are generally observed and typical seasonal movement is not observed in the North Pacific. On the other hand, the typical dispersal of fin whales has not been observed if the seasonal movement is taken into consideration. For example considerably many fin whales hit in August or September in the North waters of Aleutian Islands are caught in the south waters of Aleutian Islands in the earlier season of May and June. As those fin whales might have migrated to the north waters with advance of the season if they had not been captured, fin whales in the course of migration or movement should not be regarded as the dispersive movement. Here I would use the term 'dispersive movement*, to describe the ultimate movement of whales without any relation of seasonal movements.

Up to this time, the real 'dispersive movement' has not been indicated by the recovery of marks on fin whales as illustrate in Fig. 40. But it is probable that fin whales make 'dispersive movement' at some time in the future. The one of the most reasonable explanation may be a change of feeding condition according to the oceanographical surroundings.

5. The most important question about the migration and the movement of fin whales is that fin whales in the east and the west in the North Pacific are separate stock or not. There is already a reliable discussion that fin whales from the waters of western Aleutian Islands and the north waters of the eastern Aleutian Islands belong to the separate breeding populations respectively (Fujino, 1956), however, it is safe to say that fin whales in the northern part of the North Pacific migrate and move eastward and westward to feed on the more profitable condition of their food. And further, there is no barrier between east and west waters because fin whales have the peculiarity migrating to the marginal and the mediterranean sea as well as the ocean. I would consider the evidence that fin whales are separated by blood groups in the northern part of the North Pacific described by Fujino (1956) only support the tendency that fin whales are divided into two or more population in the breeding ground. But the segregation in the whaling ground is not so strong as it is given by the brood type investigations. The satisfactory explanation will be obtained after the many accumulation of data are completed.

6. The northern limit of the migration has not been defined by Japanese

* The term 'dispersal' is already used by Brown in 1954, and the meaning is different from my term. I would use 'dispersive movement.' here in a different meaning to describe movements of whales.

investigations yet. But considering the distribution and amount of foods of whales the Bering sea is considered the most northern feeding ground in the North Pacific for fin whales. The Japanese whaling in 1940 covered the Chukchee sea though Bering strait and caught 74 fin whales. This phenomenon suggests the herd of fin whales attain to the Arctic sea in their northward migration in considerable number in some years. The food in the waters may consist of bottom living amphipods and one euphausiid (*Thysanoëssa raschii*) is considered only a euphausiid which distributes in the shallow and cold waters. But the condition of feeding for fin whales is not so satisfactory as in the Bering sea.

A mark (J 6506 in Fig. E) hit on a fin whale in the north waters of the eastern Aleutian Islands on 6th July is recovered in the off waters of Anadyr gulf on 11th August after the lapse of about one month as a 0 year group. The mark apparently indicate the summer movement of a fin whale from the north waters of the eastern Aleutian Islands to the most northern part of the Bering sea. This apparently means the northward movement in the Bering sea, and the northern limit is not situated along the Aleutian Islands. The pack ice of the Arctic sea also restricts the feeding ground of whales. As ice is generally prevailing in the Arctic sea and the Bering strait by the early summer (Pilot chart of American navy) fin whales may penetrate the water only in July, August and September. Japanese operation was operating from 5th to 27th August in 1940, when fin whales were feeding in the waters through the Bering strait.

7. The important mark (JS7002) is illustrated in Fig. D. The mark hit on 8th September in the south waters of Aleutian Islands in 1955 was recovered on 12th July in 1956 in north waters of the same eastern Aleutian Islands. Though the moving distance in the figure is short, this movement is considered real 'dispersive movement'. The fin whale might have migrated to the north waters fairly earlier season in the next year or the fin whales was feeding in the south waters through out the season, or came down to the south waters earlier than usual when it was marked.

The movements of fin whales are also considered by the marking results of the lapse of time as well as the seasonal movement. The movement of 0 year group is illustrated in Figs. E, F and G. The marks of 0 year group in August or September and recovered in September indicate the summer feeding in the same waters. Some marks hit in July also recovered in August and September in the very near waters of marking. A mark (JS7720) hit on 19th July in the north of Komandorskiy is recovered from a little south waters on 24th August, which suggests the summer staying in the south west waters to feed on the food. The most exceeding movements is given by the mark (J6506) which connects the south and North Bering sea. The fin whale may migrate along the Alaskan continental shelf, one of the most profitable feeding course for fin whales. The short movement (J6511) of 0 year group of a fin whale indicates also the month long staying in the water. In the year 1957 when the mark (J6511) was hit and recovered, Alaska pollack was the dominant food in the waters in the late of July to the early of August. The shoals of Alaska pollack must have swarmed in the water from July to August, which caused the stay of fin whales. In the next year of 1958, fin whales migrates to the northern water off Andyr gulf and only a few herd has been observed in the waters from 58°N to 60°N along the Alaskan continental shelf. This fact apparently suggest the annual change of abundance and distribution of food cause different distribution and migration of whales. The year groups of fin whales also show the movement, which is given in the figures with the one short crossing the arrows. The definite catch of 1 year group in 1955 and 1958 is given by the next Fig. 41, but one mark (JS7243) which is illustrated Fig. D. In 1954, 209 fin whales are marked in the north waters of the eastern Aleutian Islands, 7 marks of which are recovered within the year, and 7 marks are found in the next year of 1955. The four marks illustrated in Fig. B show the movement to the off waters. The fin whales hit with marks are feeding on *Thysanoëssa inermis* along the continental shelf, and the captured fin whale are considered to feed on *Calanus cristatus*. This change of food condition make 1 year group move to the off waters, and the only consideration of the annual return habit can not explain the problem satisfactory.

The next example, the recovery of marks in 1958 indicates somewhat different movements. The marks were hit in 1957 in the off waters where the fin whales were feeding on *Calanus cristatus* and *Thysanoëssa longipes* which show about two longitudes westward transfer of the *cristatus* and *longipes* areas. Five of these fin whales were caught in the same off waters and they are considered to feed on also *Thysanoëssa longipes* and *Calanus cristatus*. These fin whales were hit in September and are caught in July, the fact of which suggests that fin whales stay from July to September with other data of 0 year group and the result of the year 1955. Two marks (J. 6799 and JS. 7243) hit in 1957 show the comparatively long movement which are illustrated in Fig. 40 D and Fig. 41 C. The former mark is recovered in the same month of hit in the south waters, and the latter hit in June in the east waters is recovered in the west through the Aleutian Islands. The latter mark may be due to the seasonal movement from the east to the west from June to July as I discussed in the former part. A mark (J. 6799) shows the 'dispersive movement' that the fin whale hit in July in the north waters of the eastern Aleutian Islands come to the south waters of Aleutian Islands in July in the next year. The fact also may be due to the feeding in the south waters from the spring, and the whale may not migrate to the north waters in 1958. The south waters whaling ground consists of the large amount of swarms of *Thysanoëssa longipes*, which had not been observed so often from 1954 to 1956.

The 2 year group shows rather long seasonal movement, the first impression of which proves the fin whales dispersing with the progress of years. The 3 year group has been recovered in a few number comparing with the 0, 1 year and 2 year groups, but the movement and 'dispersive

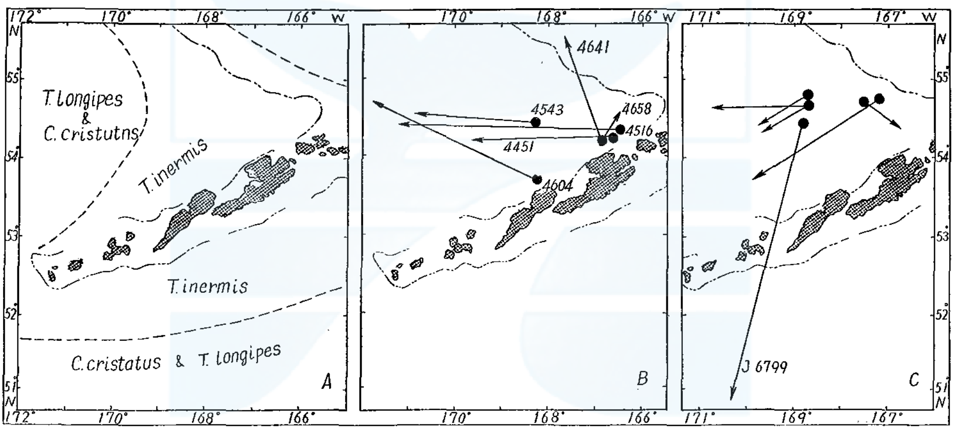


Fig. 41. The distribution of food planktons and recovery of 1 year group in 1955 and 1958. Left—Distribution of *Calanus cristatus* and *Thysanoëssa longipes* in the adjacent waters to the eastern Aleutian Islands. Middle—marking recovery in 1955. Right—marking recovery in 1958.

movement' do not demonstrate so cxceedingly as 1 and 2 year groups in 3 year group. There has been only one recovery of 4 year group, which was hit on 8th in August at the position 53–24N, 169–55W and is recovered on 11th July at the near position of 54–23N, 169–55W in the north waters of the eastern Aleutian Islands.

Swimming direction. About the swimming direction, Kemp & Bennett (1932) describe the swimming direction of fin and blue whales in the waters of South Georgia and South Shetland. Those illustration drawn by them do not demonstrate the clear seasonal tendency of swimming direction but a general tendency of moving. On the other hand, the recent study on the swimming direction of humpback whales in the Australian waters (Chitterborough, 1953), indicates clear seasonal swimming direction along the west coast of Australia. His result well demonstrate the south and north migration along the coast of Australia from May to October, which is directly connected with the migration of humpback whales to and from the Antarctic.

The swimming direction of fin whales also observed by Japanese investigations after 1952. As a example, I describe here the observation in 1953 in the western part of the northern Pacific, the south waters of Komandorkiy Islands. From May to July, the northward movement is the dominant tendency of the fin whales, but the southward movement become dominant from August to September. Besides above tendency, the fin whales feeding in the more northern waters also should be considered because those fin whales will be feeding still in August

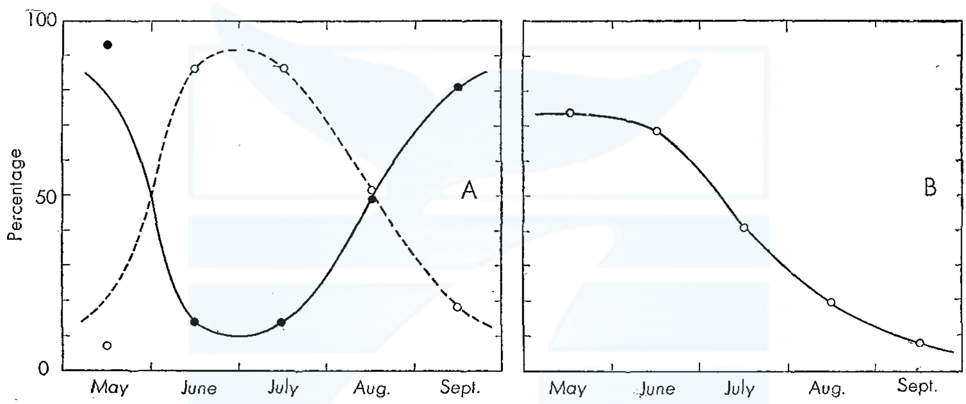


Fig. 42. Swimming direction of fin whales in the west part of the northern part of the North Pacific, south of the Komandorskiy Islands and in the off waters of Kamtchatka Peninsula. A—East and West component, Solid dots—West, Open dot—East component. B—North compornent.

according to the recent observations in the northern waters. It is reasonable, however, the change of the moving direction is accepted as a general tendency of the migration of fin whales.

The eastward movement from the earlier to the middle of the whaling season may also be obtained from the Fig. 42 A. But many fin whales move to the west-north, or to the Kamchatka Peninsula from the south-east, the Pacific Ocean in May. This fact suggests partly that the migration from the south waters does not always follow the coastal waters of Kurile Islands to the north. Kasahara (1950) consideres fin whales are coastal form from the catch statistics of the location of capture, but I would consider the fact is only due to the distribution of foods in the adjacent waters to Japan. When fin whales reach the Kamtchatkan coast and Aleutian Islands where the favourite food of *Calanus cristatus* is dominant, fin whales then migrate following two routes, along the coastal waters of Kamtchatka to the north and the Aleutian Island to the east. Zenkovich (1937) describes that fin whales are migrating from the south Kamtchatka in April and distribute in Bering sea and Arctic sea in August and September, and south moving schools of fin whales are observed in October in the south waters of Kamtchatka peninsula. The westward movement in May and the eastward movement in June and July will support the recovery of whale marks as I discussed in the former part. As a probable conclusion, fin whales migrating to the north already pass the waters south of Komandorskiy in July, thus the north moving component decreases in August, the high time of feeding in the northern hemisphere. Fin whales feeding on their food in the northern part of this water are also considered to come down from the late of August as a general tendency. The east and westward movements also endorse the marking results, but if there is any change of feeding condition the movement of fin whales may be much different one.

