FISHERY OCEANOGRAPHIC STUDY ON THE BALEEN WHALING GROUNDS

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INTRODUCTION

A Fishery oceanographic study of the whaling grounds seeks to find the factors controlling the abundance of whales in the waters and in general has been a subject of interest to whalers. In the previous paper (Nasu 1963), the author discussed the oceanography and baleen whaling grounds in the subarctic Pacific Ocean. In this paper, the oceanographic environment of the baleen whaling grounds in the coastal region of Japan, subarctic Pacific Ocean, and Antarctic Ocean are discussed. Japanese oceanographic observations in the whaling grounds mainly have been carried on by the whaling factory ships and whale making research boats using bathythermographs and reversing thermomenters. Most observations were made at surface. From the results of the biological studies on the whaling grounds by Marr (1956, 1962) and Nemoto (1959) the author presumed that the feeding depth is less than about 50 m. Therefore, this study was made mainly on the oceanographic environment of the surface layer of the whaling grounds.

In the coastal region of Japan Uda (1953, 1954) plotted the maps of annual whaling grounds for each 10 days and analyzed the relation between the whaling grounds and the hydrographic condition based on data of the daily whaling reports during 1910–1951. A study of the subarctic Pacific Ocean whaling grounds in relation to meteorological and oceanographic conditions was made by Uda and Nasu (1956) and Nasu (1957, 1960, 1963). Nemoto (1957, 1959) also had reported in detail on the subject from the point of the food of baleen whales and the ecology of plankton.

Numerous physical, chemical and biological studies of the Antarctic have been described by the Discovery Committee. Studies of the physical and chemical oceanographic environment of the whaling ground based on the data obtained by the Japanese surveys were made by Shimomura (1947), Sugiura (1949), Tsuchida (1952), Nasu (1959), Kumagori (1963), Ishino (1963), Uda (1963) and Ishino & Nasu (1965). The biological study was made by Nemoto & Nasu (1958) and Nemoto (1959).

The present paper gives the oceanographic structure of these whaling grounds and the physical environment connected with the distribution of baleen whales, using data obtained by whaling research, operation ships and other survey ships.

DISTRIBUTION OF BALEEN WHALING GROUODS OF THE WORLD IN THE PAST 10 YEARS

COASTAL WHALING GROUNDS

Coast of Japan

The sea regions from Sanriku* to Hokkaido are the most representative whaling grounds in the North Pacific, and the whale species caught consist mainly of sei and Bryde's whale. The sei whale is the most important species and its catch average about 600 in a year. Generally the favourable seasons are from May to June off Sanriku and from September to October off Hokkaido.

The catch of Bryde's whale in the Sanriku region is primarily influenced especially by the fluctuation of the Kuroshio water mass because the distribution of Bryde's whales depends on water with about 20°C or more in surface temperature Omura & Nemoto 1955, Omura 1959). The total catch of whales caught in the most abundant years in the Sanriku was 400 and the average number in a year was about 120. On the other hand, the catch off Hokkaido was less than 10 in a year, because of colder sea region than Sanriku. Sometimes the fin, blue and humpback whales were caught in this sea region, too. The catch of fin whale in the Okhotsk sea was reduced recently and a catch of few sei and humpback whales was observed. The favourable seasons being from July through August.

Whaling in the East China sea commenced in 1955. The fin whales are most important baleen whale species there. About 250–300 animals are caught in abundant catch years, Bryde's whales also were caught here.

The main whaling grounds of Bryde's whale were located off Kii Peninsula, and the total number of whales caught reached more than 200 in plentiful years.

In waters adjacent to Okinawa Island in the Ryukyu Islands humpback whales mainly were caught. More than 200 animals were taken during January to March in rich years (the catch in 1958 reached 240 animals). The catch of Bryde's whales also was observed on the coast of Formosa, but the number of whales caught was very few compared with Ryukyu Islands. The whaling operation in these waters have closed from 1963 in Ryukyu Islands and 1960 in the coast of Formosa, respectively.

Coast of North America

The most important whaling grounds in this area was located off British Columbia and the catch during April to October in 1963 were 30 blue, 220 fin, 24 humpback and 154 sei whales, the favourable whaling season for each whale species is as follows: blue whale: May-July; fin whale: May-August; himpback whale: May-June; sei whale: June-August. The coast of California is also an important baleen whaling ground, that is, the catch in 1963 are 6 blue, 16 fin, 55

* Sanriku includes the waters to the northeast of Honshu, Japan.

humpback and 97 sei whales and the favourable whaling seasons are April-May for humpback whale and July- August for sei whale, respectively.

Coast of South America

The whaling off the Chilean coast was operated for long seasons except August and September. The chief whale species was sperm whale (the total number of whole caught in 1963 was 1494). However, Clark (1962) reported that unexploited baleen whaling grounds were located in the waters of 30°–35°S latitude in the vicinity of Humbolt current. After that, 378 blue, 138 fin and 190 sei whales were caught by the operation from November of 1964 to March of 1965, and so it may be considered that the results of the survey by Clark were justified. The favourable whaling seasons are for fin : November, December and for sei and blue : after January, respectively.

In addition, according to the composition of body length and shape of baleen plate, the blue whales in this area seem likely to pigmy blue whales which were observed in the sea regions from Kerguelen to Marion Island (private information from Dr. Ichihara). The baleen whale catch in the waters of Brazil consists mainly of sei whale. The sei whale catch, recently has decreased motably.

Coast of Australia and New Zealand

In the coast of New Zealand and Australia mainly humpback whales were caught and whaling seasons are May-July in New Zealand and June-October in Australia. The number of whales caught in good years amounted to about 300 in New Zealand, and about 2,000 in Australia. The catch, however, in 1963 decreased to 9 animals in New Zealand and 87 in Australia. On the other hand, the catch of sperm whales in these waters has increased considerably recently.

Coast of South Africa

In south African waters whaling was carried on from the coast of Natal and the coast of Cape Province. The baleen whale species in these waters consists mainly of fin and sei whales. On the coast of Cape Province, 50 or less, Bryde's whales are also taken in a year. The favourable whaling seasons are May to October in both waters. In 1959. 160 humpback and 6 sei whales were caught in Gabon on the west coast of South Africa.

North Atlantic and Arctic

The representative whaling grounds in this region were Iceland and the Norwegian coast. The main species of whale was fin whale in both regions. The average catch of fin whale in a year from Iceland was more than 250. The sei whales also were caught, averaging 70 animals in a year, but the catch of sei whale has decreased notably recently (the catch in 1963 decreased to 20 animals). The whaling grounds off Norwegian coast are located near Steinshamn in the southern district of Norway and near Skjelnan in the northern district of Norway. The main whale species (fin whale) caught and the favourable whaling seasons (June to Aug.) are

quite same in both grounds. The total annual catch average in these regions reached about 160 animals.

The catch in Færoe Islands consists mainly of fin whales and reached 141 animals in 1957, but the annual average (less than 80 animals) was less than Norway and Iceland. The catch in these waters was also strongly reduced in recent years, and was only 3 fin whales in 1963.

In the west coast of Greenland the annual number of whales caught was more than 200 animals up to 1957, but the catch in recent years can not observed. The catch in Newfoundland also can not observed from 1960.

Some baleen whales also were caught in Spain and Madeira, where the high number of sperm whales were caught.

PELAGIC WHALING GROUNDS

Subarctic Pacific

The Japanese operations with floating factories in the subarctic Pacific Ocean were resumed in 1952, and the whaling grounds covered the Bering Sea the northern part of North Pacific and the Gulf of Alaska. The baleen whale catch in these waters consists mainly of fin whales, but the catch of sei whales have increased notably in recent years.

The fin whaling grounds were located from the southern region of the Aleutian Islands to the Bering Sea, but no blue or sei whaling grounds were located in the Bering Sea.

Antarctic

The locality of baleen whaling grounds operated by the Japanese floating factories varied in the recent 10 years. That is, the grounds during the seasons in 1954/55–1956/57 covered the waters of 170°W to 80°W, and the western end of whaling grounds reached to 50°E in 1960/61, 10°W in 1962/63 and 60°W in 1964/65.

The latitudinal positions of grounds also varied abruptly, that is, the whaling operations have been carried on near the Antarctic Convergence, and the northern border reached in 47°S latitude. Pigmy blue whales were caught in the adjacent waters to Marion, Crozet and Kerguelen Island in 1959/60. In 1964/65 the baleen whaling grounds operated by Japanese floating factors completely shifted to the Antarctic Atlantic sector, and the northern border reached in about 45°S which corresponded to the vicinity of Sub-tropical Convergence which was characterized by the comparative high temperature with 13°–14°C as surface temperature.

OCEAROGRAPHIC STRUCTURE OF BALEEN WHALING GROUND

IN THE WATER TO THE NCRTHEAST OF JAPAN AND OFF HOKKAIDO.

The oceanographic analysis of baleen whaling ground in this area were made on the sei whale whose catch was the most abundance. The whaling grounds were divided as Fig. 1 by the land station. In addition, the catch statistics used in this

paper were those 1955–1963. Fig. 1 shows the locality of land station from 1955 to 1963.

Moreover, the data used in this chapter are as follow.

1953 1954: Nihon Hogei Senpaku Sobikaizen Iinkai
Meteorological Agency,

1962 : Whale chaser

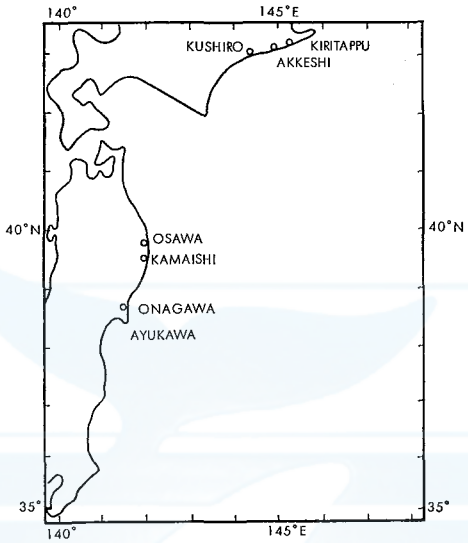


Fig. 1. Locality of land station.

Oceanographic conditions of sei whaling ground

The coastal whaling of Japan is operating from May to October, and the favourable whaling ground is generally moving from the northeast of Japan to Hokkaido.

Figs. 2–1, 2, 3 show the relation between the distribution of surface temperatures and sei whaling grounds in 1953, 1954 and 1962 respectively.

May: 1953—The favourable whaling grounds are located in the waters with 13°–16°C surface temperature which lie in mixing area*) and the edge of the branch of Oyashio.

1954—Oceanography in relation to whaling ground was not clear, because of few data of catch distribution, but the oceanographic condition was characterized by

* The waters to the northwest of Japan was divided into Kuroshio, Oyashio and Transition areas, and those surface temperature are as follows (Kawai 1959).

Season	Kuroshio	Area Transition	Oyashio
Feb.–Mar.	14°–19°C	5°–16°C	0°– 7°C
May	17°–23°C	10°–19°C	2°–12°C
Aug.	25°–29°C	20°–27°C	10°–22°C
Nov.	20°–25°C	13°–22°C	4°–15°C

the cyclonic eddy between Oyashio (O) and Kuroshio (K).
1962—The whaling ground was located in the waters with temperatures of 13°–15°C at the surface which correspond to the colder part in the mixing area.

June: 1953—The maximum catch of sei whales which generally is in June was in May in this year. The whaling ground was located in the mixing area, and es- pecially was formed around the oceanic front consists of the northwardly flowing warm waters and southwardly flowing cold waters. In addition to the warm water mass in 1953 was located more easterly than in normal years.
1954—The kuroshio water mass in 1954 was located in a more western area than 1953. The surface temperature generally was higher than in 1953 and the main whaling ground was formed in the waters of 18°–20°C (especially the most favourable whaling area is at the west side of warm water mass towards north).

July: 1953—The main whaling ground was located in the domain of 21°–23°C near the frontal zone of northwardly flowing warm water mass which corresponds with the oceanic front by the warm and cold water mass.
1954—The distribution of sei whales extends to the northeast direction, and the locality of main whaling grounds are found near the frontal zone of Oyashio which is characterized by 12°–14°C at surface temperature, too. Therefore, it seems that the whaling ground moves to the northeast of Japan to the Hokkaido area in this season.
1962—The whaling ground was located in the mixing area, and the most favourable area was found in oceanic front between the Kuroshio and Oyashio water mass near in 146°–144°E lat. which is characterized by 22°–25°C at surface temperature.

August: 1953—The distribution of temperature appears roughly similar to July, but it was supposed by the catch of whale that the amount of migrating whales was increased. The main whaling grounds were found in the mixing area between the warm and cold water mass and were divided into cold area where is near the front of Oyashio 19°–22°C (at surface temperature) and warm area where is near the front of Kuroshio (23°–26°C at surface temperature).
1954—From the locality of favourable whaling grounds which are situated in the waters with temperatures of 17°–20°C at surface. Evidently the main group of whales had moved toward the cold area to the north of Oyashio front. Morever the favourable whaling ground in the north of 42°N was located to the west of southwardly the 2nd Branch of Oyashio, and it was supposed that the whaling ground near 40°30′N, 148°E corresponded to the southern border of the 2nd Branch of the Oyashio (See Fig. 2–2).
1962—The favourable whaling grounds were in the Oyashio area (17°C–20°C at surface temperature) and bordered the Kuroshio front (23°–27°C at surface temperature), and such phenomena seemed to be a moving seasonal whaling ground.

September: 1953—The whaling grounds are similarly located in the two areas as in August and generally existed to the north. That is, the whaling ground lay in the water of 10°–18°C near 43°N in the Oyashio area and near 39°N in the warm waters, where owing to the condition of the surface temperature field, must be formed of the cyclonic eddy between the southwardly 2nd Branch of the Oyashio and the

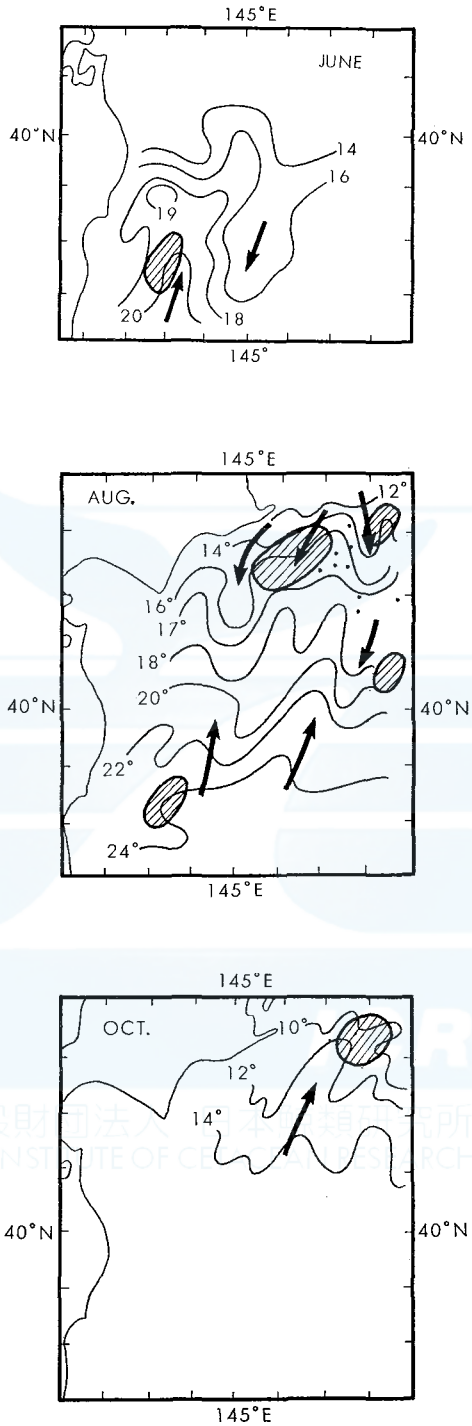


Fig. 2. Distribution of surface temperature and sei whaling ground in 1954.

warm waters.
1954—The southern whaling ground in 38°–39°N lie in the waters of 21°–26°C at surface temperature, which may be considered that the cyclonic eddy was formed between the southwardly cold and northwardly warm waters.
1962—The whaling ground in September was found far north of the previous month's, an especially favourable area located in front of tongue shaped warm waters near 42°N, 148°E. According to this phenomenon it must be presumed that the northward moving structure of whaling grounds participate in the situation of tongue shaped warm water mass.

October: 1953—The favourable whaling ground was located in the west area of the 2nd Branch of Oyashio near 42°N, 147°E, and in the oceanic front between the cold and warm waters near 40°N, 144°E, too.
1954—The whaling ground was in the Oyashio area to the north of about 43°N, which is characterized by 10°–12°C at surface temperature (Fig. 2–3).

