ON THE OCEANOGRAPHICAL CONDITIONS OF THE OKHOTSK SEA IN SUMMER OF 1958

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Introduction

In the summer of 1958, the training ship "Hokusei Maru" of the Faculty of Fisheries, Hokkaido University made cruises into the Okhotsk Sea for biological and oceanographic investigations. In the prosecution of oceanographic programs vertical series of temperature, salinity and the other oceanographic observation were made at 33 stations in July and 18 stations in August. On the cruise of July the ship roughly covered the Okhotsk Sea; in August the vicinity of the Kurile Islands was investigated. The locations of these series of oceanographic stations are shown in Fig.1.

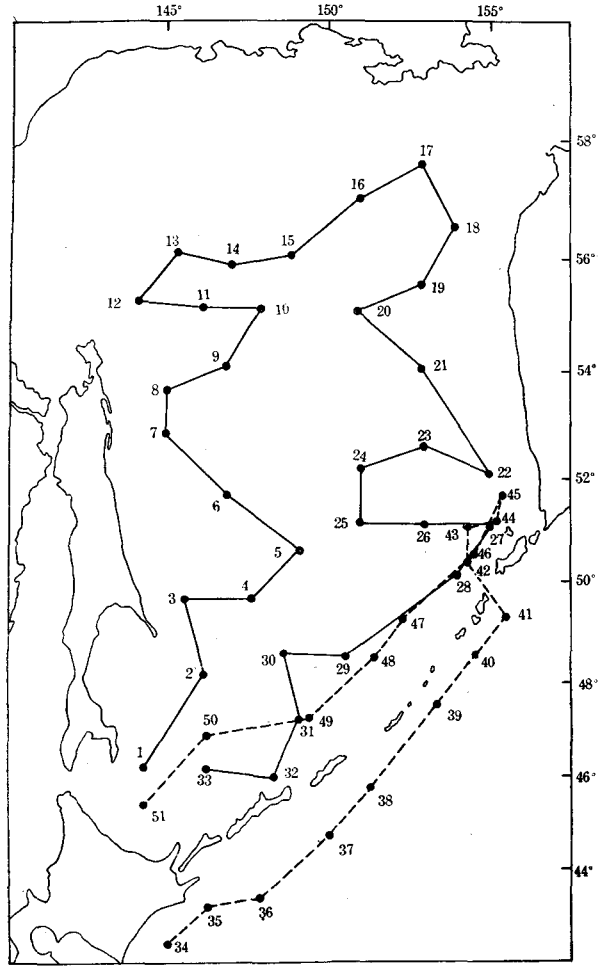

Fig. 1. Locations of the hydrographic stations occupied by the "Hokusei Maru" in 1958.

In this paper the oceanographic conditions of the Okhotsk Sea are discussed on the basis of these observations. General distribution of oceanographic coditions is shown by horizontal and vertical charts, and major features are described. The depth of the Okhotsk Sea is so variable that the observations were carried to different depths at each station. In deep region the wire paid out to 1200m usually, but in shallow region of the north Okhotsk Sea it stopped at only 100m to 200m. The detailed data will be published in the "Data Record of Oceanographic Observations and Exploratory Fishing No. 3 1959" of the Faculty of Fisheris, Hokkaido University.

Temperature and Salinity

Horizontal distribution

a) At the surface

The horizontal distributions of temperature and salinity are shown as Fig.2. In general excepting near coast area, the temperature and salinity distributions are comparatively less changeable. In the central part their value indicate 8°-10°C and 32.50-33.00‰ respectively. The highest surface temperature 12.8°C was encountered to the northeast of Hokkaido. The lowest, 3.6°C, was obtaind to the northeast of Saghalien Island.

