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# On the Fluctuation and Prediction of Ocean Temperature in the North Pacific

**Michitaka Uda**

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By

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## Introduction

Basing on the data from the "Mean Atomospheric Pressure, Cloudiness, and Sea Surface Temperature of the North pacific Ocean and the Neighbouring Seas" (1911—1941) published by the Imperial Marine Observatory at Kōbe, the author studied the fluctuation of the sea surface temperature in the northern part of the North Pacific along the zone of (35°—55°N.), with wishes to commemorate Dr. Y. Horiguti who contributed much to the pacific meteorlogy.

Thanks are due to Dr. J. Masuzawa of the Meteorological Agency (Oceanographic Section) who has kindly shown the publications cited above.

## 1. Analysis and results

At first isopleth charts of sea surface temperature distributed in the 5 degree (latitude, longitude) grids between 140°E. and 120°W. in the North Pacific Waters during the years of 1911—1941 for each zones of (35°—40°N.), (40°—45°N.), (45°—50°N.), (50°—55°N.), and for each month (season) of February (winter), May (spring), and August (summer) respectively. (Refer to Fig. 1 a, b, c, d, e.)

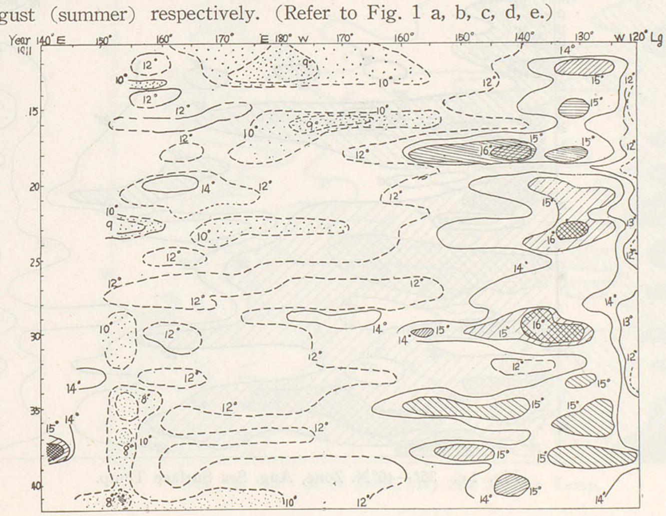



Fig. 1a. 45°—50°N. Zone, Aug. Sea Surface Temp.

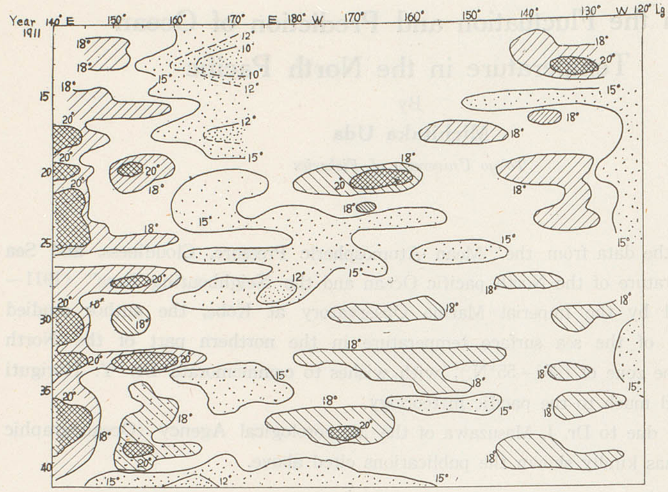


Fig. 1 b. 40°—45°N. Zone, Aug. Sea Surface Temp.

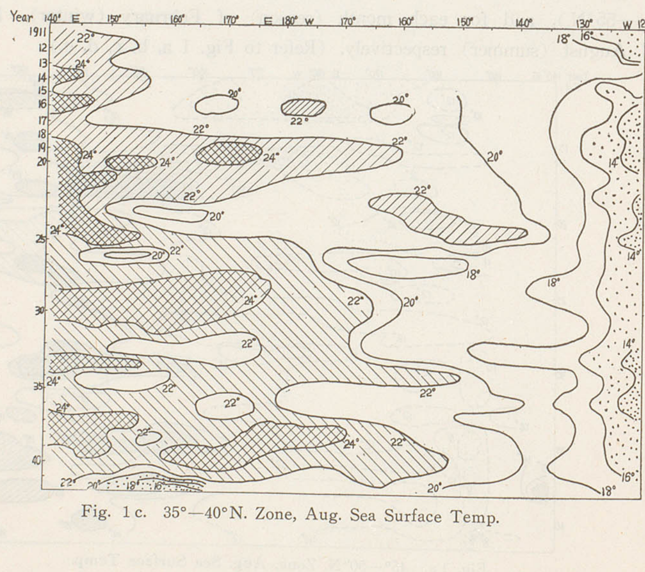


Fig. 1 c. 35°—40°N. Zone, Aug. Sea Surface Temp.