Consideration of the sei whaling grounds

According to the reports of whale chasers, the sei whales off Sanriku coast in last of April were sighted in waters of 8.5°C–13.1°C surface temperature. The area having the highest whale density existed in water of 12.2°–13.0°C where corresponds to the southern area in the Polar Frontal Zone.*

In May through June, as shown by Fig. 9, the number of sei whale in the Sanriku area abruptly increases. As already stated the whaling grounds locate in the adjacent waters to southerly Oyashio waters within the mixing area which consists of Oyashio and Kuroshio waters, and the main grounds were formed in the northerly warm waters area (Kuroshio waters). The most favourable whaling grounds exists in the extreme area of warm waters. In July, the northward flow of Kuroshio water mass predominates (In 1982, in spite of the notable predominant Kuroshio, the whaling grounds were located considerally southwards) and the whaling grounds move from Sanriku area to Hokkaido area with the northerly movement of the Kuroshio.

In August of 1953 and 1962, the whaling grounds were formed considerablly southwards, and the general character of oceanographic conditions are that the northwardly flowing warm water mass (Kuroshio system waters) became located in the waters adjacent to the Sanriku coast in these respective years. In 1954 the main whaling ground moved off Hokkaido, and the northwardly flowing warm water mass became located further from Sanriku coast than in 1953 or 1962. In addition, the surface temperature of whaling grounds in August reaches 26°C by influence of Kuroshio waters.

In September some of the main whaling grounds are located in the Sanriku sea region as 1954, but these are generally located off the Hokkaido sea region.

By above mentioned phenomena the whaling grounds off Sanriku and Hokkaido are formed in the southern part in the transition area at beginning of whaling season, and moving towards the north with the increase of Kuroshio waters. It

* The Polar Frontal Zone is a general term for the Kuroshio and Oyashio front.

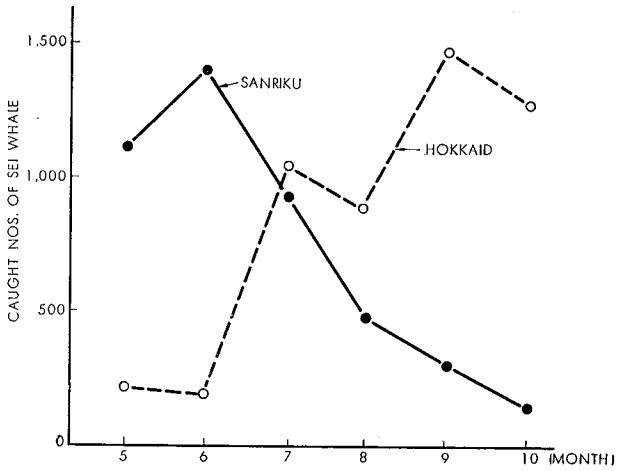


Fig. 3. Monthly catch of sei whale at Sanriku and Hokkaido in the years 1955 to 1964.

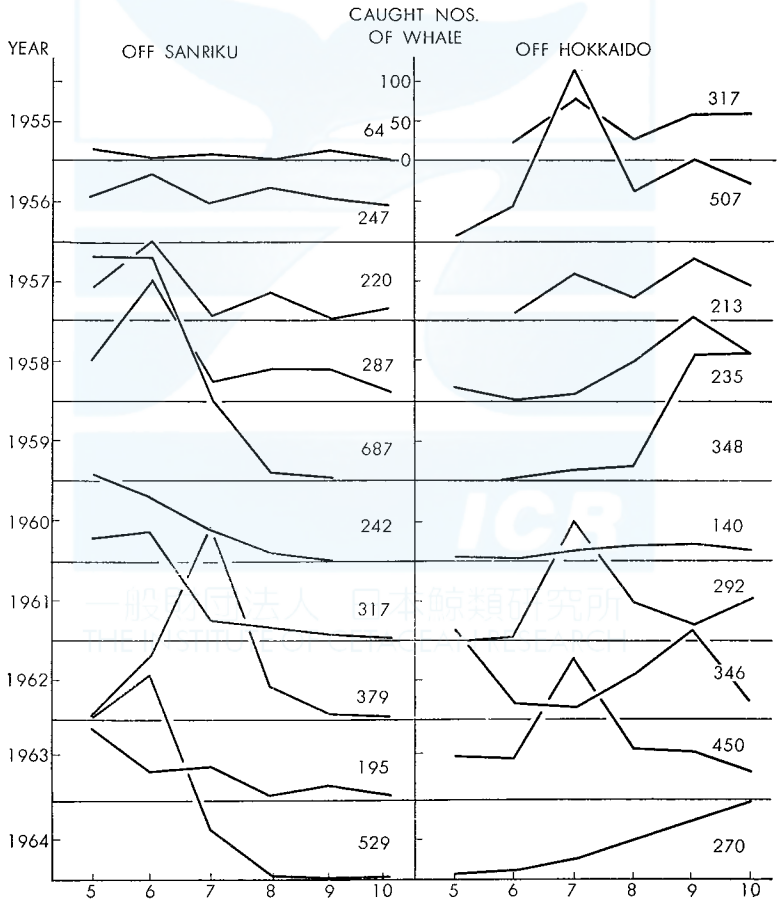


Fig. 4. Monthly and yearly catch of sei whale.

may be considered that the moving mechanism of the whaling grounds were influenced by the conspicuous tongue shaped Kuroshio waters which project towards the north.

Fig. 3 shows the monthly catch of sei whale of Sanriku and Hokkaido in the years 1955 to 1964. Judging from the monthly fluctuation we can find that the prosperous whaling times generally are in June off Sanriku and in September off Hokkaido, and it seems that the whaling grounds move from Sanriku area to Hokkaido area in July to August.

Fig. 4 shows the monthly and yearly catch of sei whale was drawn to study the moving mechanism of whaling grounds.

From Fig. 4 we can to two ground whaling condition types, the character of which are as follows.

1) Good catch off Sanriku

It is of the general type, namely, the prosperous whaling times are in June off Sanriku and September off Hokkaido respectively. Further, the catch of sei whale off Sanriku is better than Hokkaido.

2) Good catch off Hokkaido

The prosperous whaling time off Hokkaido is early that is, it is generally in July, and the catch of sei whale off Hokkaido is better than Sanriku. Then the oceanographic character have been analyzed on the situation as of the last of July in each whaling condition year in which a close correlation can be shown between the catch of sei whale and the oceanographic pattern (especially, the fluctuation of Kuroshio waters).

As shown by Fig. 5 the oceanographic conditions of good catch year in Sanriku area as 1958, 1959 and 1963 are characterized by that the Kuroshio waters flow towards the north close to the Sanriku coast.

Further, as already stated on previous chapter, the main whaling grounds located to the west of the northwardly flowing warm waters, and tend to move towards the north along with the warm waters.

Therefore it must be considered

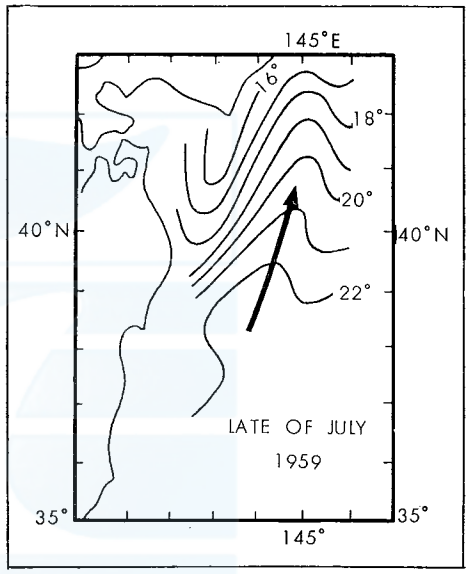


Fig. 5. Oceanographic conditions of good catch year in Sanriku.

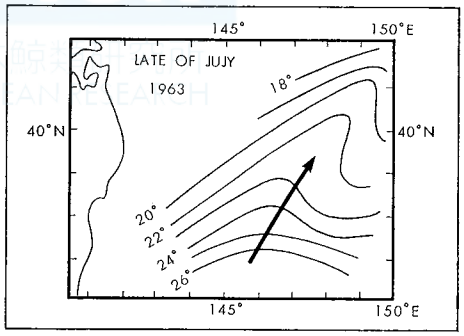


Fig. 6. Oceanographic conditions of good catch year in Hokkaido.

that the rich catch of sei whale in the yeasrich in the Sanriku area are caused by following.

1) The distribution density of whales increase because of the constriction of whaling ground area in Sanriku area.

2) The whaling grounds are located near the Sanriku land stations.

On the other hands, the catch off Sanriku area is generally poor in the years which show the good catch in Hokkaido area as 1955, 1956 and 1963 (see Fig. 6). The oceanographic character in these years is that the northward Kuroshio waters was located more easterly than good catch year off Sanriku.

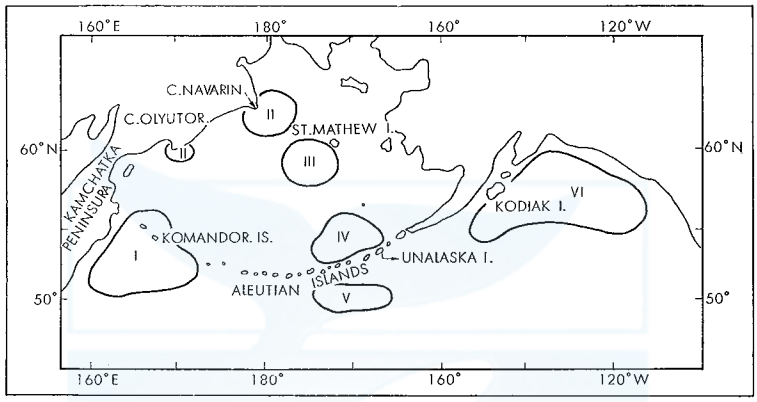


Fig. 7. Locality map of baleen whaling grounds.

Therefore it must be considered that the catch of sei whale in these years are poor in Sanriku area by following cause.

1) The distribution density of whales decrease because of the expansion of whaling area.

2) The whaling grounds are located further from the Sanriku land stations.

In addition, the whaling conditions in Hokkaido area are as follows:

1) The prosperous whaling time is early in these years.

2) The catch of sei whale is better than Sanriku area.

Their causal explanation must be summarized as follows:

1) The locality of whaling grounds which is formed near the northing tongue-like extension of Kuroshio waters become close to Hokkaido land station; because the Kuroshio waters flow northing far out from the Sanriku.

2) The catch availability of sei whale in the Hokkaido area is larger than Sanriku in these years.

SUBARCTIC PACIFIC AREA

The main baleen whaling grounds in the Subarctic Pacific area were divided as follows by the geographic distribution of Aleutian Islands, Alaskan continent and Siberia continent.

That is,

I) East area off Kamchatka Peninsula.
II) Off Cape Navarin and Olyutorski.
III) St. Mathew Island area.
IV) North area off Unalaska Island.
V) Southern area of Aleutian Islands.
VI) Gulf of Alaska.

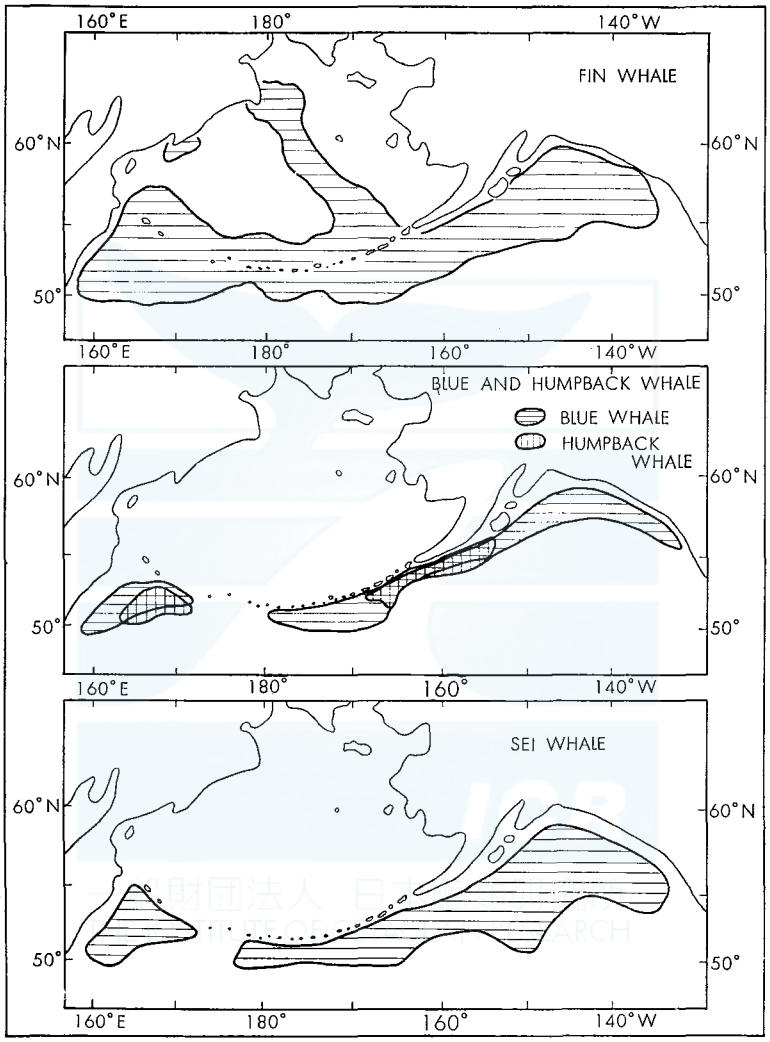


Fig. 8. Distribution of whaling grounds by species.

The locality map of baleen whaling grounds shown in Fig. 7 based upon the catch distribution of fin whale. Consequently, in here the author discussed the fin whaling grounds, but the distribution of whaling grounds by species in 1952 to 1964 also were shown in Fig. 8.

East area off Kamchatka Peninsula

The whaling grounds in this area were formed to the south and north of Komandorskii Islands and the beginning season of the whaling is most early, late in May, because of the geographic relation to Japan and migrational season of whales. Moreover the killed whale species consist of blue, fin, humpback and sei whale as shown in Table 1.

TABLE I. WHALING RESULT IN THE SUBARCTIC PACIFIC AREA IN THE YEARS 1952–1964

Years	Species of whales caught				
	Blue	Fin	Humpback	Sei	Total of Whales
1952	55	213	37	14	319
1953	90	470	42	98	700
1954	28	961	16	82	1087
1955	23	148	18	20	209
1956	1	595	35	47	678
1957	—	280	0	64	344
1958	5	269	24	60	358
1959	1	694	0	7	702
1960	0	167	0	0	167
1961	0	169	0	0	169
1962	0	3	0	0	3
1963	0	0	0	0	0
1964	0	55	0	2	57
Total	203	4024	172	394	4793

In order to obtain the center of whaling grounds the author (1963) used following formula which was shown by Uda (1930), and discussed the annually fluctuation of it. The annual fluctuation of the number of whales caught in 1 degree of latitude and longitude were discussed, too.

$$\bar{X} = \frac{n_i x_i}{n_i} \qquad \bar{Y} = \frac{n_i y_i}{n_i}$$

where x and y are the location of caught whale. n is number of whale caught. $\bar{X}$ and $\bar{Y}$ is the center of wahling ground.

That is, in the years 1952 to 1960, on the longitudinal fluctuation, two peaks were found in 1952, 1953 and 1954 during which the operation were carried out over an extended period (the operations in 1956 and 1959 were carried mainly out at the northern region of the Komandorskii Islands). These peaks are generally near 164°E and 174°E, and the highest peak of the longitudinal catch was found near 164°E. The peaks of the latitudinal catch were found 52°N to 53°N. Next, the mean position of the center of whaling grounds in the years 1952 to 1960 locate near 52°N, 165°–30'E, but the annual fluctuations of it were comparatively large.

Figs. 9 to 14 show the distribution of sighted fin whales and surface temperature obtained by whale chaser in May and June.

May: 1955 (see Fig. 9).—The isotherms run roughly paralled to Kamchatka Peninsula, but the 3.5°C-line extend to the north and south with some meander. Fin whales were found in the waters of less than 3.8°C in surface temperature and the greatest concentration of whales was located in the waters which were characterized by 3.5°–3.8°C. Whaling grounds were also located in the cold waters of less than 2.5°C in surface temperature. It seems to author that the whaling grounds which are located near 2.5°C are minimum temperature are as for whaling in the Subarctic Pacific Ocean.

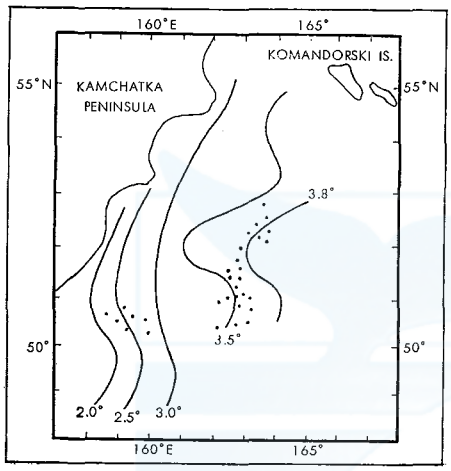


Fig. 9. Distribution of sighted fin whales and surface temperature (°C) in May of 1955.

