MARINE CLIMATOLOGY – NEW CONCEPT OF AGRICULTURAL METEOROLOGY STUDYING INTERRELATION BETWEEN ENVIRONMENT FACTORS AND SEA FARMING EFFICIENCY

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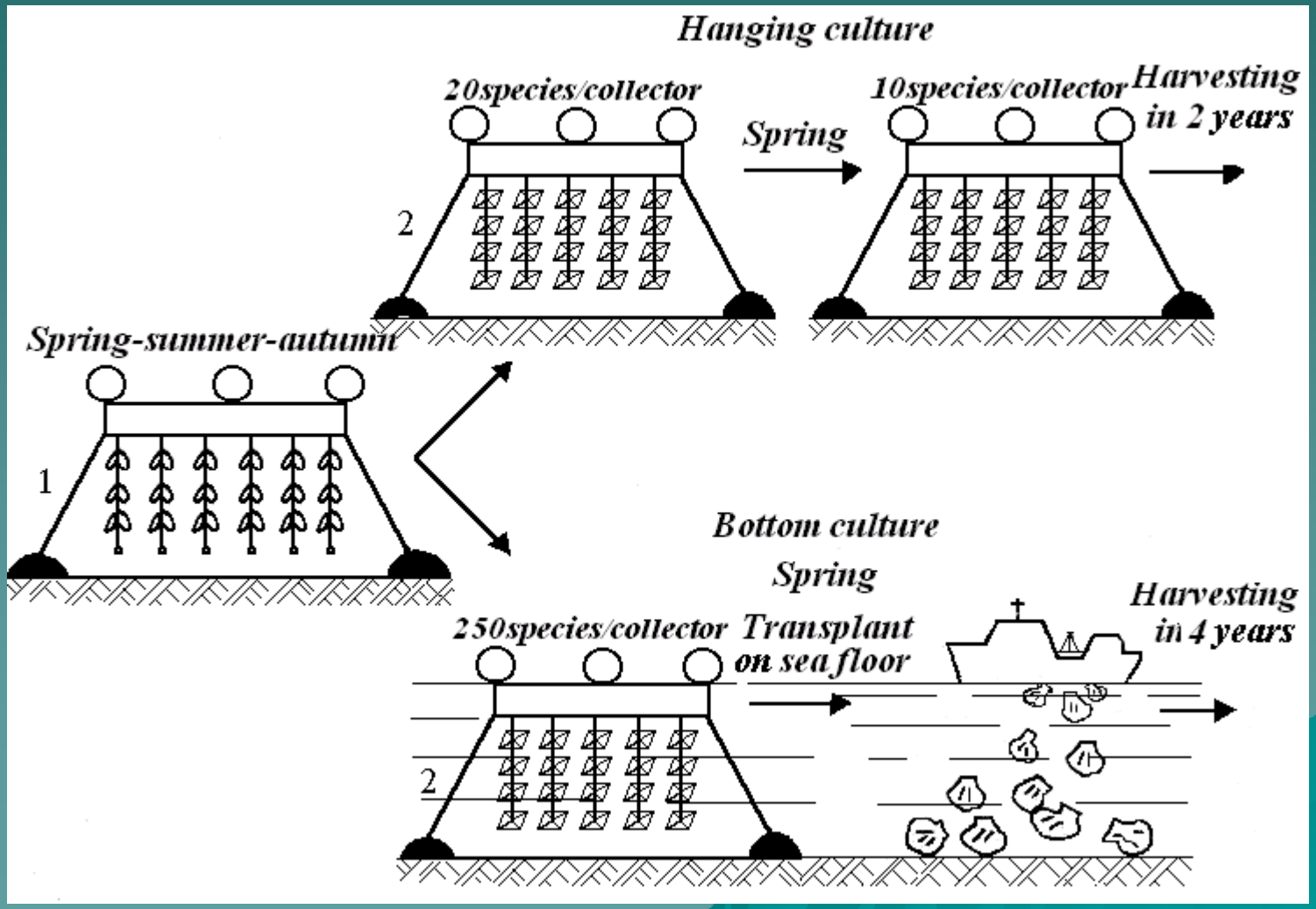
Introduction

Studying of the hydrometeorological mode influence on life cycles of sea organisms gets still greater urgency in connection with the global change of climate.