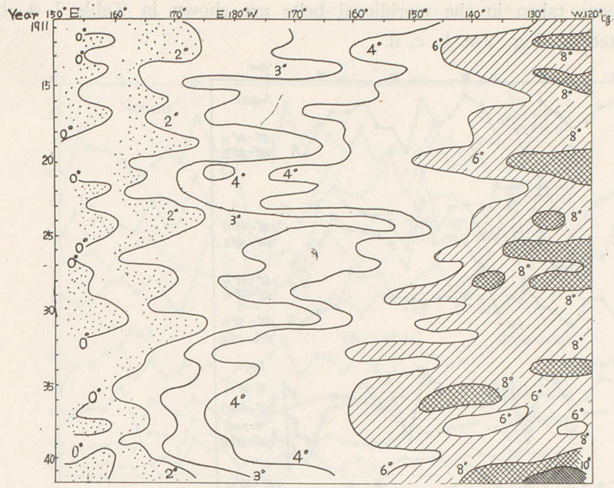



Fig. 1 d. 45°—50°N. Zone, Feb. Sea Surface Temp.

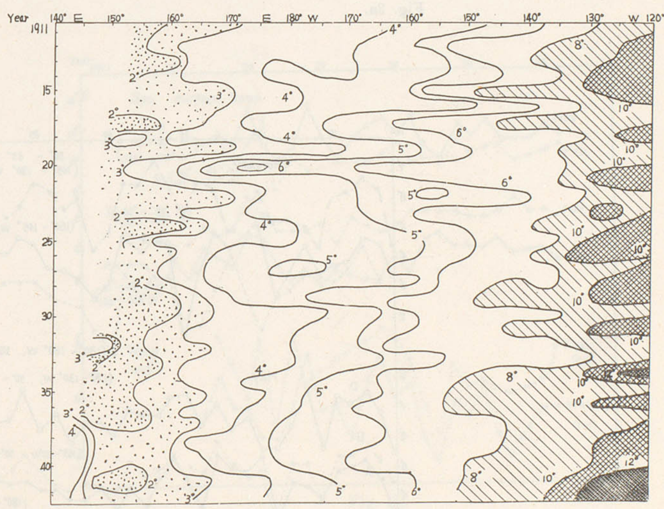



Fig. 1 e. 45°—50°N. Zone, May Sea Surface Temp.

Temperature means taken in the meridional belts are shown in Table 1 a, b, which were illustrated in Fig. 2 a, b, c, d.

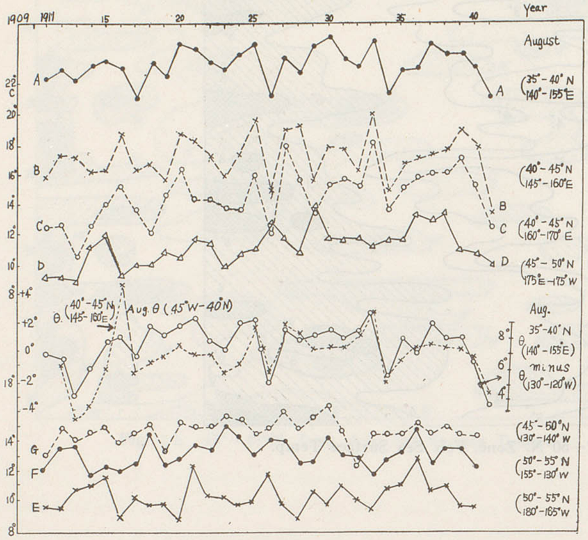



Fig. 2a.

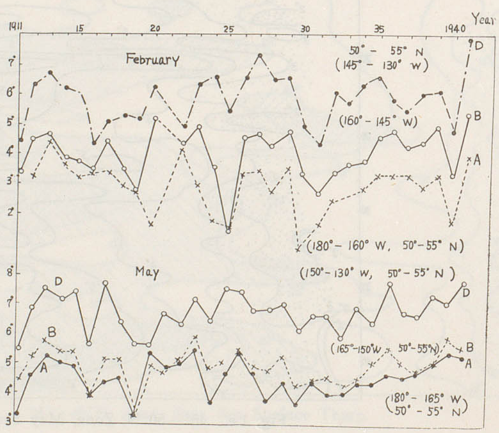
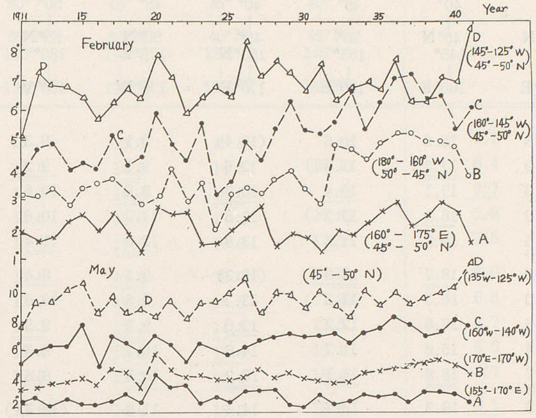
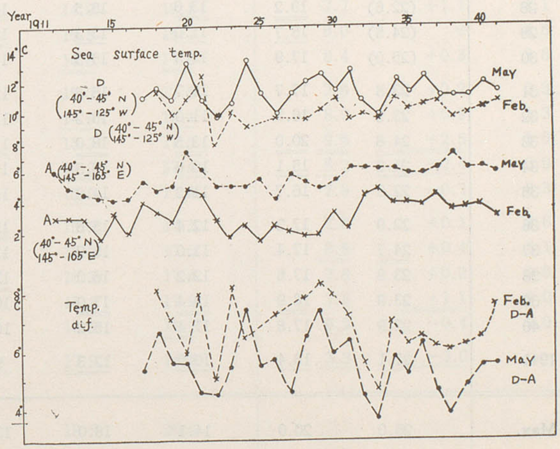



Fig. 2b.