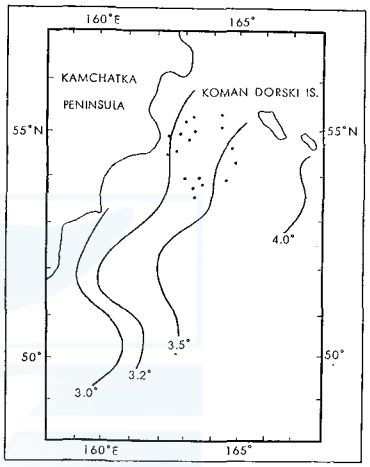


Fig. 10. Distribution of sighted fin whales and surface temperature (°C) in May of 1959.

1959 (see Fig. 10)—The distribution of isotherms generally run parallel to Kamchatka Peninsula similar to 1955, but the temperatures in the vicinity of Peninsula are higher than 1955. According to Fig. 9 and 10 the whales were sighted in the waters of 3.2°–3.5° surface temperature and were not sighted in the cold waters of less than 3.0°C, as in 1955. The surface temperatures in the area from the east of Kamchatka Peninsula to the south of Komandorskii Islands in 1959 generally were higher than 1955 and the fin whales were distributed further to the north as compared with 1955.

1960 (see Fig. 11)—The oceanographic character of this area in 1960 that the isotherms of 2.6°C to 3.0°C meandered in the vicinity of 52°–54°N, and the cold water mass near the Kamchatka Peninsula extended to the east. In general the surface temperatures were colder than in 1959 being similar to 1955. The fin whales were sighted more south to the region than in 1959.

June: 1955 (see Fig. 12)—The temperature at surface rised remarkably, and generally were more than 3.0°C as compared as in May. The isotherms run parallel to the Kamchatka Peninsula like May, but the disposition of them differed greatly. That is, the patterns of temperature are summerized as follows,

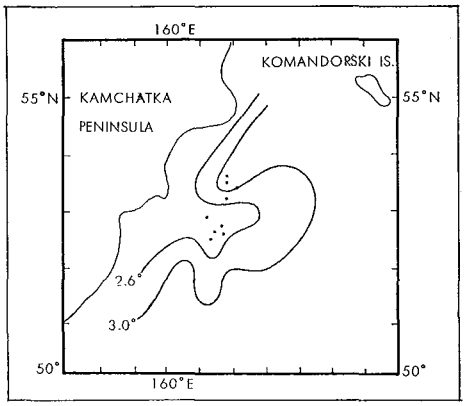


Fig. 11. Distribution of sighted fin whales and surface temperature (°C) in May of 1960.

May: lower in west and higher in east
June: higher in west and lower in east.

And it also differed in that during May the cold area which was characterized by less than 5.0°C in surface temperature was located near the Komandorskii Islands. The areas where fin whales were moved from the adjacent waters of the Kamchatka Peninsula in May to the waters south of the Komandorskii Islands where, as stated above, was found cold area of less than 5.0°C in surface temperature which proved to be the most productive whaling grounds of this season.

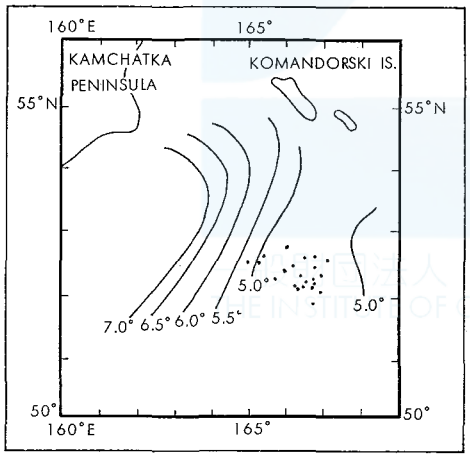


Fig. 12. Distribution of sighted fin whales and surface temperature (°C) in June of 1955.

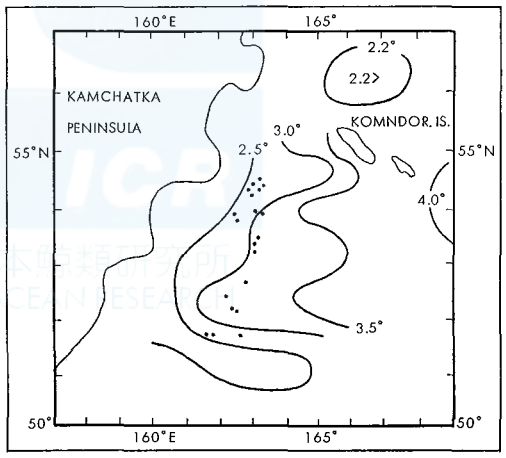


Fig. 13. Distribution of sighted fin whales and surface temperature (°C) in June of 1958.

1958 (see Fig. 13)—The temperatures in this year were especially low, and the waters with less than 3.5°C at surface covered extensive areas to the south of Ko-

mandorskii Islands as May in 1955, 1959 and 1960. The pattern of temperature distribution was lower in the west and higher in the east as in May of ordinary years. The notable cold area which was characterized by less than 2.2°C at surface was located to the north of Komandorskii Islands.

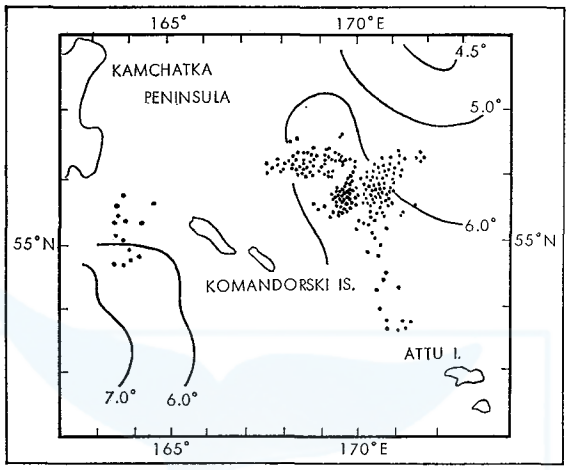


Fig. 14. Distribution of sighted fin whales and surface temperature (°C) in June of 1959.

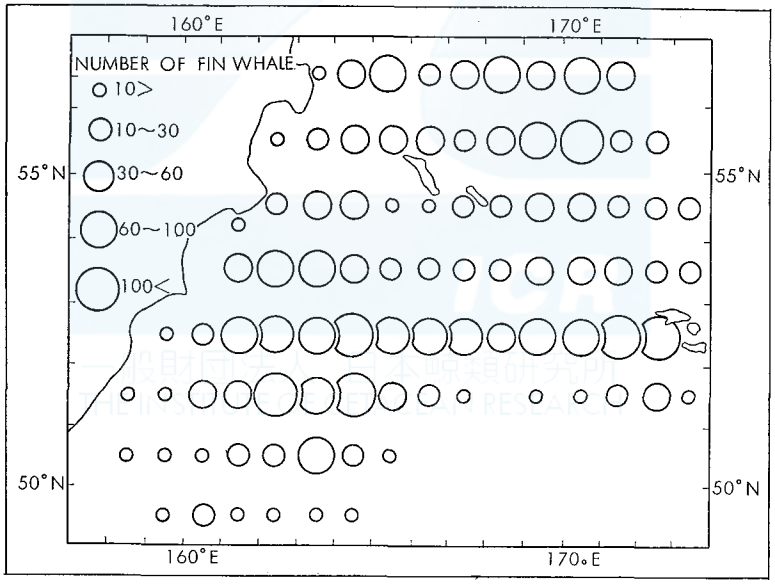


Fig. 15. Distribution of fin whales caught in the years 1952 to 1964.

Fin whales were sighted at the comparatively south sea region with 2.5°–3.0°C at surface temperature as similar to 1955 which was a colder year.

1959 (see Fig. 14)—As already evident from the distribution of temperature in May, this was warmer year and especially the warm water mass with temperatures higher than 6.0°C conspicuously extended to the northeast of the Komandorskii Islands.

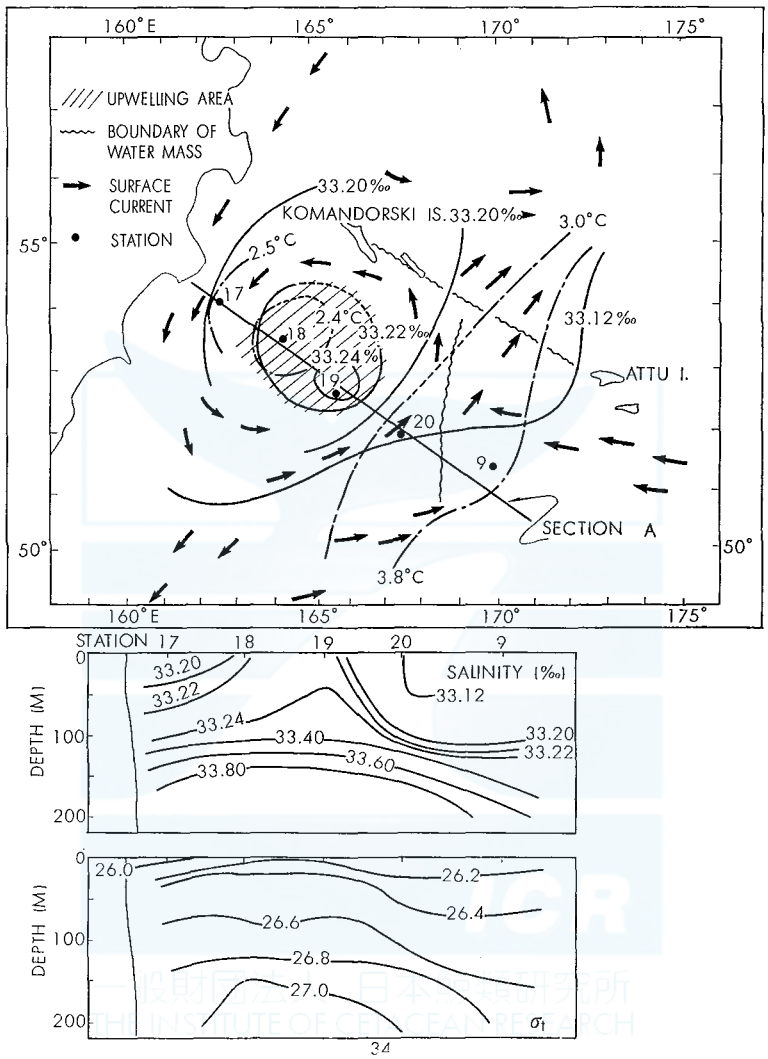


Fig. 16. Oceanographic structure in the east area off Kamchatka Peninsula.

The concentration fin whales were sighted in the warm sea region which was located to the northeast of Komandorskii Islands and was not sighted in the region east of the Kamchatka Peninsula.

Fig. 15 shows the distribution of caught fin whales in the years 1952 to 1964. As already reported by Nasu (1963), it is well known that the center of fin whaling grounds were located in the region of 51°–54°N, 162°–166°E. In order to analyze the oceanographic structure of this sea region. Fig. 16 was drawn by use of the

oceanographic data obtained by NORPAC survey.

The distributions of temperature and salinities are shown at 50 m of depth. The author presumed that the feeding depth of baleen whale is less than 50 m, because of the papers of Marr (1957, 1962) and Nemoto (1959). The surface currents which are shown by arrows were based on the current map by Taguchi (1956), Uda (1963) and Dodimead *et al.* (1963).

From these figures it was evident that the favourable fin whaling grounds coincided with the isolated cold area which formed the anticyclonic eddy. The lower figures in Fig. 16 show the profile of salinity and σt along the section A. As Koto (1958) already reported. Fig. 16 shows that the upwelling area was located near the center of anticyclonic eddy.

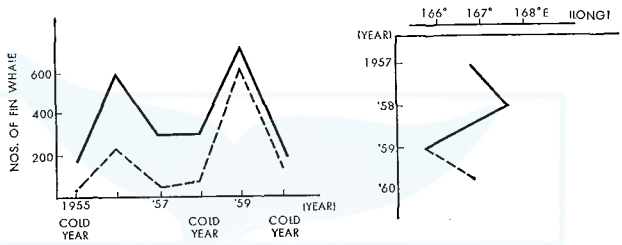


Fig. 17–1. Annual fluctuation of surface temperature and catches of fin whales.
Fig. 17–2. Annual fluctuation of intensity of Alaskan stream (After Koto 1964).

Consequently it may be considered that the whaling grounds south of Komandorskii Islands were formed by the dynamic upwelling which was caused by the anticyclonic eddy. As already shown, the whaling grounds in May, theearly season of whaling, were located in the waters with 2.0°—3.8°C surface temperatures.

To analyzed the salmon fishing grounds in this sea region, Taguchi (1956) divided to coastal and offshore waters in May and June by surface temperature as follows:

Water mass	temperature (°C)
Coastal waters	> 4.0°C
Offshore waters	< 3.0°C

According to this division, the whaling grounds in May were located at the mixing area between the coastal and offshore waters, and shifting to the east with the progress of thewhaling season. The author has analysed the situation in this region for the years 1955 to 1960. A close correlation was found between the water tempterature and fluctuation of fin whale catches. That is, from Figs. 9, 10, 11, 12, 13, and 14, the tendency are summarized as follows.

The colder year (1955, 1958, 1960).
Whaling grounds were located towards the south.
The warmer year (1956, 1959).
Whaling grounds were located towards the north.

Fig. 17—1 shows the relation between the annual fluctuation of surface temperature and fin whale catches. According to Fig. 17–2 it may be considered that

the annual fluctuation of water temperatures were introduced by the intensity of the Alaskan stream. Namely, the western extension of the Alaskan stream in warm years was located more westerly than in colder years. As shown by Fig. 16 ,the warm water masses which extend from the region east of the Kamchatka Peninsula to the region north of the Komandorskii Islands are closely connected with the Alaskan stream.

Off Cape Navarin and Olyutorskii

The catch from these sea regions was only fin whales, and the whaling seasons were from late July to the middle of August. As shown by Table 2, the fin whale catch off Cape Navarin was greater than off Olyutorskii. The total number of whales caught off cape Navarm was compared to 128 off Cape Olyutorskii.

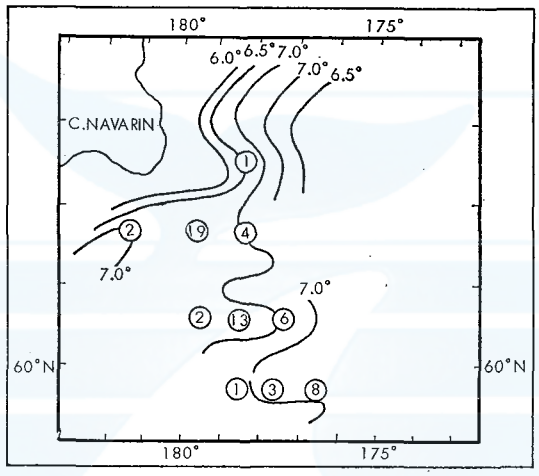


Fig. 18. Distribution of sighted fin whale and surface temperature (°C) in July of 1958.

TABLE 2. WHALING RESULT OFF CAPE NAVARIN AND OLYUTORSKII (FIN WHALE).

Year	Sea region		Total
	Olyutorskii	Navarin	
1957	6	175	181
1958	47	275	322
1959	0	0	0
1960	75	0	75
1961	0	0	0
1962	0	81	81
1963	0	0	0
1964	0	0	0
Total	128	531	659

July of 1958*:* According to Fig. 18 which was drawn from the results of whale marking survey, the isotherms near 62°N extended towards the east. This can be considered the result of the cold water mass which was formed by the melted-ice

in the vicinity of Siberia mainland. From the distribution of 7.0°C isotherm which meanders north and south, it was clear that there is oceanic front between the Bering water masses and the water masses covering the Alaskan continental shelf. The fin whales were sighted mainly along the oceanic front.

Augustof 1958: Fig. 19 shows the distribution of temperatures and salinities at the surface based on the data from the results of whales marking survey. The temperatures covered from off Navarin to the Gulf of Anadyr raised about 2.0°C over those July. The isotherms ran roughly parallel to Cape Navarin, and the cold water masses extended to the south. The fact that the cold water mass which

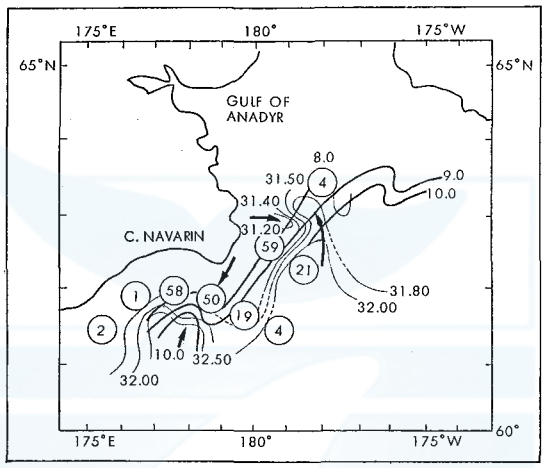


Fig. 19. Distribution of sighted fin whale and surface salinity (‰) in August of 1958.

extended to the south was caused by the melted-ice waters in the vicinity of Siberian continent is clearly shown by the distribution of salinity. That is, the distribution of cold water masses which were characterized by less than 8.0°C at surface corresponded to the waters with salinity less than 31.40‰.