At present, a perspective line of research of a sea coastal zone is searching the ways to increase biological resources. One of such ways is sea aquaculture or mariculture.

Sea aquaculture is a whole complex of biotechnologies on manufacture and processing of valuable sea animals and plants.

Figure 1. Technological scheme of culture japanese scallop: 1 - net collectors for collection scallop's spat; 2 - net cage for scallop culture



Materials & methods

The report considers the problems of formation of a **new** direction of agricultural meteorology – **marine** one, which task is information service for sea farming which is being actively developed now.

Mariculture is industrial cultivation and cash cropping of hydrobionts (seaweed, sea animals and plants) in sea or saltish water in controllable conditions. In our country mariculture is traditionally referred to fish economy, therefore sea farming is considered as the enterprises engaged in fishery.

At the same time, for mariculture enterprises it is typical large cost of plantations and coastal base that makes them identical to agricultural production.

Materials & methods

The main difference of mariculture from fishery is the obligatory control of man for survival of spawn.

For normal functioning of sea farms, located in a coastal part of the sea, and at planning their productivity of great importance is the data on abiotic factors influence on the sea ecosystem condition.

Complexities of making the forecast for a biological system are that this system is open and it is practically impossible to consider all factors influencing the process of its development.

Materials & methods

Of mollusks a most perspective species for artificial cultivation in the Far East is Japanese scallop Mizuhopecten yessoensis (Jay) which possesses high rate of growth, reaching the trade sizes on the fourth year of life, and presents production fine in flavoring and nutritious qualities.

To transform the commercial species into the mariculture object it is necessary to reveal the features of its biology and to develop the cultivation biotechnology taking into account these features.

Since 60s in Primorski Krai it has been started the activity on studying scallop biology with reference to its cultivating biotechnics. As the recommended area for cultivating scallop in Primorski Krai it is proposed the Pos'et Bay in which water area there are considerable amounts of scallop.

Materials & methods

As a basis for cultivating scallop in the Possyet Bay the Japanese experience of mollusks cultivation has been accepted. In Possyet Bay, in 1970, it was established the first experimental-industrial marine enterprise for cash cropping of scallop «Experimental Sea Base Possyet » (ESB) . The Base was aimed at working off biotechnics of cultivation of trade mollusks; annually it was gathered the data on time of spawning, dynamics of number of mollusks larvae in plankton, dynamics of intensity of larvae settling on artificial substrata – collectors, dimensional structure of larvae and spat.

It is natural, that a result of research of the relationship between the environment factors and mollusks efficiency is the forecast elaboration. On the basis of materials of the long-term researches of FERHRI, IMB FEB RAS together with employees of the Possyet ESB, and the data of Hydrometeorological Station of Possyet, it was developed empirical techniques of forecasting the time of spawning, terms and intensity of larvae settling.