The result by Chittleborough (1953) indicates the much clear swimming direction, which is apparently due to the fact that humpback whales migrate along the very coast of Australian Islands. Fin whales in the coastal waters of Kamtchatka and Aleutian Islands also migrate and move rather coastal waters, because the food plankton and fish are considered rather scarce in the center to the Bering sea, and fin whales seem not to move through the center of the Bering sea.

The swimming direction of fin whales is also considered to be affected by the feeding of them. If fin whales are absorbed in feeding, they show no indication of definite swimming direction and they are also chased more easily (Gunther, 1948). This is directly connected with the dominant occurrences of swimming undefinitely in the heavy feeding ground especially in the moving when fin whales are mainly feed on their food.

Catch and distribution in the adjacent waters to Japan. Fin whales have been caught in comparatively large number already in the pre-war seasons before 1954 in the Okhotsk sea. The main catch of fin whales concentrate to the summer season from June to September. As shown in the Fig. 39 the height is observed in July and August.

Fin whales caught in the Okhotsk sea may come from both sides of the Pacific side and the Japanese side. Omura (1950) already considers that those whales migrating northwards though the Japan sea in May or June seem to enter into Okhotsk sea through the Soya strait. According to his description (Omura, 1950, p. 53) the thickness of blubber and the diatom infection of fin whales in the Okhotsk sea differ from those of the Pacific side suggesting that there appears to be little likelihood of both groups migrating through the straits between the Kurile

Islands. The latter distinction, however, is rather difficult to be explained as a definate one. Because the whaling grounds in the Okhotsk sea are situated on the shore waters from 10 miles to 60 miles, but those in the Pacific side lie in the off waters. The long pulling of whales from the captured position to the landstation may cause the falling off of diatom covering on the body surface of the fin whales. Thus the latter distinction may not be a reason for separating the groups of fin whales. There is another interesting observation. When I visited the landstation of the Okhotsk sea, the healed oval scars are observed on the surface of fin whales. These oval scars are originated to the open pit formed in the southern waters (Nemoto, 1954, p. 76). As the fin whales caught in the east China sea have only a few oval scars on the surface of the body (Mizue & Fujino, 1957), the fin whales migrating in the Japan sea

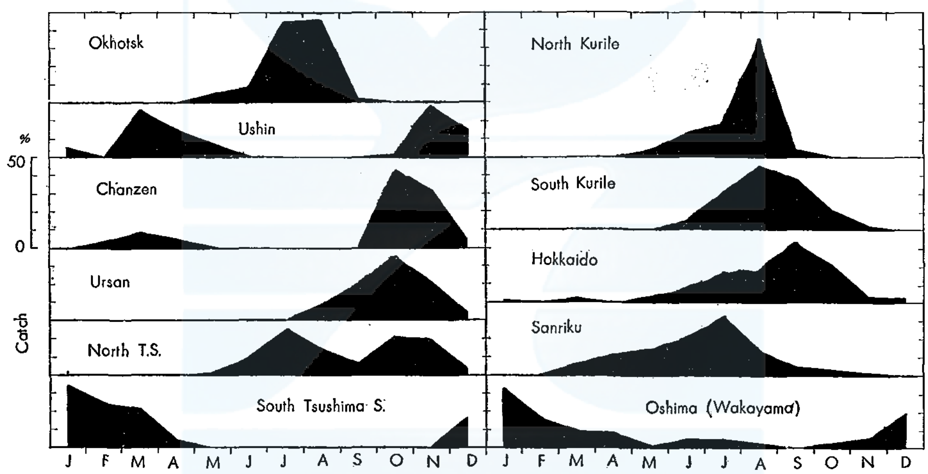


Fig. 43. The catch of fin whales in the adjacent waters to Japan in the seasons before 1954 according to available data by Japanese operations.

are considered to bear few scars. Because according to the catch statistics, those two groups of fin whales may not migrate to the subtropical waters of the Pacific Ocean where they may suffer from the open pits. The fin whales with many open pits have migrated from the Pacific side, though there is no evidence of whale marks or some other direct investigations.

Along the Pacific coast of Japan, fin whales have been caught mostly in summer in the waters north of Hokkaido in the seasons before 1945. As the recent operation has not caught the available data of fin whales in the adjacent waters to Japan, I would use only the catch before 1945 on the problem here. The catch percentage is illustrated in Fig. 43. Though only a few fin whales had been caught in the Oshima waters, Wakayama prefecture, but the main catch in Wakayama waters is observed in the January in the winter season. The catch of fin whales in the waters is not so abundant as blue whales in the very opening seasons of whaling. This would indicate that fin whales distributing along the Pacific side of Japan may disperse in the off waters more remarkably in winter season. In the summer season, fin whales had been caught mostly from May to August in Sanriku waters and the height is observed in July. From June to October, fin whales had been caught, and its height is in September in the Hokkaido waters. This difference of prosperous season of whaling for fin whale is considered to be due to the delay of the favorable feeding condition. Foods of fin whales in the waters consist mainly of 'Krill' (Mizue, 1951), which is apparently *Euphausia pacifica* in the coastal waters. Kasahara (1950) states that fin whales are swimming in the coastal waters, but it is difficult to estimate the fin whales migrate to the north along the coast of Japan, because, the fact that the fin whales had been caught from June to August in the off waters of Kamtchatka Okhotsk sea, South Kurile Islands, Hokkaido, Sanriku and South Korea, indicates fin whales which migrate early time to the north feed on their food in the north waters and late comer feed in the southern waters. This habit of migration of the fin whale has not been ascertained by recent investigations owing to the scanty of data. It is probable, however, those fin whales which had been visited the adjacent waters to Japan have decreased in number by the whaling operation or they have changed their migratory course and have gone to the further north waters to feed.

The whaling season of South Kurile waters shows no difference from that of Hokkaido region, but that of the North Kurile waters shows the height only in August suggesting short duration of migration.

The catch of fin whales in the Okhotsk sea is observed also in the short duration of July and August. This will demonstrate the connection of the group of Japan sea. Omura (1950, p. 53) considers fin whales in Japan sea seem to enter in the Okhotsk sea through the Soya strait. The catch along the coast of Korea seem to give the support to this. As shown in Fig. 43, fin whales had been caught in two seasons a year in the North Korean waters which are given by the catch of Ushin and Chanzen. The heights are observed in May, October and November, but the summer catch has not been observed, suggesting that those fin whales go to the north swimming into the Japan sea to the Okhotsk sea as described by Omura (1950). The height of catch in the Urusan waters is observed in October, a little earlier than the northern coast of Korea. If those height mean the northward and southward migration of fin whales as suggested by Omura (1950, p. 52), fin whales migration along the coast of Korea must have gone down in the very winter season, December, January and February or disperse in the off waters.

The catch of South Korea and Tsushima straits are divided into three groups, the South Korean waters, North Tsushima strait and South Tsushima strait along the Kyushu and the most west part of Japan. The north strait catch shows two peaks of heights. This summer catch of fin whales is very interesting, because fin whales have been considered as a migratory animals that they feed in the cold high latitudes in summer. The water temperature in the South Korean waters is ranging from 25°C to 30°C July, August and September which is very high as a feeding ground for fin whales. Kasahara (1950, p. 27) considers that fin whales of the late migratory herd may feed in the

TABLE 38. CATCH OF FIN WHALES IN THE EAST CHINA SEA BY JAPANESE OPERATION FROM THE LANDSTATION OF WEST KYUSHU FROM 1955 TO 1957

	July			Aug.			Sept.			Oct.		
1955	—	—	10	25	29	36	33	47	25	—	—	—
1956	34	2	18	36	45	45	23	26	29	3	3	13
1957	14	20	13	26	12	11	18	27	13	6	11	18

southern waters, but I would consider the fact is mainly due to the local segregation of fin whales. The catch of fin whale in the North strait recalls me of the recent catch of comparatively many fin whales in the East China Sea. The catch of fin whales in the east China sea also concentrated in summer from July to August. The whaling ground of the East China Sea is considered to consist of ' the Krill ' *Euphausia pacifica*, which is very dominant also in the Yellow sea and Korean water and become a very favorite food for mackerel (Nakai, 1942). This abundant *Euphusia pacifica* and other fish feeding on it, may support the stay of fin whales in the Yellow sea and the East China sea as well as the surroundings of the lands and Islands.

From the body length at the sexual maturity and size composition of fin whales, fin whales in the East China sea are rather related to the catch of the Yellow sea. The Yellow sea landstation before 1945 had distributed along the west coast of Korean Peninsula (see Fig. 24), at which the described number of fin whales had been caught by the available data in the seasons before 1945. At the most southern landstation, Daikokuzan Islands, fin whales had been caught in winter season from November to June, and the height was observed from February to April. This catch seems to have some relation with the catches of North Tsushima Straits and Ursan. If this assumption is true, fin whales migrated to the west along the South coast of Korea in winter may spend winter in the waters, then migrate to the north along the coast of Korea, but this group of fin whales might have never been caught as the summer catch of the North Tsushima Straits from May to the early of September. In the Yellow sea, fin whales had been caught from November to July. It is very interesting that the catch of the most northern part of the Yellow sea, shows its height in May, and considerable catch of fin whales also observed in April and June. These fin

TABLE 39. NUMBER OF FIN WHALES HAD BEEN CAUGHT IN THE ADJACENT WATERS OF WEST COAST OF KOREA AND IN THE YELLOW SEA

Locality	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Kaiyoto	1	1	5	31	52	31	—	—	—	—	—	2
Daiseito	56	52	20	20	—	—	—	—	—	—	4	50
Tsingtao	—	4	—	—	—	—	—	—	—	—	—	—
Oseito	4	4	4	—	—	—	—	—	—	—	—	—
Daikokuzanto	26	66	96	79	27	4	—	—	—	—	26	2

TABLE 40. CATCH OF BALEEN WHALES IN THE SOUTHERN WATERS OF THE PACIFIC FROM 1920 TO 1954*

	Blue	Fin	Hump.	Sei**	Grey
Formosa	15	—	734	10	—
Bonin Islands	27	7	849	1823	—
Lower California	989	12	1581	119	182

* Figured up from the data by Omura, Nishiwaki, Fujino & Kimura, 1957. ** Including Bryde's whales in the catch.

whales may come down to the southern waters of the East China sea in summer. Kasahara (1950, p. 29) already noticed that the size distribution of fin whales in the Yellow sea was different from that of the catch in winter season in the South Tsushima strait.

The latter catch shows the larger size distribution which is considered to have connection with the early migrater of fin whales in the Japan sea. They were different from the former Yellow sea group, which I would consider the same group as fin whales caught in the East China sea by recent operations. Mizue (1956) states fin whales caught in the East China sea may belong to the group of the Yellow sea. As I said in the former part, fin whales caught in the East China sea attain the sexual maturity in the shorter body length (Mizue, 1956), and the body proportion of fin whales in the East China sea differ from those of the nothern part of the North Pacific (Ichihara, 1957). These fin whales in the East China sea are considered as a 'local group' in the North Pacific. The local group of fin whales may be due to the oceanographical separation by lands and islands as well as the abundance of their food throughout the season. The depth of the Yellow sea is very shallow, and water temperature and salinity show the very characteristic values, however, *Euphausia pacifica* and *Pseudoeuphausia latifrons* bear possibility of dominant food for fin whales in the Yellow sea throughout the season.

The whaling ground in recent Japanese operations in the East China sea is found along the boundary of the warm current from the south and the cold current from the north. The boundary between above two current moves as illustrated in Fig. 44, which also indicates the move-

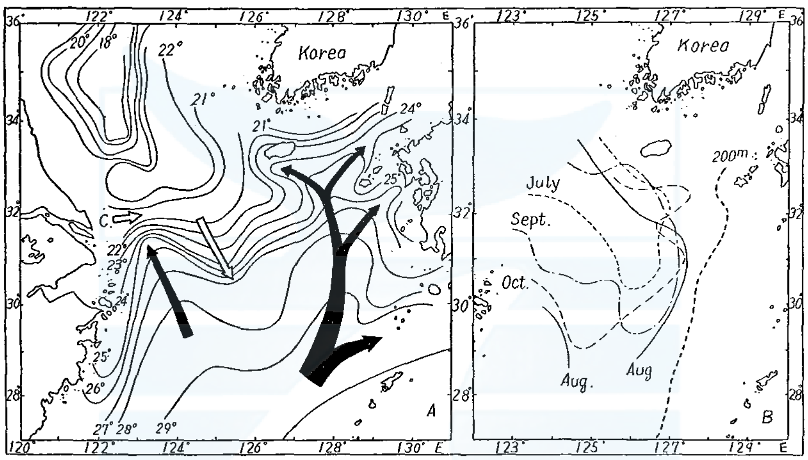


Fig. 44. A example of oceanographical condition and the distribution of the water convergence in the east China sea in summer, A—water currents and distribution of surface water temperature, Black—warm current, White—cold current, C—cold coastal waters. B—the center line of the water convergence in each month.

ment of favourable feeding position of whales. This means the movement of the swarms of *Euphausia pacifica* by the current as much as physical condition of *E. pacifica* to come up to the surface waters.