Many fin whales were sighted near the mixing zone between the water mass of low temperature and salinity along the Siberian continent, and the Bering sea water mass of relative high temperature and salinity.

Fig. 20 shows the schematic map of the distribution of fin whales caught in the years 1957 to 1962. The oceanographic conditions, and the surface currents were drawn by use of the papers of Fleming (1955), Uda, (1963), Dodimead & Hirano (1963) and Nasu (1963). The main fin whaling grounds were located from the mixing zone to the south area. From the vertical section of temperature along the L-line as shown in Fig. 20, it can be found that there is the notable vertical boundary of the water masses.

Off Cape Olyutorskii

The catch from off cape Olyutorskii was small as shown in Table 2, and the

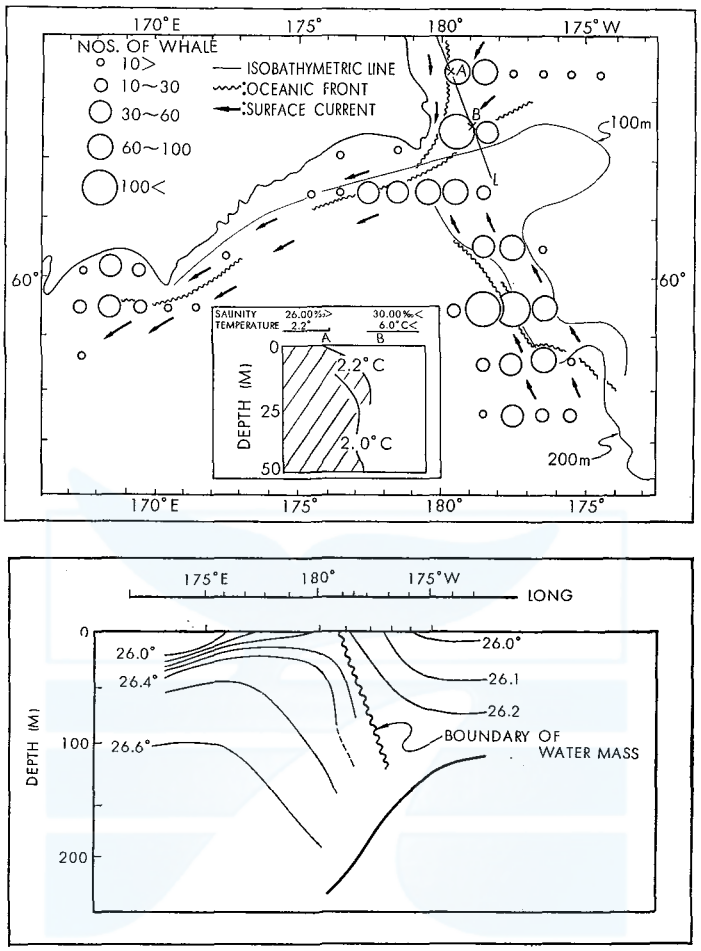


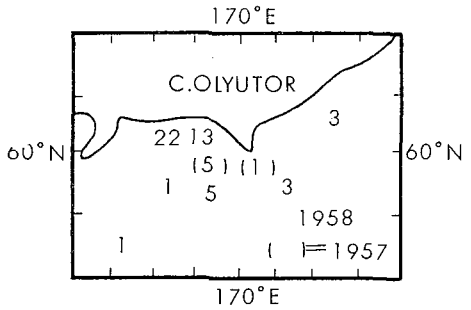
Fig. 20. Schematic map of the distribution of fin whales in the years 1957 to 1962 and the oceanographic structure.

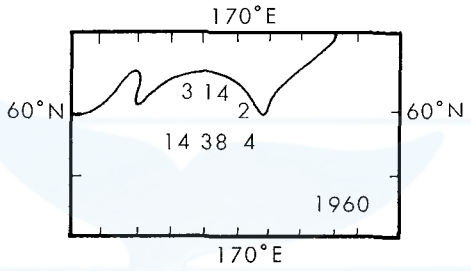
whaling seasons were short.

From the distribution of surface temperature in 1958, it may be considered that the zone of eddy was west of Cape Olyutorskii (see Fig. 21–3). Moreover, it was noted that the whaling grounds in 1958 and 1960 were located west of Cape Olyutorskii (see Fig. 21–1, 2). This can be summarized as follows: The formation of whaling ground was result of the topographic back eddy was located west of Cape Olyutorskii by the southward current along the Siberian continent.

St. Mathew Island area

Fig. 22 shows the distribution of fin whale caught in rich years (163 animals in 1957, 399 animals in 1959). The whaling grounds were located roughly same sea region, and the area of abundance of whales corresponds to the edge of continental shelf.





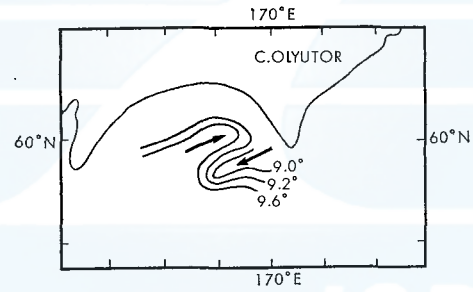


Fig. 21–1. Whaling grounds in 1958.
Fig. 21–2. Whaling grounds in 1960.
Fig. 21–3. Distribution of surface temperature in August of 1958.

From Fig. 22 the whaling grounds located at the oceanic frontal zones between the water masses covered the continental shelf to the Alaska and the water mass upwelled at the edge of shelf. The oceanic front was distributed nearly along the 200 m isobathymetric line. As already stated, the whaling grounds located nearly in the same area every year. It may be considered that the whaling grounds were at the oceanic front which was formed by the topographic upwelling.

Northern area off Unalaska Island

The whaling operations in the area north of Unalaska Island by Japanese ex-

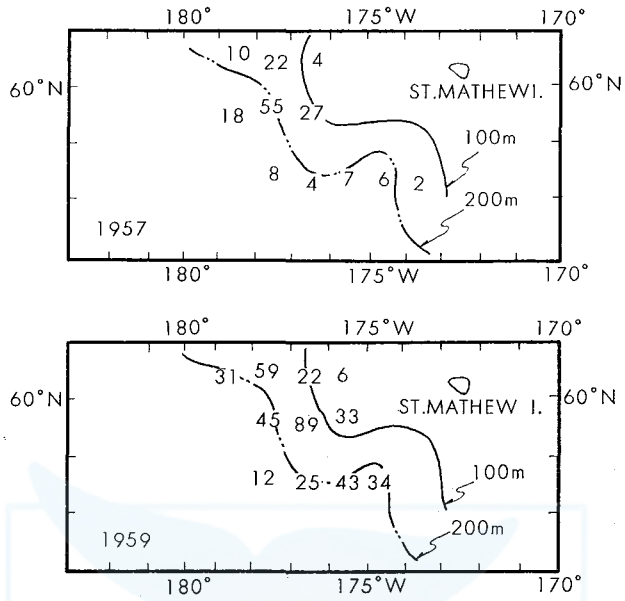


Fig. 22. Distribution of fin whale caught in rich years, 1957 and 1959.

peditions began in 1954. As shown in Table 3, the fin whale is the most important species of whale caught here. The catch from this region reached a maximum in 1955 with 1,177 animals. In 1963 and 1964, however, this catch decreased to 1 and 3 animals, respectively. A possible explanation maybe that the body lengths

TABLE 3. NUMBER OF WHALE CAUGHT BY JAPANESE EXPEDITIONS IN THE NORTH AREA OFF UNALASKA ISLAND IN THE YEARS 1954 TO 1964

Year	Species of whales caught		Total of whales
	Fin	Humpback	
1954	584	6	590
1955	1,177	10	1,187
1956	744	0	744
1957	286	0	286
1958	298	0	298
1959	703	0	703
1960	670	0	670
1961	422	0	422
1962	115	0	115
1963	1	0	1
1964	3	0	3
Total	5,003	16	5,019

of whales taken in this area were smaller than other regions (see Table 11), and the whaling operations in the Gulf of Alaska has been carried on from 1961.

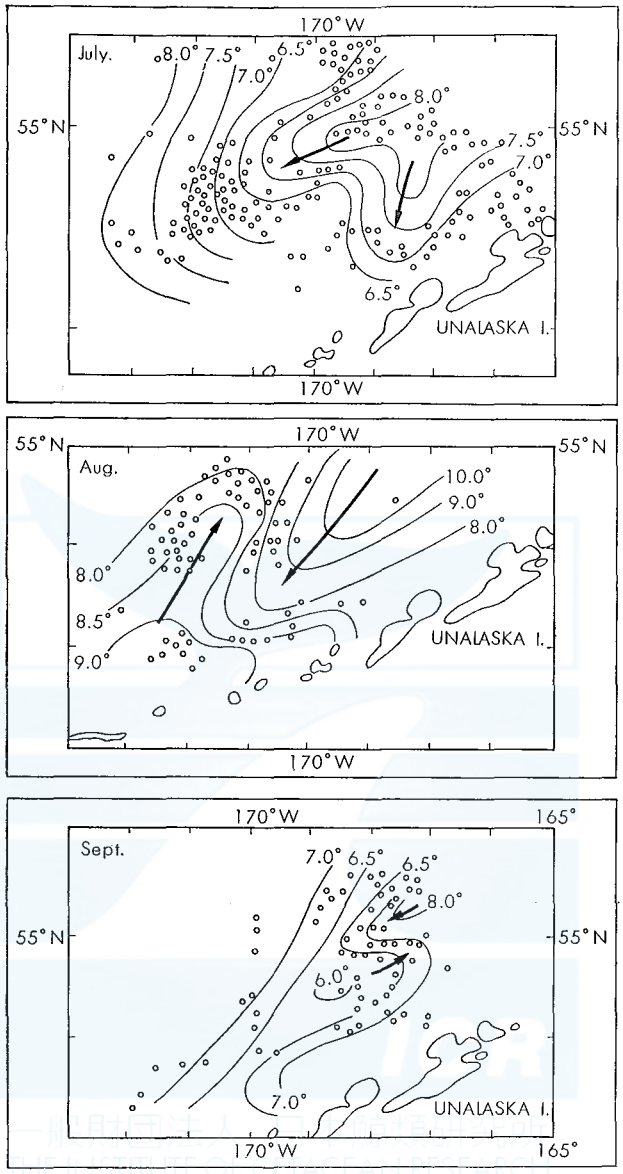


Fig. 23. Distribution of sighted fin whales and the surface temperatures in July, Augut and September of 1955.

The average center of whaling grounds in the years 1954 to 1960 were located at 54°N, 169°W. The greatest catch was found between 54°N and 55°N latitude. In general, the whaling ground north of Unalaska Island are smaller than those east of Kamchatka Peninsula (Nasu, 1963).

July of 1955 (see Fig. 23): At 56°W, the warmer water mass* which was characterized by 8.0°C or warmer at the surface extended towards the east. The

6.5, 7.0 and 7.5 isotherms were parallel to each other with meandering to the west and the south. To the south of the warmer water mass, there was cold water region which was formed by the upwelling due to the effect of the submarine topographic conditions. The favourable whaling grounds located were in the cold region having surface temperatures of 7.0°C or less.

There was a mixing area between the warmer water mass which flows to the east on the northern side of Aleutian Islands and the warm water mass which extends to the west. In Fig. 23, the mixing area having surface temperatures of less than 6.5°C are shown to be favourable whaling grounds (Nasu, 1963).

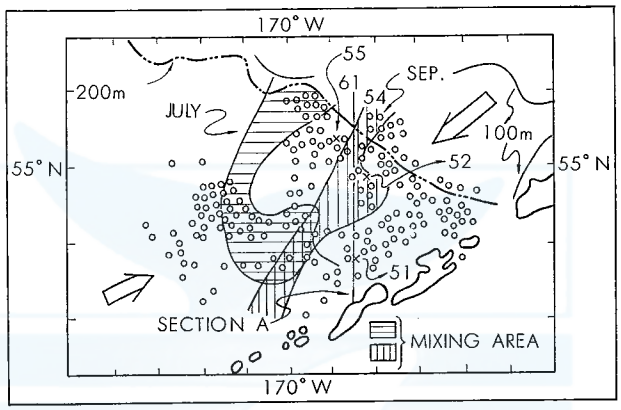


Fig. 24. Distribution of fin whales and mixing area.

August of 1955 (see Fig. 23) : The warmer water mass which was located near 56°N, 196°W in July showed temperatures higher than 10.0°C, and was strongly extended towards the southwest. The easterly-flowing water mass along the northern side of Aleutian Islands also extended tongue-like towards the northeast. More-ever, the mixing area are characterized waters with less than 8.0°C surface temperature.

September of 1955 : (see Fig. 23) : According to the distribution of surface temperature, the westerly edge of Bristol water mass retreated near 168°W, and the mixing area had temperatures of less than 6.5°C. Fig. 24 shows the distribution of fin whales and the mixing area. As already stated, the most fin whales were sighted from the mixing area to the Bristol water mass, and the position shifts month by month in accordance with the fluctuation of the two water masses, i.e. in July lying near 171°W and in September lying at near 169°W.

Fig. 25 shows the vertical distribution of σt along the section A. At isolines of σt St. 55 the water mass rise abruptly towards the surface, and St. 55 is located at just the edge of 200 m contour line. The bottom topography from this station to the west became suddenly deeper. Accordingly, the sudden rise of isoline of σt are probably caused by the bottom topography. From this phenomenon, it may be inferred that the whaling grounds of Unalaska Island are formed by the topo-

graphic upwelling and the mixing area.

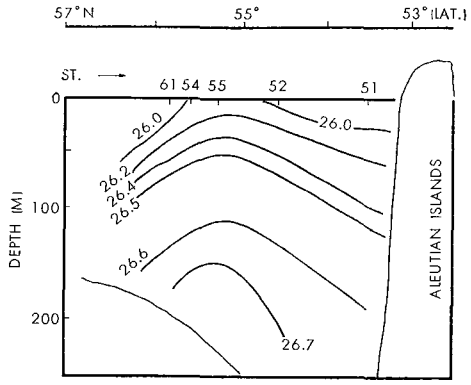


Fig. 25. Vertical distribution of σ_t along the section A (Fig. 24).

Southern area of Aleutian Islands

The main whaling ground in this area extends to the east and the west as a center to 50°–51°N. As shown in Table 4, the fin whale is the most important species of whale caught in this area, but some blue, humpback and sei whales also were captured.

TABLE 4. NUMBER OF WHALE CAUGHT BY JAPANESE EXPEDITION IN THE SOUTHERN AREA OF ALEUTIAN ISLANDS IN THE YEARS 1954 TO 1964

Year	Species of whales caught				
	Blue	Fin	Humpback	Sei	Total
1954	121	167	114	40	442
1955	47	39	89	1	176
1956	69	46	2	1	118
1957	70	500	0	102	672
1958	65	442	20	270	797
1959	69	53	0	25	147
1960	70	52	0	203	325
1961	39	273	9	4	325
1962	13	288	0	195	496
1963	0	7	0	0	7
1964	17	224	0	457	698
Total	580	2,091	234	1,298	4,203

Fig. 26 shows the distribution of sighted fin whales and the oceanographic conditions. The water mass which extended towards the southwest with tongue-shaped may be considered the Alaskan stream. On the other hand, the water mass which extended towards the northeast may be considered. From the distribution of these water masses the whaling ground seems to be closely associated with the

oceanic front which is formed between the extention of Alaskan stream and the northerly branch of Kuroshio water mass. Morever, the fin whales in this ground

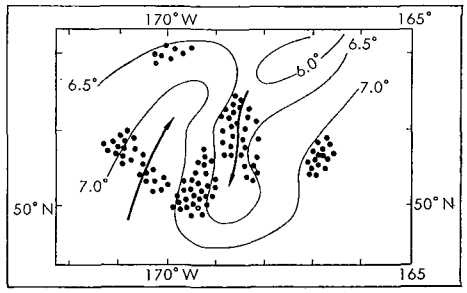


Fig. 26. Distribution of sighted fin whales and the oceanographic condition.

