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**ANNOTATED REPORT  
ON SCIENTIFIC RESEARCH**

**Complex environmental monitoring program for the Danube-Black Sea Deep-  
Water Navigation Canal operation in 2018-2019.  
The Sea Approach Canal zone**

Contract № 910/1.1/198- V-FDL-18 dated July 09, 2018

Project Lead

M. Lungu

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# ANNOTATED REPORT ON SCIENTIFIC RESEARCH

## **Complex environmental monitoring program for the Danube-Black Sea Deep-Water Navigation Canal operation in 2018-2019. The Sea Approach Canal zone.**

### **1. Actual Program execution and scope of work**

In 2018, according to the Program (Appendix A) and in accordance with the Terms of Reference to Contract No. 910 / 1.1 / 198-V-FDL-18 dated July 09, 2018. The works were carried out during the reporting period.

For work performance the main executor (USRIEP Ministry of Ecology and Natural Resources of Ukraine) have been involved the following organizations: Danube Hydrometeorological Observatory (DHMO), Odessa Centre of State Enterprise South Scientific Institute of Fisheries and Oceanography (SSIFO), State Enterprise “CHERNOMORNIIPROEKT”, Danube Biosphere Reserve National Academy of Sciences of Ukraine (DBR), Governmental Institution “Institute of Marine Biology, National Academy of Sciences of Ukraine” (IMB).

During the reporting period, according to the Program, expeditionary surveys of the riverbed Ukrainian part of the r. Danube. During scientific expeditions and on stationary hydrological posts were made observations of the hydrological characteristics of delta watercourses.

As in previous years systematic monthly studies were conducted of hydrochemical indicators of the state of the waters of the Ukrainian part of the Danube River during 2018. Danube hydrometeo-observatory selected and investigated water samples in 17 observation points. The 204 water samples were selected and analyzed in 2018.

Hydrobiological studies p. The Danube in 2018 was carried out by USRIEP specialists. The studies included sampling and processing of phyto- and zooplankton, water and bottom sediments to study the seasonal state of biological communities, the content of photosynthetic pigments of phytoplankton microalgae and bottom sediments (BS). The studies were conducted in the spring (April) and autumn (October) periods of 2018. In total over the period of the expeditionary studies the 162 samples of water and bottom sediments were selected for hydrobiological and hydrochemical analysis.

Expedition surveys of the seashore were carried out as part of control observations during hydraulic engineering works (IMB). The collection and synthesis of hydrological and hydrochemical data were performed in the bar part and adjacent water area at 12 stations in July-August and 12 stations in November. A complex of hydrological, hydrochemical and hydrobiological works was carried out at each station; meteorological observation.

Total samples selected: hydrology - 140, hydrochemistry -51, phytoplankton - 48, zooplankton - 24 zoobenthos - 24 meiobenthos - 24 granulometry - 24, oil products - 24, heavy metals - 24.

The analysis of statistical data on the fishery of migratory fish and nonmigratory fish in the Danube River and avandelta, as well as collecting and processing of materials characterizing the state of their populations (SSIFO) were carried out. The development of a scientific and biological substantiation of the possibility of dredging during the ban on fishing and other aquatic biological resources done.

Within the DBR the observations on the state of the plant communities of the coastline and marshes, macrozoobenthos of freshwater and brackish-water angles and bays in the DBR, herpetofauna and rare ichthyofauna, as well as ornithological and teriological surveys in the GSK area and on Yermakov island as part of Complex environmental monitoring were carried out.

Studies of environmental processes in the Danube Delta and in the coastal part of the sea were carried out using remote monitoring tools. The data on the dynamics of channel processes and suspended substances in the Danube Delta and the coastal part of the Black Sea based on materials from space imagery are obtained.

The impact of dredging on the aquatic environment and fish fauna in 2018 was assessed; quarterly calculations of compensation payments were made (CHERNOMORNIIPROEKT, SSIFO).

The analysis of the actual storage volumes of soils excavated during operational dredging works to restore the Danube-Black Sea GSH, the assessment of the residual soil clearance of the hydraulic mine dump, the study of the possibility of its further use in dredging operations on the marine part of the "Danube-Black Sea" DWNC (CHERNOMORNDIPROEKT) were made.

A preliminary calculation of the damage caused to components of the environment as a result of operational work on the sea approach channel of the "Danube-Black Sea" DWNC and under storing the exempt soil in 2019 was made.

The Program of Complex environmental monitoring during the operation of the Danube-Black Sea DWNC in 2018 was completed in full.

