On the Subtropical Convergence and the Currents in the Northwestern Pacific

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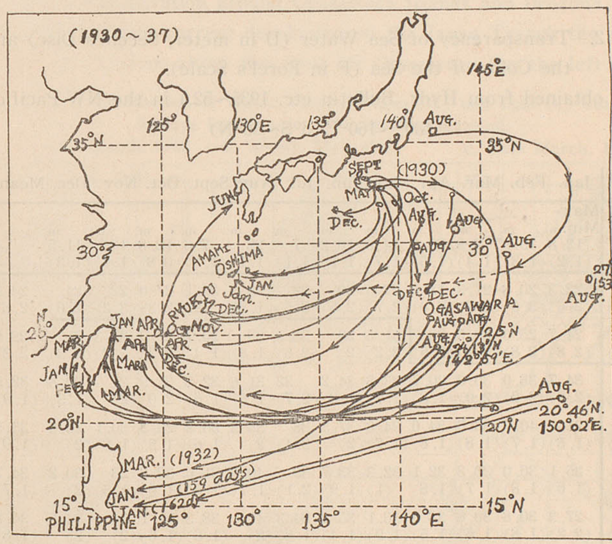
It is already known that the Subtropical Convergence is located in the middle latitudes in which the density in the upper layers increases rapidly towards the poles and is noted by the sinking of the heavy water along it.[1] However, hitherto the details of its characteristic feature and position in the Northwestern Pacific are not exactly investigated.

Fig. 2. Kuroshio Counter Current

(Drift Bottle Expt)



Now, by means of the current-bottle experiments[2] we can show roughly the pattern of the Kuroshio Counter Current (see Fig. 1), which flows in the SW-WSW direction with the average velocity of 15 sea-miles per day i. e. about 0.6 knot (drifting from Aug. thrown in southern Kuroshio waters off Idu Islands to Jan. picked up at Yaeyama- and Miyako Islands south of Ryūkyū).

The adrift of bottles on the coast of those Southwestern Islands is almost limited in the period of winter monsoon from Nov. to April and May (see Table 1).

Table 1. Recovery of Curret Bottles. (Data from the Semiannual Reports of Oceanographical Investigation 1930~37).

Thrown in		Picked Up	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
off Iwate	May.	Ogasawa-	2	–	–	–	–	–	–	–	–	–	1	6
〃 Ibaragi	July.	ra	–	–	–	–	–	–	–	1	–	–	–	–
〃 Chiba	Aug.	Kyushu	10	5	5	9	9	4	5	5	3	3	8	5
〃 Tokyo	Sept.	Okinawa	–	–	1	–	–	–	–	–	–	1	–	1
〃 Kana-gawa	Oct.	S. China	1	–	–	–	–	–	–	–	–	–	–	–
〃 Siduoka	Nov.	Philippi-nes	–	–	–	–	–	–	–	–	–	–	–	2
〃 Mie		setc.												
Sum			13	5	6	9	9	4	5	6	3	4	9	14

Table 2. Transparency of Sea Water (D in meter, Secchi's Disc) and the Color of the Sea (F in Forel's Scale).

(Data obtained from Hydr. Bulletin etc. 1935~52.) in the NW-Pacific.

(130°~160°E. 5°S~35°N)