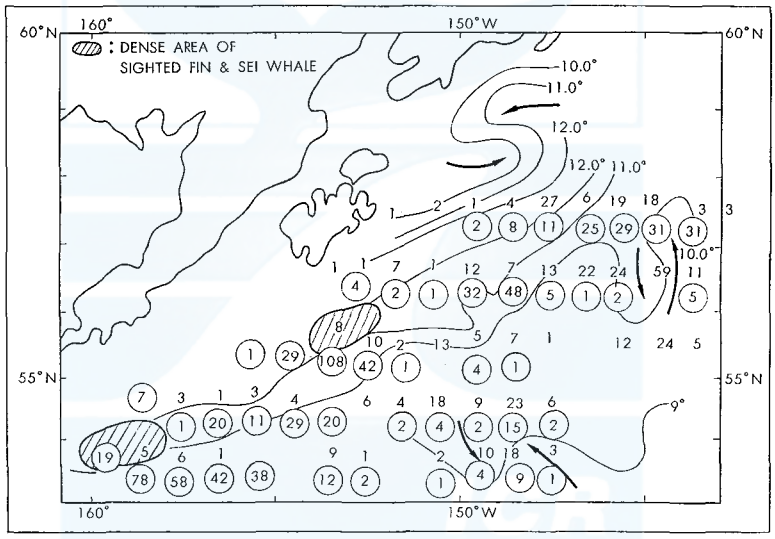


Fig. 27. Distribution of surface temperature and the number of fin and sei whale caught.

generally were captured in the area where the upwelling exists from relatively deep layer, being especially plentiful near the boundary zone which exists between the sinking and upwelling area (Nasu 1963).

Gulf of Alaska

The Japanese whaling operations in this region were started in 1961. As shown in Table 5 the catch from this region consists to a great extend of fin and sei whales. The total number of whale caught in 1963 amounted to 1,037 fin and 945 sei whales which was the greatest catch ever recorded from this area.

TABLE 5. NUMBER OF WHALE CAUGHT BY JAPANESE EXPEDITIONS IN THE GULF OF ALASKA IN THE YEARS 1961 TO 1964

Year	Species of whale caught				
	Fin	Blue	Humpback	Sei	Total
1961	425	31	0	0	456
1962	587	35	13	61	696
1963	1,037	57	20	945	2,059
1964	728	25	0	1,082	1,835
Total	2,777	148	33	2,088	5,046

Fig. 27 shows the distribution of surface temperature and the number of fin and sei whale caught every 1 degree latitude and longitude in July. The cold water mass which is characterized by less than 10.0°C in surface temperature is located from near the Alaskan continent to the adjacent waters of the Aleutian Islands. It extends eastward to an area northeast of Kodiak Island, where the warm water mass extending towards the west exists.

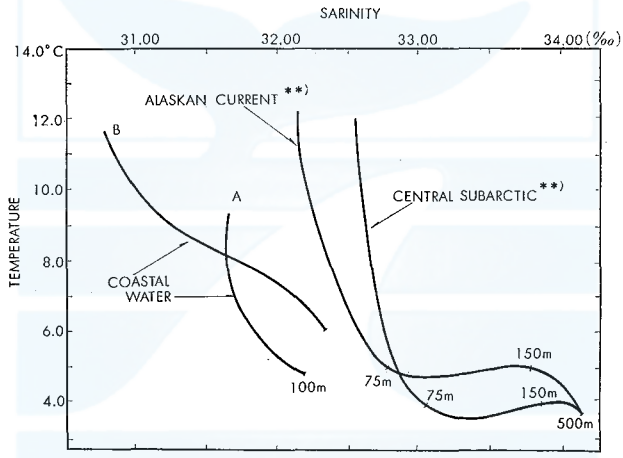


Fig. 28. Temperature and salinity diagram.

These water masses form the eddy in the east of Kodiak Island where the favourable whaling grounds was located in 1961 and 1963. The 2-isotherms of 11°C which extend towards the southwest from the eddy area must be influenced by the Alaskan stream. The distribution of fin and sei whale caught in 1964 covered the southern area of 11°C isotherms.

From the distribution of temperatures it has been found that the zone of eddy was located near 56°30′N, 144°30′W and 53°N, 149°W where the whaling grounds with fin and sei whales were formed. In addition, many sei whales were sighted in the water with 10°–12°C in surface temperatures near 56°N, 153°W and 54°N, 159°W respectively during the whale sighting survey in summer of 1964 (The regions where many sei whales were sighted were shown by the oblique line in Fig. 28).

Fig. 28 shows the temperature and salinity diagram based on the data obtained

by Brown Bear in summer of 1955, and Fig. 29 shows the schematic map of water masses and the distribution of fin whales caught.

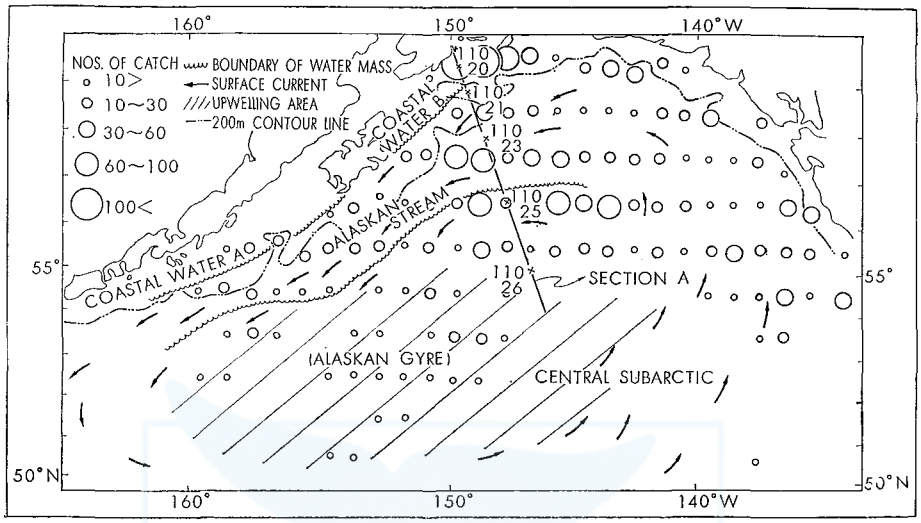


Fig. 29. Schematic map of water masses and the distribution of fin whale caught.

As already reported by Dodimead and Hirano (1963), the water masses in this whaling grounds are divided as follows;

1) Central subarctic
2) Alaskan stream
3) Coastal water (it can diveded to A and B)

Whaling grounds in 1961: The main whaling grounds were located in the Alaskan stream.

Whaling grounds in 1962: The main whaling grounds were located from the zone of eddy which situated in the northeast of Kodiak, near 59°N, 149°W to the coastal water B.

Whaling grounds in 1963: As already stated the catch of fin whale in this year was the highest. The whaling grounds covered an extensive area and were situated close to the continent compared with 1961, 1962 and 1964, and also were found near 59°N, 149°W to the northeast of Kodiak Island, similar to 1961 and 1962. The catch of sei whales in this year also increased, and the main whaling grounds, differ from that of fin whales being located in the zone of boundary between the Alaskan stream and the central subarctic water.

From the distribution of annual whaling grounds, the favourable grounds generally were found in the marginal zone of Alaskan stream. According to Fig. 30 which shows the vertical distribution of σt along the section A it can be seem that the upwelling area existed in the southern edge of the Alaskan stream. Consequently, the explanation of oceanographic structure in this whaling grounds may be summarized as follows: The whaling grounds in the southern marginal zone of Alaskan stream were formed by the convergence between the upwelling water mass

which was influenced by the anticlockwise gyr and the Alaskan stream.

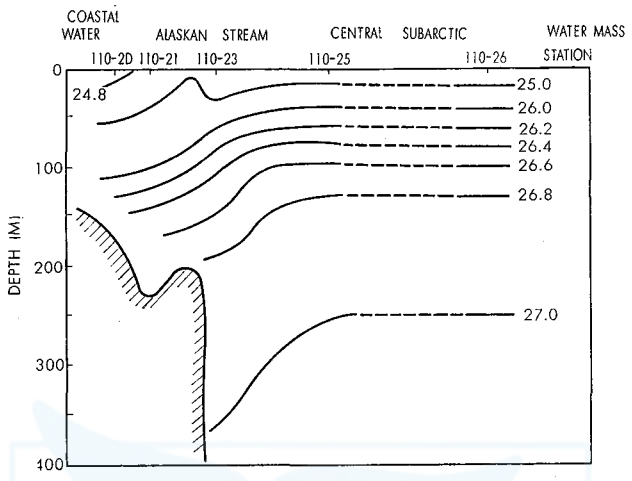


Fig. 30. Vertical distribution of σi along the section A.

The whaling grounds in the northern marginal zone of Alaskan stream were formed by the convergence between the coastal waters to the Alaskan continent and the Alaskan stream.

As above stated it may be assumed that the dynamic upwelling by the anticyclonic eddy and the Alaskan stream were the important factors in the formation of these whaling grounds.

ANTARCTIC OCEAN

Fig. 31 shows the rough map the whaling ground operatated by Japanese expeditions and the surface oceanographic condition cited from Marr (1964). In addition Table 6 shows the catch during the recent 10 years from the Antarctic region by world expeditions.

TABLE 6. BALEEN WHALES CAUGHT IN THE YEARS 1955/56–1964/65, BY SPECIES (AFTER THE INTERNATIONAL WHALING STATISTICS)

	Species of whales caught					
Year	Blue	Fin	Humpback	Sei	Total	B.W.U.
1955/56	1,611	25,102	1,425	274	28,412	14,779
1956/57	1,505	25,502	673	708	28,388	14,636
1957/58	1,682	25,067	396	2,375	29,520	14,770
1958/59	1,187	25,687	2,393	1,394	30,661	15,324
1959/60	1,228	26,271	1,332	3,219	32,050	15,421
1960/61	1,739	27,299	709	4,280	34,027	16,374
1961/62	1,116	26,364	309	4,716	32,505	15,228
1962/63	944	18,636	270	5,482	25,332	11,306
1963/64	112	13,583	2	8,256	22,223	8,448
1964/65	20	7,306	—	19,838	27,164	7,052
Total	11,144	220,817	7,509	50,542	290,282	133,338

Area of 105°W–135°W in 1957 season

Fig. 32–1 and 32–2 show the distribution of fin whales caught and the surface oceanographic conditions in January of 1957. Observation area covered from about 105°W to 130°W. The surface temperature in this area varies from 0.5°C to –0.9°C. The distribution of pack-ice is extended towards the east from the vicinity of 66°S, 117°W, and it is directed southward very sharply from 66°S, 110°W. To the west side of the south-western tongue region, the low temperature and salinity water mass is projected towards the north-east. This is probably caused by the of distribution of pack-ice.

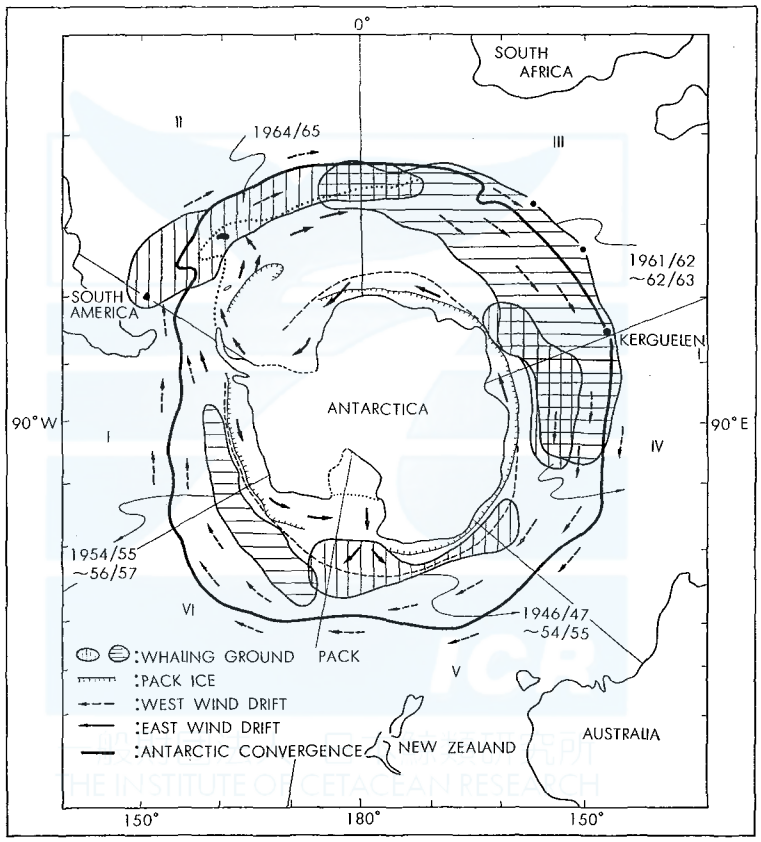


Fig. 31. Rough map of the whaling ground operated by Japanese expeditions.

It is clear that complicated sea conditions were formed in this region between the northern and southern moving water masses as evidenced by the map of isotherms and isohalines. The distribution of temperatures in this area varied abruptly.

The condition of pack-ice at the western part of 117°W is not clear, but it is assumed that the pack-ice is distributed towards southern direction from about

117°W. In the vicinity of 117°W, the high temperature and salinity water mass is found and at the west part of it, near 128°W, the definite shape running towards the south-west direction was recognized.

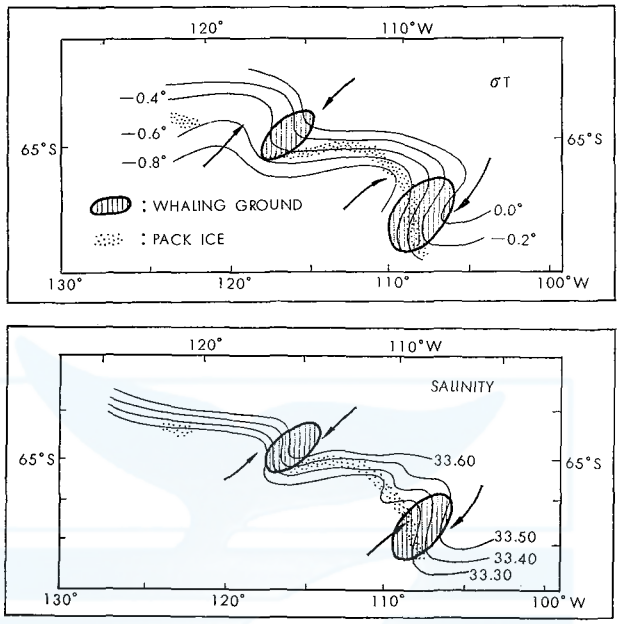


Fig. 32. Distribution of fin whales caught and the surface oceanographic condition in June, 1965.

It is clear from these phenomena that the favourable whaling ground are situated near the region of 65°S, 115°W and 66°–67°S, 108°W. In the neighbourhood of these two regions the eddies were developed on the oceanic fronts between the water mass of high temperature and salinity flowing towards the south and the water mass of low temperature and salinity flowing towards the north.

Area of 90°E–35°W in 1961/62 season

Fig. 33 shows the distribution of sighted whales by Umitaka-maru in December and January respectively in the regions east and west of 20°E. To the east of South Georgia Island, there was warm water mass which flowed towards the south and a cold water mass which flowed towards the north. In the vicinity of 65°S, 10°W the low salinity water mass with less than 33.0‰, was clearly influenced by the melting of ice, extended towards the northeast with definite shape. Fin whales were sighted near the pack-ice in the low salinity water area.

On the other hand, near 15°E, many fin whales were sighted in the area of high salinity water mass which projected towards the southwest. At 20°E fin whales were sighted in the neighbourhood of pack-ice (the area of less than −1.0°C) which was situated towards the north. Fin whales were also distributed in the waters of low temperature and salinity which were situated towards the north

near 35°E.

Generally, it can be assumed from the distribution of temperature and salinity that the clockwise eddies in the vicinity of pack-ice play a very important role for the formation of the Antarctic baleen whaling grounds. According to Fig. 34 which shows the vertical distribution of temperature along the line-A (see Fig. 34), the

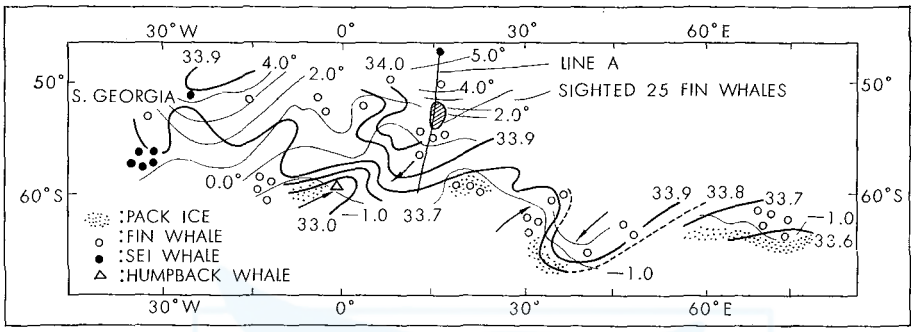


Fig. 33. Distribution of sighted whales by Umitaka Maru in December and January.

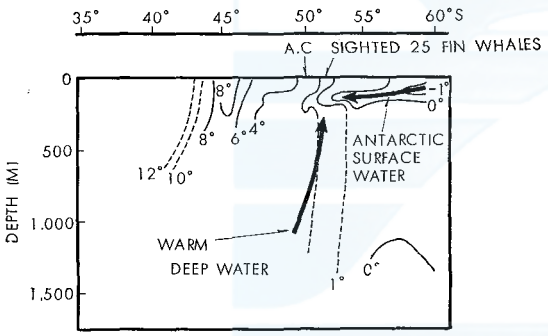


Fig. 34. Vertical distribution of temperature along the line A.