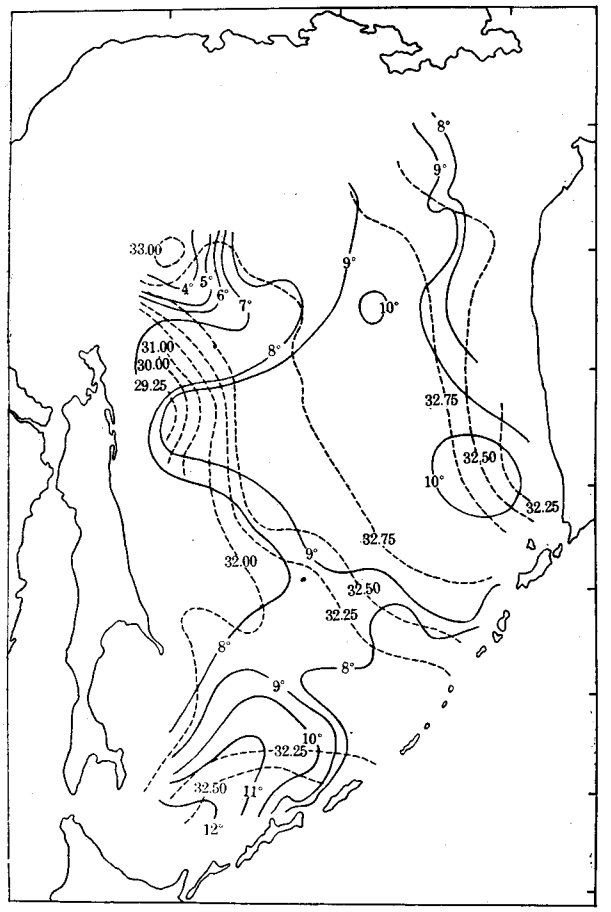

Fig. 2. Horizontal distribution of temperature and salinity at the surface.

In area to the east of north Saghalien, remarkable low saline water (At St.8 salinity indicates 29.29‰) is found. Apparently, this very low salinity is related to runoff from Siberian rivers (mainly the Amur River). Owing to the scarcity of observation data, the region influenced by the river water is not clear, but the low salinity region is considered to extend to the fairly southern part.

To the northeast of Saghalien (near 56°N 145°E) higher salintiy and very low temperature exist both of which have been noticed in other observations.

In this singular region vertical mixing is supposed to be carried out actively, and the vertical structure of the water is almost uniform.

As to salinity, the other major feature is that in the southern part of the Okhotsk from the east of south Sagalien to the Central Kuriles, low saline water (below 32.30‰) spreads widely. The cause of the existence of this wide low salinity region is not obvious. As Kajiura has pointed out, it is supposed that the low saline water resultant from melting of ice is gathered to this region by the wind.

Comparatively warmer and higher saline water is found near the northeast coast of Hokkaido. At St. 32 and 33 in this region temperature shows 9.8°C, 12.1°C and salinity values are 32.90‰, 32.58‰ respectively. This area is apparently affected by the Tsushima Warm Current from Soya Strait.

In the part to the west of Kamchatka the water is nearly uniform in character; temperature and salinity are 8°—9°C and about 32.50‰, respectively.

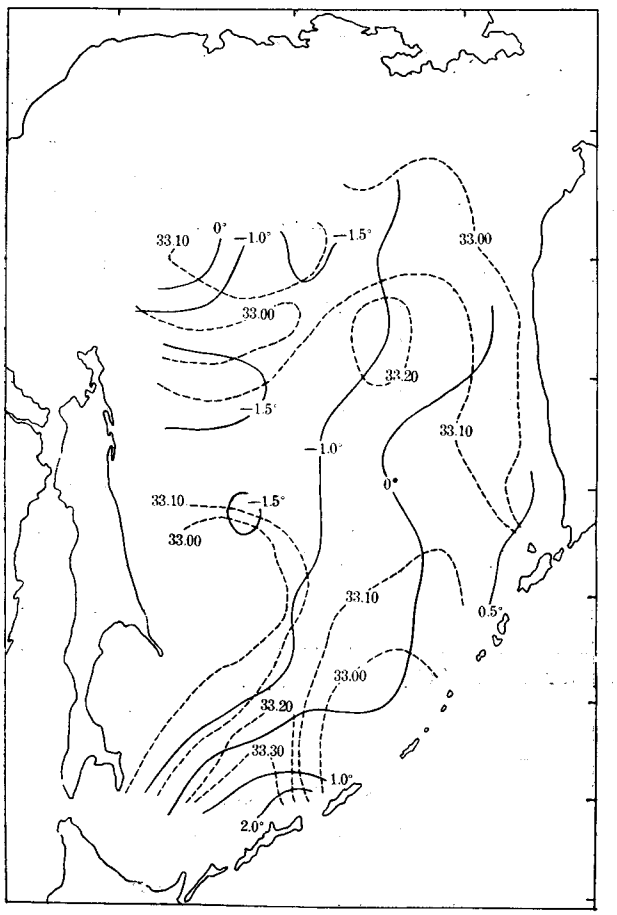

Fig. 3. Horizontal distribution of temperature and salinity at the 100m level.

