OCEANOGRAPHIC CONDITIONS OF THE WHALING GROUNDS IN THE WATERS ADJACENT TO ALEUTIAN ISLANDS AND THE BERING SEA IN SUMMER OF 1955

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INTRODUCTION

The present paper gives the outline of the results investigated by Japanese research members in the waters adjacent to Aleutian Islands and the Bering Sea during the Whaling Survey including whale-marking experiment in the summer of 1955 on boad of the " Konan-maru No. 5 ", belonging to the Nippon Suisan Co. Ltd. During the season, 73 Stations were occupied by the boat as shown in figure 1, the observed data at these stations are compiled with respect to the oceanographic elements such as water temperature, salinity (chlorinity), transparency of the sea water, colour of the sea water, dissolved oxygen, planktons, and other sea-living organisms sampled from various depths, and also with the weather elements such as air temperature, sea-fog etc. Above materials are collected on board by the author and Takehiko Kawakami of the Japanese Fisheries Agency.

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WATER TEMPERATURE AND SALINITY AT THE SEA SURFACE

The surface temperature in the period during the survey from early July to late September in the Bering Sea and the southern Aleutian Waters in the North Pacific vary from 11.8°C at its maximum to the lowest value 6.5°C. In general the isothermal lines run parallel to the Aleutian Islands from west to east. On the other hand a warm water mass flows in the sea-region on the northern side of the eastern Aleutian Islands from the continental shelf-water on the Alaskan side in the period from middle to late decade of August at its most prosperious extention, and converges to the easterly-going stream along the northern side of Aleutian Islands at about 170°W longitude. Apparently the boundary line of convergence shifts month by month in accordance with the fluctuation of the two water masses, i.e. in July lying near at