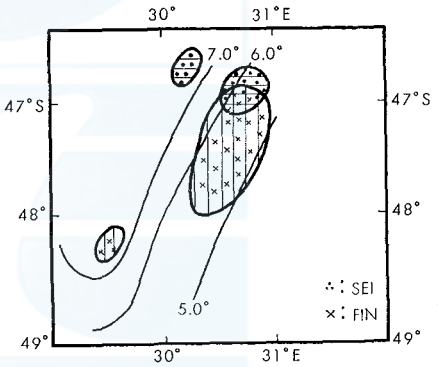


Fig. 35. Distribution of surface temperature and sighted fin and sei whale.

sea region where many fin whales were sighted correspondeds to the upwelling area of the Warm Deep Water.

Area of 29°E–39°E in 1962/63 season

In the middle of January, the main whaling grounds consisting of fin and sei whales) were in the region of 47°–48°S and 30°–31°E (see Fig. 35). The oceanographic conditions in this area were characterized by a warm water mass (more than 7.0°C surface temperature) which extended toward the southwest. Most of fin whales are caught in the relatively colder region (less than 6.0°C) and the sei whales in the same grounds are caught in the relatively warmer region. The results of stomach content observed by the author are as follows: sei whales feed mainly on *Parathemisto gaudichaudi* and *Euphausia vallentini*, and fin whale feed only *E. vallentini*.

The fin whaling grounds in late of January shifted to the region of 48°–49°S,

37°–38°E. The surface temperature in the more favourable grounds was less than 4.0°C. The colors of the water were observed 4–6 (see Fig. 36). In addition the stomach content of fin whales consisted mainly of 2 years group of *Euphausia superba*. Fin whaling grounds also located in the sea region with 4.0°–5.0°C in surface temperature and with 5–6 in water color. The stomach contents of whales observed were mainly *Euphausia vallentini*.

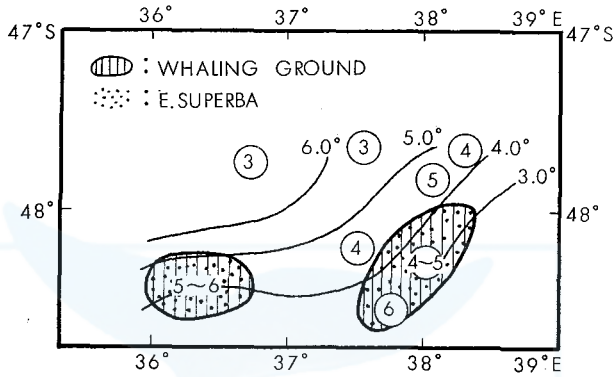


Fig. 36. Distribution of surface temperature (°C) and the color of water.

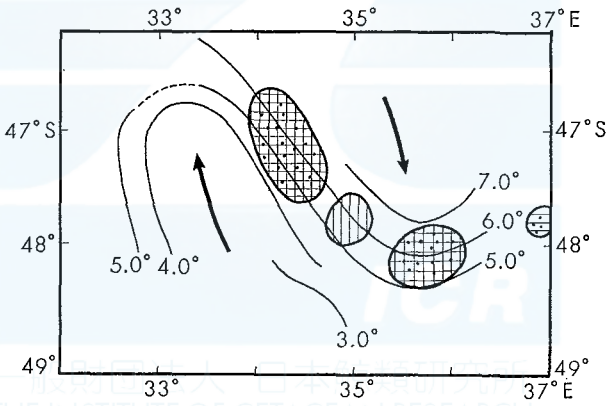


Fig. 37. Distribution of *Eaphausia superba*, sighted pigmy blue and fin whales, and surface temperature (°C). Dot: *E. superba*, Vertical line: Pigmy blue and Fin whale, Horizontel line: Fin whale.

Fig. 37 shows the distribution of pigmy blue and fin whales and the sea condition at surface in middle of January. According to the distribution of surface temperature, it indicated that there is the clockwise eddy between the warmer water mass with flowing towards the southeast and the colder water mass flowing towards the northwest. Many pigmy blue and fin whales were sighted in the

area from the southern tops of the warm water mass to the oceanic front between the warmer and colder water mass. The stomach contents of fin whales caught were mainly *Euphausia vallentini*.

Fig. 38 shows the whaling grounds of pigmy blue and fin whales and the surface sea conditions in the waters of 30°E–34°E in early of February. In the vicinity of 32°E, the colder water mass having a temperature of less than 2.5°C was located towards the north. On the other hand, the warmer water mass flowing towards the south was found in the neighborhood of 33°E.

The fin whaling grounds were situated in the water with 2.5°–4.0°C surface temperature within the colder water mass. The stomach contents were observed with *Euphausia superba* from water of less than 4.0°C, and with *Euphausia vallentini* from water of more than 4.0°C.

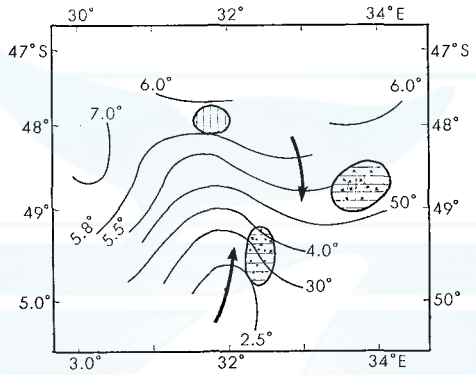


Fig. 38. Whaling ground of pigmy blue and fin whales and the surface temperature (°C), Vertical lines: Sighted pigmy blue whale, Horizontal lines: Sighted fin whale, Dot: *E. superba*, Cross ; *E. vallentini*.

The catch from the zone of the warmer water mass are pigmy blue and fin whales. The stomach contents of these whales were largely *Euphausia vallentini* from pigmy blue whales, and *Euphausia vallentini* and *Euphausia superba* from fin whales.

Area of 60°W–10°W in 1964/65 season

The whaling grounds of fin and sei whales and the distribution of surface temperature are shown in Fig. 39. The Antarctic Convergence and Subtropical Convergence in Fig. 39 were indicated by the 4.5°C and 14°C in surface temperature, respectively. As shown in the figure, to the east of South Georgia Island the cold water mass which has a northerly component of movement covered an extensive area. In the waters with a center at 22°–23°W the warm water tongue shaped mass extended towards the south. Favourable whaling grounds of fin and sei whales also were found in the sea region of 44–48°S, 55–60°W, where the extension of Brazil Current was located, and corresponded to the zone of Subtropical Convergence

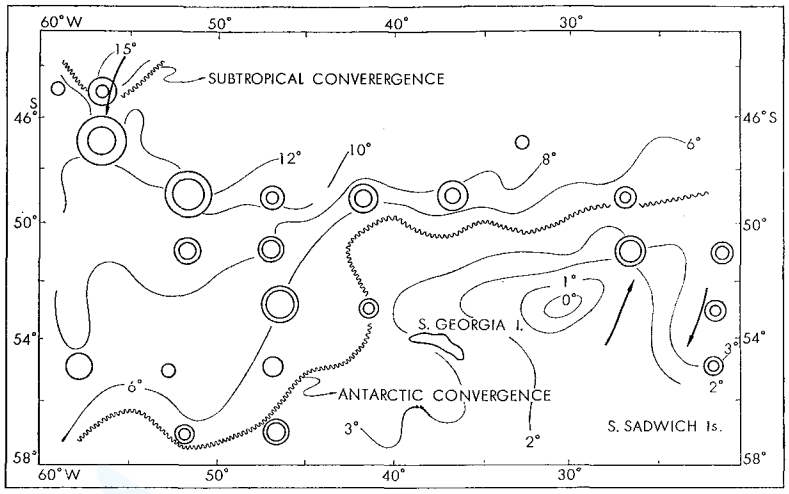


Fig. 39. Whaling ground of blue and fin whales, and the surface temperature (°C).

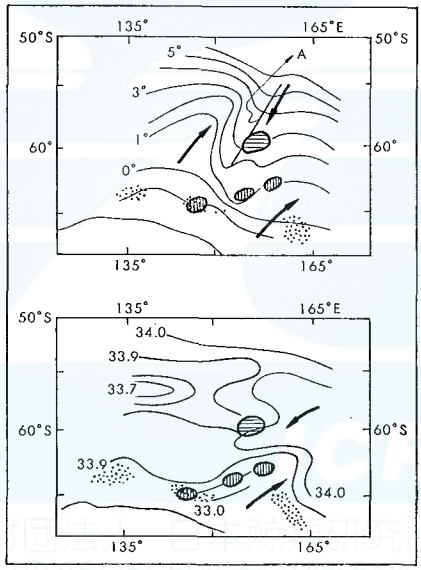


Fig. 40. Distribution of sighted fin and minke whale, and surface temperature (°C), Horizontal line: Fine whale, Vertical line: Minke whale, Dot: Pack ice.

which was reveiled assumed by 12–15°C in surface temperature.

Area of 135°E–165°E in 1965 season

Fig. 40 is drawn based on the data obtained by Umitaka-maru in January of 1965. The species of whales sighted are fin and little piked whale, or minke.

From Fig. 40 it can be seen that the fin whales were sighted in waters of high temperature and salinity, and the little piked whales were sighted in waters of low temperature and salinity.

Fig. 41 shows the vertical distribution of temperature along the line A of Fig. 40. In Fig. 41 the area of oblique lines shows that the denser region of sighted whales as observed in the area of 52°S, 15°E in January of 1962, coincided with the upwelling area of Warm Deep Water.

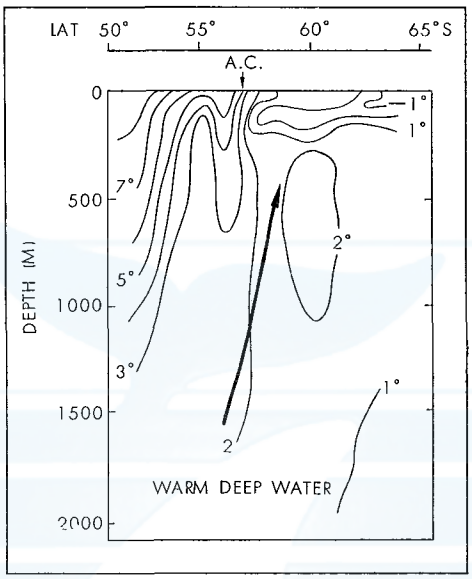


Fig. 41. Vertical distribution of temperature (°C) along the line A in Fig. 40.

As the analyses in the Antarctic whaling grounds mainly used the data obtained by Japanese expeditions, the author mostly discussed the relation between the surface sea conditions and the baleen whaling grounds.

It general can be assumed that the most favourable whaling grounds were situated in the oceanic front between the warm water mass and cold water mass with no relation to the latitude. Especially when the clockwise eddies develop along the oceanic front, the best whaling grounds were found from the top of the tongue shape of warm water which flowed towards the south to the east side of the cold water mass which flowed towards the north.

Fig. 42 is the schematic illustration of above-mentioned sea condition. Uda (1954) already analyzed the whaling grounds off Sanriku, and explained as follows: The cyclonic revolving pattern of the tongues of cold and warm currents corresponds to the centres of the most favourable whaling grounds. It may be due to the rich zone of the foods for whales. In the southern area of Antarctic Convergence, it may be considered from the vertical distribution of temperature that the favourable whaling grounds were located in the upwelling zone of warm deep water.

It is well known that the zone of high production is found in areas of upwelling. Uda (1963), Kumagori (1963) and Ishino (1963) already stated the relation between the Antarctic whaling grounds and the upwelling, Warm Deep Water.

The catch from the sea-region of 47°–51°S, 24°E–36°E where the whaling operations have been carried on since 1961/62, and the stomach contents of these whales were studied *Euphausia superba*, *Euphausia vallentini*, and *Parathemisto gaudichaudi* was found to be the primary food. Morever, the relations among the species of food predator (whales) and surface temperature generally are as follows:

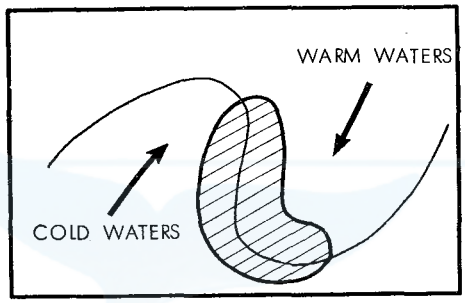


Fig. 42. Schematic illustration of sea condition in the favourable whaling ground.

Species of food	Predator (whales)	Surface temperature
Euphausia superba	Fin whale, Sei whale	<4.5°C
Euphausia vallentini	Pigmy blue whale, Fin whale, Sei whale	>4.5°C
Parathemisto gaudichaudi	Sei whale	>5.0°C

On the Antarctic whaling grounds in recent years

As shown in Fig. 31 the baleen whaling grounds in the Antarctic Ocean have been shifted from the Pacific sector to the Atlantic sector, and its latitudinal positions also moved from the vicinity of pack-ice region to the area of Antarctic and Subtropical Convergence. In order to analyze such a tendency the author discussed the fin whaling grounds which have been operated by the Japanese expeditions. Table 7 shows the whaling results in the individual areas and the catch rate of all areas during the period 1957/58–1964/65. The largest catch in the season 1957/58 was obtained in area VI with 4,107 fin whales, or 56.4 per cent of the all area. In the following two seasons the catch in the area IV varied between 42.1 in 1958/59 and 72.8 per cent of the entire area in 1959/60. In Area III the catch amounted to 8,865 fin whales, or 74.8 per cent of the entire area in 1961/62. Thus in the Antarctic season 1964/65, in Areas II and III (from 60° west and eastwards to 70° East) a total of 5,233 fin whales were obtained, or 99.2 per cent of all Area. In area I the result was only 44 fin whales, 0.8 per cent of all Area. In other areas there was no whaling activity in the latest season. Consequently, the recent Antarctic whaling by Japanese expeditions have mostly been operated in the Atlantic sector.

TABLE 7. THE NUMBER AND CATCH RATE OF ALL AREA OF FIN WHALE CAUGHT IN THE DIFFERENT AREAS OF ANTARCTIC*

Year	II	III	IV	V	VI	I
1957/58	—	832	584	1,130	4,107	628
		(11.4)	(8.0)	(15.5)	(56.4)	(8.7)
1958/59	—	53	3,314	2,395	2,103	—
		(0.7)	(42.1)	(30.5)	(26.7)	
1959/60	—	797	6,477	1,303	320	—
		(9.0)	(72.8)	(14.6)	(3.6)	
1960/61	—	4,761	2,044	236	1,861	—
		(53.5)	(23.0)	(2.6)	(20.9)	
1961/62	226	8,865	2,764	—	—	—
	(1.9)	(74.8)	(23.3)			
1962/63	2,066	7,705	699	—	—	—
	(19.7)	(73.6)	(6.7)			
1963/64	5,003	3,296	7	111	—	24
	(59.3)	(39.0)	(0.1)	(1.3)		(0.3)
1964/65	4,346	887	—	—	—	44
	(82.4)	(16.8)				(0.8)

( ): shows the catch rate for the all area.
*: whaling area was shown in Fig. 32.

For the purpose of obtaining the meridional change of fin whaling grounds, the catch between each 5 degrees latitude is shown in Table 8.

From Table 8 will be seen that the whaling operations in the Antarctic in later years have been carried on farther north than earlier.

TABLE 8. CATCH BETWEEN EACH 5 DEGREES LATITUDE IN THE ANTARCTIC (CATCH FROM THE JAPANESE EXPEDITION)

Year	40°–45°S	45°–50°S	50°–55°S	55°–60°S	60°–65°S	65°–70°S
1961/62	—	1,009	6,138	4,008	547	153
		(8.5)	(51.8)	(33.8)	(4.6)	(1.3)
1962/63	9	2,964	6,605	854	43	—
	(0.1)	(28.3)	(63.1)	(8.1)	(0.5)	
1963/64	6.5	937	6,704	617	—	—
	(0.8)	(11.3)	(80.5)	(7.4)		

A causal explanation may be as follows:

1) Change of oceanographic environment
2) Fluctuation of whale population

In the paper, the author discussed the position of the pack-ice. This factor is important in the formation of Antarctic whaling grounds. Fig. 43 shows the average positions of pack-ice in the years 1929–1934 (Mackintosh & Herdman: 1940) and in recent year obtained from the data carried out by Umitaka maru (shown by U in Fig. 43) and whaling catcher boats (shown by W in Fig. 43).

Fig. 43 shows that the fluctuations of pack-ice in the meridional average position between the previous and recent years were about 1 degree or 60 sea miles towards the north or south and consequently, it seems that the positions of pack-ice have not a tendency to change towards the low latitude in recent years.