The summer remainder of baleen whales in the low latitudes is also observed especially among humpback whales in the Indian ocean (Brown, 1957), and in the summer season of the southern hemisphere. Rouqual whales in his report may be warm water living Bryde's whales, but some occurrences of fin whales may be probable like the East China sea.

Winter catch. The winter catch of fin whales in the both side of the Pacific ocean is also should be considered to get the exact distribution of fin whales in Ocean. Up to now, very few fin whales have been caught in the southern Pacific Ocean. Namely only 7 fin whales have been caught in the winter season in the Bonin Island waters, and none in the Formosa waters (Omura, Nishiwaki, Fujino & Kimura 1957) according to

Kasahara, 1950, 1 fin whales was caught). The catch of fin whales in the Lower California along the American coast had been also very scarce in number. These catch results suggest that fin whales in the Pacific seem not to enter the subtropical waters of 25°N latitude and further south waters or perfectly disperse in the subtropical waters not to access the coastal waters of islands and continents.

In the southern hemisphere, however, Moerch (1911) states that the great number of fin back whales congregate on the waters along the Brazil coast between 12° and and 18° south latitudes during the period from May to November. This winter catch of southern hemisphere is observed at the whaling stations of South Africa, but they are situated at about 30° south latitudes.

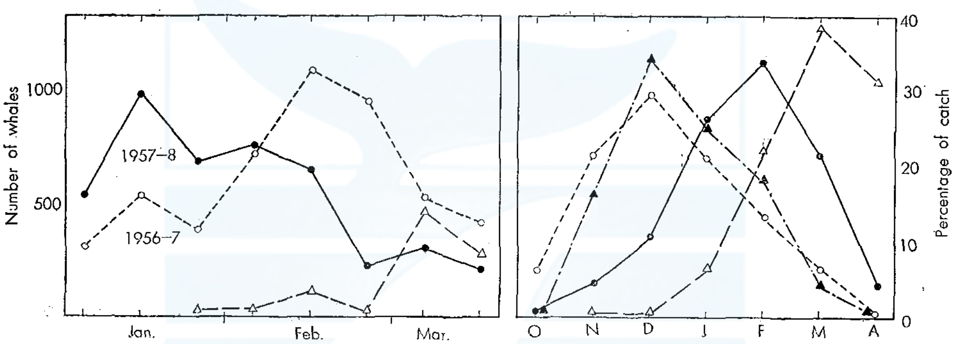


Fig. 45. Monthly catch and monthly percentage of baleen whales in the Antarctic waters. Left—Catch by Japanese operation in the Antractic waters. Solid line and symbol—Fin whales in 1957–8 season in the Antarctic area VI. Dotted line and open symbols—Fin whales in 1956–7 season in the Antarctic area VI. Chain line and triangle symbol—sei whales in 1957–8 season.: Right—monthly catch percentage in the Antarctic waters from 1927–35. Open circle—Blue whale, solid circle—Fin whales, Solid triangle—Humpback whale, Open triangle—Sei whale.

Antarctic waters. In the Antractic waters, the four large baleen whales have been caught by pelagic whaling operations, but fin whales have been the main catch in recent operations. And as the whaling regulation restricts the commencement of the catch of baleen whales, I would consider that the real migration of baleen whales should refer to the catch statistics of old operation in the Antarctic.

Mackintosh discusses (1942, p. 270) the monthly species ratio in the Antarctic as well as in the waters of South Georgia. According to his explanation, it is clear that there are some difference among the arrivals of baleen whales. Blue and humpback whales migrate to the antarctic waters earlier than fin whales, and sei whales come in the late of the summer season. Based on the old seasons' catch between 1927 and '35, the catch percentage of each whales species from October to April shows said clear tendency. Humpback whales seems to migrate to the Antarctic waters a little later than blue whales from the statistics. About the catch of the South Georgia waters, Mackintosh (1942) states the yearly change of migration of blue and fin whales referring Harmers' discussion (1941, South whaling. Proc. Linn. Soc. London, p. 69–83). This oceanographical change bears apparently the influence to migration of whales. Japanese operation in the whaling ground of the former sanctuary, that is the Antarctic area VI, also proves the yearly change. Fin whales have been caught mostly in February like the result in 1956 and 1957 season. But the height of the catch is observed in January in 1957 and 1958 season when the catch of fin whales decrease in the late of the season in March.

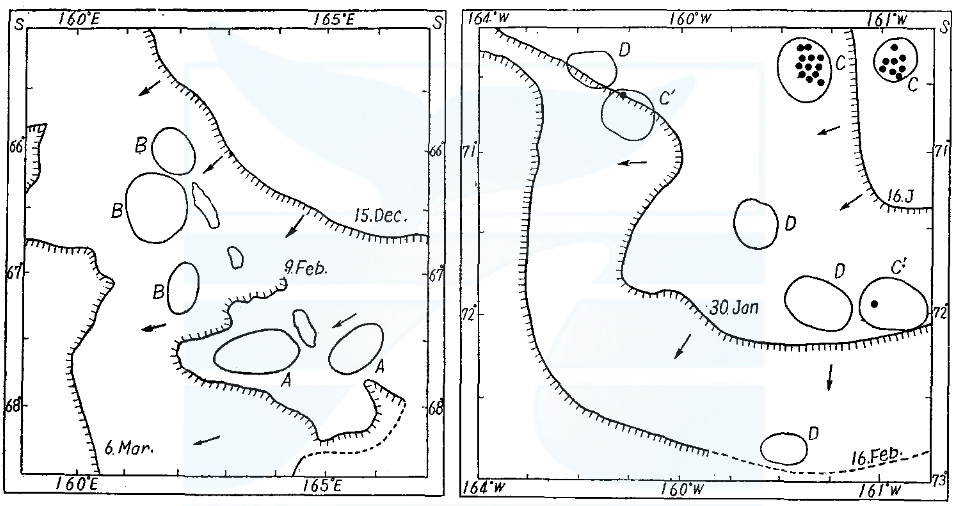


Fig. 46. Two examples of the distribution of pack ice line and food euphausiids. Left—whaling ground near Baleney Islands. A—whaling ground of Blue whales feeding the swarms of 1 year group of *Euphausia superba*. B—whaling ground of fin whales feeding 1 year group of *E. superba*: Right—C—whaling ground of fin whales consists of 1 and 2 year groups of *E. superba*. D—whaling ground of fin whales due to 1 year group of *E. superba*. Arrows show the retreat of the pacle ice lines. Lines and date show the distribution of pack ice lines in the date.

In the latter whaling season, many sei whales were caught in March, but not in the earlier season of January and February, which is the same tendency as the usual year.

The ' balance ' among whales should be considered to get the exact distribution of baleen whales. Fin whales come to the Antarctic waters after the height of blue and humpback whales, and sei whales come after the height of fin whales in general. The recent abundant catch of sei whales in the Antarctic partly may be due to the decrease of blue and fin whales by recent whaling operations as well as the oceanographical conditions.

If the waters where the swarm of *Euphausia superba* is abundant are occupied by the early comer of whales. The followers were seem to be obliged to seek their food in other waters. Of course their favorite foods in the North Pacific are so different that the baleen whales may congregate to different waters according to the distribution of food species. But the food of blue and fin whales in the Antarctic is mainly *Euphausia superba* in common, and the segregation of distribution of above two whales in the Antarctic is directly considered to be due to the occupation of favorite waters by the difference of coming and biological strength.

The segregation of fin whales in the Antarctic into some groups is already suggested by Hjort, Lie & Ruud (1933) and Mackintosh (1942, p.

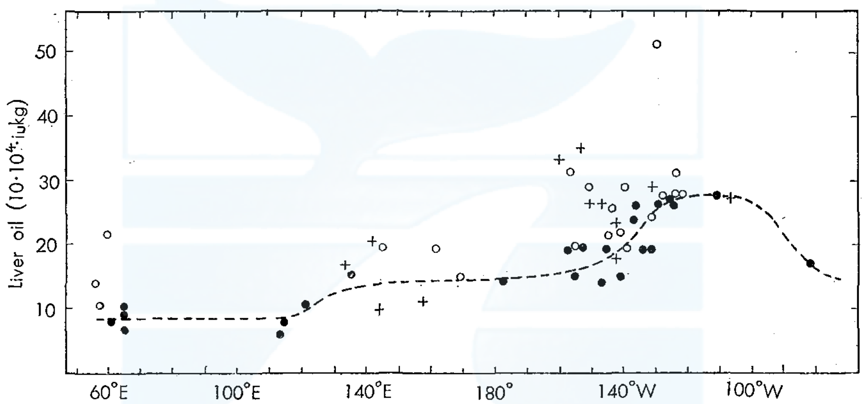


Fig. 47. Vitamin A products from the whales' liver extract by Japanese whaling expedition in the Antarctic waters in 1958. Solid circle—January, Open circle—February, Cross—March. Dotted line shows average curve in January.

258), and recent interesting results of whale marking compiled by Brown (1954) also subscribe that many fin whales are shown to return from their migrations year after year to somewhere near the place where they were marked. The evidences that the range of dispersal in fin whales appear to be limited to within 50° east or west and the dispersal is not necessary progressive are also considered to show the segregation to some extent. The body length at the sexual maturity is considered to be also somewhat different in the certain Antarctic areas (Purves & Mountfort, 1959).

Japanese whaling operations usually make vitamin A oil from the liver of baleen and sperm whales. The concentration of vitamin A extracted from the liver differs very much in each Antarctic area and month. In the western waters of Japanese operation in the Antarctic, the value of vitamin A in the liver oil is very low showing about $10 \cdot 10^4$ in 1 kg.

The value is nearly the same in the Antarctic area IV, and considerably higher in the Antarctic area VI and I of former sanctuary, where *Thysanoëssa macrura* has been observed in the stomachs of baleen whales as a staple food. As a simple and bold explanation, the vitamin concentration may be due to the difference of the vitamin concentrations between *Euphausia superba* and *Thysanoëssa macrura,* as the difference among the vitamin A concentration of *euphausiids* is already observed (Fisher, Kon & Thompson 1955). These differences of the vitamin A concentration of whales' liver suggest the local stocks of the fin whales in the Antarctic like the iodin value of whale oil differing in each Antarctic area (Lund, 1952). As the fatty acids of components of whale oil of the northern part of the North Pacific also differs from those of the Antarctic waters (Saiki & Mori 1956 ; Saiki, Shin-chen Fang & Mori 1959), the physical condition affected by food must be considered to suggest the food on which they feed.

A example of the local movement of fin whales in 1958 in the Antarctic waters is following. The whaling ground in the Antarctic waters is much affected by the distribution of pack ice, and baleen whales can feed on euphausiids smarming mainly in the near waters of the pack ice. In the early time of the Antarctic summer, the patch of *Euphausia superba* of 2 years group already appears along the pack ice, and is copulating and feeding in the surface. These patches consisting of 2 years group *Euphausia superba* are left with the advance retreat of the melting of pack ice. The comparatively late commer fin whales feed on the left patches of swarming of *E. superba* in the off waters which is illustrated in Fig. 46. The C whaling grounds in Fig. 46 are found in the waters where the pack ice was prevailing still on 16th January in 1958.

After the lapse of 10 days, the pack ice line retreats to the south west in fairly rapid speed. The patch of *Euphausia superba* has been observed in the C waters in the middle of February, but no fin whale migrates to the waters at that time. After the first observations of Euphausiid patch, fin whales come to the waters in the late of February. The difference in day is about 7 days or one decade. In the late of February, the pack line far draws to the maximum retreat, and fin whales also feeding on the swarms of 1 year group distributing in the waters of the pack ice line of 30th January. In the C'waters both 1 and 2 years groups of *Euphausia superba* are found in the stomachs of whales caught in the waters, but the adjacent whaling ground to C' waters consist of 1 year group of *Euphausia superba* only. The same kind of whaling ground consist of 1 year group of *Euphausia superba* is also observed along the most retreated pack ice line. These waters attract many baleen whales from the middle of February to March, which is apparently one evidence that the swarms of 1 year group *Euphausia superba* make the main food of baleen whales in the latter of the summer. In the C whaling ground, many fin whales come to the waters with the delay of 5 days after the swarms of patch is observed. Arseniev (1957) states the same observations with regard to the distribution of the patch of *Euphausia superba* and whales. Many schools of baleen whales usually congregate to the waters where many patchs of *Euphausia superba* have been observed. And there is a direct relation between the school of baleen whales and the distribution of food patchs. The next illustration is shown also in Fig. 46. In 1958, a Japanese whaling expedition operated in the waters of adjacent to Baleny Islands. The pack ice line in pre-whaling season of 15th December lies still closing the Islands, but on 9th February, the pack ice line retreats making the inlet of pack ice where the abundant of *Euphausia superba* of 1 year group is swarming, many blue whales are observed staying and feeding there for half a week in the early of February. The pack ice line retreats further in a week, and many swarms of *Euphausia superba* observed in the waters between the pack ice and Baleny Islands.