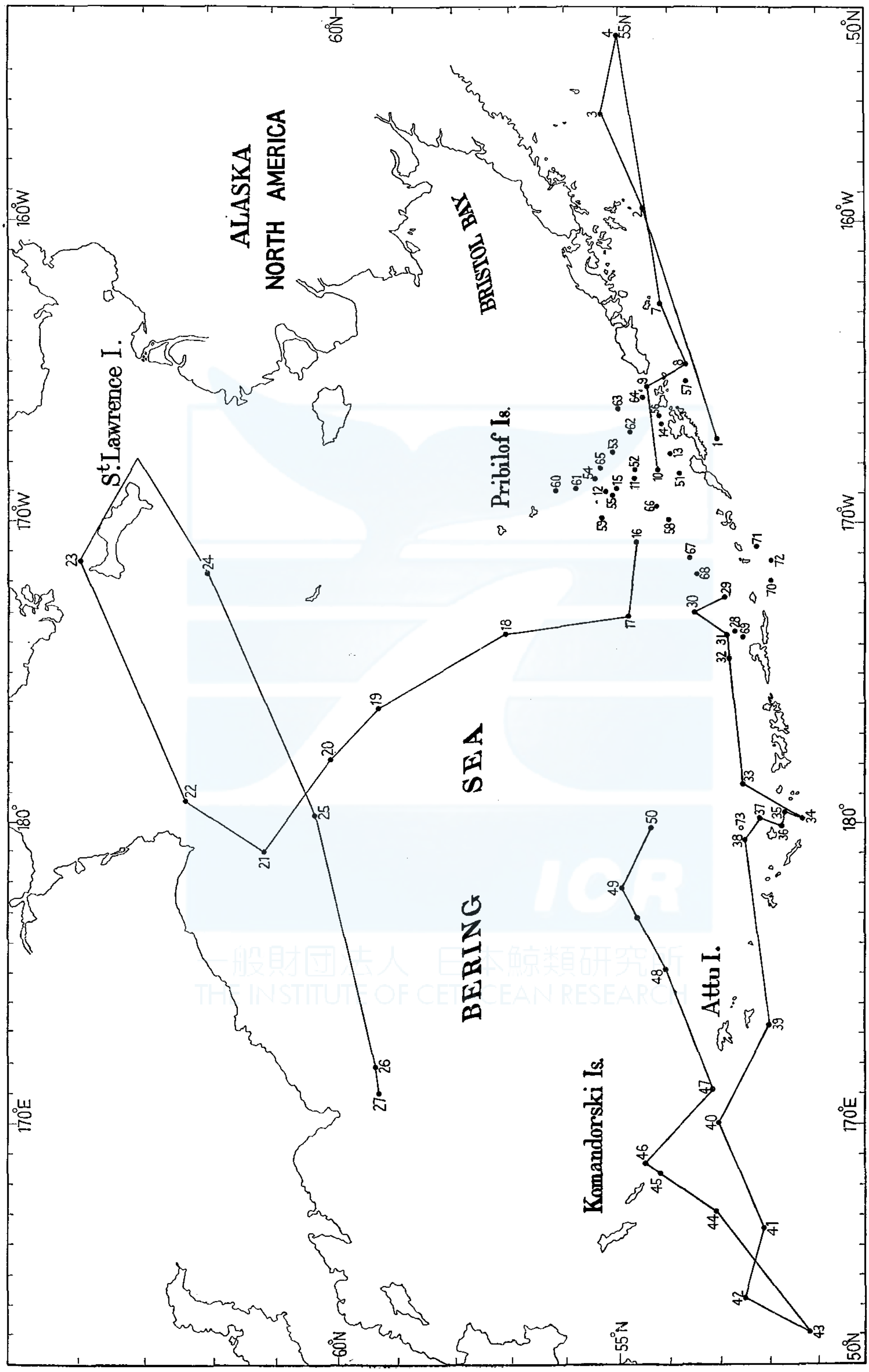

Fig. 1. Hydrographic Stations Carried out by Konan-maru No. 5 in the Summer Season of 1955.

about 170°W and in August lying near at 171°W due to its shift to southernmost and westerly location by the stronger inflow of water mass from the continental shelf region, and in September it lies at about 168°W after its easterly shift. Also, the water along the Islands shows lower temperature than that of the open sea, especially it shows a comparatively extensive cold water area in August near the Amchitka I. lying about at Lat. 52°00′N, 180°Lg. It seems that those cold water areas are formed by the upwelling due to the effect of the submarine topographical conditions. Moreover it is observed the increased rate of sea-fog occurrence over those Aleutian cold water areas on the inflowing occasion of warm and moist air current through southerly wind. It was already proved that such dense sea-fog regions are the favourable whaling grounds, especially of sperm whales (Uda & Nasu, 1956).