Materials & methods

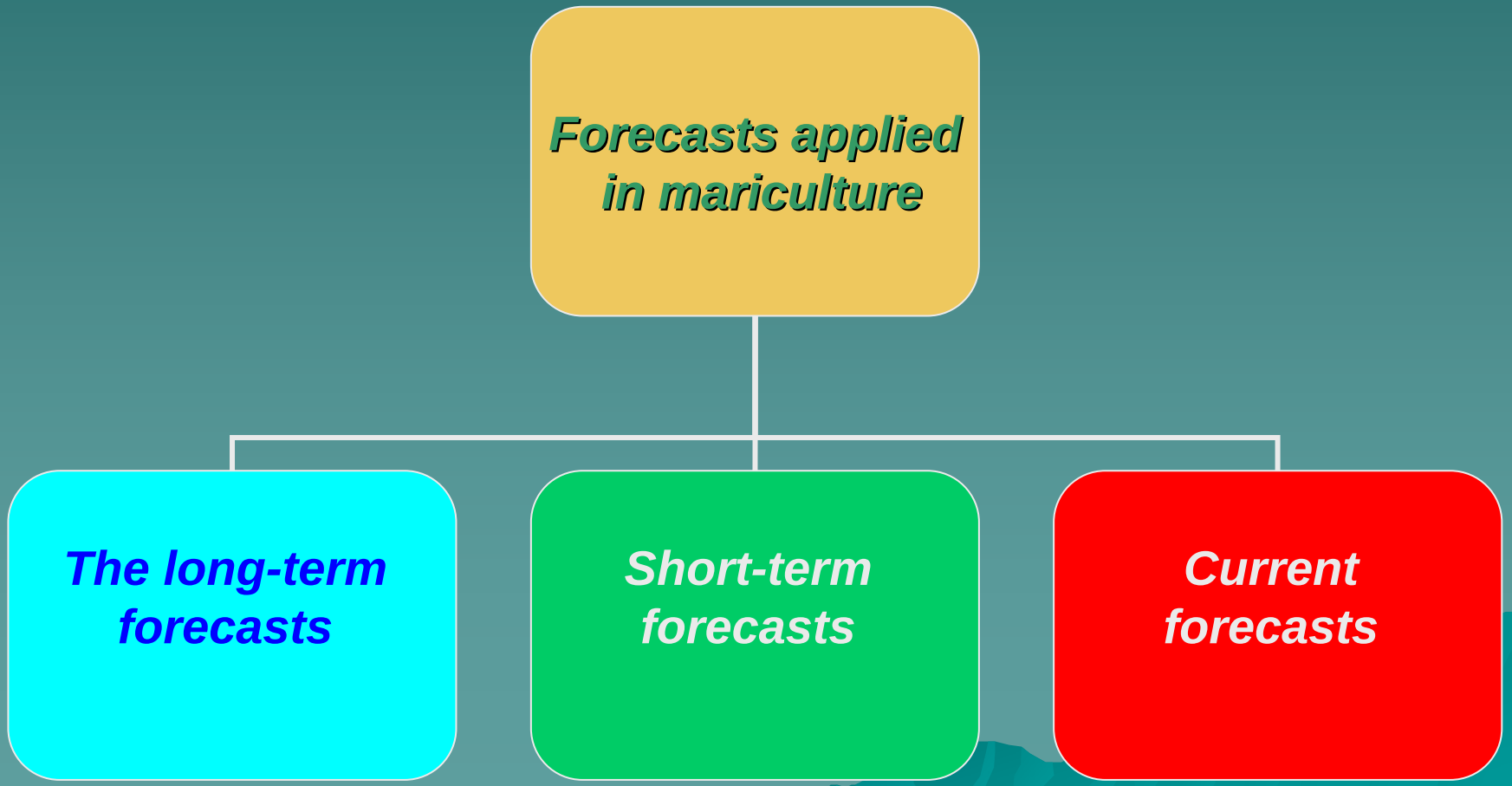
As the period of intensive settling of larvae lasts for some days the destiny of the future crop depends on correct and timely forecasting of terms of collectors installation and their quantity.

The existing techniques of forecasting the scallop spat density basically are developed on the Experimental Sea Base «Possyet» and are based on revealing empirical dependences between various biological and hydrological indicators. With this, as predictors it was used the accumulated sum of heat for certain periods of development, variability in superficial temperature of water during these periods, duration of the ice period. These indicators in various combinations were used at drawing up the forecasts.

Productivity (or efficiency) of the scallop in the given research is the quantity of spat settled on collectors (species number/collector or species number/m^2).

Results & discussion

According to advance time, all forecasts applied in mariculture for productivity predicting, may be divided into three groups:



Results & discussion

1. **The long-term forecasts** having advance time of about four months. They are made on the basis of the long-term biological, hydrometeorological and phenological observation. Accuracy of the long-term forecasts depends on duration of observation series and volume of the collected long-term material.
2. **Short-term forecasts** cover the period of some days prior to the beginning of spawning. For the forecast, out of natural populations it is done a selection of mature mollusks and the biological analysis.
3. **Current forecasts** are carried out after the beginning of larvae settling on collectors. While studying dynamics of larvae number in planktonic samples in case of occurrence of new larvae generations in plankton it is possible to recommend additional gathering of spat or to offer the measures protecting collectors from superfluous settling of larvae.

Results & discussion

This approach, entirely local in space and time, is based on use of well-known methods of the formal statistical analysis. With this, the basic attention is given to search of direct empirical relationship between the medium and object.

But the use of forecast only in this aspect considerably limits the possibilities of hydrometeorological service of sea farming and does not allow making forecasts of the great advance as the existing techniques of the spat productivity forecast have an empirical character.