Fin whales have been congregating to the waters for half a month after the melting of ice, and they become a large group consist of many schools of fin whales. These two cases may be a illustration of distributions of whales in the Antarctic in summer. Like the northern Pacific waters, where there is a food, there come many whales. But blue and fin whale do not seem to be mingled so closely with each other as it is shown in the above illustrations.

Seasonal and local changes in compositions of fin whales. Mackintosh (1942, p. 259) discuss the seasonal change in the local composition of the stock of Antarctic baleen whales, and it shows a general comprehension about the mode of the migration of whales. As it is illustrated in Fig. 45, each species ratio shows very particular tendency in the Antarctic waters. But in the northern part of the North Pacific these seasonal change in monthly species ratio has not been observed typically. On the contrary to the fact in the Antarctic waters, fin whales come earlier than blue whales in the western part of the northern part of the Pacific in ' *Calanus* year ', which is apparently due to the feeding condition. However, fin whales come earlier than sei whales in the feeding area of the northern part of the North Pacific as a general result like the Antarctic.

Up to this time, the difference in the sex ratio with the advance of seasons has not been clearly observed in the North Pacific, but males of fin whales are rather less in number in the early season of May.

The number of male fin whales become gradually dominant in the latter part of the season, and males are dominant in the total sex ratio of fin whales (Ohsumi, Nishiwaki & Hibiya, 1958, Table 1). But such tendency is not observed in some years and localities. For example, males do not become dominant in the latter part of the season in 1953, but the fluctuation of male occurrences were observed throughout the season. In the Antarctic waters, male fin whales also increase from January to February, but decrease again in March in the whaling area VI from 1956 to 1958 (Ohsumi, 1959). This has also been observed in the area I as illustrated in Fig. 48.

As a general tendency in the Antarctic areas, there is a marked change in the summer season in the percentage of adult females which

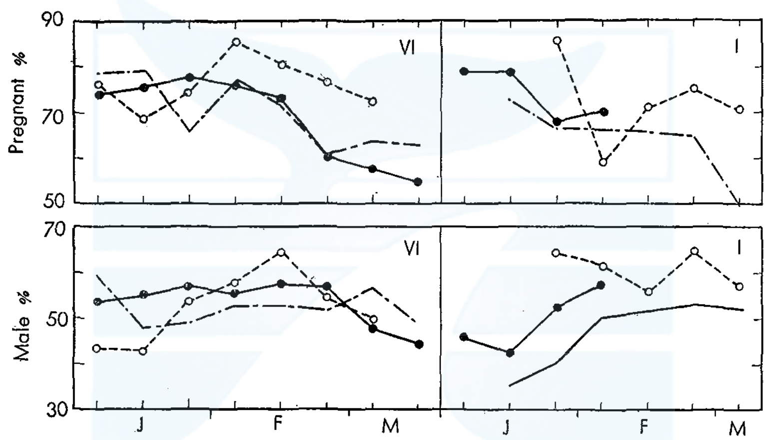


Fig. 48. Catch percentage of pregnant female and male of fin whales caught by Japanese operations in the Antarctic areas of VI and I from 1955 to 1958 seasons. Dotted line and open symbol—1955–6 season, Solid line and black symbol—1956–7 season; Chain and solid line without symbols—1957–8 season.

are pregnant (Mackintosh, 1942). Usually pregnant females decrease in number with advance of the season as illustrated in Fig. 48. This tendency has also been obtained in the northern Pacific in some years though it is not so typical as in the Antarctic waters. In the northern part of the North Pacific, near Bering sea, the pregnant female is considered to congregate in the southern waters and the pregnant percentage of female fin whales declines a little in the latter part of the summer season. But the local difference in the occurrence of pregnant female of fin whales shows the very reverse in 1958. Almost female fin whales caught in the waters off Kamtchatka Islands show the pregnant percentage of 77 and those caught in the center of the Bering sea show 44 percent in 1957. The successive operation in 1958 shows the following figures. Pregnant percentage of 70 in the waters off Navarin cape and about 55 percent in the waters off Kamtchatka Peninsula. Above fact will indicate that the migration of pregnant fin whales is rather elastic in the northern part of the North Pacific mainly according to the complicated shape of the sea surrounded by lands and Islands.

Generally speaking, Antarctic feeding grounds are situated high latitudes and colder than those of the northern part of the North Pacific. The decline of the pregnant female in the Antarctic may be due to the start of female fin whales with larger foetuses to the breeding areas for parturition (Laws, 1959). In the northern part of the North Pacific, fin whales still may be able to remain in the waters in the latter part of the seasons, because the water temperature is not so severe as in the Antarctic feeding area.

There is another tendency that the immature whales become comparatively numerous in the latter part of the season in the Antarctic waters (Mackintosh, 1942, p. 274), which is also observed in the recent Japanese operations also in the Antarctic areas of the former sanctuary. In the northern part of the North Pacific, however, the distribution of immature fin whales show the local differences. The sexual immature fin whales congregate most typically in the north waters of the eastern Aleutian Islands. On the other hand the number of immature fin whales is less in the waters off Navarin and Kamtchatka peninsula. Further the age compositions of fin whales in those waters vary through the season, but the mature whales become dominant in the latter part of the season. The south waters of the eastern Aleutian Islands show the lower catch of immature fin whales than the north waters, which indicates that the northern part of the eastern Aleutian Islands is the center of the congregation of immature and younger fin whales in the northern part of the Pacific,

These fragmental informations also demonstrate the general conclusion that the seasonal and local composition of fin whales in the northern part of the North Pacific is rather elastic and it needs further accumulation of materials before any conclusions are obtained. I would treat the problem in the coming report in future.

School of fin whales. The school of fin whales are also examined according to the observation of operations and whale marking cruises. Examples both in the Antarctic and the North Pacific are given in Tables 41 and 42, The single swimming and pair swimming fin whales are dominant in May, and schools consist of more than three fin whales are rather few in number. With the proceeding of the month, single fin whale become scarce and the rate of schools consisting of two and three fin whales become dominant. This fact seems to show fin whales of the early migration make couple or trio in the feeding grounds. There may be another explanation that the school consisting of more than two whales may migrate in the feeding ground later or the single whale comes earlier. I would consider, however, the former explanation is probable according to the other observation by Japanese expeditions. In the Antarctic waters, Japanese whale marking cruises observe the number of fin whales in a school as described in Table 41. As these marking observations

TABLE 41. NUMBER OF FIN WHALES IN A SCHOOL OBSERVED BY JAPANESE AND NORWEGIAN WHALE MARKING CRUISES IN THE ANTARCTIC WATERS FROM 1955 TO 1958

Cruise	Number of whales in a school									
	1	2	3	4	5	6	7	8	9	10
Konan maru No. 12	25	12	5	1	1	1	1	—	—	—
Seki maru No. 16	27	24	10	4	10	3	1	3	0	2
Fumi maru No. 17	56	4	2	1	1	2	1	—	—	—
Kyo maru No. 5	3	6	2	2	2	—	1	—	—	—
Enern	22	34	19	7	5	2	1	—	—	—

TABLE 42. NUMBER OF FIN WHALES IN A SCHOOL IN THE NORTHERN PART OF THE NORTH PACIFIC, OFF WATERS OF KOMANDORSKII ISLANDS

	Number of whales in a school								
	1	2	3	4	5	6	7	8	9
May	58	64	18	5	7	1	1	—	—
June	135	190	64	14	6	4	—	—	—
July	40	86	49	10	6	—	—	1	—
Aug.	26	78	44	5	4	—	1	1	1

TABLE 43. COMPOSITION OF SCHOOLS OF DIFFERENT SPECIES, BLUE AND FIN WHALES OBSERVED BY JAPANESE WHALE MARKING CRUISES IN THE ANTARCTIC FROM 1957 TO 1958

	Blue	Fin	Blue	Fin	Blue	Fin	Blue	Fin	Blue	Fin
Number of whales	1	1	1	3	1	4	2	4	2	Ca 10
Estimated length of whales in feet	62	71	72	63-65	80	65-67	73	64-65	60	70
Total number of whales in a school	2		4		5		6		Ca 12	

have been carried out in advance of the commencement of the catch of baleen whales, the results demonstrate the predominance of a single and couple swimming fin whales alike in the northern Pacific waters.

The result by 'Konan-maru No. 12' and 'Seki-maru No. 16' were obtained in 1955 to 1956, which shows the rather related tendency. But that by Fumi-maru No. 17 in 1956–57 clearly shows the excessive predominance of single swimming fin whales. These facts also seem to suggest the coming time of fin whales to the Antarctic waters. In the whaling season 1956–57, the whaling operation observed the late coming of fin whales in the Antarctic area of VI and I. The catch result illustrated in Fig. 43, also endorses the fact. The next season in 1957 and 1958, fin whales come earlier to the Antarctic area I and VI as given by the same Fig. 43. The exact observation on the constitution of fin whales is, however, only given by a catcher boat 'Kyo-maru No. 5' on which I was board. The data are so few that I can not draw any definite conclusion here, but I would consider the single swimming fin whale is dominant in the earlier time of the Antarctic summer according to other observation throughout the season,

The interesting fact that fin whales make a school with other blue whales have also been observed in the Antarctic. I noticed five schools consist of blue and fin whales. The estimated size of whales' body gives us the impression that comparatively small blue whales swim along with the moderate fin whales. The number of blue whales are always the same or less than that of fin whales as described. The smaller size immature blue whales may not have special characteristics of species, and migrate along with the fin whales of different species. The fact will add something to the consideration of 'balance of whales' that the strength of each species will develop especially after the attainment of the sexual maturity.

Diatom infection. Hart (1935), Karcher (1940) and Omura (1950, a) consider that the whales with heavy diatom infection must migrated to the Antarctic waters earlier than those without the infection, and the habit of making school in fin whales is a favorable infectious condition for diatom films. The main parasitic species of diatom infection is *Cocconeis ceticola* Nelson both in the Antarctic and in the North Pacific. As *Cocconeis ceticola* has not been found among planktons and on other things than the skim of whales, *Cocconeis ceticola* is considered the real parasitic diatoms and not holophitic. The variation of *C. ceticola* varies according to the host species of whales (Nemoto, 1958). With regard to the other species of infections diatoms, *Stauroneis*, *Navicula* and *Gomphonema* diatoms are considered to be real parasitic diatoms. But these species will not indicate the migration course or stage of whales in migration so satisfactory as *Cocconeis ceticola* (Nemoto, 1956).

The whales with heavy diatom is considered to migrate to the high latitudes of cold waters earlier than those without the diatom infection or have a chance to be infected. But the chance of being infected by diatoms is not so common for every fin whales. This mean the case that fin whales early migrated to the high latitudes have not been infected by the diatom patches, and the late comer which has the direct chances of infection bears heavy diatom patches.

Examples for these propagation of *Cocconeis ceticola* and the migration of fin whales in the northern part of the North Pacific are summarized as follows.

1, In 1952, the percentage of infection shows the minimum degree in the late and middle of the August when the ratio between body length and thickness of blubber also decreases mostly. This would indicate the migration of lean fin whales of new coming to the waters.

2. In 1953, the same tendency that the number of fin whales with heavy diatom infection vanish in the late of August, and the whales with heavy diatom infection have thick blubbers in general. But in the early season of May and June, fin whales without diatom patches also have rather thick blubbers.

3. In 1954, the whaling operation had covered the broader area. And the result obtained in the year shows that the fin whales caught in the north waters of the eastern Aleutian Islands demonstrate the high percentage of infection, and no decrease in the late of August. In the south waters of the eastern Aleutian Islands, the infection percentage is very low in May and rapidly increase with the advance of seasons in June and July.

After July, the percentage of infection is higher in the eastern waters than in the western waters.

4. The infection percentage in 1955 is comparatively higher from the early season of whaling, and fin whales in the north waters of the eastern Aleutian Islands show no difference from those west waters in the infection percentage. And there is no seasonal change throughout the season.

5. In 1956, the diatom infection percentage is also higher among the whales in the north waters of the eastern Aleutian Islands. The infection percentage of diatoms increase with advance of the whaling season, but the decrease of number of fin whales with heavy diatom infection is also observed in August.