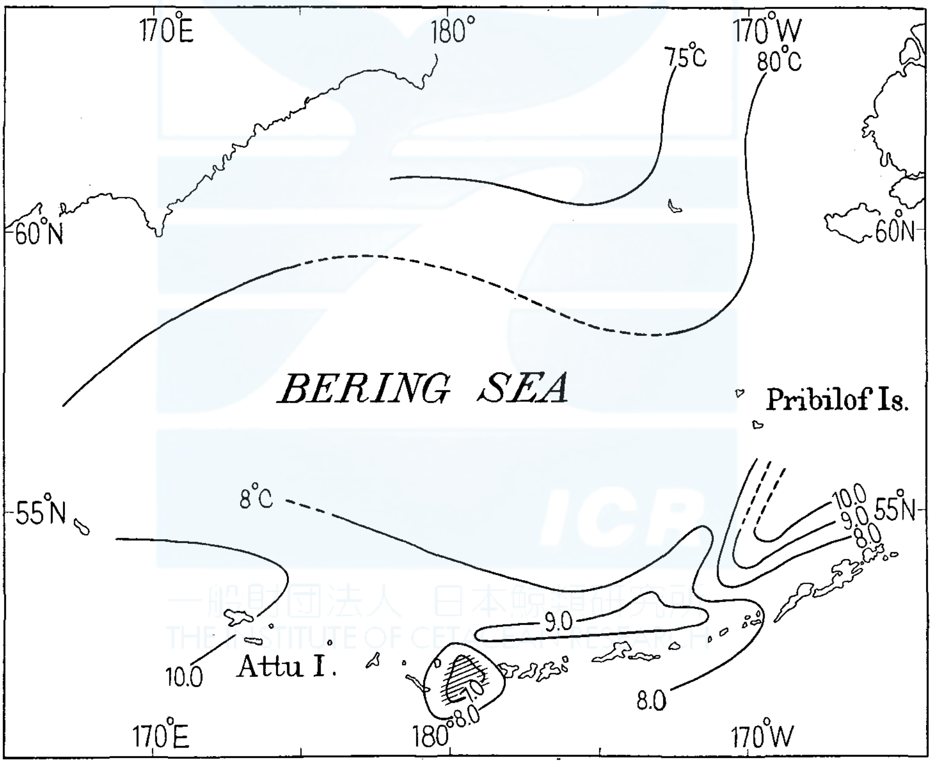

Fig. 2. Horizontal Distribution of Surface Temperature (Aug., 1955) ///: dense sea-fog.

In next, glancing over the isotherms in August in the whole area of Bering Sea, the 8°C-isothermal line running from St. Lawrence I. is found in the central Bering Sea toward south to the western part of the sea along 58°N-line. In general the water temperature in the deeper central sea-region is lower than that in the shallower sea-region on the continental shelf (see Fig. 2). Such a thermal difference in those regions may be due to the different conditions of bottom depths in the rising stage of water temperature in summer. Also a very cold water in the layer of 25-50 m depths is observed along the Siberian Coast. On the other hand, the hydrographical conditions of the monthly whaling grounds lying along the northern side of Aleutian Islands in the west-longitudes, (those found on the north to the Unalaska I. in the Aleutian chain) are following: A separated warm water area (centred at 8°C area) covers the western whaling grounds nearly along 55°N-line north to Unalaska I. in July (in Aug. of 1954 the corresponding warm water area around 9.0°C was also recognized).

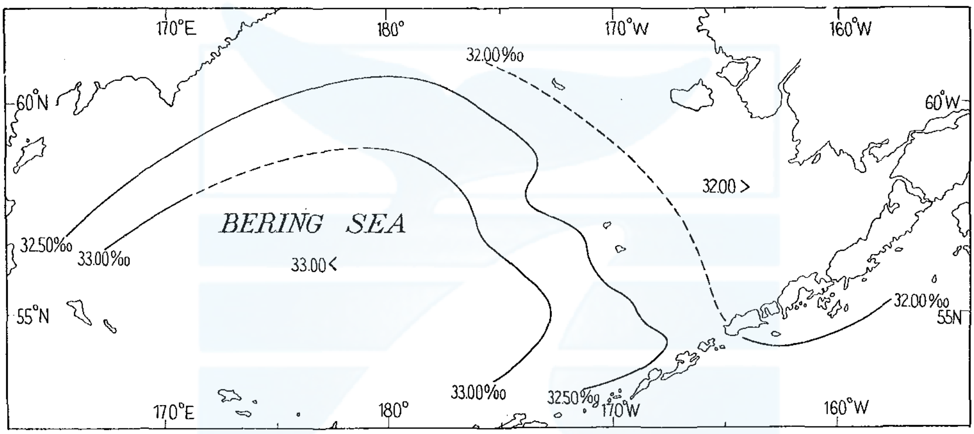

Fig. 3. Salinity (S ‰) at the Surface (July to August, 1955).

Since after about middle August the isolated water mass, combined together with the tongue-like inflow in warm water of about 10°C from the continental shelf on the side of Alaska extends to about 171°W toward south along the Aleutian Islands. In September the isolated warm water area of about 8°C which disappeared once in August appears again, and moreover in smaller scale than those in July to August. At present the origin and its process of formation of the warm water mass is not clear and is left for future study.

