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The effect of water dynamics on the size of the recruitment of the Flemish Cap Bank cod stock

by

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Abstract

Through the analysis of the geostrophic circulation charts drawn up on the data of hydrological surveys conducted by PINRO and International Ice Patrol during the period from 1955 to 1974 the avaliability of quasi-steady circulation with anticyclonic water motion over the central part of the Flemish Cap Bank had been stated.

The intensity of horizontal and vertical water circulations in the central part of the Flemish Cap Bank during the period of development of the eggs and larvae of cod was revealed to be one of the main abiotic factors determining the abundance of the year classes. These dynamic indices can be used to forecast the relative abundance of the Flemish Cap Bank young cod for two years in advance.

Water circulation in the Flemish Cap Bank area

To reveal the features of the geosrophic circulation in the Flemish Cap Bank area the dynamic topography charts were used; These charts were drawn up on the basis of the data collected during the hydrological surveys carried out by PINRO in the period from 1969 to 1974 (15 charts) and by the International Ice Patrol from 1955 to 1964 (11 charts) (Soule and Murray, 1956-1957; Soule and Morse, 1958, 1960; Soule and Morrill, 1960; Soule, Morrill and Franceschetti, 1961; Soule, Franceschetti, O'Hagan and Driggers, 1963; Franceschetti, Driggers and O'Hagan, 1964;

Kollmeyer, O'Hagan and Morse, 1965).

As a result of the analysis of the available data three areas within which water circulations mostly often appeared on the bank, had been stated. Cyclonic eddies were rather often observed on the southern and eastern slopes of the bank. In the central part of the Flemish Cap Bank water circulation was determined to be of different nature. In this area the quasi-steady clockwise water circulation exists. Statistical analysis of the horizontal parameters of this circulation demonstrated insignificant misalignment of its axis from the mean position with coordinates at $47^{o}09'N$ and $45^{o}21'W$, whereas the eddy areas can vary within rather wide limits.

The assessment of the water circulation effect on the abundance of the Flemish Cap Bank cod year classes.

It is known that the quasi-steady local eddies and circular flows of comparatively small diameters play an important part in the formation and variation of the physical, chemical and biological properties of water masses, that in turn determines the degree of their influence on the formation of the increased biological productivity zones in the ocean. Variability of water convergence over the Flemish Cap Bank significally affects the survival of pelagic ichtyoplankton and, consequently determines the abundance of the year-classes of the local cod stock (Kudlo, Borovkov, 1977).

Clockwise water circulation can directly affect the pelagic eggs and motionless or slightly motioned fish larvae, that is promote their mechanical inflow into the central part of the bank from the spawning grounds; while the indirect effect causes the plankton concentrations in the central part of the circulation area. The vertical water circulation in the eddy zone regulates the food provision for the progeny, that is promotes or prevents some favourable conditions for the formation of the regions with an increased biological productivity.

Figs.I-3 show diagrams of distribution with depth of velocity of horizontal geostrophic current, vertical water motions and

distribution of the important biogenous elements - phosphates and dissolved oxygen on the section along 47° N within 46°29' - 44°05'W in May for 1970, 1972 and 1973. These figures sufficiently demonstrate the relationship between the vertical motions and the degree of anticyclonic eddy development, as well as the relationship between the distribution of phosphates and oxygen on the section of the rising and lowering of water zones. Due to the volume of phosphates content in the surface layer one can judge the development of phytoplankton: usually, the zones rich with nutrient salts correspond to the areas of the maximum development of phytoplankton (Maksimova, 1976).

Hence, the horizontal and vertical water circulation intensity in the central part of the Flemish Cap Bank during the development period of the cod eggs and larvae is one of the main abiotic factors regulating the size of abundance.

The volume of the total horizontal water transport in the 0-100m layer across the section at 47° N (6 stations) was taken for the index of the degree of development of the anticyclonic water circulation over the top of the bank. This volume was calculated by the dynamic method (Q_g).

To indicate the strength of the vertical motions of water masses over the bank we used the volume of water rising per time unit, estimated according to the formula:

$$Q_w = V_{50-100} \cdot L \cdot D$$

where V_{50-100} - mean vertical velocity in the zone of water rising on the bank in the 50-100m layer;

L - extension of water rising zone on the section, in cm;

D - width of water rising zone in the section, equal to 1 cm;

Q_w - value of water volume rising in the 50-100 m layer per 1 second, cm^3/sec.

The gradient-convectional component of vertical velocity was cal-

culated by using the method of K. Hidaka (Tjuriakov, B.I., 1965).