b) At the 100m level

The distrbutions of temperature and salinity at 100m level are shown as Fig. 3. A noticeable feature is that much cold water lies north and south widely in almost the whole region. To the east of Saghalien the temperature of cold water is less than −1°C and in the two regions it shows average −1.5°C. The minimum temperature is −1.62°C at St. 9. The temperature increases to the southeast while from the region west of Kamchatka to the northern part of the Kuriles, there exists no temperature below 0°C. In the central region, temperature has negative value, but it is higher than that of the western part. Near the Kuriles rather warm water is found. The highest temperature is 2.30°C at St.32.

The salinity distributions at this level differ fairly from those at the surface. They are less changeable compared with the surface. In general, about 33‰ saline water is distributed far and wide. To the northeast of Hokkaido a tongue of rather higher salinity penetrates to the north. In the near-coast regions of south-Saghalien, Kamchatka and the Kuriles, salinity has somewhat less value (below 33‰). Especially to the south off Saghalien low saline water is distributed widely. In the northern part of the Okhotsk, there exists low saline water also.

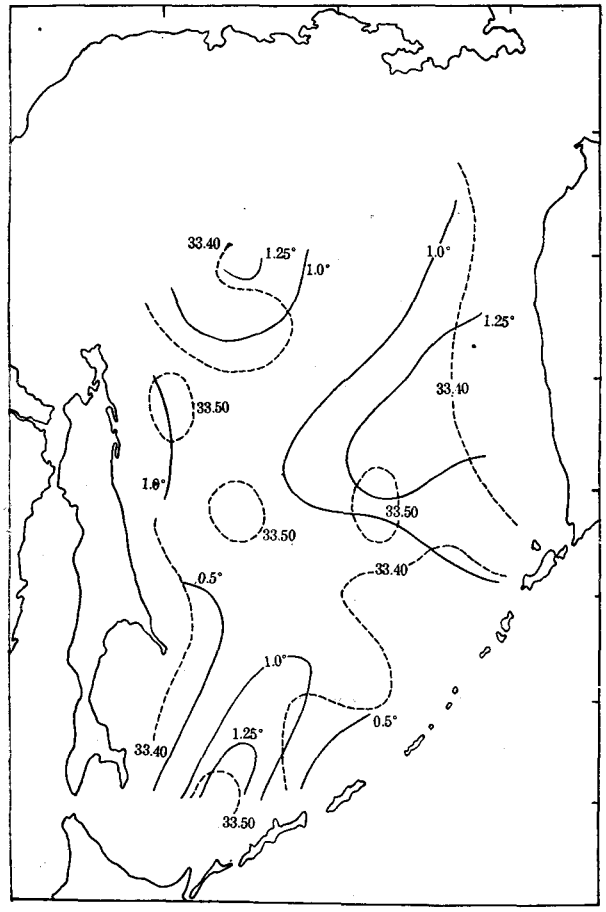

Fig. 4. Horizontal distribution of temperature and salinity at the 300m level.

c) At the 300m level

Fig. 4 shows the distributions at 300m. At this level both temperature and salinity are distributed almost uniformly. As to temperature, it stands at 1°C or so in the whole region. In the central part comparatively cool water is found; in the parts west of Kamchatka, and to the northeast of Hokkaido, temperature has rather high value. The isotherm of 1°C protrudes from the coastal region; this rather warm water extends widely off the coast of Kamchatka, but off the Hokkaido it becomes a narrow tongue. In general, in regions near coast lines comparatively warm water exists but to the east of south Saghalien cool water below 0.5°C is found even at this level. The highest temperature is 1.49°C at St.33 while the lowest is 0.21°C at St.3. Salinity at this level is almost changeless, in nearly the whole region it shows 33.40‰ but in near-coast regions it decreases to some extent. There are a few narrow regions which have comparable higher salinity (33.50‰) in the central part at places. To the northeast of Hokkaido and to the east of north Saghalien high salinity water is found.