The hydrography of the Bering Sea basing on the distribution of salinity is as follows; the isohaline of 32.50 ‰ runs nearly along the 200 m isobathymetric line, showing an arc from nearly Lat. 60°N, 180°Lg. to the middle part of the Kamchatka Peninsula with the parallel distribution of 32.00 ‰ lines on both sides of it. The sea-region of waters having lower salinity less than 32.50 ‰ in the Bering-Sea covers an extensive area on the western side of Alaska compared than that on the eastern side of Siberia-Kamchatka (except the vicinity of Anadir Bay). The above phenomena are explained by the discharge of Yukon River, Kushokwin River on the side of Alaska and of the Anadir River on the side of Siberia (Barnes & Thompson, 1938). Referring to the pilot chart published by the H.O. of U.S. Navy the limit of sea-ice distribution in its melting period resembles very well to the location of 32.50‰ isohaline, suggesting the dominant influence of ice-melted water on the surface distribution of salinity (see Fig. 3).

DICHOTHERMAL WATER AND THERMOCLINE

It is wellknown fact that in Bering Sea and North Pacific Ocean the dichothermal water (intermediate cold water) in summer has been formed by the sinking of surface water cooled in winter. Also the results of our survey ascertained it and added some new data to it. The outline is as follows; on the whole in Bering Sea, excepting the shallower sea-region on the continental shelf and the waters around the Aleutian Is., the dichothermal water lying in the depths from 25 m to 150 m and having its core water temperature ($-1.5^\circ \sim +4.0^\circ$C, and only one station 4.83°C recorded) are found evidently almost everywhere in the area and also in the northern part of North Pacific Ocean along the southern side of Aleutian Islands.

TABLE 1. POSITION AND DEPTH OF DICHOTHERMAL WATER

Position	62-28N 179-18W	61-12N 178-57W	58-45N 179-40W	57-00N 178-55W	53-31N 172-59W
Depth (m)	25	75	100	146	150

Generally the dichothermal depth as shown in table 1 is shallower in the northern region, moderately deeper in the central region and deeper in the southern region. In the western Bering Sea the dichothermal depth near the water of 57°N (56°54′N, 173°17′E. St. observed by Oshoro-maru) shows deeper than the north waters, and shallower again as it goes to south (e.g. St. 48).

On the other hand the distribution of water temperature varies gradually from the eastern region passing through the central region around 180°Lg. to the western region, i.e. the temperature in the dichothermal layer of the central region (east to C. Navarin-60°N) rises from -1.5 to 3.32°C, moreover coming on the oceanic plateau near 57°N it falls and it rises again near the Aleutian Is.

In the western Bering Sea the minimum dichothermal temperature rises from -0.58°C (St. 27) at the south to C. Olyutorskii towards the vicinity of Aleutian Is. Next in the Northwestern Part of North Pacific south to Komandorskii Is. the depth of the intermediate minimum water temperature lies uniformly about at the 100 m depth and it is relatively low except some station in Bering Sea, especially low near the coast of Kamchatka Peninsula. Moreover in the waters south to Aleutian Islands in the west Longitude the depth of 100 m, showing comparatively warmer values of about 3°–5°C. At this place, comparing the general feature of dichothermal layers in the Bering Sea and that in the Pacific Ocean north to 50°N (except those east to 160°W), the layer lies uniformly at about 100 m depth in the east and west longitudes contrary to the 25–150 m depths in the Bering Sea. This fact may be due to the somewhat conspicuous effect of topographical conditions. The water temperature shows its highest value in the area of west longitude on the Pacific side and lowest value in the area of east longitude (partly lowest in the Bering Sea) and rising gradually from west to east in general. In the Bering Sea from spring to autumn season the rise of surface water temperature by solar radiation causes the remarkable development of thermocline (spring layer), in almost all sea-regions except some few areas. Thermocline has not been found in the waters of west longitudes whaling grounds north to Unalaska I. in this research and its most remarkable development was found near the east coast of Kamchatka south to Komandorskii Is. Also in the central region of Bering Sea (e.g. St. 19) and the northernmost oceanographical station (St. 23) locating north to St. Lawrence I. thermocline developes very remarkably showing its depth at about the 10–15 m on the shallower portion of the continental shelf and about 50 m in the central part of Bering Sea together with the region south to Komandorskii Is.