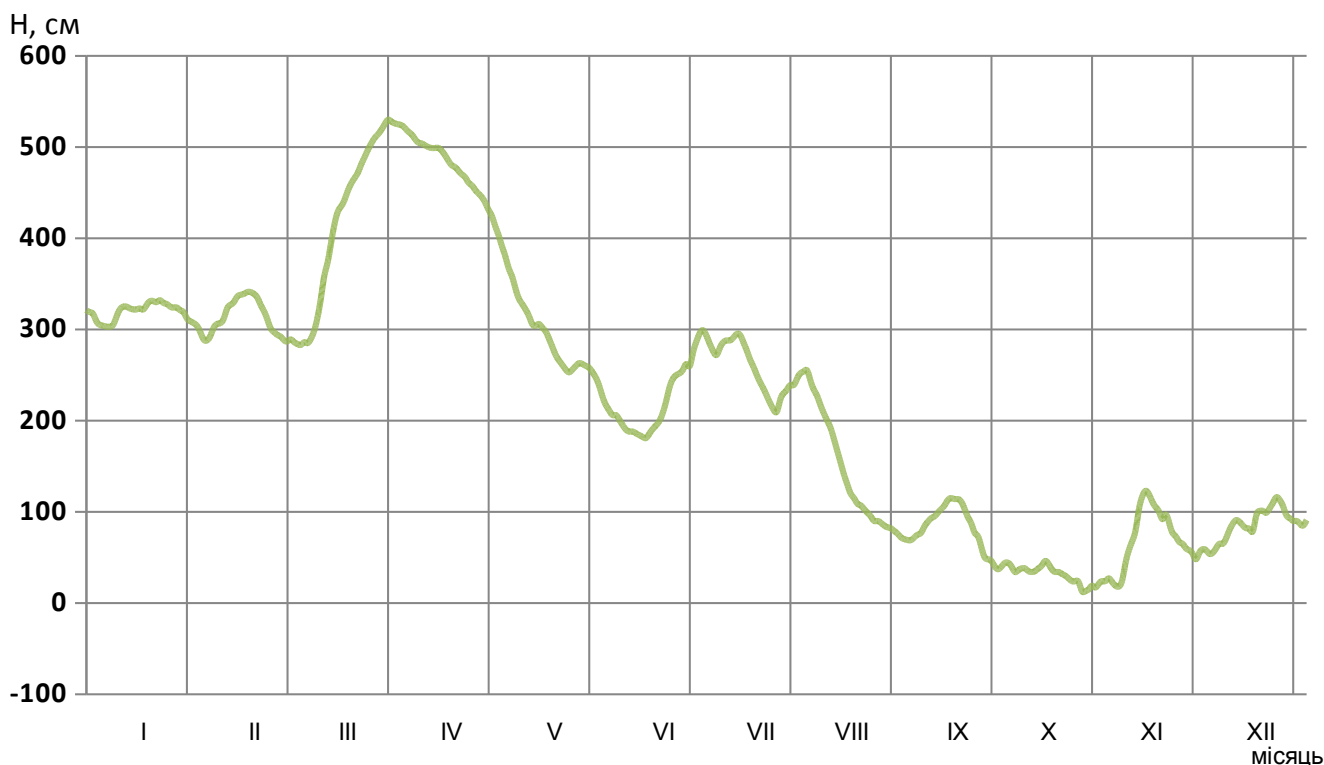
## **2. Regular hydrological and hydrochemical studies (DHMO, USRIEP)**

The Danube Hydroelectric Observatory were carried out regular hydrological and hydrometeorological studies under the operating conditions of the deep-water channel of the Danube-Black Sea in 2018 according to the Complex Environmental Monitoring Program and the Technical Assignment under the subcontract with the USRIEP.

In 2018 the hydrological monitoring program included daily monitoring of the level and temperature of water. These observations were carried out on eleven stationary posts in five of which, moreover was carried out daily monitoring on turbidity. In 2018 the expeditions to study the spatial and temporal variability of the flow of water and sediment of the Danube and the branches of its delta were carried out with the use of "Timofey Bogatyr".

Hydrochemical observations in accordance with the requirements of the Terms of Reference were carried out throughout the Ukrainian section of the R. Danube - from R. Prut to the mouth of the Bystriy. Expedition works which included hydrometeorological

observations and water sampling were carried out monthly at 17 stations followed by laboratory determination of 34 physical and chemical indicators of the Danube water.



**Figure 1.** Diagram of daily water levels of the Danube river, ГП-I Reni

*The results of regular and expeditionary hydrochemical observations.*

Hydrochemical mode of the R. Danube depends mainly on changes in hydrological factors: water content, water temperature and the amount of suspended substances. Significant flow rates and flow turbulence contribute to the homogeneity of chemical indicators and their relatively limited amplitude.

In the reporting period, BOD5 values increased in the Danube water compared to multi-year values.

Comparison of monitoring results with recommended international standards for R. Danube on the content of metals allow us to draw the following conclusions:

- the excess of the total metal content in water was not observed;
- the excess of the total metal content in the samples of bottom sediments was observed only for nickel in the sample taken at the site of arm Bystriy, 9 km, in April.
- the results of observations mediated on the river section both in individual seasons and in general for the year do not exceed the abovementioned standards for the content of metals in water and in bottom sediments.

### **3. Assessment of the environmental status of the Danube by hydrobiological and hydrochemical indicators (USRIEP)**

Generally over the period of the expeditionary studies the 162 samples of water and bottom sediments were sampled for hydrobiological and hydrochemical analysis.

#### *The results of hydrobiological studies.*

During the analysis of 24 algological samples taken during the expedition in April and October 2018 in the studied sections of the Danube River the 168 species and intraspecific taxa from 8 sections of freshwater phytoplankton were identified.

The saprobity zone, the class and the water quality category, are determined both by the saprobity index and phytoplankton biomass, in most of the river sections they corresponded to class II of surface water quality and 3 categories (saprobity index 1.6-2.0, phytoplankton biomass 1, 1-2.0 mg / dm<sup>3</sup>): “good” as the quality of the waters, “sufficiently pure” according to the degree of purity / pollution.

In general, the quantitative and qualitative composition of the phytoplankton of the studied areas of the Ukrainian part of the Danube responded to the seasons of the selection and the type of reservoirs, and in April 2018 was similar to the same period of the previous year.

The 15 species of zooplankton organisms have been found and identified in the Ukrainian part of the Danube River over the entire period of studies conducted in 2018. In general, zooplankton was very poor in numbers and biomass. The highest rates were observed in the spring and were at the level of last year this season. The number (due to rotifers and copepods), biomass, due to copepods.

The species composition of macrozoobenthos in 2018 consisted of 12 species of benthic invertebrates, belonging to 2 systematic groups. Representatives of the mollusk type dominated in the species composition. As in previous studies, there was a poverty of species diversity and quantitative indicators of the development of benthic organisms, both in the whole channel part and in the points in the coastal zone.

