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КАЗЭКОПРОЕКТ

MARINE LIFE SURVEY AT KURYK SITE FOR GREEN HYDROGEN PRODUCTION IN MANGYSTAU REGION OF THE REPUBLIC OF KAZAKHSTAN

AUTUMN-WINTER 2023, SPRING-SUMMER 2024

FINAL REPORT

Almaty, 2024

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List of Abbreviations

Abbreviation	Description
CIS	Commonwealth of Independent States
DDT	Dichloro-diphenyl-trichloroethane
EIA	Environmental Impact Assessment
GW	Gigawatt
HCCH	hexa-chloro-cyclo-hexane
LLP	Limited Liability Partnership
MPC	Maximum permissible concentrations
NTU	Nephelometric turbidity unit
PAH	Polycyclic aromatic hydrocarbons
St	Monitoring station
THC	Total hydrocarbon content
TIWW	Treated Industrial Wastewater
SRLI	Safe reference level of impact
USSR	Union of Socialist Soviet Republics

Introduction

Fichtner GmbH & Co.KG is developing the Environmental and Social Impact Assessment (ESIA) for the Hyrasia One Project of construction of a Renewable Energy Center in Mangystau Region of the Republic of Kazakhstan. The industrial site of the Project will be located to the south of Kuryk village, approximately 65 km southeast of Aktau city. The Project will include the development of wind and solar photovoltaic (PV) farms with a combined capacity of up to 40 GW. These farms will generate clean electricity to power a water electrolysis facility with a capacity of 20 GW.

Water desalination and electrolysis will be carried out at the industrial site near Kuryk and close to the Caspian Sea. The aquatic environment of the Caspian Sea will be impacted through water intake and discharge of the treated wastewater. With the help of the electricity received from the renewable sources and demineralized water, the new plant will produce green hydrogen, which will be further processed into green ammonia.

Fichtner GmbH & Co.KG has assigned Kazecoproject LLP to perform a baseline survey of the marine environment of the Caspian Sea in the Project Area of Influence, i.e. the offshore area where environmental impacts can be expected. The survey has been conducted during four climatic seasons (autumn and winter of 2023; spring and summer of 2024) and included hydrophysical, hydrochemical, hydrobiological and ichthyological studies. These studies will allow to understand the seawater quality and prepare an assessment of the baseline condition of marine flora and fauna before the construction and commissioning of water electrolysis facilities.

The survey is carried out at 20 monitoring stations of marine environment. Among these stations, 13 are located along the future water pipelines; four stations are located at 500 meters from the future treated industrial wastewater discharge point (Decree of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 250 as of July 14, 2021 “Rules of the development of industrial environmental control program for the facilities of first and second category”, item 13 of article 2). The last three monitoring stations are located far from the future treated industrial wastewater discharge point and were selected as the control points (baseline stations) according to the above-mentioned Rules. The location and layout of the monitoring stations are provided in Figure 1 and Figure 2. Coordinates of the stations are given in Table 1.

The main task of the hydrophysical study is to measure in situ the following water parameters: temperature, salinity, turbidity (Horiba U-53 probe); depth; direction and velocity of the sea currents (RCM 9 W probe); water transparency (Secchi disk).

The main task of the hydrochemical study is to collect seawater samples using a Niskin bathometer to determine the presence of biogenic substances (ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, total phosphorus, total nitrogen), as well as to determine pollutants such as hydrocarbons, organochlorine pesticides and some heavy metals. The samples selected for the hydrochemical studies are delivered to Kazecoanalysis LLP analytical laboratory.

The hydrobiological studies include the collection of phytoplankton samples using a Niskin bathometer, the collection of zooplankton samples using a Juday net, the collection of zoobenthos samples and occasional representatives of aquatic vegetation using a Van Veen bottom grab. The presence of hydrobionts indicates the state of the fodder base for ichthyofauna. The samples collected for the hydrobiological studies are delivered to SED LLP laboratory. Qualitative and quantitative parameters of the analytes are determined based on the results of laboratory studies.

Ichthyological samples were collected in order to receive data on the species, sex and age composition of fish population; their weight and size and the presence of valuable commercial or rare fish species. The ichthyological sampling was carried out using trawl catches and net setting at night. Fishing during the survey was carried out based on the permit for scientific and research fishing issued by the authorized body of the Republic of Kazakhstan (see Annex 1).

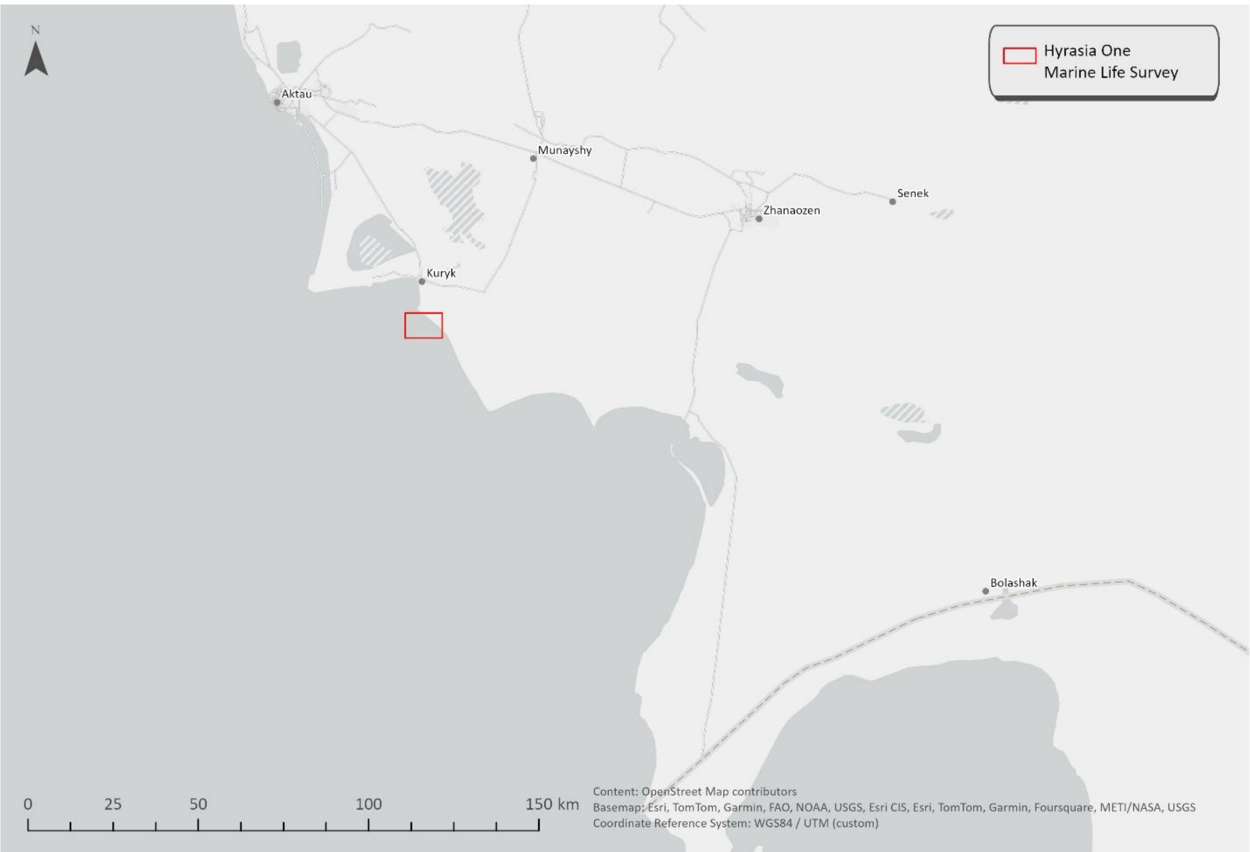

Figure 1. Area of the survey

Table 1. Monitoring stations for the collection of hydrophysical, hydrochemical, hydrobiological and ichthyological samples, and their coordinates

Point	Coordinates (degrees, minutes, seconds)	
	Latitude (N)	Longitude (E)
ST1 – station 1	43° 02' 10.413"	51° 39' 29.655"
ST2 – station 2	43° 02' 49.236"	51° 40' 09.622"
ST3 – station 3	43° 02' 52.368"	51° 40' 40.605"
ST4 – station 4	43° 03' 11.762"	51° 40' 05.702"
ST5 – station 5	43° 03' 15.074"	51° 40' 36.338"
ST6 - station 6	43° 03' 26.806"	51° 41' 16.161"
ST7 – station 7	43° 03' 36.591"	51° 40' 58.582"
ST8 – station 8	43° 03' 46.639"	51° 40' 40.713"
ST9 - station 9	43° 03' 33.529"	51° 41' 51.416"
ST10 - station 10	43° 03' 43.588"	51° 41' 33.515"
ST11 - station 11	43° 04' 03.422"	51° 40' 58.066"
ST12 – station 12	43° 04' 13.194"	51° 40' 40.452"
ST13 – station 13	43° 03' 49.324"	51° 42' 07.047"
ST14 – station 14	43° 03' 59.132"	51° 41' 49.452"
ST15 - station 15	43° 04' 18.697"	51° 41' 14.667"
ST16- station 16	43° 04' 28.453"	51° 40' 56.933"
ST17 – station 17	43° 02' 42.633"	51° 40' 58.140"
ST18 – station 18	43° 04' 15.993"	51° 42' 06.951"
ST19 – station 19	43° 04' 35.531"	51° 41' 31.514"
ST20 – station 20	43° 03' 21.643"	51° 39' 48.102"

Figure 2. Layout and location of the monitoring stations

1. Marine physical environment

1.1. Hydrophysical and hydrometrical parameters of the survey area

The environmental studies conducted are intended to collect baseline data, which then will be compared with the data of future monitoring. As a general practice, environmental data shall be compared on a year-over-year basis using the data from the same periods. Layout of the sampling stations is shown in Figure 2.

The hydrophysical survey covered the following parameters:

- Depth.
- Transparency.
- Horizons, at which the parameters shall be measured.
- Current velocity in the horizons (surface, middle, bottom).
- Current direction in the horizons (surface, middle, bottom).
- Water turbidity in the horizons (surface, middle, bottom).
- Water temperature in the horizons (surface, middle, bottom).
- Water salinity in the horizons (surface, middle, bottom).

The water depth was measured using the onboard echo sounder; water transparency was measured with a Secchi disk (m). The remaining physical and chemical parameters of water were measured using a Horiba field probe and an Aanderaa SeaGuard RCM 9 LW hydrological probe.

1.1.1 Water depth at the monitoring stations

Monitoring of the hydrophysical parameters was carried out at 20 stations for the Project in Mangystau Region of the Republic of Kazakhstan.

In autumn 2023, the greatest depth was observed at station 3, recorded as 22 m. The minimum depth, recorded was 9.3 m at station 19. In winter 2023, water depth at the monitoring stations varied from 9 m at station 18 to 22 m at station 3 (Table 1.1.1-1). During the autumn and winter survey sessions, water depth at stations varied insignificantly (up to 0.3 m).

In spring 2024, the greatest depth was recorded at station 1, recorded as 22.7 m; the lowest depth of 18 m was recorded at station 18. In summer 2024, depth at the surveyed station varied from 8 m (station 18) to 21.5 m (station 1). During the spring and summer survey sessions, water depth at stations varied up to 1.7 m.

During the period of autumn and winter of 2023 and spring and summer of 2024, hydrophysical and hydrochemical parameters of the seawater were measured in the following three horizons at each station at the location of the proposed water intake and water return pipelines:

- surface horizon - 3 m;
- middle horizon - from 5 to 10 m;
- bottom horizon - from 8 to 20 m;

Table 1.1.1-1 Sampling depth during the survey period (autumn 2023 – summer 2024)

No.	Station	Total depth at station, m				Horizon	Sampling depth, m			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer
1	Station 1	22.0	22.0	22.7	21.5	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	10.0	10.0	10.0	10,5
						Bottom horizon	20.0	20.0	20.0	21.0
2	Station 2	21.0	21.0	22.5	20.8	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	10.0	10.0	10.0	10.0
						Bottom horizon	20.0	20.0	20.0	20.0
3	Station 3	22.0	22.0	20.8	20.1	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	10.0	10.0	10.0	10.0
						Bottom horizon	20.0	20.0	20.0	19.5
4	Station 4	20.5	20.5	20.4	20.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	10.0	10.0	10.0	9.5
						Bottom horizon	18.0	18.0	18.0	19.0
5	Station 5	20.0	20.0	19.9	21.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	10.0
						Bottom horizon	18.0	18.0	18.0	20.0

No.	Station	Total depth at station, m				Horizon	Sampling depth, m			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer
6	Station 6	18.4	18.4	19.1	18.5	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	9.0
						Bottom horizon	18.0	18.0	18.0	18.0
7	Station 7	18.7	18.7	19.0	18.8	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	9.0
						Bottom horizon	18.0	18.0	18.0	18.0
8	Station 8	19.6	19.6	19.1	19.6	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	9.5
						Bottom horizon	18.0	18.0	18.0	19.0
9	Station 9	17.4	17.4	18.3	17.3	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	8.5
						Bottom horizon	15.0	15.0	15.0	17.0
10	Station 10	18.5	18.5	18.6	18.4	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	9.0
						Bottom horizon	14.0	14.0	14.0	18.0
11	Station 11	18.6	18.6	18.0	18.4	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	8.5
						Bottom horizon	17.0	17.0	17.0	17.0
12	Station 12	17.3	17.3	17.3	17.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	9.0	9.0	9.0	8.0
						Bottom horizon	17.0	17.0	17.0	16.0
13	Station 13	15.8	15.8	16.0	15.3	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	7.5
						Bottom horizon	14.0	14.0	14.0	15.0
14	Station 14	16.7	16.7	16.6	16.3	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	8.0
						Bottom horizon	15.0	15.0	15.0	15.5
15	Station 15	16.8	16.8	17.0	16.8	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	8.0
						Bottom horizon	15.0	15.0	15.0	16.0
16	Station 16	16.9	16.8	17.0	16.7	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	8.0
						Bottom horizon	15.0	15.0	15.0	16.0
17	Station 17	20.3	20.3	21.3	21.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	10.0	10.0	10.0	10.0
						Bottom horizon	18.0	18.0	18.0	20.0
18	Station 18	9.3	9.0	8.0	8.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	5.0	5.0	5.0	5.0
						Bottom horizon	8.0	8.0	8.0	7.5
19	Station 19	9.3	10.0	10.0	9.0	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	5.0	5.0	5.0	5.0
						Bottom horizon	8.0	8.0	8.0	8.5
20	Station 20	19.5	19.5	20.2	19.8	Surface horizon	3.0	3.0	3.0	3.0
						Middle horizon	8.0	8.0	8.0	8.5
						Bottom horizon	15.0	15.0	15.0	19.0
							S / M / B	S / M / B	S / M / B	S / M / B
Maximum		9.3	9.0	8.0	8.0		3.0 / 5.0 / 8.0	3.0 / 5.0 / 8.0	3.0 / 5.0 / 8.0	3.0 / 5.0 / 7.5
Minimum		22.0	22.0	22.7	21.5		3.0 / 10.0 / 20.0	3.0 / 10.0 / 20.0	3.0 / 10.0 / 20.0	3.0 / 10.5 / 21.0

Note: S – surface horizon
M – middle horizon
B – bottom horizon

1.1.2 Description of bottom sediments at the surveyed site

The bottom sediments in the Middle Caspian Sea predominantly consist of fragmental and carbonate materials, originating from both biogenic and chemical sources.. The hydrochemical regime of the Caspian Sea is characterized by an oversaturation of water with carbonates and high alkaline reserves, which create favorable conditions for the chemical precipitation of carbonates.

In the Middle Caspian Sea, sedimentation types consistently vary from the shallow coastal areas to the deeper regions.. In the coastal area, the bottom is covered with sand with the inclusion of shells, pebble stones and gravel. On the eastern slope of the Middle Caspian Sea, in the absence of river runoff, sediments are mainly formed by carbonates mostly of biogenic origin. The bottom of the central basin of the Middle Caspian Sea is covered with a subcalcareous clay silt surrounded by subcalcareous silt and clay, passing into subcalcareous fine silts on the slope and shelf.

Gray sand with broken shells was mainly observed in the samples within the survey area. However, the survey revealed rocky bottom at stations 9, 17 and 19, where large fragments of rocks were observed during the sampling.

Monitoring stations 9 and 17 are situated in the southern section along the proposed pipeline route, while station 19 is positioned 500 meters from the shore on the northern side of the route. Additionally, at monitoring station 16, which is in the northern section near stations 19 and 15, silt emitting a hydrogen sulfide odour was found in samples of gray sand containing broken shells. In the mid-term (25-30 years) continuous discharge of treated industrial wastewater into the sea's bottom and middle layers could cause significant local changes in the composition and chemistry of the bottom sediments due to the precipitation of salines. These changes can lead to major or moderate impacts on marine hydrobiology. To evaluate the impact of treated industrial wastewater discharge on the composition of the bottom sediments and its subsequent effects on marine hydrobiology, it is essential to model the sedimentation of treated industrial wastewater during the pre-construction stage. This modeling should take into account the hydrophysical and hydrochemical parameters of the discharged water and the potential areas affected.

1.1.3 Water transparency

The transparency of seawater is influenced by its color and turbidity, which are determined by the presence of various colored organic and mineral substances. In turbid water, the decrease in light intensity with depth results in greater absorption of solar energy near the surface. This warmer surface water hinders the transfer of oxygen from air to water, decreases water density, and stabilizes stratification. Moreover, reduced light penetration decreases the efficiency of photosynthesis and the biological productivity of the water. Monitoring water transparency is a crucial component of aquatic environment programs, as an increase in coarse impurities and turbidity is commonly observed in polluted and eutrophic water bodies. During the monitoring, water transparency within the survey area ranged from 6.5 m to 8.0 m in autumn, from 3.4 m to 9.5 m in winter, from 8.0 m to 15.0 m in spring, and from 8.0 m to 14.0 m in summer (Figure 1.1.3.1).

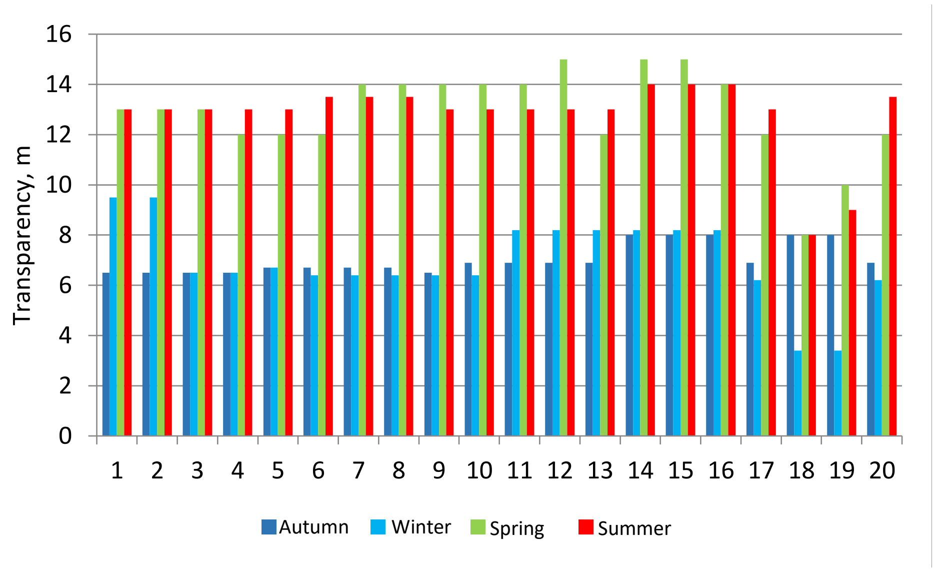

Figure 1.1.3.1 Water transparency in the surveyed area by seasons

The analysis of the autumn hydrometric survey results found no correlation between fluctuations in water transparency and water depth or distance from the shoreline. Thus, the maximum transparency (8.0 m) was recorded at the coastal stations (stations 18 and 19) characterized by the lowest water depth (9.3 m) (Table 1.1.3-1).

The lowest transparency (6.5 m) was recorded at the stations located furthest from the coast (stations 1-4) in water depths ranging from 20.5 to 22.0 m.

During winter, the fluctuation in transparency increased compared to the autumn period, ranging from 3.4 to 9.5 meters. The highest transparency, 9.5 meters, was observed at deep-water stations 1 and 2, where the water depths were 21.0 to 22.0 meters. The lowest transparency, 3.4 meters, was recorded at station 18, which had a depth of 9.0 meters. During the spring and summer periods of the survey, distribution pattern of transparency was homogeneous throughout the survey area. The lowest transparency was recorded at station 18, measuring 8.0 meters, which corresponded to the shallow water depth at that location. The Secchi disk was visible near the bottom at a depth of 8.0 meters. Maximum transparency, ranging from 14.0 to 15.0 meters, was observed in the northern part (stations 12 and 15) and the northeastern part (station 12) of the site, where the depth varied from 16.6 to 17.3 meters.

The maximum transparency was recorded in the northeastern part of the survey area and amounted to 14.0-15.0 m.

Table 1.1.3-1 Water transparency during the survey period (autumn 2023 – summer 2024)

No.	Station	Total water depth, m				Transparency, m			
		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
1	Station 1	22.0	22.0	22.7	21.5	6.5	9.5	13.0	13.0
2	Station 2	21.0	21.0	22.5	20.8	6.5	9.5	13.0	13.0
3	Station 3	22.0	22.0	20.8	20.1	6.5	6.5	13.0	13.0
4	Station 4	20.5	20.5	20.4	20.0	6.5	6.5	12.0	13.0
5	Station 5	20.0	20.0	19.9	21.0	6.7	6.7	12.0	13.0
6	Station 6	18.4	18.4	19.1	18.5	6.7	6.4	12.0	13.5
7	Station 7	18.7	18.7	19.0	18.8	6.7	6.4	14.0	13.5
8	Station 8	19.6	19.6	19.1	19.6	6.7	6.4	14.0	13.5
9	Station 9	17.4	17.4	18.3	17.3	6.5	6.4	14.0	13.0
10	Station 10	18.5	18.5	18.6	18.4	6.9	6.4	14.0	13.0
11	Station 11	18.6	18.6	18.0	18.4	6.9	8.2	14.0	13.0
12	Station 12	17.3	17.3	17.3	17.0	6.9	8.2	15.0	13.0
13	Station 13	15.8	15.8	16.0	15.3	6.9	8.2	12.0	13.0
14	Station 14	16.7	16.7	16.6	16.3	8.0	8.2	15.0	14.0
15	Station 15	16.8	16.8	17.0	16.8	8.0	8.2	15.0	14.0
16	Station 16	16.9	16.8	17.0	16.7	8.0	8.2	14.0	14.0
17	Station 17	20.3	20.3	21.3	21	6.9	6.2	12.0	13.0
18	Station 18	9.3	9.0	8.0	8.0	8.0	3.4	8.0	8.0
19	Station 19	9.3	10.0	10.0	9.0	8.0	3.4	10.0	9.0
20	Station 20	19.5	19.5	20.2	19.8	6.9	6.2	12.0	13.5
Minimum						6.5	3.4	8.0	8.0
Maximum						8.0	9.5	15.0	14.0

Summarizing the received results, it can be concluded that the minimum transparency of water in the surveyed area was observed the autumn and winter periods, when wind exposure increases, and intensive displacement of water masses occurs. In spring and summer, suspended substances settle onto the seabed which increases the transparency level.

The discharge of treated industrial wastewater to the bottom layers is not expected to cause significant changes in water transparency in the surveyed area. However, discharging treated industrial wastewater to the middle and surface layers over the mid-term (25-30 years) and continuously could lead to notable changes in water transparency, particularly within the potential impact area. Therefore, mitigation measures should be developed and implemented during the pre-construction phase and detailed at the ESIA/ESMP stage to minimize or avoid mid-term impacts on water transparency.

1.1.4 Water temperature

Water temperature is an important hydrophysical parameter of a water body that influences a range of physical, chemical, biochemical, and biological processes. It significantly impacts the oxygen regime and the intensity of self-purification processes. Additionally, water temperature values are essential for calculating the level of oxygen saturation in the water. The temperature regime of the surveyed area is predetermined by its geographical location, water depth, heat exchange with the atmosphere, convection, and internal heat exchange between the marine water of the Middle Caspian Sea and Southern Caspian Sea.

In autumn, water temperature varied depending on the weather conditions on days of monitoring. Water temperature ranged from 13.63 °C to 15.25 °C in the surface horizon; from 13.56 ° C to 14.69 °C in the middle horizon; and from 13.32 ° C to 14.58 °C in the bottom horizon (Figure 1.1.4.1).

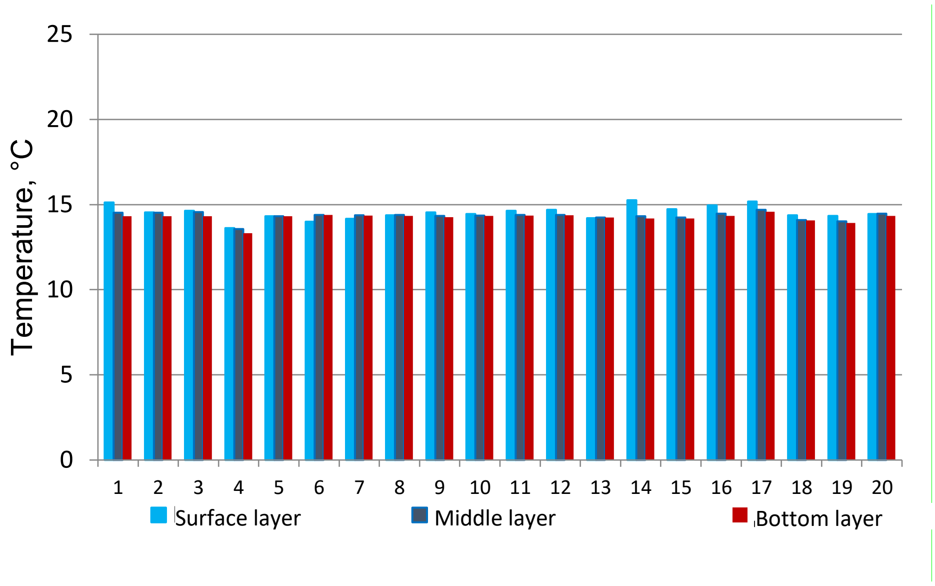

Figure 1.1.4.1 Water temperature at the surveyed stations in autumn 2023

In winter, water temperature ranged from 6.23 °C to 6.56 °C in the surface horizon; from 5.97 °C to 6.55 °C in the middle horizon; and from 5.89 °C to 6.55 °C in the bottom horizon (Figure 1.1.4.2, Table 1.1.4-1).

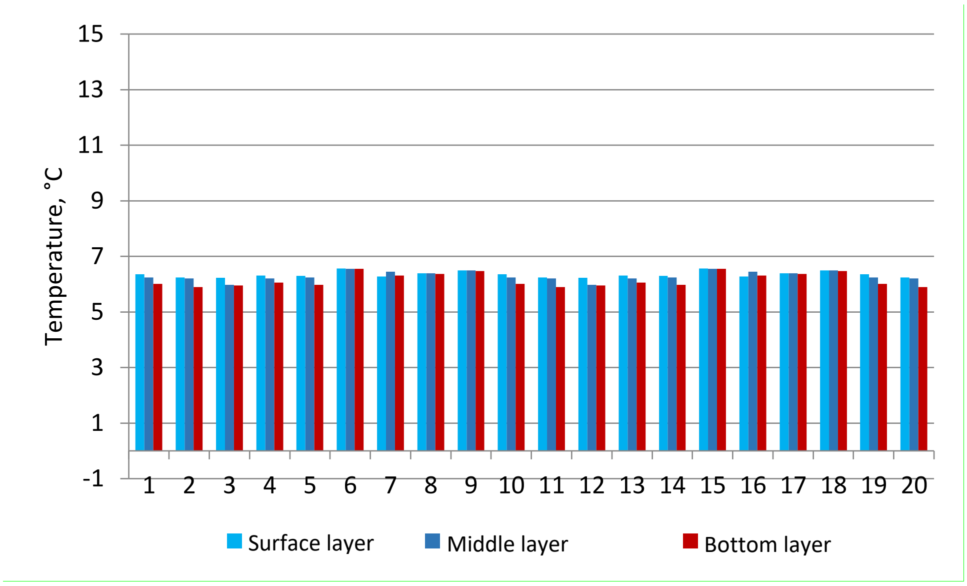

Figure 1.1.4.2 Water temperature at the surveyed stations in winter 2023

In spring, water temperature ranged from 8.22 °C to 10.18 °C in the surface horizon; from 7.93 °C to 9.58 °C in the middle horizon; and from 7.74 °C to 9.45 °C in the bottom horizon (Figure 1.1.4.3).

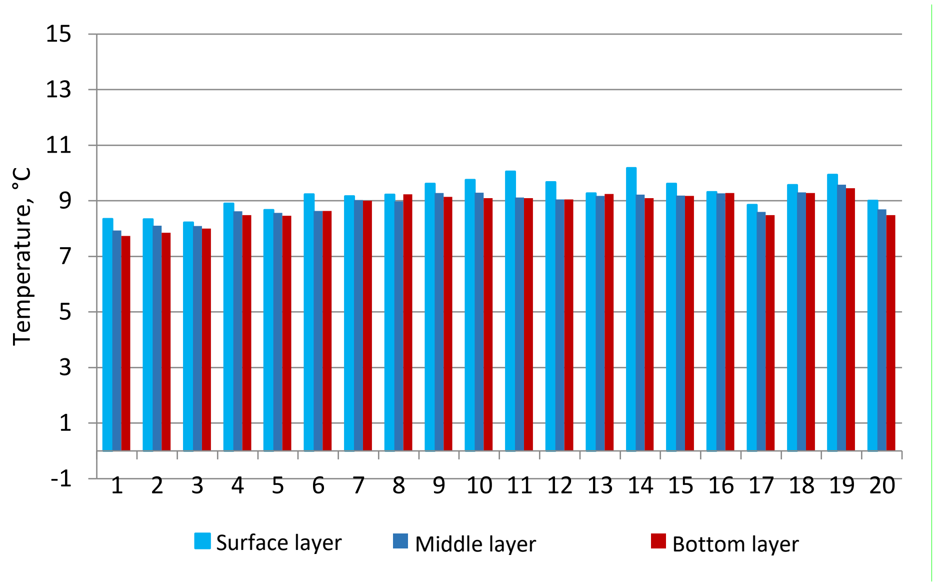

Figure 1.1.4.3 Water temperature at the surveyed stations in spring 2024

In summer, water temperature varied between 17.06 °C and 21.58 °C in the surface horizon; 14.59 °C and 18.93 °C in the middle horizon; and 13.31 °C and 18.02 °C in the bottom horizon (Figure 1.1.4.4).

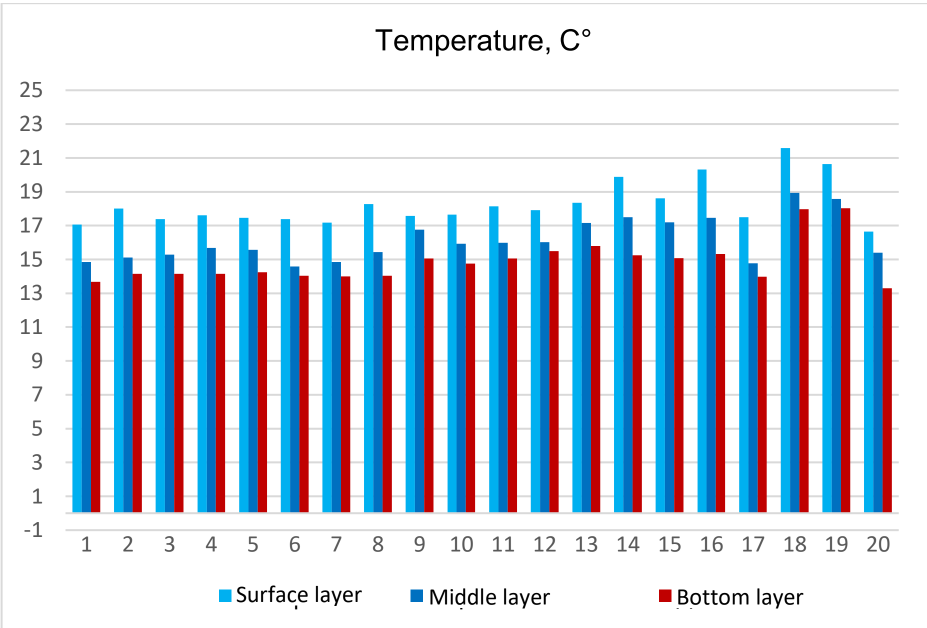

Figure 1.1.4.4 Water temperature at the surveyed stations in summer 2024

Overall, the water temperature in the surveyed area aligned with the long-term seasonal dynamics typical of the water temperature regime in the eastern part of the Middle Caspian Sea. The lack of a sharp difference between the temperatures recorded in the surface and bottom layers during autumn and winter can be attributed to phenomena commonly observed during these periods. According to this phenomenon, as air temperature declines in autumn, the surface layer of the sea cools down and the thermocline layer blurs[1]. In spring, all water layers warmed up uniformly, resulting in a consistent distribution of temperature values. During the summer period, the near-bottom and deep-water layers also warmed evenly due to active water circulation. The maximum water depth in the surveyed area was 22.7 meters, and the temperature difference between the layers did not exceed 3.6°C. Consequently, a thermocline was not observed in the surveyed area. Water temperature monitoring data for the survey period from autumn 2023 to summer 2024 is provided below in Table 1.1.4-1.

[1] On the eastern part of the Middle Casian Sea thermocline is usually fixed at a depth from 20 to 40 meters, with a jump in water temperature from 10 °C and more. In our survey, the maximum water depth in the surveyed area was 22.7 meters, and temperature difference between the layer was maximum 3.6 °C

Table 1.1.4-1 Water temperature during the survey period (autumn 2023 – summer 2024)

No.	Station	Total water depth, m				Horizon	Sampling depth, m				Temperature, °C			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
1	Station 1	22.0	22.0	22.7	21.5	Surface	3.0	3.0	3.0	3.0	15.12	6.36	8.35	17.06
						Middle	10.0	10.0	10.0	10.5	14.52	6.24	7.93	14.85
						Bottom	20.0	20.0	20.0	21.0	14.32	6.01	7.74	13.68
2	Station 2	21.0	21.0	22.5	20.8	Surface	3.0	3.0	3.0	3.0	14.55	6.24	8.33	18.01
						Middle	10.0	10.0	10.0	10.0	14.52	6.20	8.10	15.12
						Bottom	20.0	20.0	20.0	20.0	14.32	5.89	7.85	14.15
3	Station 3	22.0	22.0	20.8	20.1	Surface	3.0	3.0	3.0	3.0	14.64	6.23	8.22	17.38
						Middle	10.0	10.0	10.0	10.0	14.56	5.97	8.09	15.29
						Bottom	20.0	20.0	20.0	19.5	14.32	5.95	8.00	14.15
4	Station 4	20.5	20.5	20.4	20.0	Surface	3.0	3.0	3.0	3.0	13.63	6.31	8.90	17.60
						Middle	10.0	10.0	10.0	9.5	13.56	6.21	8.62	15.68
						Bottom	18.0	18.0	18.0	19.0	13.32	6.05	8.49	14.16
5	Station 5	20.0	20.0	19.9	21.0	Surface	3.0	3.0	3.0	3.0	14.31	6.30	8.67	17.47
						Middle	9.0	9.0	9.0	10.0	14.32	6.24	8.57	15.57
						Bottom	18.0	18.0	18.0	20.0	14.32	5.98	8.46	14.25
6	Station 6	18.4	18.4	19.1	18.5	Surface	3.0	3.0	3.0	3.0	14.00	6.56	9.24	17.38
						Middle	9.0	9.0	9.0	9.0	14.40	6.55	8.64	14.59
						Bottom	18.0	18.0	18.0	18.0	14.39	6.55	8.64	14.03
7	Station 7	18.7	18.7	19.0	18.8	Surface	3.0	3.0	3.0	3.0	14.17	6.28	9.16	17.18
						Middle	9.0	9.0	9.0	9.0	14.38	6.45	9.03	14.85
						Bottom	18.0	18.0	18.0	18.0	14.36	6.31	9.00	13.99
8	Station 8	19.6	19.6	19.1	19.6	Surface	3.0	3.0	3.0	3.0	14.37	6.39	9.22	18.27
						Middle	9.0	9.0	9.0	9.5	14.40	6.39	8.98	15.44
						Bottom	18.0	18.0	18.0	19.0	14.33	6.37	9.23	14.04
9	Station 9	17.4	17.4	18.3	17.3	Surface	3.0	3.0	3.0	3.0	14.55	6.49	9.62	17.57
						Middle	8.0	8.0	8.0	8.5	14.34	6.49	9.28	16.76
						Bottom	15.0	15.0	15.0	17.0	14.26	6.47	9.14	15.06
10	Station 10	18.5	18.5	18.6	18.4	Surface	3.0	3.0	3.0	3.0	14.44	6.36	9.75	17.65
						Middle	8.0	8.0	8.0	9.0	14.35	6.24	9.29	15.93
						Bottom	14.0	14.0	14.0	18.0	14.34	6.01	9.10	14.76
11	Station 11	18.6	18.6	18.0	18.4	Surface	3.0	3.0	3.0	3.0	14.64	6.24	10.05	18.14
						Middle	9.0	9.0	9.0	8.5	14.40	6.20	9.12	15.98
						Bottom	17.0	17.0	17.0	17.0	14.36	5.89	9.10	15.05
12	Station 12	17.3	17.3	17.3	17.0	Surface	3.0	3.0	3.0	3.0	14.69	6.23	9.67	17.91
						Middle	9.0	9.0	9.0	8.0	14.40	5.97	9.05	16.01
						Bottom	17.0	17.0	17.0	16.0	14.37	5.95	9.05	15.49
13	Station 13	15.8	15.8	16	15.3	Surface	3.0	3.0	3.0	3.0	14.20	6.31	9.27	18.34
						Middle	8.0	8.0	8.0	7.5	14.25	6.21	9.18	17.15
						Bottom	14.0	14.0	14.0	15.0	14.25	6.05	9.25	15.80
14	Station 14	16.7	16.7	16.6	16.3	Surface	3.0	3.0	3.0	3.0.	15.25	6.30	10.18	19.87
						Middle	8.0	8.0	8.0	8.0	14.32	6.24	9.22	17.49

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Station</th><th colspan="4">Total water depth, m</th><th rowspan="2">Horizon</th><th colspan="12">Sampling depth, m</th><th colspan="12">Temperature, °C</th></tr>
<tr><th>Autumn</th><th>Winter</th><th>Spring</th><th>Summer</th><th colspan="3">Autumn</th><th colspan="3">Winter</th><th colspan="3">Spring</th><th colspan="3">Summer</th><th colspan="3">Autumn</th><th colspan="3">Winter</th><th colspan="3">Spring</th><th colspan="3">Summer</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Bottom</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.5</td><td colspan="3">14.18</td><td colspan="3">5.98</td><td colspan="3">9.10</td><td colspan="3">15.25</td></tr>
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<tr><td>Bottom</td><td colspan="3">18.0</td><td colspan="3">18.0</td><td colspan="3">18.0</td><td colspan="3">20.0</td><td colspan="3">14.58</td><td colspan="3">6.37</td><td colspan="3">8.49</td><td colspan="3">13.98</td></tr>
<tr><td rowspan="3">18</td><td rowspan="3">Station 18</td><td rowspan="3">9.3</td><td rowspan="3">9.0</td><td rowspan="3">8.0</td><td rowspan="3">8.0</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">14.37</td><td colspan="3">6.49</td><td colspan="3">9.57</td><td colspan="3">21.58</td></tr>
<tr><td>Middle</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">14.10</td><td colspan="3">6.49</td><td colspan="3">9.30</td><td colspan="3">18.93</td></tr>
<tr><td>Bottom</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">7.5</td><td colspan="3">14.07</td><td colspan="3">6.47</td><td colspan="3">9.28</td><td colspan="3">17.97</td></tr>
<tr><td rowspan="3">19</td><td rowspan="3">Station 19</td><td rowspan="3">9.3</td><td rowspan="3">10.0</td><td rowspan="3">10.0</td><td rowspan="3">9.0</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">14.33</td><td colspan="3">6.36</td><td colspan="3">9.94</td><td colspan="3">20.65</td></tr>
<tr><td>Middle</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">5.0</td><td colspan="3">14.01</td><td colspan="3">6.24</td><td colspan="3">9.58</td><td colspan="3">18.58</td></tr>
<tr><td>Bottom</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.5</td><td colspan="3">13.93</td><td colspan="3">6.01</td><td colspan="3">9.45</td><td colspan="3">18.02</td></tr>
<tr><td rowspan="3">20</td><td rowspan="3">Station 20</td><td rowspan="3">19.5</td><td rowspan="3">19.5</td><td rowspan="3">20.2</td><td rowspan="3">19.8</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">14.45</td><td colspan="3">6.24</td><td colspan="3">9.00</td><td colspan="3">16.65</td></tr>
<tr><td>Middle</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.5</td><td colspan="3">14.47</td><td colspan="3">6.20</td><td colspan="3">8.69</td><td colspan="3">15.39</td></tr>
<tr><td>Bottom</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">19.0</td><td colspan="3">14.33</td><td colspan="3">5.89</td><td colspan="3">8.49</td><td colspan="3">13.31</td></tr>
<tr><td colspan="7"></td><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th><th>S</th><th>M</th><th>B</th></tr>
<tr><td colspan="2">Minimum</td><td>9.3</td><td>9.0</td><td>8.0</td><td>8.0</td><td></td><td>3.0</td><td>5.0</td><td>8.0</td><td>3.0</td><td>5.0</td><td>8.0</td><td>3.0</td><td>5.0</td><td>8.0</td><td>3.0</td><td>5.0</td><td>7.5</td><td>13.63</td><td>13.56</td><td>13.32</td><td>6.23</td><td>5.97</td><td>5.89</td><td>8.22</td><td>7.93</td><td>7.74</td><td>18.34</td><td>14.59</td><td>13.31</td></tr>
<tr><td colspan="2">Maximum</td><td>22.0</td><td>22.0</td><td>22.7</td><td>21.5</td><td></td><td>3.0</td><td>10.0</td><td>20.0</td><td>3.0</td><td>10.0</td><td>20.0</td><td>3.0</td><td>10.0</td><td>20.0</td><td>3.0</td><td>10.5</td><td>21.0</td><td>15.25</td><td>14.69</td><td>14.58</td><td>6.56</td><td>6.55</td><td>6.55</td><td>10.18</td><td>9.58</td><td>9.45</td><td>21.58</td><td>18.93</td><td>18.02</td></tr>
</table>

Note: S – surface horizon
M – middle horizon
B – bottom horizon

In general, the temperature regime of water in the surveyed area can be characterized as favorable for the Project. Thus, in winter period, the temperature of water surface was not below 5.0 °C. Therefore, ice, surface water frozen situation will not present and create an obstacle to the operation of the industrial facility.

The temperature could increase significantly (by 3°C or more) at the point of treated industrial wastewater discharge, depending on the temperature of the discharged water. However, due to the constant movement and mixing of water masses, the impact will be temporary and will decrease from significant to moderate or low over time. It will not affect the thermocline layer as well (see footnote 1 above).

To assess the possible impacts of treated industrial wastewater discharge on hydrophysical, hydrochemical, and hydrobiological parameters, modeling of water temperature dynamics should be conducted during the pre-construction phase. Although DREAM modeling carried out at the pre-FEED stage indicates no major impact or low impact on water temperature, further modeling is recommended.

1.1.5 Salinity

Salinity is one of the most important physicochemical parameters that determines the formation and distribution of various ecological groups of aquatic organisms, including fish of generative freshwater origin, which include the most valuable commercial fish species.

In autumn, salinity ranged within 11.5 – 11.64 ‰ (ppm) in the surface layer; within 11.49 – 11.67 ‰ in the middle layer; and within 11.47 – 11.67 ‰ in the bottom layer (Figure 1.1.5.1).

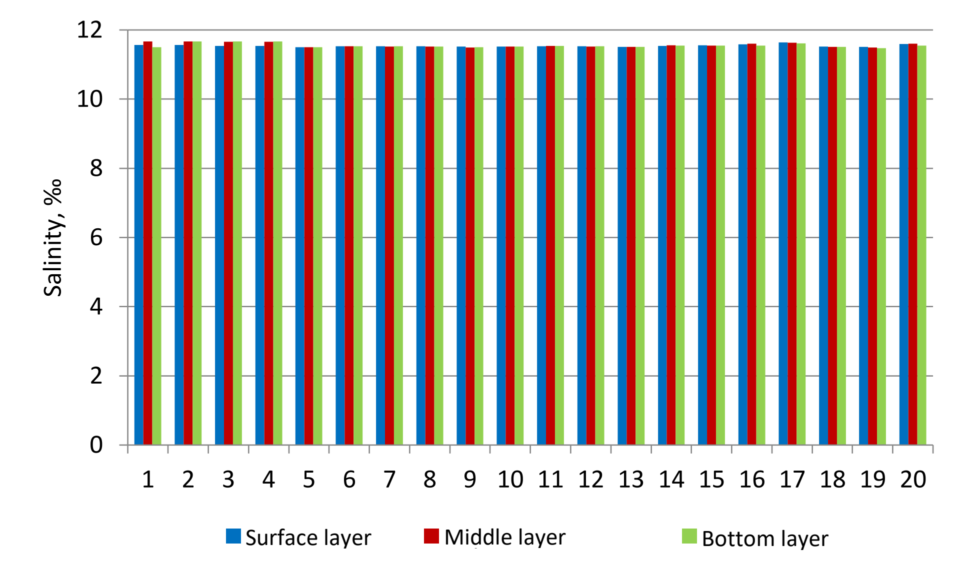

Figure 1.1.5.1 Water salinity at the surveyed stations in autumn 2023

In winter, salinity ranged from 10.71 – 10.8 ‰ (ppm) in the surface layer; from10.63 – 10.8 ‰ in the middle layer; and from 10.61 – 10.8 ‰ in the bottom layer (Figure 1.1.5.2).

