

Climate changes and their impact on the ecosystems of marine protected areas in the south of the Russian Far East

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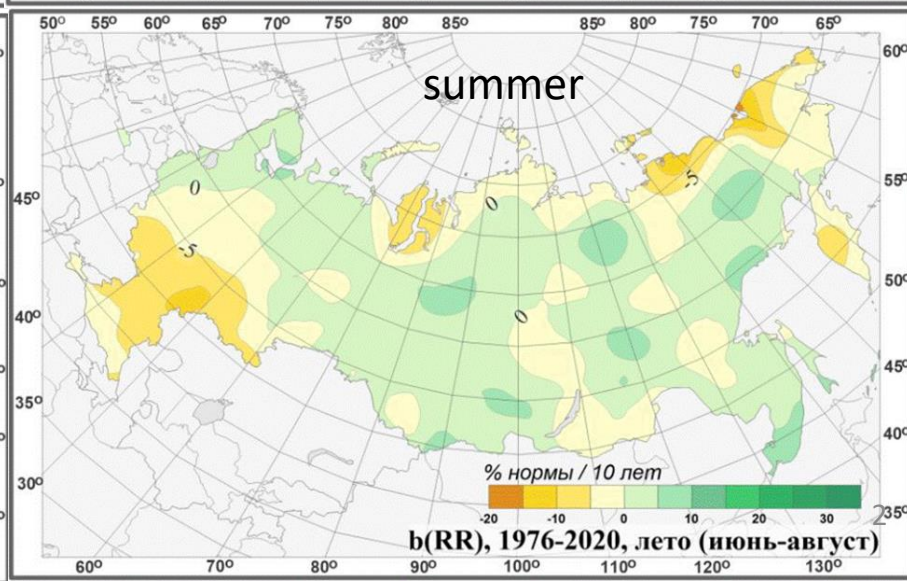
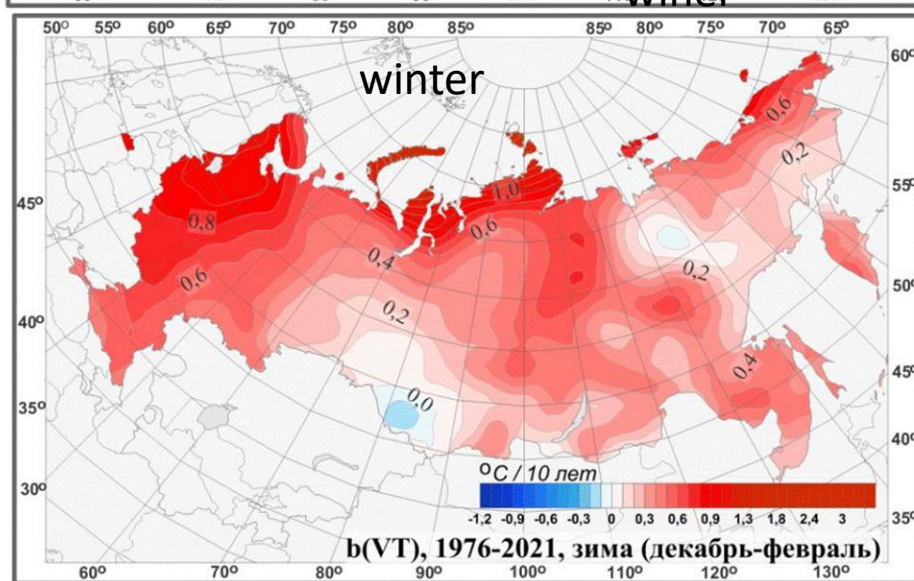
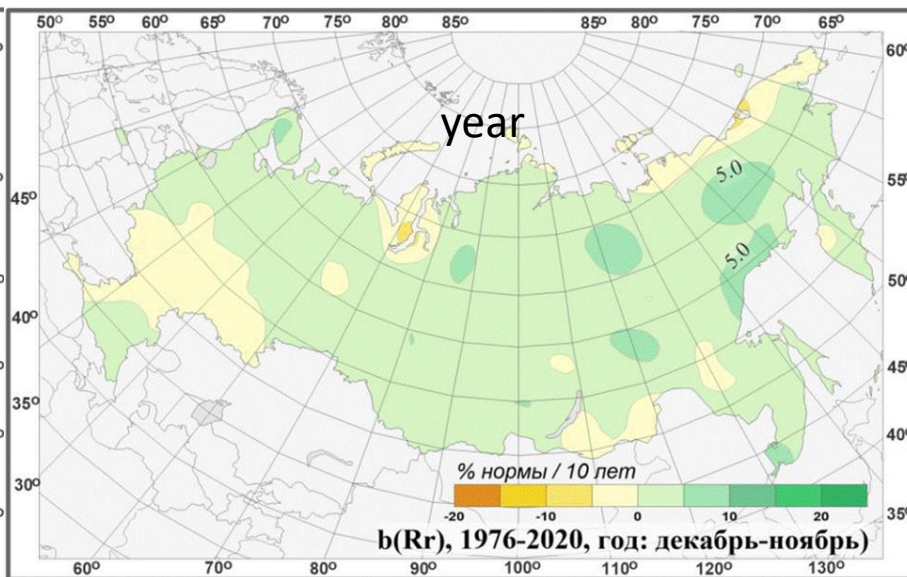
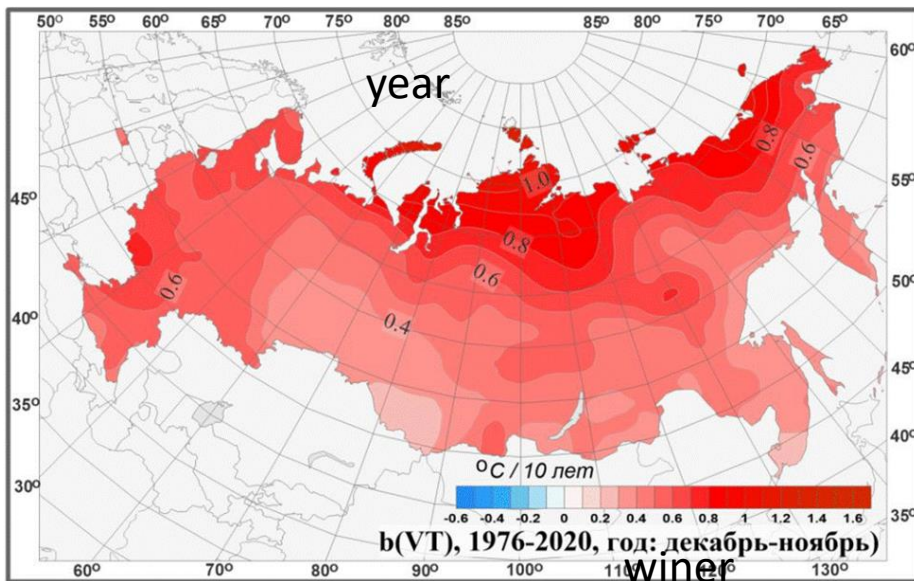
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OBSERVED CLIMATE TRENDS IN MEAN TEMPERATURE AND PRECIPITATION FIELDS.