130°-160°E		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.	Range
	Amp.	Max–Min. m	m	m	m	m	m	m	m	m	m	m	m		
	D	12.8	19.9	12.8	20.6	14.0	16.2	7	22	7.6	12.8	13	11.5	–	–
N 35°	(F)	(1.2)	(1.3)	(1.4)	(1.5)	(1.7)	(1.1)	(1.1)	(1.1)	(1.3)	(0.8)	(1.7)	(1.3)	–	–
	D	22.3	20.8	21.3	18.0	22.6	20	32	29.5	32.1	27.0	22	24	24.3	14.1
30°	(F)	(2.6)	(3.0)	(2.7)	(3.0)	(2.7)	(2.5)	(2.5)	(1.8)	(2)	(2.3)	(3.2)	(2.6)	(2.6)	(1.4)
	D	24.7	25.6	20.5	23.3	31.5	29	38.5	39	30.7	29.0	31.3	31	29.5	18.5
25°	(F)	(2.8)	(2.8)	(2.9)	(2.6)	(2.2)	(2)	(2.6)	(1.4)	(1.4)	(2.2)	(2)	(2.3)	(2.3)	(1.5)
	D	34.7	38.0	30.0	30.7	33.8	34.2	32	31.6	32.8	31.9	21	30.8	32.5	17
20°	(F)	(2.2)	(2.2)	(2.0)	(1.8)	(1.7)	(1.8)	(2.7)	(1.5)	(1.6)	(2.0)	(2)	(1.3)	(1.9)	(1.4)
	D	31.4	40.7	33.3	34.6	34.8	37.3	33	35.3	35.2	29.3	30.1	26.6	33.5	13.4
15°	(F)	(1.8)	(1.7)	(1.8)	(1.8)	(1.7)	(2)	(2.4)	(2)	(1.6)	(1.5)	(1.8)	(2)	(1.9)	(0.9)
	D	35.1	36.0	30.3	32.1	32.3	33.7	39	40.8	31.6	39.8	28	30.2	34.1	12.8
10°	(F)	(1.6)	(1.8)	(1.7)	(1.8)	(1)	(1.9)	(2.1)	(1.7)	(1.5)	(1.6)	(1.5)	(2)	(1.7)	(0.6)
	D	27.3	30.8	30.8	38.6	36.1	35.2	34.3	47	38.3	31.1	34	34.5	34.8	19.7
5°	(F)	(2.2)	(1.8)	(1.5)	(1.5)	(1.9)	(1.4)	(1.6)	(2)	(1.6)	(1.6)	(2)	(2)	(1.8)	(0.8)
	D	29.3	29.8	32.0	31.3	36.6	36.2	32.4	25	33.4	32.5	31.5	35.5	32.1	11.6
0°	(F)	(1.8)	(2.3)	(2.0)	(2.3)	(2.6)	(1.9)	(1.9)	(2.5)	(2.7)	(2.1)	(1.5)	(2)	(2.1)	(1.1)
	D	–	–	–	–	28.0	33.3	36.2	30	–	–	–	–	31.9	–
5°S	(F)	–	–	–	–	(3.2)	(2)	(2)	(2.5)	–	–	–	–	(2.4)	–
Mean	D	29.3	31.7	28.6	29.8	32.5	32.2	34.5	35.5	33.5	31.5	28.3	30.4	31.5	–
(0°~30°N)	(F)	(2.1)	(2.2)	(2.1)	(2.1)	(2.0)	(1.9)	(2.3)	(1.8)	(1.8)	(1.9)	(2.0)	(2.0)	(2.0)	–

Accordingly the Kuroshio Counter Current in the waters south of Kuroshio appears to flow southerly more strongly as the winter monsoon becomes stronger.

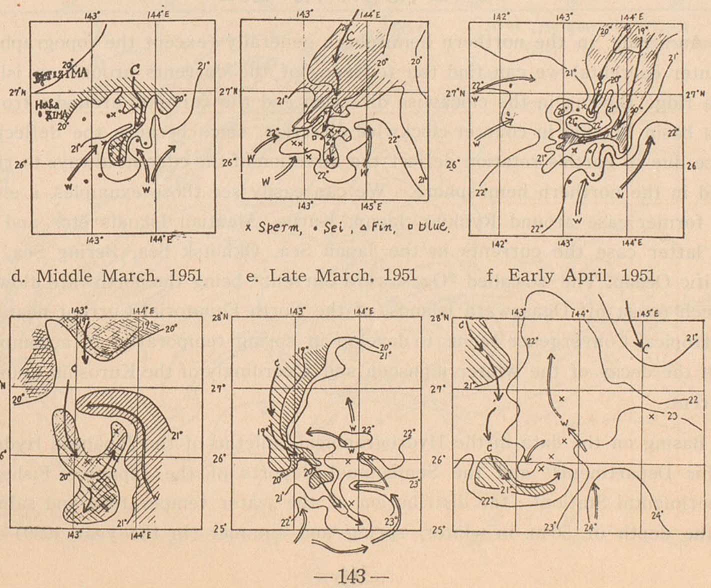
The distribution of the transparency of sea water and the color of the sea in the NW-Pacific are shown in Table 2, which indicates a sharp boundary at about 25°N. latitude in the season from Jan. to April. The relatively cold water (more turbid and of low salinity) of Kuroshio Counter Current meets to the warm Central Pacific water (more transparent and saline) in the North Pacific Ocean locating at the northern border of the North Equatorial Current near the Subtropical Convergence.

