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ON THE CIRCULATION IN THE NORTH PACIFIC IN  
RELATION TO PELAGIC FISHERIES

By

MICHITAKA UDA

Handwritten notes in Japanese characters, including "木下" (Kishita) and "a", "b" in a blue circle.

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ON THE CIRCULATION IN THE NORTH PACIFIC IN  
RELATION TO PELAGIC FISHERIES

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On the charts plotted by the author, the semi-permanent boundaries of the water masses (fronts) in the Northwest Pacific adjacent to Japan, i.e. the Coastal Fronts, Oyashio Front (Polar Front or Subarctic Convergence), Kuroshio Front, Warm and Cold Fronts in the Japan Sea, Subtropical Convergence, Equatorial Counter Front, Continental Front are shown in relation to pelagic fisheries grounds of tuna, skipjack, Pacific saury and whales (Fig. 1). Briefly we can summarize the following three types of pelagic fishing grounds on the above hydrological point of view:

(1) Those produced by the planktonic livings and fishes in the compressed zone of the optimum water temperature due to mere convergence (e.g. the skipjack fishing grounds in the northern boundary zone of Kuroshio and the Pacific saury fishing grounds near the Oyashio Front).

(2) Those produced by marine organisms due to the upwelling of the water of rich nutrients in the deeper layer obeying Nathansohn's theory (e.g. the fishing grounds of sardine, squid, yellow-tail, bluefin tuna, mackerel, etc., or some varieties of this type), indicating dense concentrations near the coastal front and the fishing grounds on the eddies around the islands or capes (mackerel, flying fish, etc.) and around banks (skipjack, tuna and mackerel, etc.).

(3) The combined fishing grounds of (1) and (2) types (e.g. the marginal convergence of the upwelling area at the front of the cold water such as the fishing grounds of the albacore, whales, Pacific saury, etc.).

Further we will inspect the oceanographic structure in the North Pacific by means of the nucleus method. The depth of the intermediate water  $S$  min. and the value of that depth during the period 1931-41 were plotted in Figures 2, 3 and 4.

The intermediate water in the Northwest Pacific may be considered as the carrier of the rich nutrients which are produced in the seas of high latitudes and fertilizer resulting in the high production in the seas of lower latitudes. The prevalence of the cold water circulation,

i.e. the prevalence of the intermediate water, was associated with the anomalous Kuroshio conditions in recent years (1935-47).

The northern intermediate water appears to extend conspicuously to south along the Japan Trench and invades in the sea basin south to Japan. Going south further, it descends to its deepest layer beneath the depth of 800 m. in the sea-region at about 34-24°N. with the salinity of 34.0-34.2 ‰ and rises again gradually up to the depth of 200 m. at about 5°N., showing the increase of salinity to 34.5 ‰.

The northern and southern intermediate waters collide with each other in the zonal region of the latitudes of 12°-2°N., lying at about the depth of 200 m. for the former (the Northern Intermediate Water) and at about the depth of 800 m. (600-1000 m. depth) for the latter (the Southern Intermediate Water).

Accordingly in that region the vertical distribution of salinity shows the double minimum which is produced by the stratification of the southern intermediate water beneath the northern intermediate water.

The distribution of the depth and the value of the maximum salinity  $S_{max.}$  In the subsurface tropical water mass (Fig. 5) indicates obviously in the deepest layer (100-200 m. depth).  $S_{max.}$  lies in the regions of the North Equatorial Current (latitudes 20°-10°N.) and in the Kuroshio area. It lies in the shallowest layer (0-100 m. depth) in the western part of the North Pacific Saline Water (Salinity more than 35 ‰), having its axis along the line of Subtropical Convergence (water temperature in the upper layer above the 100 m. depth increases suddenly in the south over this Convergence).

In the Equatorial Counter Current area the depth of  $S_{max.}$  again rises to its shallowest (depth almost less than 100 m.) above the optimum angling depth of tuna with the salinity of about 34.8 ‰ or less, which corresponds to the belt of the cold water (water temperature less than those in the surrounding north and south).