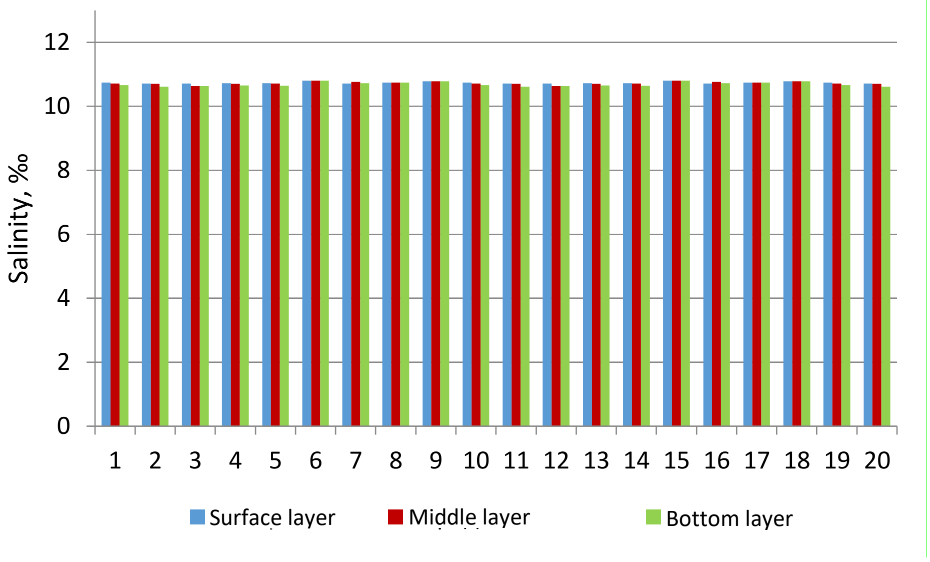

Figure 1.1.5.2 Water salinity at the surveyed stations in winter 2023

In spring, salinity ranged from 10.57 – 11.73 ‰ (ppm) in the surface layer; from 10.68 – 11.51 ‰ in the middle layer; and from 9.11 – 11.52 ‰ in the bottom layer (Figure 1.1.5.3).

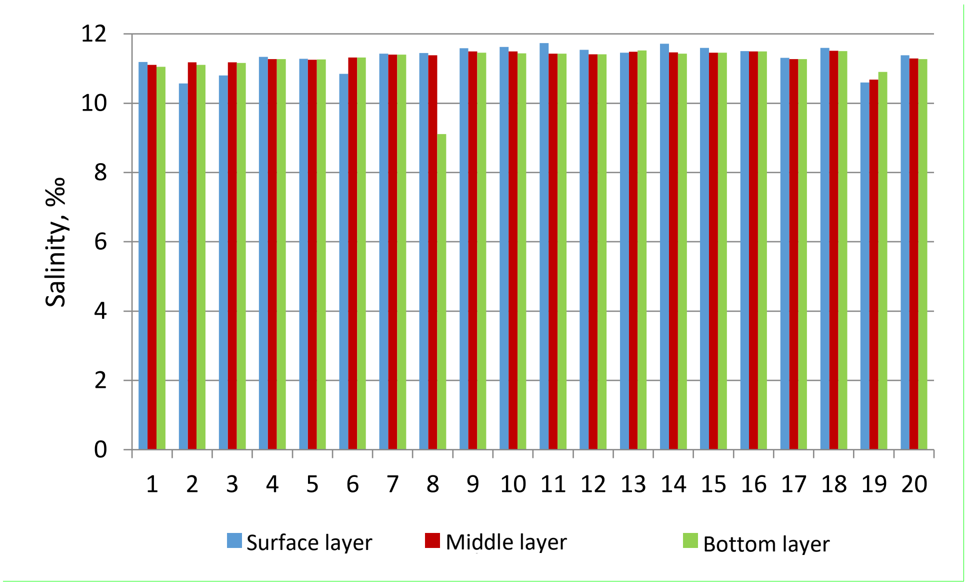

Figure 1.1.5.3 Water salinity at the surveyed stations in spring 2024

In summer, salinity ranged from 9.78 – 13.18 ‰ (ppm) in the surface layer; from 10.32 – 12.73 ‰ in the middle layer; and from 10.52 – 12.61 ‰ in the bottom layer (Figure 1.1.5.4, Table 1.1.5-1).

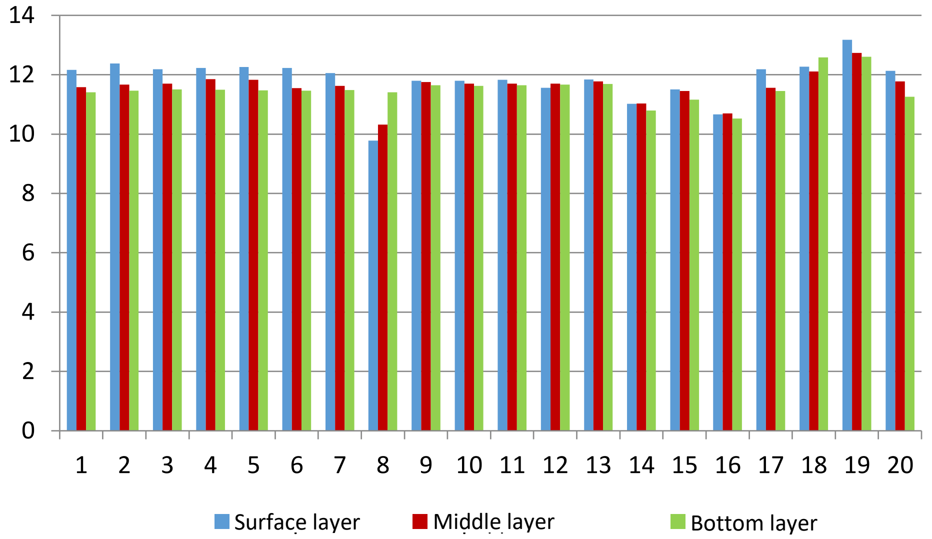

Figure 1.1.5.4 Water salinity at the surveyed stations in summer 2024

The decline in salinity levels from autumn to winter contributes to decreased horizontal circulation in summer, allowing saltier water from the southern part of the sea to flow along the eastern coast into the Middle Caspian Sea. As temperatures decrease, this saline water gradually transfers from the Middle Caspian Sea to the deep layers of the South Caspian Depression. Consequently, increasing salinity was observed across all horizons during the spring and summer periods due to the inflow of salty waters from the South Caspian Sea into the survey area. Water salinity monitoring data for the survey area from autumn 2023 to summer 2024 is provided below in Table 1.1.5-1.

Table 1.1.5-1 Water salinity during the survey period (autumn 2023 – summer 2024)

No.	Station	Total water depth, m				Horizon	Sampling depth, m				Salinity, ‰			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
1	Station 1	22.0	22.0	22.7	21.5	Surface	3.0	3.0	3.0	3.0	11.57	10.74	11.19	12.16
						Middle	10.0	10.0	10.0	10.5	11.67	10.71	11.11	11.58
						Bottom	20.0	20.0	20.0	21.0	11.50	10.66	11.05	11.41
2	Station 2	21.0	21.0	22.5	20.8	Surface	3.0	3.0	3.0	3.0	11.57	10.71	10.57	12.38
						Middle	10.0	10.0	10.0	10.0	11.67	10.70	11.18	11.67
						Bottom	20.0	20.0	20.0	20.0	11.67	10.61	11.11	11.46
3	Station 3	22.0	22.0	20.8	20.1	Surface	3.0	3.0	3.0	3.0	11.54	10.71	10.80	12.18
						Middle	10.0	10.0	10.0	10.0	11.66	10.63	11.18	11.70
						Bottom	20.0	20.0	20.0	19.5	11.67	10.63	11.16	11.50
4	Station 4	20.5	20.5	20.4	20.0	Surface	3.0	3.0	3.0	3.0	11.54	10.72	11.34	12.23
						Middle	10.0	10.0	10.0	9.5	11.66	10.70	11.27	11.85
						Bottom	18.0	18.0	18.0	19.0	11.67	10.65	11.27	11.49
5	Station 5	20.0	20.0	19.9	21.0	Surface	3.0	3.0	3.0	3.0	11.50	10.72	11.28	12.26
						Middle	9.0	9.0	9.0	10.0	11.50	10.71	11.25	11.83
						Bottom	18.0	18.0	18.0	20.0	11.50	10.64	11.26	11.47
6	Station 6	18.4	18.4	19.1	18.5	Surface	3.0	3.0	3.0	3.0	11.53	10.80	10.85	12.23
						Middle	9.0	9.0	9.0	9.0	11.53	10.80	11.32	11.55
						Bottom	18.0	18.0	18.0	18.0	11.53	10.80	11.32	11.46
7	Station 7	18.7	18.7	19.0	18.8	Surface	3.0	3.0	3.0	3.0	11.53	10.71	11.43	12.06
						Middle	9.0	9.0	9.0	9.0	11.52	10.76	11.40	11.62
						Bottom	18.0	18.0	18.0	18.0	11.53	10.72	11.40	11.48
8	Station 8	19.6	19.6	19.1	19.6	Surface	3.0	3.0	3.0	3.0	11.53	10.74	11.45	9.78
						Middle	9.0	9.0	9.0	9.5	11.52	10.74	11.38	10.32
						Bottom	18.0	18.0	18.0	19.0	11.52	10.74	9.11	11.41
9	Station 9	17.4	17.4	18.3	17.3	Surface	3.0	3.0	3.0	3.0	11.52	10.78	11.59	11.80
						Middle	8.0	8.0	8.0	8.5	11.49	10.78	11.49	11.75
						Bottom	15.0	15.0	15.0	17.0	11.50	10.78	11.46	11.65
10	Station 10	18.5	18.5	18.6	18.4	Surface	3.0	3.0	3.0	3.0	11.52	10.74	11.62	11.80
						Middle	8.0	8.0	8.0	9.0	11.52	10.71	11.49	11.70
						Bottom	14.0	14.0	14.0	18.0	11.52	10.66	11.44	11.62
11	Station 11	18.6	18.6	18.0	18.4	Surface	3.0	3.0	3.0	3.0	11.53	10.71	11.73	11.83
						Middle	9.0	9.0	9.0	8.5	11.54	10.70	11.43	11.70
						Bottom	17.0	17.0	17.0	17.0	11.54	10.61	11.43	11.64
12	Station 12	17.3	17.3	17.3	17.0	Surface	3.0	3.0	3.0	3.0	11.53	10.71	11.54	11.56
						Middle	9.0	9.0	9.0	8.0	11.52	10.63	11.41	11.70
						Bottom	17.0	17.0	17.0	16.0	11.53	10.63	11.41	11.67
13	Station 13	15.8	15.8	16.0	15.3	Surface	3.0	3.0	3.0	3.0	11.51	10.72	11.46	11.84
						Middle	8.0	8.0	8.0	7.5	11.51	10.70	11.48	11.77
						Bottom	14.0	14.0	14.0	15.0	11.51	10.65	11.52	11.69
14	Station 14	16.7	16.7	16.6	16.3	Surface	3.0	3.0	3.0	3.0	11.54	10.72	11.72	11.02
						Middle	8.0	8.0	8.0	8.0	11.56	10.71	11.47	11.03

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Station</th><th colspan="4">Total water depth, m</th><th rowspan="2">Horizon</th><th colspan="12">Sampling depth, m</th><th colspan="12">Salinity, ‰</th></tr>
<tr><th>Autumn</th><th>Winter</th><th>Spring</th><th>Summer</th><th colspan="3">Autumn</th><th colspan="3">Winter</th><th colspan="3">Spring</th><th colspan="3">Summer</th><th colspan="3">Autumn</th><th colspan="3">Winter</th><th colspan="3">Spring</th><th colspan="3">Summer</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Bottom</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.5</td><td colspan="3">11.55</td><td colspan="3">10.64</td><td colspan="3">11.43</td><td colspan="3">10.79</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Station 15</td><td rowspan="3">16.8</td><td rowspan="3">16.8</td><td rowspan="3">17.0</td><td rowspan="3">16.8</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">11.56</td><td colspan="3">10.80</td><td colspan="3">11.60</td><td colspan="3">11.50</td></tr>
<tr><td>Middle</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">11.55</td><td colspan="3">10.80</td><td colspan="3">11.46</td><td colspan="3">11.45</td></tr>
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<tr><td>Middle</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">11.60</td><td colspan="3">10.76</td><td colspan="3">11.49</td><td colspan="3">10.70</td></tr>
<tr><td>Bottom</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">15.0</td><td colspan="3">16.0</td><td colspan="3">11.55</td><td colspan="3">10.72</td><td colspan="3">11.49</td><td colspan="3">10.52</td></tr>
<tr><td rowspan="3">17</td><td rowspan="3">Station 17</td><td rowspan="3">20.3</td><td rowspan="3">20.3</td><td rowspan="3">21.3</td><td rowspan="3">21.0</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">11.64</td><td colspan="3">10.74</td><td colspan="3">11.31</td><td colspan="3">12.18</td></tr>
<tr><td>Middle</td><td colspan="3">10.0</td><td colspan="3">10.0</td><td colspan="3">10.0</td><td colspan="3">10.0</td><td colspan="3">11.63</td><td colspan="3">10.74</td><td colspan="3">11.27</td><td colspan="3">11.56</td></tr>
<tr><td>Bottom</td><td colspan="3">18.0</td><td colspan="3">18.0</td><td colspan="3">18.0</td><td colspan="3">20.0</td><td colspan="3">11.61</td><td colspan="3">10.74</td><td colspan="3">11.27</td><td colspan="3">11.45</td></tr>
<tr><td rowspan="3">18</td><td rowspan="3">Station 18</td><td rowspan="3">9.3</td><td rowspan="3">9.0</td><td rowspan="3">8.0</td><td rowspan="3">8.0</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">11.52</td><td colspan="3">10.78</td><td colspan="3">11.60</td><td colspan="3">12.27</td></tr>
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<tr><td>Bottom</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.0</td><td colspan="3">8.5</td><td colspan="3">11.47</td><td colspan="3">10.66</td><td colspan="3">10.90</td><td colspan="3">12.61</td></tr>
<tr><td rowspan="3">20</td><td rowspan="3">Station 20</td><td rowspan="3">19.5</td><td rowspan="3">19.5</td><td rowspan="3">20.2</td><td rowspan="3">19.8</td><td>Surface</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">3.0</td><td colspan="3">11.59</td><td colspan="3">10.71</td><td colspan="3">11.38</td><td colspan="3">12.13</td></tr>
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</table>

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S – surface horizon
M – middle horizon
B – bottom horizon

Regarding Project implementation, it can be asserted that the discharge of treated industrial wastewater could cause a significant local impact on the environment. The average water salinity at the discharge site and the likely impact area was homogeneous and consistent with the salinity throughout the surveyed area. Depending on the salinity concentration of the treated industrial wastewater being discharged, the impact could range from low to moderate, based on initial modelling performed, although this modelling did not take into considertion site specific parameters. Therefore, it is essential to conduct multiparameter modeling of the discharge and salinity dispersion, taking into account the acquired data on hydrophysical, hydrochemical, and hydrobiological parameters in the potential impact area, to properly assess the impact on the marine environment.

1.1.6 Turbidity

Turbidity is an indicator characterizing a decrease in water transparency due to the presence of inorganic and organic fine-dispersed suspensions, as well as the development of planktonic organisms, bacterio-, phyto- or zooplankton. One of the reasons may also be the oxidation of iron compounds by oxygen of the air, which leads to the formation of colloids in water.

In autumn, the average turbidity level in the surface layer was 0.77 Nephelometric Turbidity Units (NTU). The maximum values reached 1.57 NTU at station 10; and the minimum was 0.22 NTU at station 18 (Figure 1.1.6.1).

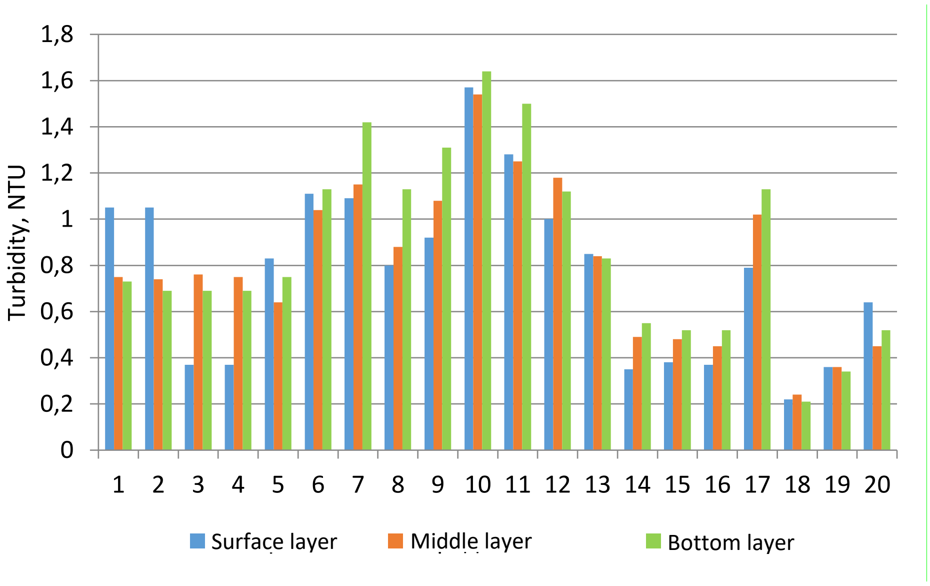

Figure 1.1.6.1 Water turbidity at the surveyed stations in autumn 2023

In winter, the average turbidity levels were as follows: 2.68 NTU in the surface layer, 2.85 NTU in the middle layer, and 3.31 NTU in the bottom layer (Figure 1.1.6.2).

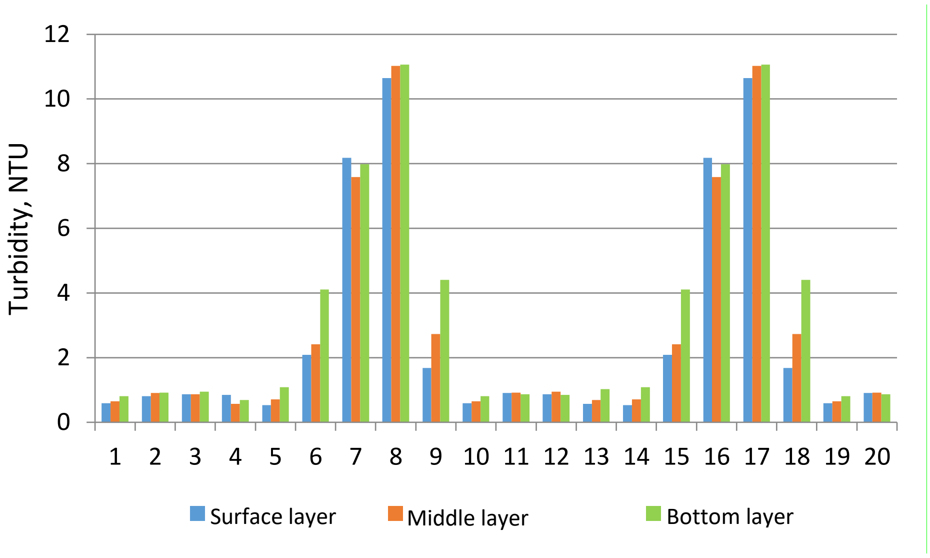

Figure 1.1.6.2 Water turbidity at the surveyed stations in winter 2023

In spring, the average turbidity level in the surface layer was 0.161 NTU. The maximum values reached 0.32 NTU; and the minimum was 0.03 NTU (Figure 1.1.6.3).

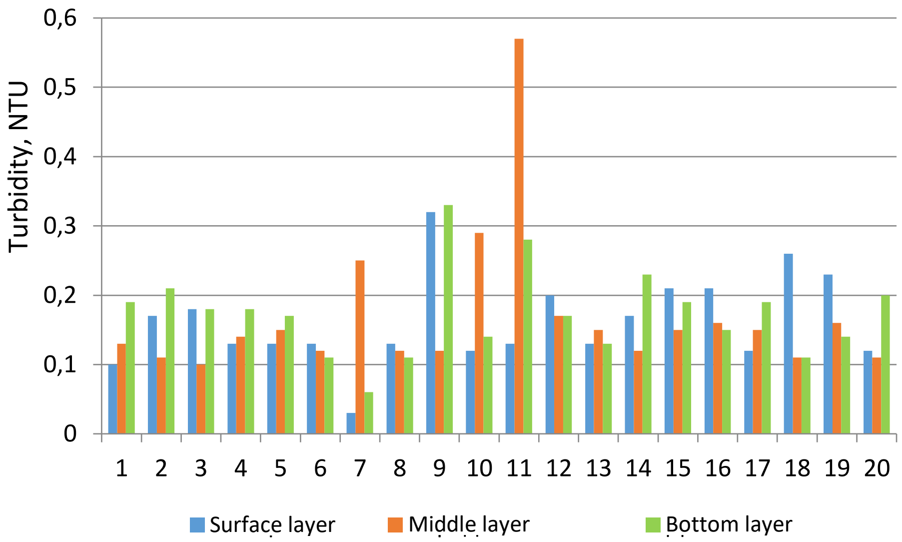

Figure 1.1.6.3 Water turbidity at the surveyed stations in spring 2024

In summer, the average turbidity level in the surface layer was 0.231 NTU. The maximum values reached 0.258 NTU; and the minimum was 0.511 NTU (Figure 1.1.6.4).

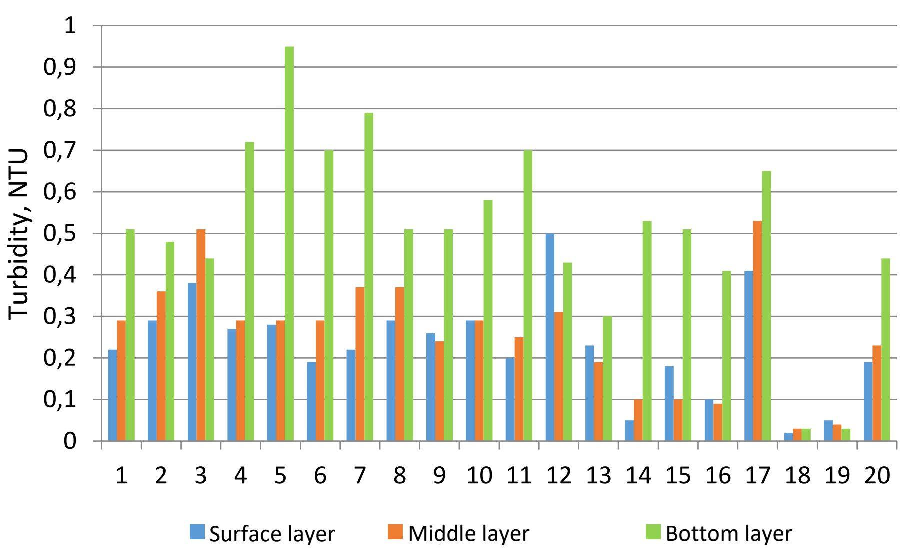

Figure 1.1.6.4 Water turbidity at the surveyed stations in summer 2024

The increase in turbidity during the autumn and winter survey sessions appears to be driven by wind-induced mixing of seawater caused by prevailing winds. In autumn, southeasterly winds predominated along the coast. In winter, westerly winds, perpendicular to the coast, were more common. This agitation of mineral suspensions led to higher turbidity levels. Conversely, during the spring and summer survey periods, there was a decline in turbidity levels due to a decrease in the concentration of suspended substances, influenced by reduced wave and wind activity. The seawater turbidity values recorded during the survey period in all 20 monitoring stations are provided in Table 1.1.6-1.

Table 1.1.6-1 Water turbidity during the survey period (autumn 2023 – summer 2024)

No.	Station	Total water depth, m				Horizon	Sampling depth, m				Turbidity, NTU			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
1	Station 1	22.0	22.0	22.7	21.5	Surface	3.0	3.0	3.0	3.0	1.05	0.59	0.10	0.22
						Middle	10.0	10.0	10.0	10.5	0.75	0.65	0.13	0.29
						Bottom	20.0	20.0	20.0	21.0	0.73	0.81	0.19	0.51
2	Station 2	21.0	21.0	22.5	20.8	Surface	3.0	3.0	3.0	3.0	1.05	0.91	0.17	0.29
						Middle	10.0	10.0	10.0	10.0	0.74	0.92	0.11	0.36
						Bottom	20.0	20.0	20.0	20.0	0.69	0.87	0.21	0.48
3	Station 3	22.0	22.0	20.8	20.1	Surface	3.0	3.0	3.0	3.0	0.37	0.87	0.18	0.38
						Middle	10.0	10.0	10.0	10.0	0.76	0.95	0.10	0.51
						Bottom	20.0	20.0	20.0	19.5	0.69	0.85	0.18	0.44
4	Station 4	20.5	20.5	20.4	20.0	Surface	3.0	3.0	3.0	3.0	0.37	0.57	0.13	0.27
						Middle	10.0	10.0	10.0	9.5	0.75	0.69	0.14	0.29
						Bottom	18.0	18.0	18.0	19.0	0.69	1.03	0.18	0.72
5	Station 5	20.0	20.0	19.9	21.0	Surface	3.0	3.0	3.0	3.0	0.83	0.53	0.13	0.28
						Middle	9.0	9.0	9.0	10.0	0.64	0.71	0.15	0.29
						Bottom	18.0	18.0	18.0	20.0	0.75	1.09	0.17	0.95
6	Station 6	18.4	18.4	19.1	18.5	Surface	3.0	3.0	3.0	3.0	1.11	2.09	0.13	0.19
						Middle	9.0	9.0	9.0	9.0	1.04	2.41	0.12	0.29
						Bottom	18.0	18.0	18.0	18.0	1.13	4.11	0.11	0.70
7	Station 7	18.7	18.7	19.0	18.8	Surface	3.0	3.0	3.0	3.0	1.09	8.18	0.03	0.22
						Middle	9.0	9.0	9.0	9.0	1.15	7.59	0.25	0.37
						Bottom	18.0	18.0	18.0	18.0	1.42	7.98	0.06	0.79
8	Station 8	19.6	19.6	19.1	19.6	Surface	3.0	3.0	3.0	3.0	0.80	10.65	0.13	0.29
						Middle	9.0	9.0	9.0	9.5	0.88	11.03	0.12	0.37
						Bottom	18.0	18.0	18.0	19.0	1.13	11.07	0.11	0.51
9	Station 9	17.4	17.4	18.3	17.3	Surface	3.0	3.0	3.0	3.0	0.92	1.68	0.32	0.26
						Middle	8.0	8.0	8.0	8.5	1.08	2.73	0.12	0.24
						Bottom	15.0	15.0	15.0	17.0	1.31	4.41	0.33	0.51
10	Station 10	18.5	18.5	18.6	18.4	Surface	3.0	3.0	3.0	3.0	1.57	0.59	0.12	0.29
						Middle	8.0	8.0	8.0	9.0	1.54	0.65	0.29	0.29
						Bottom	14.0	14.0	14.0	18.0	1.64	0.81	0.14	0.58
11	Station 11	18.6	18.6	18.0	18.4	Surface	3.0	3.0	3.0	3.0	1.28	0.91	0.13	0.20
						Middle	9.0	9.0	9.0	8.5	1.25	0.92	0.57	0.25
						Bottom	17.0	17.0	17.0	17.0	1.50	0.87	0.28	0.70
12	Station 12	17.3	17.3	17.3	17.0	Surface	3.0	3.0	3.0	3.0	1.00	0.87	0.20	0.50
						Middle	9.0	9.0	9.0	8.0	1.18	0.95	0.17	0.31
						Bottom	17.0	17.0	17.0	16.0	1.12	0.85	0.17	0.43
13	Station 13	15.8	15.8	16.0	15.3	Surface	3.0	3.0	3.0	3.0	0.85	0.57	0.13	0.23
						Middle	8.0	8.0	8.0	7.5	0.84	0.69	0.15	0.19
						Bottom	14.0	14.0	14.0	15.0	0.83	1.03	0.13	0.30
14	Station 14	16.7	16.7	16.6	16.3	Surface	3.0	3.0	3.0	3.0	0.35	0.53	0.17	0.05

No.	Station	Total water depth, m				Horizon	Sampling depth, m				Turbidity, NTU			
		Autumn	Winter	Spring	Summer		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
						Middle	8.0	8.0	8.0	8.0	0.49	0.71	0.12	0.10
						Bottom	15.0	15.0	15.0	15.5	0.55	1.09	0.23	0.53
15	Station 15	16.8	16.8	17.0	16.8	Surface	3.0	3.0	3.0	3.0	0.38	2.09	0.21	0.18
						Middle	8.0	8.0	8.0	8.0	0.48	2.41	0.15	0.10
						Bottom	15.0	15.0	15.0	16.0	0.52	4.11	0.19	0.51
16	Station 16	16.9	16.8	17.0	16.7	Surface	3.0	3.0	3.0	3.0	0.37	8.18	0.21	0.10
						Middle	8.0	8.0	8.0	8.0	0.45	7.59	0.16	0.09
						Bottom	15.0	15.0	15.0	16.0	0.52	7.98	0.15	0.41
17	Station 17	20.3	20.3	21.3	21.0	Surface	3.0	3.0	3.0	3.0	0.79	10.65	0.12	0.41
						Middle	10.0	10.0	10.0	10.0	1.02	11.03	0.15	0.53
						Bottom	18.0	18.0	18.0	20.0	1.13	11.07	0.19	0.65
18	Station 18	9.3	9.0	8.0	8.0	Surface	3.0	3.0	3.0	3.0	0.22	1.68	0.26	0.02
						Middle	5.0	5.0	5.0	5.0	0.24	2.73	0.11	0.03
						Bottom	8.0	8.0	8.0	7.5	0.21	4.41	0.11	0.03
19	Station 19	9.3	10.0	10.0	9.0	Surface	3.0	3.0	3.0	3.0	0.36	0.59	0.23	0.05
						Middle	5.0	5.0	5.0	5.0	0.36	0.65	0.16	0.04
						Bottom	8.0	8.0	8.0	8.5	0.34	0.81	0.14	0.03
20	Station 20	19.5	19.5	20.2	19.8	Surface	3.0	3.0	3.0	3.0	0.64	0.91	0.12	0.19
						Middle	8.0	8.0	8.0	8.5	0.45	0.92	0.11	0.23
						Bottom	15.0	15.0	15.0	19.0	0.52	0.87	0.20	0.44

	Total water depth, Autumn	Winter	Spring	Summer	Sampling depth, Autumn S	M	B	Winter S	M	B	Spring S	M	B	Summer S	M	B	Turbidity, Autumn S	M	B	Winter S	M	B	Spring S	M	B	Summer S	M	B
Minimum	9.3	9.0	8.0	8.0	3.0	5.0	8.0	3.0	5.0	8.0	3.0	5.0	8.0	3.0	5.0	7.5	0.22	0.24	0.21	0.53	0.65	0.81	0.03	0.1	0.06	0.02	0.03	0.03
Maximum	22.0	22.0	22.7	21.5	3.0	10.0	20.0	3.0	10.0	20.0	3.0	10.0	20.0	3.0	10.5	21.0	1.57	1.54	1.64	10.65	11.03	11.07	0.32	0.57	0.33	0.5	0.53	0.95

Note: S – surface horizon
M – middle horizon
B – bottom horizon

As for Project implementation, it can be assumed that treated industrial wastewater discharge into the bottom layers of water will not cause any major changes nor affect significantly the water turbidity and respectively water transparency in the surveyed area.

Thus, the data obtained from hydrochemical, hydrological, and hydrophysical surveys correspond to long-term average annual values] and are homogeneous and consistent. A mid-term (25-30 years) discharge of treated industrial wastewater into the sea's middle and surface layers could moderately impact turbidity and transparency in the Project's likely impact area, thereby affecting hydrophysical, hydrochemical, and hydrobiological parameters. Multiparameter modeling, encompassing both hydrochemical and hydrophysical aspects, may be required to assess the mid-term impact of the treated industrial wastewater discharge on water turbidity and transparency.

1.1.7 Velocity and direction of the sea currents

Winds and variations in the density field of the water column are the primary drivers of currents in the confined Caspian Sea, particularly in its upper layers. Additionally, the configuration of the coastline, the topography of the sea bottom, and the inflow of rivers in estuarine areas significantly influence the nature of these currents. Distribution of currents near the eastern coast of the Middle Caspian Sea is more complex than near the western one, which is primarily caused by the strong seasonal variability of the prevailing winds. In addition, the sea currents in this part of the sea are influenced by an indentation of the coastline, namely by the presence of numerous capes, coves and bays.

In the autumn and winter periods of 2023, as well as in the spring and summer periods of 2024, measurements in the survey area were carried out at 20 stations in the surface, middle and bottom horizons using Aanderaa SeaGuard RCM 9 LW marine probe.

The Aanderaa SeaGuard RCM 9 LW oceanographic measuring instrument is an automatic flow meter designed to measure and record the average vector velocity and direction of currents in the ocean.

The spring survey conducted in April 2024 was accompanied by the moderate winds and sea disturbance, which was quite typical for that period. It contributed to the minor changes in the results of hydrometrical studies comparing to the autumn and winter survey sessions. In summer 2024, the survey was accompanied by low winds, which resulted in a slight decline in the velocity of the sea currents at the site.

The results of the field measurements taken in autumn and winter 2023, and in spring and summer 2024 are provided in Tables 1.1.7-1.

Table 1.1.7-1 Velocity and direction of the sea currents within the survey area, autumn - winter 2023, spring – summer 2024

No.	Station	Horizon	Current velocity, cm/s				Current direction, °				Measuring depth, m
			Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	
1	Station 1	Surface	22.75	22.64	18.15	8.97	256.21	322.35	141.31	104.4	3
		Middle	10.82	22.83	18.98	9.42	302.59	324.77	189.75	168.6	10
		Bottom	9.84	15.64	17.91	10.78	239.09	303.59	183.28	89.19	20
2	Station 2	Surface	36.65	24.29	10.23	18.42	184.39	324.25	201.44	107.98	3
		Middle	34.40	42.49	12.13	14.23	180.73	266.35	282.91	208.24	10
		Bottom	37.23	50.87	8.55	13.72	168.42	345.74	292.53	150.63	20
3	Station 3	Surface	25.61	17.71	6.29	21.47	209.49	89.07	218.96	127.16	3
		Middle	24.03	21.21	13.04	12.06	183.51	63.20	222.17	180.15	10
		Bottom	37.23	21.45	11.07	15.15	168.42	84.40	231.05	148.11	20
4	Station 4	Surface	27.27	16.99	25.48	22.55	171.95	103.68	132.76	148.13	3
		Middle	24.62	18.47	21.68	19.61	183.90	112.94	173.17	163.36	10
		Bottom	21.65	18.65	28.57	20.1	190.65	112.63	166.81	96.9	18
5	Station 5	Surface	35.47	8.77	27.84	25.78	143.66	87.11	168.07	155.71	3
		Middle	34.28	14.20	25.94	20.36	108.27	121.82	185.49	159.34	9
		Bottom	30.13	12.85	20.87	20.5	122.87	105.80	204.49	85.09	18
6	Station 6	Surface	24.86	20.76	15.49	12.89	155.06	126.16	142.19	234.32	3
		Middle	25.71	12.37	19.68	6.94	134.75	103.40	254.10	313.61	9
		Bottom	21.98	19.93	15.87	6.01	150.23	157.28	226.30	307.57	18
7	Station 7	Surface	13.38	15.75	15.72	10.71	146.54	67.93	235.08	237.89	3

No.	Station	Horizon	Current velocity, cm/s				Current direction, °				Measuring depth, m
			Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	
		Middle	18.96	16.51	14.44	5.22	148.25	110.07	147.82	285.76	9
		Bottom	18.32	14.34	15.63	5.73	142.77	102.44	195.58	302.11	18
8	Station 8	Surface	18.39	18.58	18.64	6.41	149.72	90.54	121.11	214.93	3
		Middle	21.93	18.62	18.26	8.67	132.74	83.68	212.54	304.82	9
		Bottom	25.30	14.15	16.60	7.33	127.29	108.27	168.94	301.63	18
9	Station 9	Surface	22.88	14.79	8.85	23.34	174.54	106.27	110.37	327.81	3
		Middle	21.54	7.39	6.39	17.97	141.42	135.05	130.93	316.82	8
		Bottom	20.34	7.88	6.22	1.65	170.34	119.60	70.26	278.4	15
10	Station 10	Surface	29.72	13.49	12.37	15.97	192.15	99.55	139.07	326.8	3
		Middle	34.39	6.74	7.92	9.42	187.70	150.33	147.70	292.76	8
		Bottom	31.10	7.46	6.38	4.07	169.44	84.21	89.32	87.43	14
11	Station 11	Surface	20.79	28.44	8.20	15.55	252.50	120.55	127.54	313.82	3
		Middle	25.67	29.47	8.61	11.69	214.66	147.97	61.31	274.84	9
		Bottom	28.30	26.49	5.87	1.68	193.45	79.16	124.39	184.09	17
12	Station 12	Surface	31.57	30.64	8.50	11.73	214.40	156.07	195.99	316.7	3
		Middle	28.19	28.92	5.83	7.46	184.25	141.19	167.56	319.7	9
		Bottom	32.90	29.07	5.83	4.04	169.63	102.09	167.56	274.99	17
13	Station 13	Surface	33.32	22.65	13.21	20.7	218.18	191.30	197.57	300.98	3
		Middle	33.56	30.09	15.08	16.47	198.17	145.19	274.44	301.69	8
		Bottom	32.48	38.81	11.02	3.44	164.14	174.78	298.31	286.06	14
14	Station 14	Surface	15.10	22.36	3.90	8.22	166.00	227.41	236.51	313.45	3
		Middle	14.35	36.21	5.34	6.41	291.93	207.14	136.05	312.17	8
		Bottom	11.68	32.73	6.40	4.1	280.07	206.79	122.07	81.08	15
15	Station 15	Surface	12.73	23.31	12.47	8.57	142.83	115.72	147.76	211.4	3
		Middle	11.30	28.66	6.96	1.8	289.22	240.67	248.04	180.38	8
		Bottom	12.22	27.28	8.91	2.31	269.40	187.83	154.77	131.38	15
16	Station 16	Surface	16.95	25.20	9.83	11.3	206.73	201.15	126.49	319.75	3
		Middle	17.17	24.50	9.44	5.43	211.55	224.74	126.67	261.72	8
		Bottom	15.13	22.22	9.74	4.88	145.19	277.71	139.22	110.47	15
17	Station 17	Surface	25.05	22.18	22.30	8.01	141.05	94.61	167.29	113.94	3
		Middle	22.45	30.44	17.65	7.32	221.68	162.99	178.72	156.83	10
		Bottom	23.58	27.26	20.80	8.33	241.22	144.08	200.59	97.74	18
18	Station 18	Surface	21.52	38.37	6.59	4.42	176.58	175.58	260.68	243.77	3
		Middle	23.13	39.63	6.85	3.17	160.05	191.49	194.33	195.87	5
		Bottom	21.95	35.64	7.30	2.1	137.88	168.39	116.33	226.04	8
19	Station 19	Surface	18.20	24.14	3.59	4.77	231.83	232.63	220.54	263.16	3
		Middle	15.14	39.94	3.68	3.1	222.15	213.88	157.57	288.16	5
		Bottom	8.43	35.79	5.72	3.44	295.64	172.40	112.57	268.91	8
20	Station 20	Surface	10.24	13.13	22.69	7.23	195.06	91.86	185.31	110.39	3
		Middle	17.17	20.97	19.18	10.87	211.55	111.09	208.04	200.68	8
		Bottom	15.13	18.18	19.49	13.84	145.19	106.71	180.82	270.54	15
		Minimum	**8.43**	**6.74**	**3.59**	**1.65**	**108.27**	**63.20**	**61.31**	**81.08**	
		Maximum	**37.23**	**50.87**	**28.57**	**25.78**	**302.59**	**345.74**	**298.31**	**327.81**	
		Average	**22.94**	**23.18**	**12.94**	**10.30**	**188.82**	**157.09**	**177.01**	**219.27**	

In autumn 2023, current velocity within the survey area varied as follows:

- surface horizon - from 10.24 to 36.35 cm/s;
- middle horizon - from 10.82 to 34.4 cm/s;
- bottom horizon - from 8.43 to 37.26 cm/s.

In autumn 2023, current direction within the survey area varied as follows:

- surface horizon - from 141.05° to 256.21°;
- middle horizon - from 108.27° to 302.59°;
- bottom horizon - from 122.87° to 295.64°.

In winter 2023, velocity of the sea currents within the survey area varied as follows::

- surface horizon - from 8.77 to 38.37 cm/s;
- middle horizon - from 6.74 to 42.49 cm/s;
- bottom horizon - from 7.46 to 50.87 cm/s.

In winter 2023, direction of the sea currents within the survey area varied as follows::

- surface horizon - from 67.93° to 324.25°;
- middle horizon - from 63.20° to 324.77°;
- bottom horizon - from 79.16° to 345.74°.

In spring 2024, velocity of the sea currents within the survey area varied as follows::

- surface horizon - from 3.59 to 27.84 cm/s;
- middle horizon - from 3.68 to 25.94 cm/s;
- bottom horizon - from 5.72 to 28.57 cm/s.

In spring 2024, direction of the sea currents within the survey area varied as follows::

- surface horizon - from 110.37° to 260.68°;
- middle horizon - from 61.31° to 282.91°;
- bottom horizon - from 70.26° to 298.31°.

In summer 2024, velocity of the sea currents within the survey area varied as follows::

- surface horizon - from 4.42 to 25.78 cm/s;
- middle horizon - from 1.8 to 20.36 cm/s;
- bottom horizon - from 1.65 to 20.5 cm/s.

In summer 2024, direction of the sea currents within the survey area varied as follows::

- surface horizon - from 104.4° to 327.81°;
- middle horizon - from 156.83° to 319.70°;
- bottom horizon - from 81.08° to 307.57°.

The analysis of the measurements of sea current velocity and direction in both autumn and winter showed quite similar results. The velocity and direction of the sea currents were relatively stable, which is typical for that region and climatic season. The winter period is characterized by more intense winds; therefore, the average current velocity in winter was slightly higher than in autumn and spring. In summer, the survey showed minor changes in the velocity and direction of sea currents, which is typical for this season.

In winter 2023, the highest current velocity was recorded in the bottom layer at station 2, measuring 50 cm/s. In autumn 2023, the highest current velocity at the same station's bottom layer was 37 cm/s. In spring 2024, the highest current velocity was recorded in the bottom layer at station 4, amounting to 28.57 cm/s. In summer 2024, the highest current velocity was observed in the surface layer at station 5, measuring 25.78 cm/s.

According to the analysis, average velocities of the sea currents at all surveyed stations did not show significant increases or deviations between autumn-winter 2023 and spring-summer 2024. It was noted that the current velocities at stations closer to the coastline, except for station 13, were higher in winter than in autumn 2023. This can be explained by the prevailing easterly winds, which are known for their high velocity during this period. The current velocities in spring and summer 2024 were slightly lower than in autumn and winter 2023.

Distribution of the sea current velocities along the sampling horizons during the autumn survey session is shown in Table 1.1.7-2.

Table 1.1.7-2 Distribution of the sea current velocities along the horizons, autumn 2023

Horizon	0-10 cm/s	10-20 cm/s	20-30 cm/s	30-40 cm/s
Surface	0%	35%	45%	20%
Middle	0%	35%	45%	20%
Bottom	10%	25%	35%	30%

During the survey in autumn, percentage frequency of strong currents (30-40 cm/s) increased with depth. Currents with a velocity of 20-30 cm/s had the greatest repeatability.

In winter, currents with a velocity of 20-30 cm/s also had the greatest repeatability. The occurrence of strong currents was isolated in the bottom layers (Table 1.1.7-3).

Table 1.1.7-3 Distribution of the sea current velocities along the horizons, winter 2023

Horizon	0-10 cm/s	10-20 cm/s	20-30 cm/s	30-40 cm/s	40-50 cm/s	50-60 cm/s
Surface	5%	35%	50%	10%	0%	0%
Middle	10%	25%	35%	25%	5%	0%
Bottom	10%	35%	30%	20%	0%	5%

In spring 2024, currents with a velocity of 0-10 cm/s had the greatest repeatability.

Table 1.1.7-4 Distribution of the sea current velocities along the horizons, spring 2024

Horizon	0-10 cm/s	10-20 cm/s	20-30 cm/s	30-40 cm/s	40-50 cm/s	50-60 cm/s
Surface	40%	35%	25%	0%	0%	0%
Middle	45%	45%	10%	0%	0%	0%
Bottom	50%	35%	15%	0%	0%	0%

In summer 2024, the greatest repeatability was observed for the currents with a velocity of 0-10 cm/s, as well as during the spring survey session.

Table 1.1.7-5 Distribution of the sea current velocities along the horizons, summer 2024

Horizon	0-10 cm/s	10-20 cm/s	20-30 cm/s	30-40 cm/s	40-50 cm/s	50-60 cm/s
Surface	40%	35%	25%	0%	0%	0%
Middle	55%	35%	5%	0%	0%	0%
Bottom	70%	20%	10%	0%	0%	0%

According to the measurement results, the sea currents in the surveyed area in autumn were mainly characterized by the southerly directions with slight deviations to the east and west (Figure 1.1.7.1). The most easterly direction of the current was recorded at station 5 and was 125 °. The most westerly direction of the current was recorded at station 1 and was 266 °.