Time of paradigms change has come – instead of the empirical-statistical approach the methodology focused on the quantitative analysis of cause- and-effect relationship between hydrometeorological conditions and farming efficiency comes, i.e. ***connection*** *of the descriptive hydrobiological approach and agrometeorological one, characterized by integrated complexity and depth of the phenomena and processes analysis, but on a quantitative basis.*

Results & discussion

The new methodology is based on modeling of cause-and-effect relationships between hydrometeorological conditions and sea farming efficiency.

It is needed an essentially new approach based on use of the climatic information for sea farming in prognostic purposes which is used with success for a long time at making forecasts in agricultural meteorology. With this, it is considered large variety of abiotic factors influencing the biological object that does it possible to use physical-statistical schemes for the forecast.

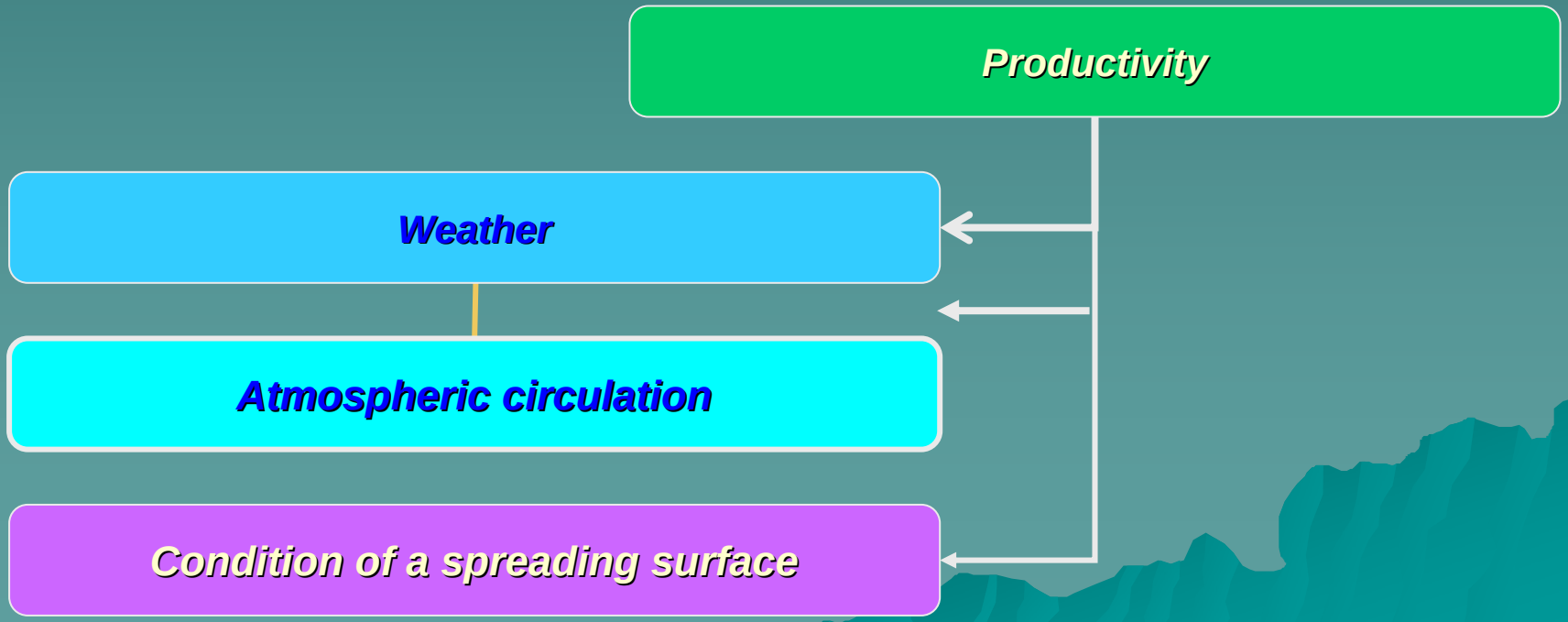
Results & discussion

Statistical methods are based on an estimation of both synchronous and asynchronous correlation dependences between the values of various hydrometeorological elements. These methods allow making forecasts for the biological objects productivity for various advance time.

Synoptical-statistical methods of the forecast of productivity of agricultural crops were developed on the basis of methods of long-term weather forecasts.

As at making the long-term weather forecasts it is considered a set of factors being sources of the long-term anomalies of weather, it is expedient to build multiple parameter schemes which would include most significant of them.