On average over the past years of observations, the values of chlorophyll a content in phytoplankton and bottom sediments tended to increase in concentrations in bottom sediments and decrease in phytoplankton as they approach the sea edge of the delta.

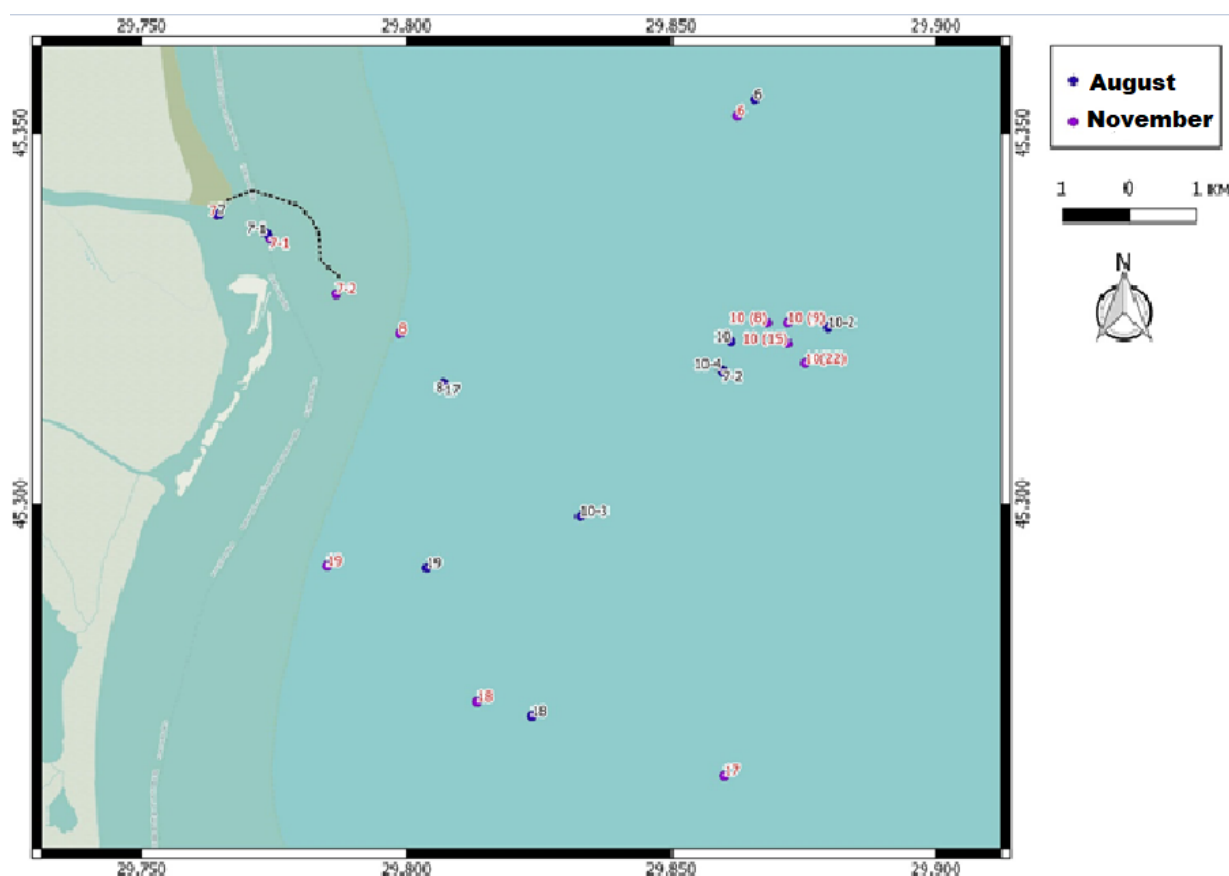
The results of calculations of environmental indices indicate the following.

On average, according to the environmental assessment, the waters of the Ukrainian section of the Danube Delta belonged to the transition between categories 2 and 3 (pure-fairly pure), and according to the average of the worst levels - up to category 4 (poorly polluted). The assessment of the quality of the waters according to the block of the trophic-saprobiological (ecological-sanitary) state turned out to be bad. According to the average values of this block the investigated waters could be attributed to category 3 with a transition to 4 (fairly pure with a transition to slightly polluted). At the same time, according to the average of the worst values for this block - up to category 6 (dirty).

It can be noted that in general noticeable violations in the state of the ecosystem p. Danube biological indicators not identified summarizing the research in 2018.

#### 4. Control observations during the operation of the Danube-Black Sea DWNC (marine part) (IMB NAS of Ukraine)

In July - August 2018 (from July 31 to August 4) and in November (from November 9 to November 11. and from November 23 to November 25.) the expedition works were carried out on the Danube seashore. After discussing the results of the first expedition in July-August 2018 it was decided before each expedition to specify the coordinates of the stations in the dumping zone and take samples using ship anchored. Therefore, the location of the stations in the dumping zone on two expeditions of 2018 coincided (Fig. 2).



**Figure 2.** Stations on the seashore of the Danube (August-November 2018)  
Legend: the selected stations which were selected in July-August – black , and red in November 2018.

The analysis of particle size of the soil was carried out and an assessment of the level of its contamination was carried out at a bottom dredging to calculate compensation payments in 2018/

The development of phytoplankton, zooplankton and zoobenthos was estimated at background stations and in areas of anthropogenic pressure to calculate losses for the fish food base in 2018; the percentage of feed biomass of fish in the zones of anthropogenic influence was specified in comparison with background stations; the procedure for obtaining the coordinates of sampling points in the dumping zone was discussed to increase monitoring efficiency.