Minimum Temperature Distridution

The distribution of minimum temperature is shown as Fig. 5. It is seen that excepting to the south of Kamchatka, cold water of negative temperature exists in the whole region and the isotherms run from north to south. The isotherm of -1°C runs in the centre and the minimum temperature increases from west to east. Especially off the coast of Saghalien much cold water below -1.5°C lies north to south extensively. In the singular region of north Saghalien, as stated before, negative temperature is not found. Near the Kurile Islands the isotherm of 0°C runs along the north of the islands; in the southern part of

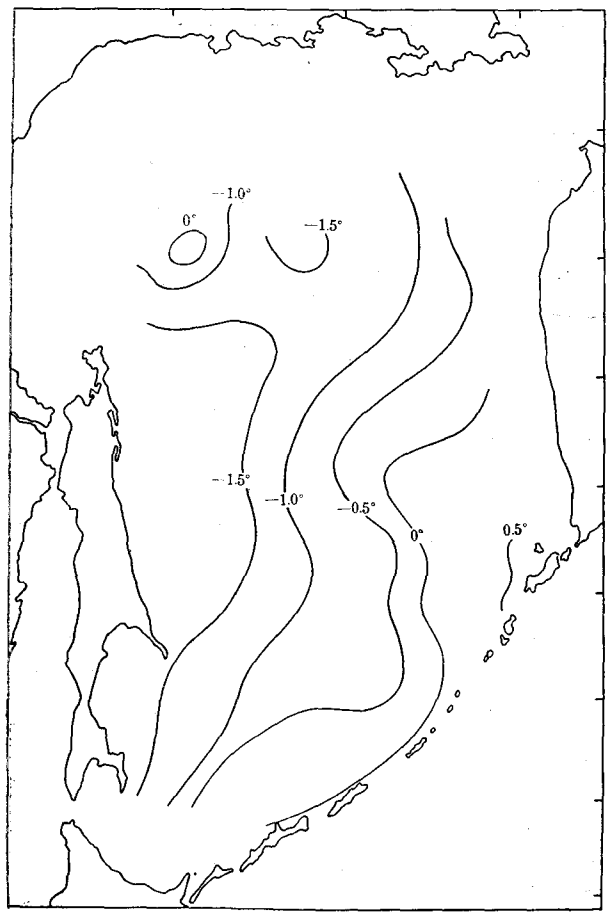

Fig. 5. Horizontal distribution of minimum temperature.

the area minimum temperature shows 1°C or so. To the south of Kamchatka, negative temperature is not found and warm water of the Pacific is supposed to penetrate through channel. As to the northern region of the Okhotsk the observations are few but according to the data of 1957 the minimum temperature of this was almost -1°C or so. The depth of minimum temperature layer generally lies between 75m and 100m, and there is no large diversity but to the south of Kamchatka it has a tendency to decend as one goes to the south. The cool water is thought of as protruding under surface warm water which comes from the Pacific.

Vertical Distribution

Vertical cross sections of temperature and salinity have been constructed across the northern part and the central part of the Okhotsk Sea. They are shown as Figs. 6 and 7. In the temperature profile the homogeneous convection layer at the surface is very thin; the thermocline layer which is indicated by a large gradient or by the crowding of isotherms lies in general between 20m and 30m for the area as a whole. Descending from a depth of about 50m, much cold water of negative temperature extends to 200m; in the eastern area cold water below -1°C extends widely. Beneath this cold layer, the temperature increases with increasing depth but the vertical temperature gradient is so slight that the isotherms in the vertical section become farther and farther apart. The temperature attains 2°C at a level of 800m.

In the salinity profile, there is distinct division of the curve into the upper layer which is characterized by rather large salinity gradient, and the deeper layer by weak salinity gradient. From surface to 50m level the salinity changes about 0.5‰, at the surface it shows 33.00‰ or so and at 50m level it attain about 33.50‰. Below the 50m level,

salinity gradient become small with slow increase down to the sea bottom. At 1000m level it shows about 34.00‰. The isohalines run almost horizontally.