As a probable conclusion, fin whales come to the Aleutian waters from May, and many fin whales migrate to the waters by July. The school of fin whales are feeding on the food planktons and make northward movements. If the food become scarce in sometimes, whales move to other waters at once. The decrease of number of whales with heavy diatom infection in the off water of Kamtchatka Islands in August may be due to the change of migration of whales owing to the scarcity of food planktons as I said in the former part. In the north waters of the eastern Aleutian Islands, the food is comparatively much and fin whales are congregated in the waters throughout the summer season. Thus it is considered that the high percentage of diatom infection is obtained. The school of fin whales with heavy diatom infections will indicate the difference of the stage of movement for feeding from those with few diatom infection.

In the Antarctic waters these observations of diatom infection by Japanese investigations also have been carried out and the results have been published in former reports (Omura, 1950 a, etc.). I found very characteristic tendency that the fin whales which had been feeding for long time in the definite school were infected with heavy diatom films.

The school of fin whales caught at the waters of B whaling ground in the left figure of Fig. 46 in 1958, and those whales were considered to feed on 1 year group of *Euphausia superba* for a long time, as fin whales caught in the near waters were different in the stage of diatom infection. Some of the latter school of fin whales lacked completely the diatom infection. Other biological characters such as the thickness of blubber endorse the above suggestion. So it is very important to treat the diatom infection on whales in the Antarctic separately in each whaling ground. The summarizing of the data may cause very elastic conclusion.

Thus the infection of *Cocconeis ceticola* indicates the stage and condition of migrations of baleen whales to some extent, but the following point should be considered to get the more definite conclusion.

a. As the observation on the diatom is made by the naked eyes infection, it is not so stable that the data of stage of infection may be uncertain in some cases.

b. It is not certain that *Cocconeis ceticola* propagates on the body surface of whales from spore or a cell in what speed. On the point, Hart (1935) considers it takes about a month that the diatom film propagate on the surface of the body of whales by observations of sei whales in the waters of South Georgia. But I would consider that the time is shorter than a month by other observations on the propagation of marine diatoms.

c. The seasonal prosperity and decay may be observed also among the propagations of parasitic diatoms. The height of the propagation of diatoms is considered in spring and autumn in the sub-Arctic and Antarctic waters, but the height is concentrated in the summer in the high latitudes. The fact would indicate the decrease of infection percentage in the middle of the season in the comparatively lower latitudes.

d. The chance for the infection of *Cocconeis ceticola* is not similar for each school of whales. For example some whales without diatom infection have very fat body with heavy thickness of blubber. On the other hand very lean whales with new half healed open pits sometimes bear diatoms infections.

e. The diatom film of dead *Cocconeis ceticola* is also found on the body surface of whales, which is very difficult to be observed. The case show a indication of probable decrease of the infection percentage in the latter part of the propagating season.

f. In the adjacent waters to Japan, the diatom infection is only observed on fin whales in high percentage in the Okhotsk sea, and whales in other waters show very few infection of diatoms. As the towing of whales in the long run cause the coming off of diatom films completely, and above fact is apparently due to the long towing of whales, because the whaling ground in the Okhotsk sea is comparatively near the land-station, but those of other waters is in the off waters.

SUMMARY

The present paper is described mainly on Japanese investigation on whales both in the Antarctic and in the North Pacific after the year 1945. And two subject of food of baleen whales and the movement of whales are discussed, but the biology of food planktons is omitted in this paper. The essential points are described follows.

1. The feeding apparatus of baleen whales and preferences for foods are discussed. Baleen characteristics such as number, shape and fringe of plates are examined according to former published reports and the preserved specimens. These characteristics show the four types. Those are blue whale, sei whale, right whale and gray whale types. The type of sei whales is included in blue whale type in one point, but is also included in right whale type in another point.

2. The summarized description on head, mouth, tongue and ventral grooves of whales body is described in order to get the comprehension of feeding of baleen whales. These body structures are also divided into above four types.

3. The Antarctic large baleen whales feed heavily on *Euphausia superba*. But blue and fin whales also feed on *Thysanoëssa macrura* in the waters of former sanctuary. Sei whales take *Parathemisto gaudichaudi* favorably, but other blue, fin and humpback whales never take it as a main food. Fish and squids are considered to bear no importance for baleen whales in the Antarctic.

4. Feeding percentage of baleen whales is high in the morning and in the evening in general. The percentage is higher in humpback and blue whales than in fin and sei whales.

5. The growth of *Euphausia superba* described according to the locality and distribution of the pack ice. *Euphausia superba* in the low latitudes or in the early ice melting waters grow more rapidly and in advance

of the late ice melting waters. But there is no difference in the relation between body length and weight of *Euphausia superba* in each locality.

6. The main foods of baleen whales in the northern part of the North Pacific are described with successive investigations after 1956. These are as follows:

Blue whale	euphausiids
Fin whale	euphausiids, copepods, swarming fish
Sei whale	copepods
Humpback whale	euphausiids, swarming fish

7. Five species of euphausiids are found in the stomachs of baleen whales in the northern Pacific. *Euphausia pacifica, Thysanoëssa longipes, T. raschii, T. inermis* and *T. spinifera* are those species.

8. Two copepods, *Calanus cristatus* and *Calanus plumchrus* are also described as main foods of baleen whales. *Calanus cristatus* is important for fin whales and *C. plumchrus* is important for sei whales.

9. Swarming fish, herring, Alaska pollack, capelin, Atka mackerel and saury are fed by fin, humpback and sei whales. A squid, *Ommastrephes sloani pacificus* is sometimes fed by sei and fin whales.

10. There are annual changes among the abundances of foods and the distribution and fluctuation of foods which influence the migration and movement of baleen whales in the North Pacific. These problems are discussed to some extent in the paper.

11. There are 'Calanus year' and 'Euphausiid year', in the adjacent waters to Aleutian Islands and the South Bering Sea.

12. The quantity of stomach contents in the northern part of the North Pacific is examined. Humpback whales usually take more abundant food than sei and fin whales like whales in the Antarctic waters.

13. Along the coast of Kurile Islands, baleen whales also feed on planktons, *Thysanoëssa longipes, T. raschii, T. inermis, Calanus cristatus* and *C. plumchrus. Thysanoëssa raschii* in the Kurile waters should be noted. Squids and swarming fish are found in the stomachs of baleen whales and these names are described.

14. Fin whales in the Okhotsk sea feed on mainly euphausiids, *Euphausia pacifica, Thysanoëssa inermis, T. longipes* and *T. raschii.* Little piked whales are also feeding on *Euphausia pacifica* in the coastal waters. Some other fish, sand lance, herring, cod and Alaska pollack are found in the stomachs of both species of whales.

15. In the Japanese main shore whaling grounds in Sanriku and Hokkaido, the food of sei whales are euphausiids, fish and squids. The species of euphausiids are *Euphausia pacifica, Thysanoëssa longipes* and *T. inermis* in the Hokkaido waters, and *Euphausia pacifica* in the Sanriku waters. Among the fish, anchovy, sardin, mackerel and saury are

the most important species. Anchovy is dominant in the early season and saury is dominant in the latter season of the waters. Squid (*Ommastrephes sloani pacificus*) is also important in the Sanriku and Hokkaido waters. Some occurrences of *Calanus* copepods are also suggested.

16. Bryde's whales in the Wakayama waters take a euphausiid *Euphausia similis* and anchovy, and the latter is dominant in June and July. Bryde's whales in Bonin water take also *Euphausia similis* and *Euphausia recurva*, Myctophid and Gonostomid fish (*Yarrella microcephala* and *Myctophum asperum*). In the catch of probable sei whales from December to April, the occurrence of some copepods is considered.

17. In the East China sea and west Kyushu area, fin whales feed on a euphausiid *Euphausia pacifica*. Bryde's whales caught along the west coast of Kyushu feed on anchovy and horse mackerel dominantly.

18. Foods of baleen whales in the other part of the world are described according to published papers. The foods of baleen whales in the subtropical waters and the North Atlantic need further investigations.

19. Basing on the data of stomach contents of baleen whales, the distribution of euphausiids is discussed. New consideration on the distribution of the spineless form of *Thysanoëssa longipes* and one and two spine form of *Thysanoëssa inermis* is suggested.

20. Feeding habit of baleen whales is examined. Swallowing and Skimming types are considered as feeding types of baleen whales. Blue, fin, Bryde's, little piked and humpback whales are Swallowing type and right and Greenland whales belong to Skimming type. Sei whales take above two feeding methods in general.

21. These feeding types of baleen whales show some effect on the selection or preference for their food. These subjects are discussed and the examples are given in the paper. The favourite food of baleen whales differ in the local waters, in each whale species, and there are selection orders among foods. These feeding types are described on each species.

22. Food patchs also have characteristic features, which affect the feeding of baleen whales. The congregation, diurnal migration and inhabiting depth of food planktons and fishes are the main factors to have relations to the feeding habits of whales.

23. Feeding activity is considered to be active in the morning and in the evening in baleen whales of euphausiids feeder. In the shallow water regions, the feeding activity is still high in the daytimes. Squids are also fed mostly in the morning and in the evening, but *Calanus plumchrus* is fed still in daytimes at the surface of the sea.

24. The exact weights of the stomach contents of fin whales are obtained in the northern part of the North Pacific. Fin whales take foods

about 100 kg to 700 kg in the full stomach condition in the North Pacific. Bryde's whales also take foods from 100 to 200 kg in the adjacent waters to Bonin Islands and sei whales take foods from 100 to 400 kg in the Kurile Island waters.

25. The distribution of baleen whales in the North Pacific is discussed considering the catch of each whaling center and the shape of the sea. Baleen whales migrate and distribute in the sea according to the shape of the sea. These distributional types are 'ocean denizen' (blue, sei and Bryde's whales), 'ocean and marginal sea denizen' (fin, right, little piked and grey whales) and marginal sea denizen (Greenland whale). Some oceanographical conditions are examined to make general comprehension of the distribution of baleen whales and special characteristics of whaling grounds.

26. Migration and movement of sei and Bryde's whales are examined and discussed by the catch statistics and whale marking research. The migration and the movement of Bryde's whales cover tropical, subtropical and warm temperate waters more than 20°C and never go down to waters under 15°C.

27. Sei whales are considered to be also warmer water species than other blue, fin and humpback whales. The movement of sei whales in the adjacent waters to Japan has close relation to the oceanographical conditions and the distribution of their foods. The probable segregation in the composition of migrational herds of sei whales is suggested both in the Antarctic and in the North Pacific.

28. Seasonal movement and distribution of fin whales in the North Pacific are discussed basing on the data of the food distribution and catch statistics. The clear movement of fin whales in the northern part of the North Pacific following the favorable feeding area is described. A local group of fin whales in the east China sea, which does not migrate to the higher latitudes is suggested by the catch statistics and other biological characters.

29. The results of Japanese marking research on fin whales in the northern part of the North Pacific are examined in view of the seasonal movement. The term 'dispersive movement' is used and discussed to describe the movement of fin whales in the northern part of the North Pacific. But the marking research in the waters needs further investigation to reach the definite conclusion.

30. The segregation in the migration of fin whales is examined by sex, age, pregnancy and maturity of whales and physical condition of whales, and those physical factors have close connection with the migrational segregation of whales in the feeding area.

31. The diatom infection is examined to study the migration of whales,

and it is considered not to show the typical indication of the stage of migration, but the infection shows some indication about the migration of whales.
32. It is desirable to accumulate the further collection of data on foods of whales and the whale marking research to get the definite information of whales' migration. And it is hoped to examine foods of baleen whales in many localities of whaling grounds in the world in connection with the oceanographical conditions for some years.

REFERENCES

ABE, T. (1957). Notes on fishes from the stomachs of whales taken in the Antarctic. 1. *Xenocyttus nemotoi*, a new genus and new species of zeomorph fish of the subfamily *Oreosominae* Goode and Bean, 1895. *Sci. Rep. Whales Res. Inst.*, no. 12: 225–32.

ANDREWS, R. C. (1909). Observation on the habits of the finback and humpback whales of the eastern north Pacific. *Bull. Amer. Mus. Nat. Hist.*, 36: 213–26.

——— (1914). Monographs of the Pacific cetacea. 1. The California gray whale (*Rhachianectes glaucus* Cope). *Mem. Amer. Mus. Nat. Hist.*, N. S. 1(V): 231–84.

——— (1916). Monographs of the Pacific cetacea. The sei whale (*Balaenoptera borealis* Lesson). *Mem. Amer. Mus. Nat. Hist.*, N.S. 1(V): 293–387.

ARSENIEV, V. A. (1957). Distribution of feeding grounds and concentrations of whalebone whales in the Antarctic. *VNIRO Transactions*, 33: 96–100.

BAKER, A. de D. (1954). The circumpolar continuity of Antarctic Plankton species. *Discovery Rep.*, 27: 201–18.

BANNER, A. H. (1949). A Taxonomic Study of the Mysidacea and Euphausiacea (Crustacea) of the Northeastern Pacific (Part III). *Trans. Roy. Canad. Inst.*, 28(58): 1–56.