The analysis of the long-term monitoring of the environmental status of the class in

the avandelta of Danube based on morphofunctional indicators of the phytoplankton shows that over the past eight years (2011-2018) it is within the same category - “Good”.

The received data for the calculation of losses according to pollution of bottom sediments and fish feed base for areas of anthropogenic influence (dredging zone on the approach channel and soil dumping zone) are shown in Table 2 .

**Table 1.** Characteristics of fish food base in various areas of the Ukrainian part of the Danube seashore

Fish feeding objects	Zones of anthropogenic influence		background
	bottom dredging	dumping	
<b>July 30 - August 4, 2018</b>			
phytoplankton,(grams per cubic meter)	0.603±0.099	1.263± 0.355	0.592± 0.144
zooplankton, (grams per cubic meter)	0.269±0.199	0.545± 0.033	0.341± 0.036
meyozoobenthos + macrozoobenthos, (gram per square meter)	0.229±0.234	78.319±25.039	56.164±25.810
<b>9-11 and 23-25 November 2018</b>			
phytoplankton, (grams per cubic meter)	0.659±0.323	0.421±0.092	0.144±0.053
zooplankton, (grams per cubic meter)	0.028±0.035	0.078± 0.035	0.052±0.014
meyozoobenthos + macrozoobenthos, (gram per square meter)	8.692±2.567	9.818± 0.936	25.721±4.837

## 5. Results of ichthyological monitoring (SSIFO)

Ichthyological studies in 2018 were carried out as a part of complex monitoring during the operation of the deep-water navigation channel (DWNC) of the Danube-Black Sea at the mouth of the Bystriy according to the Terms of Reference for the agreement between USRIEP and SSIFO and “Programs ...”.

The work on the Program was carried out within the framework of the activities of the joint monitoring center of SSIFO and the Danube Biosphere Reserve with the involvement of the fishing organizations of the region, or with own forces of the UDC SSIFO and DBR.

*The results of the work carried out indicate the following.*

In industrial and research catches the species of 4 families were encountered: sturgeon, herring, carp, and perch. The most important industrial object in the Danube is a Danube migratory herring. In 2018 the herring catch was 254.4 tons, which is almost half the catch of 2017 for the same period of time, and approximately at the level of 2014 and 2015.

In the current year, the spawning stock was based on the 2014 and 2015 generations

(which were scarce in terms of yield), which led to its low number.

The main effect of dredging and storage of soils during the recovery of DWNC is appeared on the fodder base of fish, to a lesser extent - on their early juveniles. However, studies carried out within the framework of the environmental monitoring of the construction of indicate that this action is mainly limited to local areas during period of work. Dredging causes a short-term increase in the concentration of suspended solids in the water.

As part of ichthyological monitoring, there was developed the “Scientific-biological rationale for the possibility of dredging during the ban on fishing and other aquatic biological resources, including a preliminary calculation of losses of biological resources during the operational dredging works at the Sea Approach Channel DWNC of the Danube-Black Sea and storage of soil on the sea underwater dump, the development of recommendations for limiting economic activity during the work on 2019”.

## **6. Monitoring of terrestrial and coastal ecosystems on the territory of the Danube Biosphere Reserve (DBR)**

Monitoring of plant and animal groups of the coastline and wetlands of the DBR during the operation of the deep-water navigation channel of the Danube-Black Sea in 2018 was carried out in accordance with the Terms of Reference and the Program.

The structure of the monitoring, which is carried out by the staff of the DBR, included observations of various international conventions and are listed in the Red Book of Ukraine. In connection with the approval in 2009 of a new edition of the Red Book of Ukraine these species received additional attention during the work.

Considerable attention was paid to alien species, due to the fact that they are distributed primarily due to existing traffic flows.

The Ukrainian part of the Danube Delta continues large-scale hydrological changes due to a number of natural and anthropogenic factors. The most powerful of them is reducing the flow of the Kiliya arm of the Danube. The most active processes of delta formation in 2018 were seen on the bars of the arms of Starostambulsky, Vostochniy and Tsiganka.

The decrease in water flow in the Ochakov arm has led to the formation of 5 islands inside the arm itself, the surface of the largest of which has a length of more than a kilometer.

The greatest bloom of water was observed at the Bystriy bar, in coastal areas of almost all brackish-water bays, such as Badik, Solenyiy, Durnoy, Taranov.

In 2018 the number and distribution of rare ichthyofauna under the work of the “Danube-Black Sea” DWNC as a whole has been common in recent years. During 2018 there was no significant effect of the operation of DWNC on rare ichthyofauna in the study area. Direct effects of the consequences of the shipping (pollution, waveformation phenomena, etc.) are also not noted.

Inventory of ichthyofauna on the island Ermakov shows the presence of 26 species of fish after ecological reconstruction compared to 22 species before the



beginning of recovery. For ichthyofauna, including rare, coastal dumps of soil is more optimal because its places of spawning, feeding and living are not sedimentations stemming and destroyed. In addition, the coastal dumps of soil are already overgrown with trees and shrubs, which are inhabited by many species of birds, and it is these upper levels are a shelter during floods and winter wind setup of water.

The direct influence of DWNC on the mouth of the Bystriy on the nature of migrations in the spring period of 2018 was not found. Certain bird species were adversely affected by a cold cyclone in the third decade of March 2018.

Considering the distribution of birds in the territory during the autumn migrations and the volumes of exploitation of DWNC, we can assume that there was no negative impact on the fauna of birds associated with the operation of the channel.