It has been well-known that the baleen whaling grounds in high latitude mainly were formed in the waters with 1.0°–0.0 in surface temperature, so that the

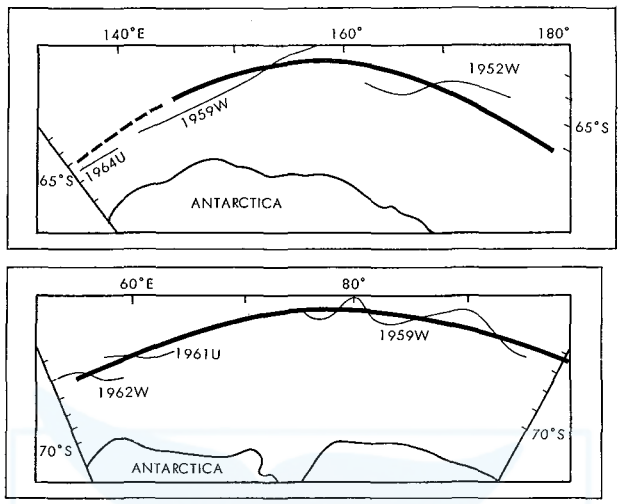


Fig. 43. Average position of pack ice in the years 1929–1934 (black line) (Mackintosh & Herdman 1940) and recent year (slender line).

meridional fluctuations of 0°C isotherm at surface was illustrated in Fig. 44 for comparison to the pack-ice. The data sources used in Fig. 44 were similar to those of Fig. 43.

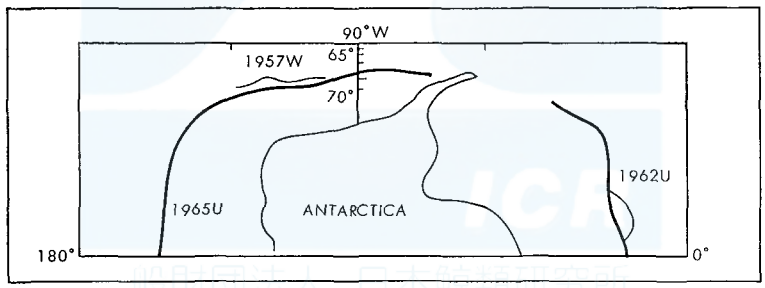


Fig. 44. Average position of 0°C-isotherm in the years 1926–39 (black line) (Mackintosh 1946) and recent year (slender line).

The maximum difference of meriditional position between the previous and recent years was about 1 degree in latitude, or 60 sea miles, and consequently, it seems that the position of 0°–isotherm have not a tendency to change towards the low latitude in recent years.

According to these phenomena it may be not considered that the change of whaling ground in recent years was influenced by the oceanographic environments such as pack-ice and surface temperature.

In next, the discussion on the fluctuation of fin whale population was made on the C.P.U.E. (Catch per unit of effort) in area III and IV, because the fin whales are the most important species, and occupied more than 80 per cent of the total catch. Table 9 shows the value of C.P.U.E. on the Antarctic fin whales caught by the Japanese expeditions. As seen from Table 9 it may be considered that the population of Antarctic fin whales have been decrease in recent years.

According to these phenomena as already stated by Ichihara (1962), it supposes that the shift of fin whaling grounds were influenced by the relation of demand and supply between the amount of available food and the number of whales.

TABLE 9. ANNUAL VALUES OF C.P.U.E. ON THE FIN WHALES IN AREA III AND IV (BY THE JAPANESE DATA)

Year	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64
III	—	—	2.69	2.57	2.62	1.94
IV	2.46	2.21	1.64	1.77	1.52	—

MOVEMENT OF BALEEN WHALE AND OCEANOGRAPHIC ENVIRONMENT

Generally, the movement of animals was divided into 1) recurrent movement, or migration 2) none-recurrent movement, or mere movement (hereafter termed movement). As to terms migration and movement of whales. I would refer to the work by Mackintosh (1942) and Nemoto (1959). That is, the migration means the long annual journeys between the cold feeding area and temperate or tropical breeding area, and the movement is used in the case of the local movement or short journey in the feeding and breeding areas. In this paper, the movements of fin whales in the Subarctic Pacific region are discussed. The research on the movement of whales have been made by the whale marking directly, and by biological survey etc. in directly.

According to the results of biological and marking investigations on the whales, it is clear that the blue and fin whales in the southern hemisphere migrate between high latitude feeding area and low latitude, breeding area (Mackintosh and Wheeler 1929, Mackintosh 1942, Brown 1960). In a addition in the southern hemisphere, humpback whales also migrates with regularly period (Mathews 1937, Chittleborough 1953, Dawbin 1949, Mackintosh 1942).

In the northern hemisphere it is clear from the results of whale marking that humpback whales migrate between the Bering Sea in summer and the waters of the Ryukyus in winter. Current maps indicate that theimigrations of humpback between the Antarctic Ocean (Area IV and V) and the adjacent waters to Australia have no consist relationship to current conditions. Dawbin (1956) also reported that the direction of current flow appears to be unimportant as the known south-north movements of humpback whales in the southern hemisphere.

Ing eneral, the important factors for the migration of baleen whales are not explained, however, the moving mechanism in the feeding area was reported by some papers. In the Sanriku area Uda (1954) stated that the moving route of whales

appears in the zone of abundant food. Nemoto (1959) also reported that the movement of baleen whales bears close relation with the abundance of food. And further, in the Antarctic Ocean the distribution of blue and fin whales was intimately related to the areas rich in *Euphausia superba* and other organisms (Kemp & Bennet 1932: Hardy & Gunther 1935).

MOVEMENT OF FIN WHALES IN THE SUBARCTIC PACIFIC OCEAN

The whale marking survey by Japanese vessels in the Subarctic Pacific has been carried on since 1953. The migration and movements of fin whales are indicated by the marking results (Kakuwa, Kawakami & Ito, 1955: Omura & Kawakami, 1956: Kawakami & Ichihara, 1958: Nemoto 1959).

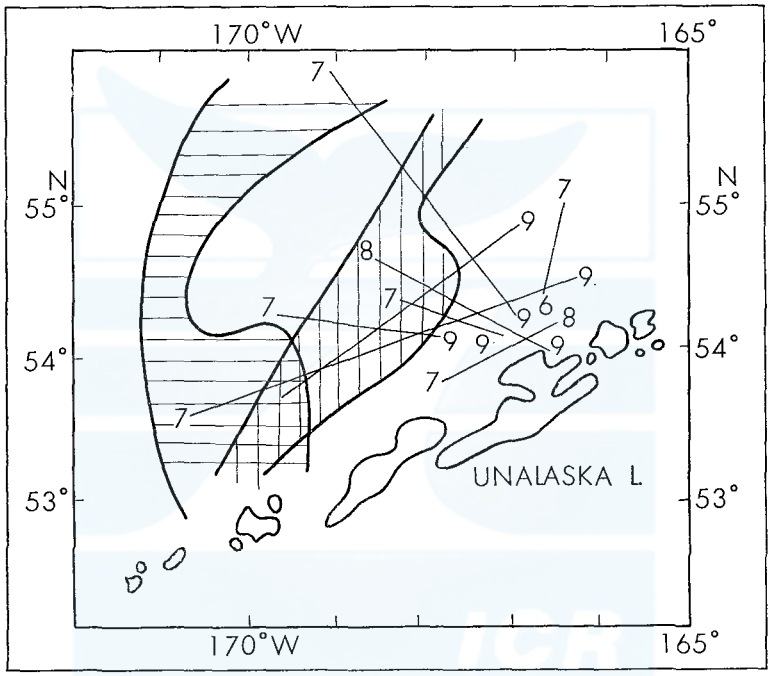


Fig. 45. Marking results by the Japanese marking research in the northern area of Unalaska Island, Horizontal line: Frontal zone in August, Vertical lines: Frontal zone in September.

Fig. 45 shows the marking results by the Japanese marking research in the northern area of Unalaska Island. In the earlier season, the fin whales which come to the nothern area of Unalaska Island may be divided into two groups, one of which moves towards the adjacent waters to Cape Navarin, while the other group approachs towards the Unalaska Island with the progress of the season. The latter seems likely to stay in the vicinity of the Aleutian Islands as will seen from the fact that the movement of fin whales in this region corresponds to the seasonal shift of oceanic front (see Figs. 23–1, 23–2, 23–3 and 45). It seems that the movement of whales

in the feeding area generally is influenced by the oceanographic circumstances. For the purpose of analyzing the movement among the whaling grounds, the instances of comparatively long distances between marked and recaptured position are shown in Fig. 46. It must be considered that the distribution of the whales caught

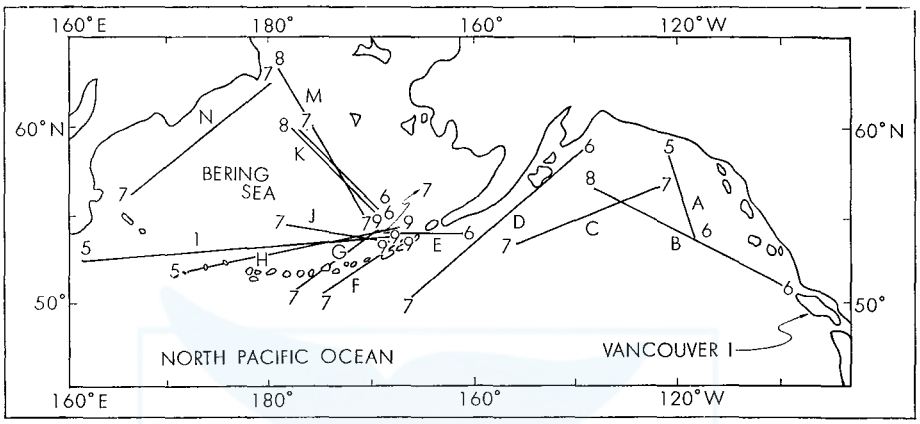


Fig. 46. Map of comparatively long distance between marked and recaptured position.

shows the movement of it, and so the map of whaling grounds and the monthly sighted whales show in Fig. 47 and 48, respectively. According to five instances in the Gulf of Alaska the fin whales which came from off Vancouver Island prior to June tend to move towards the Gulf of Alaska, and it will be seen from the distribution of whales caught that these moving routes run along the marginal zone of Alaskan stream. In addition Kellogg (1929) already stated that the fin whales may move between the Lower California and Bering Sea.

The fin whales which moved towards the west along the Aleutian Islands came to the northern area of Unalaska Island between the Islands (E.F.G. in Fig. 46), and the movement of these whales in general may be related to the eastward current along the northern area of Aleutian Islands.

The marking results indicate some fin whales which came to the east area off Kamchatka Peninusula move towards the east area, and those routes also may be related to the eastward current similar to case of E.F.G. in Fig. 46. Fin whales which came to the northern area of Unalaska Island must be divided into two groups. One group closely follows the oceanic front between the water mass covering the continental shelf of Alaska and the water mass upwelling at the edge of shelf in a north-westerly direction as far as near Cape Navarin. The other group must stay a long time in the northern area of Unalaska Island. In addition, as will be seen from Table 10 it seems that the staying group is characterized by the high percentage of young and lactating whales.

Therefore, it supposes that the group which moves towards the north consists comparatively of older whales.

The reasons why the whaling ground in the northern area of Unalaska Island

was formed by the special biological group are obscure. Consequently, the author thinks that the analysis of the relationship between the physiology and ecology of whales and the oceanographic environment is a very important problem for the fishery oceanographic study of whaling grounds.

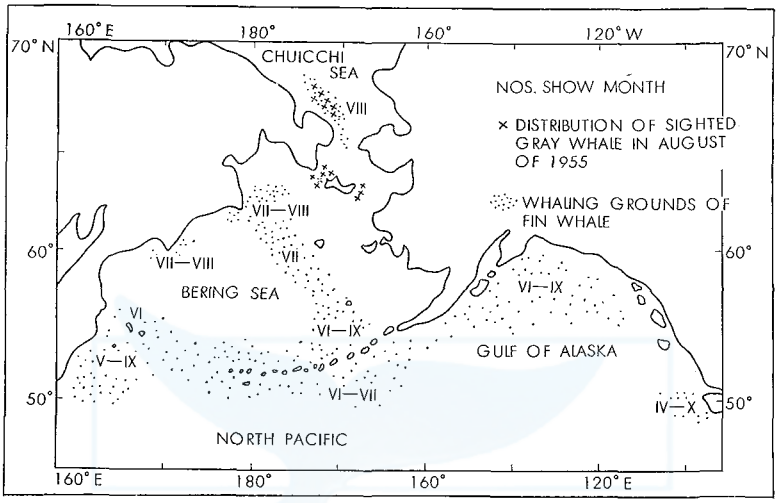


Fig. 47. Map of monthly whaling grounds.

TABLE 10. AVERAGE SIZE, IMMATURE RATE, AVERAGE OVULATION AND LACTATING RATE OF FIN WHALE CAUGHT IN THE SUBARCTIC PACIFIC OCEAN BY INDIVIDUAL AREA 1958 (AFTER NASU 1959)

Area*	Average size (feet)		Immature rate		Average Ovulation	Lactating rate*
I	60.5	63.1	18.8	27.6	8.1	5.6
II**	60.6	63.2	20.6	23.0	8.0	3.8
IV	59.4	60.8	41.5	54.6	5.6	12.5
V	60.8	62.6	25.0	32.4	6.3	3.2

* Shown in Fig. 8.

** Off Cape Navarin.

*** Lactating rate $= \frac{\text{number of Lactating whale}}{\text{number of female mature whale}} \times 100\%$

North-bound fin whales which travel up to the Bering Sea in summer season were seen in the Chukchi Sea, where few already were observed in July, and some of them were staying until October (Nikulin 1964). According to the results of survey in 1937 and whaling operation in 1940 by Japanese expedition it seems that the number of fin whales in the Chukchi Sea decreases from the middle of August, on the contrary the gray whales increase. Such a tendency also was indicated by the survey carried out on 16–20, August of 1958 (The number of the sighted whales during the survey were as follows: Fin whale: 1, Right whale: 2, Gray whale: 82, Unknown: 1, Total 86). Also most gray whales during the survey in 1958 were sighted in the fin whaling ground operated by Japanese expedition in 1940.

Furthermore, it is clear from the distribution of physical (temperature and salinity) and chemical (dissolved oxygen and hydrogen-ion concentration) element that the conspicuous oceanic front was formed in the dense concentration area of sighted whales, of which the marine productivity seems to be high.

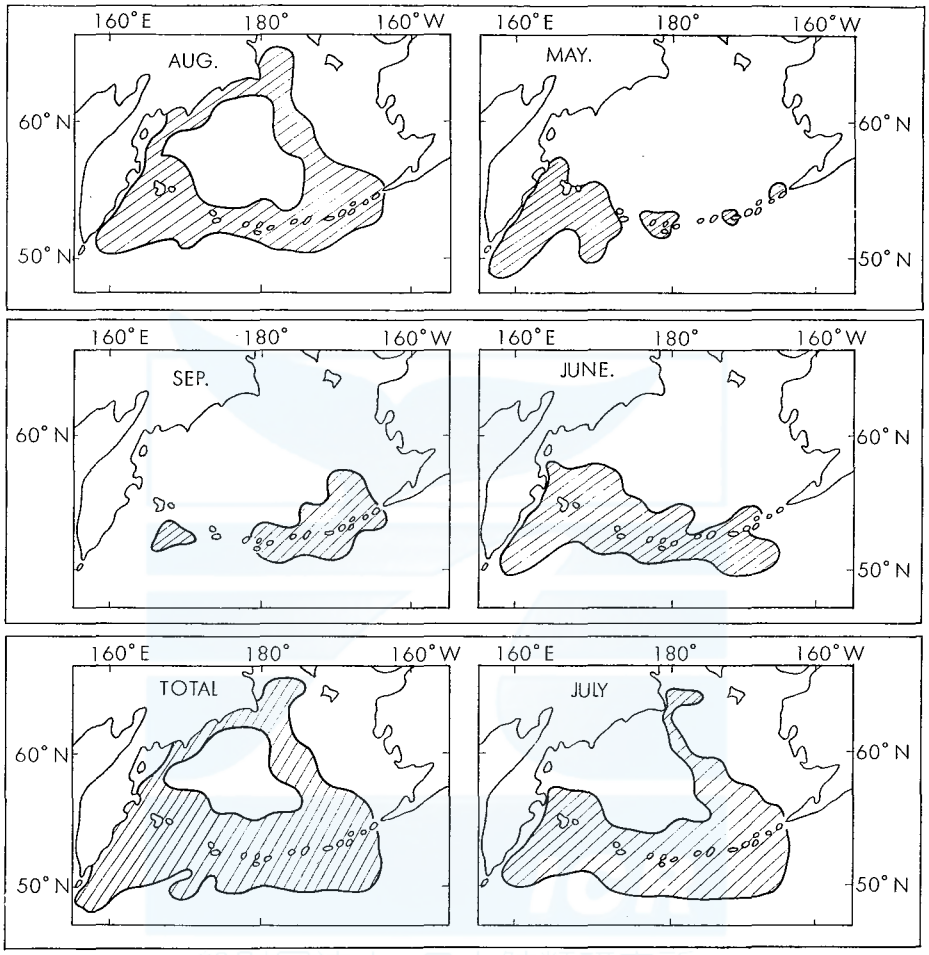


Fig. 48. Map of monthly distribution of sighted fin whale.