Beyond it to the south (latitudes 3°N.-3°S.), again the  $S_{max.}$  layer sinks beneath 100-200 m. depth with the high salinity of 35.0-35.7 ‰, which corresponds to the water of the South Equatorial Current.

The distribution of surface salinity in winter and summer during the period 1931-35 (Fig. 6) shows the expansion of the North Pacific Central Saline Water mass in winter, lying in the zone of lat. 20°-30°N. around the axis of 22°-26°N., 165°-180°E., and the shrinkage in summer season in the period of 1931-35.

The water mass of low surface salinity (34.0-34.3 ‰) lying in the zone of the Equatorial Counter Current (lat. 5°-12°N.) which corresponds to the Equatorial Calm or Equatorial Rainy zone, and also

to the belt of the cold water at the depth 100 m. appearing more remarkable in winter than in summer.

In the region south from the lat.  $4^{\circ}\text{N}$ . to  $3^{\circ}\text{S}$ . we meet again the saline water mass of the Central South Pacific (salinity  $34.5\text{--}35.2\text{‰}$ ).

The northern and southern boundary lines of the Equatorial Counter Current (Equatorial Counter Front) lie at about  $12^{\circ}\text{N}$ . and  $4^{\circ}\text{N}$ ., corresponding to the theoretical results obtained by Dr. K. Yoshida and others (1953).

## ILLUSTRATIONS

FIG. 1.—Principal Watermasses and the Fronts in the NW Pacific. Explanation of Notations: LC—Liman Current, NKC—North Korean Cold Current, JCC—Central Cold Current in the Japan Sea, EKC—East Korean Warm Current, TC—Tsushima Current, CCC—Continent Coastal Current, ConF—Continental Front, CF—Cold Front in the Japan Sea, WF—Warm Front in the Japan Sea, KC—Kuroshio Current, OC—Oyashio Current, ESC—East Saghalin Cold Current, OF—Oyashio Front, KF—Kuroshio Front, STC—Subtropical Convergence, NEC—North Equatorial Current, ECF<sub>1</sub>, ECF<sub>2</sub>—Equatorial Counter Front, SEC—South Equatorial Current, ECC—Equatorial Counter Current, CoF—Coastal Front.

FIG. 2.— $S_{min.}$  ( $^{\circ}/_{00}$ ) and its Depth during 1931–1935. (Shaded area means the zone of Double  $S_{min.}$ .)

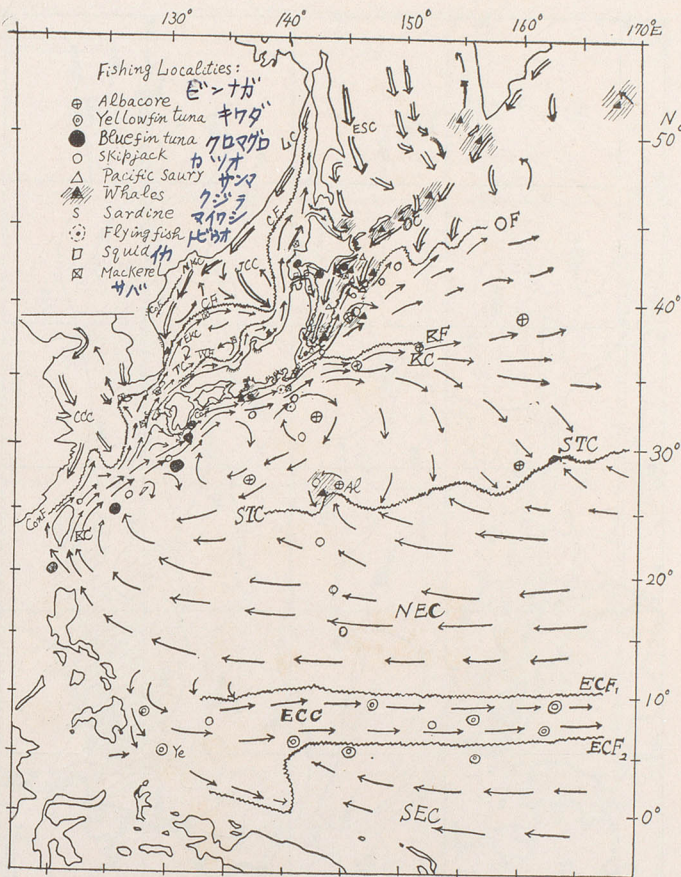
FIG. 3.— $S_{min.}$  ( $^{\circ}/_{00}$ ) and its Depth during 1935–1938. (Shaded area means the zone of Double  $S_{min.}$ .)

