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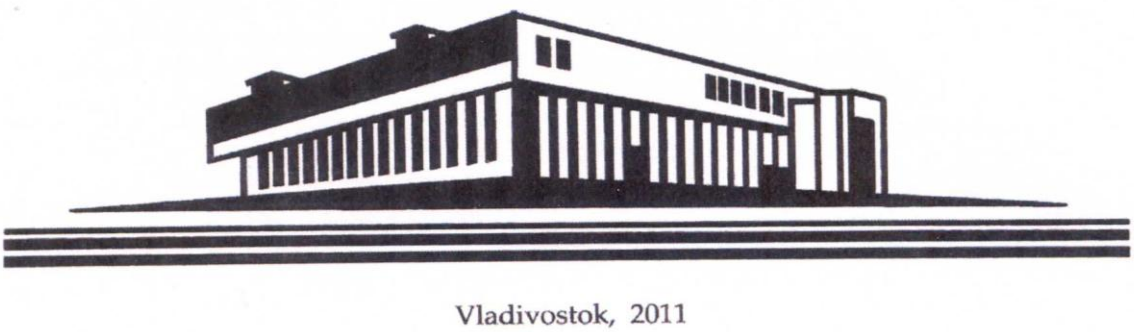
ABSTRACTS

СБОРНИК ТЕЗИСОВ



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HYDROPHYSICAL STRUCTURES AND BIOLOGY CONCENTRATIONS IN BARENTS SEA

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1. The general circulation of the Barents Sea. Warm Atlantic waters from the Norwegian Current with a salinity of about 35 flows in through the Fugløya- Bear Island section. This current divides into two branches, one southern branch, which follows the coast eastwards against Novaja Zemlya and one northern branch, which flows into the Hopen Trench [1]. The Coastal Water near Kola is fresher than the Atlantic Water, and has a stronger seasonal temperature signal. In the northern part of the Barents Sea fresh and cold Arctic water flows from northeast to southwest. The Atlantic and Arctic water masses are separated by the Polar Front, which is characterised by strong gradients in both temperature and salinity. Position of the Polar front is closely connected with topography. In the western Barents Sea the position of the front is relatively stable, but in the eastern part the position of this front has large seasonal, as well as year- to-year, variations. The Barents Sea is characterised by large year-to-year variations both in heat content and ice conditions. The most important cause of this is variation in amount and temperature of the Atlantic water that enters the Barents Sea.

2. Mechanisms of primary production formations. The Barents Sea is a spring bloom system and during winter the primary production is low and the chlorophyll concentrations are close to zero. The timing of the phytoplankton bloom is variable throughout the Barents Sea. We shall consider the main mechanisms of the shaping the productive zones in Barents Sea. The necessary conditions of the primary productivity shaping are a sunshine, carbon dioxide and nutrients. Formation primary organic material occurs consequently in upper the photic layer at presence of the carbon dioxide, oxygen and nutrients.

There are several ways of delivery of the nutrients in upper layers.

a. Winter convection may reach the large depth or a bottom in Barents Sea. Thus there is vertical mixing and nutrients enrichment of the full mixed layer. In summer intense formation of primary production begins under the shaping of stratification by mean heating, ice melting or horizontal heat advection. Along the marginal ice zone, the increased sun radiation during spring leads to melting of the sea ice and thereby to a thin upper layer of relatively fresh melt water. In the Atlantic water masses the stratification is a consequence of solar heating of the surface waters. In the southern part close to the Norwegian coast, the bloom may start following increased vertical stability caused by lateral spreading of coastal water from the Norwegian Coastal Current. Measuring and modeling results throughout the Barents Sea in 2004 show that the bloom was earliest close to the coast at the western entrance of the sea [1]. Also close to some of the bank areas, the bloom started early. Particularly in the eastern part close to Goose Bank and North Kanin Bank. Some of these banks are very shallow and water masses may be trapped there. The bank may therefore act as a barrier to downward transport of plankton cells in the same way as a stratification of the water masses. This may explain the early and intensive bloom in the bank areas.

b. The role of the coast frontal zones. Mechanisms of the shaping of the biological productivity of marine ecosistems were explored in Laboratory of the ecologies of the plankton Oceanography Institute SAR [2]. The role of the coast frontal zones of the different genesis was explored too. Similar processes occur, probably, on declivity of the isles and banks in Barents Sea. As noted above intensive bloom runs at presence of the stratifications, but on shallow bank can occur the destruction of the thermocline and the mixing of thick masses of water. Intensive forming of the phytoplankton on shallow part is supported to account of the nutrients supply through coast front. The "peace" phytoplankton creates base for the further food chain. Such process exists, probably, in Goose Bank region.

c. Role of the frontal eddies and meanders. Eddies and meanders at the frontal zone have important role in temperature, salinity and density distribution (hence in productivity distribution too). Analysis of the hydrophysical data measurements has revealled that both separates formation, and pairs and chains mesoscale meanders and eddies exist in Barents. Character scales of these formations equal from 20-30 km up to 50-60 km. Eddies and meanders take place at the surface and they may reach big depth (100-150m) up to bottom [3]. Intensive vertical movements can appear in the central parts of eddies and these processes provide the upper layer with the necessary nutrients.