Year
February
May
(145°-125° W / 45°-50° N)
(160°-145° W / 45°-50° N)
(180°-160° W / 50°-45° N)
(160°-175° E / 45°-50° N)
(45°-50° N)
(135°W-125°W)
(160°W-140°W)
(170°E-170°W)
(155°-170° E)


Fig. 2c.



Year
Sea surface temp.
D (40°-45° N / 145°-125° W)
A (40°-45° N / 145°-165° E)
May
Feb.
Temp. dif.
Feb. D-A
May D-A


Fig. 2d.

Table 1 a. Sea Surface Temperature (°C) in August.

| Lat.(N) / Lg.(E) / Mean / Year | A 35°–40°N 140°–155°E | B 40°–45°N 145°–160°E | $C_1$ 45°–50° 155°–160°E | $C_2$ 40°–45° 160°N–170°E | D 45°–50°N 175°E–175°W | E 50°–55°N 180°–165°W |
|---|---|---|---|---|---|---|
| 1911 | 22.3 | 15.8 | 10.6 | (12.4) | 9.1 | 9.3 |
| 12 | 22.9 | 17.3 | 11.9 | 12.6 | 9.1 | 9.2 |
| 13 | 22.3 | 17.1 | 10.4 | 10.3 | 8.8 | 10.6 |
| 14 | 23.2 | 16.2 | 12.2 | 12.5 | 11.0 | 10.8 |
| 15 | 23.5 | 16.2 | 11.5 | 13.9 | 12.0 | 11.4 |
| 16 | 23.0 | 18.7 | 12.9 | (15.2) | 9.1 | 8.4 |
| 17 | 21.0 | 16.3 | 11.2 | 13.7 | 9.8 | 10.0 |
| 18 | 23.5 | 16.8 | 12.2 | 12.0 | 9.8 | 9.5 |
| 19 | 22.4 | 15.8 | 11.7 | 14.6 | 10.7 | 9.6 |
| 20 | 24.7 | 18.8 | 14.1 | 16.2 | 10.3 | 8.6 |
| 21 | 24.3 | 18.3 | 13.7 | 14.4 | 11.6 | (12.1) |
| 22 | 23.4 | 17.3 | 12.0 | 14.3 | 11.4 | 10.2 |
| 23 | 22.9 | 15.9 | 10.3 | 13.7 | 9.6 | 10.0 |
| 24 | 23.9 | 17.3 | 10.6 | 13.5 | 10.6 | 9.6 |
| 25 | 24.5 | 19.7 | 12.4 | 15.9 | 10.9 | 9.8 |
| 26 | 21.0 | 14.9 | 10.7 | 12.0 | 12.7 | 11.5 |
| 27 | (23.9) | 19.1 | 12.4 | 17.9 | 11.7 | 9.8 |
| 28 | (22.6) | 19.2 | 13.6 | 15.5 | 10.6 | ( 8.6) |
| 29 | (24.5) | 15.7 | 11.0 | 13.3 | 13.8 | 10.4 |
| 30 | (25.0) | 17.9 | 12.5 | 15.3 | 11.6 | 9.6 |
| 31 | 23.5 | 17.7 | 11.7 | 15.6 | 11.6 | 10.9 |
| 32 | 23.2 | 16.3 | 11.0 | 15.2 | 11.7 | 9.9 |
| 33 | 24.8 | 20.0 | 13.5 | 18.0 | 11.0 | 9.2 |
| 34 | 21.3 | 15.1 | 10.6 | 13.5 | 11.5 | 10.7 |
| 35 | 22.9 | 16.7 | 11.2 | 14.9 | 11.6 | 10.9 |
| 36 | 22.9 | 17.2 | 12.4 | 15.6 | 13.2 | 12.7 |
| 37 | 24.7 | 17.4 | 11.0 | 15.9 | 11.8 | 10.5 |
| 38 | 23.9 | 17.6 | 12.2 | 16.0 | 12.5 | 10.7 |
| 39 | 23.9 | 18.9 | 12.4 | 17.0 | 10.9 | 9.6 |
| 40 | 22.9 | 17.8 | 11.4 | 15.2 | 10.6 | 9.3 |
| 1941 | 21.1 | 13.4 | 10.0 | 12.3 | 9.9 | — |
| Max. | 25.0 | 20.0 | 14.1 | 18.0 | 13.8 | 12.7 |
| Min. | 21.0 | 13.4 | 10.0 | 10.3 | 8.8 | 8.4 |
| Dif. | 4.0 | 6.6 | 4.1 | 7.7 | 5.0 | 4.3 |