FIG. 4.— $S_{min.}$  ( $^{\circ}/_{00}$ ) and its Depth during 1938–1941. (Shaded area means the zone of Double  $S_{min.}$ .)

FIG. 5.— $S_{max.}$  ( $^{\circ}/_{00}$ ) and its Depth during 1931–1938.

FIG. 6.— $S_{om.}$  ( $^{\circ}/_{00}$ ) in Winter (Real line) and in Summer (Dotted line) 1931–1935.

北西太平洋漁場と海流、潮境



W Pacific. Explana-  
 -North Korean Cold  
 an Sea, EKC—East  
 nt, CCC—Continent  
 -Cold Front in the  
 KC—Kuroshio Cur-  
 Cold Current, OF—  
 ropical Convergence,  
 -Equatorial Counter  
 -Equatorial Counter

1935. (Shaded area  
 1938. (Shaded area  
 1941. (Shaded area  
 1938.  
 summer (Dotted line)

Figure 1

LC ..... リマン海流, NKC ..... 北鮮寒流, JCC 日本海中央寒流,  
 EKC ..... 東鮮暖流, TC ..... 対馬暖流, CCC ..... 大陸沿岸流,  
 ConF ..... 大陸前線, CF ..... 日本海寒流前線, WF ..... 日本海暖流前線  
 KC ..... 黒潮暖流, OC ..... 親潮寒流, ESC ..... 東樺太寒流,  
 OF ..... 親潮前線, KF ..... 黒潮前線, STC ..... 亜熱帯収束  
 NEC ..... 北赤道海流, ECF<sub>1</sub>, ECF<sub>2</sub> ..... 赤道逆流前線(北界南界),  
 SEC ..... 南赤道流, ECC ..... 赤道逆流, CoF ..... 沿岸前線