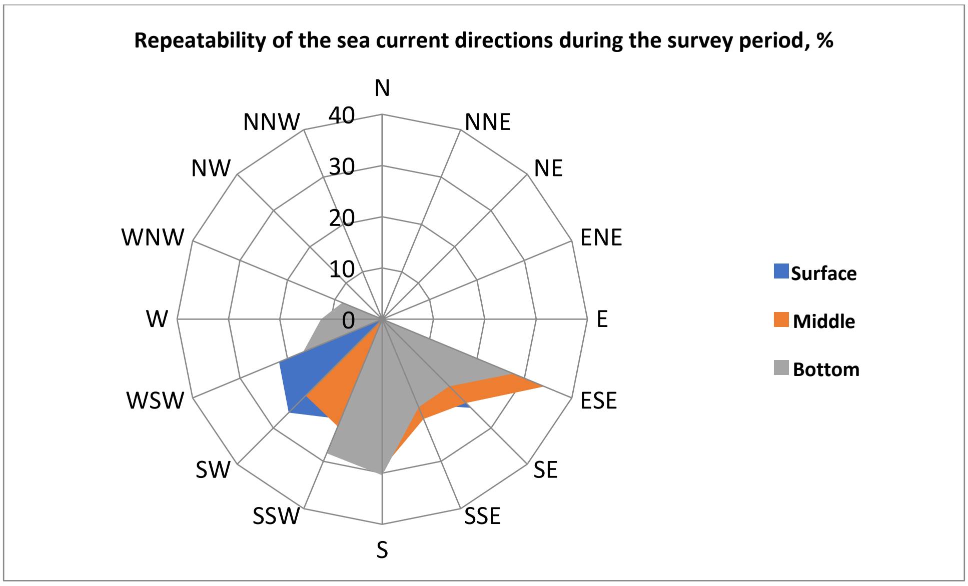

Figure 1.1.7.1 Diagram of the sea current directions, autumn 2023

The southerly and the southwesterly directions prevailed in the surface currents in autumn (Figure 1.1.7.2)

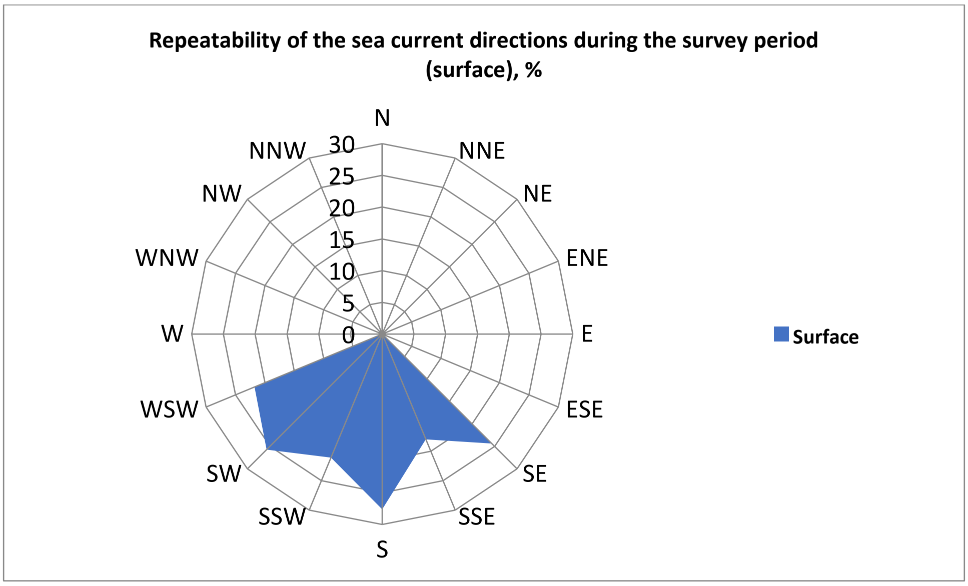

Figure 1.1.7.2 Diagram of the sea current directions in the surface horizon, autumn 2023

The southerly and the southeasterly directions of the sea currents prevailed in the middle horizon in autumn (Figure 1.1.7.3)

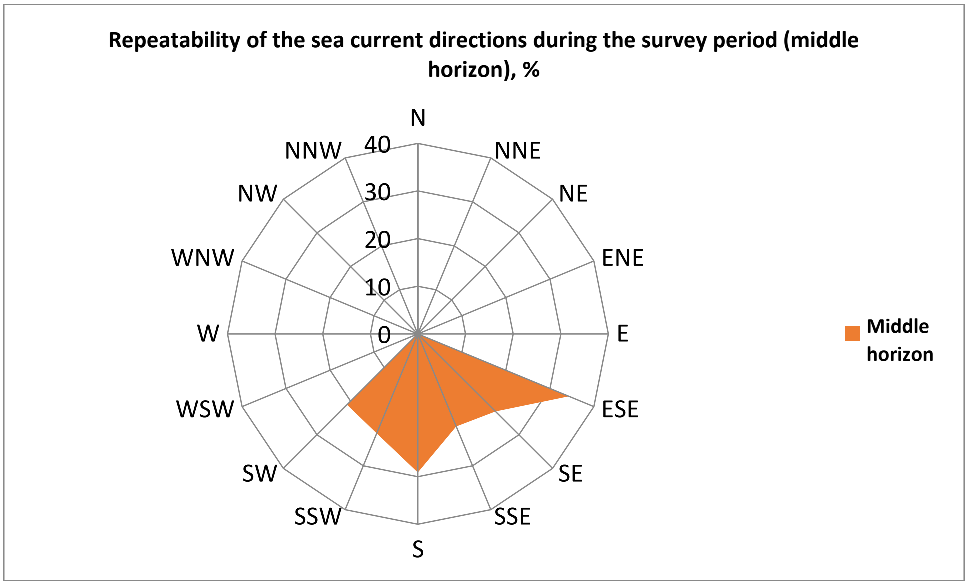

Figure 1.1.7.3 Diagram of the sea current directions in the middle horizon, autumn 2023

The southerly direction of the sea currents prevailed in the bottom horizon in autumn (Figure 1.1.7.4)

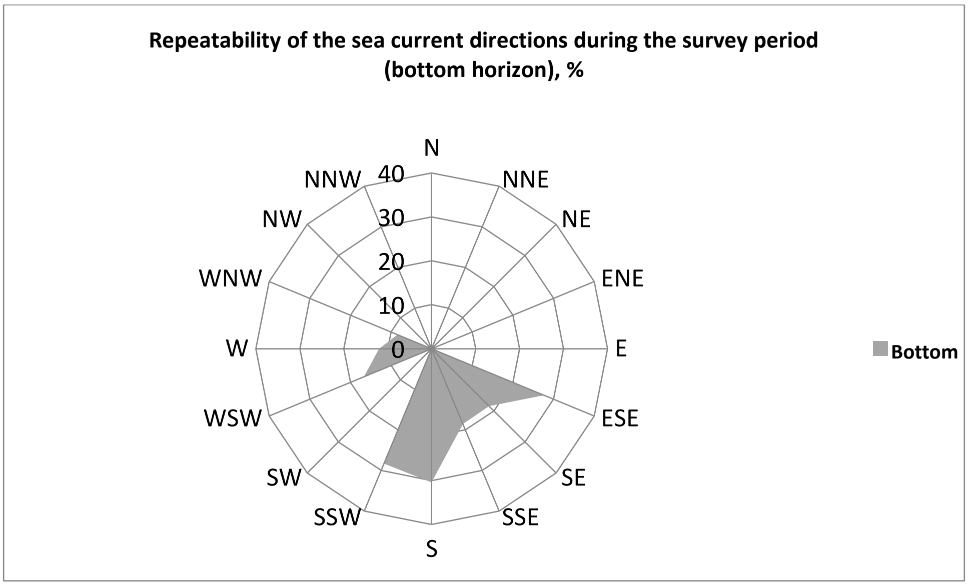

Figure 1.1.7.4 Diagram of the sea current directions in the bottom horizon, autumn 2023

In winter 2023, the sea currents were mainly characterized by the southerly and southwesterly directions with slight deviations to the east. The most eastward direction of the current was recorded at station 20 and was 91°. The most westerly direction of the current was recorded at station 1 and was 303°.

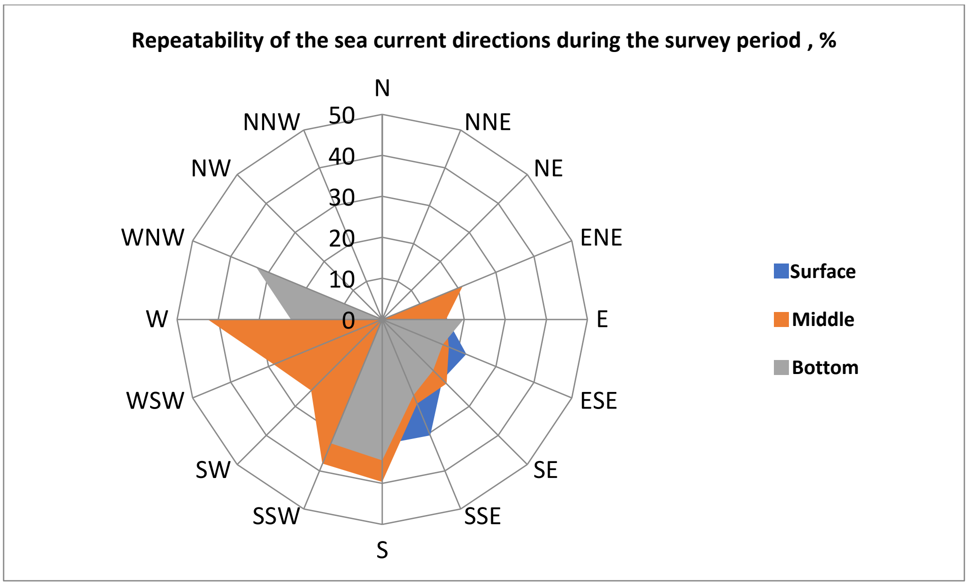

Figure 1.1.7.5 Diagram of the sea current directions, winter 2023

The southerly direction with deviation to the east prevailed in the surface currents in winter (Figure 1.1.7.6)

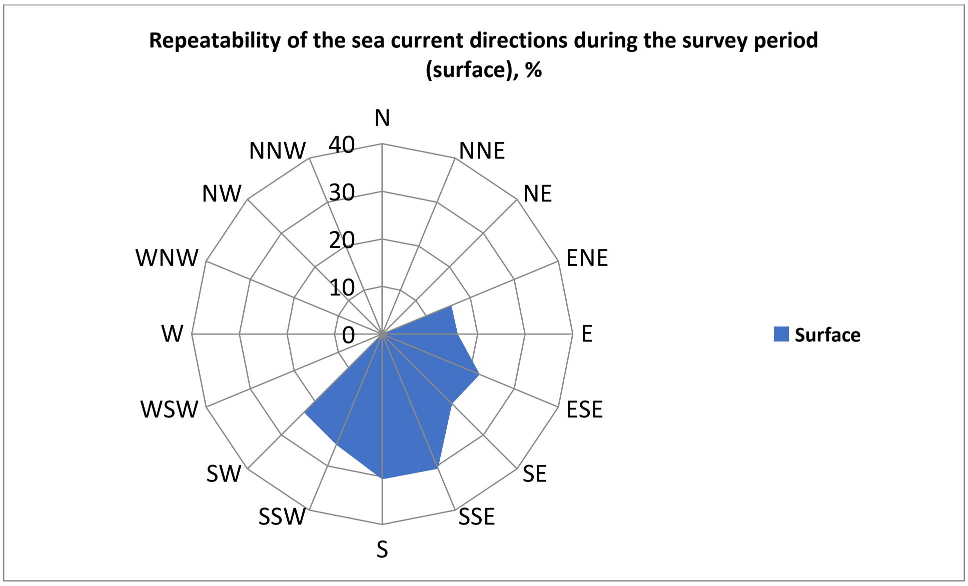

Figure 1.1.7.6 Diagram of the sea current directions in the surface horizon, winter 2023

The southerly and the southwesterly directions of the sea currents prevailed in the middle horizon in winter (Figure 1.1.7.7)

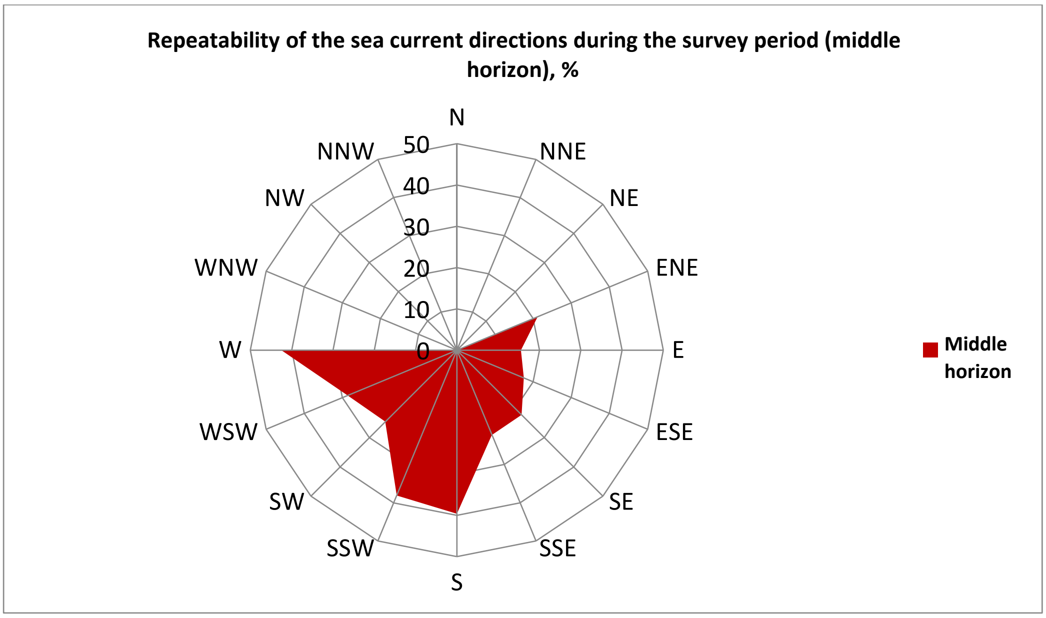

Figure 1.1.7.7 Diagram of the sea current directions in the middle horizon, winter 2023

The southerly direction of the sea currents prevailed in the bottom horizon in winter. The sea currents of the westerly direction were also recorded (Figure 1.1.7.8).

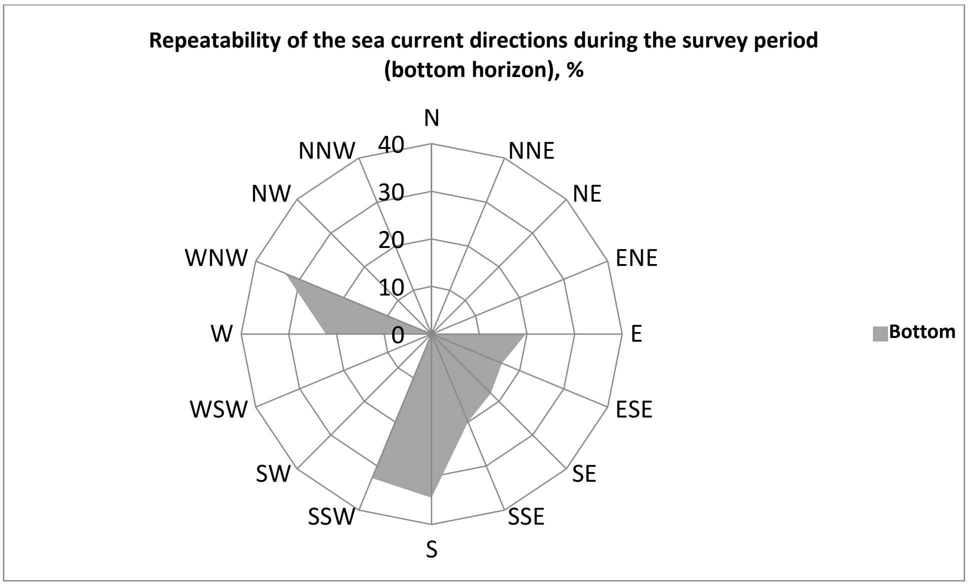

Figure 1.1.7.8 Diagram of the sea current directions in the bottom horizon, winter 2023

According to the measurement results, the sea currents in the surveyed area in spring 2024 were mainly characterized by the southerly direction with slight deviations to the east and west (Figure 1.1.7.9). The most easterly direction of the current was recorded at station 11 and was 61°. The most westerly direction of the current was recorded at station 13 and was 298°.

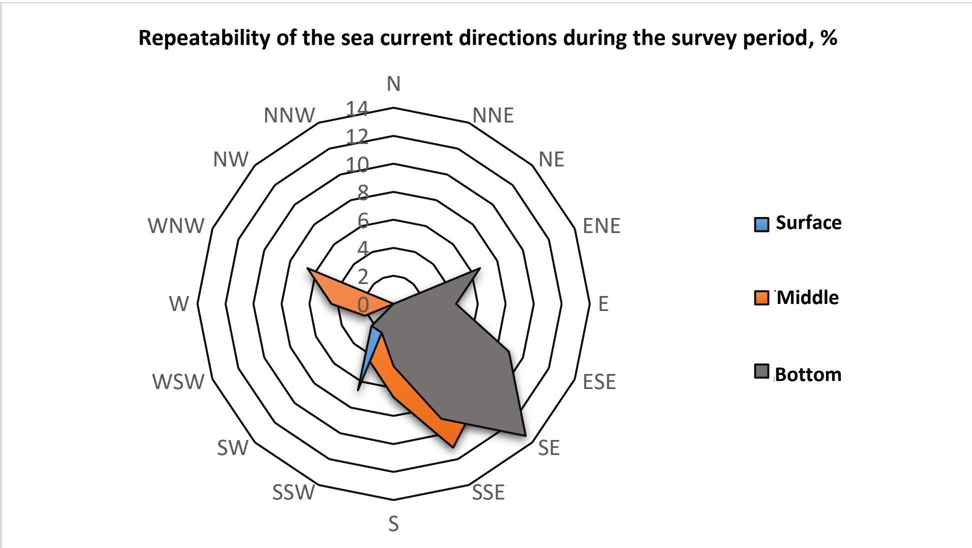

Figure 1.1.7.9 Diagram of the sea current directions, spring 2024

The southerly and southeasterly direction prevailed in the surface currents in spring (Figure 1.1.7.10)

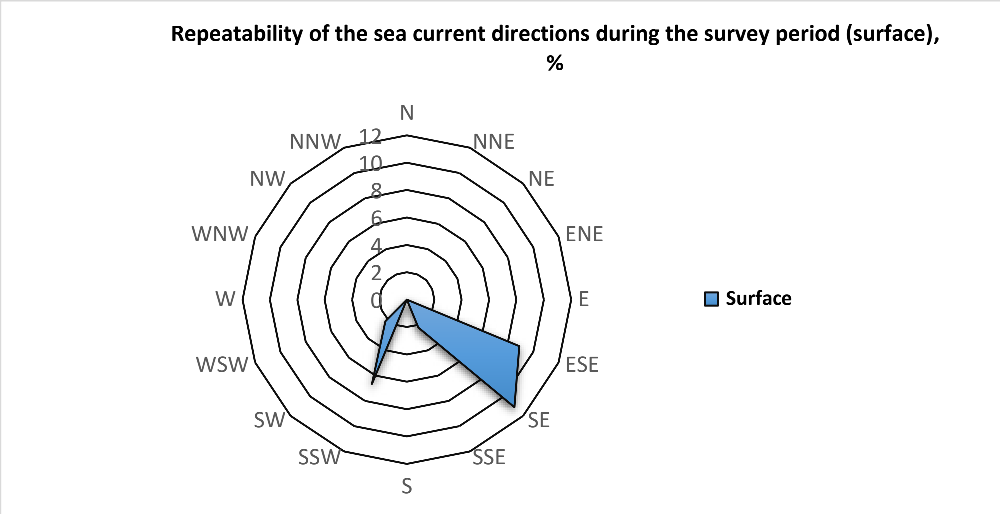

Figure 1.1.7.10 Diagram of the sea current directions in the surface horizon, spring 2024

The southerly and the southeasterly directions of the sea currents prevailed in the middle horizon in spring (Figure 1.1.7.11)

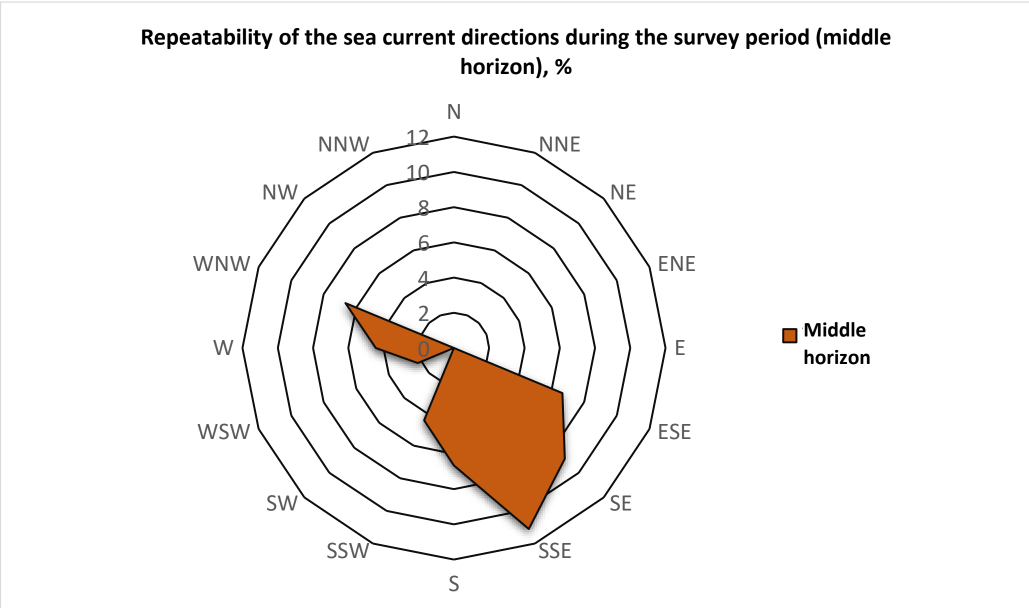

Figure 1.1.7.11 Diagram of the sea current directions in the middle horizon, spring 2024

The southerly direction of the sea currents prevailed in the bottom horizon in winter (Figure 1.1.7.12).

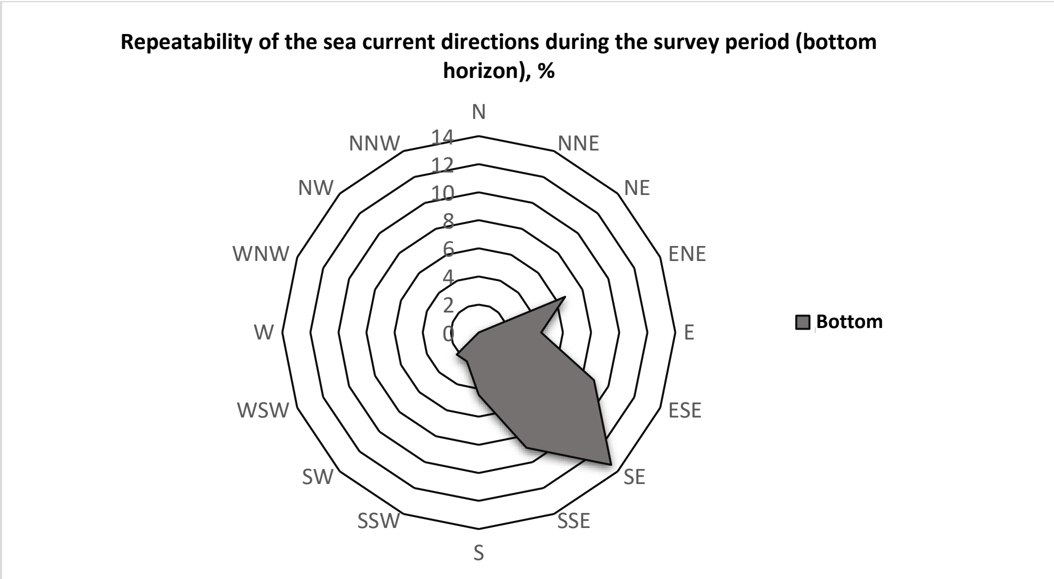

Figure 1.1.7.12 Diagram of the sea current directions in the bottom horizon, spring 2024

In summer 2024, the sea currents were mainly characterized by the southeasterly directions (Figure 1.1.7.13). The most easterly direction of the current was recorded at station 1 and was 89.19°. The most westerly direction of the current was recorded at station 19 and was 268.9°.

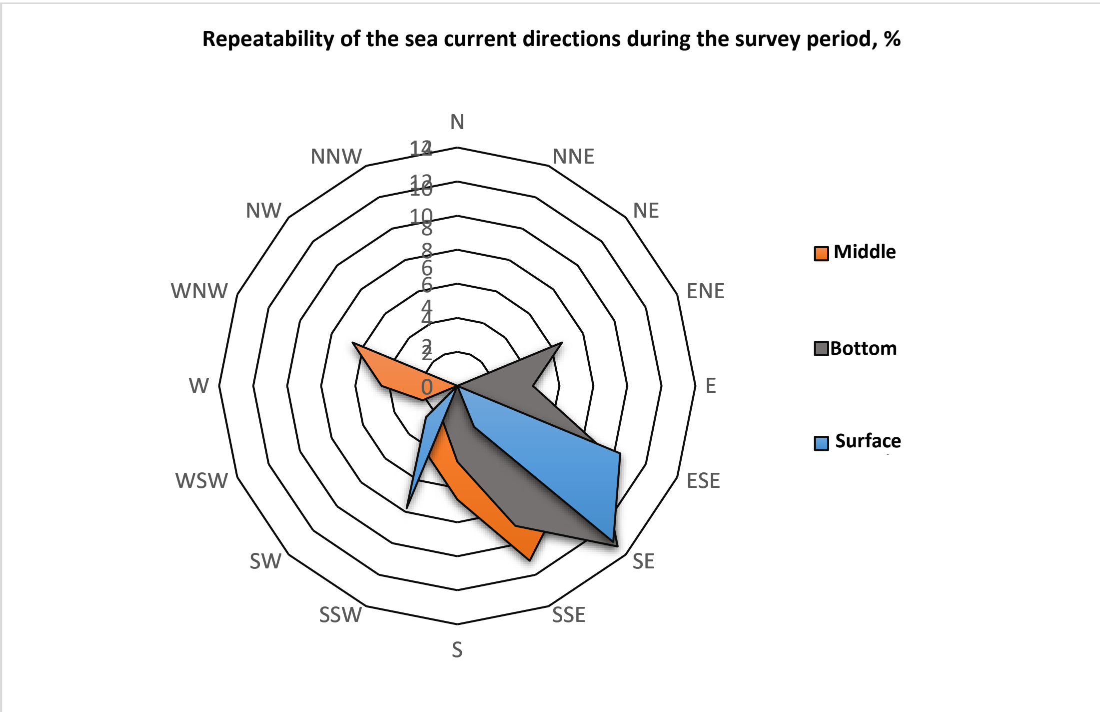

Figure 1.1.7.13 Diagram of the sea current directions, summer 2024

The southeasterly direction prevailed in the surface currents in the summer (Figure 1.1.7.14).

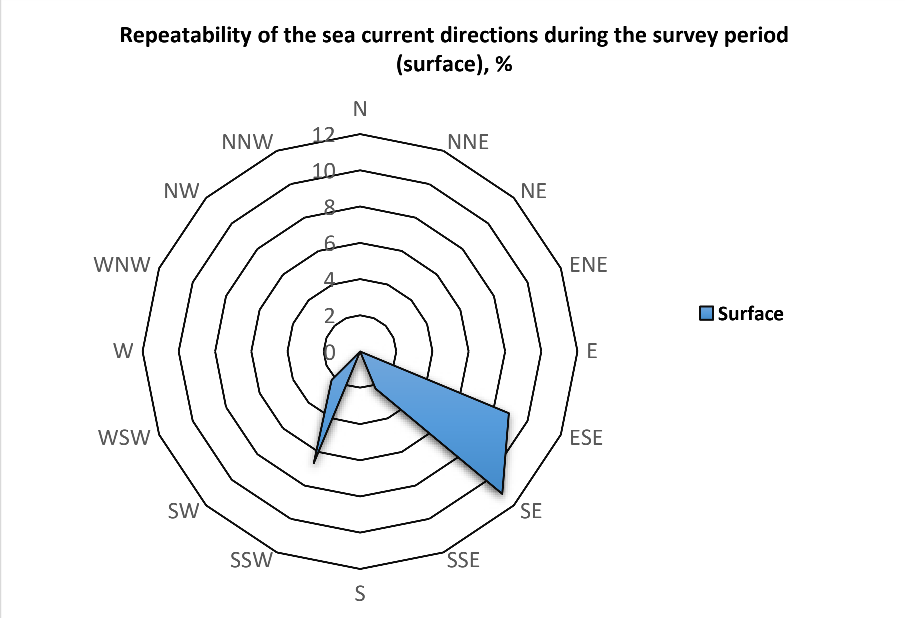

Figure 1.1.7.14 Diagram of the sea current directions in the surface horizon, summer 2024

The southeasterly directions of the sea currents prevailed in the middle horizon in summer (Figure 1.1.7.15)

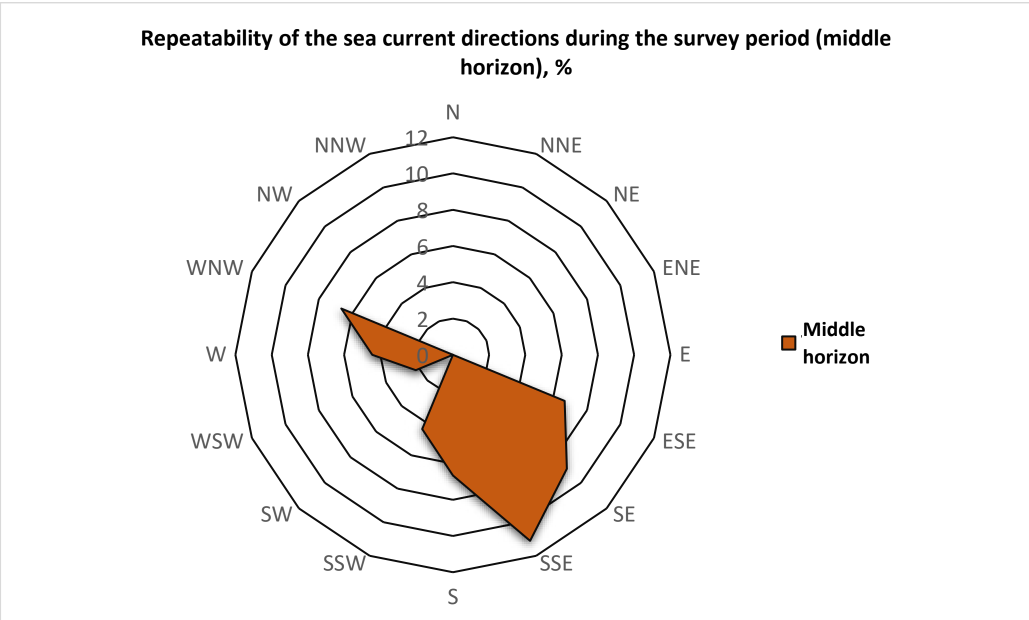

Figure 1.1.7.15 Diagram of the sea current directions in the middle horizon, summer 2024

The southeasterly direction of the sea currents prevailed in the bottom horizon in summer 2024 (Figure 1.1.7.16).

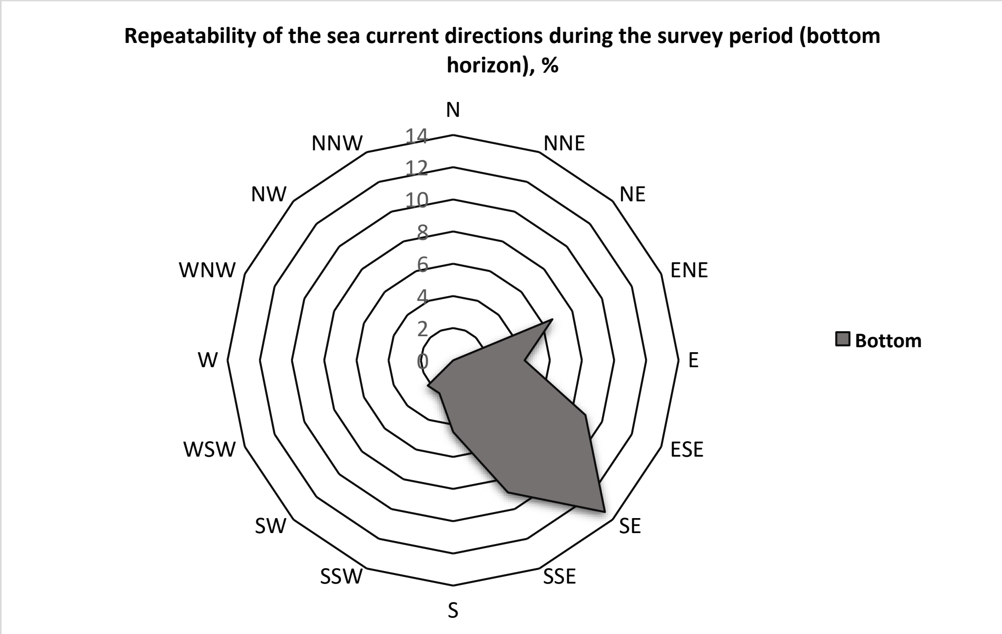

Figure 1.1.7.16 Diagram of the sea current directions in the bottom horizon, summer 2024

The analysis of changes in the velocity and direction of the sea currents in autumn 2023 also showed no significant fluctuations depending on the depths at the surveyed stations. Depending on the depth of measurement, the average values of the current velocity in the area were as follows:

- Surface - 23.1 cm/s;
- Middle layer - 22.9 cm/s;
- Bottom - 22.7 cm/s.

Average sea current directions in autumn 2023 did not vary significantly depending on the measurement depth. Southward direction prevailed:

- Surface – 184°;
- Middle – 195°;
- Bottom – 184°.

In winter 2023, average current velocities were rather stable depending on the measurement depth. Average current velocities in winter period were as follows:

- Surface - 21.2 cm/s;
- Middle - 24.5 cm/s;
- Bottom - 23.8 cm/s.

The sea current directions in winter were characterized mainly by the easterly and southeasterly directions and did not depend on the depth of measurement:

- Surface – 151°;
- Middle – 162°;
- Bottom – 157°.

In spring 2024, average current velocities were also rather stable depending on the measurement depth. Average current velocities in spring period were as follows:

- Surface – 13.5 cm/s;
- Middle – 12.85 cm/s;
- Bottom – 12.44 cm/s.

The sea current directions in spring were characterized mainly by the easterly and southeasterly directions and did not depend on the depth of measurement:

- Surface – 173°;
- Middle – 184°;
- Bottom – 172°.

In summer 2024, average current velocities were lower than in the other survey periods:

- Surface – 13.35 cm/s;
- Middle – 9.88 cm/s;
- Bottom – 7.66 cm/s.

The sea current directions in summer were characterized mainly by the southerly and southwesterly directions and did not depend on the depth of measurement:

- Surface – 224°;
- Middle – 244°;
- Bottom – 188°.

According to the analysis of the data of hydrometric studies in autumn-winter 2023 and spring-summer 2024, the maximum values of the current velocities were observed in winter, which was driven by the strong winds at the site (Figure 1.1.7.17).

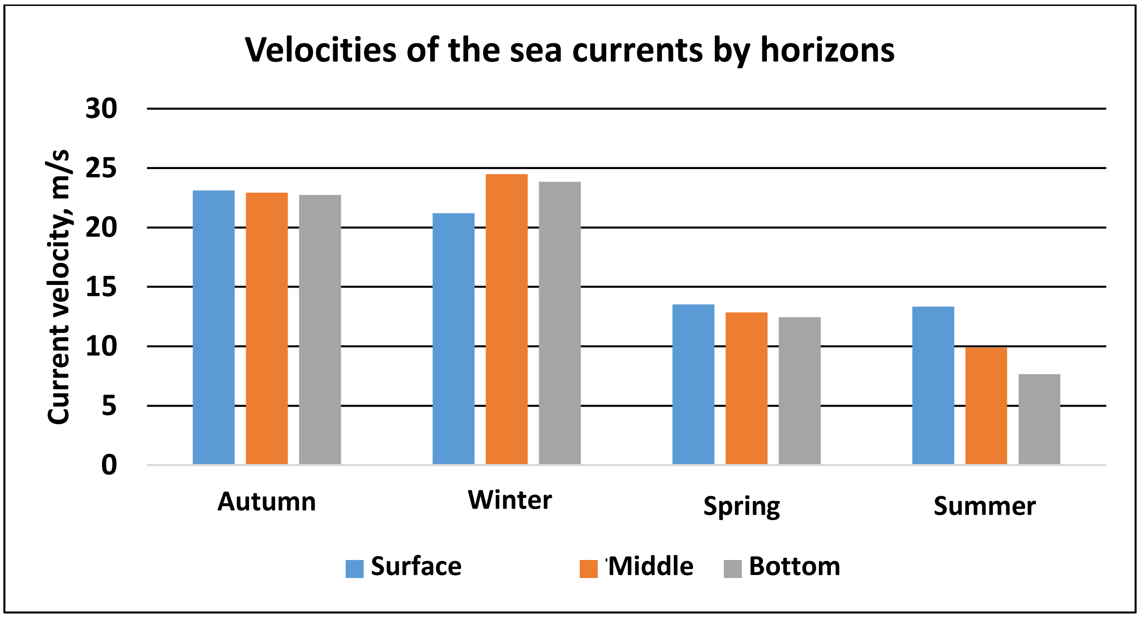

Figure 1.1.7.17 Velocities of the sea currents by horizons

During the autumn survey session, the sea current velocities showed minimal variation across different horizons. In autumn 2023, the lowest velocity was recorded at station 19, measuring 8.43 cm/s. The highest velocity was recorded at station 3, measuring 37.23 cm/s. In winter 2023, there was a slight increase in the velocities of sea currents in the middle and bottom horizons compared to the surface horizon. The highest velocity was recorded in the bottom horizon at station 2, measuring 50 cm/s. Current velocities in the middle horizon were also higher than those observed in the surface horizon, with the maximum current velocity in the middle horizon likewise recorded at station 2. The survey session in spring 2024 indicated that sea current velocities in this season were significantly lower than those recorded in autumn and winter. A slight decline in velocities was observed from the surface to the bottom horizon in spring. The highest velocity, 28.57 cm/s, was recorded in the bottom horizon at station 4.

During the summer, measurements showed a clear decline in velocity values from the surface to the bottom horizon. The highest velocity, 25.78 cm/s, was recorded in the surface layer at station 5. In the bottom horizon, station 5 also recorded the highest velocity, amounting to 20.5 cm/s.

Throughout the 2023-2024 survey period, southerly directions of sea currents prevailed at the survey area (Figure 1.1.7.18).

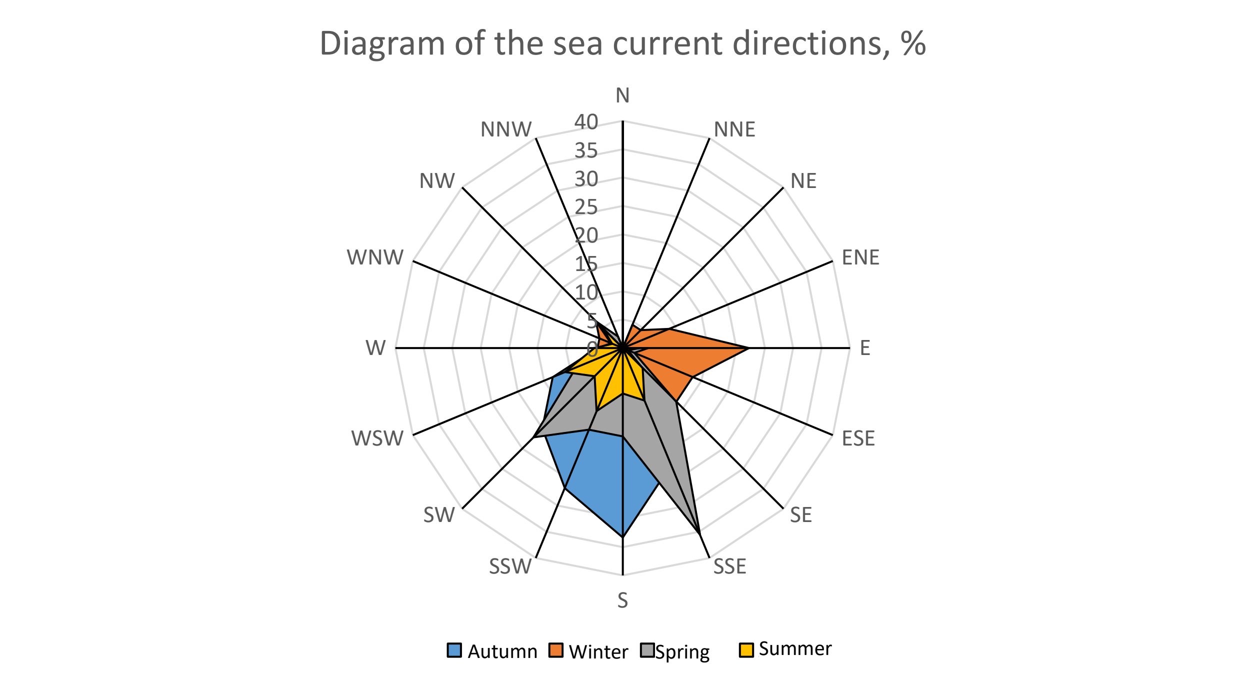

Figure 1.1.7.18 Directions of the sea currents by seasons

The main direction of the sea currents throughout all horizons (surface, middle, bottom) was southerly in autumn, and southeasterly and easterly in winter. During the spring period, southwesterly and southeasterly directions prevailed. In summer, southerly and southwesterly directions prevailed. According to Figures 1.1.7.1, 1.1.7.5, 1.1.7.9, and 1.1.7.13, there were no significant changes in the current directions across different horizons from autumn 2023 to summer 2024.

1.1.8 Conclusions of hydrophysical and hydrometrical data analysis

During the survey, water depth within the survey area ranged from 9.0 m to 22 m in autumn and winter. In the spring and summer periods, survey works were carried out at depth ranged from 8.0 to 22.7 m.

The analysis of the results of hydrometric survey in autumn did not reveal any dependencies between the fluctuations in water transparency and water depth or distance from the shoreline. Thus, the maximum transparency (8.0 m) was recorded at the coastal stations (stations 18 and 19) characterized by the lowest water depth (9.3 m). The lowest transparency was recorded at the stations located as far from the coast as possible (stations 1-4), water depth of which ranged from 20.5 to 22.0 m. In spring, the maximum transparency (15.0 m) was observed at stations 12, 14 and 15 and depth of 16 m, 16.6 m and 17 m. The lowest transparency (8.0 m) was observed at station 8. During the summer survey session, the maximum transparency (14.0 m) was recorded at stations 14 and 16 at depth of 16.3 m and 16.8 m. The lowest value was recorded at station 8 at depth of 8.0 m.

In general, the water temperature in the surveyed area aligned with the long-term seasonal dynamics typical of the water temperature regime in the eastern part of the Middle Caspian Sea. The lack of a sharp difference between temperatures recorded in the surface and bottom layers during autumn and winter is attributed to a common phenomenon for these periods. As air temperature declines in autumn, the surface layer of the sea cools down, leading to the blurring of the thermocline layer. In spring, all water layers warmed up evenly, resulting in a uniform distribution of temperature values. During the summer period, the near-bottom and deep-water layers warmed up consistently due to active water circulation. The decline in salinity levels from autumn to winter at the survey site leads to a reduction in horizontal circulation in summer. This results in saltier water from the southern part of the sea flowing along the eastern coast to the Middle Caspian Sea. As temperatures decline, this saline water gradually moves from the Middle Caspian Sea to the deep layers of the South Caspian Depression. Consequently, salinity increases across all horizons during the spring and summer periods due to the inflow of salty waters from the South Caspian Sea into the survey area. The increase in turbidity observed during the autumn and winter survey sessions appears to be driven by wind-induced mixing of seawater caused by prevailing winds. In autumn, southeasterly winds predominated along the coast, while in winter, westerly winds, perpendicular to the coast, were more common. This agitation led to an increase in turbidity levels due to the suspension of mineral particles. During the spring and summer survey periods, there was a decline in turbidity levels, likely caused by a decrease in wave and wind activity, which reduced the concentration of suspended substances. Water temperature, salinity and turbidity were within the limits predetermined by the seasonal changes in climatic conditions of the surveyed area.

The analysis of the data of hydrometric studies showed that the sea currents with a velocity of 20-30 cm/s were predominant during the autumn and winter survey sessions. The main direction of the sea currents throughout all horizons (surface, middle, bottom) was southerly in autumn, and southeasterly in winter. It should be noted that the sea currents with a velocity of 40-50 cm/s were observed in winter, which was probably driven by the strong winds during the survey, which caused intense wind-induced mixing of water masses. Lower values were recorded in spring and summer. In spring, the sea currents with a velocity of 10-20 cm/s prevailed. In summer, as in the most windless period, velocity of the sea currents varied mainly from 0 to 10 cm/s. The main direction of the sea currents was southeasterly in spring and southwesterly in summer.

1.2. Hydrochemical parameters of marine water

The hydrochemical parameters of seawater at the surveyed stations are provided based on the materials collected during baseline environmental surveys. (autumn 2023 – summer 2024).

Water samples were taken during the survey and delivered to the analytical laboratory of Kazecoanalysis LLP (Almaty) to determine hydrochemical parameters. Standard analysis methods accepted in the Republic of Kazakhstan were used during the laboratory works. All methods and devices, on which analyses were performed, are described in the analysis reports and in the scope of accreditation of the laboratory.

The Republic of Kazakhstan has not developed any standards for maximum permissible concentrations (MPC) of harmful substances in water bodies of commercial fishing importance. Therefore, compliance with the "Agreement on the implementation of coordinated policy in the field of standardization, metrology, and certification," signed by the heads of governments of CIS countries in 1992, has been maintained. The "Generalized list of maximum permissible concentrations (MPC) and approximately safe exposure levels of harmful substances for the waters within fishing grounds, Ministry of Fisheries of the USSR, 1990" was used to assess the hydrochemical conditions of seawater.

This list, however, does not provide maximum permissible concentrations for all substances in the sea. Consequently, the analysis of changes in seawater was performed for those substances lacking MPCs by comparing the data collected during the survey sessions from 2023 to 2024.

1.2.1 Biogenic elements

Biogenic elements play a crucial role in the life of hydrobionts in the Caspian Sea. These elements are products of the vital activities of various organisms and primarily include nitrogen compounds such as nitrates, nitrites, and organic and inorganic ammonium compounds. Seasonal changes in the concentrations of biogenic substances in the Caspian Sea are complex and depend on several factors. These include the inflow from river waters, the intensity of consumption by marine organisms, the rate of regeneration, and the exchange processes between soil and water. Additionally, water exchange between the Northern and Middle Caspian Sea also significantly influences the seasonal dynamics of biogenic substances. Biogenic substances were analyzed using a DR 2800 instrument. Analyses were made by Kazecoanalysis LLP analytical laboratory.

In the Northern and in the Middle Caspian Sea, nitrogen is observed mostly in the form of ammonium nitrogen (NH_4). *Ammonium nitrogen* enters water bodies primarily from untreated wastewater and the decomposition of organic substances at the bottom. Various factors, including anthropogenic ones, influence nitrogen in nature. Blue-green algae are the biological system that fixes nitrogen in marine water. The maximum permissible concentration (MPC) of ammonium nitrogen in fishing grounds is 2.9 mg/dm³. According to the results of the survey conducted during autumn 2023, the content of ammonium nitrogen did not exceed the fisheries regulations, ranging from 0.01 to 0.14 mg/dm³, with an average of 0.07 mg/dm³. In winter, the concentration of ammonium nitrogen in water continued to remain below the MPC value, ranging from 0.02 to 0.12 mg/dm³, with an average of 0.06 mg/dm³. In spring, the concentration varied from less than 0.03 to 0.90 mg/dm³, averaging 0.09 mg/dm³. In summer 2024, the concentration of ammonium nitrogen in water ranged from less than 0.03 to 0.08 mg/dm³, with an average of 0.06 mg/dm³. According to the survey results for four seasons in the eastern Caspian Sea, concentrations of ammonium nitrogen did not exceed the MPC value and was insignificant. Therefore, it can be concluded that the seawater is not polluted and is not considered as a harmful environment.

Total nitrogen, phosphorus and nitrite nitrogen do not have MPC values, so the analysis was performed by comparing the analysis results received in autumn and winter of 2023 and spring and summer of 2024.

In autumn, the *total nitrogen* content ranged from 0.5 to 0.8 mg/dm³, averaging to 0.648 mg/dm³. In winter, the total nitrogen concentrations varied within 0.5 - 0.7 mg/dm³, averaging to 0.6 mg/dm³. In spring and summer of 2024, concentrations of nitrogen varied from 0.3 to 0.9 mg/dm³ and from 0.4 to 0.8 mg/dm³ respectively. This can be explained by the fact that the seasonal fluctuations of ammonium nitrogen in the eastern part of the Middle Caspian Sea are more moderated compared to those in the western part of the sea. According to the survey results (autumn and winter of 2023 and spring and summer of 2024), concentrations of nitrogen varied slightly staying within the same limits.