Several eddies are formed on the undulated line of the Subtropical Convergence. A conspicuous cyclonic eddy in the waters adjacent to Ogasawara Islands (see Fig. 2 a-f) is observed in winter and spring (from Feb. to May), corresponding to the well-known whaling grounds (nearly in the rectangle of 26°-27° N. 143°-144°E).[3] The eddy constituted by the narrow band of the southward intrusion of the cold current from N-NNE direction along the longitudes of 143°-144°E. and its sharp contact to the warm current on both sides of it may be related to the bottom configuration around Ogasawara Islands and Iwōzima. Contrary to the southgoing cold current developing on the Japan Trench the northgoing warm current develops along the west off Ogasawara (on the left hand side)

Fig. 2. Distribution of Water Temp., Warm (W) and Cold (C) Curr.
Surface Isotherms ×……Whaling Ground.

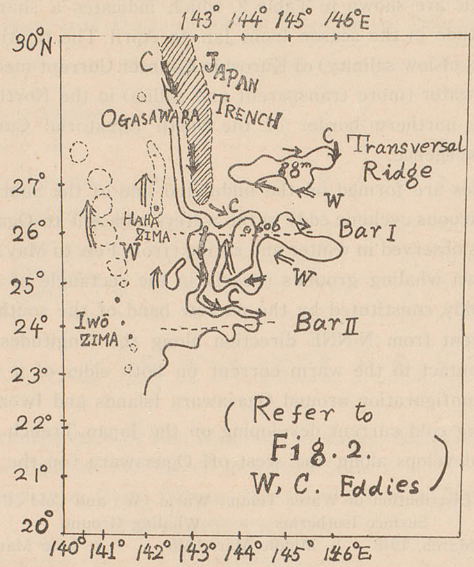
a. Early March. 1948 b. Middle Mar. 1948 c. Late March. 1948

d. Middle March. 1951 e. Late March. 1951 f. Early April. 1951



and along the transversal ridge east off Iwōzima (on the right hand side). (See Fig. 3).

Fig. 3. Warm and cold currents related to the Topographical Conditions.



As a rule, in the northern hemisphere generally (except the topographical counter currents) we can find the tendency of the currents around an island or a ridge flowing in the clockwise direction and the currents around a trough or a basin flowing in counter-clockwise direction, since because the deflecting force due to earth's rotation deflect the direction of the current always to right hand in the northern hemi-sphere. We can easily see those examples. i. e. for the former case around Ryūkyū, Japan, Kurile, Aleutian Islands etc. and for the latter case the currents in the Japan Sea, Okhotsk Sea, Bering Sea and Pacific Ocean. The so-called "Ogasawara Current", being the northward flowing branch (west off Ogasawara Islands) of the North Equatorial Current near the Subtropical Convergence seems to develop in spring temporarily in accompany with the decay of the winter monsoon and accordingly of the Kuroshio Counter Current.

Basing on the data in the Hydrographical Bulletins of the Japanese Hydrographic Department[4] and the Semiannual Reports of the Japanese Fisheries Experimental Station[5] the distribution of the water temperature and salinity at the depth of 50 m. in winter, spring and summer (in the year 1939) and

Fig. 4. Water Temp. at 50m. Depth in Winter

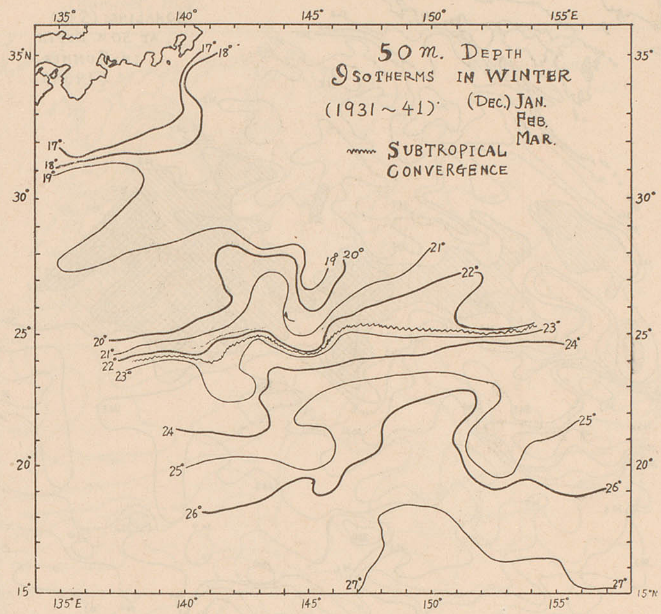


Fig. 5. Water Temp. at 50 m Depth in spring.