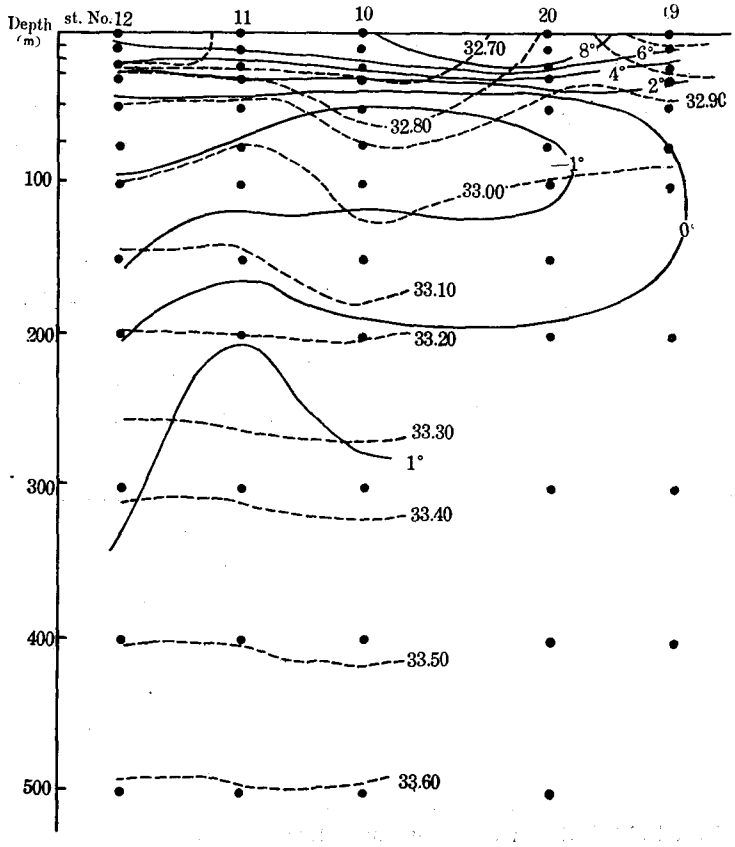

Fig. 6. Vertical distribution of temperature and salinity in Sec. 1 in the north Okhotsk Sea.

Section 1 (55°N)

Section 1 runs west and east in latitude 55° north. The surface temperature shows 7°-8°C in general and the thermocline can be seen at 20m-30m level; however at St.9 which is located near the coast of Kamchatka this thermocline is somewhat obscure. At this station negative temperature between 50m-200m is not clear also, which fact suggests that vertical mixing occurs actively in the upper layer in this region. Cold water of negative temperature spreads widely within the 50-200m level in the whole region. Especially near the 100m level there is found much cold water below -1°C having a thickness of about 50m. Below this layer of cold water, temperature increases with depth but the gradient is very small so at 500m level it shows only about 1.2°C.

As regards salinity distribution, at St.12 in the western part low saline water is found; this region is thought to be affected by water from the Siberian rivers. In the eastern

region salinity is rather high. In the upper layer, isohalines are comparatively crowded but below the 100m layer salinity increases almost uniformly with small vertical gradient.

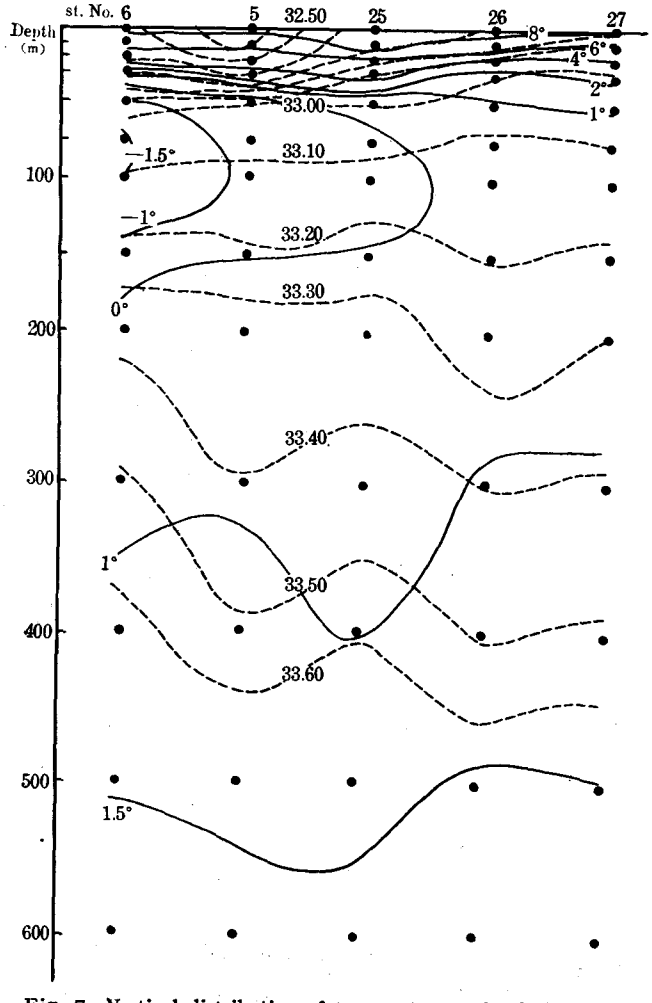

Fig. 7. Vertical distribution of temperature and salinity in Sec. 2 in the central Okhotsk Sea.