Fig. 49 shows the presumed moving route of fin whales, and the distribution of oceanic fronts and current pattern at surface in the Subarctic Pacific Area. In the Antarctic as already stated in previous chapter, the catch of fin and sei whales from near 47°S, 57°W were distributed along the southward tongue-shaped extension of the Brazil current. To the south of Antarctic Convergence, fin and sei whales near 54°S, 22°W were caught along the tongue shaped southward current indicated by the 2°–3°C isotherms.

In the waters to the north east of Japan, the northwards moving mechanism of sei whaling grounds were influenced by the conspicuous tongue shaped Kuroshio

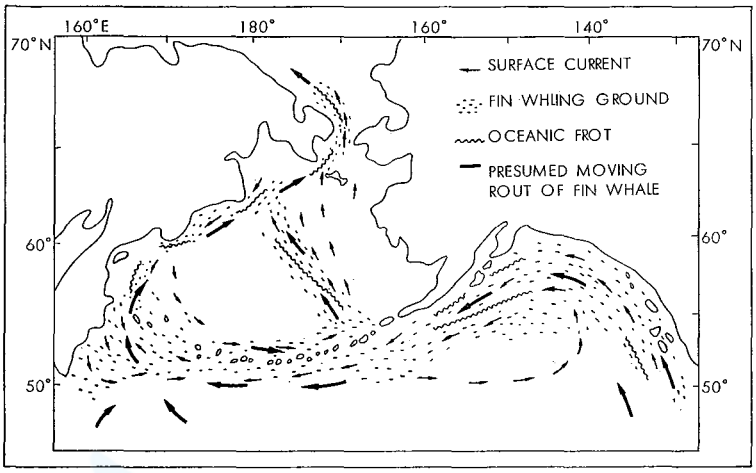


Fig. 49. Presumed moving route of fin whale and the oceanographic environment.

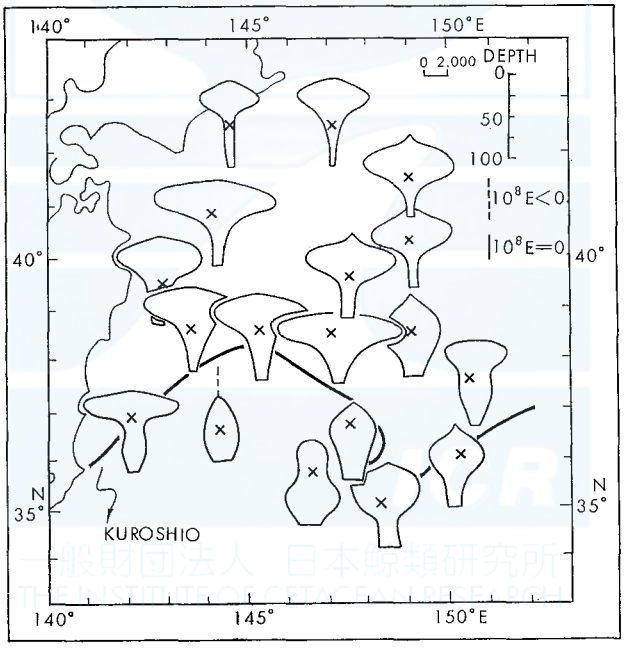


Fig. 50. Vertical stability in the northeast sea region of Japan, Sanriku to Hokkaido. Black line whows the Kuroshio current.

waters which projects towards the north. As stated in previous chapter, the distributions of the sei whales which came to the waters off Hokkaido correspond to the waters which the Oyashio Front projects towards south. Consequently, the baleen whales in the feeding area have a tendency to move along the oceanic front and the current which it developes in this region.

GENERAL CONSIDERATION OF THE BALEEN WHALING GROUNDS

Generally, the whaling grounds are divided into feeding and breeding grounds. There are breeding grounds such as humpback whales in the Ryukyu Islands which were investigated by Nishiwaki (1959). However, most whalings is done in feeding grounds (especially, in the pelagic whaling grounds). Favourable feeding grounds of whales are characterized by the special oceanographic structures such as the upwelling and vertical convection etc. Such oceanographic characters are found in the waters to the northeast of Japan, Subarctic Pacific Ocean and Antarctic Ocean.

That is, the vertical convection based on the increase of surface density in winter was recognized in the whaling grounds by the existence of intermediate cold water (Uda 1935, 1955, 1956, 1963, Nasu 1957, 1963). The upwelled deep waters in the euphotic zone form the notable spring layer of density by the increase of surface temperature or the melted-ice waters. For the purpose of obtaining the depth of spring layer, the vertical stability in individual sea region shown in Fig. 50, 51 and 52. As Elizarov (1963) also stated on the sea region at Newfound Banks, the vertical stability is a very imprtant element for the formation of fishing grounds. In the Antartic, Halse (1956) stated that the large phytoplandton popullti ons were confined to a surface large of 25–50 m, which coincided with the pronounced stable layer, Nasu (1963) also pointed out that the vertical stability is the important factor for the formation of whaling grounds.

Of course, the oceanographic analysis of whaling grounds must include the structure of deep water, however, from the results reported by Marr (1957, 1962) and Nemoto (1959) the author presumed that the feeding depth of baleen whale is less than about 50 m. Consequently, the vertical stability is within 100 m in Antarctic, Subarctic Pacific and Northeast area of Japan as shown in Fig. 50, 51 and 52. For the calculation of vertical stability the following approximate formula was used:

$$E = 10^{-3} \frac{d\sigma t}{dz}$$

Where E is vertical stability, σt is density of sea water, and Z is depth). As will be seen from these figures the maximum layer of E in the favourable whaling grounds generally existed at depth less than about 50 m which roughly corresponded to the maximum layer of dissolved oxygen. This may be explained by an upwelling water mass during the winter seasons supplying the surface layer, where phytoplankton increase. Halse (1956) stated that in the Antarctic zone, with its pronounced stability, the large phytoplankton populations were confined to a surface layer of 25–50 m.

According to Mackintosh & Wheeler (1929), Hardy & Gunther (1935), Mizue (1951), Peters (1955), Marr (1956, 1962) and Nemoto (1957, 1959, 1963), it is well known that the staple food of baleen whales is euphausiids. Kemp &

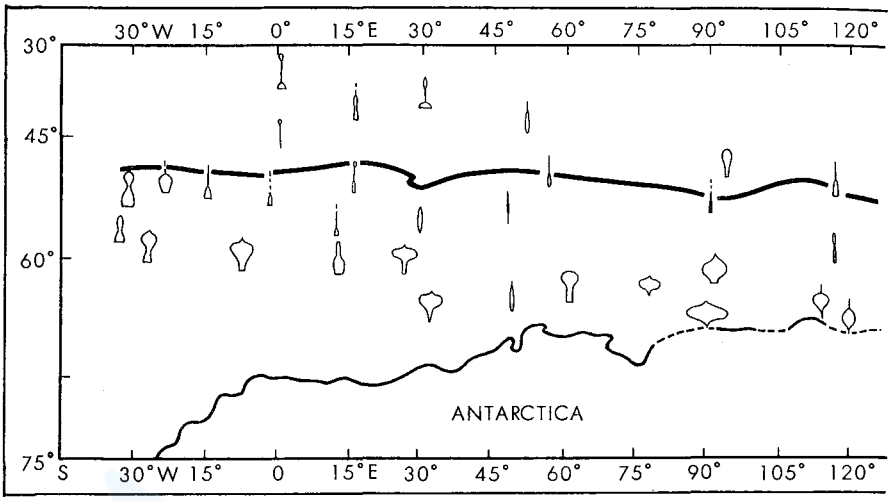


Fig. 51. Vertical stability

Bennett (1932) stated that the distribution of blue and fin whales in the Antarctic Ocean is closely correlated with the euphausia distribution. Euphausiids feed mainly on phytoplankton (Barkley, 1940; Einarson, 1945; Ponomareva 1959) and it also is known that the high concentration layer of diatom exists less than 50 meters in depth (Moberg, 1928; Phifer, 1934 a, 1934 b; Kokubo and Tamura, 1934). Consequently, the baleen whaling grounds seems to be closely related to the maximum layer of vertical stability.

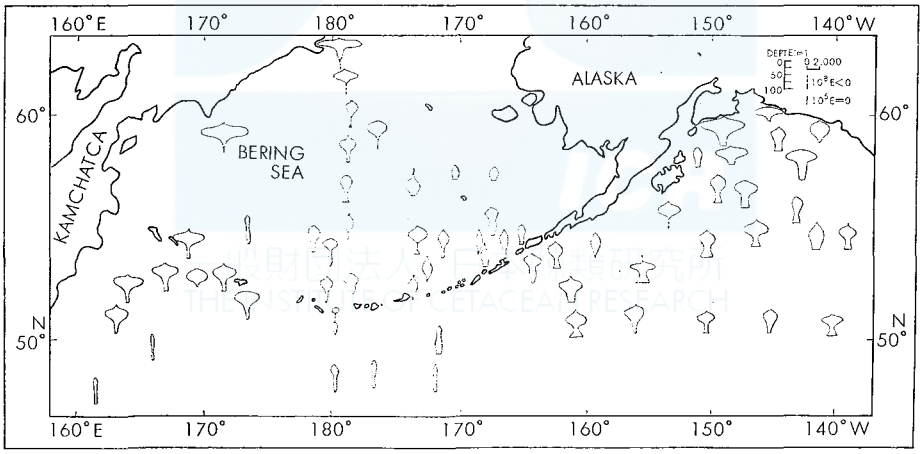
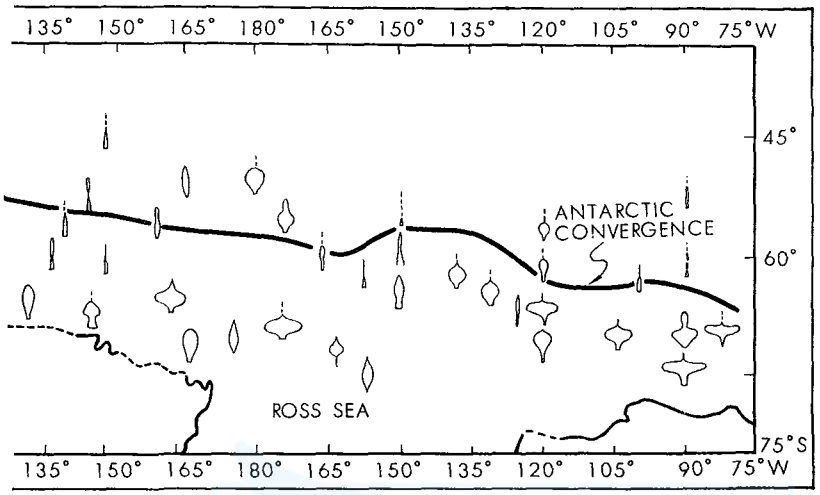


Fig. 52. Vertical stability in the Subarctic Pacific Ocean.

As already discussed in previous chapter it is clear that the favourable whaling grounds correspond to each special three-dimensional oceanographic structure. Especially favourable whaling ground are formed in the zone of dynamic eddy along



in the Antarctic Ocean.

the oceanic fronts between the water masses. Topographically-developed back-eddy systems also are good whaling grounds as shown in the vicinity of South Georgia (Hardy and Gunther 1935) and the Cape Olyutorsokii in the Bering Sea. The good whaling grounds also were found in the area of upwelling caused by the submarine topography and gyre.

The oceanographic character of the baleen whaling grounds can be summarized as follows;

1) Oceanic front type

Off Sanriku and Hokkaido	Polar Front between the Oyashio and Kuroshio waters.
Subarctic Pacific	
East area off Navarin	Oceanic front between the melted-ice waters of the Siberia Continent and the Bering warm waters.
Southern area of Aleutian Is.	Oceanic front between the westward Alaskan stream and eastward West Wind Drift.
Antarctic	Oceanic front between the southward warm water mass and northward melted-ice water mass in the vicinity of pack-ice. Antarctic Convergence Subtropical Convergence

2) Eddy type

a) Dynamic eddy	Eddy develops along the oceanic fronts, and found in the Antarctic, Subarctic Pacific, and off Sanriku-Hokkaido.

b) Topographic eddy	
Subarctic Pacific	
West of Cape Olyutorskii	Back eddy which was formed at the west of Cape by the southward current along the Siberia continent.
Antarctic	
South Georgia	Back eddy which was formed at the east of island by the West Wind Drift.
3) Upwelling type	
a) Dynamic upwelling	
Subarctic	
East area of Kamchatka Peninsula	Upwelling by the anticlockwise gyre.
Gulf of Alaska	Upwelling by the anticlockwise gyre.
b) Topographic upwelling	
Subarctic	
St. Mathew I.	Upwelling along the edge of continental shelf.
Unalaska I.	,, ,, ,,
Antarctic	
South Georgia I.	Upwelling in the vicinity of the Island.

SUMMARY

In this paper the formation mechanism of whaling grounds and the movement of ballen whales were discussed from the view point of fishery oceanography.

1) The concentrated sei whales off Sanriku coast in last of April came along the waters of 12.2–13.0°C which corresponds to the southern area in the Polar Frontal Zone.

2) Favourable whaling seasons of sei whale in the east sea regions of Japan are in May to June off Sanriku area and are in September to October off Hokkaido, respectively. It may be considered that the moving mechanism of whaling grounds from off Sanriku to Hokkaido were influencd by the conspicuous tongue shaped Kuroshio waters which project towards the north.

3) In the east sea regions of Japan there are two whaling condition types. Good catch off Sanriku—It is general type, the prosperous whaling season are in June off Sanriku, and the catch of sei whale off Sanriku is better than Hokkaido. The oceanographic conditions were characterized by that the Kuroshio waters flowing towards the north close to the Sanriku coast.

Good catch off Hokkaido—The prosperous whaling seasons generally are in July, and the catch of sei whale off Hokkaido is better than Sanriku. The oceanographic character in these years is that the northward Kuroshio waters are located more easterly than good catch year off Sanriku.

4) The main whaling grounds in the Subarctic Pacific Ocean were divided into six areas by the geographic distribution of Islands and continents etc. i) East

area off Kamchatka Peninsula—it may be considered that the whaling grounds in this region were formed by the dynamic upwelling which was developed by the anticyclonic eddy.

ii) Off Cape Navarin and Olyutorskii—The whaling grounds off Cape Navarin were located near the mixing zone between the water mass of low temperature and salinity along the Siberian Continent and the Bering Sea water mass of relative high temperatured and salinity. The formation of whaling ground off Olyutorskii was the result of the topographic back eddy which was located at the west of Cape Olytorskii.

iii) St. Mathew Island area—It may be considered that the whaling grounds were at the oceanic front which was formed by the topographic upwelling and the water mass covering the continental shelf to the Alaska.

iv) North area off Unalaska Island—It seems that the whaling grounds was formed by the topographic upwelling and the mixing area.

v) Southern area of Aleutian Islands—Many fin whales in this area were captured mostly of in the upwelling area from the relative deep layer, being especially plentiful near the boundary zone which exists between the sinking and upwelling area.

vi) Gulf of Alaska—It may be assumed that the dynamic upwelling by the anticyclonic eddy and the Alaskan stream were the important factors in the formation of the whaling grounds.

5) The results of oceanographic analysis in some Antarctic whaling grounds were summarized up as follows. The favourable whaling grounds were located in the oceanic front between the southward warm water and northward cold water, melted-ice water. To the south of Antarctic Convergence, the favourable whaling grounds corresponded to the upwelling zone of Warm Deep Water.

6) The whaling operation in the sea-region of 47–51°S, 24°E–36°E have been carried on since 1961/62. The stomach contents of whales caught in this area were found to contain *Euphausia superba*, *Euphausia vallentini*, and *Parathemisto gaudichaudi*.

Morever, the relation among the species of food, predator (whales) and surface temperature was as follows:

Species of food		Surface temperature
E. superba	Fin whale, Sei whale	<4.5°C
E. vallentini	Pigmy blue whale, Fin whale Sei whale	>4.50°C
P. gaudichaudi	Sei whale	>5.0°C

7) The whaling operations in the Antarctic in later years have been carried on further north than earlier. A possible explanation may be 1) Change of oceanographic environment 2) Decreasing of whale population. According to the results in this paper, as already stated by Ichihara (1962) it supposed that the shift of fin whaling grounds were influenced by the relation of demand and supply between the amount of foods and whales ensuing the diatom of whale population.

8) The baleen whales in the feeding area have a tendency to move along the oceanic front and the current which develops in local regions.

9) The favourable whaling grounds seems to be closely related with the maximum layer of vertical stability.

10) The oceanographic character in the baleen whaling grounds can be summarized as follow:

2) Eddy type
   a) Dynamic eddy develops along the oceanic eddy
   b) Topographic eddy
3) Upwelling type
   a) Dynamic upwelling develops in the anticyclonic (northern hemisphere) or cyclonic (southern hemisphere) gyre
   b) Topographic upwelling

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