The results of DBR teriofauna monitoring in the area of the DWNC Danube-Black Sea during 2018 confirmed the data on the species composition and the number of mammals present here. The results of route surveys carried out in the reporting period indicate a high number of some mammal species, namely: jackals and sewer rats. There are 1 species that are mentioned in the Red Book of Ukraine - European otter.

During the research in 2018, no significant direct influence of the DWNC of the Danube-Black Sea on the teriofauna DBR was found.

During 2018, there was a significant effect of the operation of the DWNC Danube-Black Sea on plant and animal groups in the study area. The direct effects of the consequences of the shipping (pollution wave formation phenomena, etc.) are also not noted. The development of the flora and fauna of the reserve was stipulated mainly by the hydrometeorological features of the year.

## **7. Analysis of the watercourse processes and suspended solids dynamics in the Danube Delta and the coastal part of the Black Sea based on satellite images**

### *Selection of satellite images.*

In the course of the work, the presence of images was analyzed and the database of images was replenished. With 46 available images of the study area made by the Landsat 8, the 13 space images of the Danube estuary were selected by quality criteria.

### *Coastline dynamics.*

The analysis of satellite images allowed to investigate the space-time changes of the coastline. A combination of the far, middle and near infrared channels was used for the analysis, which evens out the photo-tone of the water surface and makes it more contrast to the land surface.

In the course of the comparative visual analysis of the images the most significant changes in the coastline in the areas of Taranov Bay, Ptichiy island and Novaya Zemlya islands were marked.

Spatio-temporal changes in the coastline of the Danube estuary have seasonal fluctuations while preserving the overall shape of the structural elements.

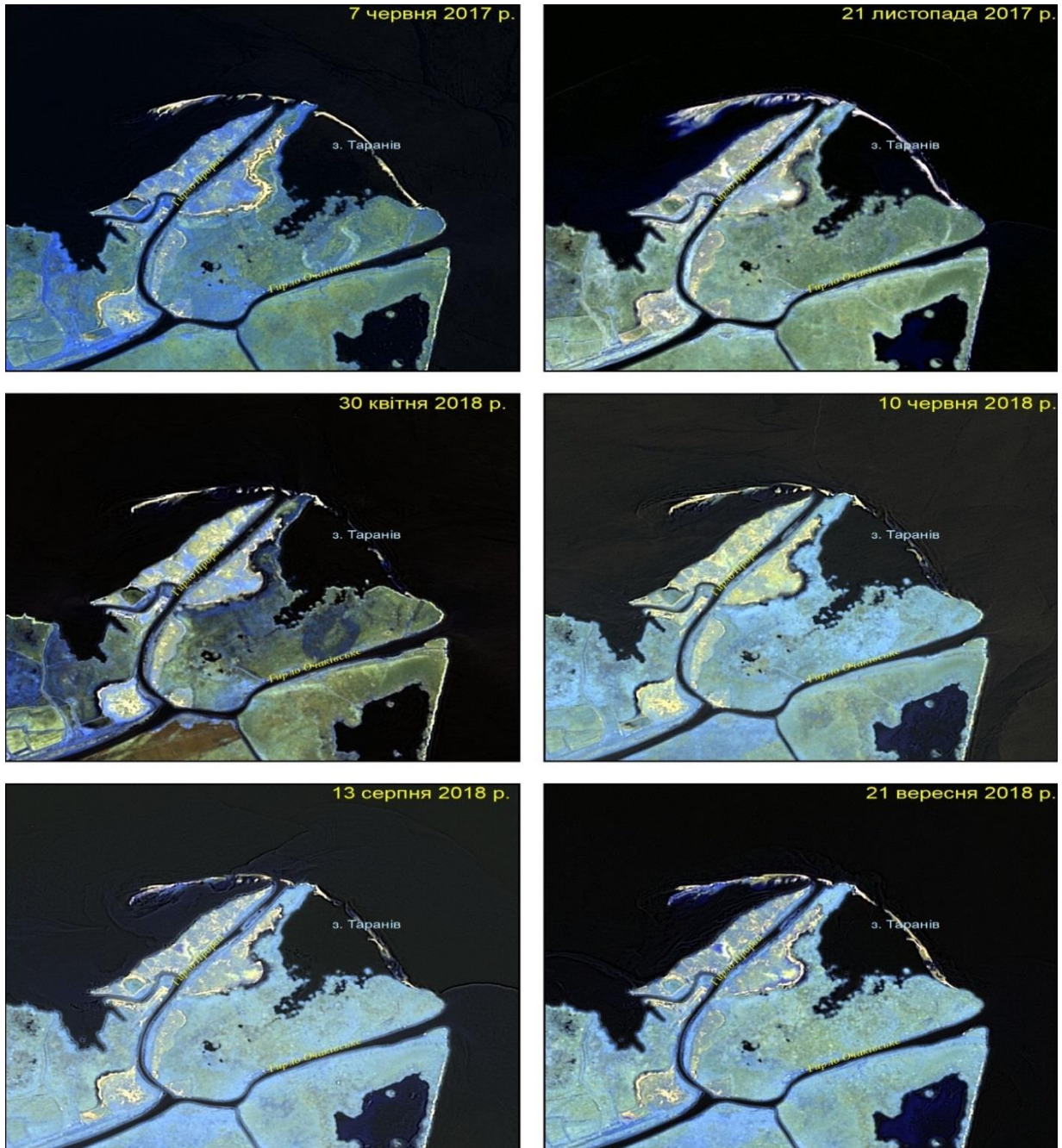
Analysis of the distribution of suspended substances in the western part of the Black Sea in the delta area of Danube showed the following dynamics:

- the zones of maximum degree of turbidity are observed in the area of the main flow of each of the mouths of the Danube. The structure of the turbidity field has a vortex view with lighting towards the sea;