Phosphorus, along with carbon, oxygen, hydrogen and nitrogen, is of great importance for the existence of living organisms. It is the most important indicator of the trophic status of natural water bodies. It often determines the biomass and productivity of aquatic organisms, including the marine ones. Control and monitoring of phosphorus accumulation in the biological objects and environment is crucial, including for the marine biological system of the Caspian Sea. During the survey in autumn, winter and spring, concentrations of total phosphorus in the survey area were below the threshold sensitivity of the measuring instrument (0.005). In summer, concentration of total phosphorous varied from <0.005 to 0.08 mg/dm^3 averaging 0.008 mg/dm^3. Thus, the observed fluctuations were insignificant.

Nitrite nitrogen (NO_2) serves as an indicator of water body pollution. Elevated levels of nitrite nitrogen suggest increased decomposition of organic matter. In autumn 2023, concentrations of nitrite nitrogen in the seawater at all stations were insignificant, ranging from 0.014 to 0.036 mg/dm³. In winter, the nitrite nitrogen content varied slightly from 0.011 - 0.032 mg/dm^3. According to the survey results, the average concentration of nitrite nitrogen was 0.024 mg/dm^3 in autumn and 0.018 mg/dm^3 in the winter period. In spring and summer of 2024, concentration of nitrite nitrogen varied within the same limits (from 0.02 to 0.06 mg/dm^3) averaging 0.04 mg/dm^3. According to the results of all survey sessions, concentration of nitrite nitrogen varied slightly staying within the same limits.

Nitrates are formed from nitrites through the process of nitrification or can enter water bodies from agricultural runoff containing fertilizers, atmospheric precipitation, and various other runoffs. Nitrates are significantly less toxic than nitrites. The maximum permissible concentration (MPC) of *nitrate nitrogen* (NO_3) for fishing grounds is 9.0 mg/dm³. In autumn 2023, the concentration of nitrate nitrogen varied from 1.8 to 3.0 mg/dm³, with an average value of 2.4 mg/dm³ across the surveyed sea area. In winter 2023, the concentration of nitrate nitrogen ranged from 1.6 to 2.5 mg/dm³, averaging 2.0 mg/dm³. The MPC value for nitrate nitrogen was not exceeded during the autumn and winter periods of 2023. In spring 2024, the concentration of nitrate nitrogen ranged between 1.4 and 2.5 mg/dm^3 averaging 1.9 mg/dm^3. In summer, the concentration of nitrate nitrogen ranged between 0.7 and 2.2 mg/dm^3 averaging 1.74 mg/dm^3.

Thus, MPC values of biogenic elements were not exceeded in autumn and winter periods of 2023, nor in spring and summer of 2024. The concentrations of biogenic elements varied within the same limits or were below the threshold sensitivity of the instruments.

Data on the concentrations of biogenic elements in the seawater for the period of survey are provided in Table 1.2.1-1.

Table 1.2.1-1 Concentrations of biogenic elements within the survey area in the Caspian Sea during the survey period (autumn 2023 – summer 2024, mg/dm^3)

No.	Sampling point	Season	Concentration of biogenic element, mg/dm^3							
			NH_4		NO_2		NO_3		N_{total}	P_{total}
			NH_4	$N\text{-}NH_4$	NO_2	$N\text{-}NO_2$	NO_3	$N\text{-}NO_3$		
1	Station 1 Surface	Autumn	0.14	0.11	0.036	0.011	2.9	0.6	0.7	< 0.005
		Winter	0.12	0.09	0.032	0.010	2.3	0.5	0.6	< 0.005
		Spring	0.07	0.05	0.02	0.006	2.1	0.5	0.5	< 0.005
		Summer	0.05	0.04	0.03	0.009	1.8	0.4	0.6	0.009
2	Station 1 Bottom	Autumn	0.12	0.10	0.029	0.009	2.8	0.6	0.7	< 0.005
		Winter	0.11	0.09	0.021	0.006	2.5	0.6	0.6	< 0.005
		Spring	0.08	0.06	0.02	0.006	1.8	0.4	0.4	< 0.005
		Summer	0.06	0.05	0.02	0.006	0.7	0.2	0.4	0.08
3	Station 2 Surface	Autumn	0.11	0.08	0.026	0.008	3.0	0.7	0.8	< 0.005
		Winter	0.10	0.08	0.024	0.007	2.3	0.5	0.6	< 0.005
		Spring	0.05	0.04	0.04	0.012	1.4	0.3	0.8	< 0.005
		Summer	0.06	0.05	0.03	0.009	1.5	0.3	0.5	< 0.005
4	Station 2 Bottom	Autumn	0.12	0.10	0.016	0.005	2.9	0.7	0.8	< 0.005
		Winter	0.09	0.07	0.014	0.004	2.4	0.5	0.6	< 0.005
		Spring	0.04	0.03	0.03	0.009	1.6	0.4	0.9	< 0.005
		Summer	0.05	0.04	0.03	0.009	1.4	0.3	0.5	0.006

No.	Sampling point	Season	Concentration of biogenic element, mg/dm³							
			NH_4		NO_2		NO_3		N_{total}	P_{total}
			NH_4	$N\text{-}NH_4$	NO_2	$N\text{-}NO_2$	NO_3	$N\text{-}NO_3$		
5	Station 3 Surface	Autumn	0.07	0.05	0.018	0.006	2.6	0.6	0.7	< 0.005
		Winter	0.07	0.05	0.017	0.005	2.2	0.5	0.6	< 0.005
		Spring	0.09	0.07	0.03	0.009	1.7	0.4	0.4	< 0.005
		Summer	0.07	0.05	0.04	0.012	1.5	0.3	0.6	0.007
6	Station 3 Bottom	Autumn	0.08	0.06	0.017	0.005	2.4	0.5	0.6	< 0.005
		Winter	0.05	0.04	0.013	0.004	2.0	0.5	0.7	< 0.005
		Spring	0.07	0.05	0.03	0.009	1.8	0.4	0.6	< 0.005
		Summer	0.06	0.05	0.03	0.009	1.7	0.4	0.5	< 0.005
7	Station 4 Surface	Autumn	0.14	0.11	0.025	0.007	2.6	0.6	0.7	< 0.005
		Winter	0.07	0.05	0.019	0.006	2.0	0.5	0.7	< 0.005
		Spring	0.05	0.04	0.04	0.012	1.4	0.3	0.5	< 0.005
		Summer	0.06	0.05	0.04	0.012	1.5	0.3	0.4	< 0.005
8	Station 4 Bottom	Autumn	0.08	0.06	0.034	0.010	2.7	0.6	0.8	< 0.005
		Winter	0.09	0.07	0.024	0.007	2.1	0.5	0.6	< 0.005
		Spring	0.06	0.05	0.02	0.006	1.7	0.4	0.7	0.006
		Summer	0.04	0.03	0.03	0.009	1.6	0.4	0.6	0.009
9	Station 5 Surface	Autumn	0.11	0.08	0.031	0.010	2.5	0.6	0.7	< 0.005
		Winter	0.08	0.06	0.018	0.005	1.9	0.4	0.5	< 0.005
		Spring	< 0.03	< 0.02	0.03	0.009	1.9	0.4	0.6	< 0.005
		Summer	0.03	0.02	0.05	0.015	1.7	0.4	0.6	0.007
10	Station 5 Bottom	Autumn	0.12	0.10	0.028	0.009	2.4	0.5	0.6	< 0.005
		Winter	0.06	0.05	0.019	0.006	1.9	0.4	0.5	< 0.005
		Spring	0.03	0.02	0.02	0.006	2.1	0.5	0.6	< 0.005
		Summer	0.06	0.05	0.04	0.012	1.8	0.4	0.6	0.007
11	Station 6 Surface	Autumn	0.05	0.04	0.022	0.007	2.0	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.021	0.006	1.6	0.4	0.5	< 0.005
		Spring	0.90	0.70	0.06	0.018	2.2	0.5	0.4	< 0.005
		Summer	0.05	0.04	0.06	0.018	1.7	0.4	0.5	< 0.005
12	Station 6 Bottom	Autumn	0.03	0.02	0.026	0.008	1.9	0.4	0.5	< 0.005
		Winter	0.04	0.03	0.022	0.007	2.3	0.5	0.6	< 0.005
		Spring	0.10	0.08	0.05	0.015	2.0	0.5	0.3	< 0.005
		Summer	0.06	0.05	0.03	0.009	1.9	0.4	0.5	< 0.005
13	Station 7 Surface	Autumn	0.05	0.04	0.031	0.009	2.3	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.028	0.009	1.8	0.4	0.5	< 0.005
		Spring	0.08	0.06	0.02	0.006	1.6	0.4	0.7	< 0.005
		Summer	0.05	0.04	0.03	0.009	2.1	0.5	0.8	0.006
14	Station 7 Bottom	Autumn	0.05	0.04	0.028	0.009	2.6	0.6	0.7	< 0.005
		Winter	0.05	0.04	0.026	0.008	1.9	0.4	0.6	< 0.005
		Spring	0.06	0.05	0.04	0.012	1.8	0.4	0.6	< 0.005
		Summer	0.07	0.05	0.02	0.006	1.8	0.4	0.5	< 0.005
15	Station 8 Surface	Autumn	0.06	0.05	0.023	0.007	2.5	0.6	0.7	< 0.005
		Winter	0.04	0.03	0.02	0.006	2.1	0.5	0.6	< 0.005
		Spring	0.05	0.04	0.05	0.015	2.0	0.4	0.5	< 0.005
		Summer	0.06	0.05	0.04	0.012	1.6	0.4	0.6	< 0.005
16	Station 8 Bottom	Autumn	0.06	0.05	0.036	0.011	2.3	0.5	0.6	< 0.005
		Winter	0.03	0.02	0.017	0.005	1.8	0.4	0.5	< 0.005
		Spring	0.06	0.05	0.04	0.012	1.8	0.4	0.6	< 0.005
		Summer	0.05	0.04	0.03	0.009	2.1	0.5	0.6	0.008
17	Station 9 Surface	Autumn	0.03	0.02	0.017	0.005	2.6	0.6	0.7	< 0.005
		Winter	0.04	0.03	0.013	0.004	1.9	0.4	0.6	< 0.005
		Spring	0.08	0.06	0.03	0.009	2.2	0.5	0.4	< 0.005
		Summer	0.07	0.05	0.04	0.012	1.8	0.4	0.5	< 0.005
18	Station 9 Bottom	Autumn	0.04	0.03	0.018	0.006	2.4	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.019	0.006	1.9	0.4	0.5	< 0.005
		Spring	0.07	0.05	0.03	0.009	2.3	0.5	0.5	< 0.005
		Summer	0.06	0.05	0.02	0.006	2.1	0.5	0.5	< 0.005
19	Station 10 Surface	Autumn	0.07	0.05	0.028	0.009	2.1	0.5	0.7	< 0.005
		Winter	0.03	0.02	0.016	0.005	1.8	0.4	0.5	< 0.005
		Spring	0.09	0.07	0.04	0.012	1.8	0.4	0.9	< 0.005
		Summer	0.08	0.06	0.05	0.015	1.6	0.4	0.7	< 0.005
20	Station 10 Bottom	Autumn	0.08	0.06	0.029	0.009	2.3	0.5	0.6	< 0.005
		Winter	0.07	0.05	0.018	0.005	2.0	0.5	0.6	< 0.005
		Spring	0.06	0.05	0.03	0.009	1.7	0.4	0.8	< 0.005
		Summer	0.06	0.05	0.04	0.012	1.5	0.3	0.5	< 0.005
21	Station 11 Surface	Autumn	0.07	0.05	0.027	0.008	2.5	0.6	0.7	< 0.005
		Winter	0.06	0.05	0.021	0.006	1.9	0.4	0.5	< 0.005
		Spring	0.04	0.03	0.05	0.015	1.9	0.4	0.6	< 0.005
		Summer	0.04	0.03	0.04	0.012	1.8	0.4	0.5	0.006
22	Station 11 Bottom	Autumn	0.09	0.07	0.024	0.007	2.7	0.6	0.7	< 0.005
		Winter	0.07	0.05	0.021	0.006	2.1	0.5	0.6	< 0.005

No.	Sampling point	Season	Concentration of biogenic element, mg/dm^3							
			NH_4		NO_2		NO_3		N_{total}	P_{total}
			NH_4	$N\text{-}NH_4$	NO_2	$N\text{-}NO_2$	NO_3	$N\text{-}NO_3$		
		Spring	0.03	0.02	0.03	0.009	1.9	0.4	0.5	< 0.005
		Summer	0.04	0.03	0.04	0.012	1.8	0.4	0.5	0.006
23	Station 12 Surface	Autumn	0.04	0.03	0.016	0.005	2.4	0.5	0.7	< 0.005
		Winter	0.05	0.04	0.019	0.006	1.9	0.4	0.5	< 0.005
		Spring	0.07	0.05	0.06	0.018	1.7	0.4	0.6	< 0.005
		Summer	< 0.03	< 0.02	0.05	0.015	1.9	0.4	0.7	< 0.005
24	Station 12 Bottom	Autumn	0.06	0.05	0.014	0.004	2.4	0.5	0.6	< 0.005
		Winter	0.05	0.04	0.012	0.004	1.9	0.4	0.6	< 0.005
		Spring	0.06	0.05	0.05	0.015	1.8	0.4	0.5	< 0.005
		Summer	0.04	0.03	0.04	0.012	1.7	0.4	0.6	< 0.005
25	Station 13 Surface	Autumn	0.05	0.04	0.022	0.007	2.1	0.5	0.6	< 0.005
		Winter	0.07	0.05	0.019	0.006	2.0	0.5	0.7	< 0.005
		Spring	0.10	0.08	0.02	0.006	2.1	0.5	0.7	< 0.005
		Summer	0.06	0.05	0.04	0.012	2.1	0.5	0.7	0.007
26	Station 13 Bottom	Autumn	0.06	0.04	0.02	0.006	2.3	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.013	0.004	1.8	0.4	0.6	< 0.005
		Spring	0.09	0.07	0.03	0.009	2.0	0.4	0.4	< 0.005
		Summer	0.05	0.04	0.03	0.009	0.8	0.2	0.5	< 0.005
27	Station 14 Surface	Autumn	0.01	0.01	0.034	0.010	2.2	0.5	0.7	< 0.005
		Winter	0.05	0.04	0.013	0.004	2.0	0.5	0.6	< 0.005
		Spring	0.07	0.05	0.03	0.009	1.8	0.4	0.3	< 0.005
		Summer	0.06	0.05	0.04	0.012	2.1	0.5	0.8	< 0.005
28	Station 14 Bottom	Autumn	0.02	0.01	0.032	0.010	2.1	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.018	0.005	1.8	0.4	0.5	< 0.005
		Spring	0.06	0.05	0.04	0.012	1.9	0.4	0.5	< 0.005
		Summer	0.05	0.04	0.03	0.009	1.8	0.4	0.7	0.009
29	Station 15 Surface	Autumn	0.07	0.05	0.018	0.006	2.5	0.6	0.7	< 0.005
		Winter	0.06	0.05	0.018	0.005	1.8	0.4	0.5	< 0.005
		Spring	0.04	0.03	0.02	0.006	2.1	0.5	0.6	< 0.005
		Summer	0.06	0.05	0.03	0.009	1.7	0.4	0.6	< 0.005
30	Station 15 Bottom	Autumn	0.09	0.07	0.023	0.007	2.4	0.5	0.6	< 0.005
		Winter	0.05	0.04	0.012	0.004	2.1	0.5	0.6	< 0.005
		Spring	0.06	0.05	0.03	0.009	2.2	0.5	0.6	< 0.005
		Summer	0.07	0.05	0.02	0.006	1.9	0.4	0.5	0.007
31	Station 16 Surface	Autumn	0.05	0.04	0.015	0.005	2.2	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.013	0.004	1.9	0.4	0.5	< 0.005
		Spring	0.09	0.07	0.05	0.015	2.4	0.5	0.6	< 0.005
		Summer	0.08	0.06	0.03	0.009	2.1	0.5	0.6	0.006
32	Station 16 Bottom	Autumn	0.02	0.02	0.014	0.004	2.1	0.5	0.7	< 0.005
		Winter	0.02	0.02	0.011	0.003	1.8	0.4	0.6	< 0.005
		Spring	0.07	0.05	0.04	0.012	2.5	0.6	0.7	< 0.005
		Summer	0.05	0.04	0.03	0.009	2.2	0.5	0.7	< 0.005
33	Station 17 Surface	Autumn	0.06	0.04	0.022	0.007	2.1	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.021	0.006	1.6	0.4	0.5	< 0.005
		Spring	0.10	0.08	0.04	0.012	1.8	0.4	0.9	< 0.005
		Summer	0.06	0.05	0.05	0.015	2.1	0.5	0.8	0.009
34	Station 17 Bottom	Autumn	0.05	0.04	0.017	0.005	2.3	0.5	0.6	< 0.005
		Winter	0.03	0.02	0.019	0.006	1.8	0.4	0.5	< 0.005
		Spring	0.11	0.09	0.04	0.012	1.8	0.4	0.8	< 0.005
		Summer	0.07	0.05	0.04	0.012	2.0	0.5	0.7	< 0.005
35	Station 18 Surface	Autumn	0.03	0.02	0.024	0.007	1.8	0.4	0.5	< 0.005
		Winter	0.04	0.03	0.019	0.006	1.6	0.4	0.5	< 0.005
		Spring	0.07	0.05	0.03	0.009	2.0	0.5	0.8	< 0.005
		Summer	0.08	0.06	0.04	0.012	1.8	0.4	0.6	0.008
36	Station 18 Bottom	Autumn	0.02	0.02	0.026	0.008	2.0	0.5	0.6	< 0.005
		Winter	0.04	0.03	0.016	0.005	1.9	0.4	0.5	< 0.005
		Spring	0.05	0.04	0.04	0.012	2.0	0.4	0.7	< 0.005
		Summer	0.06	0.05	0.03	0.009	1.9	0.4	0.7	< 0.005
37	Station 19 Surface	Autumn	0.04	0.03	0.02	0.006	2.1	0.5	0.7	< 0.005
		Winter	0.03	0.02	0.022	0.007	1.8	0.4	0.6	< 0.005
		Spring	0.08	0.06	0.02	0.006	2.1	0.5	0.6	< 0.005
		Summer	0.07	0.05	0.03	0.009	1.8	0.4	0.8	< 0.005
38	Station 19 Bottom	Autumn	0.05	0.04	0.025	0.007	2.3	0.5	0.6	< 0.005
		Winter	0.02	0.01	0.023	0.007	2.0	0.5	0.5	< 0.005
		Spring	0.06	0.05	0.02	0.006	2.0	0.4	0.5	< 0.005
		Summer	0.06	0.05	0.02	0.006	1.6	0.4	0.5	0.007
39	Station 20 Surface	Autumn	0.07	0.06	0.016	0.005	2.7	0.6	0.6	< 0.005
		Winter	0.06	0.05	0.014	0.004	1.9	0.4	0.5	< 0.005
		Spring	< 0.03	< 0.02	0.05	0.015	1.8	0.4	0.4	< 0.005
		Summer	0.04	< 0.02	0.03	0.009	1.7	0.4	0.6	0.006

No.	Sampling point	Season	Concentration of biogenic element, mg/dm³							
			NH_4		NO_2		NO_3		N_{total}	P_{total}
			NH_4	$N\text{-}NH_4$	NO_2	$N\text{-}NO_2$	NO_3	$N\text{-}NO_3$		
40	Station 20 Bottom	Autumn	0.10	0.07	0.02	0.006	1.9	0.4	0.5	< 0.005
		Winter	0.07	0.05	0.012	0.004	2.1	0.5	0.6	< 0.005
		Spring	0.04	0.03	0.04	0.012	1.6	0.4	0.6	< 0.005
		Summer	0.03	0.02	0.02	0.006	1.6	0.4	0.5	< 0.005
	Minimum	Autumn	0.01	0.01	0.014	0.004	1.8	0.4	0.5	< 0.005
		Winter	0.02	0.01	0.011	0.003	1.6	0.4	0.5	< 0.005
		Spring	< 0.03	< 0.02	0.02	0.006	1.4	0.3	0.3	< 0.005
		Summer	< 0.03	< 0.02	0.02	0.01	0.7	0.16	0.4	< 0.005
	Maximum	Autumn	0.14	0.11	0.036	0.011	3	0.7	0.8	< 0.005
		Winter	0.12	0.09	0.032	0.01	2.5	0.6	0.7	< 0.005
		Spring	0.90	0.70	0.06	0.018	2.5	0.6	0.9	< 0.005
		Summer	0.08	0.06	0.06	0.02	2.2	0.5	0.8	0.08
	Average	Autumn	0.07	0.05	0.024	0.007	2.4	0.5	0.6	< 0.005
		Winter	0.06	0.04	0.018	0.006	2.0	0.4	0.6	< 0.005
		Spring	0.09	0.07	0.04	0.011	1.9	0.4	0.6	< 0.005
		Summer	0.06	0.04	0.04	0.01	1.74	0.39	0.59	0.008
MPC*			**2.9**				**9.0**			

** Generalized list of maximum permissible concentrations (MPC) and approximately safe reference level of impact (SRLI) of hazardous substances in water in fishing grounds. Ministry of Fisheries of the USSR, 1990.*

1.2.2 Heavy metals

Heavy metals are among the priority pollutants, making their monitoring mandatory in fishing grounds. The surveyed site identified the presence of cadmium, copper, lead, mercury, and zinc. Kazecoanalysis LLP's analytical laboratory used the ICPE 9000 instrument for heavy metal analysis.

According to the survey results in autumn, winter, spring, and summer, the concentrations of these heavy metals were below the threshold sensitivity of the measuring instrument and below the MPC value (Table 1.2.2-1). Data on the concentrations of heavy metals in water in autumn and winter of 2023 and spring and summer of 2024 are provided in Table 1.2.2-1.

Table 1.2.2-1 Concentrations of heavy metals within the survey area in the Caspian Sea during the survey period (autumn 2023 – summer 2024, mg/dm³)

Sampling point	Cadmium (Cd)	Copper (Cu)	Zink (Zn)	Lead (Pb)	Mercury (Hg)
Autumn – winter of 2023, spring – summer of 2024					
Station 1. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 1. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 2. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 2 .Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 3. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 3 .Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 4. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 4. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 5. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 5. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 6. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 6. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 7. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 7. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 8. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 8. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 9. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 9. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 10. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 10. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 11. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 11. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 12. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 12. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 13. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001

Sampling point	Cadmium (Cd)	Copper (Cu)	Zink (Zn)	Lead (Pb)	Mercury (Hg)
Station 13. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 14. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 14. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 15. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 15. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 16. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 16. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 17. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 17. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 18. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 18. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 19. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 19. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 20. Surface	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Station 20. Bottom	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Minimum	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Maximum	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Average	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
MPC*	**0.01**	**0.005**	**0.05**	**0.01**	**0.0001**

Note: concentrations recorded in all survey sessions were below the sensitivity threshold of the instrument (0.001 mg/dm^3 for Cd, 0.0025 mg/dm^3 for Cu, 0.005 mg/dm^3 for Zn, 0.005 mg/dm^3 for Pb, and 0.0001 mg/dm^3 for Hg).

** Generalized list of maximum permissible concentrations (MPC) and approximately safe reference level of impact (SRLI) of hazardous substances in water in fishing grounds. Ministry of Fisheries of the USSR, 1990.*

1.2.3 Petroleum products

Experts consider petroleum products to be the most common and toxically hazardous substances polluting the natural aquatic environment. Petroleum products are highly toxic and have severe negative effects on hydrobionts, such as causing motor reflex disorders, loss of orientation, disturbance of physiological processes (including loss of skin sensitivity and damage to reproductive function), accumulation of carcinogens (leading to deformity and decreased vitality of juveniles), among other consequences. Therefore, monitoring these pollutants is crucial for the wellbeing of the aquatic organisms in the Caspian Sea.

Petroleum products were measured using the GCMS-QP2010 instrument. The MPC value for petroleum products in fishing grounds is 0.05 mg/dm³. During surveys conducted in autumn and winter of 2023, as well as in spring and summer of 2024, the recorded concentrations of petroleum products did not exceed the MPC value. The values were below the threshold sensitivity of the measuring instrument (Table 1.2.3-1).

Table 1.2.3-1 Concentrations of petroleum products within the survey area in the Caspian Sea during the survey period (autumn 2023 – summer 2024, mg/dm^3)

Sampling point	Concentration of petroleum products, mg/dm^3
Autumn – winter of 2023, spring – summer of 2024	
Station 1. Surface	below 0.02
Station 1. Bottom	below 0.02
Station 2. Surface	below 0.02
Station 2. Bottom	below 0.02
Station 3. Surface	below 0.02
Station 3. Bottom	below 0.02
Station 4. Surface	below 0.02
Station 4. Bottom	below 0.02
Station 5. Surface	below 0.02
Station 5. Bottom	below 0.02
Station 6. Surface	below 0.02
Station 6. Bottom	below 0.02
Station 7. Bottom	below 0.02
Station 7. Surface	below 0.02
Station 8. Bottom	below 0.02
Station 8. Surface	below 0.02

Sampling point	Concentration of petroleum products, mg/dm^3
Station 9. Bottom	below 0.02
Station 9. Surface	below 0.02
Station 10. Bottom	below 0.02
Station 10. Surface	below 0.02
Station 11. Bottom	below 0.02
Station 11. Surface	below 0.02
Station 12. Bottom	below 0.02
Station 12. Surface	below 0.02
Station 13. Bottom	below 0.02
Station 13. Surface	below 0.02
Station 14. Surface	below 0.02
Station 14. Bottom	below 0.02
Station 15. Surface	below 0.02
Station 15. Bottom	below 0.02
Station 16. Surface	below 0.02
Station 16. Bottom	below 0.02
Station 17. Bottom	below 0.02
Station 17. Surface	below 0.02
Station 18. Surface	below 0.02
Station 18. Bottom	below 0.02
Station 19. Surface	below 0.02
Station 19. Bottom	below 0.02
Station 20. Bottom	below 0.02
Station 20. Surface	below 0.02
MPC*	**0.05**

Note: concentrations recorded in autumn, winter, spring and summer survey sessions were below the sensitivity threshold of the instrument (0.02 mg/dm^3 for petroleum products).

** Generalized list of maximum permissible concentrations (MPC) and approximately safe reference level of impact (SRLI) of hazardous substances in water in fishing grounds. Ministry of Fisheries of the USSR, 1990*

1.2.4 Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) are a part of petroleum products and can accumulate in various components of aquatic ecosystems. They migrate along food chains, while retaining the ability to cause mutagenic changes in organisms of hydrobionts. PAHs were determined using the GCMS-QP2010 instrument. In the autumn and winter periods of 2023 and spring and summer periods of 2024, the recorded PAH values were below the sensitivity threshold of the instrument (Table 1.2.4-1).

Table 1.2.4-1 Concentrations of PAH within the survey area in the Caspian Sea during the survey period (autumn 2023 – summer 2024, mg/dm^3)

Sampling point	Concentration, mg/dm^3															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Benzo[g,h,i]perylene	Dibenzo[a, h]anthracene	Indeno[1.2.3-cd]pyrene
Autumn-winter of 2023, spring – summer of 2024																
Station 1. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 1. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 2. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 2. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 3. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 3. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 4. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 4. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 5. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 5. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 6. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007

Sampling point	Concentration, mg/dm^3															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Benzo[g,h,i]perylene	Dibenzo[a, h]anthracene	Indeno[1.2.3-cd]pyrene
Station 6. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 7. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 7. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 8. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 8. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 9. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 9. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 13. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 13. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 10. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 10. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 11. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 11. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 12. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 12. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 17. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 17. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 20. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007

Sampling point	Concentration, mg/dm^3															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Benzo[g,h,i]perylene	Dibenzo[a, h]anthracene	Indeno[1.2.3-cd]pyrene
Station 20. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 16. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 16. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 18. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 18. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 19. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 19. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 14. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 14. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 15. Surface	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Station 15. Bottom	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Minimum	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Maximum	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Average	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007

Note: concentrations recorded in autumn and winter of 2023 and spring and summer of 2024 were below the sensitivity threshold of the instrument (0.007 mg/dm^3 for polycyclic aromatic hydrocarbons).

1.2.5 Organochlorine pesticide

An important condition for the effective protection of water bodies and their biological resources from pollution is obtaining complete and adequate information on the qualitative and quantitative composition of toxicants in the main elements of aquatic ecosystems. Among a wide range of pesticides, the most dangerous are those compounds that can accumulate in the vital organs of fish: persistent organochlorine pesticides, isomers of DDT (dichloro-diphenyl-trichloroethane), and HCCH (hexa-chloro-cyclo-hexane). Even at low concentrations, persistent organochlorine pesticides can cause pathological disorders in fish and other hydrobionts. High concentrations of these pesticides represent one of the most severe types of pollution in water bodies. The MPC values of DDT and HCCH in fishing grounds are 0.01 mg/dm³ and 0.05 mg/dm³, respectively.

Pesticide concentrations were determined using the GCMS-QP2010 instrument. According to the survey results from autumn and winter 2023, and spring and summer 2024, the content of pesticides was below the threshold sensitivity of the measuring instrument. Concentrations of organochlorine pesticides in both the surface and bottom horizons remained below the MPC values. The concentrations of pesticides in water for autumn and winter of 2023 and spring and summer of 2024 is provided in Table 1.2.5-1.

Table 1.2.5-1 Concentration of pesticides within the survey area in the Caspian Sea during the survey period (autumn 2023 – summer 2024, mg/dm³)

Sampling point	DDT	HCCH
Autumn – winter of 2023, spring – summer of 2024		
Station 1. Surface	< 0.0001	< 0.0001
Station 1. Bottom	< 0.0001	< 0.0001
Station 2. Surface	< 0.0001	< 0.0001
Station 2. Bottom	< 0.0001	< 0.0001
Station 3. Surface	< 0.0001	< 0.0001
Station 3. Bottom	< 0.0001	< 0.0001
Station 4. Surface	< 0.0001	< 0.0001
Station 4. Bottom	< 0.0001	< 0.0001
Station 5. Surface	< 0.0001	< 0.0001
Station 5. Bottom	< 0.0001	< 0.0001
Station 6. Surface	< 0.0001	< 0.0001
Station 6. Bottom	< 0.0001	< 0.0001
Station 7. Surface	< 0.0001	< 0.0001
Station 7. Bottom	< 0.0001	< 0.0001
Station 8. Surface	< 0.0001	< 0.0001
Station 8. Bottom	< 0.0001	< 0.0001
Station 9. Surface	< 0.0001	< 0.0001
Station 9. Bottom	< 0.0001	< 0.0001
Station 10. Surface	< 0.0001	< 0.0001
Station 10. Bottom	< 0.0001	< 0.0001
Station 11. Surface	< 0.0001	< 0.0001
Station 11. Bottom	< 0.0001	< 0.0001
Station 12. Surface	< 0.0001	< 0.0001
Station 12. Bottom	< 0.0001	< 0.0001
Station 13. Surface	< 0.0001	< 0.0001
Station 13. Bottom	< 0.0001	< 0.0001
Station 14. Surface	< 0.0001	< 0.0001
Station 14. Bottom	< 0.0001	< 0.0001
Station 15. Surface	< 0.0001	< 0.0001
Station 15. Bottom	< 0.0001	< 0.0001
Station 16. Surface	< 0.0001	< 0.0001
Station 16. Bottom	< 0.0001	< 0.0001
Station 17. Surface	< 0.0001	< 0.0001
Station 17. Bottom	< 0.0001	< 0.0001
Station 18. Surface	< 0.0001	< 0.0001

Sampling point	DDT	HCCH
Station 18. Bottom	< 0.0001	< 0.0001
Station 19. Surface	< 0.0001	< 0.0001
Station 19. Bottom	< 0.0001	< 0.0001
Station 20. Surface	< 0.0001	< 0.0001
Station 20. Bottom	< 0.0001	< 0.0001
Minimum	< 0.0001	< 0.0001
Maximum	< 0.0001	< 0.0001
Average	< 0.0001	< 0.0001
MPC*	**0.01**	**0.005**

Note: concentrations recorded during the survey period (autumn and winter of 2023 and spring and summer of 2024) were below the sensitivity threshold of the instrument (0.0001 mg/dm^3 for DDT and HCCH).

Thus, in autumn and winter periods of 2023 and in spring and summer periods of 2024, MPC values of biogenic elements were not exceeded. Concentrations of biogenic elements varied within the same limits or were below the threshold sensitivity of the instruments.

Concentrations of heavy metals in all four seasons were below the MPC and below the sensitivity level of analytical methods.

Concentrations of total hydrocarbons and organochlorine pesticides in the surface, middle and bottom horizons were below the established MPC.

Concentrations of polyaromatic hydrocarbons were below the threshold sensitivity of the instrument during the survey period.

Based on the data obtained during the survey sessions, the hydrochemical conditions of marine water within the survey area were favorable for the lifecycle of hydrobionts.

1.2.6 Control of analyses of the collected samples

Control samples

Additional samples of water (for biogens, heavy metals, petroleum products, aromatic hydrocarbons, organochlorine pesticides) were collected at one of the points of each group of stations to verify the accuracy of analytical studies.

Wipe samples

Wipe samples were collected from the instruments and laboratory dishes in order to assess the effectiveness of the cleaning procedures.

Biogenic elements

Table 1.2.6-1 shows the results of statistical analysis of control samples and wipe samples for biogenic elements. In autumn and winter of 2023, spring and summer of 2024, the content of biogenic elements in the control samples and wipe samples did not exceed the average concentrations recorded at all surveyed stations.

Table 1.2.6-1 Results of statistical analysis of the control samples and wipe samples for biogenic elements (mg/l), autumn 2023 – summer 2024

No.	Parameter, sample	NH_4		NO_2		NO_3		N_{total}	P_{total}
		NH_4	N-NH_4	NO_2	N-NO_2	NO_3	N-NO_3		
Autumn									
1	Control sample	0.04	0.03	0.015	0.005	2.7	0.6	0.7	< 0.005
2	Equipment Blank	<0.003	<0.02	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005
3	Wipe sample from the laboratory dishes	<0.003	<0.002	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005
4	**Average**	**0.067**	**0.051**	**0.024**	**0.007**	**2.373**	**0.535**	**0.648**	below 0.005
Winter									
1	Control sample	0.03	0.02	0.016	0.005	1.7	0.4	0.5	< 0.005
2	Equipment Blank	<0.003	<0.002	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005

No.	Parameter, sample	NH_4		NO_2		NO_3		N_{total}	P_{total}
		NH_4	$N\text{-}NH_4$	NO_2	$N\text{-}NO_2$	NO_3	$N\text{-}NO_3$		
3	Wipe sample from the laboratory dishes	<0.003	<0.002	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005
4	**Average**	**0.06**	**0.04**	**0.018**	**0.006**	**2.0**	**0.4**	**0.6**	**< 0.005**
Spring									
1	Control sample	0.03	0.02	0.04	0.012	1.7	0.4	0.6	< 0.005
2	Equipment Blank	<0.003	<0.002	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005
3	Wipe sample from the laboratory dishes	<0.003	<0.002	<0.01	<0.003	<0.05	<0.01	<0.5	< 0.005
4	**Average**	**0.09**	**0.07**	**0.04**	**0.011**	**1.9**	**0.4**	**0.6**	**< 0.005**
Summer									
1	Control sample	0.06	0.05	0.02	0.006	1.6	0.4	0.5	0.007
2	Equipment Blank	<0.003	<0.002	<0.01	<0.003	<0.05	<0.1	<0.5	< 0.005
3	Wipe sample from the laboratory dishes	<0.003	<0.002	<0.01	<0.003	<0.05	<0.1	<0.5	< 0.005
4	**Average**	**0.06**	**0.04**	**0.04**	**0.01**	**1.74**	**0.39**	**0.59**	**0.008**

Heavy metals

Table 1.2.6-2 shows the results of statistical analysis of the control samples and wipe samples for heavy metals. In autumn and winter of 2023, spring and summer of 2024, the concentrations of heavy metals in the control samples and wipe samples were below the sensitivity level of the instruments, as well as at all surveyed stations.

Table 1.2.6-2 Results of statistical analysis of control samples and wipe samples for heavy metals (mg/l), autumn 2023 – summer 2024

Parameter, sample	Cadmium Cd	Copper Cu	Zinc Zn	Lead Pb	Mercury Hg
Autumn					
Control sample	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Equipment Blank	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Wipe sample from the laboratory dishes	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Average	**< 0.001**	**< 0.0025**	**< 0.005**	**< 0.005**	**< 0.0001**
Winter					
Control sample	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Equipment Blank	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Wipe sample from the laboratory dishes	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Average	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Spring					
Control sample	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Equipment Blank	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Wipe sample from the laboratory dishes	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Average	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Summer					
Control sample	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Equipment Blank	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001
Wipe sample from the laboratory dishes	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001

Parameter, sample	Cadmium Cd	Copper Cu	Zinc Zn	Lead Pb	Mercury Hg
Average	< 0.001	< 0.0025	< 0.005	< 0.005	< 0.0001

Petroleum products

Table 1.2.6-3 shows the results of statistical analysis of the control samples and wipe samples for petroleum products. The concentrations of petroleum products in the control samples and wipe samples were below the detection threshold of the instrument.

Table 1.2.6-3 Results of statistical analysis of control samples and wipe samples for petroleum products (mg/l), autumn 2023 – summer 2024

Sampling point	Concentration of petroleum products, mg/dm^3
Autumn	
Control sample	below 0.02
Equipment Blank	below 0.02
Wipe sample from the laboratory dishes	below 0.02
Winter	
Control sample	below 0.02
Equipment Blank	below 0.02
Wipe sample from the laboratory dishes	below 0.02
Spring	
Control sample	below 0.02
Equipment Blank	below 0.02
Wipe sample from the laboratory dishes	below 0.02
Summer	
Control sample	below 0.02
Equipment Blank	below 0.02
Wipe sample from the laboratory dishes	below 0.02

Pesticides

Table 1.2.6-4 shows the results of statistical analysis of the control samples and wipe samples for pesticides. The concentrations of pesticides in the control samples and wipe samples were below the sensitivity level of the instrument.

Table 1.2.6-4 Results of statistical analysis of control samples and wipe samples for DDT and HCCH (mg/l), autumn 2023 – summer 2024

Sampling point	DDT	HCCH
Autumn		
Control sample	< 0.0001	< 0.0001
Equipment Blank	< 0.0001	< 0.0001
Wipe sample from the laboratory dishes	< 0.0001	< 0.0001
Winter		
Control sample	< 0.0001	< 0.0001
Equipment Blank	< 0.0001	< 0.0001
Wipe sample from the laboratory dishes	< 0.0001	< 0.0001
Spring		
Control sample	< 0.0001	< 0.0001
Equipment Blank	< 0.0001	< 0.0001
Wipe sample from the laboratory dishes	< 0.0001	< 0.0001
Summer		
Control sample	< 0.0001	< 0.0001
Equipment Blank	< 0.0001	< 0.0001
Wipe sample from the laboratory dishes	< 0.0001	< 0.0001

Polycyclic aromatic hydrocarbons

Table 1.2.6-5 shows the results of statistical analysis of control samples and wipe samples for polycyclic aromatic hydrocarbons. In autumn and winter of 2023, spring and summer of 2024, the concentrations of polycyclic aromatic hydrocarbons in the control samples and wipe samples were below the detection threshold of the instrument.

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Table 1.2.6-5 Results of statistical analysis of control samples and wipe samples for polycyclic aromatic hydrocarbons (mg/l), autumn 2023 – summer 2024

Sampling point	Concentration, mg/dm³															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Benzo[g,h,i]perylene	Dibenzo[a, h]anthracene	Indeno[1.2.3-cd]pyrene
Autumn																
Control sample	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Equipment Blank	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Wipe sample from the laboratory dishes	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Winter																
Control sample	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Equipment Blank	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Wipe sample from the laboratory dishes	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Spring																
Control sample	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Equipment Blank	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Wipe sample from the laboratory dishes	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Summer																
Control sample	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Equipment Blank	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Wipe sample from the laboratory dishes	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007

CONCLUSION

There was no measurement error when comparing the results of analyses based on the average actual concentrations recorded at the surveyed stations and in the control water samples.

There was also no measurement error caused by the contamination of laboratory dishes and equipment, which was confirmed by the analysis of wipe samples.

2. Marine biological environment

2.1 Hydrobiological survey

2.1.1 General state of hydrobionts in the Caspian Sea

Hydrobiological communities of the Caspian Sea are diverse. In total, there are 632 species of the phytoplankton of the Caspian Sea, 100 species of zooplankton, and 379 species of zoobenthos (Yablonskaya, 2007). Hydrobionts can be classified in various ways in relation to their origin, habitat factors, and other circumstances. Freshwater, brackish-water and marine groups of species are distinguished depending on water salinity.

The species diversity of algal flora in the Caspian Sea decreases from the northern areas to the southern areas, attributed to the loss of freshwater algae species. The phytoplankton community in the Middle Caspian Sea includes all ecological groups of algae, with diatoms having the highest biomass among them.

Diatoms (*Bacillariophyta*) are represented by the largest number of species, varieties and forms among the phytoplankton of the Middle Caspian Sea (Proshkina-Lavrenko, 1968). Representatives of 47 genera are registered in this group: *Aulacoseira, Melosira, Podosira, Hyalodiscus, Sceletonema, Cyclotella, Stephanodiscus, Thalassiosira, Coscinodiscus, Actinocyclus, Rhizosolenia, Pseudosolenia, Chaetoceros, Attheya, Cerataulina, Tabellaria, Thalassionema, Diatoma, Opephora, Fragilaria, Synedra, Asterionella, Grammatophora, Achnanthes, Rhoicosphaenia, Diploneis, Navicula, Pinnularia, Gyrosigma, Pleurosigma, Amphiprora, Amphora, Cymbella, Epithemia, Rhopalodia, Bacillaria, Nitzschia, Pseudo-nitzschia, Cymatopleura, Surirella, Caloneis, Cocconeis, Gomphonema, Campylodiscus, Eunotia, Hantzschia, Ditylum.*

The second in taxonomic diversity is the division of green algae, *Chlorophyta*, which includes plant cells of 45 genera: *Chlamydomonas, Gonium, Treubaria, Schroderia, Lambertia, Dictyochloris, Pediastrum, Sorastrum, Tetraedron, Eremosphaera, Lagerchemia, Golenkiniopsis, Oocystis, Ankistrodesmus, Monoraphidium, Hyaloraphidium, Kirchneriella, Selenastrum, Coenochloris, Coenolamellus, Dictyosphaerium, Botryococcus, Coelastrum, Crucigenia, Westella, Tetrastrum, Actinastrum, Scenedesmus, Micractinium, Binuclearia, Ulothrix, Mougeotia, Spirogyra, Zygnema, Closterium, Cosmarium, Staurastum, Sphaerozosma, Gonium, Pandorina, Eudorina, Volvox, Desmidium, Oedogonium, Ophyiocytium.*

The division of blue-green algae, *Cyanophyta*, consists of 22 genera: *Synechocystis, Dactylococcopsis, Microcystis, Aphanothece, Gloeocapsa, Merismopedia, Pseudoholopedia, Coelosphaerium, Gomphosphaeria, Johannesbaptistia, Anabaena, Anabaenopsis, Aphanizomenon, Nodularia, Tolypothrix, Rivularia, Oscillatoria, Spirulina, Phormidium, Lyngbya, Nostoc, Aphanocapsa.*

Phytoplankton of the *Dinophyta* division are represented by nine genera: *Prorocentrum, Gymnodinium, Sphaerodinium, Glenodinium, Peredinium, Goniaulax, Gyrodinium, Amphidium, Pyrocystis.*

Euglenophyta (*Euglena* genus, *Phacus* genus, *Trachelomonas* genus) and *Cbrysophyta* (*Dinobryon* genus) algae are the least numerous.

The species diversity of the planktonic fauna in the Caspian Sea is relatively small. The degree of study of individual systematic groups of zooplankton varies. The taxonomic diversity of representatives of the crustacean class, *Crustacea*, is the most thoroughly studied. (Atlas of Invertebrates of the Caspian Sea, 1968; Determinant of fish and invertebrates of the Caspian Sea, 2015). Zooplankton in the Middle Caspian Sea is characterized by a low species diversity and is primarily inhabited by copepods (*Copepoda* order) of *Calanipeda, Heterocope, Halicyclops, Eurytemora, Heterocope, Paraergasilus, Acartia* genera and cladocerans (*Cladocera* order) of *Alona, Pleopis, Apagis, Cercopagis, Podonevadne, Cornigerius, Leptodora* and other genera.

One of the numerous groups of zooplankton are rotifers, Rotatoria class, belonging to the following genera: *Brachionus, Conochilus, Filinia, Hexarthra, Testudinella, Asplanchna, Bipalpus, Ploesoma, Polyarthra, Collotheca, Colurella, Lepadella, Euchlanis, Keratella, Notholca,* *Trichocerca, Synchaeta.* Protozoans can also be found (*Acineta* genus, *Tintinnopsis* genus, *Epistylis* genus, *Zoothamnium* genus, *Vorticella* genus), although these have been studied in less detail.

Macrozooplankton contains the coelenterates of *Aurelia* genus and *Blackfordia* genus, as well as comb-bearers *Ctenophora* of *Mnemiopsis* genus. The number of zooplankton species recorded in the Middle Caspian Sea varies in different years depending on the abiotic factors and distribution of salinity zones. According to quantitative indicators, copepods prevail. Zooplankton also contains planktonic forms of *Cirripedia* barnacles and *Bivalvia* bivalves.

Benthic invertebrates of four groups (*Crustacea*, including *Malacostraca*, *Vermes*, *Mollusca* and hydroids (*Hydrozoa*)) have been recorded in the zoobenthos of the Middle Caspian Sea (Atlas of Invertebrates of the Caspian Sea, 1968). Crustaceans of *Amphipoda*, *Crustacea*, *Mysidacea*, *Decapoda* and *Cirripedia* orders of the following genera are diverse: *Paramysis, Caspiomysis, Katamysis, Limnomysis, Schizorhynchus, Pterocuma, Volgocuma, Pseudocuma, Stenocuma, Caspiocuma, Hyrcanocuma, Carinocuma, Axelboeskia, Amathillina, Dikerogammarus, Niphargoides, Pandorites, Iphigenella, Gmelinopsis, Gmelina, Cardiophilus, Zernovia, Gammarus (Chaetogammarus), Caspicola, Revulgammarus, Corophium, Rhithropanopeus, Balanus*. Annelida segmented worms, Polychaeta worms, Oligochaeta worms, and Nematoda threadworms of the following genera are next in order of importance: *Hediste, Marenzelleria, Hypania, Hypaniola, Parhypania, Manayunkia, Fabricia, Mercierella, Piscicola*, *Archaeobdella* genus, as well as *Oligochaeta* and *Nematoda* (not classified by genus) and *Gastrotriteia* and *Gastropempta* molluscs of the following genera: *Mytilasster, Dreissena, Cerastoderma, Didacna, Hypanis (Adacna), Abra, Theodoxus*). The smallest are representatives of *Hydrozoa* genera: *Cardylophora, Bougainvillia, Moerisia*. Representatives of crustaceans are the most numerous; representatives of mollusks dominate in biomass.