Section 2 (51°N)

Section 2 runs nearly along 51° north latitude. A distinct thermocline is found at 20-30m layer; at St.25 in the central region it descends a little. In the eastern part no thermocline is apparent. The surface temperature shows 8°C or so and in the east it shows a slightly high value. Cold water of negative temperature is found from 50m to 150m but in this section negative temperature is less in comparison with northern section; such cold water is not found in the eastern region. Much cold water under -1°C can be seen only in a limited region of the western part. Temperature gradient at depths below 200m is very small just as in the northern section. In the salinity profile, the vertical gradient at the surface layer is somewhat large as compared with the northern section, and in deep layer salinity is comparatively high. The isohaline of 33‰ is found at 100m level in the northern section but in section 2 it is seen at 50m layer. At St.5 and 6 low saline water of 32.50‰ is found as stated before.

Temperature-Salinity Relationship

The temperature salinity diagrams for representative stations in the Okhotsk Sea are shown as Fig. 8. As seen in this figure these stations show fairly similar T-S curves. Salinity at the surface is very low in the whole region; especially at St.1 and St.8 which

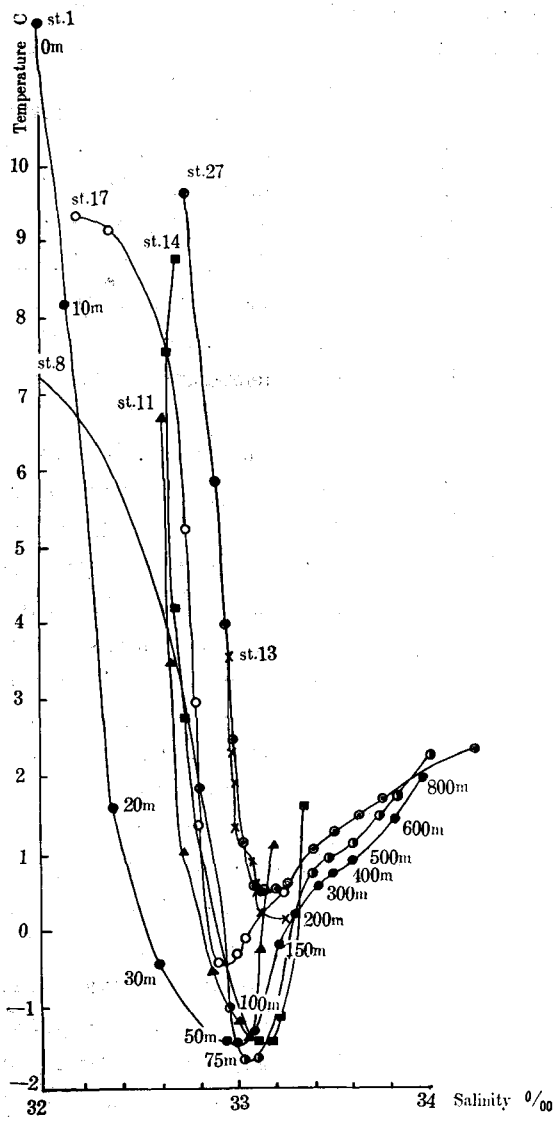

Fig. 8. Temperature-Salinity diagrams from stations in the Okhotsk Sea.

