On the Convergence and Divergence in the NW Pacific iu Relation to the Fishing Grounds and Productivity

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Basing on the oceanographic charts obtained by the present author the semi-permanent boundaries of the water masses in the NW Pacific adjacent to Japan[1)2)] i,e, the Coastal Front, Kuroshio Front, Warm Front in the Japan Sea, Subtropical Convergence, [3)] Equatorial Counter Front, [2)] Continental Front are shown in addition to the temporary fronts of the isolated cold water masses in the South Sea of Japan. In general, the hydrological consideration on fishing grounds distinguishes the following kinds; (1) those produced by the accumulation of planktonic livings and fishes in compressed zone of optimum water temperature due to convergence, (2) those produced by the production of marine organisms due to the upwelling of nutrients, and (3) the combination of (1) and (2).

For example, the skipjack fishing ground[3)] in the boundary zone of Kuroshio and the Pacific Saury fishing ground[3)] near the Oyashio front belong to (1). The fishing grounds of sardine[4)], squids, yellow-tail, blue-fin-tuna[2)], mackerel etc. belong to (2) which indicates the dense concentration near the coastal front. And the fishing grounds of albacore[2)], whales etc. belong to (3). The fishing grounds in the eddies around the island (ex. Tsushima mackerel and Hachijo flying fish) and the fishing banks as for skipjack, tuna and mackerel may be considered as the varieties of (2) which correspond to the Nathansohn's theory. The offshore upwelling areas of cold deep water due to the cyclonic eddies in the northern hemi-sphere or due to the submarine topography (banks, ridges, canyons, shelf margin etc.) are associated with the albacore fishing grounds. The convergence coupled with the divergence (upwelling)[1)] should be noted as the sink and source of vortices in the hydrodynamical pattern in analogy of banks to the doublet in the general current. Since. the intensity of upwelling can be denoted relatively by the area of cold water mass at its hydrographic section, it is better indicated by the abundance of nutrients or planktons. In the case of (2) the carbon assimilation by the active process of photosynthesis by marine plants results to the rich production of oxygen[5)6)] which shows the excess of the dissolved oxygen in the upper layer to the compensation depth (about at 100 m.), $\Delta O_2 = 100\frac{O_2}{O_2'} - 100$.

Received May 7. 1953. (印刷費負担)

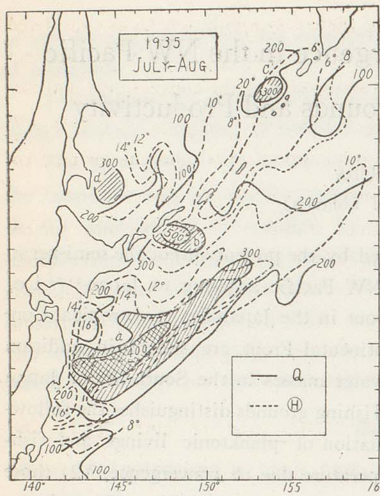

Fig. 1. Distribution of $Q=\sum_{0m}^{25m} \Delta 0'_2 \cdot \Delta z$ and $\theta = {}_0m - \theta_{100}m$ (Dif. of Water Temp.) in July-Aug. 1935.

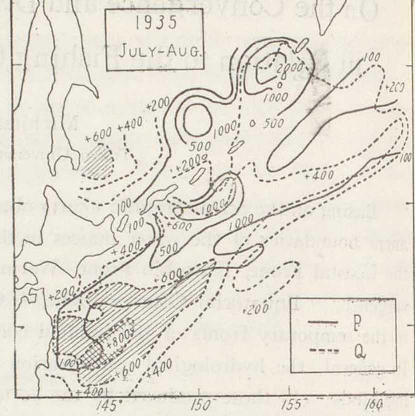

Fig. 2. Distribution of P=Indiv. No. of phyto-pl.(10^3) in 0—50 m.haul and $Q=\sum_{0m}^{50m} \Delta 0'_2 \cdot \Delta z$ in July-Aug. 1935.

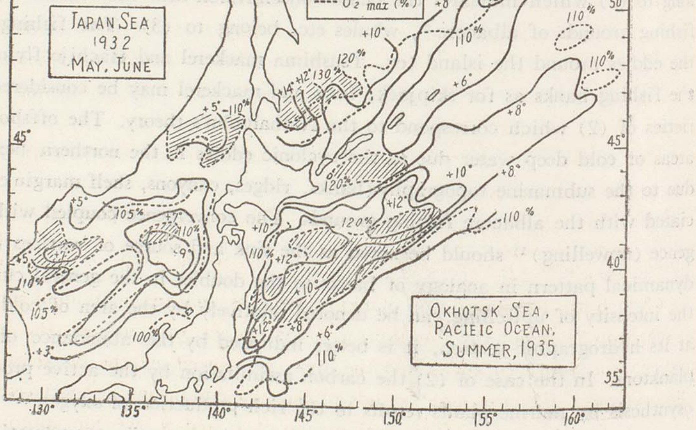

Fig. 3. Distribution of $\theta=\theta_{0m}-\theta_{50m}$ and $0'_2$ max. (%).