BARGMANN, H. E. (1945). The development and life-history of adolescent and adult Krill, *Euphausia superba*. *Discovery Rep.*, 23: 105–32.

BARKLEY, E. (1940). Nahrung und Filterapparat des Walkrebschens *Euphausia superba* Dana. *Zeitschr. f. Fish. u.d. Hilfwiss. Beih.*, 1: 65–156.

BETESHEVA, E. I. (1954). Nekotoryye dannyye o pitanii usatykh kitov v rayone Kuril'skoy gryady. [Data on the feeding of baleen whales in the Kurile region.] *Trans. Inst. Oceanogr. Acad. Sci. USSR*, 11: 238–45.

——— (1955). [Food of whalebone whales in the Kurile Islands region.] *Trans. Inst. Oceanogr. Acad. Sci. USSR*, 18: 78–85.

BODEN, B. P., JOHNSON, M. W. & BRINTON, E. (1955). The Euphausiacea (Crustacea) of the North Pacific. *Bull. Scripps Inst., Oceanogr. Univ. Calif.*, 6(8): 287–400.

BOGOROV, B. G. (1958). Biogeographical regions of the plankton of the North-Western Pacific Ocean and their influence on the deep sea. *Deep-Sea Res.*, 5: 149–61.

BRODSKY, K. A. (1950). Calanoida of the far eastern and polar seas of the USSR. *Fauna of the USSR*, 35: 1–442.

BROWN, S. G. (1954). Dispersal in blue and fin whales. *Discovery Rep.*, 26: 357–78.

——— (1957). Whales observed in the Indian Ocean. *Marine Observer*, 27: 157–

CAPEILINI, G. (1877). Della balena di Taranto, confrontata con quelle della Nocovo zelanda e con talune fossili del Belgio e della Tascana. *Mem. Roy. Accad. Sci. Bologna*, 3(8): 3–32.

CHITTLEBOROUGH, R. G. (1953). Areal observations on the humpback whale, *Megaptera nodosa* (Bonnaterre) with notes on other species. *Aust. J. Mar. Freshw. Res.* 4(2): 219–26.

——— (1959). *Balaenoptera brydei* Olsen on the west coast of Australia *Norsk Hvalfangst-Tid.*, nr. 2: 62–5.

CLARKE, R. (1954). Whales and seals as resources of the sea. *Norsk Hvalfangst-Tid.*, nr. 9: 489–510.

——— (1956). Sperm whales of the Azores. *Discovery Rep.*, 28: 337–98.

——— (1957). Migration of marine mammals. *Norsk Hvalfangst-Tid.*, nr. 11: 609–29.

COLLETT, R. (1911–2). *Norges Pattedyr* (*Norges Hvirveldyr I*). Kristiania.

CUSHING, D. H. & RICHARDSON, I. D. (1956). A record of Plankton on the echo sounder. *J. Mar. Biol. Assoc.*, 35(1): 231–40.

CROMWELL, T. (1956). What it seeks, and Where it fits into Practical industrial fishing. *Cont. Scripps Inst. Oceanogr.* 1197–99, *Pacific Fisherman* July.

DALL, W. & DUNSTAN, D. (1957). *Euphausia superba* Dana from a humpback whale, *Megaptera nodosa* (Bonnaterre), caught off southern Queensland. *Norsk Hvalfangst-Tid.*, nr. 1: 6–12.

DAWBIN, W. H. (1954). Personal communication.

EINARSSON, H. (1945). Euphausiacea, 1. Northern Atlantic species. *Dona Rep.*, no. 27: 1–185.

FISHER, L. R., KON, S. K. & THOMPSON, S. Y. (1955). Vitamin A and Carotenoids in certain invertebrates III. Euphausiacea. *J. Mar. Biol. Assoc. U.K.*, 34(1): 81–100.

FLEMING, R. H. (1955). Review of the oceanography of the northern Pacific. *Bull. Intern. North Pacific Fish.*, 2: 1–43.

FOXTON, P. (1956). The Distribution of the standing crop of zooplankton in the southern Ocean. *Discovery Rep.*, 28: 191–236.

——— (1936). On the Development and Distribution of the Young Stages of Krill (*Euphausia superba*). *Discovery Rep.*, 14: 3–190.

FRASER, F. C. (1937). see Norman & Fraser.

FUJINO, K. (1956). On the serological constitution of the fin whales. II. Further Studies on Blood Groups. *Sci. Rep. Whales Res. Inst.*, no. 11: 85–98.

GILMORE, R. M. (1955). The return of the gray whale. *Sci. Amer.*, 192(1): 62–6.

GUNTHER, E. R. (1948). The habits of fin whales. *Discovery Rep.*, 25: 113–42.

HARDY, A. C. & GUNTHER, E. R. (1935). The plankton of the South Georgia Whaling Grounds and Adjacent Waters, 1926–27. *Discovery Rep.*, 11: 1–377.

HARRISSON, T. & JAMUH, G. (1958). Pigmy sperm whale (*Kogia breviceps*) in Borneo. *Nature*, (4634): 543.

HART, J. T. (1935). On the diatoms of the skin film of whales, and their possible bearing on problems of whale movements. *Discovery Rep.*, 10: 249–82.

HIYAMA, Y. & YASUDA, F. (1957). The Methods of Utilization of Plankton by Fishes. *Rec. Oceanogr. Work Japan*, Sp. No. 1957: 67–70.

HJORT, J. & Ruud, J. T. (1929). Whaling and Fishing in the North Atlantic. *Rapp. Proc. Verb., Conseil. Intern. l'Exploration Mer.* 56:

HJORT, J., Lie, J. & RUUD, J. T. (1933). Norwegian Pelagic whaling in the Antarctic II. Hvalrod Ski. No. 7: 128–152.

HONJO, K. (1957). Distribution of Euphausiacea in the 'Kuroshio' Area, South of Honshu, May 1955. *Rec. Oceanogr. Works Japan*, Sp. No., 1957.

HOTTA, H. &. OGAWA, T. (1955). On the stomach contents of the skipjack *Katsuwonus pelamis*. *Bull. Tohoku Reg. Fish. Res. Lab.*, 4: 62–82.

HOWELL, A. B. & HUEY, S. (1930). Food of gray and other whales. *J. Mammal.*, 11(3): 321–2.

ICHIHARA, T., (1957). An application of linear discriminant function to external measurement of fin whale. *Sci. Rep. Whales Res. Inst.*, 11: 127–189.

INGEBRIGTSEN, A. (1929). Whales caught in the north Atlantic and other Seas. *Rapp. Proc. Verb. Conseil Intern. l'Exploration Mer*, 56.

INOUE, M. & OGURA, M. (1958). The swimming-water depth for anchovy shoals in Tokyo Bay. *Bull. Japan Soc. Sci. Fish.*, 24(5): 311–6.

IZUKA, A., KUROHAGI, T., IKUTA, K. & IMAI, T. (1954). Composition of the food of Alaska pollack (*Theragra chalcogramma*) in Hokkaido with special reference to its local difference. *Bull. Hokkaido Reg. Fish Lab.*, 11: 7–20.

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

JOHNSON, M. W. (1956). The plankton of the Beaufort and Chucchi sea areas of the Arctic and its relation to the hydrography. *Arctic Inst. North Amer. Technic. Pap.*, no. 1.

JONSGÅRD, Å. (1957). Some comments on W. Dall and B. Dunstan's Article of the find of *Euphausia superba* in a Humpback whale caught near South Queensland. *Norsk Hvalfangst-Tid.*, nr. 1: 10–12.

KARCHER, F. H. (1940). Uber den Algenbewnchs auf südlichen Walen *Z. Fish. Hilfwiss*, Beihefte 1: 13–36.

KASAHARA, H. (1950). [Whales and whaling in the adjacent waters to Japan]. *Rep. Nihon Suisan Co. Ltd. Inst.* no. 4. (In Japanese).

——— (1951). On the post-war whaling in the adjacent waters of Japan. *Bull. Jap. Soc. Sci. Fish.*, 17: 313–20.

KAWAI, H. (1955). On the polar frontal zone and its fluctuation in the waters to the north-east of Japan (1). *Bull. Tohoku Reg. Fish. Res. Lab.* 4: 1–46.

KAWAKAMI, T. & ICHIHARA, T. (1958). Japanese whale marking in the North Pacific in 1956 and 1957. *Norsk Hvalfangst-Tid.*, nr. 6: 285–91.

KAWAKAMI, T., OTSURU, K., WATASE, S. & IGUCHI, K. (1953). *Report on whale marking in Japan.* No. 4. Tokyo, Japanese Fisheries Agency.

KELLOGG, R. (1929). What is known of the migration of the whalebone whales. *Ann. Rep. Smithsonian Inst.*, 1928: 467–94.

——— (1931). Whaling statistic for the Pacific coast of North America. *J. Mammal.*, 12(1): 73–7.

KEMP, S. & BENNETT, A. G. (1932). On the Distribution and Movements of Whales on the South Georgia and South Shetland Whaling Ground. *Discovery Rep.*, 6: 167–90.

KLEINENBERG, S. E. & MAKAROV, T. I. (1955). *Kitoloinyi promysel Soretskogo Soiuza* [The whaling in USSR] Moscow.

KOMAKI, U. & MATSUE, Y. (1958). Occurrences and ecology of some important euphausiids in Tsushima current. *Rep. Ex. Tsushima Current*, 2. *Egg. larvae of Fish and Plankton.*

KUENEN, PH. H. (1950). *Marine geology*,

LAWS, R. M. (1959). The foetal growth rates of whales with special reference to the fin whale *Balaenoptera physalus* Linn. *Discovery Rep.*, 29: 281–307.

LUND, J. (1952). Iodine value charting of the whale stocks in the Antarctic in season 1951/52. *Norsk Hvalfangst-Tid.*, nr. 8: 426–9.

MACKINTOSH, N. A. (1934). Distribution of the Macroplankton in the Atlantic sector of the Antarctic. *Discovery Rep.*, 9: 67–158.

——— (1942). The southern stocks of whalebone whales. *Discovery Rep.*, 22: 197–300.

——— (1946). The natural history of whalebone whales. *Biol. Rep.*, 21: 60–74.

——— (1946b). The Antarctic convergence and the distribution of surface temperature in Antarctic waters. *Discovery Rep.*, 23: 179–212.

MACKINTOSH, N. A. & BROWN, S. G. (1956). Preliminary estimate of the southern populations of the larger baleen whales. *Norsk Hvalfangst-Tid.*, nr. 9: 469–80.

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

MARR, J. W. S. (1956). *Euphausia superba* and the Antarctic surface currents (An advance note on the distribution of the whale food). *Norsk Hvalfangst-Tid.*, nr. 3: 127–34.

——— (1957). Further comments on the occurrence of *Euphausia seperba* in a humpback whale caught off Southern Queensland. *Norsk Hvalfangst-Tid.*, nr. 4: 181.

MARSHALL, S. M. & ORR, A. P. (1955). The Biology of a Marine Copepod *Calanus finmarchicus* (Gunnerus). London,

MATSUBARA, K. (1955). Fish morphology and hierarchy. Part I, II, III. Tokyo, 1955.

MATSUURA, Y. & MAEDA, K. (1942). [Biological investigation of the Northern Pacific whales]. *Report for whaling*, 9(1).

MATTHEWS, H. (1932). Lobster-Krill Anomuran Crustacea that are food of whales. *Discovery Rep.*, 5: 469–84.

——— (1938a). The sei whale, *Balaenoptera borealis*. *Discovery Rep.*, 17: 185–290.

——— (1938b). The humpback whale, *Megaptera nodosa*. *Discovery Rep.*, 17: 9–92.

——— (1938c). Note on the southern right whale, *Eubalaena australis*. *Discovery Rep.*, 17: 169–82.

MIYAZAKI, I., OTSURU, K. & WATASE, S. (1953). *Report on whale marking in Japan. No. 4. II. The Sanriku-Hokkaido and south Kurile Islands Areas.* Tokyo, Japanese Fisheries Agency.

MIZUE, K. (1950). Factory ship whaling around Bonin Islands in 1948. *Sci. Rep. Whales Res. Inst.*, no. 3: 106–18.

——— (1951). Food of whales (in the adjacent waters of Japan). *Sci. Rep. Whales Res. Inst.*, no. 5: 81–90.

——— (1956). [*Report on biological investigation for the whales from Eastern China Sea in 1955*]. Tokyo, Whales Research Institute, p. 34. (Mimeographed copy). (In Japanese).

MIZUE, K. & FUJINO, K. (1957). [Report on biological investigation for the whales from Eastern China Sea]. Tokyo, Japan Whaling Association, p. 26 (Mimeographed copy in Japanese).

MIZUE, K. & MURATA, T. (1951). Biological investigation on the whales caught by the Japanese Antarctic whaling fleets season 1949–50. *Sci. Rep. Whales Res. Inst.*, no. 6: 73–131.

