
DYNAMICS OF ECOSYSTEMS AND THEIR COMPONENTS

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**PROBLEMS OF CASPIAN SEA LEVEL FORECASTING:
LESSONS FROM HISTORY AND GUIDELINES FOR THE FUTURE (REVIEW)**

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The long-term fluctuation of the average annual Caspian Sea Level (CSL) causes significant geoecological problems in its coastal zone. Solutions to these problems typically come from the reliable long-term forecasts of its water balance. The lowest drop in the mean sea level in the entire period of instrumental observations to a record low in 2025 (-29.02 m relative to the Makhachkala Tide Gauge Station) makes research into the processes that determine the hydrological regime of the sea even more urgent.

In this article we aim to identify the main reasons for the poor accuracy of long-term forecasts compared to short-term ones, based on a retrospective critical review of publications concerning predictive approaches to studying CSL fluctuation patterns. The main types of long-term forecasts are examined, including those using empirical relationships between the CSL and heliophysical processes, patterns of periodic and cyclical changes in phases of level rise and fall associated with changes in atmospheric circulation patterns, and other possible factors influencing the components of its water balance. It is established that, besides the natural complexities associated with forecasting climatic factors, the uncertainty of plans for the economic use of water resources in the Caspian basin also contributes to the inaccuracy of long-term forecasts. Such difficulties are not characteristic of short-term forecasts of seasonal and non-periodic level fluctuations.

In the absence of the possibility for long-term forecasting using clear predictors, all forecasts (both deterministic and probabilistic) are based on extrapolating identified patterns from previous periods, assuming that their main determining parameters will remain constant in the future. In the planned economy of the USSR, such an approach for forecasts exceeding three years was considered unacceptable due to large errors, even if the trend direction persisted. In the conditions of the Caspian catchment area, a change in this trend direction caused the maximum forecast errors, making it impossible to recommend this approach for solving economic planning problems.

A change in strategy is required, one based not on focusing on level forecasts, but on a mechanism for adapting the economy to the range of its variability within ecologically justified limits determined by the modern climate. An analysis of paleogeographic and historical sea-level data, which correspond well with the geomorphological features of the sea basin, provides specific quantitative indicators of level fluctuation. G.I. Rychagov called this range the risk zone and defined it within the interval from -30 m to -25 m, based on the natural flow of the Volga, or with an upper boundary of -26 m, accounting for irretrievable

water withdrawal for economic needs.

The adaptation strategy may also include elements of level regulation, which were considered during the implementation of the “Greater Volga” project developed at the beginning of the 20th century, and incorporate short-term forecasting of water balance components as an important auxiliary element.

Keywords: elements of water balance; climatic and anthropogenic factors of formation; history, authors and forecasting methods; strategy of environmental management.

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