are located near the coast, extremely low salinity is shown. This low saline water at the surface is caused partly by inflowing of fresh water from the continent, partly by melting of ice. As regards temperature it shows relatively high value in summer season at the surface. The vertical thermal structure in the Okhotsk is characterized by distinct discontinuity at the surface layer. Excepting at a few stations remarkably cold water is found around the 100m layer with minimum temperature existing between 75m and 100m. This cold water spreads to the 200m level. Below 200m level both temperature and salinity increase almost uniformly. At about 800m layer, temperature attains maximum value 2°C. Under this maximum layer the temperature would seem to be changeless. At St.8 located near north Saghalien, resultant from inflowing of Amur river fresh water, extremely low saline water is found at the surface layer but below 30m layer the curve shows similar pattern to the other stations. At St. 13, the special region mentioned before, practically uniform water is found; the temperature shows only 3°C change from surface to bottom while the salinity scarcely changes. At St. 27 located near south Kamchtka the surface salinity is relatively high and negative temperature is not found; minimum temperature 0.5 °C is seen at 150m layer, which is a little deeper compared with the other stations. Inflowing of the warm and high saline water from the Pacific Ocean is apparently seen in this region.

Currents

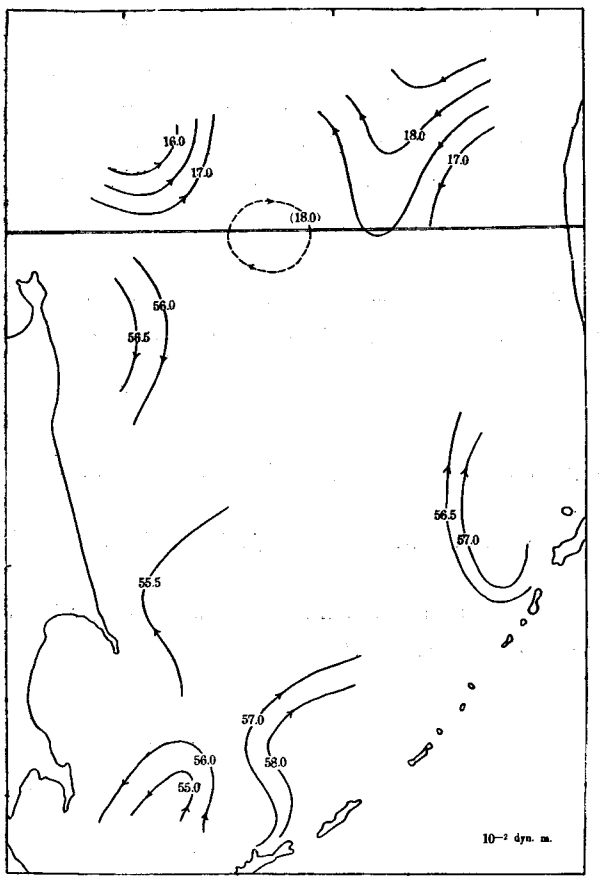

Fig. 9. The dynamical topography of the sea surface relative to the 400-decibar surface. In the shallow region relative to 100-decibar is shown.

In Fig. 9 is shown the dynamic topography of the sea surface relative to the 400-decibar surface (in shallow region of the north, relative to the 100-decibar surface). Owing to the scarcity of stations, the current pattern is necessarily merely an outline. As seen in this figure the current in the Okhotsk region is generally very weak. In the northern part a current from Penzhinsky Bay is seen; a portion of this strem runs towards the south along the Kamchatka coast while the rest turns towards the northeast. To the north of Saghalien, the water moves towards the east; this stream turns to the north and forms a counter-clockwise eddy around St. 13. In the area east of Saghalien a southward moving current can be seen in the northern part while in the central part current runs to the northeast. Near 50°N and 147°E a small clockwise eddy would seem to exist but this is not clearly apparent. Off south Kamchatka, except near the coast, a northward moving current is found. This stream would probably make a circular current together with the coastal southward moving current in this area, In the area near the south Kuriles, a stream runs towards the northeast. A part of it turns to the west and forms an anti-clockwise circle off south Saghalien, while in north Kuriles the other part forms a large clockkwise moving circle of water.

Summery

The general oceanographic conditions of Okhotsk Sea were considered on the basis of observations recorded in the summer of 1958 on board the training ship "Hokusei Maru".

Surface temperature is relatively high in summer and a distinct discontinuity of temperature is found at the 20–30m level. Cold water of negative temperature spreads almost through the whole region from 50m to 200m with the minimum teperature at the depth between 75m and 100m. In deep layer, vertical temperature gradient is very slight. Salinity at the surface is very low; especially in areas near coast extremely low saline water is found because of inflowing of fresh water from the continent. In southern region inflow of warm and high saline water from the Pacific is apparently seen. Currents, within this area, are generally very weak.

Acknowledgment

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