MOERCH, J. A. (1911). On the natural of whalebone whales. *Proc. Zool. Soc. London.* 661–670 cited by Kellog (1928).

NAKAI, J. (1942). [The chemical composition, volume, weight and size of the important marine plankton]. *J. Oceanogr. Soc. Japan*, 1(1): 45–55. (In Japanese).

——— (1954). Species of Food Plankton for Baleen Whales in the Sea Adjacent to Japan. *Tokai Reg. Fish. Res. Lab. Sp. Publ.*, no. 4: 1–6.

NASU, K. (1957). Oceanographical conditions of the whaling grounds in the waters adjacent to Aleutian Islands and the Bering sea in summer of 1955. *Sci. Rep. Whales Res. Inst.*, no. 12: 91–101.

NEMOTO, T. (1956). On the diatoms of the skin film of whales in the Northern Pacific. *Sci. Rep. Whales Res. Inst.*, no. 11: 99–132.

——— (1957). Foods of baleen whales in the northern Pacific. *Sci. Rep. Whales Res. Inst.*, no. 12: 33–90.

——— (1958). *Cocconeis* diatom parasitic on the whales in the Antarctic. *Sci. Rep. Whales Res. Inst.*, 13: 185–91.

NEMOTO, T. & NASU, K. (1958). *Thysanoëssa macrura* as a food of baleen whales in the Antarctic. *Sci. Rep. Whales Res. Inst.*, no. 13: 193–9.

NIKULIN, V. G. (1946). [On the distribution of whales in the adjacent seas to Chukchee Peninsula], cited from the translation by H. Sakiura in Geiken Tsushin.

NISHIMOTO, S., TOZAWA, M. & KAWAKAMI, T. (1952). Food of Sei whales (*Balaenoptera borealis*) caught in the Bonin Island waters. *Sci. Rep. Whales Res. Inst.*, no. 5: 79–85.

NISHIWAKI, M. (1959). Humpback whale in Ryukuan waters. *Sci. Rep. Whales Res. Inst.*, 14. 49–87.

NISHIWAKI, M. & OYE, T. (1952). Biological investigations on Blue whales (*Balaenoptera musculus*) and Fin whales (*Balaenoptera physalus*) caught by the Japanese Antarctic Whaling Fleets. *Sci. Rep. Whales Res. Inst.*, no. 5: 91–167.

NORMAN, J. R. & FRASER, F. C. (1937). *Giant fishes, whales and dolphins*. London,

OHSUMI, S. (1959). Personal communication.

OHSUMI, S., NISHIWAKI, M., & HIBIYA, T. (1958). Growth of fin whales in the Northern Pacific. *Sci. Rep. Whales Res. Inst.*, 13: 97–133.

OMMANNEY, F. D. (1933). Whaling in the dominion of New Zealand. *Discovery Rep.*, 7: 239–52.

OMURA, H. (1950a). Diatom intection on blue and fin whales in the Antarctic whaling area V (The Ross sea area). *Sci. Rep. Whales Res. Inst.*, 4: 14–26.

——— (1950b). Whales in the adjacent waters of Japan. *Sci. Rep. Whales Res. Inst.*, no. 4: 27–113.

——— (1953). Biological study on humpback whales in the Antarctic whaling area IV and V. *Sci. Rep. Whales Res. Inst.*, no. 8: 81–102.

——— (1958). North Pacific right whale. *Sci. Rep. Whales Res. Inst.*, no. 13: 1–52.

——— (1959). Bryde's whale from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 14: 1–33.

OMURA, H. & FUJINO, K. (1954). Sei whales in the adjacent waters of Japan. II. Further studies on the external characters. *Sci. Rep. Whales Res. Inst.*, no. 9: 89–104.

OMURA, H. & SAKIURA, H. (1956). Studies on the little piked whales from the coast of Japan. *Sci. Rep. Whales Res. Inst.*, no. 12: 1–38.

OMURA, H. & KAWAKAMI, T. (1956). Japanese whale marking in the North Pacific. *Norsk Hvalfangst-Tid.*, nr. 10: 555–63.

OMURA, H. & NEMOTO, T. (1955). Sei whales in the adjacent waters to Japan. III. Relation between movement and water temperature of the sea. *Sci. Rep. Whales Res. Inst.*, no. 10: 79–87.

OMURA, H., NISHIMOTO, S. & FUJINO, K. (1952). *Sei whales (Balaenoptera borealis) in the adjacent waters of Japan.* Tokyo, Fisheries Agency of Japanese Government, Japan Whaling Association.

OMURA, H., NISHIWAKI, M., FUJINO, K. & KIMURA, S. (1957). On the stock of baleen whales in the North Pacific. *Suisangaku Shusei*, 507–35.

OWATARI, A., MATSUMOTO, S. & KIMURA, Y. (1954). The behaviors of the Sardine schools by fish-detector 3. Behavior of sardines when attacked by dolphins. *Bull. Jap. Soc. Sci. Fish.*, 19(12): 1144–9. (In Japanese).

PETERS, N. (1938). *Der neue deutsche Walfang.*

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

PIKE, G. C. (1950). Stomach contents of whales caught off the coast of British Columbia. *Progress Rep. Pacific Coast Stat.*, no. 83: 1–2.

PONOMAREVA, L. A. (1949). [On the nourishment of the plankton eating whale in the Bering Sea]. *C. R. Acad. Sci.*, 18(2). Cited by Betesheva (1954).

——— (1954). [The significance of euphausiids as foods of whales and fish]. *Trans. Inst., Oceanogr.*, 8: 200–5.

——— (1954). Vesovaia kharakteristika eufauzid Iaponskobo moria. *Doklady Akademii Nauk SSSR*, 49(1).

——— (1957). [The distribution of Euphausiacea in the Okhotsk, the Japan Sea and the East China Sea]. *Trudy Akademii Nauk SSSR*, 114(6): 1214–6.

PURVES, P. E. & MOUNTFORD, M. D. (1959). Ear plug laminations in relation to the age composition of a population of fin whales (*Balaenoptera physalus*). *Bull. British Museum*, 5(6): 6–161.

RAYNER, G. W. (1935). The Falkland species of the crustacean genus *Munida*. *Discovery Rep.*, 10: 211–45.

——— (1940). Whale marking Progress and results to December 1939. *Discovery Rep.*, 19: 247–84.

RUSTADT, D. (1930). Euphausiacea with note on their biogeography and development. *Sci. Res. Norw. Antarc. Exped.*, 1927–28 and 1929–30. No. 5- *Norsk Vidensk. Akad. Oslo*, 12: 1–83.

RUUD, J. T. (1932). On the biology of Southern Euphausiidae. *Hvalradets Skrifter*, nr. 2.

——— (1952). Do swordfish attack the large baleen whales? *Norsk Hvalfangst-Tid.*, nr. 4: 191–3.

——— (1952b). Catch of Bryde's whale off French equatorial Africa. *Norsk Hvalfangst-Tid.*, nr. 12: 662–4.

RUUNSTRøM, S. (1928). Uber die Thermopathie der Fortpflanzung und Entwickling mariner Tiere in Beziehung zu ihrer geographischen Verbreitung. *Bergens Mus. Aarb. Naturn, RK.*, no. 2, 1927. Cited by Einarsson 1945.

——— (1930). Weitere studien über die Temperaturanpassung der Fortpflanzung und Sutwickling mariner Tiere. *Begens Mus. Aarb. Naturn. RK.*, no. 10, 1929. Cited by Einarsson, 1945.

SAIKI, M. & MORI, T. (1956). Studies on the Whale Oil—12, On the Lipid from *Calanus cristatus* (Part I). Fatty Acids Composition of Oil from *Calanus cristatus* Collected in the Stomach of Fin whale Caught at the Northern Pacific Ocean. *Bull. Japan Soc. Sci. Fish.*, 21(9): 1041–4.

SAIKI, M., SHIN-CHEN FANG & MORI, T. (1959). Studies on the Lipid of plankton II. Fatty acid composition of Libid from Euphausiacea collected in the Antarctic and Northern Pacific Ocean. *Bull. Jap. Soc. Sci. Fish.*, 24(10): 837–9.

SCATTERGOOD, L. W. (1949). Notes on the little piked whale (with bibliography). *The Murrelet*, 30(1): 3–16.

SCHEFFER, M. B. & REINTJES, W. J. (1950). Additional records confirming the Trans-Pacific distribution of the Pacific Saury, *Cololalis saira* (Brevoort). *Pacific Sci.*, 4(2).

SCORESBY, W. (1820). *An account of arctic regions*. 2 volts. Edinburgh. Cited from Marshall & Orr, 1955.

SENOO, J. (1958). Personal communication.

SLEPTSOV, M. M. (1955). *Biologiia i promysel kitov gal'nevostochnyx morei.* [The biology and industry of whales in the waters of the Far East]. Moscow.

TAYLOR, F. H. C., FUJINAGA, M. & WILKE, F. (1955). *Distribution and Food Habits of the Fur seals of the North Pacific Ocean.* Rep. Cooperative Invest. by the government Canada, Japan and U.S.A. Feb.–July, 1952.

TAYLOR, R. J. F. (1957). An unusual record of three species of whale being restricted to pools in Antarctic sea ice. *Proc. Zool. Soc. Lond.*, 129: 325–331.

TOMILIN, A. G. (1954). Adaptive types in the order cetacea (The problem of an ecological classification of cetacea, Translated by the Bureau for Translations, Foreign Language Division, Department of the Secretary of State of Canada in 1957). *Zoologi-cheskii Zhurnal*, 33(3): 677–92.

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

UDA, M. (1954). Studies of the relation between the whaling grounds and the hydrographycal conditions (1). *Sci. Rep. Whales Res. Inst.*, no. 9: 179–87.

VINOGRADOV, M. E. (1956). Raspredelenie zooplanktona v zapadnykh raionakh Beringova moria. *Trudy Vsesojuznogo Gidrobiologicheskogo Obshestva*, 7: 173–203.
ZENKOVICH, B. A. (1934). [Whaling in Kamtchatka waters and Bering sea]. Cited by KASAHARA, 1950.
——— (1937). [Foods of whales in the far eastern waters]. Cited by Betesheva, 1955.

APPENDIX I. JAPANESE MARK RECOVERY FROM FIN WHALES IN THE NORTHERN PART OF THE NORTH PACIFIC

Mark	Body length	Sex	Date marked	Date recovered	Position marked		Position recovered		Year group
4266	62	F	1954–7– 7	1954–7– 8	54–29N	166–10W	54–35N	165–45W	0
4725	59	M	〃 8–11	〃 8–24	54–08N	166–55W	53–55N	167–36W	0
4270	63	F	〃 7– 7	〃 9– 2	54–29N	166–10W	54–09N	167–17W	0
3369	65	M	〃 8– 6	〃 9– 6	53–30N	169–50W	54–00N	167–40W	0
4802	65	F	〃 8–11	〃 9–13	54–01N	167–03W	53–40N	167–27W	0
4684	61	F	〃 8–11	〃 9–13	54–08N	166–55W	54–10N	166–56W	0
4560	59	M	〃 9–21	〃 9–22	54–22N	165–44W	54–13N	166–43W	0
4658	58	F	〃 8–10	1955–7– 6	54–10N	166–58W	54–31N	166–23W	1
4516	61	M	〃 9–13	〃 7–17	54–20N	166–21W	54–30N	171–02W	1
4451	56	M	〃 8–10	〃 7–22	54–18N	166–40W	54–11N	169–30W	1
4281*	?	?	〃 7– 7	〃 7–14–22	55–09N	165–47W	?	?	1
4604	61	M	〃 9–11	〃 8– 1	53–46N	168–10W	54–45N	171–50W	1
4543	66	F	〃 9–13	〃 8– 2	54–20N	168–11W	54–32N	170–55W	1
J 5966* J 5968*	58	M	1955–7–18	〃 9– 2	54–06N	167–04W	54–30N	167–20W	0
J S 6989	?	?	〃 9– 3	〃 9– 8	53–44N	168–08W	?	?	0
J 6050	56	M	〃 9– 8	〃 9– 9	53–37N	164–57W	53–42N	165–04W	0
J S 7000*	?	?	〃 9– 8	〃 9– 9–10	53–37N	164–57W	?	?	0
4641	60	M	1954–8–10	〃 9–16	54–10N	166–58W	55–22N	167–34W	1
J 6060* J 6061*	?	?	1955–9–12	1956–6–18	54–15N	169–56W	?	?	1
3243	55	F	1953–6–23	〃 6–23	50–25N	170–22E	53–14N	168–33E	3
J S 7002	58	M	1955–9– 8	〃 7–12	53–37N	164–57W	54–37N	165–45W	1
4267	63	F	1954–7– 5	〃 7–13	54–16N	160–10W	54–32N	165–55W	2
3213	63	F	1953–5–12	〃 7–25	51–16N	177–50E	54–02N	170–31W	3
4552	62	F	1954–9–19	〃 7–25	54–08N	167–45W	54–50N	169–54W	2
4461	59	M	〃 8–29	〃 7–31	54–38N	165–44W	54–32N	166–28W	2
J 6042	64	F	1955–9– 7	1957–5–19	54–08N	166–51W	52–18N	162–38E	2
J S 6987	62	M	〃 9– 3	〃 6–20	53–42N	167–17W	49–53N	167–20W	2
J 5995	65	F	〃 8–11	〃 7– 2	52–49N	175–16W	49–48N	168–12W	2
J S 7269*	?	?	1957–6–10	〃 ?	55–47N	169–04W	?	?	0
4558	62	M	1954–9–19	〃 7–12	54–08N	167–45W	54–15N	169–50W	3
J S 6939	64	F	1955–8–10	〃 7–18	53–24N	173–05W	55–19N	169–55W	2
J S 6923	64	F	〃 7–28	〃 7–26	56–36N	173–00W	59–58N	176–46W	2
J 5979	58	M	〃 7–29	〃 8– 5	59–20N	176–25W	59–48N	177–58W	2
J 6511*	?	?	1957–7– 8	〃 8– 8	59–05N	176–06W	?	?	0
J 6506	?	?	〃 7– 6	〃 8–11	56–62N	170–45W	?	?	0
J S 7720	66	F	〃 7–19	〃 8–24	55–37N	168–35E	53–49N	170–10E	0
J 6834	61	M	〃 9–11	1958–5–27	54–49N	167–04W	52–00N	171–26E	1
J S 7026	62	M	1955–9–15	〃 7– 3	54–33N	166–10W	53–34N	170–45W	3