The mean values of horizontal and vertical water transports during the period from March to May were calculated for 1962-1974, excluding 1965 and 1966, when the observations were not carried out.

As the relative index of abundance of the Flemish Cap Bank cod year classes we used the value of mean catch (number of specimens) of the two-year old young per trawling hour, taken with fish determining trawl (Konstantinov and Noskov, 1974).

The degree of the effect of the strength of development of anticyclonic circulation as well as the rising intensity of the deep water masses in the central part of the bank during the period of development of the eggs and larvae of cod on the size of the year classes was expressed through the multiple coefficient of correlation equal to 0,867. The calculated dependency was characterized by the following regression equation:

$$N = 0{,}20\ Q_s + 0{,}36\ Q_w - 175{,}38$$

where

N - relative index of the abundance of the cod year classes (the abundance of the two year olds);

Q_s - total horizontal water transport in the 0-100m layer across the section at 47°N (6-A) within 6 stations (46°29' - 44°05'W) in $n\ 10^{-3}\ m^3/sec$.

Q_w - volume of the water rising to the surface per time unit in the 50-100 layer on the section 6-A, in cm^3/sec.

The relationship obtained, shows that the most abundant Flemish Cap Bank cod year classes appear during the years of vividly expressed horizontal circulation and intensification of the processes of the deep water masses rising to the surface on the Flemish Cap Bank in March-May during the development period of the eggs and larvae of cod.

Apparently, it seems to be possible to use this method with other methods for the long-term forecast of the commercial indices of the Flemish Cap Bank cod stock.

Conclusions

1. There is a quasi-steady circulation of the anticyclonic water motion over the top of the Flemish Cap Bank.
2. One of the main abiotic factors of the environment regulating the size of abundance of the Flemish Cap Bank cod year classes is the intensity of the horizontal and vertical water circulations in the central part of the Flemish Cap Bank during the development period of the eggs and larvae of cod.
3. The forecasting methods for the relative abundance of the Flemish Cap Bank cod at the age of 2 years on the basis of the assessment of indices of the water dynamics over the Flemish Cap Bank for two years in advance had been suggested.

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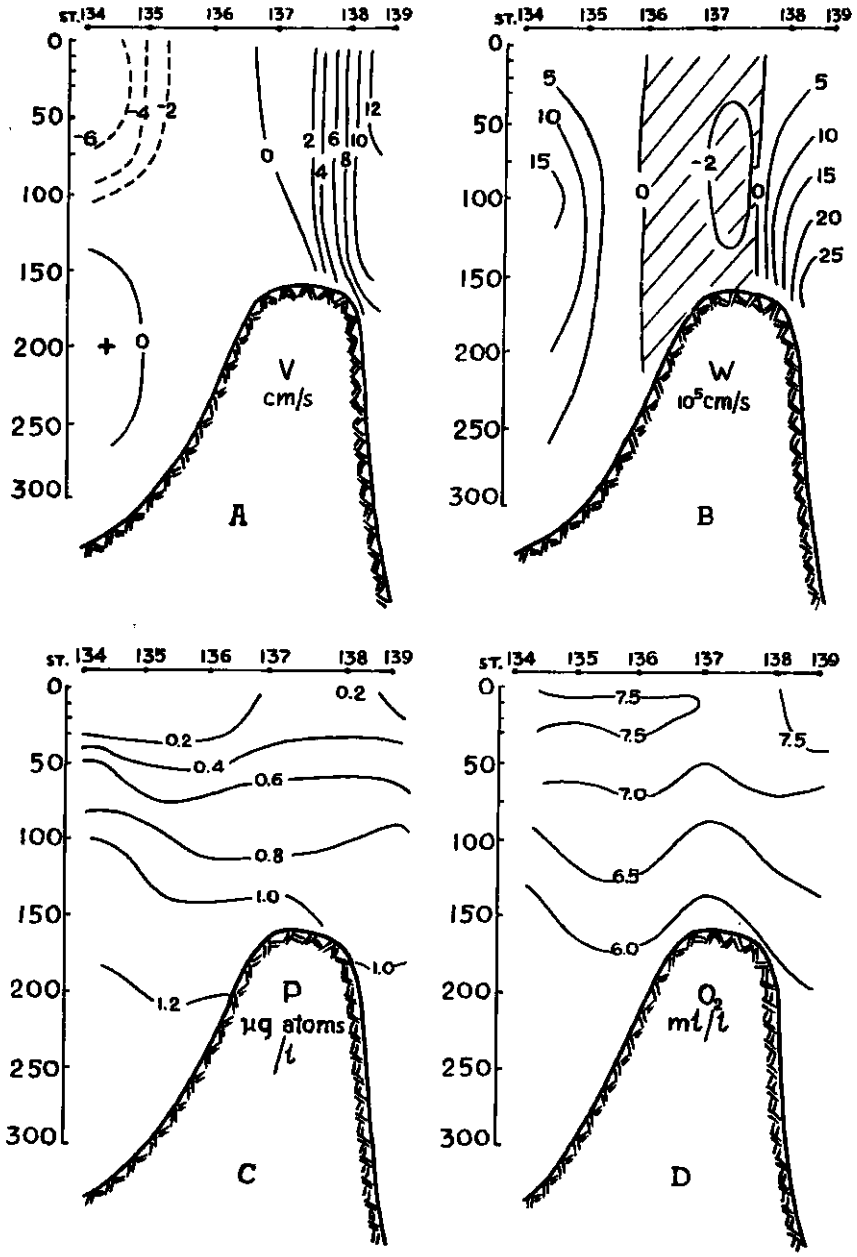