| F 50°–55°N 150°–135°W | G 45°–50°N 140°–130°W | H 35°–40°N 130°–120°W | G′ 40°–45°N 145°–140°W | A—H | B—G′ | G—$C_1$ |
|---|---|---|---|---|---|---|
| 12.1 | 13.0 | 15.5 | — | 6.8 | — | 2.4 |
| 13.5 | 14.9 | 16.5 | (18.1) | 6.4 | (−0.8) | 3.0 |
| 13.5 | 14.0 | 18.6 | — | 3.7 | — | 3.6 |
| 11.5 | 14.6 | 17.3 | (20.0) | 5.9 | (−3.8) | 2.4 |
| 12.0 | 15.0 | 16.0 | 17.3 | 7.5 | −1.1 | 3.5 |
| 11.8 | 13.8 | 15.0 | 14.0 | 8.0 | +4.7 | 0.9 |
| 12.3 | 14.5 | 14.5 | (17.8) | 6.5 | (−1.5) | 3.3 |
| 14.3 | 15.1 | 14.8 | 17.5 | 8.7 | −0.7 | 2.9 |
| 12.1 | 13.1 | 14.4 | 16.1 | 8.0 | −0.3 | 1.4 |
| 12.6 | 15.2 | 16.0 | 18.4 | 8.7 | +0.4 | 1.1 |
| (13.6) | 14.9 | 15.2 | 18.5 | 9.1 | −0.2 | 1.2 |
| 13.2 | 14.9 | 15.8 | 17.5 | 7.6 | −0.2 | 2.9 |
| 14.9 | 15.5 | 16.1 | 17.5 | 6.8 | −1.6 | 5.2 |
| 14.2 | 15.4 | 15.1 | 18.2 | 8.8 | −0.9 | 4.8 |
| 12.8 | 14.4 | 15.5 | 18.0 | 9.0 | +1.7 | 2.0 |
| 13.9 | 14.8 | 16.1 | 16.4 | 4.9 | −1.5 | 4.1 |
| 13.9 | 16.0 | 15.4 | 17.3 | 8.5 | +1.8 | 3.6 |
| 12.4 | 14.7 | 14.9 | 18.1 | 7.7 | +1.1 | 1.1 |
| 12.5 | 15.6 | 16.5 | 15.7 | 8.0 | 0 | 4.6 |
| 14.1 | 16.3 | 16.6 | 17.6 | 8.4 | +0.3 | 3.8 |
| 13.0 | 14.6 | 15.7 | 17.5 | 7.8 | +0.2 | 2.9 |
| 12.7 | 12.3 | 14.9 | 15.4 | 8.3 | +0.9 | 1.3 |
| 11.6 | 14.5 | 15.3 | 17.5 | 9.5 | +2.5 | 1.0 |
| 12.6 | 14.5 | 16.2 | 17.4 | 5.2 | −2.4 | 3.9 |
| 13.1 | 14.5 | 15.0 | 17.4 | 7.9 | −0.7 | 3.3 |
| 14.8 | 15.0 | 15.9 | 17.1 | 7.0 | +0.1 | 2.6 |
| 12.3 | 14.4 | 15.9 | 17.0 | 8.8 | +0.4 | 1.1 |
| 13.5 | 15.0 | 16.1 | 17.4 | 7.8 | +0.2 | 2.8 |
| 12.3 | 14.4 | 16.1 | 17.9 | 7.8 | +1.1 | 2.0 |
| 12.2 | 14.3 | 16.7 | 18.2 | 6.2 | −0.4 | 2.9 |
| — | — | 17.9 | 16.4 | 3.3 | −3.0 | — |
| 14.9 | 16.3 | 18.6 | 20.0 | | | |
| 11.5 | 12.3 | 14.4 | 14.0 | | | |
| 3.4 | 4.0 | 4.2 | 6.0 | | | |

Table 1 b. Sea Surface Temperature in Feb. and May.