d. Formation of the productivity in convergence zones. If horizontal flow with divergent streams (zones of divergence) exist in a certain areas of sea then by the continuity of flows in this area will be the water rise from some depth. Accordingly, the water with high concentrations of nutrients may be raised on the sea surface, and then in this area may be formation of the primary organic matter, that is formation of zone with some concentration of chlorophyll-A. If in the surface layer was formed area with some concentration of phytoplankton and there are fairly intense horizontal motion, then in the areas of the flow convergence, zone with high concentration of primary production will be marked. Zones of divergence and zones of convergence can be identified as a local centers of efficient productivity formation. Such zones can be clearly identified by remote methods in the visible, infrared and radar images.

e. The direct rise of water enriched nutrients from deep layers occurs in the ocean upwelling zones. Except the last mechanism (e) four first mechanisms exist in the Barents. The zones of primary organic material production are situated in Barents Sea in accordance with these mechanisms. The sign of high productivity is a high concentration of the chlorophyll-A in surface layer. Later the food pyramid (up to commercial fish and mammals) is formed in such zone.

3. Hydrometeorological conditions and remote sensing results in the Goose Bank region. It was shown that the accumulation of plankton observed in the area with warm Atlantic waters what is limited by thermosalinity frontal zone. Satellite images from different years in the visible range [4] confirm the fact that concentrations of phytoplankton in the early summer months are formed most frequently in warm water mass in the coastal frontal zone. In July and August chlorophyll concentrations are formed in central and eastern Barents, around Goose Bank and Central Bank between the southern branch of the thermal front and coastal salinity front. Satellite images of the area (in the visible and in the infrared range) around Goose Bank in the summer months from 2002 to 2009 confirm this fact. The reasons for the formation of phytoplankton clusters and high productive fisheries zones near Goose Bank are: a. Shallow depth of the bank (less than 60m) and a significant difference of the depths on the slopes (to 350 m). b. Complex dynamic conditions created by the interaction of warm waters of Murmansk, Kolguyev-Pechora and Novaya Zemlya currents and cold waters of the Barents Sea. c. The reaction of the upper layers of the sea over the bank on the atmospheric force (especially on cyclones).

4. Modeling of the hydrological processes in the Goose Bank region. This region is characterized by large depth difference between the Central Valley and the Goose Bank, large temperature and salinity gradients, high chlorophyll concentrations in spring and summer months and high fishery productivity. The data sets (August-October 2004) from Survey reports of the joint Norwegian-Russian ecosystem Surveys in the Barents Sea [5] was available.

Modeling system CARDINAL [6] was chosen for the simulation of the hydrological regime of the area limited by 70.5° and 73.0° N and 40.0° and 49.0° E for period 20-30 August

2004. For the simulation of dynamics of the Barents Sea 3D model [7] were used. The curvilinear boundary-fitted co-ordinates with variable grid steps are used in this model. Depth changes from 48 to 346 m. In the horizontal plane the computational grid contains 4225 (65 * 65) knots. 16 layers in vertical, which was condensed to the bottom and the surface. Average spacing between the grid points of level 4336m. The wind stresses, 3D water, temperature and salinity fluxes on the open boundaries and the initial temperature and salinity distributions were assigned. Temperature, salinity and velocity data on the open boundaries were received from TOPAZ3 model [8]. Data for the period 19-30 August 2004 were provided by L. Bertino of Mohn-Sverdrup Center / NERSC.

Simulated temperature and salinity fields demonstrate the sufficient compatibility with the observed ones. We consider the modeling results of processes in the Goose Bank area in the vertical plane on control section along 71.75° N. During the first 5 days 20-24.08.2004 the relatively weak winds eastwards dominated over the Goose area. Thermocline with temperature gradient of about 4 ° C is expressed most clearly over the bank and it is located at a depth of 35-40 m. Intense cyclone run over the eastern part of the Barents Sea on the August 25-26. During August 25-26, strong northern winds (15 m/s or more) dominated over the area of Goose Bank. Destruction of the thermocline on the bank was observed and cold water with a temperature of 2.5-3.0 ° C raised to the surface. It is seen that the water raise occurs not only from the depth of 50-60 meters above the bank, but also from great depths on the bank slopes. This raised water probably provides the upper layers with additional nutrients. Vertical temperature profile shows fairly rapid response of the sea upper layers on the atmospheric disturbance. We should expect that violations of vertical stratification quickly restored. Although these changes in the surface layer are short, they cause the influx of deep water enriched by nutrients in upper layer.

Conclusions

1. Arrival of the nutrients in upper layers of Barents Sea occurs during winter convection, which reaches large depth or bottom in the Barents Sea. Nutrients, which enter to upper layers under convection, are consumed completely already at spring months, when phytoplankton and high levels of food coin intense develop.

2. In summer time local deep water raises are the additional sources of the nutrients in the coastal regions, on shallows near islands and on banks. Local water raises also occur in central parts of the frontal eddies and meanders. After that important fisheries zones are formed here. Goose Bank area is the example of such regions.

3. The cyclone passing over sea promotes the mixing processes in upper layer. This leads to destruction of thermocline and raise of deep water saturated by nutrients. During cyclones passage clouds interfere with solid data reception about the sea surface in a visible and infra-red range. Ship measurements are also not reliable under cyclonic conditions.

4. Numerical modeling allows to simulate physical processes and productive zones formation in the sea under any hydrometeorological conditions.

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