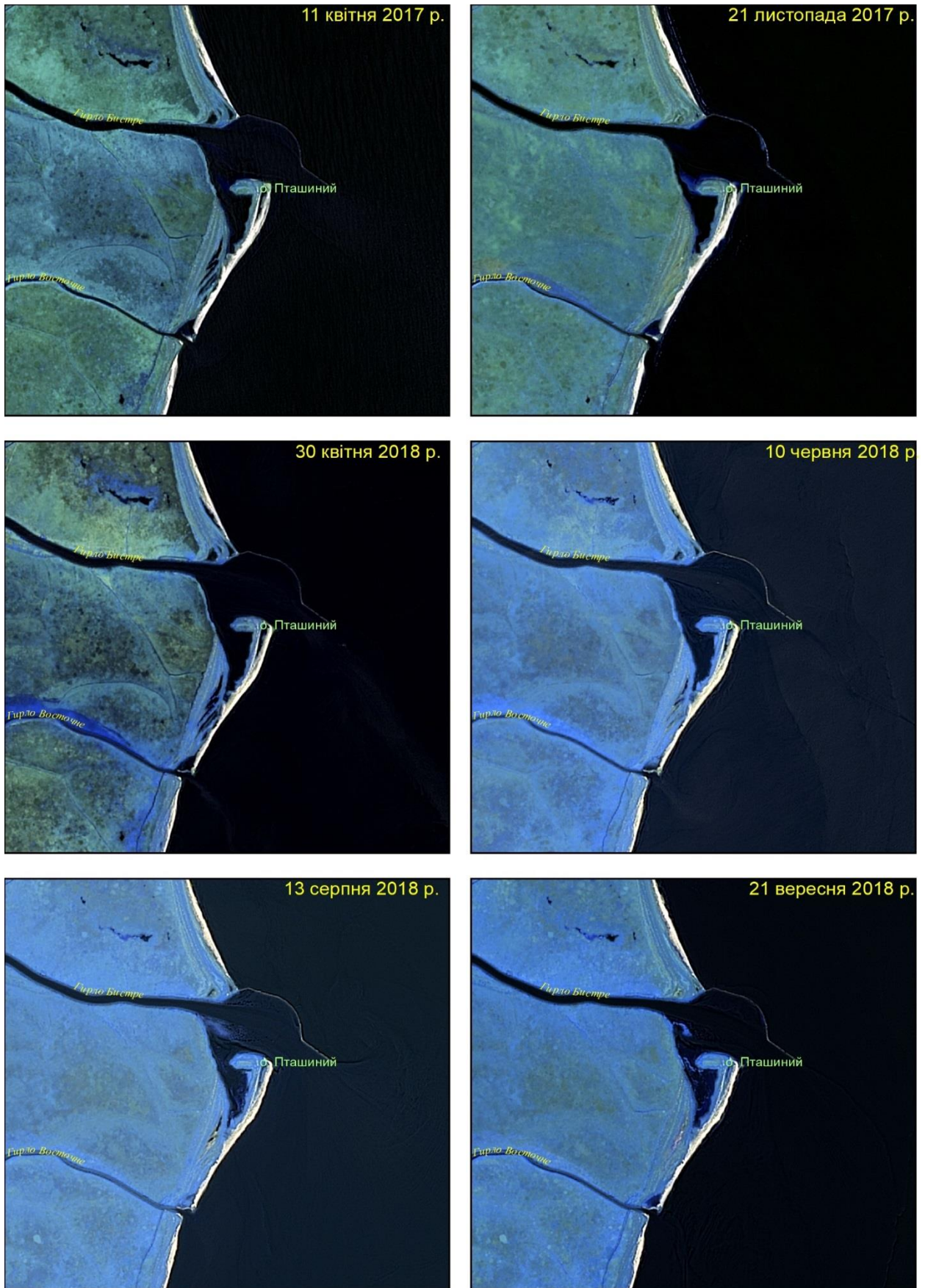
- the general direction of removal of suspended substances is southern, but at certain times along the coastal line the current and (or) winds take them eastwards;

- the intensive removal of suspended substances was observed on August 4 in a southerly direction in the form along the coastal scarf; in late May – early June, the outflow was minimal, in a southeast direction.

