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MESOSCALE HETEROGENEITY OF BIOLOGICAL FIELDS OF THE INDIAN OCEAN TROPICAL ZONE : STRUCTURE, DYNAMICS AND INTERRELATIONS

HETEROGENEITE A MOYENNE ECHELLE DES COMPARTIMENTS BIOLOGIQUES ET TROPHIQUES DANS L'OCEAN INDIEN, STRUCTURE, DYNAMIQUE ET INTERRELATIONS

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In 1980-1985 the expeditions of the Ukrainian SSR Academy of Sciences undertook a number of comprehensive studies of the Indian Ocean tropical zone (22nd voyage of the "Akademik Vernadsky" research ship, 8th an 14th voyages of the "Professor Vodyanitsky" research ship). The research covered the studies of dynamic characteristics of synoptic vortexes and estimation of their impact on structural and dynamic characteristics of oceanic biological fields (phytoplankton, primary production, zooplankton, micronekton).

On completion, the field studies were illustrated by publication of alert information on the results of these studies (comprehensive studies, 1981, Kosnyrev, Shapiro, 1981), part of the material being in print (Piontkovsky, 1985, Piontkovsky, *et al.* 1985).

The author of the present work followed probabilistic approach in his consideration of certain results. The calculations required were based on primary findings kindly provided to the author by the expedition participants.

Spatial autocorrelation functions according to field measurements were estimated for studies of the field spatial structure properties. These functions show the change of the correlation force between two points in space where the parameter was measured with the growth of distance between the points. Fast function decrease shows that correlation is significant within small scales of space only, i. e. those close to discreteness of measurements. Slow function decrease indicates to the agreement in the parameter change within relatively large spatial scales. The measure of this agreement is expressed by the correlation factor. According feature, the space region with agreed parameter changes is treated as homogeneous by the zone structural properties againsts the background of random (uncorrelated) parameter fluctuations. (Goldberg, Piontkovsky, 1985 ; Piontkovsky, et al. 1985).

Polygon layout is given in figure 1. The number of stations comprehensive parameter measurements was 120 in the first polygon, 57 in the second, 44 in the third, 48 in the Ist and 50 in the IInd. The average step of measurements amounted to 50 km.

Statistical structure analysis of biological fields was carried out with regard to their particular instability in time. The characteristic quality of time instability of the later is the 10-12 hour periodicity. Time trends of zooplankton fields, for example, are explained by periodic vertical travel of organims. Similar trends having period close to semidiurnal are characteristic to phosphate dynamics as well. One of the explanations consists, probably, in internal waves of the tidal period. Another reason consists in organic excretions of zooplankton. During estimation of spatial autocorrelation functions these trends were eliminated.

One common property of biological field functions is their fast decrease (Fig. 2). It shows significant contribution of the small- scale component to the formation of mesoscale (hundreds of kilometers) spatial field structure. For some functions the very first values appear negative (phosphates in polygon 3, primary productions and zooplankton of the surface layer in polygon 2).This means that at the given measurement discreteness the areas where parameter changes are correlated do not exist. The fields are "random" and their mapping based on linear interpolation without prior smoothing of small-scale components is incorrect.

In measurements with 5-10 times less discreteness (Goldberg, Piontkovsky, 1985 ; Piontkovsky, *et al.* 1985) the estimation of spatial autocorrelation functions has shown that the characteristic scale of zooplankton field spatial heterogeneities is close to 35 km. These are probably the small-scale component requiring smoothing in estimations of the field mesoscale structure.

The calculation of mutual spatial autocorrelation functions has proven that spatial interrelations among biological fields with respect to hydrophysical fields (temperature, conditional density, dynamic levels) are low. Spatially, the fields are shifted concerning each other by heterogeneity of correlation function correlation radii tend to decrease from physical fields to chemical and biological ones. This is reflected in the table which gives correlation factor values at single shift of the autocorrelation function using polygon 1 as an example (Table 1).

Generalization of experimental data obtained during expeditions allowed to perform initial approximate estimations of biological fields changeability of the Indian Ocean tropical zone at different levels of the space extent. For this purpose, the primary material of voyages and the International Indian Ocean Expedition (IIOE) were used.

Figure 3 gives the averaged parameter variance plotted on the ordinate, while the scale of the space within which the variance has been estimated is plotted on the abscissa. The common property of the field changeability is obviously the changeability maximum over the scales from tens to first hundred of kilometers. It corresponds to maximum energy supply of the vortex structure in the ocean of the scale (Fig.3b) described in generalized energy spectrum of the oceanic waters movement (Ozmidov, 1965).

This figure also shows that the normalized variance grows at trophic levels over all scales of space. This may be treated as an increase of distribution heterogeneity, i. e. at each level the relatively homogeneous field of "victims" is superimposed by the heterogeneous field of "predators".