PERIOD: 1976-2021.

Geographic distribution of linear trend coefficients for mean temperature [$^{\circ}\text{C}/10$ years]

precipitation [$\%/10$ years]



According to Yu.I. Zuenko (2009) at the end of the 20th - beginning of the 21st century, significant changes occurred in the Sea of Japan over a thirty-year observation period: an increase in water temperature by 0.01-0.04 ° / year, depending on the area and season, a decrease in the oxygen content in the lower layers water, the weakening of convection and the intensity of coastal water circulation.

Dynamic processes significantly affect the circulation of biogenic elements and oxygen. In particular, the decrease in the intensity of convective mixing of sea waters in the coastal zone, observed as a result of the weakening of the winter monsoon, is the main reason for the increase in the concentrations of nutrients in the water and the decrease in the oxygen content in the deep and near-bottom layers of sea water.

The changes taking place in recent decades in the ecosystems of the Sea of Japan under the influence of climate change consist in their transformation from a highly productive system with low functioning efficiency, which is typical for ecosystems of temperate latitudes, to a less productive system with a higher functioning efficiency, typical for subtropical zones of the oceans

Due to climate change the task of preserving species and ecosystems in protected areas is becoming more difficult. There was a need to take additional adaptation measures. To develop them, studies are carried out to assess the degree of vulnerability of the territory: what and to what extent is subject to adverse climatic influences, which ones, with what frequency?

Under these conditions, in the waters of specially protected natural areas, species appear that are of little character for this geographical zone.