Accordingly the integrated value of super-saturation of 0_2 in the water column of an area $Q=\iint \Delta 0_2' dz \cdot dA$ may be taken as a measure of the productivity which varies in proportion to the quantity of the marine organism P. In the resting water area the excess of oxygen saturation due to the plankton population Q_0 is considered as the product of the solar intensity ($I=I_0 \sin \omega t e^{-mz}$) and the supply of nutrient salts $N=N_0 \cos(\omega t+\alpha) z^n$ which is inversely proportional to the convectional and turbulent mixing [7) 8)] i. e. to the vertical stability of sea water. Simply we may put $Q_0=kIN=\frac{kI_0N_0}{2}\sin 2(\omega t+\alpha)$ which shows the semi-annual maximum in spring (April-May) and Autumn (October-November).

In general we should take the horizontal mass transport by the oceanic current in consideration. The data of O_2 % obtained by the simultaneous surveys in the Japan Sea (May-Jun, 1932 and October- November, 1933) and in the Pacific (Aug. 1933 and July-Aug. 1935) indicates the especially rich distribution of O_2 % near the frontal zone presumably due to the aeration by the horizontal mixing of water masses. Accordingly we may put $Q=Q_0+Q' \propto$ productivity (P).

Hence we plotted the distributions of the O_2 % max. and its depth, $\sum_{0}^{25m} \Delta O_2' \Delta z$, $\sum_{0}^{50m} \Delta O_2' \Delta z$, plankton contents (cc), individual number of phytoplankton, $\theta_{0m}-\theta_{50m}$, $\theta_{0m}-\theta_{100m}$, transparency (m) (eg. Fig. 1,2,3.). The prosperous photosynthesis in the euphotic zone (O_2 % max.) is found at a depth of 0—50 m. and most frequently near the depth of 25 m.

Inspecting them, we can remark the following results:

(1) The high concentration of Q (the region of Q max) in the NW Pacific distributes in 4 masses (a), (b), (c), (d) near the zone of the maximum horizontal gradient of water temperature on the sea surface, and the depth of 50 m i. e. along the frontal zone, (a) The sea-region off Kinkazan corresponding to the great fisheries grounds of skipjack, pacific saury, whales etc. and to the swarming zone of the feeders such as squid, sardine, euphausia and copepods etc. (b) off Etorohu Is. of southern Kurile, (c) off Northern kurile in the Okhotsk sea, (d) off SE of Saghaline in the Okhotsk Sea.

(2) The abundant area of Q coincides prettily well the massive distribution of $\Theta \max=\left(\frac{\partial\theta}{\partial z}\right)\max.$ (with respect to (a) and (b) in the maps of $\theta_{0m}-\theta_{50m}$, $\theta_{0m}-\theta_{100m}$.

(3) Both distribution of plankton contents and and individual number or phyto-plankton represent the distribution of P. In the mid-summer the area (b) centred off the Southern kurile and the area (c) centred off the Northern kurile in the Okhotsk Sea. The area (b) extends to Sanriku region and connects with (a).

(4) Combining the distribution map of P and Θ, we can approximate to the actual distribution of Q.

(5) In the Japan Sea the most abundant area of P, Q, Θ lies near the frontal zone and in the upwelling region i.e. (a) off Tsushima-Yamaguchi Pref. (South co-

ast in thy Japan Sea), (b)′ off North Korea, (c)′ North off Sado-Is (the most conspicuous region), (d)′ west off Hokkaidō.

Summarizing the above, we can recognize the cold northern waters (upwelling area) as the source of productivity in combination with the influence of the convergence area.

In conclusion the vertical gradient of water temperature Θ in the euphotic zone such as the difference of water temperature $\theta_{0m}-\theta_{100m}$ or $\theta_{0m}-\theta_{50m}$ is proved to be the useful indicator or a measure for the marine productivity. Why does Qmax. correspond to the remarkable fishing ground ? It is considered that in the northern feeding migration the pelagic fishes are attracted to the densely concentrated belt of P and moreover in this sea-region the plankton population flourishes due to the abundance of Q. Therfore we may call P as the statical productivity and Q as the kinematical productivity.

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