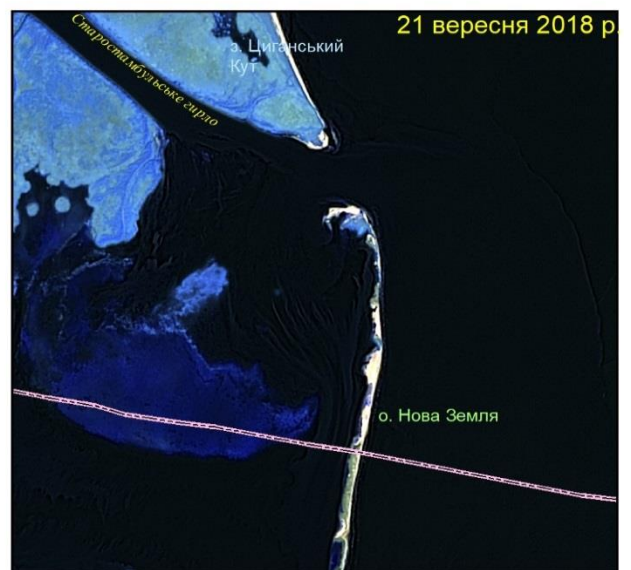
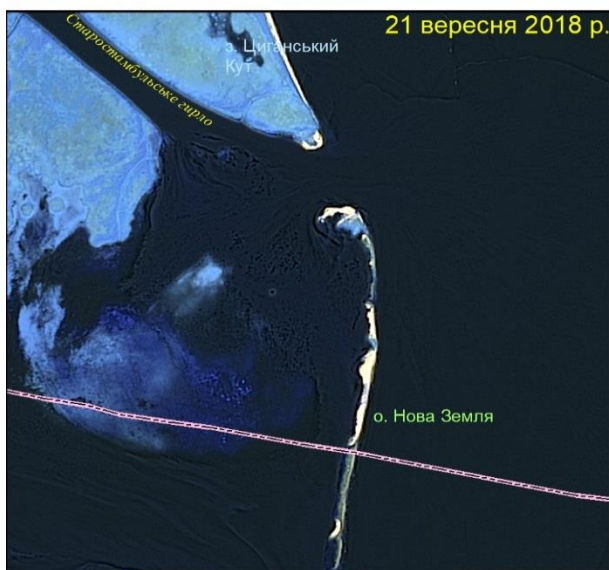
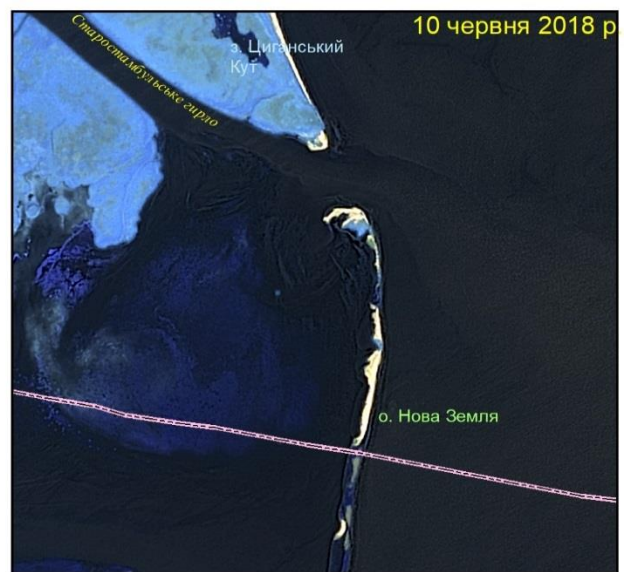
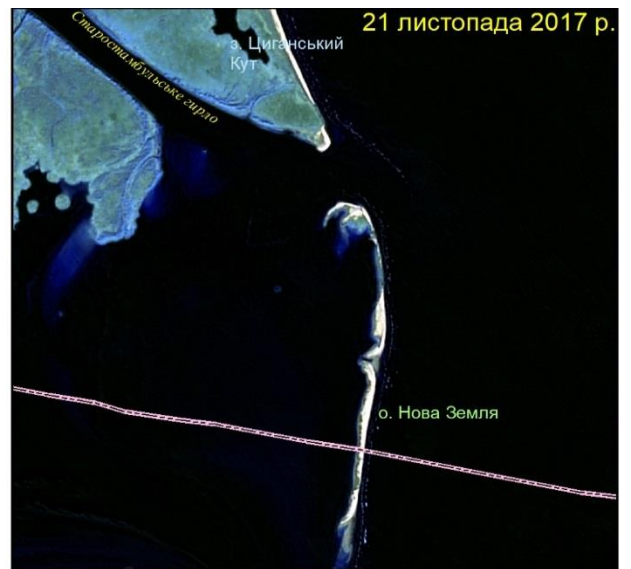
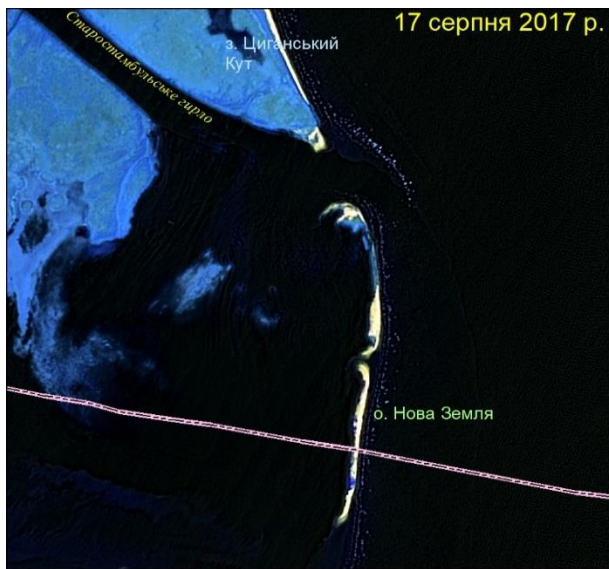
The anomalies of phototones were not observed in the zone of the sea dump of soil.



**Figure 3.** Changes in the coastline and sand bars in the area of the Taranov Bay



**Figure 4.** Changing the configuration of the banks of the Ptichiy island



**Figure 5.** Changing the configuration of the coast of the island of Novaya Zemlya island

## 8. Monitoring of the marine soil dump under the conditions of operation of the Danube - Black Sea DWNC (CHERNOMORNDIPROEKT)

The analysis of the depths at the marine disposal area according to the depth measurement on May 4, 2018 was performed. The calculation of the residual soil content of the disposal area was performed.

The measurement is made with a digital echo sounder "HydroBox" with the definition of the coordinates of the DGPS by equipment company TRIMBLE NAVIGATION. The results of the processing of measurements are presented in tables 2 and 3.