2.1.2 Hydrobiological survey at the potential construction site near Kuryk in the autumn, winter, spring and summer periods of 2023-2024

Phytoplankton

As noted above, phytoplankton of the Caspian Sea is characterized by a predominance of brackish and freshwater forms and is poor in algae compared to the phytoplankton of the open seas (Yablonskaya, 2007). According to literature, species diversity decreases from north to south, due to a loss of freshwater species. Several widespread species stand out of all the diversity demonstrating high abundance and biomass. These include, for example, *Pseudosolenia calcar-avis*, *Actinocyclus ehrenbergii* from diatoms (*Bacillariophyta*), *Prorocentrum cordatum* from dinophytes (*Dinophyta*) and some others (Karpinsky, 2002).

During the field survey (autumn, winter, spring and summer),160 samples of phytoplankton were collected at 20 monitoring stations and analyzed. Qualitative and quantitative indicators of phytoplankton abundance and biomass in the survey area in the autumn and winter periods of 2023, as well as in the spring and summer periods of 2024, are provided below.

Twenty-two taxonomic units were identified in the qualitative composition of phytoplankton in the surface horizon within the survey area in autumn period. Diatoms were characterized by the highest species diversity (14 species). Dinophytes and blue-green algae were represented by a smaller number of species (five and two species respectively). There was one species of euglena algae. The representatives of Chlorophyta division were not recorded (Table 2.1.2-1).

Table 2.1.2-1 Number of species in the phytoplankton groups within the survey area, autumn 2023

Algae group	Horizon	
	Surface	Bottom
Cyanophyta	2	-
Bacillariophyta	14	23
Dinophyta	5	6
Euglenophyta	1	-
Chlorophyta	-	-
Total	**22**	**29**

In winter, the taxonomic diversity of plant cells in the surface horizon within the survey area amounted to 18 species ranked below the genus. Diatoms were characterized by the highest species diversity (13 species). Dinophytes and green algae were represented by almost the same number of species: three and two species, respectively. Blue-green algae and euglena algae were not recorded (Table 2.1.2-2).

Table 2.1.2-2 Number of species in the phytoplankton groups within the survey area, winter 2023

Algae group	Horizon	
	Surface	Bottom
Bacillariophyta	13	14
Dinophyta	3	3
Chlorophyta	2	2
Total	**18**	**19**

In spring, phytoplankton in the surface horizon within the survey area was represented by 37 taxonomic unites. Floristic composition was mainly formed by diatoms (26 species). Dinophytes and green algae were next (five and three species, respectively). Euglena algae were represented by two species, and blue-green algae were represented by one species (Table 2.1.2-3).

Table 2.1.2-3 Number of species in the phytoplankton groups within the survey area, spring 2024

Algae group	Horizon	
	Surface	Bottom
Cyanophyta	1	1
Bacillariophyta	26	26
Dinophyta	5	5
Euglenophyta	2	-
Chlorophyta	3	4
Total	**37**	**36**

Species distribution of algae flora in the surface horizon within the survey area was defined by 51 taxonomic units in summer. Diatoms prevailed (31 species). Dinophytes were represented by nine species. Blue-green algae and green algae were represented by four species each. Three species of euglena algae were recorded (Table 2.1.2-4).

Table 2.1.2-4 Number of species in the phytoplankton groups within the survey area, summer 2024

Algae group	Horizon	
	Surface	Bottom
Cyanophyta	4	3
Bacillariophyta	31	29
Dinophyta	9	5
Euglenophyta	3	-
Chlorophyta	4	4
Total	**51**	**41**

In autumn, the phytoplankton community in the surface horizon was represented by all ecological complexes of algae with the predominant development of cells of freshwater and brackish-freshwater origin (Table 2.1.2-5).

Table 2.1.2-5 Quantitative indicators in ecological groups of phytoplankton within the survey area, autumn 2023

Algae group	Ecological group										Total	
	Freshwater		Brackish freshwater		Brackish-water		Marine		Other			
Horizon	I	II	I	II	I	II	I	II	I	II	I	II
Cyanophyta	2	-	-	-	-	-	-	-	-	-	2	-
Bacillariophyta	1	5	4	7	3	4	4	5	2	2	14	23
Dinophyta	-	-	2	2	1	2	2	2	-	-	5	6
Euglenophyta	1	-	-	-	-	-	-	-	-	-	1	-
Total	4	5	6	9	4	6	6	7	2	2	22	29

Note: I – surface horizon, II – bottom horizon.

In winter, the phytoplankton community in the surface horizon was represented by all ecological complexes of algae. Freshwater algae included two species; brackish-freshwater and marine included five species each; brackish–water and other groups included four and two species respectively (Table 2.1.2-6).

Table 2.1.2-6 Quantitative indicators in ecological groups of phytoplankton within the survey area, winter 2023

Algae group	Ecological group										Total	
	Freshwater		Brackish freshwater		Brackish-water		Marine		Other			
Horizon	I	II	I	II	I	II	I	II	I	II	I	II
Bacillariophyta	1	1	3	4	3	3	4	3	2	3	13	14
Dinophyta	-	-	1	1	1	1	1	1	-	-	3	3
Chlorophyta	1	1	1	1	-	-	-	-	-	-	2	2
Total	2	2	5	6	4	4	5	4	2	3	18	19
Note: I – surface horizon, II – bottom horizon.												

In spring, the phytoplankton community in the surface horizon was represented by all ecological complexes of algae. Cells of marine origin prevailed.

Table 2.1.2-7 Quantitative indicators in ecological groups of phytoplankton within the survey area, spring 2024

Algae group	Ecological group										Total	
	Freshwater		Brackish freshwater		Brackish-water		Marine		Other			
Horizon	I	II	I	II	I	II	I	II	I	II	I	II
Cyanophyta	1	1	-	-	-	-	-	-	-	-	1	1
Bacillariophyta	4	5	7	6	6	4	8	9	1	2	26	26
Chlorophyta	2	3	1	1	-	-	-	-	-	-	3	4
Dinophyta	-	-	1	1	1	1	3	3	-	-	5	5
Euglenophyta	2	-	-	-	-	-	-	-	-	-	2	-
Total	9	5	9	8	7	56	11	12	1	2	37	36
Note: I – surface horizon, II – bottom horizon.												

In summer, the phytoplankton community in the surface horizon was represented by all ecological complexes of algae. Species of brackish-freshwater and marine origin prevailed. The highest diversity was observed among the species of brackish-water origin (Table 2.1.2-8).

Table 2.1.2-8 Quantitative indicators in ecological groups of phytoplankton within the survey area, spring 2024

Algae group	Ecological group										Total	
	Freshwater		Brackish freshwater		Brackish-water		Marine		Other			
Horizon	I	II	I	II	I	II	I	II	I	II	I	II
Cyanophyta	2	1	2	1	-	-	-	-	-	1	4	3
Bacillariophyta	4	5	9	7	7	5	11	10	-	2	31	29
Chlorophyta	1	3	3	1	-	-	-	-	-		4	4
Dinophyta	-	-	2	1	2	1	5	3	-	-	9	5
Euglenophyta	3	-	-	-	-	-	-	-	-	-	3	-
Total	10	9	16	10	9	6	16	10	-	3	51	41
Note: I – surface horizon, II – bottom horizon.												

Quantitative indicators of phytoplankton development at the site were low in autumn. Their number amounted to 2,099.98 thousand cells/m^3; their biomass amounted to 8.81 mg/m^3 (Table 2.1.2-9).

Table 2.1.2-9 Quantitative indicators of phytoplankton within the survey area (surface layer), autumn 2023

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Cyanophyta		
Oscillatoria sp.	52.94	0.01
Microcystis aeruginosa	+	+
Bacillariophyta		
Coscinodiscus perforatus v. cellulosus	23.53	1.31
Cyclotella caspia	23.53	0.03
Navicula cincta	64.71	0.32
Nitzschia acicularis	76.47	0.08
Nizschia sublinearis	176.47	0.82
Nizschia tertuirostris	47.06	0.08
Rhoicosphaenia curvata	111.76	0.06
Sceletonema subsalsum	11.76	0.02
Rhoicosphaenia sp.	11.76	0.04
Thalassiosira caspica	52.94	0.64
Conticribra weissflogii	464.71	0.18
Thalassiosira incerta	276.47	1.66
Gomphonema sp.	35.29	0.05
Gomphonema olivaceum	476.47	0.76
Dinophyta		
Prorocentrum cordatum	123.53	0.25
Goniaulax polyedra	29.41	0.35
Peridinium latum v. halophila	11.76	0.35
Prorocentrum micans	82.35	1.81
Dinophysis ovum	+	+
Euglenophyta		
Phacus sp.	+	+
Total	**2099.98**	**8.81**

Note: Organisms encountered in qualitative composition are marked with "+"

The basis of quantitative indicators was formed by diatoms, accounting for 86.5% of the total number and 68.6% of the total biomass of phytocenosis. In this group, *Conticribra weissflogii* and *Gomphonema olivaceum* were distinguished by mass development (abundance). *Thalassiosira incerta* and *Rhoicosphaenia curvata* subdominated. The second by importance were dinophytes, among which *Prorocentrum cordatum* prevailed. Numerically, blue-green algae (*Oscillatoria sp.*) were inferior to diatoms and dinophytes - 52.94 thousand cells/m^3. Euglena algae (*Phacus sp.*) was noted only in qualitative composition. *Coscinodiscus perforatus v. cellulosus* had the highest biomass among diatoms. *Prorocentrum micans* dominated in biomass among dinophytes.

In winter, abundance of phytoplankton within the survey area amounted to 1,649.99 thousand cells/m^3; its biomass amounted to 11.50 mg/m^3 (Table 2.1.2-10).

In winter period, quantitative indicators were mainly formed by the diatoms, as well as in the autumn period. In this group, *Conticribra weissflogii* and *Thalassionema nitzschioides* prevailed in abundance, *Coscinodiscus perforates* and *Thalassiosira caspica* prevailed in biomass. Among dinophytes, *Prorocentrum cordatum* had the highest abundance, and *Prorocentrum obtusum* had the largest biomass. Green algae were recorded only in qualitative composition.

Table 2.1.2-10 Quantitative indicators of phytoplankton within the survey area (surface layer), winter 2023

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Chlorophyta		
Monoraphidium contortum	+	+
Binuclearia lauterbornii	+	+

Bacillariophyta		
Coscinodiscus perforatus v. cellulosus	60.00	3.36
Fragilaria construens	160.00	0.03
Nitzschia acicularis	13.33	0.01
Nizschia sublinearis	10.00	0.47
Nizschia seriata	133.33	0.27
Rhoicosphaenia sp.	80.0	0.04
Thalassionema nitzschioides	333.33	0.44
Thalassiosira caspica	233.33	2.80
Conticribra weissflogii	386.67	0.15
Cocconies placentula	60.0	2.74
Gomphonema olivaceum	80.0	0.13
Nizschia closterium	+	+
Chaetoceros pendulus	+	+
Dinophyta		
Prorocentrum cordatum	66.67	0.13
Prorocentrum obtusum	33.33	0.93
Dinophysis ovum	+	+
Total	**1649.99**	**11.50**

Note: Organisms encountered in qualitative composition are marked with "+"

In spring, quantitative indicators of phytoplankton at the site were the following: abundance amounted to 9,176.00 thousand cells/m^3; its biomass amounted to 45.74 mg/m^3.

These indicators were mainly formed by diatoms, among which *Actinocyclus ehrenbergii* and *Chaetoceros pendulus* dominated in biomass (6.39 mg/m^3 and 5.29 mg/m^3), while *Cotricribra weissflogii* and *Thalassionema nitzschioides* dominated in number. *Pseudopediastrum integrum* prevailed among green algae (6.87 mg/m^3). Blue-green algae and euglena algae did not have significant contribution in the development of phytoplankton in spring (Table 2.1.2-11).

Table 2.1.2-11 Quantitative indicators of phytoplankton at within the survey area (surface layer), spring 2024

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Cyanophyta		
Oscillatoria sp.	120.00	0.02
Chlorophyta		
Ankistrodesmus pseudomirabilis	165.00	0.03
Binuclearia lauterbornii	2135.00	1.16
Pseudopediastrum integrum	135.00	6.87
Bacillariophyta		
Actinocyclus ehrenbergii	190.00	6.39
Chaetoceros pendulus	170.00	5.29
Coscinodiscus perforatus	71.00	3.9
Staurosira construens	340.00	0.08
Navicula cryptocephala	70.00	0.12
Nitzschia acicularis	615.00	0.66
Nizschia closterium	90.00	0.18
Nizschia reversa	55.00	0.08
Nizschia sublinearis	185.00	1.20
Nizschia tenuirostris	140.00	0.44
Nizschia seriata	745.00	1.49
Pinnularia sp.	40.00	0.12
Pseudosolnia calcar-avis	5.00	0.02
Thalassionema nitzschioides	1150.00	0.99
Tabelaria fenestrata	420.00	0.09
Thalassiosira caspica	655.00	8.34
Cotricribra weissflogii	1215.00	2.14
Cocconies placentula	100.00	0.56
Gomphonema olivaceum	240.00	3.94
Mastogloia sp.	55.00	0.60
Rhoicosphaenia sp	+	+
Diploneis interrupta	+	+
Sceletonema subsalsum	+	+

Amphiprora poludosa	+	+
Rhoicosphaenia curvata	+	+
Stephanodiscus socialis		
Dinophyta		
Prorocentrum cordata	40.00	0.08
Prorocentrum obtusum	25.00	0.93
Dinophysis ovum	+	+
Pyrosystis lunula	+	+
Prorocentrum scutullum	+	+
Euglenophyta		
Euglena sp.	5.00	0.02
Euglena van-goori	+	+
Total	**9176.0**	**45.74**

Note: Organisms encountered in qualitative composition are marked with "+"

In summer, quantitative indicators of phytoplankton at the site were the following: abundance amounted to 23,863.00 thousand cells/m^3; its biomass amounted to 70.60 mg/m^3 (Table 2.1.2-12).

As in the previous periods, quantitative indicators were mainly formed by diatoms. In this group, *Cotricribra weissflogii* and *Thalassionema nitzschioides* dominated in number, while *Coscinodiscus perforates* and *Thalassiosira caspica* dominated in biomass. Among dinophytes, the highest biomass was observed for *Prorocentrum obtusum*, and the highest abundance was recorded for *Glenodinium lenticicula*. Green algae, blue-green algae and euglena algae were recorded in smaller numbers.

Table 2.1.2-12 Quantitative indicators of phytoplankton within the survey area (surface layer), summer 2024

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Cyanophyta		
Oscillatoria sp.	240.0	0.03
Anabaenopsis cunningtonii	750.0	1.44
Gloeocapsa cohaerens	623.0	0.07
Dolichospermum crassum	242.0	2.17
Chlorophyta		
Ankistrodesmus pseudomirabilis	470.0	0.04
Binuclearia lauterbornii	1710.0	0.04
Pseudopediastrum integrum	146.0	4.32
Dictyosphaerium pulchellum	57.0	1.80
Bacillariophyta		
Actinocyclus ehrenbergii	228.0	7.52
Chaetoceros pendulus	174.0	3.27
Coscinodiscus perforatus	166.0	7.91
Staurosira construens	452.0	0.10
Navicula cryptocephala	168.0	0.20
Nitzschia acicularis	721.0	0.56
Nizschia closterium	90.0	0.17
Nizschia reversa	48.0	0.05
Nizschia sublinearis	201.0	0.81
Nizschia tenuirostris	137.0	0.25
Nizschia seriata	782.0	1.75
Pinnularia sp.	53.0	0.13
Pseudosolnia calcar-avis	24.0	0.10
Thalassionema nitzschioides	1538.0	1.62
Tabelaria fenestrata	466.0	0.11
Thalassiosira caspica	780.0	8.37
Cotricribra weissflogii	1364.0	1.02
Cocconies placentula	105.0	0.58
Gomphonema olivaceum	222.0	3.63
Mastogloia sp.	59.0	0.43
Diploneis interrupta	+	+

Sceletonema subsalsum	+	+
Amphiprora poludosa	+	+
Rhoicosphaenia curvata	+	+
Stephanodiscus socialis	+	+
Stephanodiscus astraea var. minutulus	3750.0	2.39
Sceletonema costatum	3100.0	1.12
Rhoicosphaenia sp.	1890.0	0.43
Chaetoceros rigidus	352.0	0.54
Rhizosolenia fragilissima	1218.0	4.85
Campylodiscus daemelianus	20.0	0.25
Dinophyta		
Prorocentrum cordata	84.0	0.17
Prorocentrum obtusum	161.0	4.67
Dinophysis ovum	+	+
Pyrosystis lunula	+	+
Prorocentrum scutullum	+	+
Glenodinium lenticicula	519.0	2.24
Peridinium latum	209.0	3.18
Peridinium trochoideum	145.0	0.03
Gymnodinium variabile	145.0	0.30
Euglenophyta		
Euglena sp.	36.0	0.14
Euglena van-goori	+	+
Euglena viridis	218.0	1.80
Total	**23863.0**	**70.60**

Note: Organisms encountered in qualitative composition are marked with "+"

In autumn, distribution of phytoplankton biomass in the surface horizon within the survey area was uneven. The highest biomass of algae (17.0 mg/m^3) was noted at station 20, where the diatom species, *Coscinodiscus perforatus v. cellulosus*, developed in mass. The lowest phytoplankton biomass was observed at station 13 and amounted to 2.95 mg/m^3 (Figure 2.1.2.1).

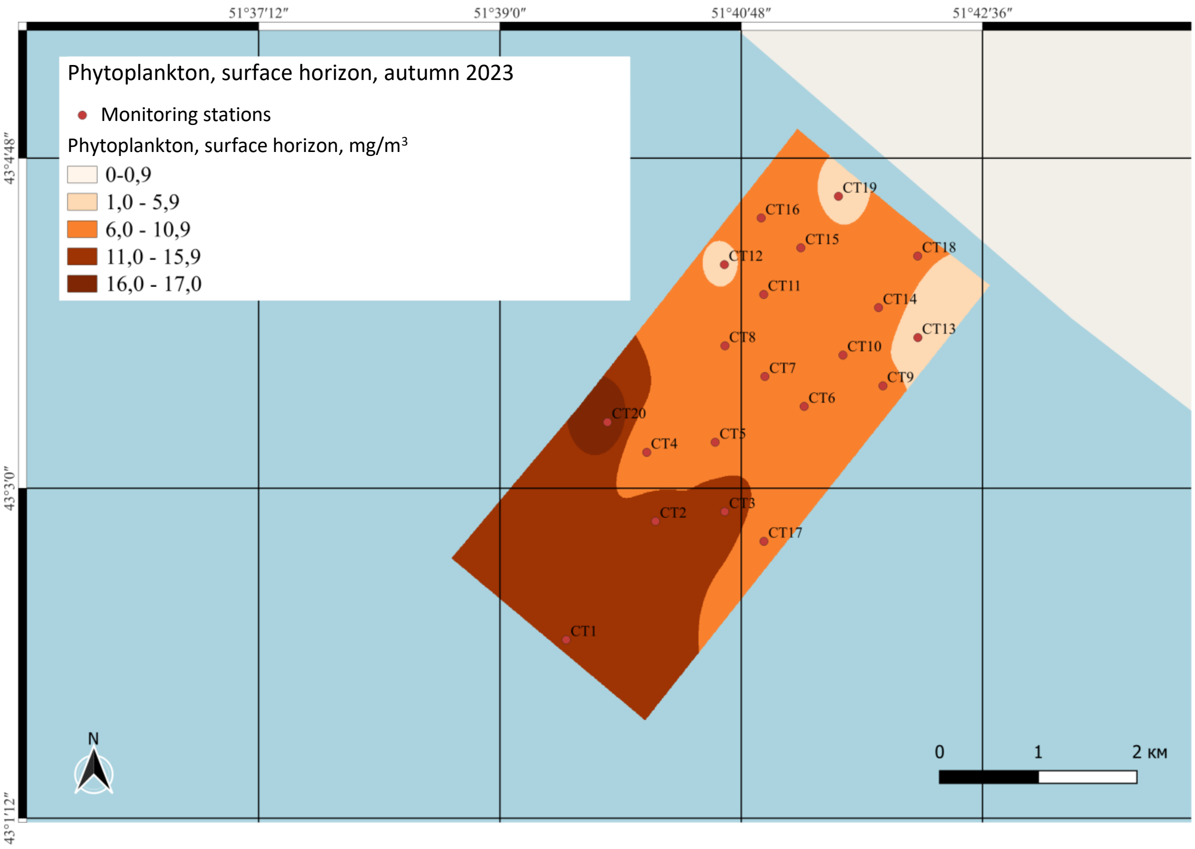

Figure 2.1.2.1 Distribution of phytoplankton within the survey area (surface layer) in

autumn 2023, mg/m³

Distribution of phytoplankton biomass in the surface horizon within the survey area was uneven in winter period. Maximum biomass of algae (16.60 mg/m³) was recorded at station 19, where the diatom specie, *Coscinodiscus perforatus v. cellulosus*, developed in mass. The lowest, phytocenosis, was observed at station 20 and amounted to 1.53 mg/m³ (Figure 2.1.2.2).

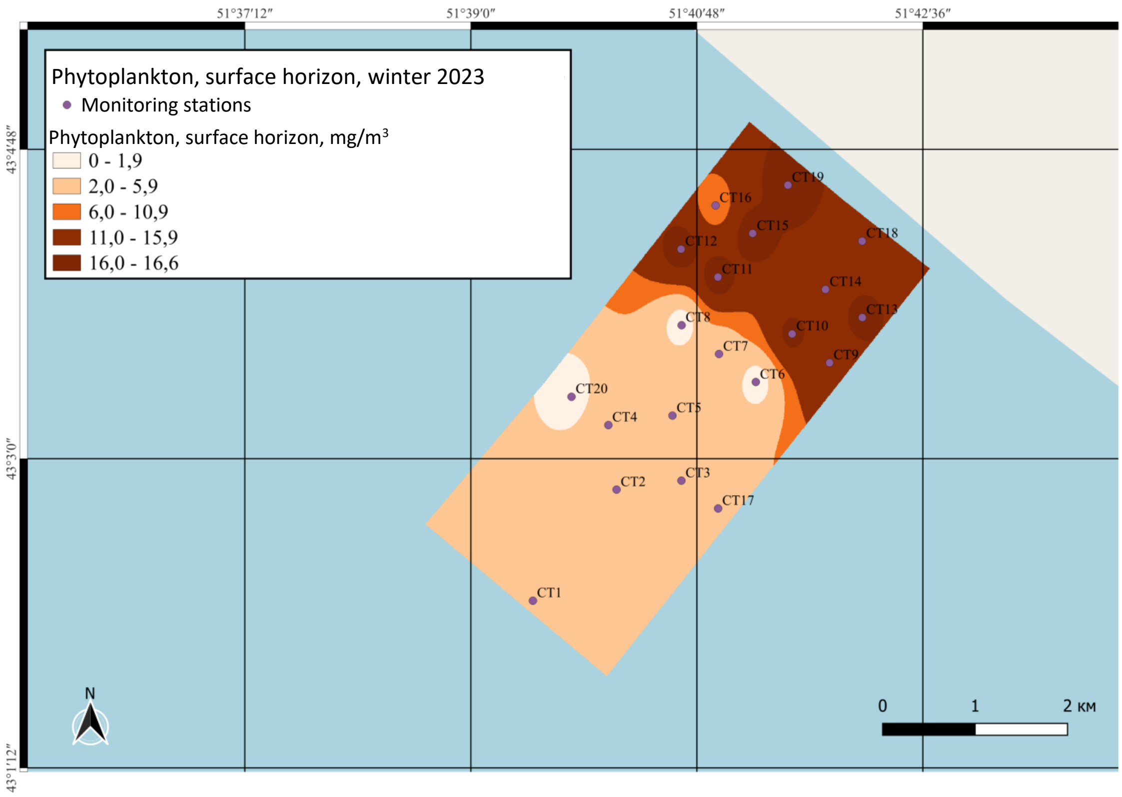

Figure 2.1.2.2 Distribution of phytoplankton within the survey area (surface layer) in winter 2023, mg/m³

In spring, distribution of biomass in the surface horizon of phytocenosis was uneven (Figure 2.1.2.3). Maximum biomass of algae (75.12 mg/m³) was recorded at station 1. The lowest biomass was recorded at station 19 (25.95 mg/m³).

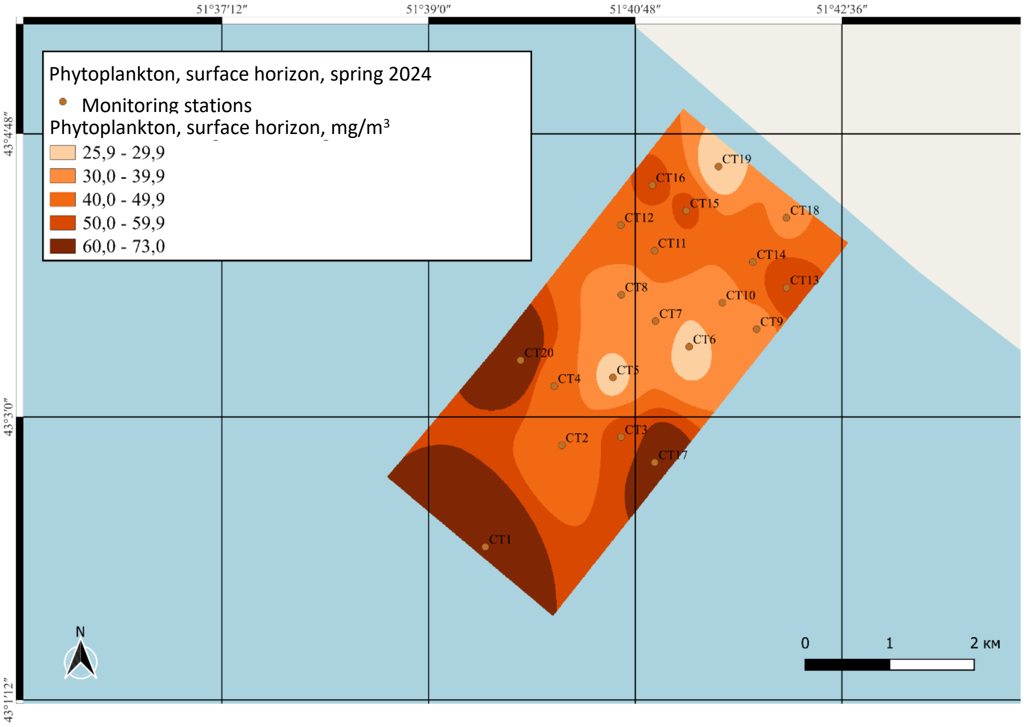

Figure 2.1.2.3 Distribution of phytoplankton within the survey area (surface layer) in spring 2024, mg/m^3

In summer, distribution of phytoplankton biomass in the surface horizon was uneven (Figure 2.1.2.4). Maximum biomass of algae (131.90 mg/m^3) was recorded at station 1. The lowest biomass was recorded at station 19 (37.20 mg/m^3).

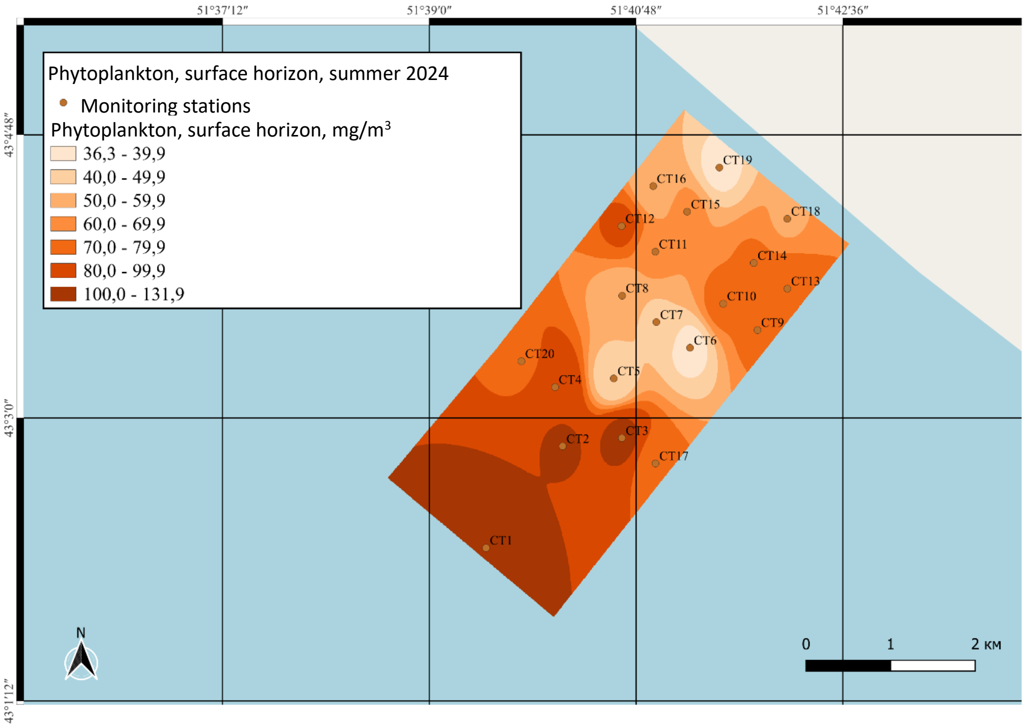

Figure 2.1.2.4 Distribution of phytoplankton within the survey area (surface layer) in summer 2024, mg/m^3

In autumn, the number of species in the bottom horizon increased slightly, compared to the surface, and amounted to 29 versus 22 species, varieties and forms. The basis of floral diversity was formed, as before, by diatoms in amount of 23 species ranked below genus (80% of the total phytoplankton composition). Then, in order of importance, diatoms were followed by dinophytes (6). Blue-green algae, green algae and euglena algae were not recorded (Table 2.1.2-13).

The ecological complex was dominated by the species of brackish-freshwater origin.

Quantitative indicators of the development of benthic phytoplankton were slightly lower than those of the surface horizon were and amounted to 1,888.21 thousand cells/m^3. Biomass was above 11.80 mg/m^3 (Table 2.1.2-13). This fact is explained by the development of large dinophytes: *Pyrocystis lunula, Prorocentrum micans*, and diatoms: *Coscinodiscus perforatus v. cellulosus*, *Thalassiosira caspica*.

Table 2.1.2-13 Quantitative indicators of phytoplankton within the survey area (bottom layer), autumn 2023

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Bacillariophyta		
Chaetoceros pendulus	17.65	0.32
Coscinodiscus perforatus v. cellulosus	29.41	1.65
Cyclotella caspia	52.94	0.05
Cymbella tumida	5.88	0.02
Diatoma hiemale	58.82	0.14
Diploneis interrupta	23.52	0.04
Navicula cincta	70.59	0.34
Navicula minima	58.82	0.01
Navicula cryptocephala	5.88	0.01
Navicula sp.	17.65	0.08
Nitzschia acicularis	88.24	0.09
Nitzschia closterium	70.59	0.12
Nizschia sublinearis	170.59	0.80
Nizschia tertuirostris	58.82	0.10
Rhoicosphaenia curvata	29.41	0.02
Sceletonema subsalsum	464.71	0.56
Rhoicosphaenia sp.	23.53	0.07
Stephanodiscus binderanus	5.88	0.01
Tabellaria fenestrata	64.71	0.01
Thalassiosira caspica	88.24	1.06
Conticribra weissflogii	176.47	0.07
Thalassiosira incerta	11.76	0.07
Gomphonema olivaceum	105.88	0.17
Dinophyta		
Prorocentrum cordatum	41.18	0.08
Prorocentrum micans	58.82	1.29
Prorocentrum obtusum	17.64	0.49
Prorocentrum proximum	17.64	0.78
Pyrocystis lunula	29.41	2.77
Dinophysis ovum	23.53	0.58
Total	**1888.21**	**11.80**

In autumn, abundance and biomass of diatoms in both horizons were approximately similar (1,852.93 thousand cells/m^3 and 6.05 mg/m^3 for the surface horizon; 1,699.99 thousand cells/m^3 and 5.81 mg/m^3 for the bottom horizon). Abundance of dinophytes in the bottom horizon decreased by 1.3 times compared to the surface horizon. The biomass increased by 2.2 times due to the development of *Pyrocystis lunula*.

In winter, the number of phytoplankton species in the bottom horizon was approximately the same as those in the surface horizon (19 and 18 species, respectively). The basis of floral diversity was formed, as before, by diatoms in amount of 14 species ranked below genus (73% of the total phytoplankton composition). Dinophytes were represented by three species; green algae were represented by two species. Representatives of Chlorophyta division were not recorded.

The ecological complex was dominated by the species of brackish-freshwater origin.

Quantitative indicators of the development of benthic phytoplankton in winter were 1.7 times lower than those of the surface horizon and amounted to 1,649.99 thousand cells/m^3. Biomass was above 16.25 mg/m^3 (Table 2.1.2-14). As observed during the autumn, this fact is explained by the development of large diatoms, *Chaetoceros pendulus* and *Coscinodiscus perforatus v. cellulosus*, and dinophyte, *Prorocentrum micans*.

Table 2.1.2-14 Quantitative indicators of phytoplankton within the survey area (bottom layer), winter 2023

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Chlorophyta		
Binuclearia lauterbornii	+	+
Monoraphidium contortum	+	+
Bacillariophyta		
Chaetoceros pendulus	206.67	3.76
Rhopalodia sp.	26.67	0.80
Coscinodiscus perforatus v. cellulosus	60.00	3.36
Navicula cryptocephala	40.0	0.06
Nitzschia acicularis	80.0	0.08
Nitzschia closterium	113.33	0.19
Nizschia seriata	866.67	1.73
Rhoicosphaenia curvata	53.33	0.03
Sceletonema subsalsum	33.33	0.04
Thalassionema nitzschioides	433.33	0.57
Tabellaria fenestrata	373.33	0.08
Thalassiosira caspica	113.33	1.36
Conticribra weissflogii	208.00	0.11
Navicula sp.	+	+
Dinophyta		
Prorocentrum micans	140.00	3.08
Dinophysis ovum	40.00	1.00
Prorocentrum cordatum	+	+
Total	**2787.99**	**16.25**

Note: Organisms encountered in qualitative composition are marked with "+"

Abundance of diatoms in the bottom horizon in winter was 1.7 times higher than in the surface (2,607.99 thousand cells/m^3 and 1,549.99 thousand cells/m^3, respectively). Biomass in the bottom layer was higher than in the surface: 12.17 mg/m^3 versus 10.44 mg/m^3. An increase was also observed in the group of dinophytes from 100.0 thousand cells/m^3 to 180.0 thousand cells/m^3 and from 1.06 mg/m^3 to 4.08 mg/m^3.

In spring, the number of species in the bottom horizon was nearly the same as in the surface horizon, amounting to 36 species (Table 2.1.2-3). Floristic diversity was primarily constituted by diatoms, which represented 26 species (72% of the overall phytoplankton composition). These were followed by dinophytes (5 species), green algae (4 species), and blue-green algae (1 species) in terms of significance. Euglena algae were not recorded during this period. Species of marine origin prevailed in the ecological complex.

Quantitative indicators of the development of benthic phytoplankton were lower than those of the surface horizon, and amounted to 18,090.00 thousand cells/m^3. Biomass was above 53.72 mg/m^3 (Table 2.1.2-15). This fact is explained by the development of large dinophytes, *Prorocentrum micans*, and diatoms, *Chaetoceros pendulus* and *Thalassiosira caspica*.

Table 2.1.2-15 Quantitative indicators of phytoplankton within the survey area (bottom layer), spring 2024

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Cyanophyta		
Oscillatoria sp.	69.00	0.01
Aphanothece stagnina	70.00	1.96
Gomphosphaeria multiplex	65.00	1.95
Chlorophyta		

Binuclearia lauterbornii	714.00	0.01
Ankistrodesmus pseudomirabilis	52.00	0.01
Pseudopediastrum integrum	166.00	8.32
Lyngbya aestuarii	+	+
Bacillariophyta		
Actinocyclus ehrenbergii	193.00	6.37
Chaetoceros pendulus	335.00	6.18
Coscinodiscus gigas	18.00	0.14
Coscinjdiscus perforatus	261.00	13.74
Cymbella meneghiniana	290.00	2.85
Cymbella affinis	6.00	
Navicula peregrina	112.00	1.09
Navicula pusilla	128.00	0.44
Nitzschia acicularis	518.00	0.66
Nitzschia closterium	471.00	0.80
Nizschia seriata	1993.00	5.33
Rhoicosphaenia curvata	53.00	0.03
Sceletonema subsalsum	107.00	0.13
Thalassionema nitzschioides	1171.00	1.55
Tabellaria fenestrata	685.00	0.15
Thalassiosira caspica	122.00	1.23
Cotricribra weissflogii	360.00	0.41
Gomphonema olivaceum	110.00	1.53
Mastogloia sp.	103.00	0.75
Amphora ovalis	+	+
Pseudosolnia calcar-avis	+	+
Stephanodiscus socialis	+	+
Navicula cryptocephala	+	+
Navicula sp.	+	+
Rhopalodia sp.	+	+
Staurosira construens	+	+
Sceletonema constratum	1030.00	0.32
Stephanodiscus astraea	320.00	1.32
Campylodiscus clypeus	65.00	1.50
Dinophyta		
Prorocentrum micans	310.00	6.86
Prorocentrum scutullum	75.00	2.48
Dinophysis ovum	30.00	0.75
Prorocentrum cordata	+	+
Prorocentrum lima	+	+
Total	**10002.00**	**68.87**

Note: Organisms encountered in qualitative composition are marked with "+"

In summer, quantitative indicators of benthic phytoplankton were 10,002.00 thousand cells/m^3 and 68.87 mg/m^3. Abundance of phytoplankton in the bottom horizon was 2.5 times higher than in the surface horizon, but biomass was the same in both horizons. It is explained by the presence of small-celled forms of phytoplankton in the surface horizon (Table 2.1.2-16).

Table 2.1.2-16 Quantitative indicators of phytoplankton within the survey area (bottom layer), summer 2024

Organisms	Abundance, thousand cells m^3	Biomass, mg/m^3
Cyanophyta		
Oscillatoria sp.	69.0	0.01
Aphanothece stagnina	70.0	1.96
Gomphosphaeria multiplex	65.0	1.95
Chlorophyta		
Binuclearia lauterbornii	714.0	0.01
Ankistrodesmus pseudomirabilis	52.0	0.01
Pseudopediastrum integrum	166.0	8.32
Lyngbya aestuarii	+	+

Bacillariophyta		
Actinocyclus ehrenbergii	193.0	6.37
Chaetoceros pendulus	335.0	6.18
Coscinodiscus gigas	18.0	0.14
Coscinjdiscus perforatus	261.0	13.74
Cymbella meneghiniana	290.0	2.85
Cymbella affinis	6.0	
Navicula peregrina	112.0	1.09
Navicula pusilla	128.0	0.44
Nitzschia acicularis	518.0	0.66
Nitzschia closterium	471.0	0.80
Nizschia seriata	1993.0	5.33
Rhoicosphaenia curvata	53.0	0.03
Sceletonema subsalsum	107.0	0.13
Thalassionema nitzschioides	1171.0	1.55
Tabellaria fenestrata	685.0	0.15
Thalassiosira caspica	122.0	1.23
Cotricribra weissflogii	360.0	0.41
Gomphonema olivaceum	110.0	1.53
Mastogloia sp.	103.0	0.75
Amphora ovalis	+	+
Pseudosolnia calcar-avis	+	+
Stephanodiscus socialis	+	+
Navicula cryptocephala	+	+
Navicula sp.	+	+
Rhopalodia sp.	+	+
Staurosira construens	+	+
Sceletonema constratum	1030.0	0.32
Stephanodiscus astraea	320.0	1.32
Campylodiscus clypeus	65.0	1.50
Dinophyta		
Prorocentrum micans	310.0	6.86
Prorocentrum scutullum	75.0	2.48
Dinophysis ovum	30.0	0.75
Prorocentrum cordata		+
Prorocentrum lima		+
Total	**10002.0**	**68.87**

Note: Organisms encountered in qualitative composition are marked with "+"

In autumn, the maximum biomass of phytoplankton in the bottom horizon, as well as in the surface, was observed at station 20 (32.09 mg/m^3). The lowest biomass was observed at stations 13 and 19 (3.08 mg/m^3 and 2.53 mg/m^3 respectively) (Figure 2.1.2.5).

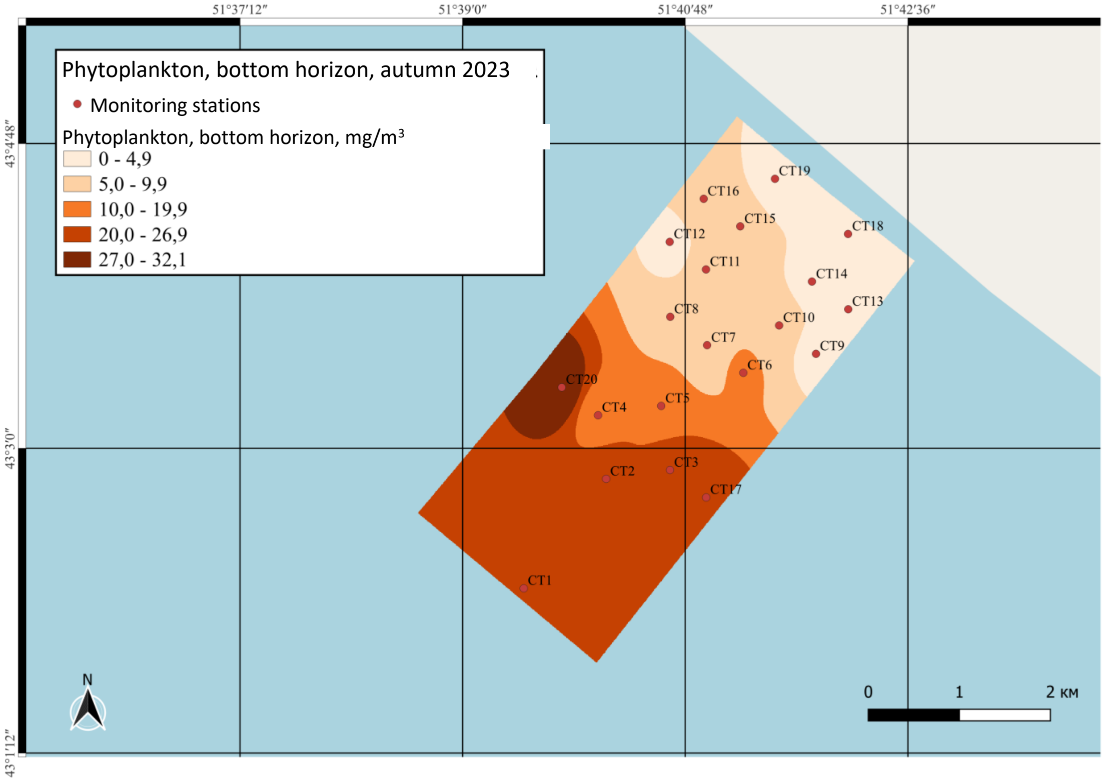

Figure Ошибка! Текст указанного стиля в документе отсутствует.**2.1.2.5 Distribution of phytoplankton within the survey area (bottom layer) in autumn 2023, mg/m^3**

In winter, the highest values of biomass in the bottom horizon within the survey area were recorded at station 20 (24.98 mg/m^3), the lowest values were recorded at station 19 (10.2 mg/m^3), which was inversely proportional to the values recorded in the surface layer (Figure 2.1.2.6).

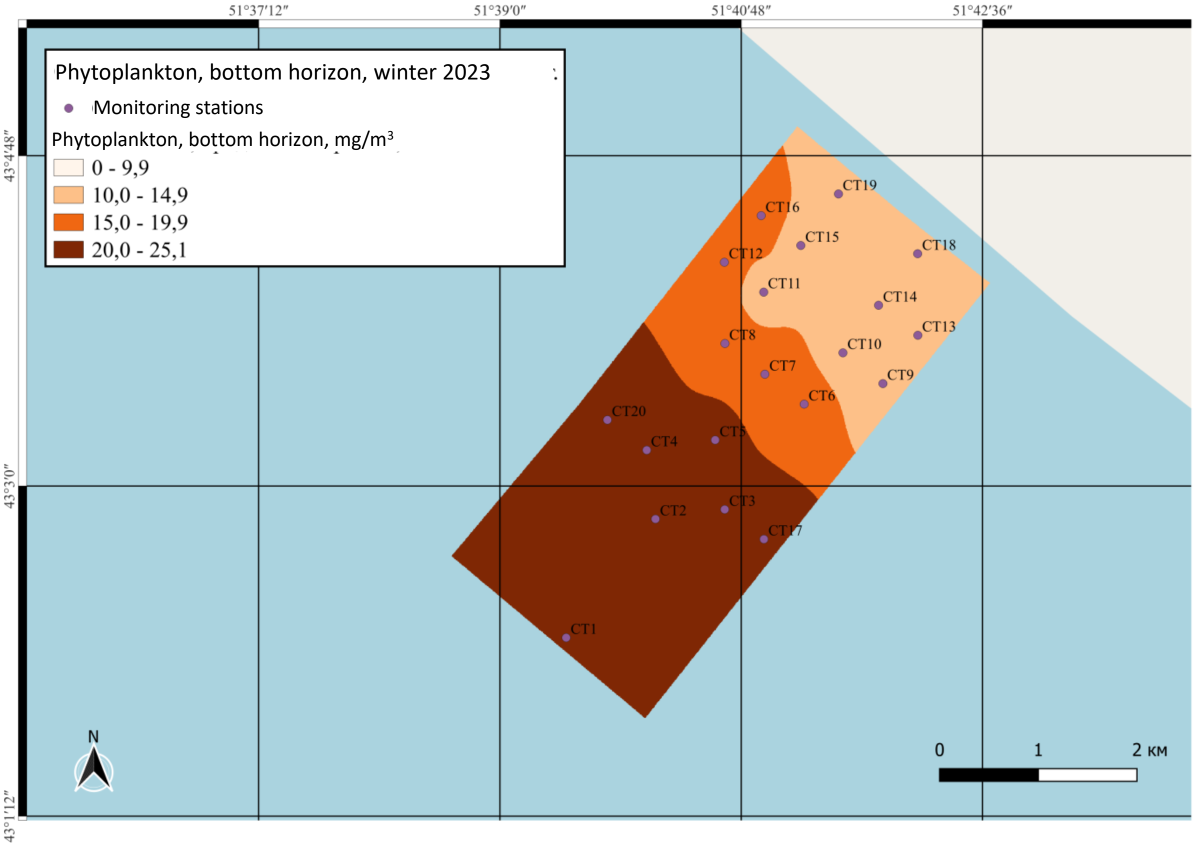

Figure 2.1.2.6 Distribution of phytoplankton within the survey area (bottom layer) in winter 2023, mg/m^3

In spring, the highest values of biomass in the bottom horizon within the survey area were recorded at station 1 (75.46 mg/m^3), the lowest values were recorded at station 19 (27.84 mg/m^3), which was inversely proportional to the values recorded in the surface horizon (Figure 2.1.2.7).