DISSOLVED OXYGEN

The quantity of dissolved oxygen at the sea surface in the Bering Sea and its adjacent Pacific areas amounts from 4.43 to 11.05 cc/L. In general its distribution shows higher quantity near to the side of Kamchatka Peninsula and Siberian Coast compared to the Alaskan side, in the region from Attu I. to Boweres Bank on the east the richly dissolved exygen area more than 10 cc/L. On the other hand in the region around Boweres Bank and from near Amchtka Pass to Umnak I. On the both sides of Aleutian Islands the poorest area of dissolved oxygen is found in the surveyed region of Bering Sea. Its pattern resembles well to the prescribed distribution of cold water area denoted by surface isotherms, representating the effect of upwelling by the Aleutian ridge (see Fig. 4).

Regarding to the vertical distribution of dissolved oxygen in the East Longitudes Whaling Grounds, the distribution of dissolved oxygen differs

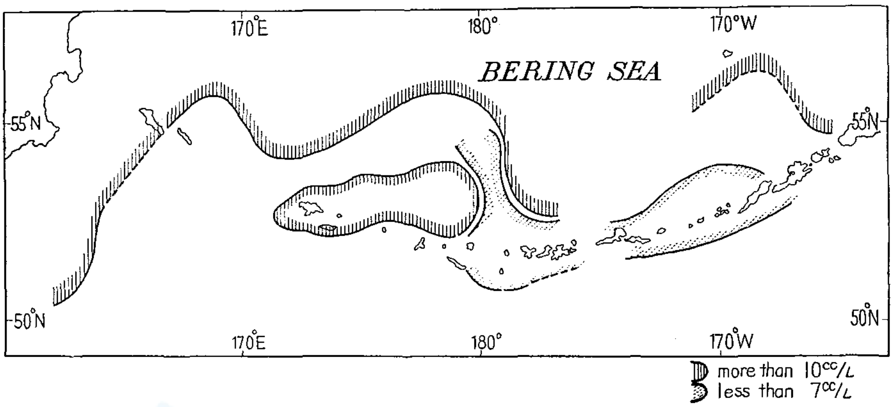

Fig. 4. Horizontal Distribution of Surface Dissolved Oxygen. (Aug. to Sep. 1955)