| Year | February 50°—55°N | | | February 45°—50°N | | | |
|---|---|---|---|---|---|---|---|
| | 180°W 160°W | 160°W 145°W | 145°W 130°W | 160° E 175° E | 180°W 160°W | 160°W 145°W | 145°W 125°W |
| 1911 | 3.3 | 3.3 | 4.3 | 1.9 | 3.1 | 3.8 | 5.1 |
| 12 | 3.2 | 4.5 | 6.3 | 1.6 | 3.0 | 4.7 | 7.3 |
| 13 | 4.4 | 4.7 | 6.7 | 1.7 | 3.3 | 4.9 | 6.9 |
| 14 | 3.6 | 3.9 | 6.2 | 2.3 | 2.7 | 4.0 | 6.8 |
| 15 | 3.2 | 3.8 | 6.1 | 2.5 | 3.4 | 4.2 | 6.4 |
| 16 | 3.4 | 3.5 | 4.4 | 1.9 | 3.5 | 4.0 | 5.7 |
| 17 | 3.4 | 4.6 | 5.1 | 2.6 | 3.7 | 5.2 | 6.2 |
| 18 | 3.0 | 3.5 | 5.3 | 1.8 | 3.2 | 4.1 | 6.7 |
| 19 | 2.8 | 2.7 | 5.2 | 1.2 | 2.9 | 4.4 | 6.4 |
| 20 | 1.7 | 5.2 | 6.3 | 2.8 | 3.0 | 6.0 | 7.9 |
| 21 | — | — | — | 2.5 | 4.1 | 4.8 | 7.1 |
| 22 | (4.2) | 4.4 | 4.9 | 2.6 | 3.9 | 4.3 | 5.9 |
| 23 | (3.0) | 5.0 | 6.4 | 1.5 | 4.6 | 5.6 | 6.4 |
| 24 | 1.8 | 3.6 | 6.6 | 1.5 | 1.9 | 3.2 | 6.8 |
| 25 | 1.6 | 1.5 | 5.5 | 2.0 | 3.2 | (3.6) | 6.4 |
| 26 | 3.4 | 4.6 | 6.6 | 2.4 | 3.4 | 5.0 | 8.3 |
| 27 | 3.5 | 4.7 | 7.4 | 2.9 | 3.2 | 4.3 | 7.1 |
| 28 | 2.8 | 4.3 | 6.6 | 1.4 | 3.7 | 5.4 | 7.7 |
| 29 | 3.6 | 4.8 | 6.6 | 1.9 | 4.0 | 6.3 | 7.3 |
| 30 | 0.9 | 3.3 | 5.0 | 1.8 | 3.4 | 5.4 | 6.6 |
| 31 | 1.7 | 2.8 | 4.4 | 1.3 | 2.8 | 5.2 | 7.6 |
| 32 | 2.5 | 3.4 | 6.2 | 2.0 | 4.7 | 5.6 | 6.3 |
| 33 | — | 3.7 | 5.8 | 1.9 | 4.4 | 6.7 | 6.7 |
| 34 | 2.9 | 3.8 | 6.4 | 2.3 | 4.9 | 5.4 | 7.0 |
| 35 | 3.4 | 4.7 | 6.7 | 2.7 | 5.2 | 6.3 | 6.7 |
| 36 | 3.4 | 4.9 | 5.9 | 3.0 | 5.2 | 7.2 | 7.8 |
| 37 | 3.4 | 4.3 | 5.6 | 2.2 | 5.0 | 7.3 | (6.4) |
| 38 | 3.0 | 4.5 | (6.1) | 2.5 | 5.0 | 6.4 | 6.3 |
| 39 | (3.4) | 5.0 | 6.2 | 3.0 | 5.0 | 6.5 | 7.2 |
| 40 | 1.8 | 3.3 | (4.8) | 2.7 | 4.8 | 5.4 | 7.0 |
| 1941 | 4.0 | 5.4 | 7.9 | 1.6 | 3.8 | 6.1 | 8.8 |

| February | | May | | | May | | | May | |
|---|---|---|---|---|---|---|---|---|---|
| 40°—45°N | | 50°—55°N | | | 45°—50°N | | | 40°—45°N | |
| 145° E<br>165° E | 145°W<br>125°W | 180°W<br>155°W | 165°W<br>150°W | 150°W<br>135°W | 155° E<br>170° E | 170° E<br>170°W | 135°W<br>125°W | 145° E<br>165° E | 145°W<br>125°W |
| 3.1 | — | 3.2 | 4.3 | 5.4 | 2.6 | 3.4 | 7.7 | 6.3 | — |
| 3.2 | — | 4.5 | 5.1 | 6.8 | 3.0 | 3.5 | 9.3 | 6.1 | — |
| 3.2 | — | 5.2 | 5.7 | 7.5 | 2.5 | 3.8 | 9.3 | 4.7 | — |
| 1.8 | — | 5.0 | 5.3 | 7.1 | 2.9 | 3.9 | 10.1 | 4.5 | — |
| 3.7 | — | 4.8 | 3.3 | 7.3 | 2.7 | 4.2 | 10.4 | 4.2 | — |
| 2.1 | — | 3.9 | 3.9 | 5.6 | 2.5 | 3.8 | 8.4 | 4.4 | — |
| 4.2 | — | 4.3 | 5.1 | 7.6 | 2.7 | 4.8 | 9.5 | 5.5 | (11.0) |
| 3.5 | (11.7) | 4.5 | 5.1 | 6.4 | 3.3 | 4.5 | 8.5 | 5.0 | 11.7 |
| 2.8 | 10.0 | 3.2 | 3.1 | 5.7 | 2.6 | 3.4 | 8.8 | 5.2 | 10.9 |
| 5.2 | (11.1) | 5.3 | 4.9 | 5.6 | 4.6 | 5.9 | 8.4 | 7.7 | 13.3 |
| 4.7 | (12.8) | 4.8 | 4.7 | 6.7 | 3.9 | 4.7 | 9.5 | 6.4 | 11.1 |
| 3.0 | (8.0) | 4.9 | 5.1 | 6.2 | 2.7 | 4.2 | 8.1 | 5.2 | 9.8 |
| 1.9 | 10.2 | 5.5 | 5.9 | (7.1) | 3.0 | 4.5 | 9.2 | 5.2 | (10.7) |
| 2.8 | (9.3) | 3.6 | 4.8 | 6.3 | 2.4 | 4.1 | 9.3 | 5.2 | (12.7) |
| 1.6 | — | 4.6 | 5.0 | 7.5 | 3.3 | 4.1 | 9.9 | 5.8 | 11.4 |
| 2.6 | 9.9 | 5.4 | 5.4 | 7.4 | 3.5 | 4.3 | 10.9 | 4.3 | 10.1 |
| 2.3 | — | 4.7 | 4.9 | 6.8 | 3.7 | 4.9 | 8.6 | 6.1 | 11.4 |
| 1.9 | 9.8 | 3.7 | 4.7 | 6.8 | 3.2 | 4.3 | 10.0 | 5.7 | 12.3 |
| 2.0 | 10.4 | 4.4 | 5.2 | 7.0 | 2.6 | 4.7 | 9.9 | 5.2 | 12.6 |
| 3.5 | 11.5 | 3.6 | 4.2 | 6.1 | 2.4 | 4.3 | 8.9 | 5.6 | 11.6 |
| 2.4 | (9.7) | 4.4 | 4.4 | 6.6 | 3.2 | 4.1 | 10.1 | 6.5 | 12.9 |
| 4.6 | 10.2 | 3.9 | 4.5 | 6.6 | 2.7 | 4.0 | 9.1 | 6.5 | 11.0 |
| 5.1 | 9.8 | 4.0 | 4.3 | 5.8 | 2.7 | 4.0 | 8.3 | 6.4 | 10.1 |
| 4.1 | 11.2 | 4.4 | 4.5 | 6.9 | 3.3 | 4.7 | 10.3 | 6.5 | 12.4 |
| 4.2 | 10.5 | 4.3 | 5.0 | 6.4 | 3.1 | 4.8 | 9.1 | 6.2 | 11.5 |
| 4.2 | 10.8 | 4.7 | 5.6 | 7.8 | 3.2 | 5.0 | 10.1 | 6.1 | 12.6 |
| 4.8 | 11.0 | 4.5 | 5.1 | 6.8 | 2.8 | 5.2 | 9.3 | 6.4 | 11.1 |
| 3.8 | 9.9 | — | 4.8 | 6.7 | 3.6 | 5.6 | 9.7 | 7.5 | 11.4 |
| 3.9 | 10.2 | 5.2 | 5.1 | 7.3 | 3.5 | 5.6 | 10.0 | 6.5 | 11.4 |
| 4.1 | 10.6 | 5.4 | 5.9 | 7.1 | 3.4 | 5.2 | 10.4 | 6.6 | 12.2 |
| 3.4 | 11.0 | 5.3 | 5.6 | 7.8 | 2.8 | 4.6 | (12.1) | 6.1 | 11.7 |