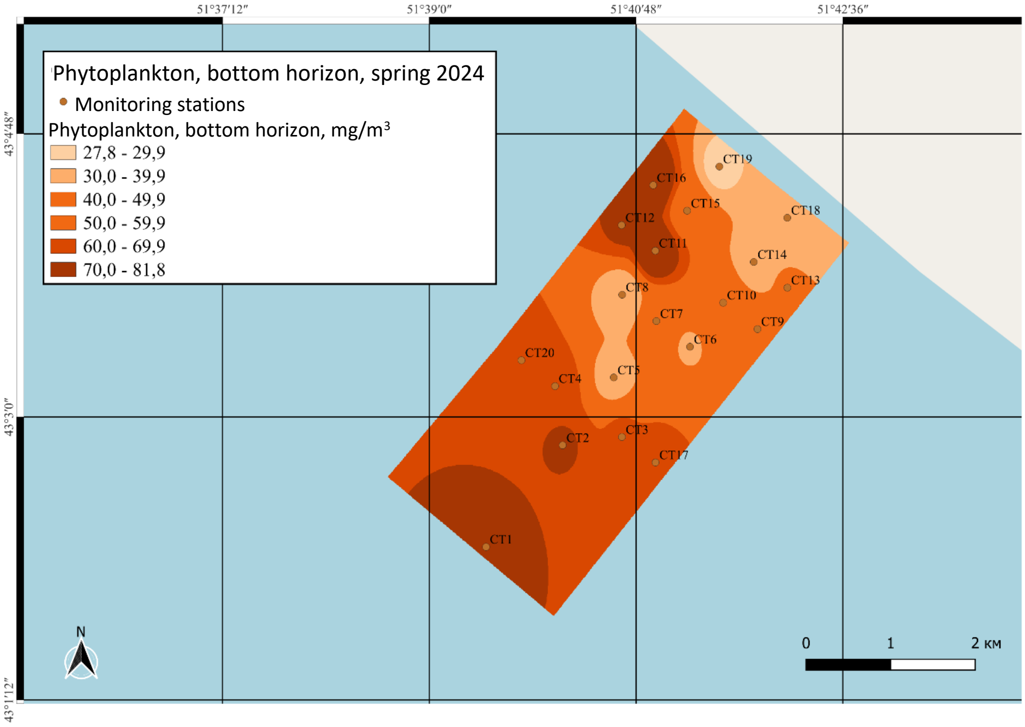

Figure 2.1.2.7 Distribution of within the survey area (bottom layer) in spring 2024, mg/m³

In summer, the highest biomass in the bottom horizon was observed at station 1 and amounted to 123.6 mg/m³. The lowest values were observed at station 19 and amounted to 43.5 mg/m³ (Figure 2.1.2.8).

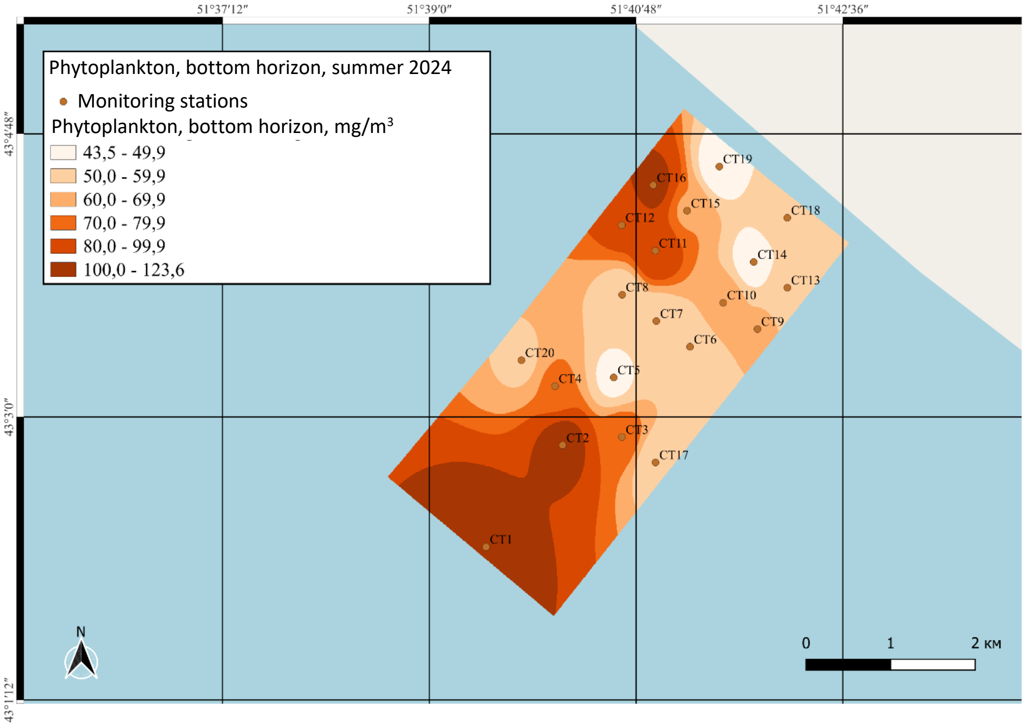

Figure 2.1.2.8 Distribution of phytoplankton within the survey area (bottom layer) in summer 2024, mg/m³

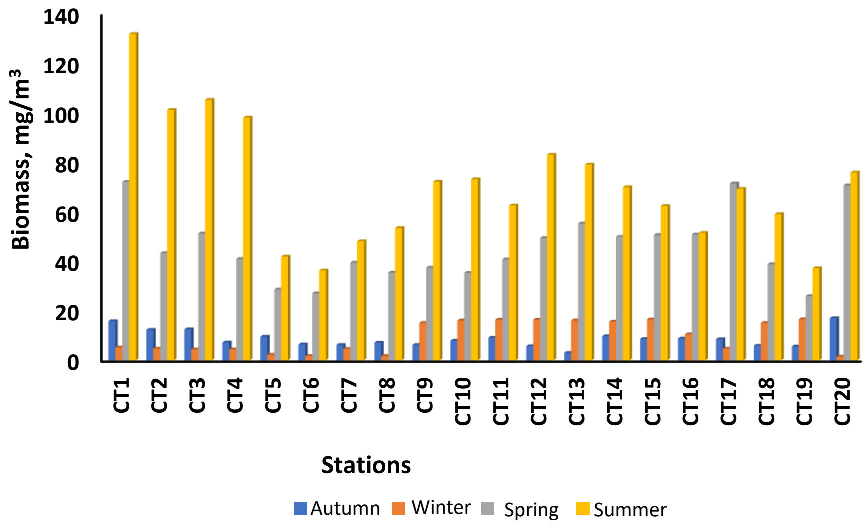

Figure 2.1.2.9 Distribution of phytoplankton biomass in the surface horizon within the survey area (autumn, winter, spring, summer).

In all seasons of the survey, the main contribution to the biomass of algae in the surface horizon was made by the development of diatoms: *Coscinodiscus perforatus v. cellulosus, Actinocyclus ehrenbergii,* and *Chaetoceros pendulus*. The largest aggregations of algae were observed in the deep-water areas; the smallest ones were observed in the shallow water areas (Figure 2.1.2.9).

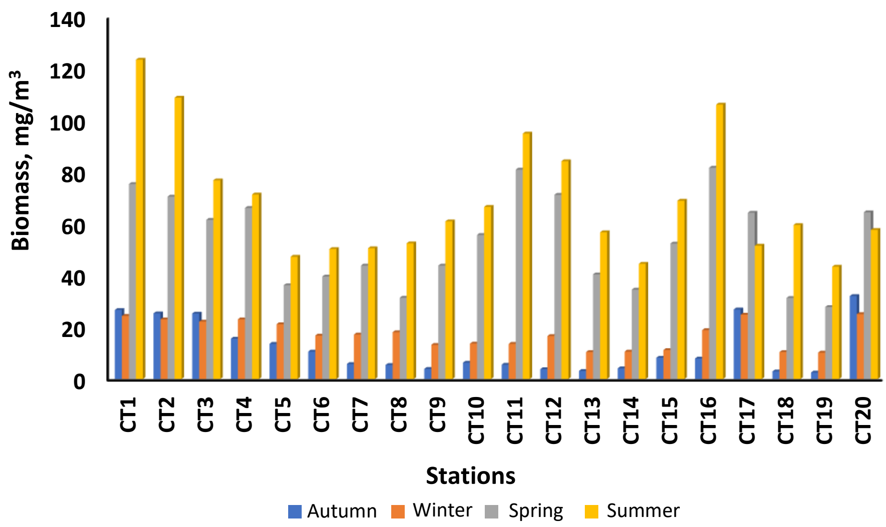

Figure 2.1.2.10 Distribution of phytoplankton biomass in the bottom horizon within the survey area (autumn, winter, spring, summer).

During the autumn, winter, spring and summer survey sessions, the highest biomass of benthic phytoplankton was observed at station 1. The lowest biomass was recorded at station 19. This is explained by intense development of diatoms and dinophytes at a depth above 17 m (Figure 2.1.2.10).

According to the comparative analysis of the received data on phytoplankton prior the construction and commissioning of the production facilities, qualitative diversity of phytoplankton corresponded to the retrospective data. During the vegetative period, floristic diversity of phytoplankton in the survey area was determined by diatoms. Quantitative indicators of algal flora can be assessed as favorable, which is positive for the development of the further trophic chain (zooplankton).

During the implementation of the Project, the number and biomass of phytoplankton will be subject to the seasonal dynamics.

Monitoring production and destruction processes is crucial for assessing the integrated impact of natural, climatic, and anthropogenic factors on the ecosystem, including the potential effects of construction activities on phytoplankton development at the site. To evaluate the impact of planned construction activities, it is important to understand the biotic balance, or the ratio of primary production to destruction. Positive changes in the biotic balance, with values close to one at most stations by the completion of construction, will indicate minimal impact from the construction works on the formation of primary products and the overall development of phytoplankton.

Zooplankton

As noted above, the species diversity of zooplankton in the Caspian Sea is low. As with phytoplankton, it decreases from north to south due to a loss of freshwater species (Karpinsky, 2002). The zooplankton community primarily consists of several widespread species: *Acartia tonsa*, *Halicyclops sarsi*, and *Calanipeda aquaedulcis* from copepods; *Asplanchna priodonta* and *Brachionus quadridentatus* from rotifers (*Rotatoria*); as well as representatives of the *Podonevadne* and *Evadne* genera from cladocerans (*Cladocera*).

During the field survey in autumn, winter, spring and summer, 80 samples of zooplankton were collected from 20 stations and analyzed.

In autumn, zooplankton was represented by the following groups of invertebrates: *Ctenophora*, *Copepoda*, larvae of *Cirripedia* benthic organisms, as well as others represented by the larvae of *Hediste diversicolor* polychaetes. Qualitative diversity of plankton consisted of five species, varieties and forms of invertebrates (the Shannon-Weaver diversity index was 1.454 bits/sample). The highest number of species was observed in the *Ctenophora* group (2) (Table 2.1.2-17). From an ecological aspect, organisms of marine origin dominated in the zooplankton composition in terms of the number of taxonomic units.

Table 2.1.2-17 Number of species in the ecological groups of zooplankton within the survey area, autumn 2023

Zooplankton group	Number of species	Ecological group	
		Marine	Euryhaline
Ctenophora	2	2	-
Copepoda	1	-	1
Cirripedia	1	1	-
Total	4	3	1

In winter, the planktonic fauna within the survey area was characterized by low diversity. In total, six taxonomic units of hydrobionts from four groups were recorded: *Copepoda*, *Ctenophora*, *Cirripedia* and others (Table 2.1.2-18). The Shannon-Weaver diversity index was 1,374 bits/specimen. From an ecological aspect, organisms of marine origin dominated in the zooplankton composition in terms of the number of taxonomic units.

Table 2.1.2-18 Number of species in the ecological groups of zooplankton within the survey area, winter 2023

Zooplankton group	Number of species	Ecological group	
		Marine	Euryhaline
Ctenophora	2	2	-
Copepoda	1	-	1
Cirripedia	1	1	-
Total	4	3	1

In spring, zooplankton was represented by the following groups of invertebrates: *Protozoa*, *Copepoda*, *Cladocera*, *Rotifera,* larvae of Cirripedia benthic organisms, and Others represented by the larvae of *Hediste diversicolor* and *Marenzelleria sp* polychaetes. Qualitative diversity of plankton consisted of nine species, varieties and forms of invertebrates (the Shannon-Weaver diversity index (H_N) was 1.584 bits/sample). The highest number of species was observed in

Protozoa group (3) (Table 2.1.2-19). From an ecological aspect, organisms of marine origin dominated in the zooplankton composition in terms of the number of taxonomic units.

Table 2.1.2-19 Number of species in the ecological groups of zooplankton within the survey area, spring 2024

Zooplankton group	Number of species	Ecological group			
		Fresh-water	Marine	Euryhaline	Other
Protozoa	3	1	-	-	2
Rotifera	1	1	-	-	-
Copepoda	2	-	-	2	-
Cladocera	2	-	2	-	-
Cirripedia	1	-	1	-	-
Total	9	2	3	2	2

In summer, planktonic fauna was characterized by low diversity. In total, nine taxonomic units of hydrobionts from five groups were recorded: Protozoa, *Copepoda*, *Ctenophora*, *Cirripedia* and others (Table 2.1.2-20). The Shannon-Weaver diversity index (H_N) was 1.478 bits/specimen. From an ecological aspect, organisms of marine origin dominated in the zooplankton composition in terms of the number of taxonomic units.

Table 2.1.2-20 Number of species in the ecological groups of zooplankton within the survey area summer 2024

Zooplankton group	Number of species	Ecological group			
		Fresh-water	Marine	Euryhaline	Other
Protozoa	3	1	-	-	2
Rotifera	1	1	-	-	-
Copepoda	2	-	-	2	-
Cladocera	2	-	2	-	-
Cirripedia	1	-	1	-	-
Total	9	2	3	2	2

In autumn, quantitative indicators of zooplankton were determined by nauplial and mature individuals of copepods represented by a single species, *Acartia tonsa* (6,930.7 specimens/m^3 and 33.89 mg/m^3) (Table 2.1.2-21). The age structure of acartia was dominated by the copepodid stage of development. The numerical values were supplemented by the cypris stages of barnacle: 643.0 specimen/m^3. The biomass of representatives of *Cirripedia* and *Ctenophora* was almost equal.

Table 2.1.2-21 Quantitative indicators of zooplankton within the survey area, autumn 2023

Organisms	Abundance, specimen/m^3	Biomass, mg/m^3
Copepoda		
Acartia (nauplii)	4419.80	8.559
Acartia tonsa	2510.90	25.332
Cirripedia		
Balanus nauplii	638.10	1.276
Balanus cypris	4.90	0.059
Ctenophora		
Mnemiopsis leidyi (larvae)	11.2	0.224
Mnemiopsis leidyi	29.2	0.730
Beroe ovata	4.9	0.098
Other		
Hediste (larvae)	151.8	-
Total	**7619.0**	**36.278**

Note: Quantitative indicators do not include Others group

Abundance of *Ctenophora* was at the level of 45.3 specimen/m^3 with the predominance of *Mnemiopsis leidyi*. Share of new invader, *Beroe sp.*, discovered in the Caspian Sea in 2020 accounted for 10.8% of the total number of comb-bearers.

In winter, quantitative values of plankton were formed mainly by copepods, accounting for 93% of the total number and 98% of the plankton biomass. The only representative of this group was

Acartia tonsa (3,751.7 specimen/m^3, 25.07 mg/m^3). The ratio of the individuals of nauplial stage and mature individuals was approximately at the same level (1,874.0 specimen/m^3 and 1,877.7 specimen/m^3, respectively). Quantitative values of the cypris stages of barnacles were at the level of 286.9 specimen/m^3; 0.6 mg/m^3. The abundance and biomass of comb-bearers were insignificant. Group of others was represented by the larvae of polychaetes (Table 2.1.2-22).

Table 2.1.2-22 Quantitative indicators of zooplankton within the survey area, winter 2023

Organisms	Abundance, specimen/m^3	Biomass, mg/m^3
Copepoda		
Acartia (nauplii)	1874.0	3.141
Acartia tonsa	1877.7	21.929
Cirripedia		
Balanus nauplii	286.9	0.574
Ctenophora		
Mnemiopsis leidyi (larvae)	0.1	0.002
Beroe ovata	0.1	0.002
Other		
Hediste (larvae)	2.8	-
Marenzelleria (larvae)	40.3	-
Total	**4038.8**	**25.648**

Note: Quantitative indicators do not include Others group

Average number and biomass of zooplankton amounted to 4,038.8 specimen/m^3 and 25.6 mg/m^3.

In spring, quantitative indicators of zooplankton were determined by nauplial and mature individuals of copepods, namely by *Acartia tonsa* (5,549.0 specimens/m^3 and 24.0 mg/m^3). In the age structure of acartia, number of individuals in copepodid stage of development and mature ones was particularly the same (Table 2.1.2-23). The numerical values were supplemented by protozoans. Biomass of the representatives of *Cirripedia*, *Rotifera* and *Cladocera* was not high.

Table 2.1.2-23 Quantitative indicators of zooplankton within the survey area, spring 2024

Organisms	Abundance, specimen/m^3	Biomass, mg/m^3
Protozoa		
Foraminifera sp.	143.5	—
Vorticella sp.	418.5	0.084
Tokophrya sp.	422.5	—
Copepoda		
Calanipeda aquaedulcis	60.7	0.440
Calanipeda aquaedulcis (nauplii)	52.0	0.137
Acartia (nauplii)	2661.7	5.319
Acartia tonsa	2887.3	18.700
Cirripedia		
Balanus nauplii	246.9	0.491
Cladocera		
Podon intermedius	10.0	0.090
Evadne nordmanii	122.8	0.780
Rotatoria		
Synchaeta pectinata	114.3	0.015
Others		
Hediste (larvae)	3.2	-
Marenzelleria (larvae)	52.1	-
Total	**7139.7**	**26.056**

Note: Quantitative indicators do not include Others group.
Organisms, biomass of which is less than 0.001 mg/m^3, are marked with "-"

In summer, quantitative values of plankton were formed mainly by copepods, accounting for more than 90% of the total number and biomass of plankton. Dominating representative of this group was *Acartia tonsa* (6,387.0 specimen/m^3 and 49.4 mg/m^3). The number of the individuals of nauplial stage was two times lower than the number of mature individuals. Quantitative values of the cypris stages of barnacles were at the level of 381.0 specimen/m^3 and 0.8 mg/m^3. Representatives of the groups of *Protozoa*, *Rotifera* and *Cladocera* were not numerous. Group of

Others was represented by the larvae of polychaetes (Table 2.1.2-24).

Table 2.1.2-24 Quantitative indicators of zooplankton within the survey area, summer 2024

Organisms	Abundance, specimen/m³	Biomass, mg/m³
Protozoa		
Foraminifera sp.	182.8	—
Vorticella sp.	286.7	0.100
Tokophrya sp.	356.9	—
Copepoda		
Calanipeda aquaedulcis	60.6	0.400
Calanipeda aquaedulcis (nauplii)	64.7	0.200
Acartia (nauplii)	2072.7	4.000
Acartia tonsa	4314.3	45.400
Cirripedia		
Balanus nauplii	381.0	0.800
Cladocera		
Podon intermedius	27.1	0.200
Evadne nordmanii	135.9	0.500
Rotatoria		
Synchaeta pectinata	545.7	0.500
Other		
Hediste (larvae)	3.8	-
Marenzelleria (larvae)	41.9	-
Total	8474.1	52.100

Note: Quantitative indicators do not include Others group.
Organisms, biomass of which is less than 0.001 mg/m³, are marked with "-"

In autumn, average number and biomass of zooplankton within the survey area amounted to 7,619.0 specimen/m³ and 36.3 mg/m³. The highest concentrations of organisms were recorded at station 13 and amounted to 19,268.0 specimen/m³ and 98.72 mg/m³ (Figure 2.1.2.11). This is due to the maximum abundance of *Acartia tonsa* copepods at various stages of development. The minimum zooplankton values were recorded at station 2.

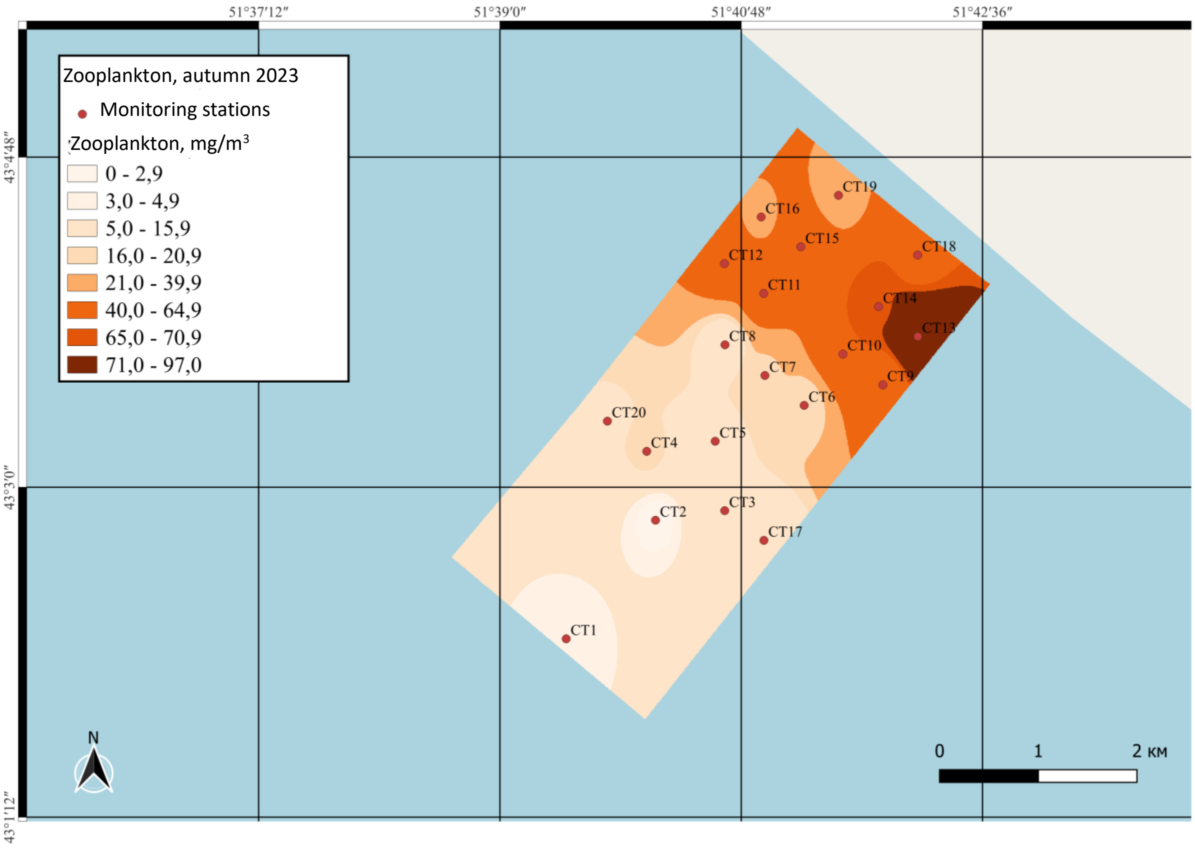

Figure 2.1.2.11 Distribution of zooplankton within the survey area in autumn 2023, mg/m3

In winter, the highest concentrations of plankters were recorded at station 20 and amounted to 5,987.4 specimen/m^3 and 33.2 mg/m^3 (Figure 2.1.2.12).

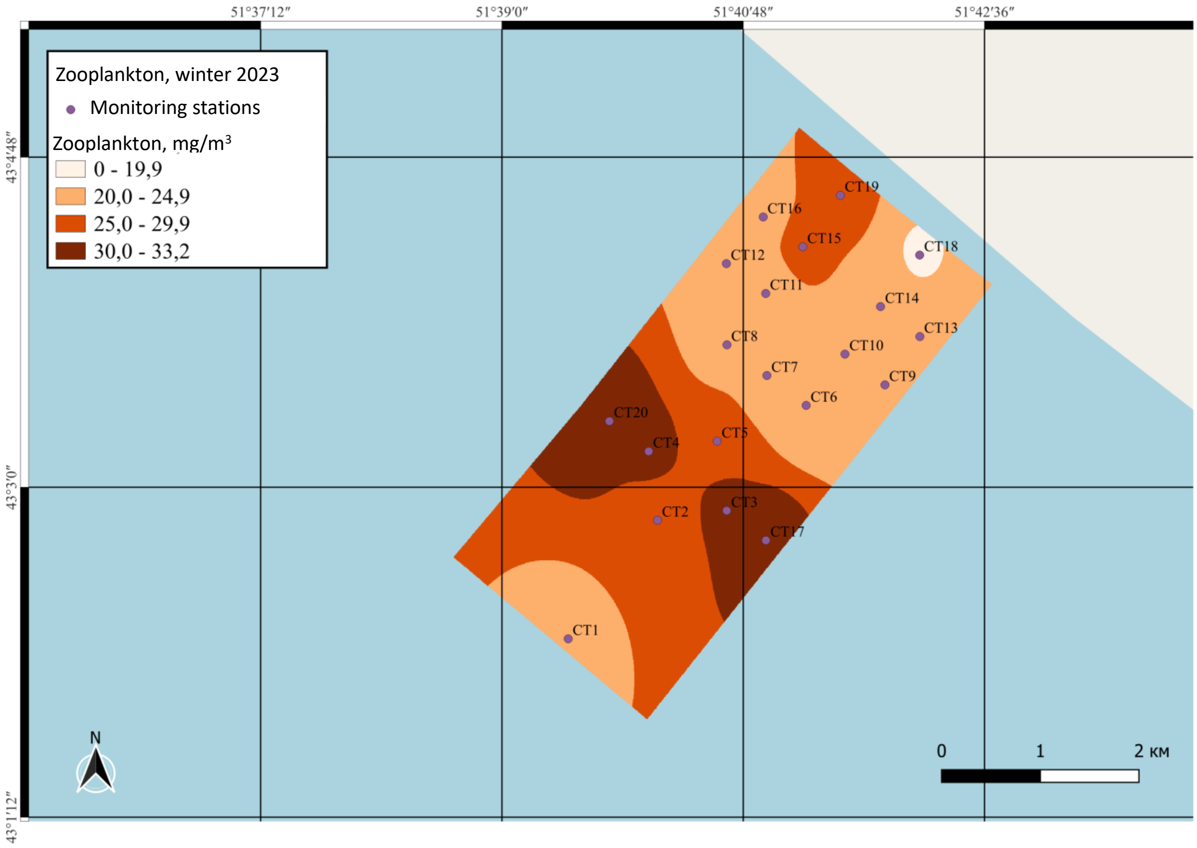

Figure 2.1.2.12 Distribution of zooplankton within the survey area in winter 2023, mg/m^3

This is explained by the maximum abundance of *Acartia tonsa*. The lowest abundance of zooplankton was recorded at station 16 (2,052.6 specimen/m^3).

In spring, maximum concentrations of plankton were recorded at station 19 and amounted to 62.3 mg/m^3 (Figure 2.1.2.13). This is due to the maximum abundance of *Acartia tonsa* copepods at various stages of development. The minimum zooplankton values were recorded at station 1.

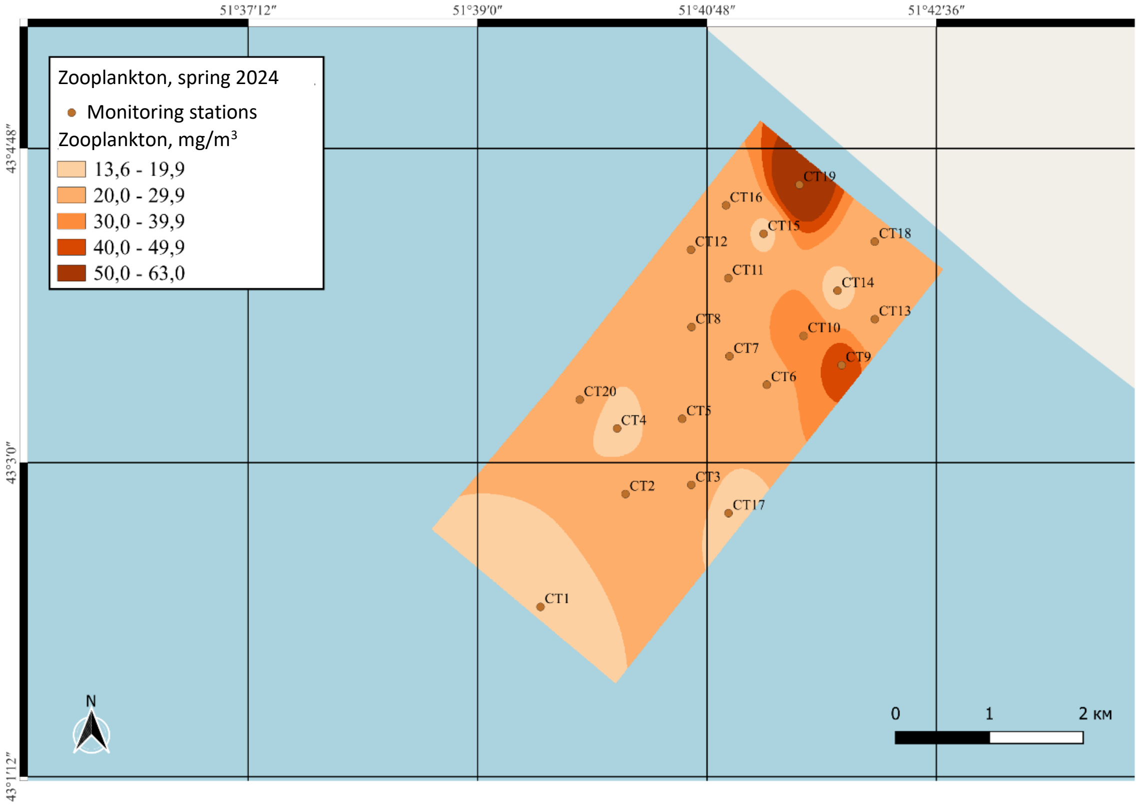

Figure 2.1.2.13 Distribution of zooplankton within the survey area in spring 2024, mg/m^3

In summer, maximum concentration of plankters was recorded at station 19 and amounted to 114.6 mg/m^3 (Figure 2.1.2.14).

In spring and summer periods, zooplankton values were inversely proportional to the development of algal flora, which was caused by the eating of forage phytoplankton.

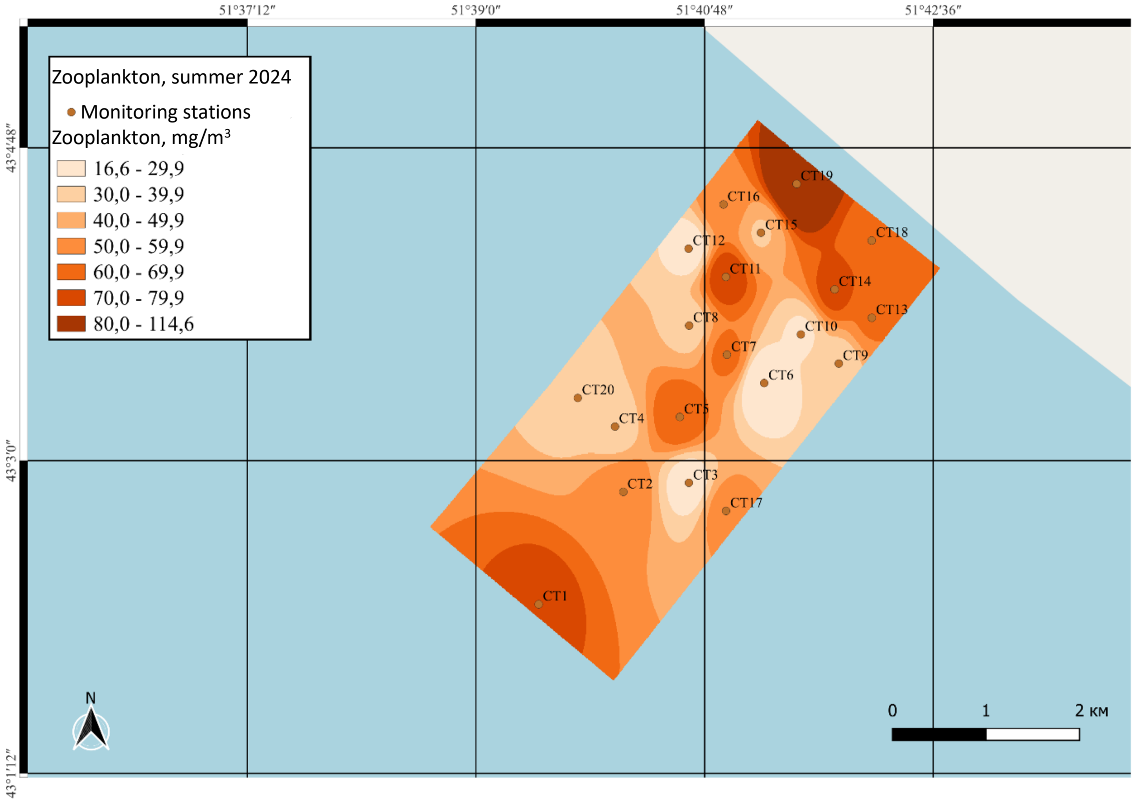

Figure 2.1.2.14 Distribution of zooplankton within the survey area in summer 2024, mg/m³

Distribution of quantitative indicators of planktonic invertebrates in the survey area was uneven (Figure 2.1.2.15).

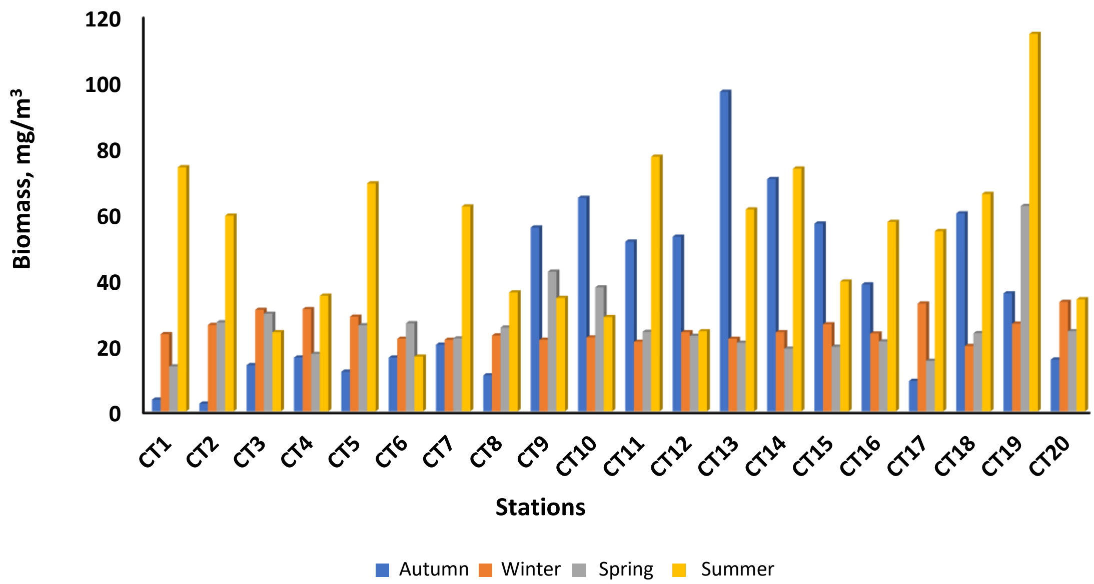

Figure 2.1.2.15 Distribution of zooplankton biomass in the survey area (autumn, winter, spring, summer)

During all survey sessions, the minimum concentrations of phytoplankton and the maximum concentrations of zooplankton in both the surface and bottom horizons were recorded at station 13. This can be explained by the trophic pressure exerted by zooplankters on the plant cells. (Figure 2.1.2.15).

The highest biomass of zoocenosis with prevailing mature plankters was observed in the summer period, as expected.

According to the survey of zooplankton conducted, the zooplankton population was predominantly composed of copepods. This finding is consistent with retrospective data on the development of plankton in the surveyed area. During the vegetative period, an increase in the abundance and biomass of zooplankton was observed, indicating satisfactory feeding conditions for plankton-eating fish.

The implementation of the planned Project at the site may lead to a decrease in the quantitative indicators of zooplankton due to disruptions in their habitat, specifically the mixing of bottom sediments with marine water during construction activities. Zooplankton organisms are very sensitive to changes in water temperature and transparency, which can significantly affect their lifecycle processes.

Zoobenthos

The species composition of benthic fauna of the Caspian Sea is relatively poor; about 379 species of free-living benthic invertebrates have been recorded. The species diversity is characterized by crustaceans, gastropods and bivalves (Yablonskaya, 2007). The main feature of the Caspian bottom fauna is a very high degree of endemism, a large number of endemic species are characteristic of bottom crustaceans (Karpinsky M.G., 2002).

During the period of field survey in autumn, winter, spring and summer, 240 samples of zoobenthos were collected at 20 stations and analyzed.

In autumn, benthic fauna was represented by 22 species and forms: worms – 5, crustaceans – 15, and mollusks – 2. From the ecological aspect, all groups of zoobenthos were registered (Table 2.1.2-25).

Table 2.1.2-25 Number of species in the ecological groups of zoobenthos within the survey area, autumn 2023

Zoobenthos group	Ecological group					Total
	Freshwater	Low-saline water	Brackish water	Marine	Other	
Vermes	1	-	-	2	2	5
Crustacea	-	6	2	7	-	15
Mollusca	-	-	-	2	-	2
Total	1	6	2	11	2	22

**Note: "Others" include zoobenthos representatives, species of which could not be identified*

In winter, zoobenthos of the survey area was represented by 16 taxonomic units: worms – 4, crustaceans – 10, and mollusks – 2. From the ecological aspect, all groups of benthic fauna were registered (Table 2.1.2-16).

Table 2.1.2-26 Number of species in the ecological groups of zoobenthos within the survey area, winter 2023

Zoobenthos group	Ecological group					Total
	Freshwater	Low-saline water	Brackish water	Marine	Other	
Vermes	1	-	-	2	1	4
Crustacea	-	3	2	5	-	10
Mollusca	-	-	-	-	2	2
Total	1	3	2	7	3	16

Note: "Others" include zoobenthos representatives, species of which could not be identified

In spring, benthic fauna was represented by 17 species and forms: worms – 3, crustaceans – 11, and mollusks – 3. From the ecological aspect, all groups of zoobenthos were registered (Table 2.1.2-27).

Table 2.1.2-27 Number of species in the ecological groups of zoobenthos in the survey area, spring 2024

Zoobenthos group	Ecological group					Total
	Freshwater	Low-saline water	Brackish water	Marine	Other	
Vermes	1	-	-	2	-	3
Crustacea	-	4	2	5	-	11
Mollusca	-	-	-	3	-	3
Total	1	4	2	10	0	17

**Note: "Others" include zoobenthos representatives, species of which could not be identified*

In summer, zoobenthos of the survey area was represented by 23 taxonomic units: worms – 3, crustaceans – 15, and mollusks – 4, hydrozoans - 1. From the ecological aspect, all groups of benthic fauna were registered (Table 2.1.2-28).

Table 2.1.2-28 Number of species in the ecological groups of zoobenthos within the survey area, summer 2024

Zoobenthos group	Ecological group					Total
	Freshwater	Low-saline water	Brackish water	Marine	Other	
Vermes	1	-	-	2	-	3
Crustacea	-	6	2	6	1	15
Mollusca	-	-	-	4	-	4
Hydrozoa	-	1	-	-	-	1
Total	1	7	2	12	1	23

Note: "Others" include zoobenthos representatives, species of which could not be identified

In autumn, average hydrobiological indicators of benthic cenosis were 3,055.0 specimen/m^2 and 14.7 g/m^2 (Table 2.1.2-29).

Table 2.1.2-29 Quantitative indicators of zoobenthos within the survey area, autumn 2023

Organisms	Abundance, specimen/m^2	Biomass, g/m^2
ANNELIDA		
Polychaeta		
Marenzelleria sp.	5.0	0.174
Hediste diversicolor (Miiller)	34.0	0.467
Fabricia sabella	1.0	-
Oligochaeta	182.0	0.153
Nematoda	461.0	0.019
CRUSTACEA		
Mysidacea		
Mysidacea sp.	1.0	0.002
Paramysis baeri	2.0	0.001
Cirripedia		
Balanus improvisus (Darwin)	52.0	0.639
Cumacea		
Schizorhynchus bilamellatus (G.O.Sars)	5.0	0.006
Pterocuma rostrata (G.O Sars)	12.0	0.011
Pterocuma sowinskyi	4.0	0.008
Stenocuma graciloides	19.0	0.005
Gammaridae		
Amathillina cristata (Grimm)	12.0	-
Amathillina pusilla (G.O.Sars)	2.0	-
Dikerogammarus haemobaphes (Eichwald)	4.0	0.036
Stenogammarus similis	1954.0	1.693
Gmelina pusilla (G.O.Sars)	13.0	0.004
Chinogammarus behnningi	3.0	0.002
Chinogammarus ischnus	109.0	0.023
Chaetogammarus pauxillus	87.0	0.024

Isopoda		
Jaera sarsi caspica (Kesselyak)	26.0	0.002
MOLLUSCA:		
Bivalvia		
Mytilus galloprovincialis	2.0	11.337
Mytilaster lineatus	65.0	0.023
Total	**3055.0**	**14.629**

Note: Organisms, biomass of which is less than 0.0001 g/m³ are marked with "-".

The population was mainly formed by crustaceans (excluding barnacle) and amounted to 2,253.0 specimen/m² in total. This group included gammarids, mysids, cumaceans, and isopods. The dominant species in the area was *Stenogammarus similis*: 1,954.0 specimen/m². The species composition of the group of malacostracans was characterized by the greatest diversity, but the total biomass was low (1.8 g/m²). The structure–forming role in the formation of biomass belonged to the representatives of "hard" benthos, namely mollusks and barnacles - 14.6 g/m². Among the bivalves, the invasive species large Azov-Black Sea , *Mytilus galloprovincialis*, discovered in the Caspian Sea in 2023, prevailed (11.3 g/m²).

Worms were represented by oligochaetes, polychaetes and nematodes. In terms of population, *Nematoda* prevailed in the group: 461.0 specimen/m². Small-scale worms were of secondary importance (182.0 specimens/m²). In terms of biomass, polychaete worms, *Hediste diversicolor (Miiller)*, dominated (0.5 g/m²). Invasive species from the *Spionidae* order, *Marenzelleria sp.*, discovered in the Caspian Sea in 2018, subdominated.

In winter, average hydrobiological indicators of benthic cenosis were 738.0 specimen/m² and 90.0 g/m² (Table 2.1.2-30).

Table 2.1.2-30 Quantitative indicators of zoobenthos within the survey area, winter 2023

Organisms	Abundance, specimen/m²	Biomass, g/m²
ANNELIDA		
Polychaeta		
Marenzelleria sp.	4.0	0.162
Hediste diversicolor (Miiller)	35.0	0.353
Oligochaeta	47.0	0.058
Nematoda	98.0	0.008
CRUSTACEA		
Cirripedia		
Balanus improvisus (Darwin)	43.0	0.350
Cumacea		
Schizorhynchus bilamellatus (G.O.Sars)	1.0	0.001
Pterocuma rostrata (G.O Sars)	1.0	0.003
Stenocuma graciloides	7.0	0.001
Gammaridae		
Amathillina pusilla (G.O.Sars)	2.0	-
Stenogammarus similis	309.0	0.248
Gmelina pusilla (G.O.Sars)	8.0	0.002
Chinogammarus behnningi	1.0	0.004
Chinogammarus ischnus	125.0	0.031
Chaetogammarus pauxillus	12.0	0.006
MOLLUSCA:		
Bivalvia		
Mytilus galloprovincialis	6.0	88.718
Mytilaster lineatus	39.0	0.013
Total	**738.0**	**89.958**

Note: Organisms, biomass of which is less than 0.0001 g/m³ are marked with "-".

The population was mainly formed by crustaceans (excluding barnacle) and amounted to 466.0 specimen/m² in total. This group included gammarids and cumaceans. The dominant species in this survey area was *Stenogammarus similis*: 309.0 specimen/m². The species composition of the group of malacostracans was characterized by the highest diversity. It included 10 species. The structure–forming role in the formation of biomass belonged to the representatives of "hard" benthos - 88.7 g/m². Among the bivalves, the large invasive species Azov-Black Sea , *Mytilus* *galloprovincialis*, still prevailed.

Worms were represented by oligochaetes, polychaetes and nematodes. In terms of population, *Nematoda* prevailed in the group: 98.0 specimen/m^2. Small-scale worms were of secondary importance (47.0 specimens/m^2). In terms of biomass, polychaete worms, *Hediste diversicolor (Miiller)*, dominated (0.4 g/m^2). Invasive species of the *Spionidae* order, *Marenzelleria sp.*, subdominated with the biomass of 0.4 g/m^2.

In spring, qualitative composition of benthic fauna was represented by 17 species (Table 2.1.2-31).

Table 2.1.2-31 Quantitative indicators of zoobenthos within the survey areas, spring 2024

Organisms	Abundance, specimen/m^2	Biomass, g/m^2
ANNELIDA		
Polychaeta		
Marenzelleria sp.	83.0	0.012
Hediste diversicolor (Miiller)	21.0	0.004
Oligochaeta	514.0	0.211
CRUSTACEA		
Cirripedia		
Balanus improvisus (Darwin)	38.0	0.849
Cumacea		
Schizorhynchus bilamellatus (G.O.Sars)	119.0	0.043
Pterocuma rostrata (G.O Sars)	98.0	0.045
Pterocuma sowinskyi	4.0	
Stenocuma graciloides	221.0	1.884
Caspiocuma campylaspoides	1.0	-
Gammaridae		
Chaetogammarus pauxillus	74.0	0.019
Stenogammarus similis	367.0	2.184
Gmelina pusilla (G.O.Sars)	54.0	0.012
Amathilina cristata (Grimm)	1.0	-
Amathilina pusilla	1.0	-
MOLLUSCA		
Bivalvia		
Mytilus galloprovincialis	43.0	0.133
Mytilaster lineatus	1.0	0.001
Cerastoderma lamarcki (Reeve)	4.0	0.833
Total	**1644.0**	**6.230**

Note: Organisms, biomass of which is less than 0.0001 g/m^3 are marked with "-".

The population was mainly formed by representatives of “soft” benthos: worms and crustaceans (excluding barnacle). Among worms, oligochaetes and polychaetes were observed. Oligochaetes were the most numerous and amounted to 514.0 specimen/m^2. The group of crustaceans included gammarids and cumaceans. The dominant species in the survey area was *Stenogammarus similis*: 367.0 specimen/m^2. The species composition of the group of malacostracans was characterized by the greatest diversity. This group included 11 species.

The structure–forming role in the formation of biomass belonged to crustaceans, namely to *Stenogammarus similis.* The development of this species amounted to 2,288.7 g/m^2 or 30% of the total biomass.

In summer, average indicators of zoobenthos in the survey area were 4,412.0 specimen/m^2 and 22.8 m^2 (Table 2.1.2-32).