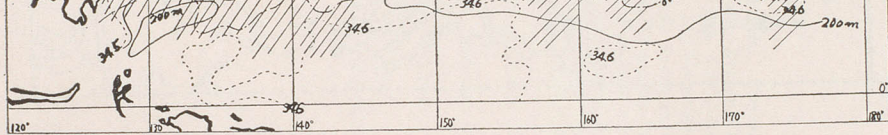


FIGURE 2

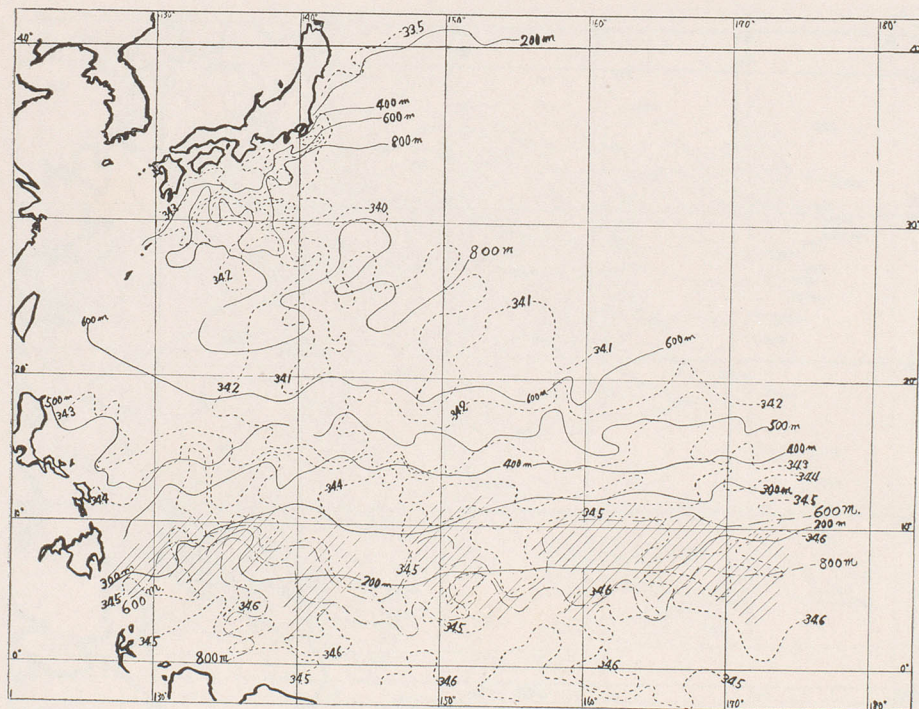


FIGURE 3

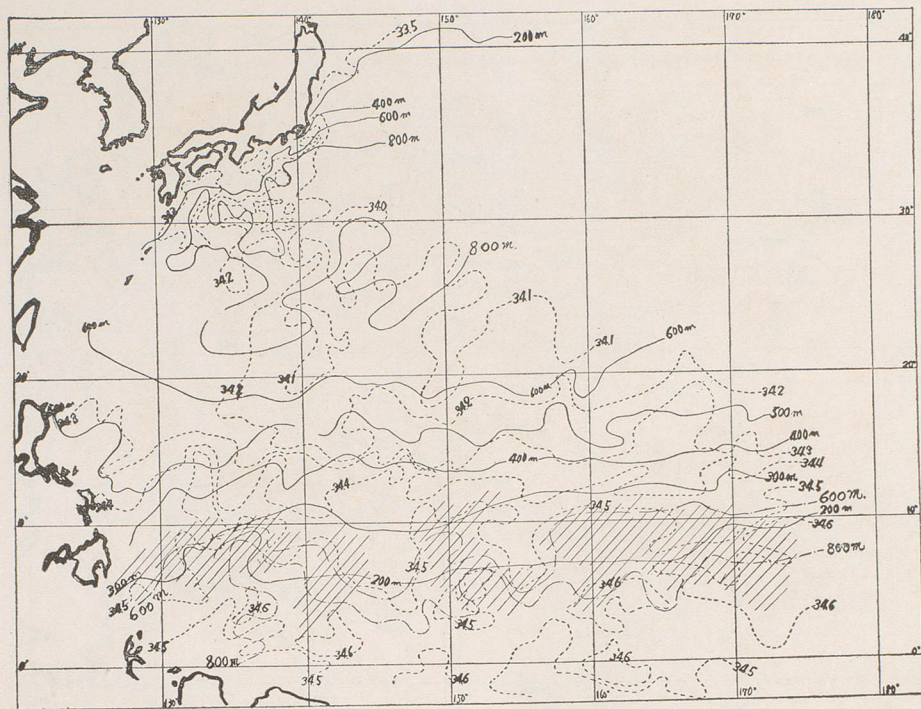
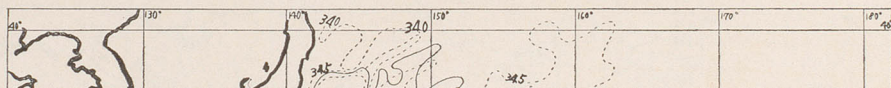