The results are shown in the following:

(1) Basing on Figs. 1, 2 and Table 1, in summer (August) sea temperature in the western part of the North Pacific (west to 160°E.) has indicated minima in the years 1913, 1923, 1926, 1934, and 1941 which correspond to the bad year of rice crop due to cool summer. Moreover, in such years, waters in the eastern part of the North Pacific Ocean are warmer remarkably than normal. Conversely, we can notice the warmer years (rich rice crop years) in the western region of the ocean contrasted to the colder years in the eastern region of the ocean. The temperature difference between the western and eastern parts of the ocean shows the trends of fluctuation such as greater minus value in the cooler years and greater plus values in the warmer years.

(2) Basing on Fig. 2, we can easily recognize the trends of the reciprocal variation between the temperature in the western part (west to 160°E.) and in the eastern part (east to 160°W.) of the ocean along the Polar Frontal Zone (35°—50°N.). In particular, such a trend is obvious along the zones of 40°—45°N. and 45°—50°N. by the mean sea temperature in the western part contrasted to that of the eastern part (e. g. between two meridional belts of A and D) in the months of February, May and August respectively. In the zone of 50°—55°N., in the eastern Bering Sea (east to 180° Lg.) the temperature trend is similar to the variation in the eastern part of the North Pacific Ocean (east to 160°W.).

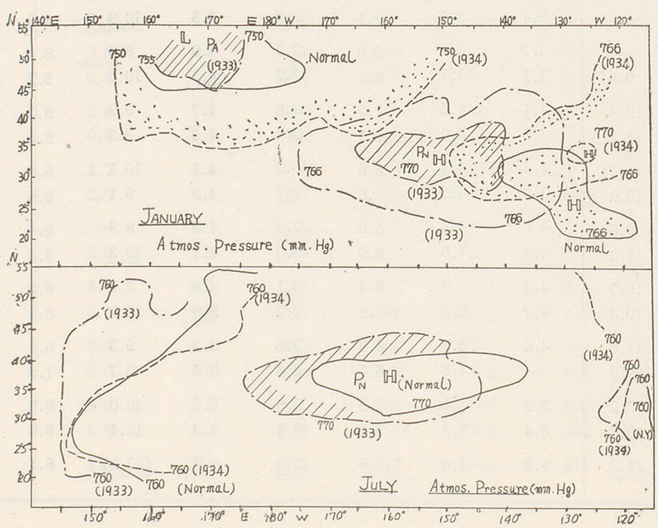



Fig. 3. Atmos. Pressure Pattern.

(3) The above mentioned results may be interpreted by the yearly fluctuation of atmospheric pressure system such as "Siberian High" ($P_S$), "Aleutian Low" ($P_A$), "North Pacific High" ($P_N$) depressions.

For example the pressure patterns in February (winter) and August (summer) of 1934 (western cool year and lower pressure generally) are quite different from those of 1933 (western warm year, higher pressure generally) compared to the normal year (Fig. 3).

In winter higher pressure on the continent and lower pressure on the sea arouses stronger monsoon (between $P_S$ and $P_A$) in the western sea regions (carrying colder water to south) brings cooler climate and transports more warmer waters by westerly or southwesterly drift current due to prevailing wind between $P_N$ and $P_A$ into the eastern part of the ocean.