Table 2.1.2-32 Quantitative indicators of zoobenthos within the survey area, summer 2024

Organisms	Abundance, specimen/m^2	Biomass, g/m^2
HYDROZOA		
Cordylophora caspia	2.0	0.006
ANNELIDA		
Polychaeta	83.0	0.012
Marenzelleria sp.	2460.0	1.064

Hediste diversicolor (Miiller)	284.0	0.233
Oligochaeta	491.0	0.529
CRUSTACEA		
Mysidacea		
Paramysis baeri	1.0	0.004
Cirripedia		
Balanus improvisus (Darwin)	39.0	0.838
Cumacea		
Schizorhynchus bilamellatus (G.O.Sars)	230.0	0.149
Schizorhynchus eudorelloides (G.O.Sars)	15.0	0.004
Pterocuma sowinskyi	116.0	0.077
Stenocuma tenuicauda	2.0	0.001
Pterocuma rostrata (G.O Sars)	22.0	0.005
Stenocuma graciloides	98.0	0.029
Caspiocuma campylaspoides	6.0	0.003
Gammaridae		
Gmelina pusilla (G.O.Sars)	54.0	0.012
Dikerogammarus haemobaphes (Eichwald)	1.0	0.002
Amathillina pusilla (G.O.Sars)	3.0	0.002
Chinogammarus behnningi	1.0	0.019
Chaetogammarus pauxillus	3.0	0.002
Stenogammarus similis	430.0	3.263
Gmelina pusila (G.O. Sars)	113.0	0.024
MOLLUSCA		
Bivalvia		
Mytilus galloprovincialis	12.0	7.914
Cerastoderma lamarcki	7.0	4.517
Abra ovata (Phil.)	9.0	0.007
Mytilaster lineatus	120.0	4.086
Total	**4412.0**	**22.790**

The population was mainly formed by representatives of worms, namely by Marenzelleria sp (2,460.0 specimen/m^2). Among the crustaceans, *Stenogammarus similis* demonstrated high development (430.0 specimen/m^2). The species composition of the group of malacostracans was characterized by the greatest diversity and included 15 species.

The structure–forming role in the formation of biomass belonged to the representatives of “hard” benthos (17.3 g/m^2). Among the bivalves, the large invasive species Azov-Black Sea , *Mytilus galloprovincialis*, still prevailed (7.9 g/m^2).

In autumn, biomass of benthic cenosis varied from station to station. The minimum biomass was recorded at station 17 (0.076 g/m^2), where only small forms of *Mytilaster lineatus* mollusk with a length of 1-3 mm were noted in the benthic samples. The maximum biomass was observed at station 1 (229.7 g/m^2), formed due to the presence of a large mollusk, *Mytilus galloprovincialis*, 57-59 mm long in the samples (Figure 2.1.2.16).

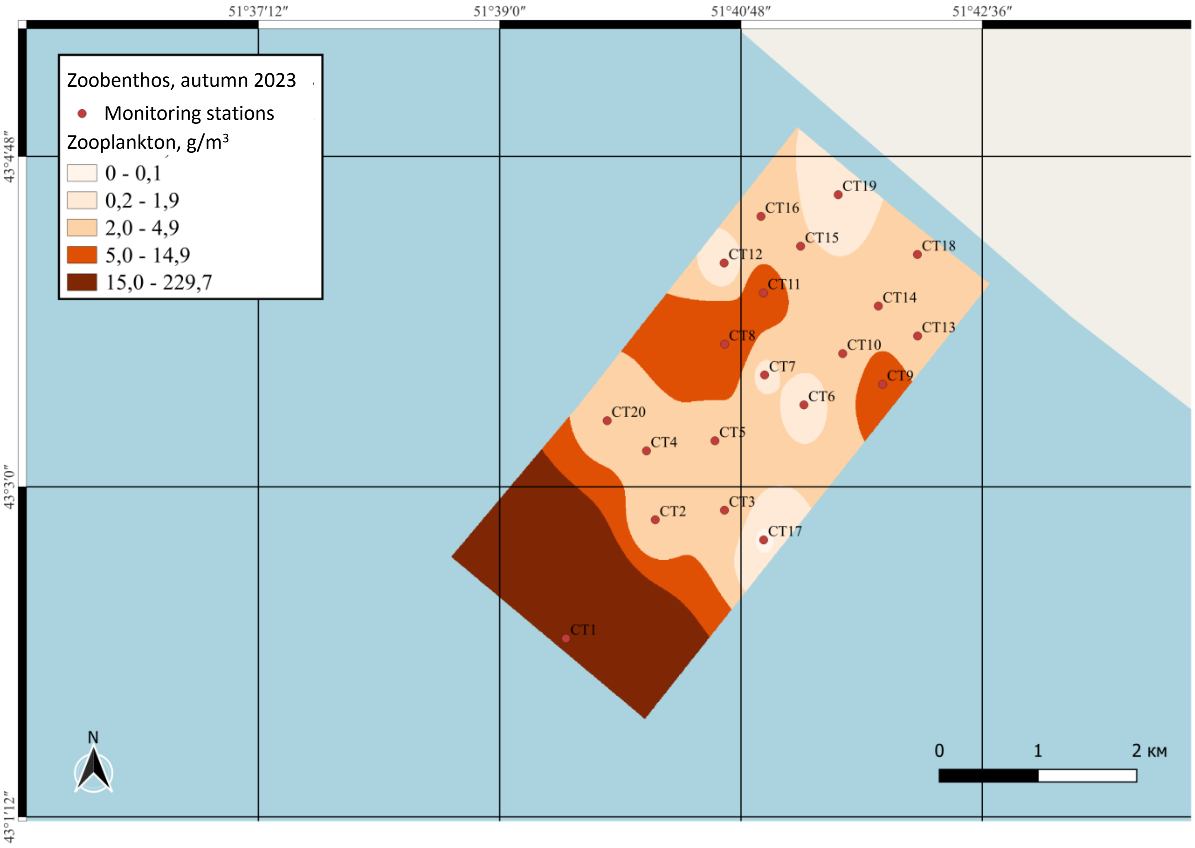

Figure 2.1.2.16 Distribution of zoobenthos within the survey area in autumn 2023, g/m^2

In winter, biomass of benthic cenosis varied from station to station. The minimum biomass was recorded at station 12 and amounted to 0.034 g/m^2 (Figure 2.1.2.17)

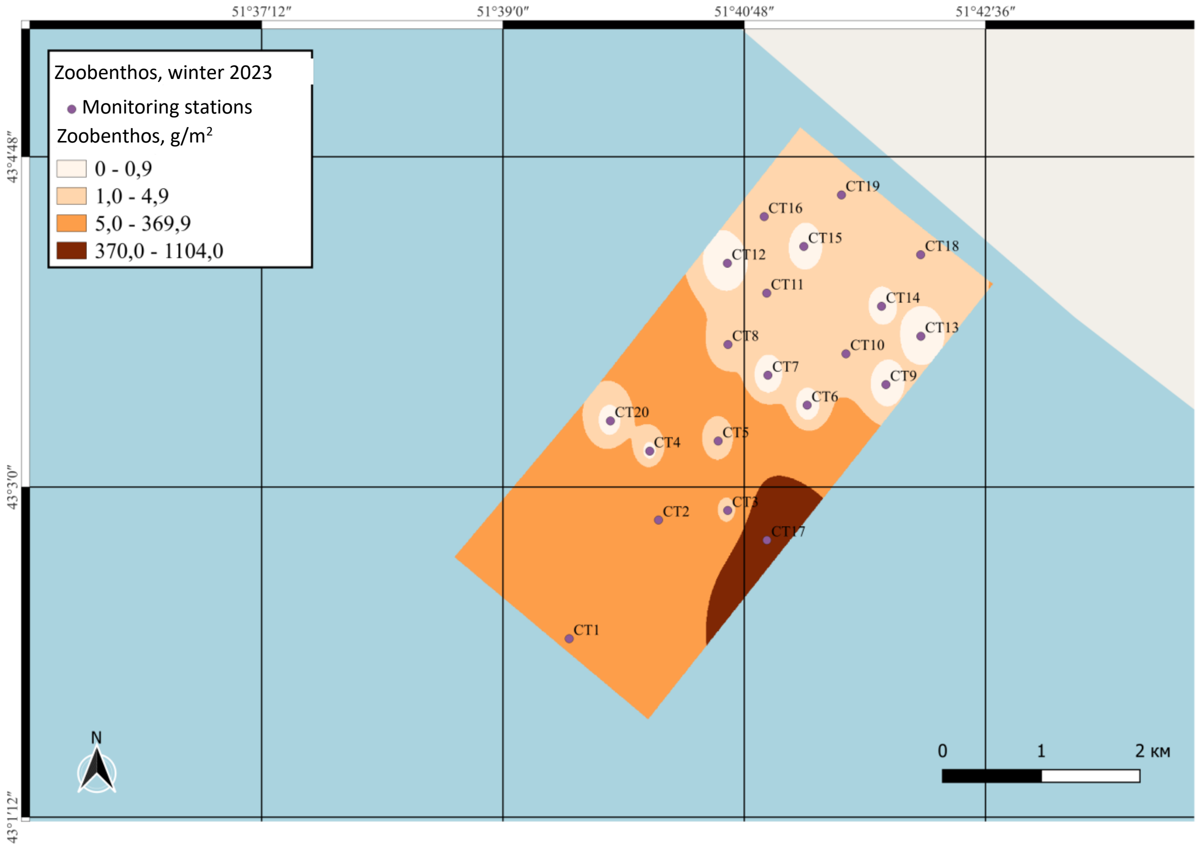

Figure 2.1.2.17 Distribution of zoobenthos within the survey area in winter 2023, mg/m²

In spring, the maximum biomass of benthos was observed at station 1 (16.4 g/m²). The minimum biomass was recorded at station 6 (1.1 g/m²) (Figure 2.1.2.18).

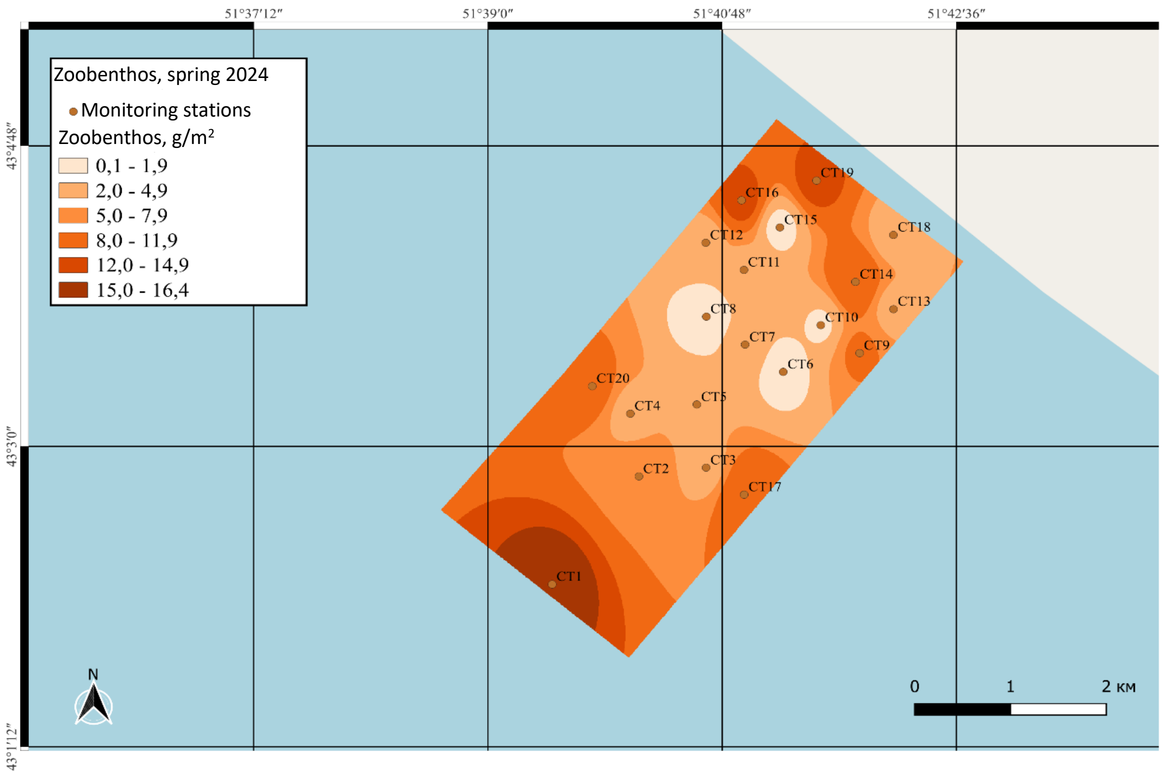

Figure 2.1.2.18 Distribution of zoobenthos within the survey area in spring 2024, mg/m²

In summer, the highest concentration of benthic organisms was observed at station 4 (92.2 g/m^2); the minimum concentration was observed at station 6 (5.1 g/m^2) (Figure 2.1.2.19).

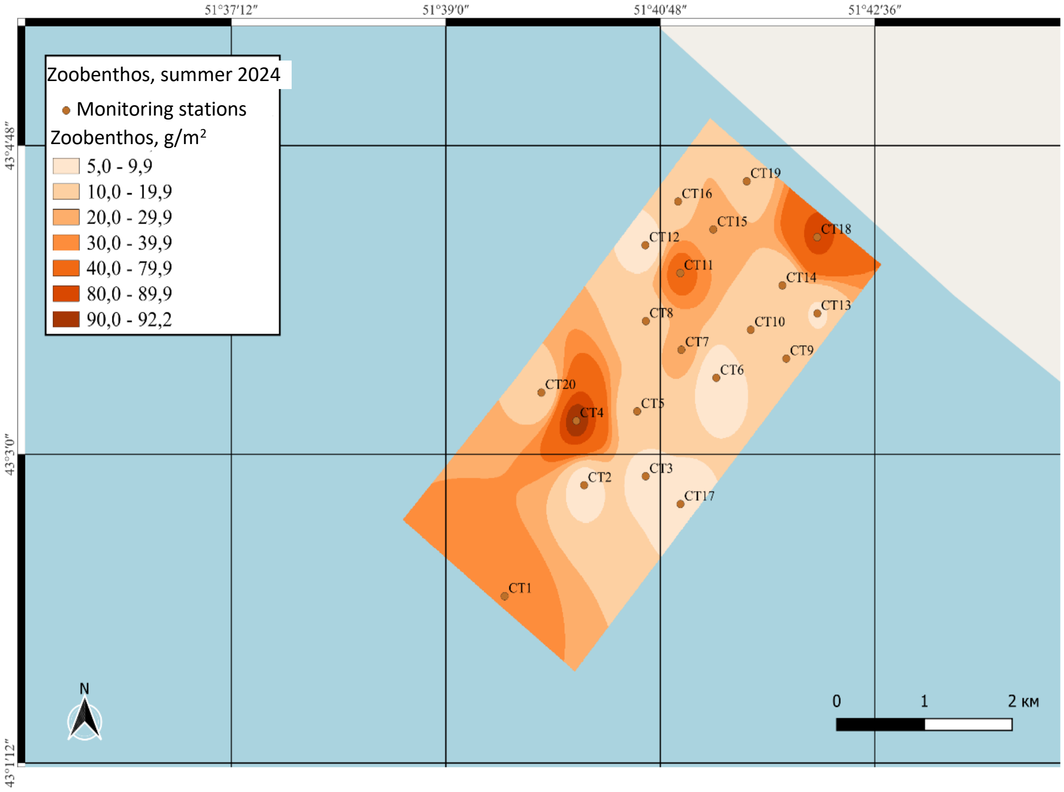

Figure 2.1.2.19 Distribution of zoobenthos within the survey area in summer 2024, mg/m^2

The distribution of zoobenthos biomass within the survey area was localized during all survey periods (Figure 2.1.2.20).

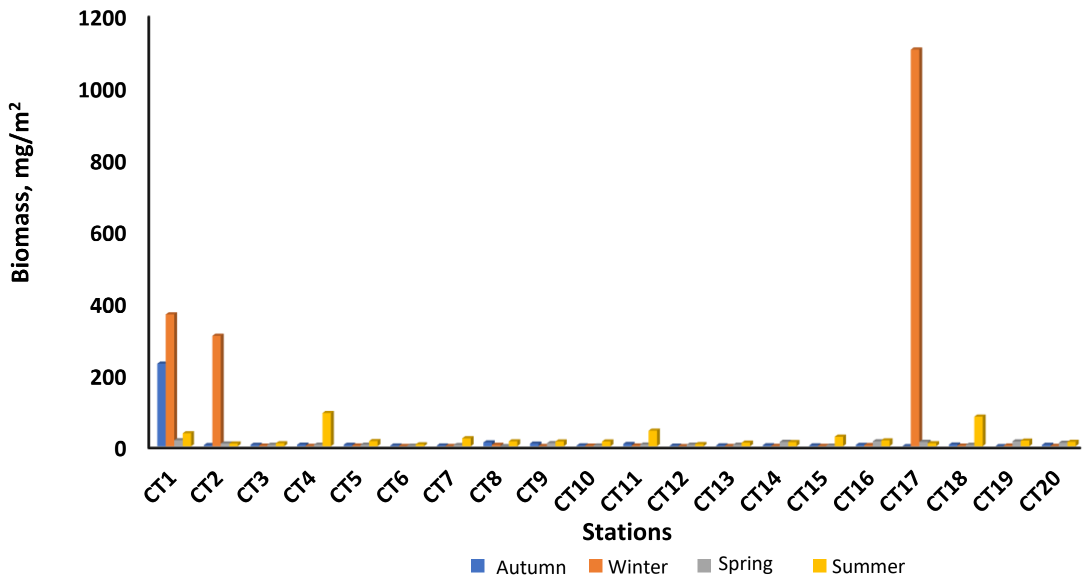

Figure 2.1.2.20 Distribution of zoobenthos biomass in the survey area (autumn, winter, spring, summer)

The Biomass of benthic community mainly depends on the development of mollusks. High biomass recorded at station 17 in winter is explained by the presence of a large mollusk, *Mytilus galloprovincialis*, 57-59 mm long in the samples.

According to the analysis of the development of benthic, crustaceans were characterized by high species diversity and indicators. The established distribution of benthic invertebrates fully corresponds to the individual preferences of taxa in the nature of soil. The recorded species of zoobenthos are one of the main components of the diet of juveniles and mature individuals of bottom-feeding fish. Therefore, the trophological conditions in the survey area were favorable. Implementation of the Project may lead to a decrease in the quantitative indicators of zoobenthos due to the mechanical impact on bottom relief during the construction activities.

Aquatic vegetation

In the autumn period, the biomass of macrophytes was low due to the cooling of the water. The soils in the surveyed area consisted of sandy-shell fractions with fragments of rocky slabs, and aquatic vegetation was nearly absent throughout the area. Only two species of macrophytes, *Laurencia caspica* and *Polysiphonia caspica*, were found at isolated stations, with a macrophyte biomass of 4.6 g/m².

In winter, the water temperature was lower than in autumn (almost by half). Prolonged wave activity from winter storms reaching the bottom resulted in a total biomass of macrophytes of 2.8 g/m². These values corresponded with the presence of *Laurencia caspica* and *Polysiphonia caspica* at isolated stations, with complete absence at others.

The low biomass of aquatic vegetation in autumn and winter is explained by seasonal peculiarities and the temperature regime of the aquatic environment. This does not deviate from general parameters of macrophyte development and is consistent with long-term average values.

In the spring and summer periods, as water temperature increased, *Laurencia caspica* was the only recorded species of algae. Communities of red algae, *Laurencia caspica*, grew on rocky ledges at a distance from the shore. The biomass of macrophytes remained low, amounting to 5.2 g/m² in spring and 8.7 g/m² in summer.

Analysis of the distribution of macrophyte biomass in the survey area prior to planned construction and commissioning of the production facilities indicated uneven concentrations of macrophytes, which corresponded to the seasonal development of aquatic vegetation. The surveyed site features predominantly single-type biotopes with similar lithodynamic regimes, represented by rocky soils and silty sands, influencing the dynamics of macrophyte biomass. The trophic base for phytophagous hydrobionts was assessed as satisfactory.

Implementation of the Project may lead to a decrease in the quantitative indicators of aquatic vegetation due to mechanical disturbances of the bottom relief, where microphytes are located, caused by planned construction activities.

Overall, the development of hydrobiological communities at the site during the survey period was typical for the observed area, and the formation of these communities corresponded to seasonal dynamics.

To understand the possible impact of the planned Project on hydrobiological communities, it is necessary to conduct surveys during the construction work and after its completion to compare against the baseline surveys.

2.2 Marine fauna

2.2.1 General state of ichthyofauna in the Caspian Sea

The Caspian Sea is the largest enclosed natural water body on our planet. Ichthyofauna of the Caspian Sea is not very diverse. In terms of the number of species it is inferior to fish of the Azov and Black Seas, which are close in origin, and much poorer than the ichthyofauna of the open seas (Yablonskaya, 2007; Mirzoyan, 2018).

According to available literature, the Caspian Sea is predominantly inhabited by fish from the herring (*Clupeidae*) and goby (*Gobiidae*) families. These families are characterized by notable species diversity and abundance (Ivanov, Komarova, 2012).

According to the ecological features, fish of the Caspian Sea are divided into four groups: marine, semi-anadromous, river, and anadromous fish. Their dynamics and population are closely related to the river systems and sea areas affected by river runoff (Yablonskaya, 2007).

Among the marine species, for example, Caspian sprats of *Clupeidae* family are widely distributed and include three species: anchovy sprat (*Clupeonella engrauliformis (Borodin)*), Southern Caspian sprat (*Clupeonella grimmi (Kessler)*) and Caspian tulka (*Clupeonella delicatula caspia (Svetovidov)*). Only Caspian tulka (*Clupeonella delicatula caspia (Svetovidov)*) was encountered in the surveyed area during the field works. Additional marine species include herrings, namely the Caspian shad (*Alosa caspia (Eichwald)*), Saposhnikovi shad (*Alosa saposchnikowii (Grimm)*), and Dolginsky herring (*Alosa braschnikowii (Borodin)*).

The marine fish species found in the Caspian Sea also include the big-scale sand smelt (*Atherina mochon caspia (Risso)*) *Atherinidae* family, and two species of Black Sea mullet of the *Mugilidae* family acclimatized in the first half of the 20th century: singil (*Liza aurata (Risso)*) and leaping mullet (*Liza saliens (Risso)*). Singil is encountered more frequently in the Middle Caspian Sea.

Representatives of the *Gobiidae* family (gobies) are characterized by a high species diversity. The Caspian Sea is inhabited by 37 species and subspecies of this family (Annotated reference book, 1998). The most common species in the Middle Caspian Sea are Caspian sand goby (*Neogobius fluviatilis (Pallas)*), deepwater goby (*Neogobius bathybius (Kessler, 1877)*), round goby (*Neogobius melanostomus (Pallas)*), Syrman goby (*Neogobius syrman (Nordman)*), Caspian goby (*Neogobius caspius (Eichwald)*), tubenose goby (*Proterorhimus marmoratus (Pallas)*), and as well Caspian tadpole goby (*Benthophiloides macrocephalus (Kessler)*).

There are 51 species of semi-anadromous and river fish in the Caspian Sea (Ivanov, 2000), inhabiting desalinated areas of the sea and near-mouth areas.

Common representatives of semi-anadromous and river fish in the North Caspian Sea are representatives of two families: *Cyprinidae Bonaparte* of carps and *Percidae Cuvier* of perches (Kazancheev, 1981).

In the Middle Caspian Sea, Caspian roach is mainly found (*Rutilus caspicus*) (Atlas of freshwater fish of Russia, 2002).

Anadromous fish of the Caspian Sea are represented by Caspian lamprey (*Caspiomyzon wagneri (Kessler)*); all Caspian salmons (Salmonidae); all Caspian sturgeons (Acipenseridae) except for sterlet; Volga shad (*Alosa kessleri volgensis (Berg)*) and Caspian anadromous shad (*Alosa kessleri (Grimm)*); and others.

The Caspian Sea is also home to numerous populations of fish from the Acipenseridae family, specifically beluga (*Huso*) and sturgeon (*Acipenser*) orders. Notable species within these orders include beluga (*Huso huso* (Linnaeus)), Russian sturgeon (*Acipenser gueldenstaedtii* (Brandt)), Persian sturgeon (*Acipenser persicus* (Borodin)), starry sturgeon (*Acipenser stellatus* (Pallas)), ship sturgeon (*Acipenser nudiventris* (Lovetsky)), and sterlet (*Acipenser ruthenus* (Linnaeus) (Atlas of Freshwater Fish of Russia, 2002; Kamelov, 2023).

The main biological characteristics of marine fish in terms of distribution, density of aggregations, seasonal migrations, qualitative structure, reproductive potential, and total and commercial stocks of populations have been analyzed and described in various scientific publications (Kiselevich, 1937; Lovetskaya, 1951; Svetovidov, 1952; Smirnov, 1952; Prikhodko, 1975; Kazancheev, 1981; Kanatiev et al., 2014; Paritskii et al., 2018; Kamelov, Mortuzi, 2019).

The Kazakhstan sector of the Middle Caspian Sea is inhabited by many commercial, rare fish species and species listed in the Red Book of Kazakhstan (Table 2.2.1-1). The most valuable ones are unique representatives of the oldest ichthyofauna of the planet – sturgeon fish. The IUCN Red List of Endangered Species and the IUCN Red List of Ecosystems determine which species and natural areas deserve protection. They include Caspian lamprey, Volga shad, Caspian trout and sheefish among the aquatic biological resources of the Caspian Sea of the Republic of Kazakhstan. Moreover, according to the status of the species, Volga shad is an extinct species; sheefish is in a state close to threatened; Caspian lamprey and Caspian trout are among the species of least concern.

Table 2.2.1-1 The species composition of fauna found in eastern Caspian Sea and listed in the Red Book of Kazakhstan and in the IUCN Red List

Specie			Status of the specie	
Latin	Kazakh	English	IUCN Red List	Red Book of Kazakhstan
Fish				
Caspiomyzon wagneri	Каспий тілтісі	Caspian lamprey	LC Least concern	1 category. Endangered specie
Alosa volgensis	Волга коп атылықты майшабағы	Volga shad	EX Extinct	2 category. The species whose number is declining catastrophically
Salmo trutta caspius	Каспий албырты	Caspian trout	LC Least concern	1 category. Endangered specie
Stenodus leucichthys	Ақбалық	Sheefish	NT Near Threatened	IV category. Number and condition of populations of the species are alarming due to the lack of reliable information
Mammals				
Pusa caspica	каспий итбалығы	The Caspian seal	EN Endangered	IV category. Number and condition of populations of the species are alarming due to the lack of reliable information

2.2.2 Hydrobiological survey at the potential construction site near Kuryk in 2023-2024

According to the survey, the possible impact of the Project on the distribution and abundance of surveyed fish species is expected to be at a level indicating the predominance of natural factors over anthropogenic ones. The species diversity will depend on the seasonal migration cycles, which encompass spawning, feeding, and wintering. During the spring period, which is the reproduction period for marine fish species, high aggregations of fish are characteristic. Later, during the feeding period, these aggregations disperse over extensive feeding grounds, leading to a decrease in abundance and biomass of fish in the survey area.

For semi-anadromous and river fish species, the distribution and concentration of aggregations are influenced by environmental factors such as water salinity, temperature regime, and fodder base.

It is impossible to assess the possible impact of the Project activities on sturgeon fish species due to their low occurrence rate, which is explained by the current reserves of these fish species.

To understand the potential impact of Project implementation on fish communities at the site, it is necessary to conduct fishery research during the construction works and after their completion, during the operation phase, to compare against the baseline surveys.

A relative indicator of the average concentration of a species per unit of time (specimen per hour of trawling) is used to characterize the population of juveniles and adult fish in the sea. Modern methods of calculating fish stock require knowledge of their absolute population size. Calculating the absolute population size of fish at feeding grounds is based on the method of direct counting (Mesyatsev et al., 1935; Aksyutina, 1968; Russ, 1938; Stroganov, 1979; Belogolova, 2008) (see Appendix 2).

2.2.2.1 Sturgeon fish

The maximum catches of sturgeons in the Zhaiyk-Caspian Sea basin were observed in late 1970s, when the catch of the most abundant specie, starry sturgeon, reached 10 thousand tons. Due to a sharp decrease in the number of sturgeons, which began in 1991, Caspian littoral countries have banned the commercial fishing of sturgeons since 2010.

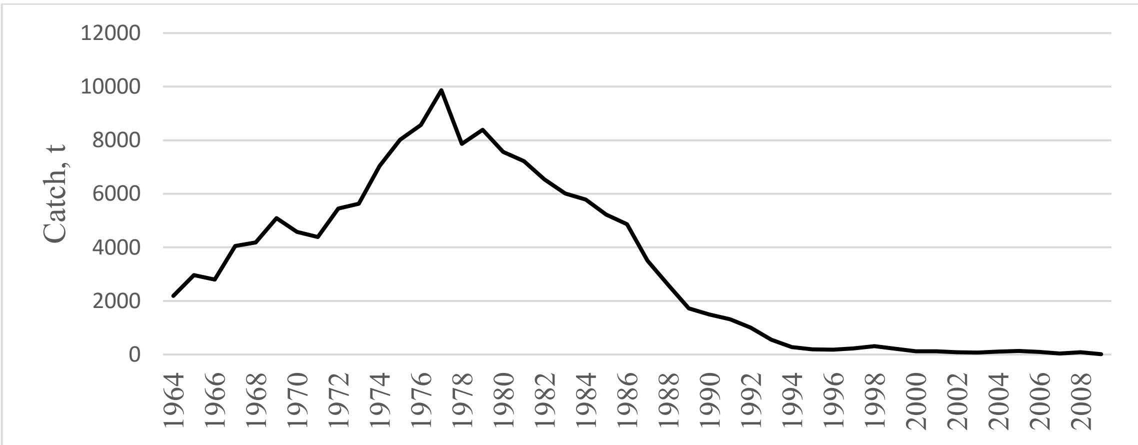

Figure 2.2.2.1.1 Catches of starry sturgeon in the Zhaiyk River in 1964 – 2009 (Kamelov, 2023)

During the monitoring in autumn 2023, only representatives of the Russian sturgeon (*Acipenser gueldenstaedtii*) were observed in the research catches.

Russian sturgeon *(Acipenser gueldenstaedtii)* is a species of sturgeon family. The species has anadromous and fresh-water forms. The species belongs to euryhaline fishes that inhabit freshwater areas and seawater areas with salinity of up to 1-18‰. In terms of oxyphility (Karpanin and Ivanov, 1967), sturgeons belong to the ecological group of fish that demand relatively high concentrations of oxygen in water (6-7 mg/l), but they can also live at an oxygen content of 5-6 mg/l. The death of sturgeon (oxygen threshold) occurs at oxygen concentrations below 2.5 mg/l (Lozinov, 1953). Fluctuations in the active reaction of the medium within pH 6.7-7.2 do not affect gas exchange. The Russian Sturgeon is an eurythermal species, tolerating large fluctuations in water temperature.

Anadromous migrations of all biological groups of sturgeon in the Caspian basin have many common features. Within its habitat, Russian sturgeon makes seasonal migrations mainly associated with the water temperature regime and distribution of food. During the summer feeding period, the sturgeon adheres to depths of 10-25 m, while in autumn and winter the species migrates to deeper depths (sometimes it is observed at depths of 100 m or more), i.e. in denser and saltier water layers with relatively constant water temperature. During the wintering period, juveniles and adults stay together. During the feeding period, they can stay together or separate. In spring, as the water warms up to 6 - 7 °C and the forage base develops, fish migrate from their wintering grounds to the shallower coastal part of the sea for feeding. Therefore, shoals of weight gaining fish could be sparser in summer (except in the areas rich in benthic prey). By autumn, with the gradual cooling of coastal waters, aggregations of sturgeon slowly move further to the south to the deeper areas (juveniles, adults after spawning, and weight gaining fish), where their wintering takes place. However, a part of the spawning population of sturgeon moves to rivers for wintering. Some individuals approach river mouths and winter in the areas of depth depressions and pre-mouth regions, while others winter in sea pastures until the following spring.

The Russian sturgeon is a benthos and mollusks eating species. At the feeding grounds in the sea, the species feeds all day and night without significant breaks. Food consumption intensifies a little in the morning and evening hours (Polyaninova, 1979).

In the Northern Caspian Sea, Russian sturgeon feed mainly on crustaceans, but also eats gobies, sprats and, less frequently, juveniles of other fish. Along the shores of the Middle and South Caspian Sea, Russian sturgeon mainly eats mollusks and gobies. The invasive species of syndesmia (*Abra ovata*) and *Nereis* in the Caspian Sea and appearance of crabs (*Rhithropanopeus*) have taken a significant share in the sturgeon's diet.

The maximum age of Russian sturgeon in recent catches does not exceed 35 years (Kamelov, 2023), while in earlier years individuals up to 50 years old and more were encountered (Chugunov and Chugunova, 1964).

By nature and growth rate, Russian sturgeon belongs to the species that slowly grows throughout its life. Unlike the starry sturgeon and beluga, Russian sturgeon gives maximum linear growth in the first year of life. Then, annual growth gradually decreases (until the onset of sexual maturity). The subsequent decline of average annual growth gain is slow and amounts to 4-5 cm per year (approximately up to 20 years of age). At older ages, growth gain declines to 2-3 or even 1 cm per year (Chugunov and Chugunova, 1964).

The length and weight of Russian sturgeon varies depending on a sex and feeding conditions. In 2009, fish reached 123 cm in length and 9.0 kg in weight in average (Kamelov, 2023).

Spawning of Russian sturgeon does not occur annually. Males spawn every 2-4 years, and females of Russian sturgeon spawn every 4-6 years (Pavlov, 1970).

Absolute fecundity of female Russian sturgeon in the Kazakhstan sector of the Caspian Sea varies from 122.4 to 756.8 thousand eggs depending on a size, body weight and age of the fish (Kamelov, 2023).

After controlling the flow of the Volga River , the highest population of Russian sturgeon in the Caspian Sea was observed in 1968 and amounted to 113.2 million eggs (Legeza, Mailyanova, 2001). In the subsequent period, absolute population of the species at the sea pastures decreased to 42.7 million specimens by 1988 due to the reduction of natural reproduction of Russian sturgeon in the Volga River. In 2005, it did not exceed 33.3 million specimens. At present time (2016-2020), population of Russian sturgeon in the Volga-Caspian fishery basin has stabilized at the level of 6-7 million specimens. (Lepilina et al., 2020).

Representatives of the species were feeding in the northern coastal part of the survey area at stations 13, 16, 19 at depths of 9.3-16.9 m, and in the central part of the survey area at station 5 at 20 m depth.

The average catch of the species at the site was 1.6 specimen per net laying. Absolute population of Russian sturgeon in the waters of the surveyed stations did not exceed eight specimens. Its biomass did not exceed 7.7 kg (Table 2.2.2.1-1).

Table 2.2.2.1-1 Species composition of sturgeon fish within the survey area, autumn 2023

Parameter	Russian sturgeon	Starry sturgeon	Beluga
Share in the catches, %	100.0	0	0

Only juvenile Russian sturgeons at the age of 3 years in average were observed in the catches. Their average length was 77.0 cm, and average weight was 1.88 kg (Table 2.2.2.1-2).

Table 2.2.2.1-2 Average biological parameters of Russian sturgeon, autumn 2023

Specie	Length, cm	Weight, g	Average age	Sex ratio
Sturgeon	77.0	1880.0	3	–

It should be noted that the survey area is used by Russian sturgeon for feeding. However, aggregations of the species are not dense. The majority of the species inhabits the northeastern part of the survey area. The largest aggregations (4 specimen per net setting) were recorded at station 16 (Figure 2.2.2.1.2).

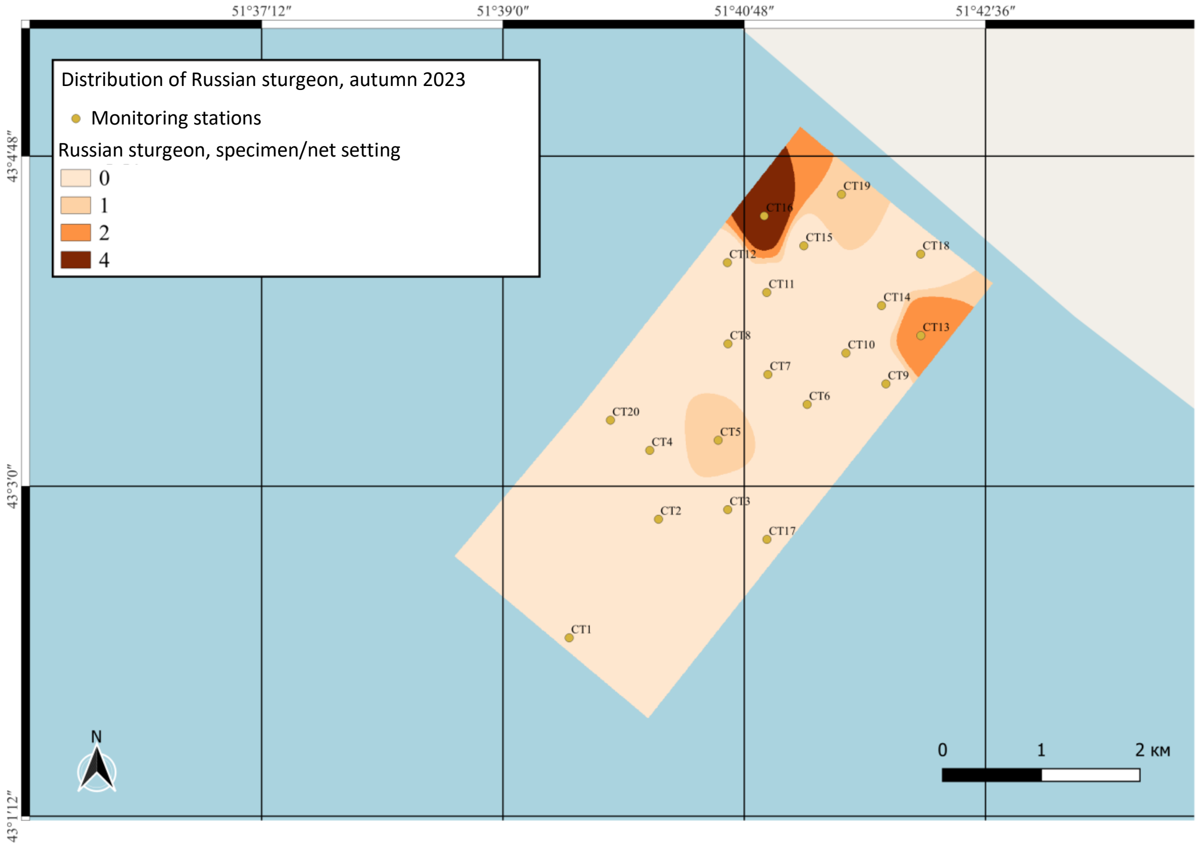

Figure 2.2.2.1.2 Distribution of Russian sturgeon within the survey area in autumn 2023, specimen/net setting

The population of Russian sturgeon in the survey area of the site in autumn amounted to 640 specimen/km^2, its biomass was 1.2 t/km^2.

In winter, representatives of Russian sturgeon were not observed within the survey area nor in the trawl catches nor in the gill net catches.

Starry sturgeon (*Acipenser stellatus*) and beluga (*Huso huso*) were not found in the catches in the autumn and winter periods.

Only the Russian sturgeon (*Acipenser gueldenstaedtii*) representatives were observed in the survey catches during the monitoring in spring 2024.

The species gained weight in the central part of the survey area, namely at station 5 at a depth of 20 m, and in the northern coastal parts of the survey at station 16 at a depth of 17 m.

Average catch of the species amounted to 1.5 specimen per net setting. Absolute population of Russian sturgeon in the waters of the surveyed stations did not exceed three specimens. Its biomass did not exceed 24.9 kg (Table 2.2.2.1-3).

Table 2.2.2.1-3 Species composition of sturgeon fish in the survey area, spring 2024

Parameter	Russian sturgeon	Starry sturgeon	Beluga
Share in the catches, %	100.0 (1 species)	0	0

Only juvenile Russian sturgeons at the age of 3 years in average were observed in the catches. Their average length was 116.0 cm, and average weight was 8.3 kg (Table 2.2.2.1-4).

Table 2.2.2.1-4 Average biological parameters of Russian sturgeon, spring 2024

Specie	Length, cm	Weight, g	Average age	Sex ratio
Sturgeon	116.0	8300.0	3	–

It should be noted that the survey area is used by Russian sturgeon for feeding. Aggregations of the species are not dense. The majority of the species were observed in the northern part of the survey area. The largest aggregations (2 specimen per net setting) were recorded at station 16 (Figure 2.2.2.1.3).

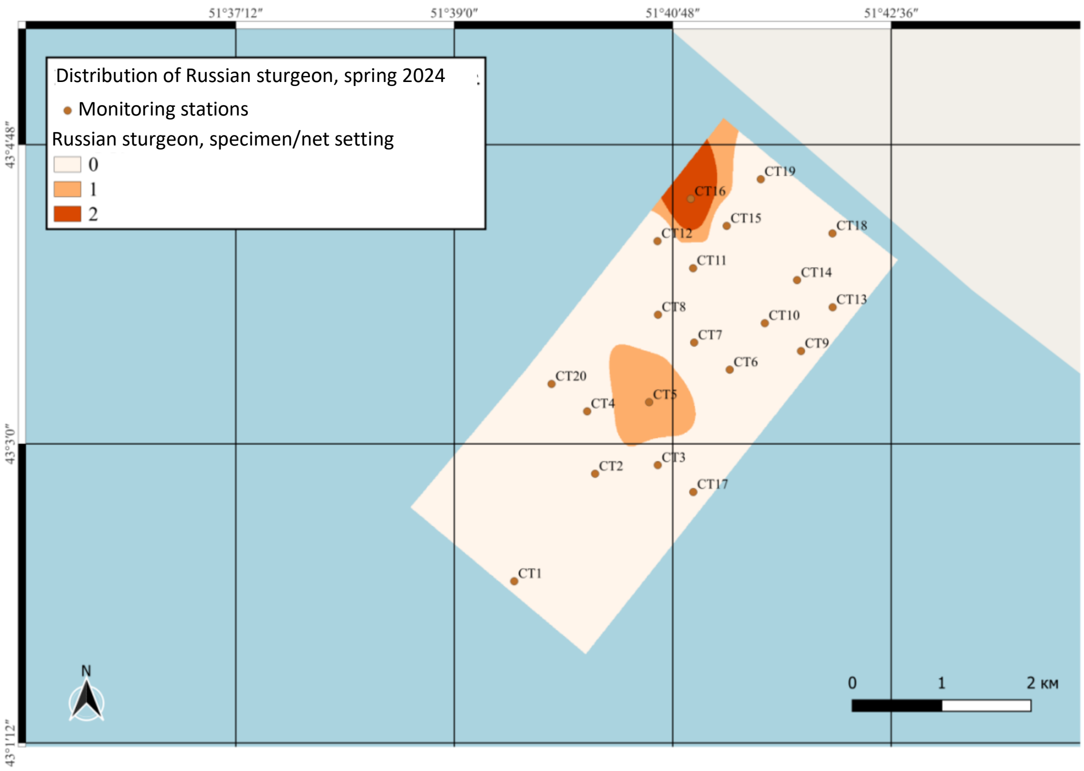

Figure 2.2.2.1.3 Distribution of Russian sturgeon in the survey area in spring 2024, specimen/net setting

Populations of Russian sturgeon in the survey area amounted to 240 specimen/km^2, its biomass was 5.9 km^2.

Starry sturgeon (*Acipenser stellatus*) and beluga (*Huso huso*) were not found in spring.

In summer, representatives of Russian sturgeon were found in the gill net catches at stations 5, 13, 16, 18, 19 in the central, northern and northeastern parts of the survey area.

The largest catch amounted to 20 specimen per net setting and was recorded at station 18 in the northeastern part of the survey area.

Average catch of the species amounted to 9.5 specimen per net setting. Absolute population of Russian sturgeon in the waters of the surveyed stations was 60 specimens. Its biomass was 49.25 kg (Table 2.2.2.1-5).

Table 2.2.2.1-5 Species composition of sturgeon fish in the survey area, summer 2024

Parameter	Russian sturgeon	Starry sturgeon	Beluga

Share in the catches, %	100.0	0	0

Only juvenile Russian sturgeons at the age of 3 years in average were observed in the catches. Their average length was 54.2 cm, and average weight was 0.82 kg (Table 2.2.2.1-6).

Table 2.2.2.1-6 Average biological parameters of Russian sturgeon, summer 2024

Specie	Length, cm	Weight, g	Average age	Sex ratio
Sturgeon	54.2	820.0	3	–

It should be noted that the species occupies mainly the northern part of the survey area. The largest aggregations (20 specimen per net setting) were recorded at station 18 (Figure 2.2.2.1.4).

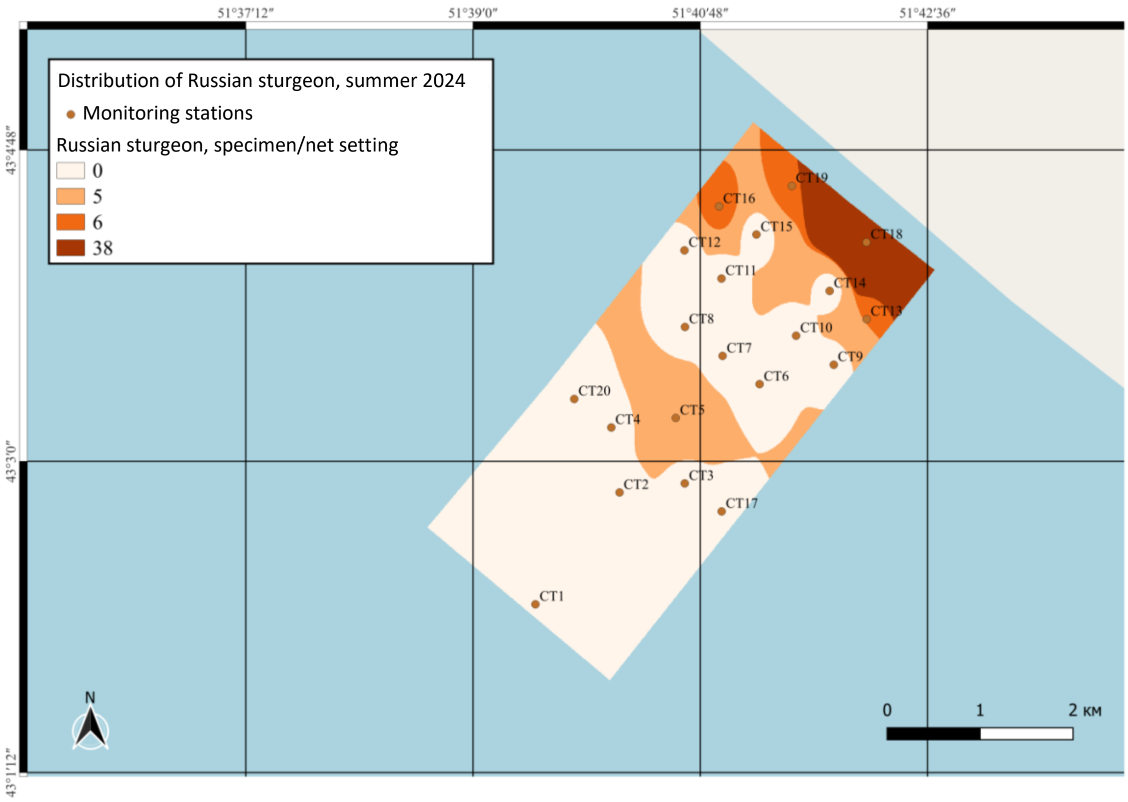

Figure 2.2.2.1.4 Distribution of Russian sturgeon within the survey area in summer 2024, specimen/net setting

Population of Russian sturgeon in the survey area amounted to 480 specimen/km^2, its biomass was 4.2 km^2.