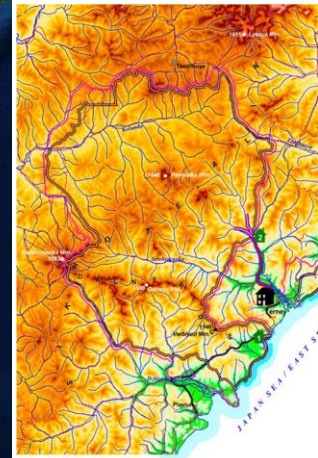
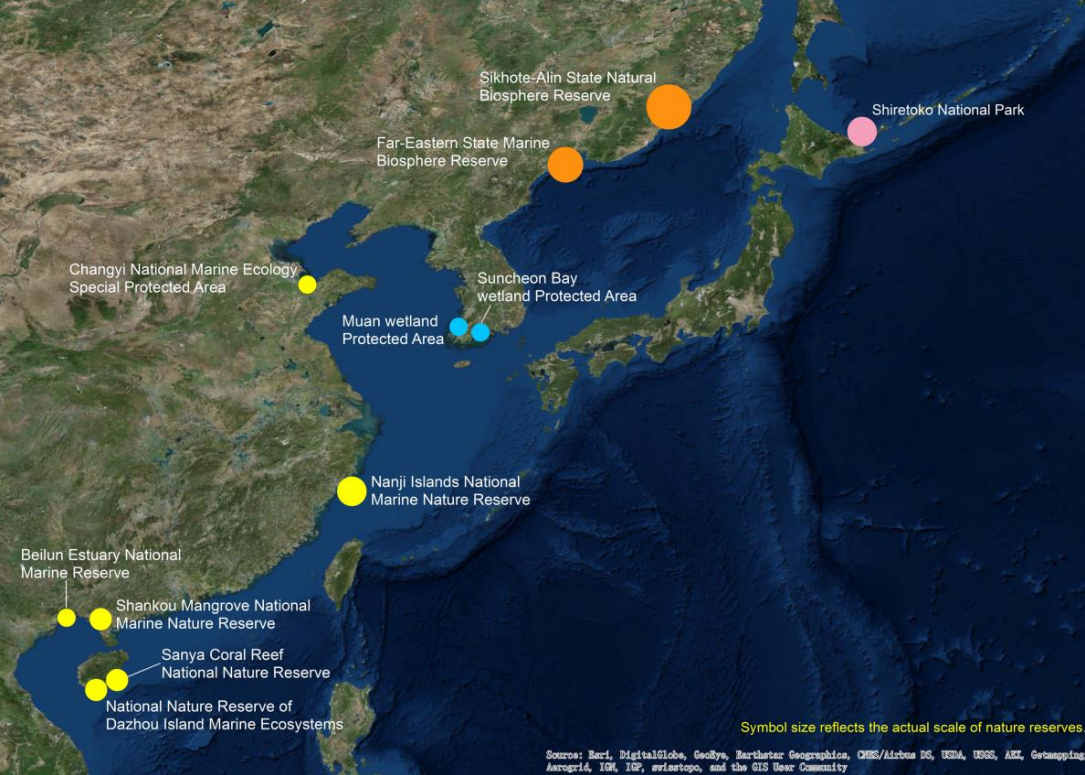


Among security sea water areas and adjoining territories in Primorsky Krai are the Far Eastern Marine Natural Biospheric Reserve (64,360 hectares), marine refuge in Vostok Bay (1,820 hectares) and “Ostrovnoy” refuge (9,400 hectares). Besides.

Sihote-Alin Natural Biospheric Reserve has 2,900 hectares of protected marine water area, and “Goraliy” refuge has a kilometer marine security zone covering total area of 2,500 hectares.

Within their limits inland island systems and water areas along the coastal slope are under protection. However, pollution of the marine environment has been growing worse since the recent years, and in some cases uncontrolled use of biological resources of the coastal slope demands new security territories and water areas.





Sikhote-Alin State Natural Biosphere Reserve

Far Eastern State Marine Biosphere Reserve



The main objectives of the Sikhote-Alin State Natural Biosphere Reserve after K.G. Abramov under the MNRE of Russia (Sikhote-Alin Reserve) and the Far Eastern State Marine Biosphere Reserve (FESMBR) are the preservation of the natural functioning of typical and unique natural complexes, including the marine, of the Sikhote-Alin mountain system, and the environmental protection of the richest marine and island flora and the fauna of the Peter the Great Bay, and in the first turn – the conservation of the gene pool of marine and coastal communities, as well as the study of the natural course of natural processes and phenomena, certain species, typical and unique ecological systems, as well as the development of principles and methods for monitoring the state of the environment.

Changes in various environmental factors as a result of climatic fluctuations and anthropogenic impact lead to serious changes in microalgae communities, including a sharp change in their productivity, an increase in abundance, and the development of harmful blooms (HABs). The phenomenon of mass development of microalgae in coastal waters is becoming epidemic in the Far Eastern seas of the Russian Federation.