APPENDIX I. (Continued)

Mark	Body length	Sex	Date marked	Date recovered	Position marked		Position recovered		Year group
J 6837 } J 6831 }	58	M	1957-9-11	1958-7- 3	54-48N	167-04W	53-42N	169-54W	1
J 6815	60	F	〃 9-10	〃 7- 4	54-40N	168-47W	54-11N	170-31W	1
J 6264	56	M	1956-9- 4	〃 7- 7	54-15N	166-55W	55-56N	169-09W	2
J 6843	56	F	1957-9-11	〃 7- 8	54-48N	167-09W	54-21N	166-49W	1
J 6829*	?	?	〃 9-11	〃 7- 8	54-48N	167-04W	?	?	1
J S7745	62	M	1958-6-24	〃 7- 8	54-29N	166-43W	54-49N	166-28W	0
J 6801 } J 6802 }	58	F	1957-9-10	〃 7-11	54-41N	168-41W	54-28N	169-44W	1
3391	64	M	1954-8- 6	〃 7-11	53-24N	169-55W	54-23N	169-30W	4
J 6804*	?	?	1957-9-10	〃 7-11	54-40N	168-47W	?	?	1
J S7243*	?	?	〃 6- 3	〃 7-11	54-26N	160-50W	?	?	1
J 6859*	?	?	1958-6-17	〃 ?	50-37N	168-33W	?	?	0
J 6149	?	?	1956-7-18	〃 ?	54-42N	159-25W	?	?	2
J 6799	59	M	1957-9-10	〃 7-16	54-30N	168-50W	50-53N	170-10W	1

* These marks are found in cooker or refrigerator ship and the exact position of recovery is unknown but estimate data are obtained.

APPENDIX II. JAPANESE MARK RECOVERY FROM SEI AND BRYDE'S WHALE IN THE NORTH PACIFIC

Mark	Species	Body length	Sex	Date marked	Date recovered	Position marked		Position recovered		Year group
0876	*	41 ft	M	1950-5-21	1950-5-22	27-14N	144-14E	27-10N	144-00E	0
0916	*	42	F	〃 5-21	〃 5-22	27-17	144-08	27-15	144-03	0
0781	*	43 or 39	F	〃 5- 8	〃 7-15	26-43	142-40	Ca37-02	Ca143-02	0
1772	*	44	F	1951-5-15	1951-5-27	25-35	143-45	25-47	143-40	0
2058	*	44	M	〃 8-23	1952-7- 6	41-33	147-32	38-31	144-16	1
0910	*	44	F	1950-5-21	〃 8-21	27-24	144-23	37-51	143-22	2
2675 } 2687 }	*	43	F	1952-9- 2	〃 10-21	38-46	149-25	38-24	142-26	0
0086	*	47	F	1949-7-21	1953-6-25	39-15	149-36.5	38-42	143-34	4
3826	*	45	F	〃 7- 9	1953-7-10	42-27.5	148-32	42-37	147-57	0
3782	*	43	F	〃 7- 7	1953-9-12	42-19.3	149-37.5	38-55	145-37	0
3823	*	42	M	1953-7- 9	1955-7-10	42-27.5	148-32	40-17	147-43	2
2761 } 2762 }	*	40	F	1952-9- 7	〃 8- 8	40-15	150-01	41-26	145-53	3
2769 } 2770 }	*	50	F	〃 9-11	1955-9-15	43-08	147-54	42-26	146-28	3
3027 } 3043 }	*	47	F	〃 9-12	〃 9-17	43-54	149-05	43-07	147-21	3
2691 } 2692 }	*	47	M	〃 9- 3	〃 9-25	39-33	153-17	41-07	147-59	3
1365	*	42	M	1950-9- 7	1956-7- 9	40-10	155-50	44-53	149-30	6

APPENDIX II. (Continued)

Mark	Species	Body length	Sex	Date marked	Date recovered	Position marked		Position recovered		Year group
2852, 2853, 2854	Sei	46	F	1950-9- 5	1957-8- 5	39-25	155-32	39-30	144-01	5
3042	Sei	42	F	〃 9-12	〃 9-17	43-54	149-05	42-10	149-30	5
2819	Sei	45	M	〃 9- 4	1958-6- 4	39-27	154-02	37-33	145-30	6
0775	Bryde's	42	F	1950-5- 8	〃 8-10	26-43	142-40	38-10	145-20	8
3783	Sei	45	F	1953-7- 7	〃 9-29	42-19.7	149-26	41-24	145-03	5
2271	Bryde's**	44	F	1952-6-29	1959-7- 9	25-08	142-06	33-46	136-38	7
2334	Bryde's**	41	M	〃 7- 1	〃 7-21	26-28	142-35	32-45	136-26	7
4196	Sei	47	F	1954-6-13	1958-7-22	53-26	163-22W	49-58	177-49W	4
4201	Sei	?	?	〃 6-13	〃 7-12	53-26	163-22W	Ca50-00	Ca178-00W	4

* These whale species are sei or Bryde's whales, but exact examination has not been made at their flensing.

** These marks are found after completion of the paper, which clearly show the migration of Bryde's whales from Bonin Islands to Oshima, Wakayama prefecture.

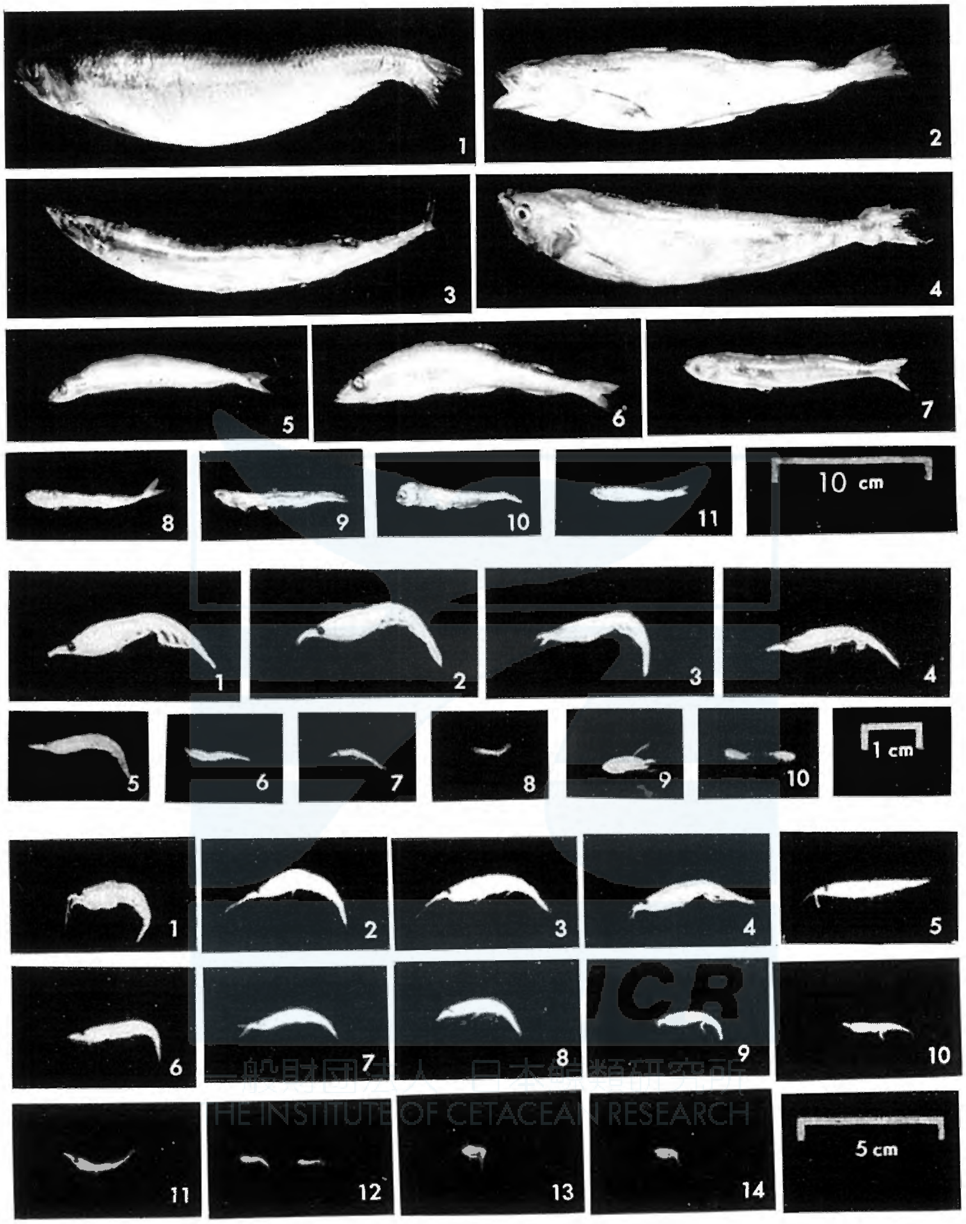
EXPLANATION OF THE PLATE

Showing the relative size of each foods of baleen whales

Upper: Food fish from stomachs of baleen whales in the northern Pacific. Fig. 1—Herring from a stomach of a fin whale in the waters off Cape Navarin. Fig. 2—Alaska pollack from a fin whale in the Bering sea. Fig. 3—Saury from a sei whale in the waters off Kamtchatka. Fig. 4—Atka mackerel from a humpback whale in the adjacent waters to the Near Islands. Fig. 5—Capelin from a fin whale in the waters off Navarin. Fig. 6—Alaska pollack from a fin whale caught in the waters in the middle of Bering sea. Fig. 7—Atka mackerel from a fin whale in the waters of Near Islands. Fig. 8—Mackerel from a sei whale in the waters adjacent to Japan. Fig. 9—Anchovy from a sei whale in the waters adjacent to Japan. Fig. 10—*Myctophum asperum* from a Bryde's whale in the Bonin Islands waters. Fig. 11—*Yarella microchephala* from a Bryde's whale in the Bonin Islands waters.

Middle: Food planktons in the North Pacific. Figs. 1 & 2—*Thysanoëssa inermis* from a stomach of fin a whale in the Bering sea. Figs. 3 & 4—*Thysanoëssa longipes* from a fin whale in the waters off Kamtchatka. Fig. 5—*Euphausia pacifica* from a fin whale in the waters adjacent to the Near Islands. Fig. 6—*Thysanoëssa longipes* from a fin whale in the south waters adjacent to the eastern Aleutian Islands. Fig. 7—*Euphausia pacifica* from a fin whale in the East China sea. Fig. 8—*Thysanoëssa longipes* from a blue whale in the south waters adjacent to the eastern Aleutian Islands. Fig. 9—*Calanus cristatus* from a fin whale in the waters off Kamtchatka. Fig. 10—*Calanus plumchrus* from a sei whale in the south waters adjacent to the eastern Aleutian Islands.

Lower: Food planktons in the Antarctic waters. Figs. 1, 2, 3 & 4—*Euphausia superba* of 2 years group. Figs. 5, 6, 7, 8, 9 & 10 *Euphausia superba* of 1 year group. Figs. 11 & 12—*Thysanoëssa macrura*. Figs. 13 & 14—*Parathemisto gaudichaudi*.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