**Table 2.** The state of the depths and the calculation of the residual soil flow at the boot blocks I-VII and the hydraulic waste dumps of the soil. Measurement on 05.10.2017

№ of boot blocks	Block area, m <sup>2</sup>	Depths on the entire block area, m			Depth ≤ 19.0 m				Depth > 19.0 m				Residual soil capacity m <sup>3</sup>
		average	max	min	area, m <sup>2</sup>	average	max	min	area, m <sup>2</sup>	average	max	min	
I	241800	20,3	22,1	18,6	3841	18,8	19,0	18,6	237959	20,3	22,1	19,1	309347
II	241800	21,8	22,4	21,0	-	-	-	-	241800	21,8	22,4	21,0	677040
III	241800	22,3	24,0	20,7	-	-	-	-	241800	22,3	24,0	20,7	797940
IV	241800	22,5	23,6	21,3	-	-	-	-	241800	22,5	23,6	21,3	846300
V	241800	20,7	23,4	17,6	41770	18,5	19,0	17,6	200030	21,3	23,4	19,1	460069
VI	241800	20,8	22,2	18,6	13480	18,9	19,0	18,6	228320	21,0	22,2	19,1	456640
VII	241800	20,0	21,7	17,2	51820	18,2	19,0	17,2	189980	20,5	21,7	19,1	284970
Total, m <sup>3</sup> 3832306													
Calculation of the residual soil capacity on the disposal area, m <sup>3</sup>													
disposal area	2692475	21,4	24,2	17,2	158400	18,4	19,0	17,1	2534075	21,6	24,2	19,1	6588595

**Table 3.** The state of the depths and the calculation of the residual soil flow at the boot blocks I-VII and the hydraulic waste dumps of the soil. Measurement on 04.05.2018

№ of boot blocks	Block area, m <sup>2</sup>	Depths on the entire block area, m			Depth ≤ 19.0 m				Depth > 19.0 m				Residual soil capacity m <sup>3</sup>
		average	max	min	area, m <sup>2</sup>	average	max	min	area, m <sup>2</sup>	average	max	min	
I	241800	20,4	22,1	18,9	757	18,9	19	18,9	241043	20,4	22,1	19,1	337460,2
II	241800	21,9	22,7	21,2	-	-	-	-	241800	21,9	22,7	21,2	701220
III	241800	22,3	24,2	20,8	-	-	-	-	241800	22,3	24,2	20,8	797940
IV	241800	22,6	24	21,1	-	-	-	-	241800	22,6	24	21,1	870480
V	241800	20,8	23,5	17,7	36955	18,5	19	17,7	204845	21,4	23,5	19,1	491628
VI	241800	20,9	22,5	18,7	10397	18,9	19	18,7	231403	21,1	22,5	19,1	485946,3

№ of boat blocks	Block area, m <sup>2</sup>	Depths on the entire block area, m			Depth ≤ 19.0 m			Depth > 19.0 m			Residual soil capacity m <sup>3</sup>		
		average	max	min	area, m <sup>2</sup>	average	max	min	area, m <sup>2</sup>	average		max	min
VII	241800	20,2	22,1	17,4	47971	18,2	19	17,4	193829	20,6	22,1	19,1	310126,4
Total, m <sup>3</sup> 3994801													
Calculation of the residual soil capacity on the disposal area, m <sup>3</sup>													
disposal area	2692475	21,6	24,5	14,4	137827	18,4	19	17,4	2554648	21,8	24,5	19,1	7153014

As part of the monitoring work the preliminary calculation of compensation payments for the impact on the aquatic environment during operational dredging in 2019 was made, taking into account the planned volumes of dredging.

## CONCLUSIONS

The Program of Complex ecological monitoring of the environment during the operation of the “Danube-Black Sea” Deep-Water Navigation Canal on 2018 was fully executed in all directions.

The hydrochemical regime of the Danube River primarily depends with changes in hydrological factors: water amount, water temperature, suspended matter amount. The significant flow velocities and stream turbulence contribute to the homogeneity of chemical parameters and their relatively limited amplitude.

The average phenols concentration is insignificantly exceeded the sanitary-household norms. At the same time, the maximum levels of indicators exceeded the sanitary-household norms for the BOD<sub>5</sub>, the phenols content and the total iron.

It can be noted, that, in general, no noticeable violations of the Danube River ecosystem according to biological indicators summarizing the 2018 research materials.

During 2018 there was no significant impact on the plant and animal groups in the research area from the side of the “Danube-Black Sea” Deep-Water Navigation Canal operation. The impact of the consequences, directly, of the shipping itself (such as pollution, wave formation phenomena, etc.) was also not noted. The flora and fauna development in the reserve was conditioned mainly by the hydrometeorological features of the year.

The greatest negative impact on the natural ecosystems in the reserve has the reduction of the water runoff across the Danube Kilia estuary due to reasons of its redistribution in behalf of the Romanian estuaries.

For the reduce the negative impact on the fish reproduction conditions during the ban of fishing of the Kalkan flounder (in May) and Azov-Black Sea mullet (at the end of August - in the beginning of September), it is advisable to carry out the dredging work at the sea part of the approach channel near the Bystriy estuary (the most freshwater area).

As a whole, the processes, which actively expanded the coastal structures in 2014, slowed in 2015-2017. In 2018, the spatial-temporal changes of the Danube coastal line were characterized with seasonal variations with the keeping of main form of the structural

elements.

The photo-tone anomalies were not observed in the area of the sea dump of soil.

As a whole, according to the results of 2018 monitoring observations, no significant impacts on the environment of the Ukrainian part of the Danube Delta from the operation of the “Danube-Black Sea” Deep-Water Navigation Canal and from the works for keeping of passport characteristics of the sea approach channel, from the sea dumping of soils, and from excavation and storage of sediments. As well as was not identified the cross-border effects on adjacent territories. The changes, which were noted in the Danube Delta ecosystem state are mainly formed by the traditional complex of factors of natural and anthropogenic impact. The development of the plant and animal groups in the delta during the reporting period was associated mainly with climatic and seasonal hydrological changes.