To use these methods with reference to agricultural meteorology it is necessary to consider real-life relationship between weather, features of atmospheric circulation and condition of a spreading surface during the previous period on the one hand, and the productivity of agricultural crops formed under the influence of these conditions, on the other hand.



Results & discussion

Let's consider theoretical approaches of agricultural meteorology with reference to sea farming.

By analogy, the major problem at long-term forecasting of productivity in sea farming is the choice of the most informative predictors. First of all, considered are the factors influencing annual cycle of mollusks, such as water temperature, especially its variability; salinity of water; number of degree-days; food conditions; wind mode; solar radiation, quantity and intensity of precipitation; atmospheric pressure; sea currents; tidal phenomena; Moon phases; lunar and other rhythms; solar eclipses; etc.

Further it is carried out the quantitative analysis of synchronous dependences of predictand and predictors by calculation of factors of correlation and analogousness that allows revealing the closest dependences between productivity of scallop and abiotic factors.

Results & discussion

Research of a temporal series of sea faming productivity allows us to draw a conclusion, that both in agricultural production, and in mariculture, it is **non-stationary** since productivity fluctuations are caused by level of farming techniques, long-term climate fluctuations, etc.

To distinguish these essential factors from time series of productivity the agrometeorologists proposed concept "**tendency**" or "**trend component of productivity**".

Such approach with regard to mariculture on the example of the scallop productivity forecast was applied by the author for the first time.

By analogy with agricultural meteorology, productivity of mollusks (Pt) is considered as a sum of two basic components: nonrandom or trend (Et) one, caused by agricultural technology and long-term climate fluctuations, and a random component (∆Pt) which is determined by weather peculiarities of a concrete year (t), that is

$$P_t = E_t + \Delta P_t$$

To distinguish nonrandom or trend component of productivity it is carried out smoothing of a mollusks productivity time series and its alignment by means of analytical functions.