FIGURE 4



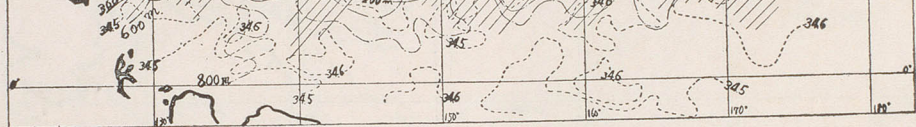


FIGURE 4

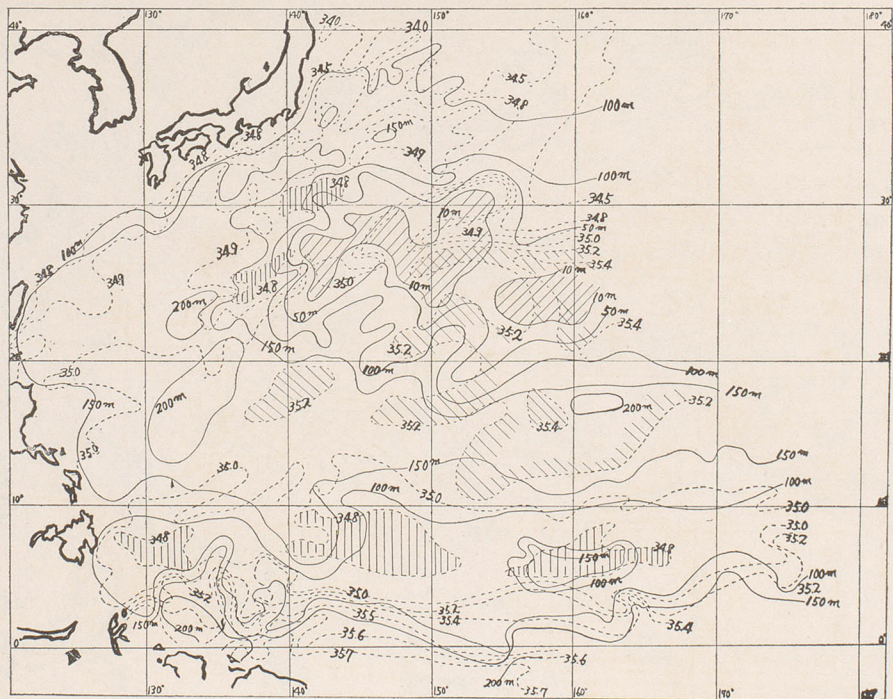


FIGURE 5

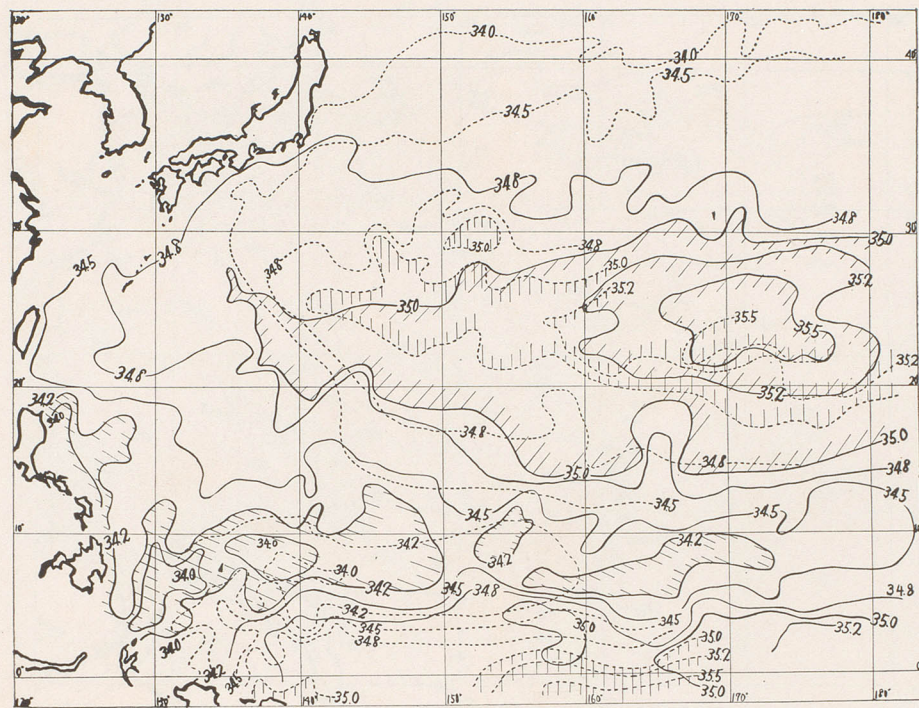


FIGURE 6