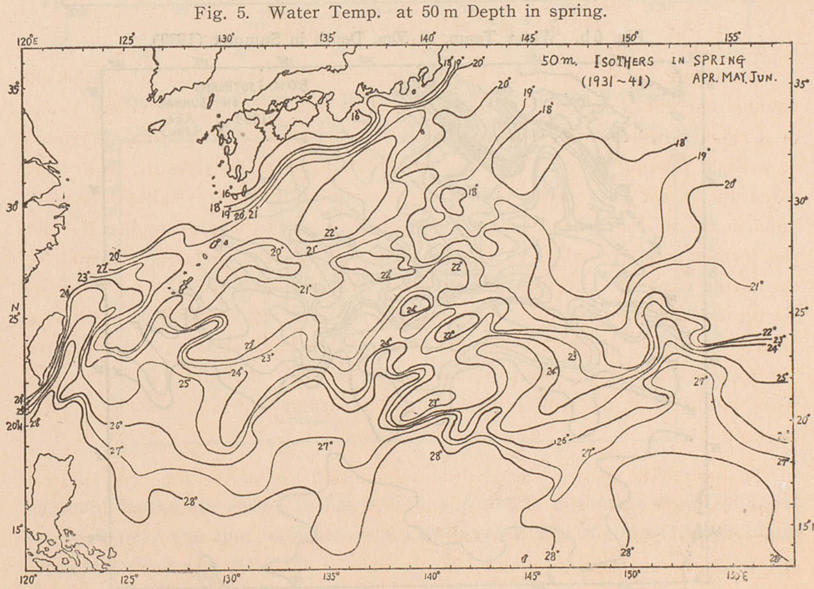


Fig. 6 a. Salinity at 50 m. Depth in Summer (1939).

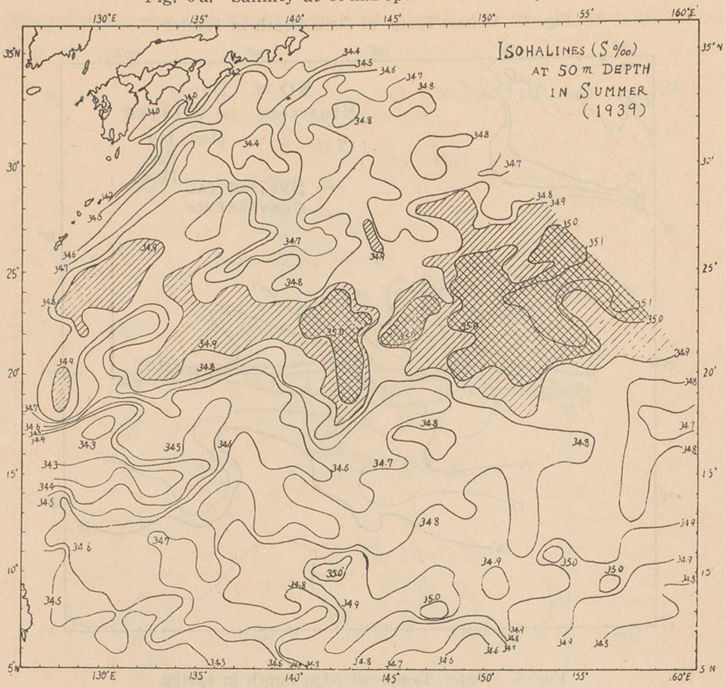


Fig. 6 b. Water Temp. at 50m. Depth in Summer (1939).