(4) During the period (1911—1941) in question we can remark the general warming (+1°—4°C) of the northern waters in the Pacific, especially notable in winter and in spring (conspicuous in the eastern and western part), also in summer (conspicuous in the middle and eastern part of the ocean) in the Polar Frontal Zone (40°—45°N.). We may explain them on the maritime meteorological basis as before. (See Figs. 1, 2 and Table 1.)

(5) In general the distribution patterns of sea temperature in the North Pacific (Fig. 1) indicate the western warmer, eastern cooler pattern in the )35°—45°N.) zone and the western cooler, eastern warmer pattern in the (45°—50°—55°N.). zones i. e. as the contact zones of two independent great circulations (subtropical and

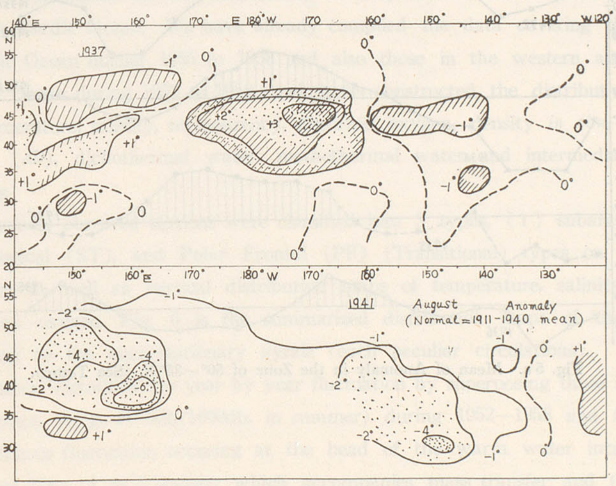



Fig. 4. In 1937 and 1941, August Anomaly.

subarctic circulations).

(6) The anomaly distribution of sea temperature ($\Delta\theta$) during the period of 1930—1941 is shown in Fig. 4. From them we can find:

( i ) The zonal maximum of the year by year fluctuation concerning sea temperature locates in the zone of 40° to 50°N. i. e. around the Poalr Frontal Zone.

( ii ) The meridional fluctuation of the year by year fluctuation centres around (A) 140°—165°E., (B) 170°E—160°W., (C) 155°—120°W., ($A_1$ 140°—155°E., $A_2$ 160°—165°E.) as seemingly independent areal blocks which correspond to the warm water intrusion areas. (See the following 2.)

(7) Fig. 5a, b show the transpacific pattern (from west to east) of temperature anomaly in the years (1930—1941).

We can recognize the variation from the western higher, eastern lower type, through the middle higher type unto the western lower, eastern higher type successively and cyclically (cycle of about more than seven years).

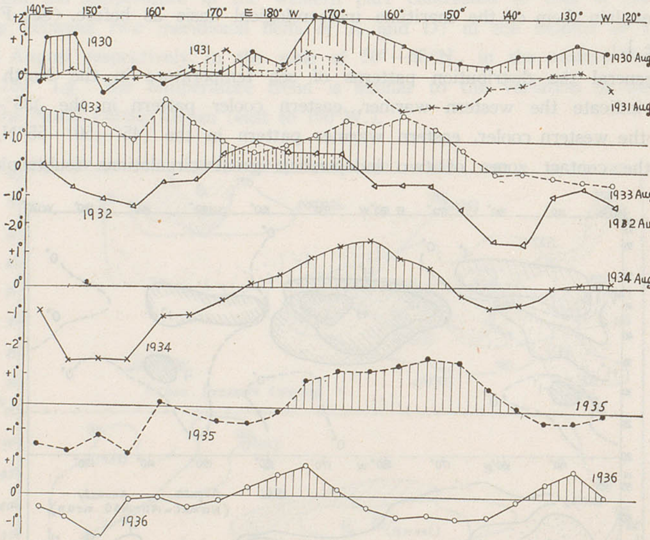



Fig. 5a. Mean of Anomaly in the Zone of 50°—35°N. (Sea Temp).

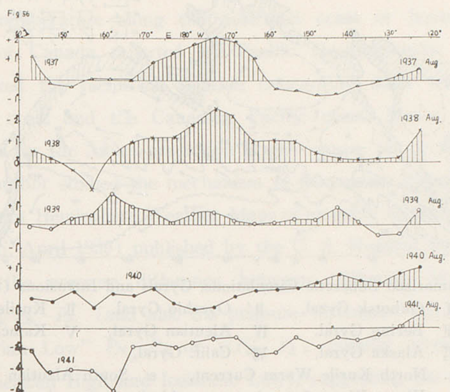



Fig. 5b. Mean of Anomaly in the Zone of 50°—35°N.
(Sea Temp.)

## 2. Considerations

First we will discuss on the mechanism of reciprocal variation of east to west in the North Pacific Ocean. We have already compiled the data covering the whole North Pacific Ocean during 1955 to 1958 and also those in the western and middle parts of the Ocean during 1952 to 1958, and have constructed the distribution charts of water temerature, salinity, transparency, dissolved oxygen, density *in situ*, dynamic topography ($\Delta D$), dichothermal water, methothermal water and intermediate water topographies.

Thousands of observed stations were classified into 3 types, (I) subarctic (SA), (II) Subtropical (ST), and Polar Frontal (PF) (Transitional) types on the basis of TS-curves as well as vertical distribution maps of temperature, salinity, density and dissolved oxygen. Fig. 6 is the summarized distribution maps of those types corresponding to the quasi-stationary gyrals (each peculiar circulations).