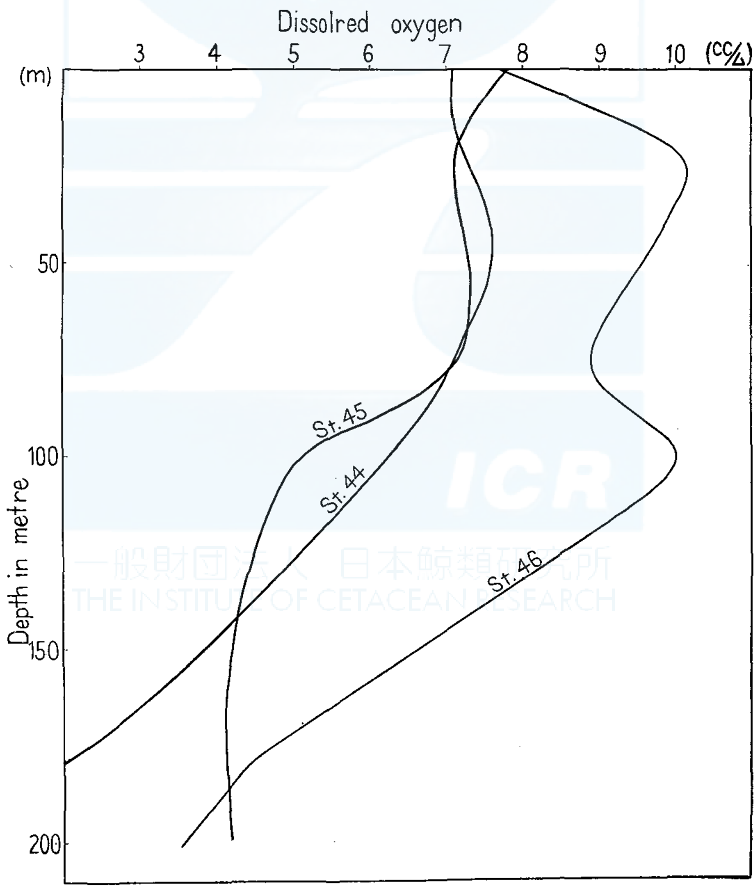

Fig. 5. Vertical Distribution of Dissolved Oxygen. (Aug. to Sept. 1955).

considerably between the upper and lower layers separated by the boundary layer at about 100 m depth. In short, in the upper layer less than 100 m depth a maximum dissolved oxygen layer is found at about 25 m depth (St. 46) which may be produced by the blooming of phytoplankton in the euphotic layer due to photosynthesis, and on the other hand the dissolved oxygen decreases with the depth at 80 m and again increased at 110 m depth. Roughly speaking, in the above mentioned area the value of oxygen keeps nearly constant at the depths less than 100 m and shows spring layer in the depths from 100 to 200 m (there is no datum of below 200 m depth due to the lack of observation) (see Fig. 5).

Next, in the West Longitudes Whaling Grounds the distribution of dissolved oxygen somewhat varies to the depth of 100 m, however below 100 m depth it decreases with the increase of depth gradually. The saturation percentage of dissolved oxygen shows supersaturation over the almost whole area (except the poor dissoloved oxygen areas in the region near Boweres Bank and the region along the Aleutian Islands from 180°Lg. to 168°W), especially the higher supersaturation % in the region south to C. Olyutorskii. Though there is no datum of dissolved oxygen in the region north to 56°N in the summer of 1955 owing to the lack of water sampling for oxygen analysis, referring to the survey of U.S. Navy in 1933 and that in 1934 by U.S. Coast and Geodetic Survey, it may be concluded that in the waters along the 170°W line extending to St. Lawrence I. except the vicinity of Pribilof Is. the rich dissolved oxygen amounts to supersaturation. Generally the oxygen at the sea surface of Bering Sea shows almost supersaturation over the whole area of the sea except the regions near Boweres Bank and on the both sides of Aleutian Islands from 180° to 168°W together with Pribilof Is.

WHALING GROUNDS IN RELATION TO HYDROGRAPHIC CONDITIONS

It is well-known that in the waters around the line of convergence as the boundary of two currents a favourable fishing grounds is formed by the accumulation of concentrated planktons (phyto- and zoo-plankton) and other sea-livings attracted to them. The good example is seen also in northern waters i.e. as already mentioned above the concentrated abundance of whales are shown around the line of convergence in the fishing grounds north to Unalaska I. and the movement of whales following the shift of the line of convergence is seen.

These features may be explained as follows : the dense populations of phyto- and zoo-plankton due to blooming in the richly fertilized region along the Aleutian Islands due to the upwelling of deep water having rich nutrient salts are transported by the east-going Aleutian current and then collides with the fresh water mass inflowing from Alaskan coastal area, where the densely concentrated food-planktons of whales may be resulted near the boundary of two water masses. In order to estimate the rate of whales sighted (S_w) in relation to water temperature, we may put the following quantity,

$$S_w = \frac{We}{Ne} \times 100(\text{‰})$$

where *We* : the observed frequency of whales for each 1°C of water temperature.

Ne : the observed frequency of water temperature for each 1°C.

