

The goal of the project is to assess the changes in the ecological state of the Caspian Sea since the beginning of the current century under the impact of natural and anthropogenic factors. This calls for a detailed analysis of large banks of satellite data acquired over the Caspian Sea from 1999 to 2022 jointly with multi-year hydrometeorological data.

The goal is achievable due to powerful capabilities of the See the Sea (STS) information portal developed by the Space Research Institute of the Russian Academy of Sciences (IKI RAS) as part of IKI - Monitoring Center for Collective Use. STS offers oceanographers new and unique tools to work with remote sensing data, enabling comprehensive analysis of data different in physical nature, spatial resolution and time of acquisition.

A multi-factor analysis of the ecological status of the Caspian Sea is made for the first time for the entire Caspian Sea based on multi-sensory and multiplatform remote sensing data, which determines the scientific novelty of the project.

In 2020, the following works were carried out and the main results were obtained.

ERS-2 SAR and ASAR Envisat radar data from the archives of the European Space Agency, obtained over the Caspian Sea in 2007-2013 were analyzed, selected and integrated into the STS system.

Data of operational multi-sensor monitoring for 2020 analyzed, systematized and annotated.

All the results obtained are entered into the IS STS, which is an integral part of the OI CKP "IKI-Monitoring".

Based on the analysis, the following tasks were solved.

1. Based on the analysis of satellite radar data for 2007-2013 and multisensor satellite monitoring data for 2020, mapping of various types of oil pollution of the Caspian Sea surface was carried out. It was confirmed that the nature of the surface oil pollution of the Caspian Sea, revealed during satellite monitoring, is determined by the special natural properties of the Caspian Sea, namely the presence of large oil and gas fields at its bottom. Areas of the most intense pollution of the sea surface are identified and sources of pollution are identified.

The distributions of the areas of individual oil pollution of the sea surface in different test areas are calculated. In the area of oil production Neftyaneye Kamni, pollution with an area of about 400 km² is most often observed, but in some cases their areas may exceed 1000 sq.km.

The interannual variability of the water area potentially exposed to oil film pollution in different regions is estimated

Integral estimates of oil pollution of the sea surface, revealed by satellite data in areas of intense pollution, are obtained. The annual integral area of oil showings revealed by satellite data varies within 3000-15000 sq. km. in the oil production area Oil Rocks, within 50 - 100 sq. km. on the

Iranian shelf near Cape Sefid Rud and within 106-210 sq. km. on the Turkmen shelf near the Cheleken peninsula. The integral area of oil pollution of the sea surface as a result of underwater mud volcanism in the southwestern part of the Caspian Sea per year exceeds one thousand square meters. km. The results obtained during the second phase of the project indicate that the main contribution to the integral oil pollution of the Caspian Sea surface is made by continuous oil pollution of the sea surface in the Oil Rocks area, as well as mud volcanic activity on the seabed in the South Caspian Basin.

Natural hydrocarbons from the seabed make a slightly smaller contribution to the overall pollution picture. More than 80 percent of this type of oil show is detected from May to September. The integral area of oil pollution of the sea surface as a result of underwater mud volcanism in the southwestern part of the Caspian Sea per year exceeds one thousand square km.

The contribution of unauthorized discharges of oil-containing films from ships does not belong to the main sources of film pollution of the sea surface and is small compared to the contribution of the above pollution sources.

2. On the basis of a comprehensive analysis of optical and radar images, as well as information on chlorophyll concentration in the STS IS, maps of areas of regular intensive phytoplankton bloom were constructed. During the period under study, areas of regular manifestations of intense phytoplankton bloom were, as in previous years, the western coast of the Middle and South Caspian, the southern and eastern coasts of the South Caspian, and almost the entire water area of the North Caspian. The most susceptible to phytoplankton bloom are the water areas located in the estuarine zones of rivers flowing into the Caspian Sea. It was revealed that areas of intense phytoplankton bloom are absent along the eastern coast of the Middle Caspian.

On average, the area of areas with intensive phytoplankton blooms during the study period remained constant, with the exception of anomalous blooms in the South Caspian in 2009 and 2010. The smallest areas of phytoplankton bloom identified from satellite data were observed in 2012 and 2013.

3. The characteristics of interannual variability and trends of the main hydrometeorological parameters of the Caspian Sea have been obtained, including sea surface temperature, air temperature, precipitation, cloud cover, wind strength and field for 2007-2019. Their spatial and temporal variability in this period have been studied.

4. The main characteristics of the ice cover in the North Caspian Sea have been assessed, such as: the index of the severity of winters; the duration of the ice cover; maximum area of ice cover. On the basis of satellite data, schematic maps of the ice cover in the Northern Caspian for 2007-2013 and in 2020 were constructed. It was noted that the winter of 2019-2020 was abnormally warm. The maximum area of the ice cover was observed in mid-January, it amounted to 36 thousand sq.km.

5. The maps-schemes of the identified by satellite radar and optical data for 2007-2012 were built. and 2020 of the elements of the Caspian Sea water circulation: vortex structures, internal waves, surge phenomena and upwelling influencing the transport of pollution.

The predominance of submesoscale eddy structures in the coastal part of the Caspian Sea (at the boundary of the shelf zone and the continental slope) was revealed.

For each part of the Caspian Sea, the main areas of eddy formation were identified.

Areas of regular surface manifestations of internal waves and their seasonal variability have been determined.

Analysis of the long-term and monthly average (May – September, 2003–2019) maps of the sea surface temperature in the coastal upwelling zone off the eastern coast of the Caspian made it possible to trace the changes in the boundaries in the meridional and zonal directions characteristic of this zone and the displacement of the position of the upwelling foci in the seasonal cycle, and also to establish the reasons for this shift, taking into account the information obtained on the months of the most frequent manifestation of the elements of the mesoscale circulation of sea waters, which affect the length of the upwelling zone along the coast.

6. Work has been carried out to improve the information system "See the Sea", aimed at development of new tools for solving problems arising in during the completion of the project. A software toolkit for the analysis of spatial distributions and probabilistic-temporal characteristics of various phenomena on the sea surface has been developed. The data on the time and place of occurrence of the phenomena identified by the users of the system during operation are stored in the database in the form of contours linked to satellite images. The new toolkit allows, based on this data, to determine the number of episodes of occurrence of phenomena at the nodes of a regular grid.

The results of the project have been presented in 8 publications indexed in the databases SCOPUS, Web of Science and RSCI (One in Q1). 7 reports have been presented at two international conference (EGU General Assembly 2020, Online, 4–8 May 2020, SPIE Remote Sensing of the Ocean, Sea Ice, Coastal Waters, and Large Water Regions 2020, September 21-26, 2020, Free Digital Forum) and one all-Russian conference with international participation.

The materials devoted to this project can be found on the website http://www.iki.rssi.ru/asp/dep_proj/proj_20060.htm.