As a whole, today's revealing of typology of oceanic mesoscale heterogeneities in plankton fields requires the undertaking of comprehensive studies related to the comparative biology of the oceanic mesoscale vortexes of various origins (vortexes resulting from baroclinic instability of jet flows, bottom relief anomalies, direct atmospheric effects on the ocean, etc.).

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Parameters	Horizons	
	0 m	100 m
1. Temperature	0.45	0.63
2. Salinity	0.48	0.18
3. Oxygen	0.21	0.55
4. Phosphates	0.46	-0.04
5. Suspended material (total)	0.27	-0.21
6. Chlorophyll (total)	0.21	0.22
7. Primary production	0.39	0.10
8. Zooplankton biomass	-0.21	0.25 (0-100 m)

TABLE I - CORRELATION FACTOR VALUES AT SINGLE SHIFT OF SPATIAL AUTOCORRELATION FUNCTIONS (POLYGON I)

Goldberg G. A., Piontkovsky S. A., 1985. - Space and time structure of the mesoplankton field in the surface layer of the Indian Ocean tropical zone. -*Ekologiya morya*, 19 ; 86-110, (in russian).

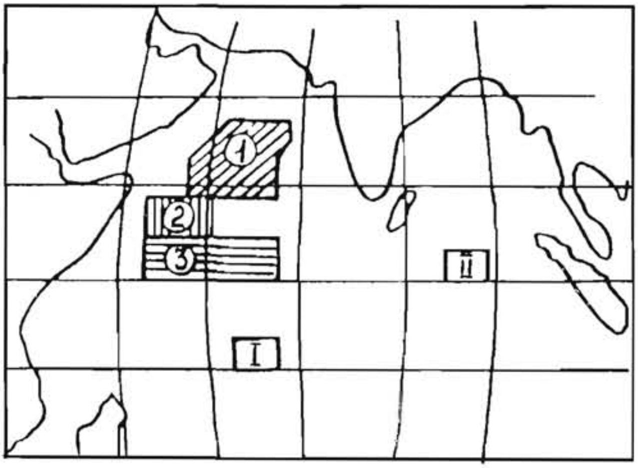
Comprehensive oceanographic studies of the Indian Ocean. 1981. Sevastopol, MGI, 155 p., (in russian).

Kosnyrev V. K., Shapiro N. B., 1981. - Synoptic changeability of the northwest part of the Indian Ocean. Sevastopol, MGI, 44 p.

Ozmidov R. V. 1965. - On some properties of the oceanic turbulence energy spectrum. -DAN SSSR, 161, (4) ; 828-831, (in russian).

Piontkovsky S. A., Melnik T. A. - Plotnikov V. A., 1985. The elements of spatial structure of pelagic communities of quasihomogeneous layer of the Indian Ocean. -*Pol. Arch. Hydrobiol.*, 33, (in print).

Piontkovsky S. A., 1985 - Statistical estimations of mesoscale structure of biological fields and its connections with fields of hydrophysical and chemical elements. -*Pol. Arch. Hydrobiol.* 33 ; (in print).



◀ *Figure 1*
Layout of major polygons

Figure 3
Changeability characteristics of quasihomigeneous layer biological fielss over different space scales (a,b) and generalized pattern of energy density distribution over different-scale movements of oceanic aters (c, [4]).
Scale of events is plotted on abscissa ;
a : 1 = chorophyll concentration, 2 = primary production, 3 = zooplankton concentration, 4 = flying fishes concentration, 5 = myctophids concentration, 6 = squid concentration ;
b : zooplankton concentration of the 0/100 m layer S² -dispersion, X-mean.

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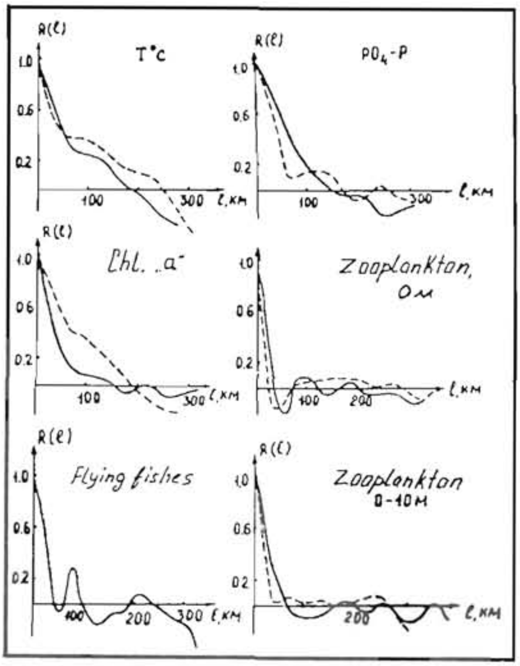

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Figure 2
Spatial autocorrelation functions of quasihomogeneous layer fields in polygons 1 (solid line) and 2 (dotted line).
The above biological parameters are calculated on the basis of their of their concentration values.