Fig. I. Distribution: a -geostrophic horizontal velocity (minus - to the north, plus - to the south), b -vertical velocity (plus - lowering, minus - rising), c - phosphates, and d -dissolved oxygen on section 6-A across the Flemish Cap Bank in May 1970.

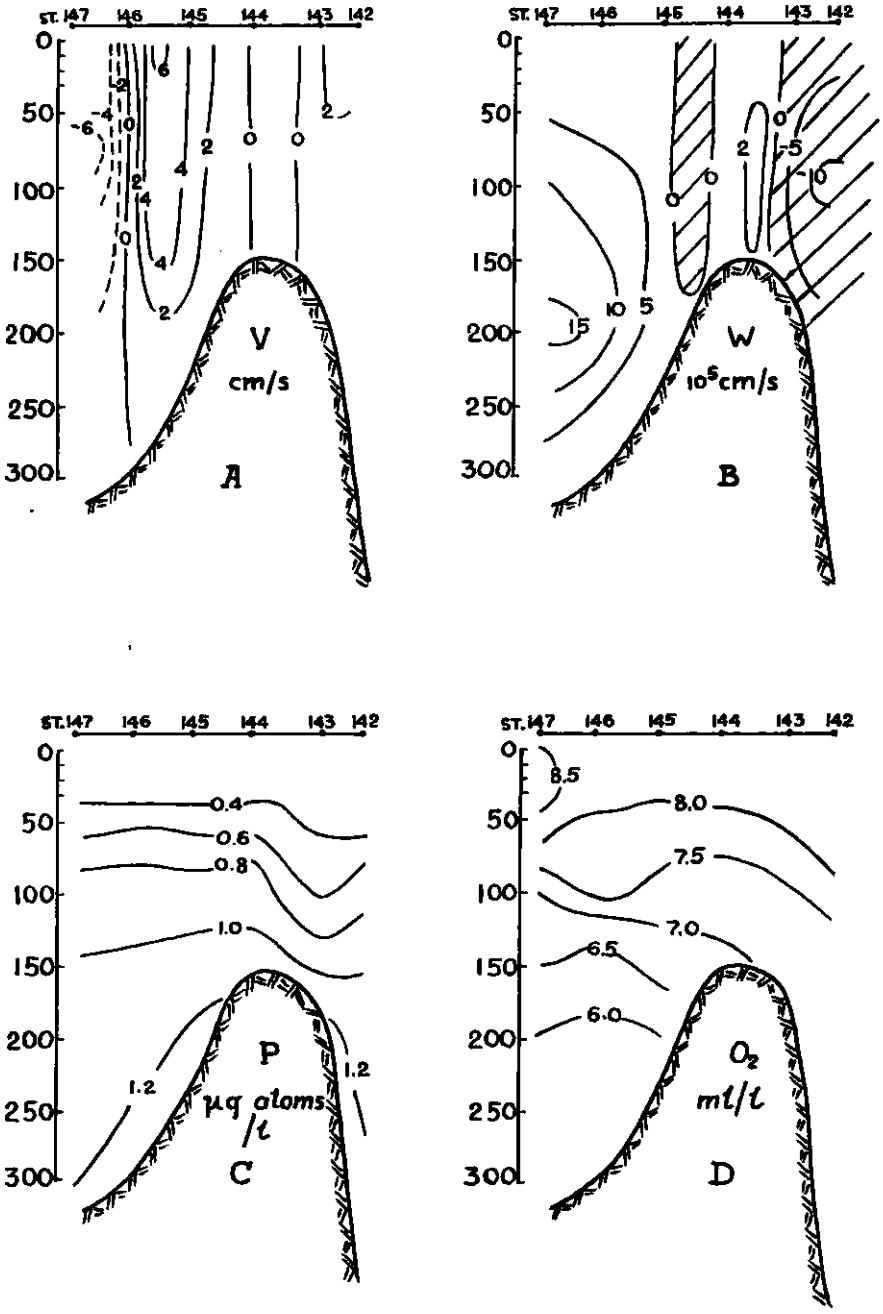

Fig. 2. Distribution: a -geostrophic horizontal velocity (minus - to the north, plus - to the south), b -vertical velocity (plus - lowering, minus - rising), c - phosphates, and d -dissolved oxygen on section 6-A across the Flemish Cap Bank in May 1972.

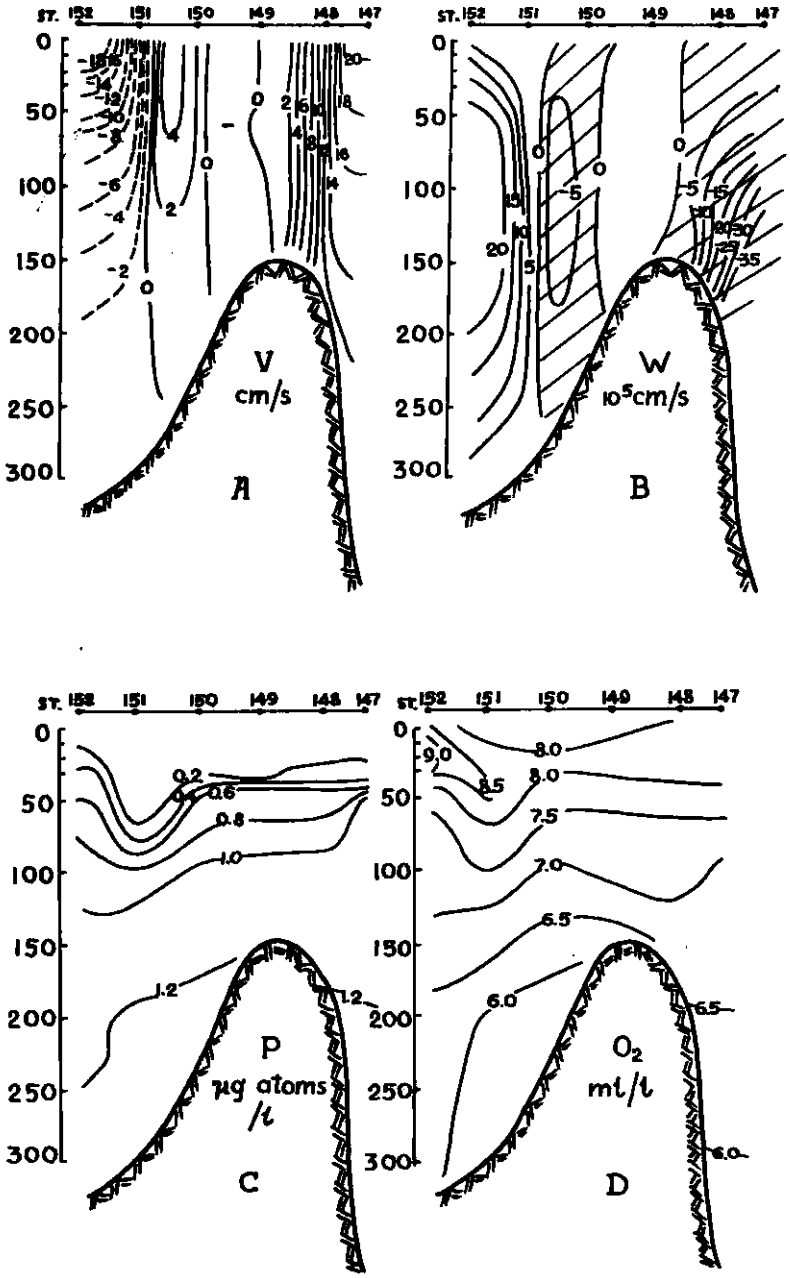

Fig. 3. Distribution: a -geostrophic horizontal velocity (minus - to the north, plus - to the south), b -vertical velocity (plus - lowering, minus - rising), c -phosphates, and d -dissolved oxygen on section 6-A across the Flemish Cap Bank in May 1973.