Calling S_w-curve as the Appearance Curve of whales and then plot

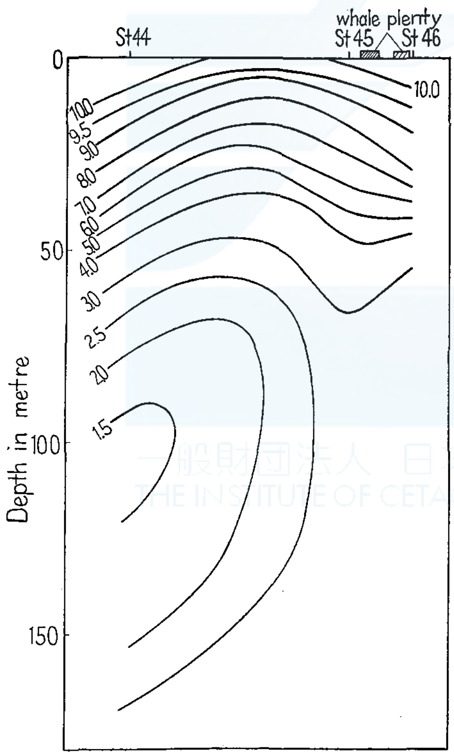

Fig. 6. Relation to the Dichothermal Core Water and the Whales. (Aug. 1955).

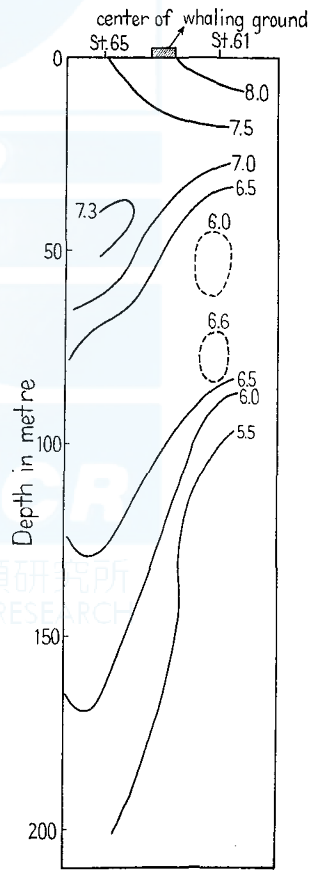

Fig. 7. Vertical Distribution of Dissolved Oxygen (cc/L) and the Whaling Ground. (Aug. 1955).

them for each species of whales during the whole fishing period, the mode of the S_w-curve can find at (8.0±1.0°C) with respect to the surface water temperature statistically i.e. the highest rate of whale appearance at the temperature. The distribution of whales in relation to dichothermal water was noticed already by Uda (1956), and in this investigation also the same is proved. In other words, except the relatively cold water area at the surface influenced by the intermediate cold water. Comparatively many whales are found on both sides of it in somewhat warmer water area (see Fig. 6). In the Northeast sea-region of Japan off Sanriku a similar feature of whaling grounds, especially of sperm whales, is conspicuously noted by the result of whale-marking survey in 1955.

Next, regarding to the relation of dissolved oxygen, the concentration of whales is observed in the narrow zone denoting the steep horizontal gradient from very rich oxygen water mass to poor oxygen water mass in the layer of depths from 10 m to 150 m (see Fig. 7). With respect to the relation between the abrupt change of dissolved oxygen in the layer about at 10 m depth and the distribution of whales, Marr (1956) has pointed out the densely concentrated krills as the favourite food of whales in the very surface layer within 10 m depth in the Antarctic. And author also observed many swarms of euphausiids in the surface areas south by east off Komandorskii Islands. The distribution of whales are considered to show its denser concentration in the such region slightly shifted from the maximum portion of the phytoplankton quantity.

DEEP SCATTERING LAYER AND WHALING GROUNDS

The author has observed the deep scattering layer on echogram with its evening ascent and morning descent in the fishing grounds such as of Sergestes shrimps etc. (Uda, 1956). In this investigation we recorded it off the cape of Olyutorskii and euphausia (*T. inermis*) was sampled by planktonnet hawl at the same time, of which creature was not sampled at the St. 27 (59°18′N, 170°52′E). The author hopes in the indirect searching method of whales during the night by utilizing the echo-trace of deep scattering layer due to the food plankton of whales may be put to practical use.

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