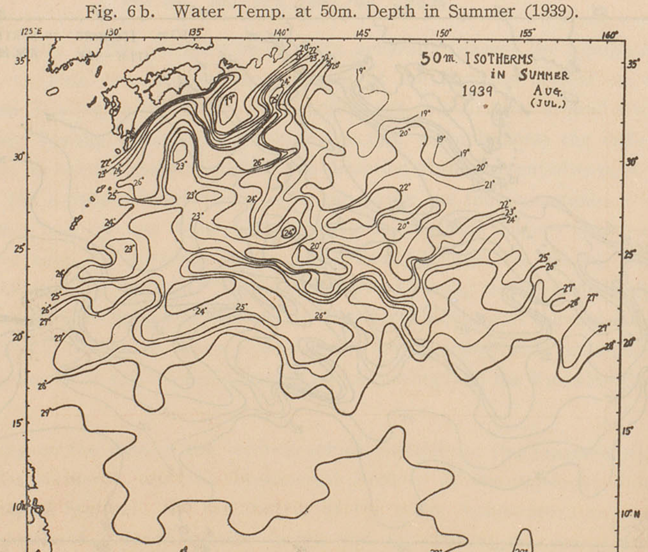


Fig. 7. Chart of Dynamic Isobaths showing the Current Fields at the Surface (Summer, 1939).

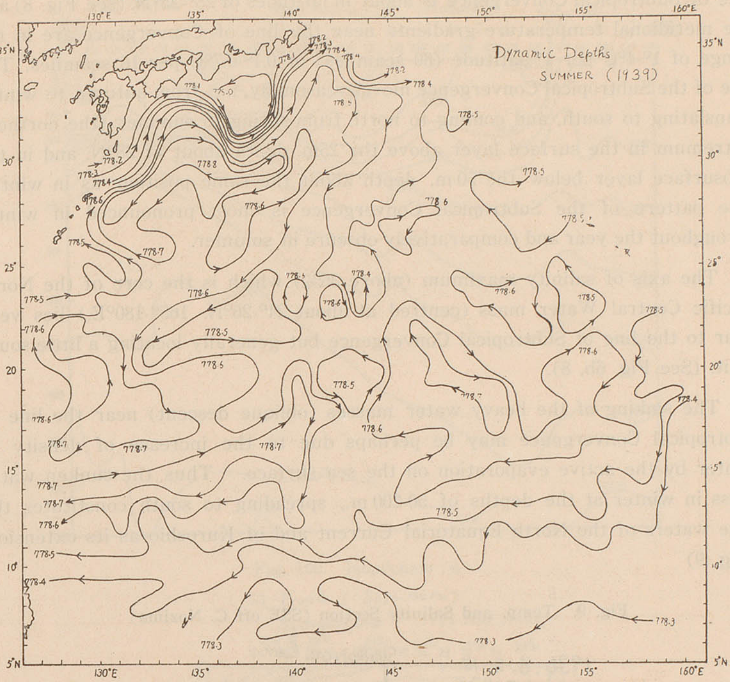
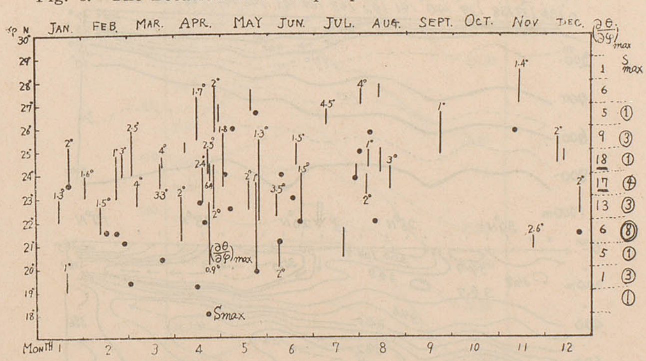


Fig. 8. The Location of the Suptropical Conv. in the NW-Pacific.



dynamic depths are shown in Fig. 4, 5, 6, a, b and 7. Isotherms of 20°-26°C are crowded near the line of Subtropical Convergence and in somewhat undulated form in latitudes of 20°-27°N.

Statistics on the hydrographic profiles show that the average position of the line of Subtropical Convergence is about in latitudes of 23°-25°N. (see Fig. 8) and the meridional temperature gradients near the line of Convergence are in the range of 1°-4°C per 1° latitude (60 seamiles) or 0.1°-0.7°C per 10 seamiles. The line of the Subtropical Convergence moves seasonally, i. e. from autumn to winter translating to south, and coming to north from spring to summer (the northern extremum in the surface layer above the 25m. depth about at 28°N. and in the subsurface layer below the 50 m. depth about the same position as in winter. The pattern of the Subtropical Convergence is most pronounced in winter throughout the year and comparatively obscure in summer.

The axis of salinity maximum (above 35‰) which is the core of the North Pacific Central Water mass (centred at about 24°-26°N. 165°-180°E.) lies very near to the line of Subtropical Convergence but generally locating a little south of it. (See Fig. 6b, 8).