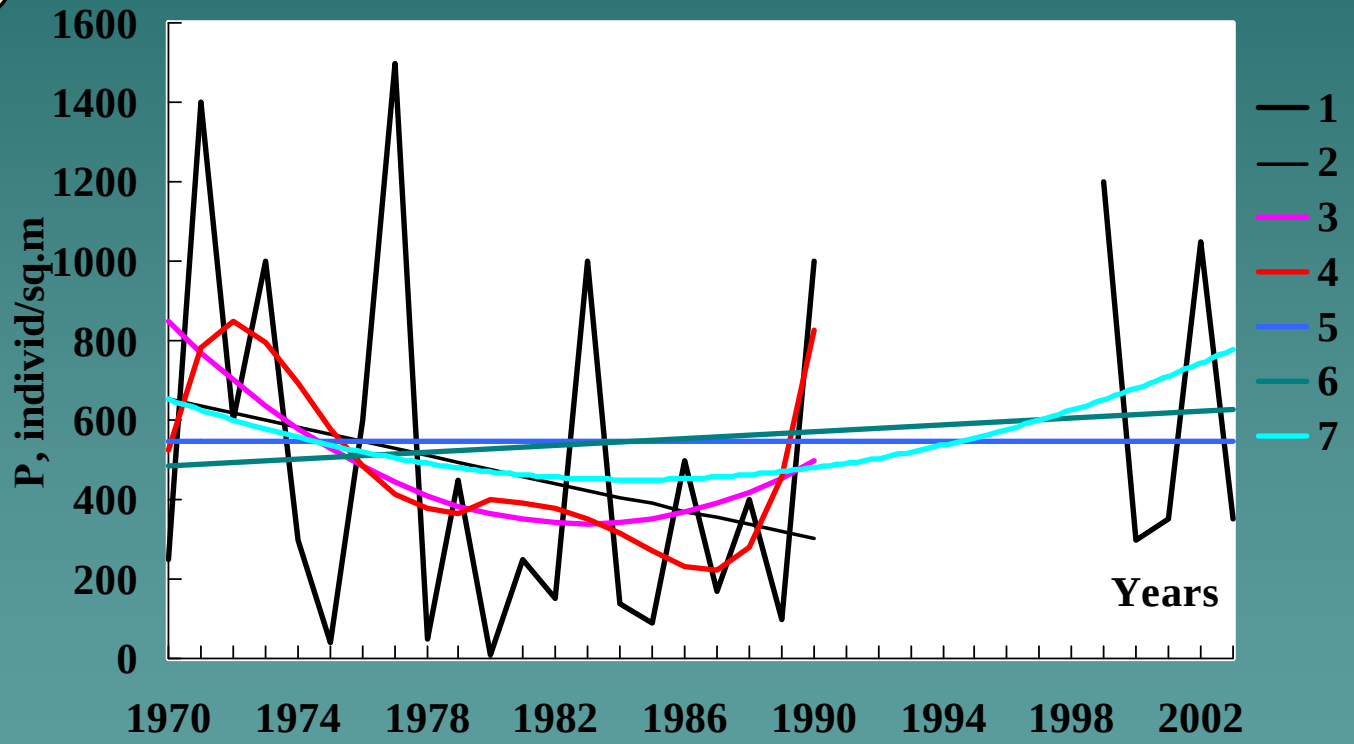


Figure 2. *Dynamics of scallop productivity in Minonosok Intel (1) and its trend constituent, and average many-year productivity (546 specimens/m²) (5)*

Results & discussion

On the basis of the analysis of distribution of deviations from a trend all initial time series of productivity by a rule of the majority of voices was conventionally divided into three groups: high-yielding (above the trend) years, low-yielding (below the trend) years and average-yielding (about the trend) years.

Years									
Good-harvest	1971	1973	1977	1983	1986	1990	1996	1999	2002
Low-harvest	1970	1974	1975	1978	1980	1982	1984	1985	1989

Results & discussion

At construction of a prognostic scheme as a basis it was taken a three-level model by N.M.Pestereva (Chirkov, Pestereva, 1990), which well recommended itself at the rice crop forecast.

The mollusks crop forecasting model developed by the author (ΔP) considers simultaneously environment condition of the sea, surface layers of atmosphere, tropospheric circulation, circulation in a stratosphere and helio-physical factors. Taking into account these factors the forecasting model is the following

$$\Delta P = a_1 (A_1, A_2) + a_2 B + a_3 (C_1, C_2, C_3) + a_4$$

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Where a_1, a_2, a_3 and a_4 – equation factors;

A_1, A_2 – predictors, considering helio-physical factors (solar activity, solar and lunar eclipses) and stratosphere circulation (position and intensity of Circum-Polar-Vortex);

B – predictor, considering troposphere circulation (forms of atmospheric circulation, types of synoptic processes);

C_1, C_2, C_3 – predictors, considering features of a surface atmosphere condition over a surface of the area where the crop is predicted; features of condition of a spreading surface of the given area (anomaly of superficial temperature and salinity of sea water, duration of the ice period etc.) and considering biological features of the cultivation object (thermohaline characteristics of various biological periods, dates of origin of these periods, their duration etc.).

Results & discussion

As the algorithm of the forecast scheme was based on statistical methods with the account of helio-physical, synoptic and hydrometeorological features, such scheme of the forecast is physical – sinoptical – statistical.

On the basis of the above-stated it is possible to assert, that application of agricultural meteorology methods to mariculture is reasonable and progressive.

But the agricultural meteorology is the science studying meteorological, climatic and hydrological conditions (land hydrology) important for agriculture; therefore, in our case we deal with the new direction of agricultural meteorology studying the influence of the environment factors on sea farms engaged in growing up hydrobionts.

The science studying the influence of the environment factors on productivity of cultivated objects of mariculture, should be named mariclimatology.

Results & discussion

So, it follows the definition, that **mariclimatology** is a science which studies real-life relationship between weather, atmospheric circulation and water environment parametres during the previous period on the one hand, and the productivity of cultivated cultures formed under the influence of these conditions, on the other hand, and the same as agricultural meteorology, it is based on the methods of mathematical statistics and a probability theory.

Important line of development in applied **mariclimatology** is creation of systems of various levels for information service of sea farms, elaboration of hydrometeorological-technological block-diagrams of economic decisions and the hydrometeorological long-term forecasts necessary for their acceptance, and the recommendation for choice of the economic decisions related to production of scallop.

Conclusions

Conclusions

Thus, the objective of **mariclimatology** is working out of the long-term forecast of sea farm productivity and creation of a concrete prognostic physical-statistical model and a calculation technique to forecast the productivity of the cultivation object.

We have done forecast using this new method for **scallop spat** productivity, and obtained good result.

This new method is published in to book

Thank you for your attention!