Over the past decades, the frequency and intensity of harmful microalgae blooms in the Russian Far East have increased by more than 5 times.

Raphidophyta, *Heterosigma akashiwo*



In July 2022, there was a large-scale "bloom" of *Heterosigma akashiwo* (46.3 million cells/l) in the Amur Bay. The species is known as a producer of ichthyotoxins. Spring-summer "blooms" of *H. akashiwo* can lead to mass mortality of invertebrates and fish, including salmon on marine farms.

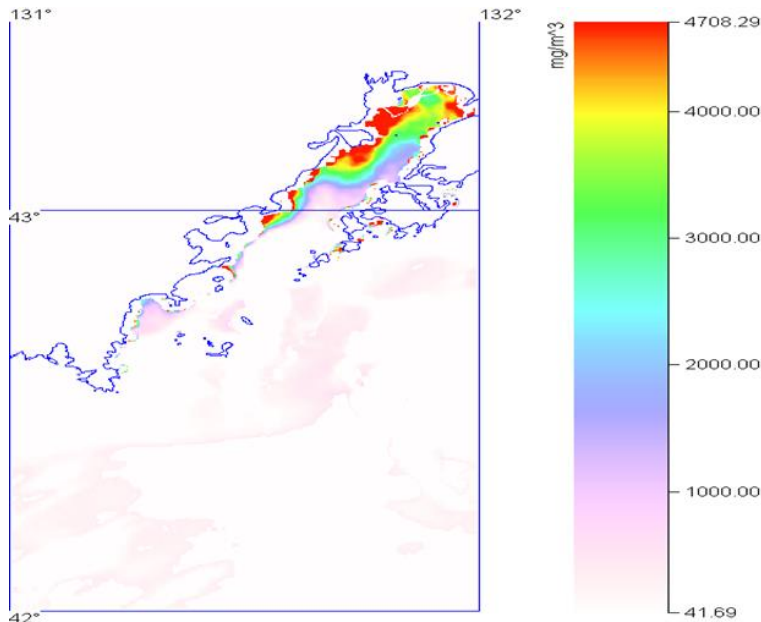
Dinophyta, *Noctiluca scintillans*



To assess the risks of development of negative consequences of climatic changes on coastal ecosystems, new types of environmental monitoring are being developed.

Environmental monitoring of marine areas by remote means

For the first time in the world practice, in the waters of the Peter the Great Bay, tests of the microalgae monitoring system were carried out using modern fluorometric methods simultaneously with the use of satellite observations (based on the data of the MODIS radiometer of the AQUA satellite), underwater autonomous vehicles, underwater controlled buoys and a unique complex of spectral express methods for operational tracking the state of phytoplankton and assessing primary production.



The concentration of the alga *Coscinodiscus oculus-iridis* calculated from satellite data



Another new serious environmental problem, associated with global warming of sea waters, for marine ecosystems has become the rapid disintegration of bottom gas hydrates. This process has been recorded on the shelf of Sakhalin Island and the Kuril Islands. This led to methane emissions into sea water.



Due to the increase in precipitation in the south of the Far East of the Russian Federation, the number of powerful cyclones has increased, which has led to an increased removal of flood waters into bays and bays. This leads to severe desalination of coastal sea waters, transformation of coastal ecosystems and, due to this, the death of a number of populations of coastal hydrobionts, such as sea cucumbers, scallops and others

Environmental education is an important area of work for protected areas in modern conditions. It is necessary to provide information to population about changes occurring in nature due to climate change, possible problems, and types of marine organisms that appear in coastal waters due to climate change.



There are more than 20 tourist routes and ecological trails in the Far Eastern Marine Nature Biosphere Reserve.



ECOLOGICAL EDUCATION AND TOURISM IN SIKHOTE-ALIN RESERVE



Annual action «Clean Coast»



Annual planting of Korean pines



Annual festival «Tiger Day»



Visit of cruise ship «M5 Bremen» to the Reserve



Shootings of BBC film «Siberian Tigers»

The most significant changes in ecosystems due to climate change occur in the north of the Russian Far East. First of all, species whose life is associated with ice and permafrost suffer. The decrease in the ice content of the northern seas has a negative impact on the populations of polar bears, walruses and other animals.



A large flock of seagulls is captured in flight over a sandy beach. The birds are scattered across the sky and the sand, with some landing and others taking off. In the background, a green, rocky cliff rises from the beach, and the ocean is visible in the distance under a clear blue sky.

**Thank You Very Much for your
attention**