The author examined the year by year fluctuation by superposing those isolines in the same season (e. g. $\Delta D$ 0db/1000db, in summer) during 1952—1958 and found the most conspicuous fluctuation occuring at the head of the warm water intrusions of Polar Frontal Zone (4 or 5 waves) which accompanies mass transfer and fluctuation of fisheries (stronger intrusion, richer fisheries conditions).

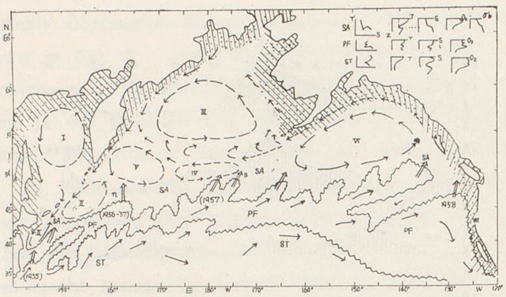


Fig. 6. Summarized Subarctic Circulations, Gyrals and Intrusions (by Uda).
Ⅰ Okhotsk Gyral, Ⅱ′ Oyashio Gyral, Ⅱ Kurile Gyral
Ⅲ Bering Gyral, Ⅳ Aleutian Gyral, Ⅴ Kamchatka Gyral,
Ⅵ Alaska Gyral, Ⅶ Calif. Gyral,
n. North Kurile Warm Current, s. South Aleutian Warm Current
⇐ Warm Water Intrusion, a. Alaska Stream, hatched area......
Low Salinity Water

Table 2. Shift of the Peak of Intrusion in the Pacific Ocean.

| Year | Western part | Middle part 1. | Middle part 2. | Eastern part |
|---|---|---|---|---|
| 1952 | ⊙ | — | — | — |
| 1953 | ⊙ | ● | — | — |
| 1954 | ○ | ⊙ | — | — |
| 1955 | ◎ | ○ | ⊙ | ▲ |
| 1956 | ○ | ◎ | ○ | ⊙ |
| 1957 | ● | ○ | ◎ | ○ |
| 1958 | ▲ | ⊙ | ○ | ◎ |

The amplitudes of intrusion shifted its peak successively from west to east such as shown in Table 2, i. e. warmest in 1955 in the adjacent waters in east to Japan, in 1957 in the middle Aleutian waters and in 1958 in the neighbouring waters off American Pacific coasts, seemingly the peak of oceanographic intrusion (temperature rise etc.) shifted from west to east. In 1958, compared to the western cooling the eastern warming was remarkable.

In the past the peak in 1937—1938 (warming maximum with sardine fisheries prosperity) and the following decline since 1941 moved from oriental waters to American waters after the delay of 3—4 years.

Peaks (±) appeared in the course of temperature variation along American coast studied by M. Robinson seems reciprocal to our experienced one along the Japanese coastal waters. Formerly J. Fukuoka (1957) has noticed the reciprocal relation between the sea temperature along the northeast coast of Japan and those along the B. C. coast of Canada reported by Pacific Oceanographic Group. M. Okada (1941) also remarked the reciprocal relation concerning daily temperatures observed along the Japanese coast and the Canadian Pacific coast. Really these are very encouraging evidences for the future prediction of the ocean temperature in the Pacific.

Further, the author studied the mechanism of fluctuation mentioned above on the bases of the Northern Hemisphere Weather Maps of monthly mean atomospheric pressure (from Jan. 1955 to April 1959) published by the U. S. Weather Bureau and discovered the amplitude of the pressure difference between "Siberian High" and "Aleutian Low" $P_S - P_A$ or $\sqrt{P_S - P_A}$ (and also the pressure difference between "North Pacific High" and "Aleutian Low" $P_N - P_A$ or $\sqrt{P_N - P_A}$, (similar trend of the difference between North American High and Icelandic Low), suggesting the common fluctuation in the northern hemisphere circulation) in winter increased year by year during 1955—1958. Therefore, the winter monsoon $W_1 = K_1\sqrt{P_S - P_A}$, $W_2 = K_2\sqrt{P_N - P_A}$ corresponding to intensified gradient and duely also wind stress $\tau = D\rho V^2$ (Reid, 1948) increased. Following H. Stommel (1958, Gulf Stream, p. 155) $\beta M_y$ = curl $\tau$ and accordingly vorticity may be increased. Consequently we can infer that in quasi-stationary state gyrals were intensified successively from west to east by such mechanism aroused intrusion.

However, this wave is not due to the mere planetary wave, but the quasi-stationary pulsational wave with fluctuating amplitude due to topographically confined or boundary conditioned gyrals. (Pulsation theory proposed.)

P. S.

Remembering Mr. G. Roden's suggestion to the interpretation of reciprocal trends of temperature anomaly on the west and east sides of North Pacific Ocean in relation to the location of Aleutian Low and North American High on 22 April, 1959 at Biological Station (Nanaimo), the author states his hearty acknowledgement. Also the author wishes to state his thanks to Mr. M. Hanzawa who kindly reminded me his excellent work on reciprocal relation of water temperature on both sides of the North Pacific Ocean in 1955. Referring to Rodewald's paper (1957) the trends of temperature variation along the west coasts of the North Pacific and North Atlantic Oceans appear concurrently.

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