The sinking of the heavy water masses (oblique descent) near the line of Subtropical Convergence may be perhaps due to the increase of density in winter by the active evaporation on the sea surface. Thus the sunken water mass in winter at the depths of 50-200 m., spreading to south constitutes the core waters of the North Equatorial Current and of Kuroshio as its extension. (Fig. 9)

Fig. 9. Temp. and Salinity Section (SSE off C. Nozima)

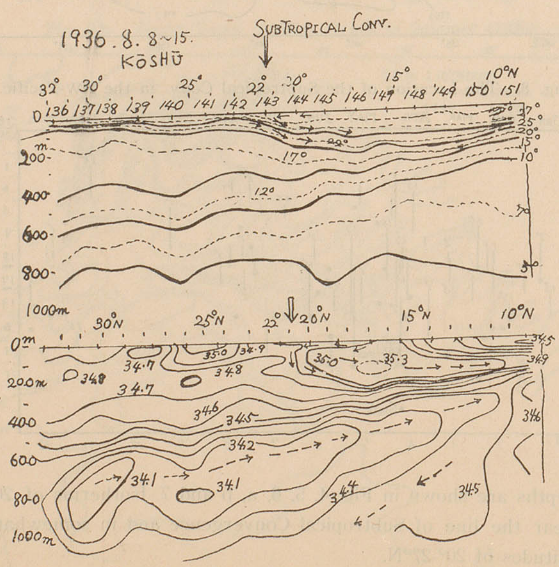


Fig. 10 a. Isopycnals (σ_t-Profile).

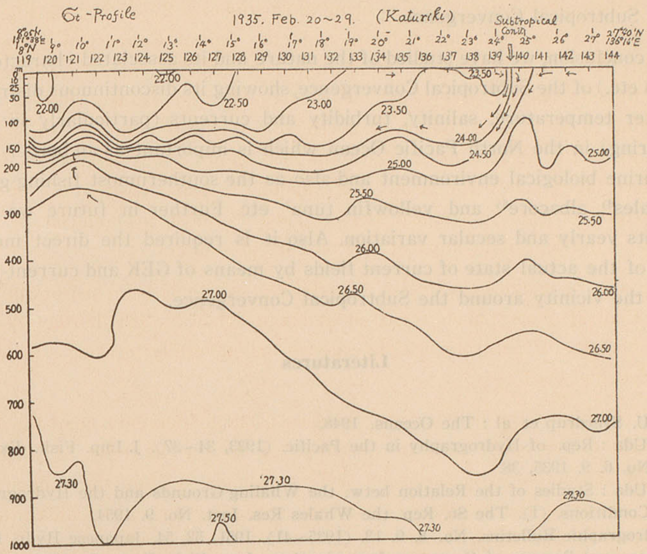
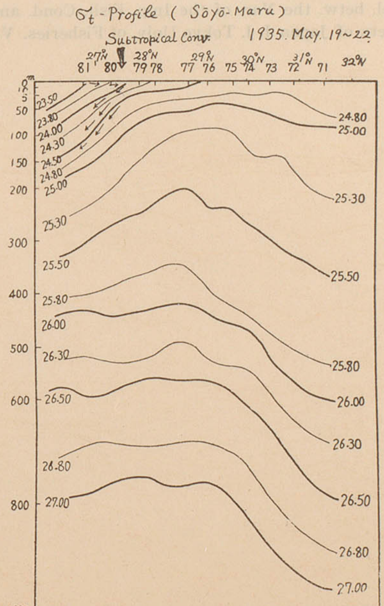


Fig. 10b. Isopycnals (σ_t).



The isopycnal profiles (Fig. 10) indicate the meridional discontinuity of σ_t on the Subtropical Convergence.

In conclusion, we have studied of the nature and its associated characteristics (eddies etc.) of the Subtropical Convergence, showing its discontinuous distribution of water temperature, salinity, turbidity and currents (particularly in winter and spring) in the North Pacific Ocean which is important as an border line of the marine biological environment and also as the southernmost fishing grounds of whales[3], albacore[6] and yellowfin tuna[7] etc. Further in future we should study its yearly and secular variation. Also it is required the direct measurements of the actual state of current fields by means of GEK and current-meters etc. in the vicinity around the Subtropical Convergence.

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