Starry sturgeon (*Acipenser stellatus*) and beluga (*Huso huso*) were not found in spring.

2.2.2.2 Marine fish species

The species composition of marine fish was rather high and included Caspian tulka, herrings, and the family of gobies (Table 2.2.2.2-1).

Table 2.2.2.2-1 The species composition, population and biomass of marine fish within the survey area

Parameter	Caspian tulka (*Clupeonella cultriventris caspia*)	Herrings (*Alosa*)	Gobies (*Gobiidae*)	Total
Species composition, %	78.70	7.22	14.08	100.0
Population, specimen/km^2	34400	29600	27882	91882
Biomass, t/km^2	0.4128	3.555	0.2868	4.2546

Caspian tulka

Caspian tulka *(Clupeonella cultriventris caspia)* is a small commercial marine species of the family of herrings. The Caspian tulka inhabits the whole water area of the Caspian Sea, the lower reaches of the Volga, Ural, Terek Rivers. This species is characterized by a wide amplitude of adaptation to habitat conditions (euryhalinity, eurythermality), which makes it possible to use the entire water area for reproduction and feeding. Representatives of the Caspian tulka become mature early. Most individuals already have mature reproductive products at the age of one year. Fecundity of the species varies from 9.5 to 60 thousand eggs. Length of mature individuals reaches 14 cm. Their weight reaches 23 g, age - 6 years. Multiple spawning occurs everywhere in the shallow water areas of the Caspian Sea. The main spawning grounds of Caspian tulka are in the Northern Caspian Sea. Caspian tulka is a pelagic specie. Incubation period lasts for 27-30 hours at a temperature of 14.3 °C. The larvae hatched in May are 1.3-1.8 mm in size. By September, juveniles reach 50-55 mm in size. Population of new generation is formed depending on environmental conditions during the breeding and feeding period in the Northern Caspian Sea.

In recent years, the stock of Caspian tulka has remained stable, which is explained by the peculiarities of ecology and biology of the specie. The ecological flexibility of Caspian tulka has determined its broad distribution in the Caspian Sea, including the surveyed area.

Caspian tulka is one of the most abundant species among the marine fish species. It is found in all coastal areas of the Caspian Sea.

Catches of Caspian tulka varied widely (from 0 to 27 specimen/net setting) averaging to 8.6 specimen/net setting. Aggregations of fish within the site boundaries were not evenly distributed: distribution of the species was limited to five stations reaching its maximum density in the southwestern part of the survey area at station 5 (Figure 2.2.2.2.1).

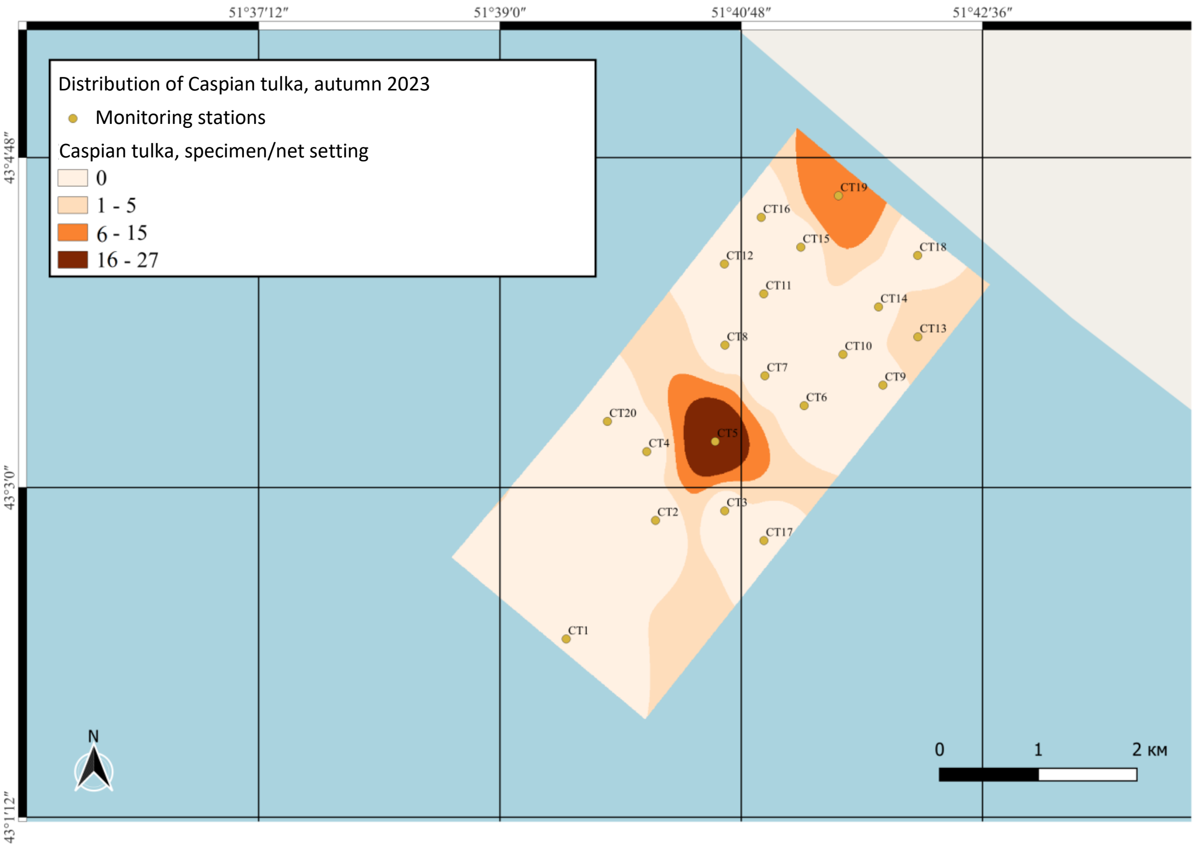

Figure 2.2.2.2.1 Distribution of Caspian tulka within the survey 2023, specimen/hour of trawling

The length of the species representatives varied from 10.0 to 13.5 cm, their weight varied from 7.0 to 17 g, averaging to 11.75 cm and 12.0 g respectively. The Fulton's condition factor amounted to 0.697. Average age was 2 years (Table 2.2.2.2-2).

Table 2.2.2.2-2 Average biological parameters of Caspian tulka within the survey area, autumn 2023

Specie	Length, cm	Weight, g	Fulton's condition factor	Age, years	Sex ratio, % of males
Caspian tulka (*Clupeonella cultriventris caspia*)	11.75	12.0	0.697	2.0	54.7

Males prevailed (54.7%).

Population of Caspian tulka in the survey area amounted to 34,400 specimen/km^2, its biomass was 0.4128 t/km^2.

In winter 2023, as well as in summer and spring of 2024, the Caspian tulka was not observed during survey operations.

Marine herrings

Marine herrings (*Alosa*) include species such as Dolginsky herring, Saposhnikovi shad, Caspian shad, and Agrakhan shad. These species migrate for spawning from the southern part of the Caspian Sea to its northern regions.

Representatives of marine herrings usually reach sexual maturity at the age of 2-3 years with an average fecundity of 60 to 100 thousand eggs. The highest size-weight parameters were recorded for Dolginsky herring: up to 47 cm and 1200 g. For small Caspian shad, these parameters were 25 cm and 250 g, respectively, with an age limit of 9 and 7 years. The reproductive cycle (formation of pre-spawning aggregations, spawning and its completion) of herring occurs in a short period of time (April - early June). However, there are individual peculiarities of each species depending on the hydrological conditions, in particular on a temperature regime. Saposhnikovi shad reach the peak of their spawning run in the third decade of April and early May, at water temperatures ranging from 12.2 to 14.5 °C. Dolginsky herring's peak spawning occurs in the first decade of May, at temperatures of 14.5-16 °C. Caspian shad spawn in May and June, at water temperatures between 14-24 °C, with the maximum spawning run occurring in the third decade of May. After spawning is complete, the commercial shoals of migrating marine herring typically disperse, and the spawned individuals spread out across the feeding grounds of the Caspian Sea.

In the summer - autumn period, the marine spawning areas of the Northern Caspian Sea act as feeding grounds for newly emerged generations of marine herring, as evidenced by the high concentrations of juveniles observed up to the beginning of October.

Herrings in autumn survey period were distributed throughout the survey area, with the maximum density recorded at station 19 (21 specimen/net setting). The average concentration of herrings at the site was 7.4 specimen/net setting; while catch per effort varied from 0 to 21 specimen/net setting (Figure 2.2.2.2.2).

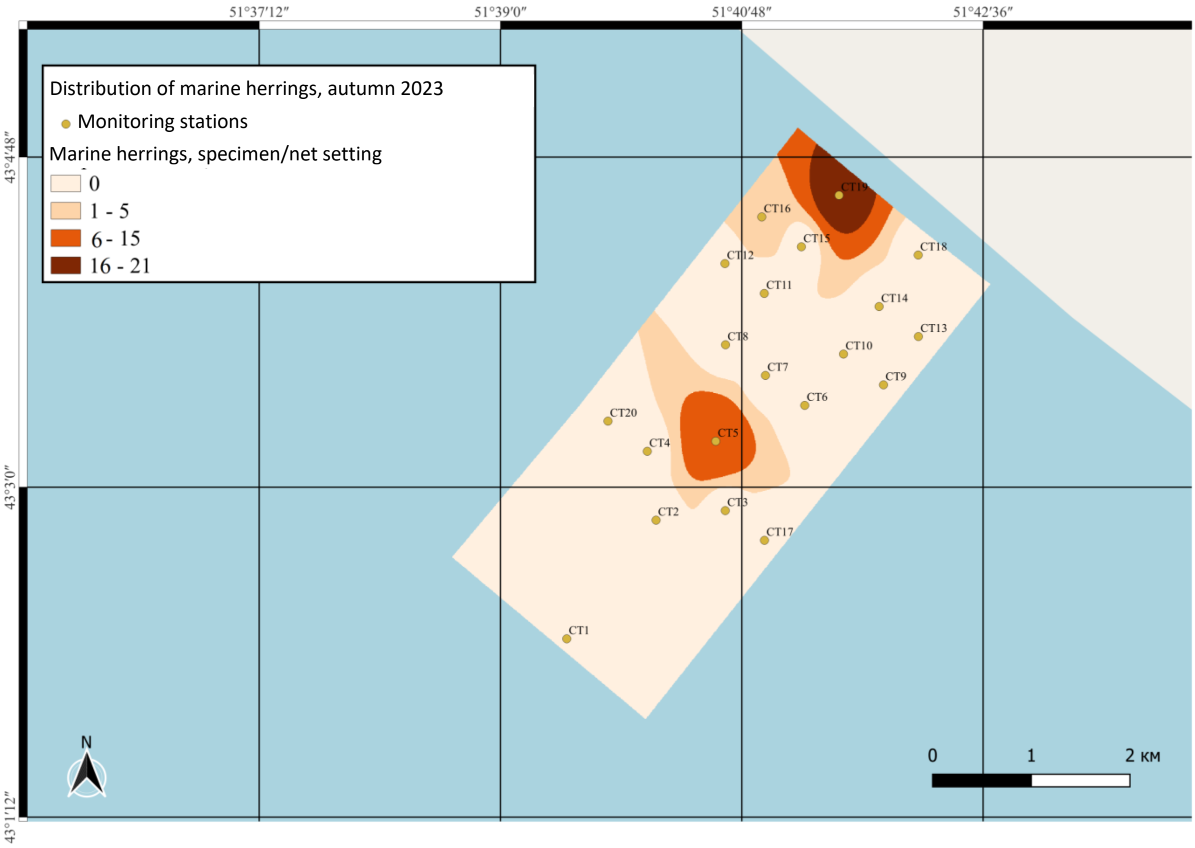

Figure 2.2.2.2.2 Distribution of marine herrings within the survey area in autumn 2023, specimen per net setting

Caspian shad (*Alosa caspia caspia*) and Saposhnikovi shad (*Alosa saposchnikowii*) were encountered in the catches. The age of fish ranged from two to four years (87.5 % of 2 years old, 11.3% of 3 years old, and 1.2% of 4 years old). Immature individuals of 2 years old dominated. Sex ratio of sexually mature fish was close to 1:1. Average size-weight indicators of Caspian shad at the site were 23.6 cm in length and 99.0 g in weight with a fatness coefficient of 0.725. Average age of fish was 2.5 years.

Average size-weight indicators of Saposhnikovi shad at the site were 20.7 cm in length and 123.4 g in weight with a fatness coefficient of 1.224. Average age of fish was 1.7 years.

Table 2.2.2.2-3 Average biological parameters of marine herrings within the survey area, autumn 2023

Specie	Length, cm	Weight, g	Fulton's condition factor	Age, years	Sex ratio, % of males
Saposhnikovi shad (*Alosa saposchnikowii)*	20.7	123.4	1.224	1.7	50
Caspian shad *(Alosa caspia caspia)*	23.6	99.0	0.725	2.5	50

In autumn, population of herrings in the survey area amounted to 29,600 specimen/km^2, their biomass was 3.555 t/km^2.

In winter, marine herrings were not observed within the survey area.

In spring 2024, herrings were distributed throughout the survey area, with the maximum density recorded at station 13 (7 specimen/net setting). The average concentration of herrings 4.2 specimen per net setting; while catch per effort varied from two to seven specimen per net setting (Figure 2.2.2.2.3).

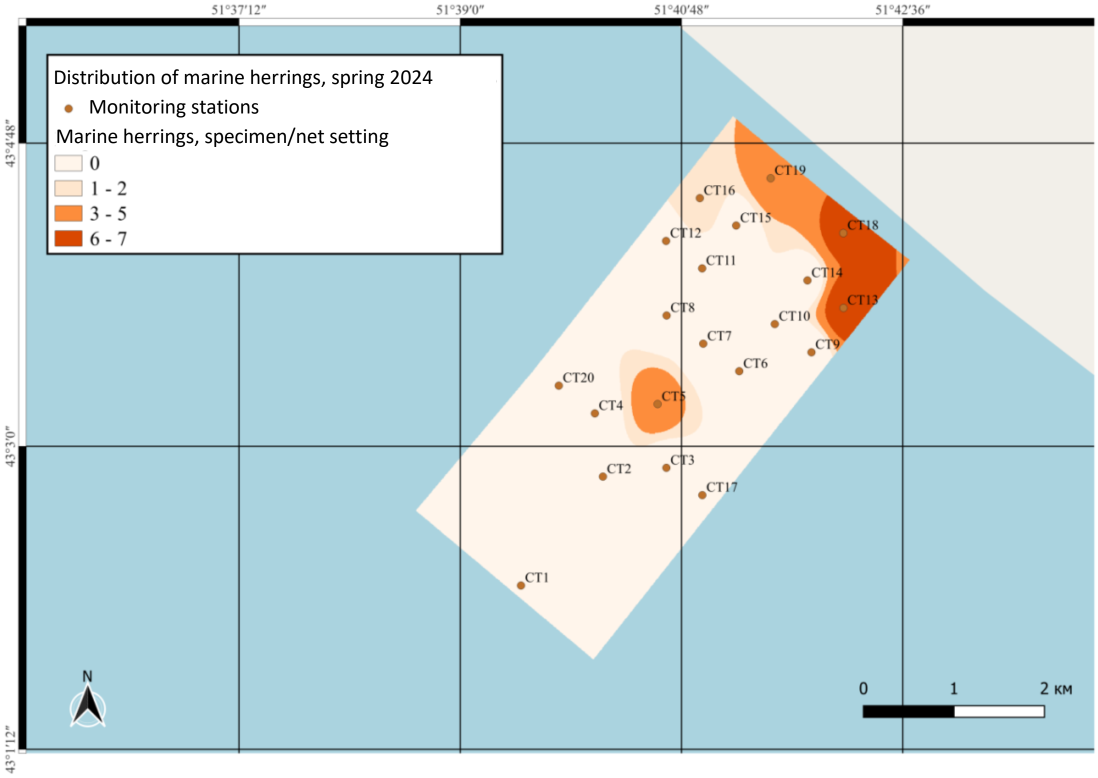

Figure 2.2.2.2.3 Distribution of marine herrings within the survey area in spring 2024, specimen per net setting

Saposhnikovi shad (*Alosa saposchnikowii*) and Caspian shad (*Alosa caspia caspia*) were encountered in the catches. The age of fish ranged from two to four years (68.2 % of 2 years old, 23.4 % of 3 years old, and 8.4% of 4 years old). Immature individuals of 2 years old dominated. Sex ratio of sexually mature fish was close to 1:1. Average size-weight indicators of Caspian shad at the site were 23.6 cm in length and 99.0 g in weight with a fatness coefficient of 0.725. Average age of fish was 2.5 years.

Average size-weight indicators of Saposhnikovi shad at the site were 38.5 cm in length and 506.15 g in weight with a fatness coefficient of 0.863. Average age of fish was 1.9 years.

Population of herrings in the survey area amounted to 16,800 specimen/km^2, their biomass was 228.65 t/km^2.

In summer 2024, herrings were encountered in the catches at station 5 in the deep-water area and at stations 18 and 19 in the coastal area. Maximum density was observed at stations 5. The average concentration of herrings at the site was 2.2 specimen per net setting; while catch per effort varied from one to nine specimen per net setting (Figure 2.2.2.2.4).

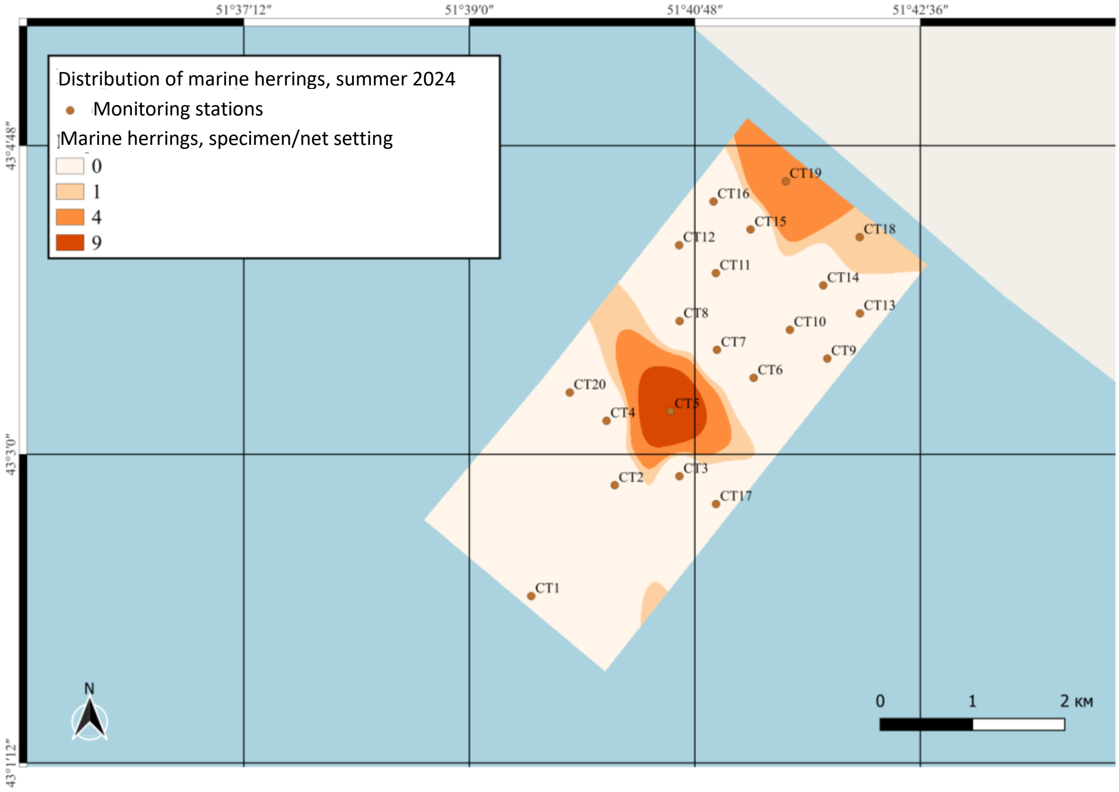

Figure 2.2.2.2.4 Distribution of marine herrings within the survey area in summer 2024, specimen per net setting

Saposhnikovi shad (*Alosa saposchnikowii*) and Caspian shad (*Alosa caspia caspia*) were encountered in the catches. The age of fish ranged from 2 to 4 years (62.3 % of 2 years old, 17.8 % of 3 years old, and 19.9% of 4 years old). Immature individuals of 2 years old dominated. Sex ratio of sexually mature fish was close to 1:1. Average size-weight indicators of Saposhnikovi shad at the site were 17.9 cm in length and 28.7 g in weight.

Average size-weight indicators of Caspian shad were 40.55 cm in length and 434.5 g in weight with a fatness coefficient of 0.624.

Population of herrings in survey area amounted to 10,400 specimen/km^2, their biomass was 12.284 t/km^2.

Gobies

Gobies (*Gobiidae*). Goby species are among the most numerous fish populations, represented by both stenohaline and euryhaline forms. These species do not undertake long migrations for spawning, feeding, rolling, or wintering and are considered non-migratory fish. The Northern Caspian Sea is characterized by significant variability in hydrochemical and hydrological regimes, which influences the species composition of gobies. The primary factors determining their diversity are salinity, river runoff, and sea level. Changes in these parameters lead to alterations in the species composition, distribution, quality indicators, and population of gobies.

Gobies are bottom-dwelling fish with distinctive biological features. They possess a large, broad head with closely set eyes, two dorsal fins (one typically with rigid fin-rays), and a cup-shaped disc formed by united pelvic fins. This disc enables them to attach firmly to bottom rocks, even during strong storms. Gobies share several similar biological characteristics: their life span extends up to 5 years, they reach sexual maturity within the first or second year of life, and they spawn on the bottom from May to July. The fecundity of individuals varies from 20 to 925 eggs.

The densest aggregations of gobies were observed in the central part survey area (stations 7, 11, 15) in autumn 2023. Catches ranged from 0 to 85 specimen per hour of trawling, averaging 22.3

specimen per hour of trawling. Maximum aggregations at a level of 85 specimen per hour of trawling were recorded in the central part of the site (Figure 2.2.2.2.5).

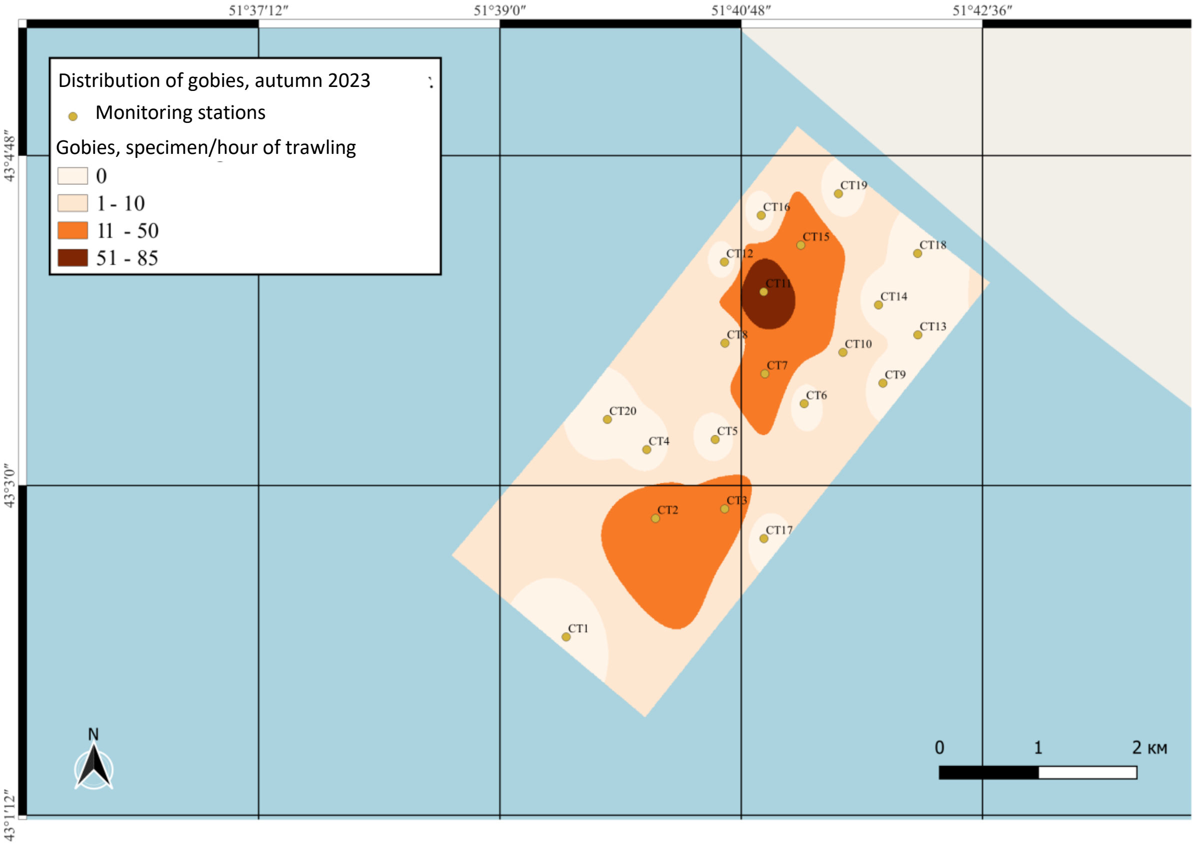

Figure 2.2.2.2.5 Distribution of gobies within the survey area in autumn 2023, specimen/hour of trawling

Species composition of gobies at the surveyed site was represented by six species: Caspian sand goby (*Neogobius fluviatilis (Pallas, 1814)*) (3.4%); Caspian naked goby (*Caspiosoma caspium*) (4.5%); round goby (Neogobius *melanostomus (Pallas, 1814)*) (73.6%); tadpole-goby (*Benthophilus macrocephalus (Pallas)*) (16.9%); ratan goby (*Ponticola ratan (Kessler, 1877)*) (0.6%); and Syrman goby (*Ponticola syrman*) (1.1%).

The Round goby is a small fish of the goby family. It is not a commercial fish species. It spawns from April to September. Puberty occurs by the second or third year of life in females and by the third or fourth year of life in males. Males die at the end of their first breeding season.

Round goby prevailed in the catches. The catches included individuals with a length from 4.6 to 17.2 cm (9.6 cm in average) and weight from 1.0 to 58 g (12.0 g in average). Males prevailed (61.1%). Fulton's condition factor amounted to 1.356.

The Caspian sand goby is a species of actinopterygian fish belonging to the goby family. It is a Ponto-Caspian relict species and is not considered commercially significant. This species typically resides on sandy bottoms near shores with running water. During winter, the sand goby moves to deeper waters, covers itself with a thick layer of mucus, refrains from eating, and remains almost immobile. It has a life span of 5-7 years, reaching puberty in its second year when it attains a length of about 10 cm. The spawning period for the Caspian sand goby lasts from late April to early June, occurring at water temperatures between 10-13 °C. For spawning, it selects shallow areas along the shores. The sand goby is a typical molluscivore, although mollusks play a somewhat lesser role in its diet compared to the round goby. Caspian sand goby in the catches was characterized by a length from 3.0 to 9.3 cm (5.3 cm in average) and weight from 1.0 to 11.0 g (4.27 g in average). Males prevailed (55.6%). Fulton's condition factor amounted to 2.81.

The Caspian naked goby is a species of actinopterygian fishes of the goby family. It is a single representative of *Caspiosoma* genus. The species is not commercial. Caspian naked goby inhabits the slightly saline estuarine river areas, as well as the lower and deltaic sections of the river basins. It is a typical bottom fish that does not form massive aggregations. Reproduction occurs in shallow areas in the upper estuarine parts of rivers and their lower reaches with a sandy or clayey bottom and small vegetation. Spawning takes place on nests made of empty shells of mollusks. Adult fish feed on crustaceans, annelid worms and larvae of insects.

The Caspian naked goby in the catches was represented by individuals with a length from 8.0 to 10.0 cm (8.8 cm in average) and weight from 10.7 to 20.9 g (14.3 g in average). 100% of the specie's representatives were males. Fulton's condition factor amounted to 2.098.

The Tadpole-goby is a brackish–water actinopterygian fish of the goby family (*Gobiidae*). The species is not commercial. Its total body length does not exceed 10 cm. Tadpole-goby lives in fresh and brackish waters with a salinity of up to 20 % and slightly higher but never goes into the real seawaters with a salinity of more than 30%.

The Tadpole-goby in the catches was characterized by a length from 5.5 to 8.5 cm (7.1 cm in average) and weight from 4.5 to 16.0 g (9.1 g in average). Males prevailed (60%). Fulton's condition factor amounted to 2.543.

The Ratan goby is a species of the goby family. The species is not commercial. Body length is up to 20 cm, usually up to 10 cm. Weight is up to 125 g, usually up to 90-100 g. Life expectancy of the species is up to 4-5 years. It is a marine bottom dwelling fish that inhabits coastal areas. It keeps near the coasts and concentrates on the so-called banks. In spring, the species goes to the shallow water areas for spawning, often almost to the water edge, after which it migrates at a distance of 100-150 m (up to 15 km) from the coasts for feeding and in winter as a temperature declines. It reaches sexual maturity at the age of two years with a body length of about 7 cm and a weight of about 8 g. Reproduction begins in the second half of April, possibly from the end of March. Multiple spawning takes place among the rocks of the coastal shallow waters.

Ratan goby was represented by a single male, which length was 8.1 cm, and weight was 11.0 g. Fulton's condition factor amounted to 1.693.

The Syrman goby is an actinopterygian fish of the goby family. The species is not commercial. Body length is up to 21.2 cm, usually up to 16-18 cm. Weight is up to 120 g, usually 90-100 g. Life expectancy is up to 4-5 years. It is a brackish-water, partially freshwater, bottom dwelling fish that inhabits the coastal areas of the sea, estuaries and lower reaches of the rivers. The Syrman goby is quite resistant to oxygen deficiency in water and fluctuations in water temperature and occurs mainly in the saline water areas. The fish prefers the places with shelly, sandy or silty soil, which are associated with accumulations of the main food object, mollusks. It holds at depths of up to 10-12 m. The species comes closer to the coasts in spring. After spawning, Syrman goby migrates to great depths for feeding and later for wintering. It reaches puberty with a body length of about 7 cm and a weight of 6 g, usually at the age of two years, occasionally at the end of the first year of life. Breeding takes place from April to June. Multiple spawning takes place at a water temperature of 10-21 °C in the coastal areas with sandy-silty soil and shells and stones.

Syrman goby in the catches was characterized by a length from 4.5 to 7.6 cm (6.4 cm in average) and weight from 3.5 to 11.0 g (7.1 g in average). Males prevailed (64%). Fulton's condition factor amounted to 2.314 (Table 2.2.2.2-4).

Table 2.2.2.2-4 Average biological parameters of gobies within the survey area, autumn 2023

Specie	Length, cm	Weight, g	Fulton's condition factor	Age, years	Sex ratio, % of males
Caspian naked goby (*Caspiosoma caspium*)	8.8	14.3	2.098	-	100
Caspian sand goby *(Neogobius pallasi)*	5.3	4.27	2.81	-	55.6
Round goby *(Circum-virens taurus)*	9.6	12.0	1.356	-	61.1

Syrman goby (*Ponticola syrman*)	6.4	7.1	2.314	-	64
Tadpole-goby *(Sidereum goby)*	7.1	9.1	2.543	-	60.0
Ratan goby (*Ponticola rattan*)	8.1	11.0	1.693	-	100

In autumn 2023, population of gobies in the survey area amounted to 27,882.03 specimen/km^2, its biomass was 0.2868 t/km^2.

In winter 2023, a single representative of goby was recorded in research catches. Caspian sand goby was caught by a 9-meter trawl at station 1, in the southwestern part of the survey area at a depth of 22 m. (Figure 2.2.2.2.6).

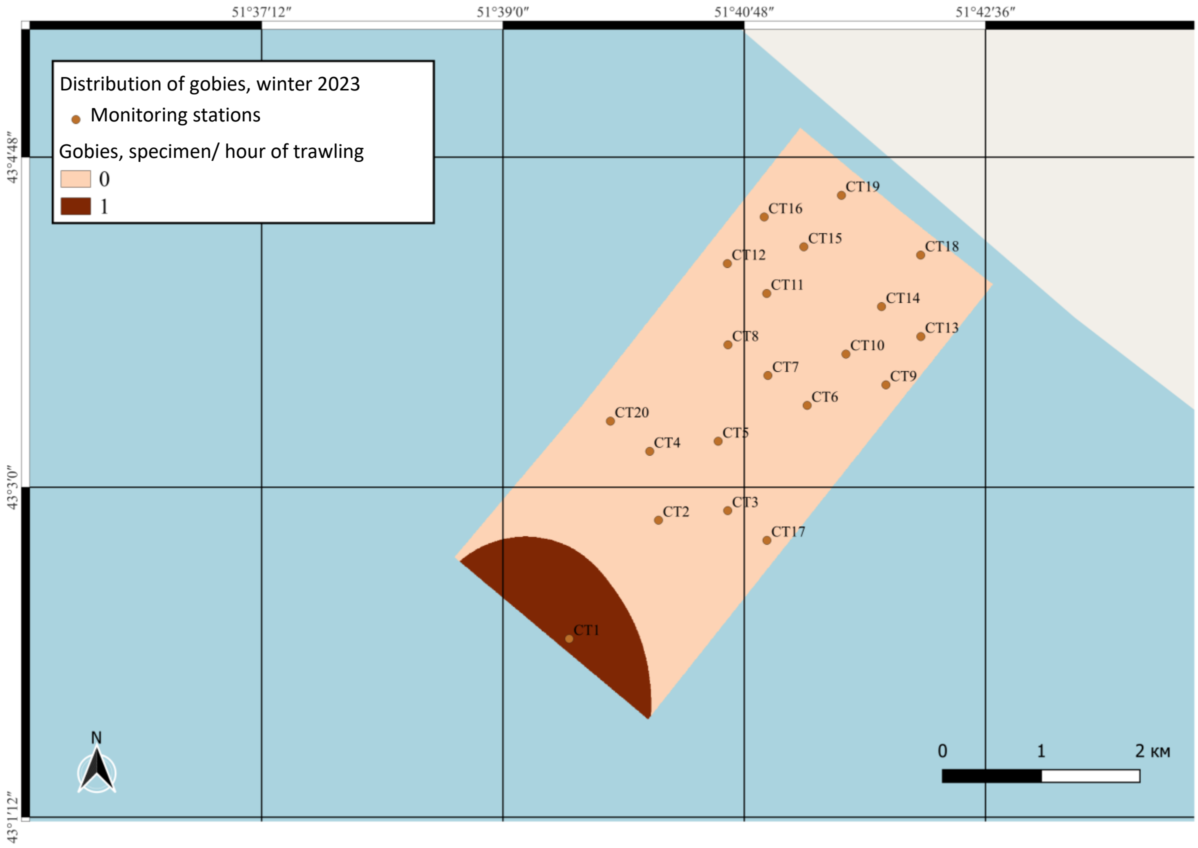

Figure 2.2.2.2.6 Distribution of gobies within the survey area in winter 2023, specimen/trawling

Fish length was 5.1 cm; weight was 2 g. Fulton's condition factor was 1.51. It was male.

The population of gobies in the survey area amounted to 46.3 specimen/km^2, their biomass was 0.0001 t/km^2.

In spring 2024, species composition of gobies was represented by Caspian naked goby, Caspian sand goby, round goby, and tadpole-goby (Table 2.2.2.2-5).

Table 2.2.2.2-5 Average biological parameters of gobies within the survey area, spring 2024

Specie	Length, cm	Weight, g	Fulton's condition factor	Age, years	Sex ratio, % of males
Caspian naked goby (*Caspiosoma caspium*)	4.4	1.0	1.173	-	100
Caspian sand goby *(Neogobius pallasi)*	5.43	1.71	1.0	-	62.3
Round goby *(Circum-virens taurus)*	7.9	6.12	1.21	-	59.1

Tadpole-goby *(Sidereum goby)*	3.2	1.0	3.05	-	100

The largest aggregations of gobies were observed in the deep-water area of the southwestern part of the survey area (stations 1 and 17). Catches ranged from three to nine specimen per hour of trawling, averaging 6.5 specimen per hour of trawling. Maximum aggregations at a level of 9 specimen per hour of trawling were recorded in the southwestern deep-water part of the site (Figure 2.2.2.2.7).

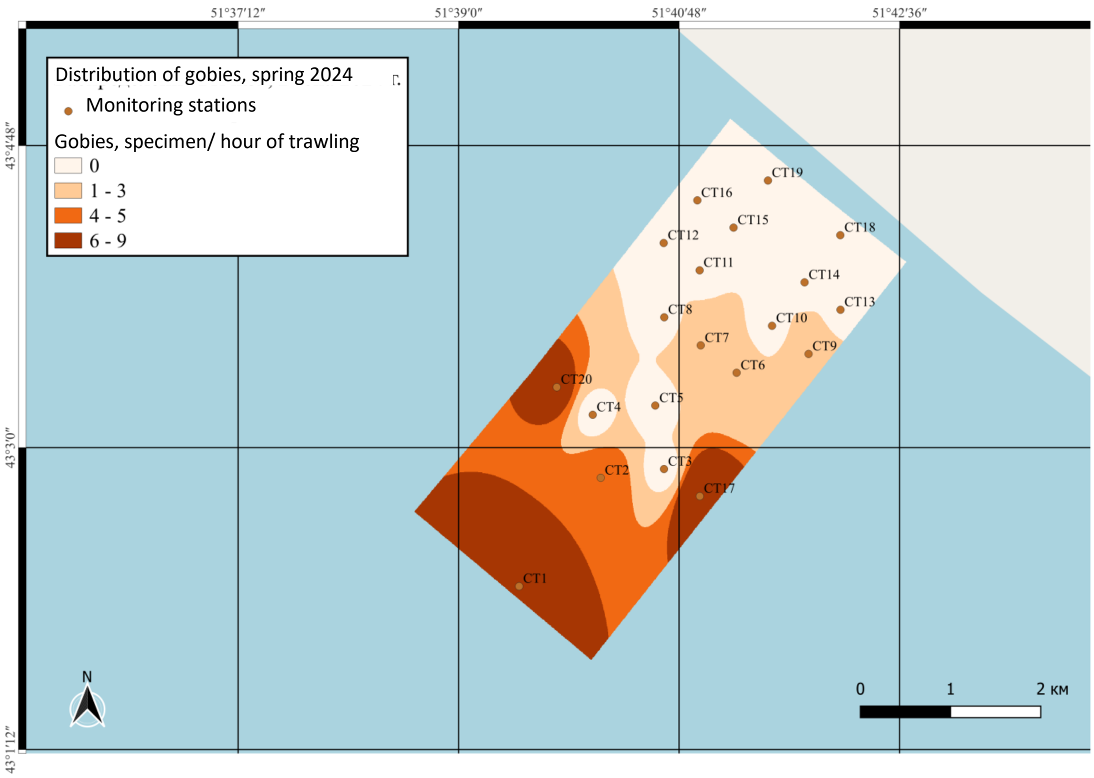

Figure 2.2.2.2.7 Distribution of gobies at the within the survey area in spring 2024, specimen/hour of trawling

Species composition of gobies within the survey area was represented by five species: Caspian sand goby (*Neogobius fluviatilis (Pallas, 1814)*) (20.6%); Caspian naked goby (*Caspiosoma caspium*) (2.9%); round goby (*Neogobius melanostomus (Pallas, 1814)*) (73.5%); tadpole-goby (*Benthophilus macrocephalus (Pallas)*) (2.9%). Round goby prevailed in the catches. Length of the encountered fish varied from 5.9 to 10.7 cm (7.8 cm in average); weight varied from 2.0 to 12 g (6.1 g in average). Males prevailed in the catches (62.3%). Fulton's condition factor amounted to 1.21. Sand goby in the catches had a length from 4.9 to 7.5 cm (5.4 cm in average) and weight from 1.0 to 4.0 g (1.71 g in average). Males prevailed (59.2%). Fulton's condition factor amounted to 1.0. Caspian naked goby was represented by one individual (male) with a length of 4.4 cm and weight of 1.0 g. Fulton's condition factor amounted to 1.17. Tadpole-goby (male) had length of 3.2 cm and weight of 1.0 g. Fulton's condition factor was 3.05.

Concentration of gobies at the site was 2,468.34 specimen/km^2. Their biomass was 0.048 t/km^2.

Thus, the species composition of the marine fish was characterized by a high diversity. According to the concentration of fish, gobies prevailed in the species composition (61.81%) followed by marine herrings (38.18%) and Caspian tulka (0.01%). Overall population was 19,128.58 specimen/km^2; biomass was 18.8 t/km^2.

In summer 2024, round goby, Caspian sand goby, toad goby, and tubenose goby were encountered in the catches.

Round gobies were observed at stations 3, 6, 7, 9, 17 in the deep-water area (Figure 2.2.2.2.8).

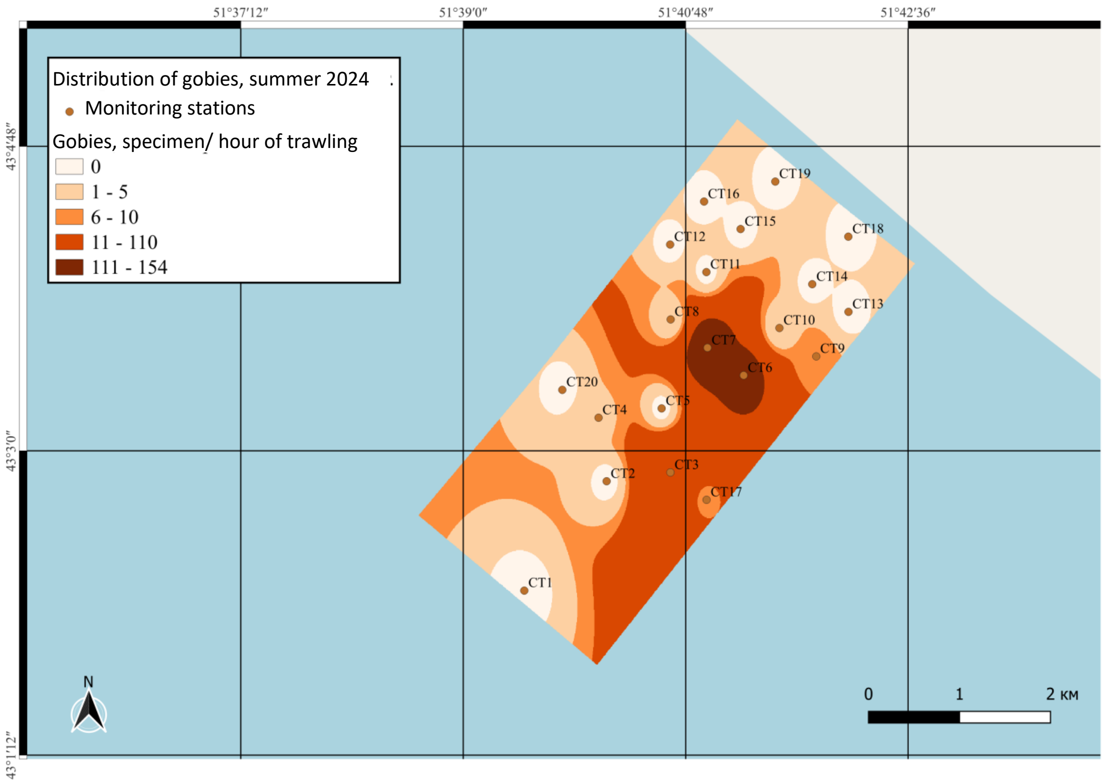

Figure 2.2.2.2.8 Distribution of gobies within the survey area in summer 2024, specimen/hour of trawling

Average length of caught individuals was 6.1 cm; weight was 2.8 g. Fulton's condition factor was 3.05. Fulton's condition factor was 0.94. Concentration of round gobies amounted to 56,770.9 specimen/km^2; biomass was 0.029 t/km^2.

Caspian sand gobies were caught at station 3 in the deep-water area. Their length in the catches varied from 4.5 to 4.8 cm (4.65 cm in average); weight was 1.0 g. Fulton's condition factor was 0.84. Concentration of Caspian sand gobies at the site amounted to 261.4 specimen/km^2; biomass was 0.0005 t/km^2.

Toad gobies were observed at stations 6 and 7. Average length of the caught individuals was 11.73 cm; their average weight was 17.0 g. Fulton's condition factor was 0.94. Concentration of toad gobies at the site amounted to 641.8 specimen/km^2; biomass was 0.00006 t/km^2.

Tubenose gobies were observed at stations 6, 7, 9 and 10. Their length was 6.0 cm; weight was 1.63 g. Fulton's condition factor was 0.72. Concentration of tubenose gobies at the site amounted to 2,438.6 specimen/km^2; biomass was 0.024 t/km^2.

Mullets

Singil (*Chelon auratus*) is a marine fish species from the mullet family and is commercially significant. Singil is a schooling, bottom-pelagic fish that is fast and timid. Juveniles and adults make seasonal migrations to coastal waters for feeding and reproduction during spring and summer. When water temperatures cool to 10 °C, it moves to deeper sea areas for wintering. During the feeding period, schools of singil, sometimes very numerous, migrate to shallow waters, bays, lagoons, saline and desalinated estuaries, coastal lakes, and occasionally river mouths, preferring areas with silted bottoms covered by vegetation. This species can withstand high fluctuations in water salinity, the presence of hydrogen sulfide, and high water temperatures (up to 29-31 °C, and even up to 35 °C).

Singil reaches puberty at 3-5 years of age, with males having a body length of 20-24 cm and females reaching 26-36 cm. Spawning occurs from the middle of August to October in the open sea, far from the coast. Adults primarily feed on microbenthos and detritus. In the 1930s, extensive efforts were made to introduce various hydrobionts into the Caspian Sea. These efforts included the importation of juveniles from three species of mullet – singil, leaping mullet, and striped mullet – from the Black Sea. Naturalization, or the formation of self-reproducing populations in the water bodies, was successfully achieved only for singil and leaping mullet, both of which are now commercially significant.

Mullets are characterized by high fecundity, which compensates for the large displacement at early stages of development common to pelagic fish eggs. The largest females, measuring 45-50 cm in length, can have up to 4 million oocytes in their ovaries. The feeding migration of singil to the northern part of the Caspian Sea begins in April, when the water column warms up to 14 °C on average. In May, as water temperature rises, aggregations of the species spread to the shallow area of the Northern Caspian Sea.

In summer, the area inhabited by singil expands in the northeastern direction.

In the surveyed area, single representative of the species was encountered in autumn (one specimen/net setting) (Figure 2.2.2.2.9).

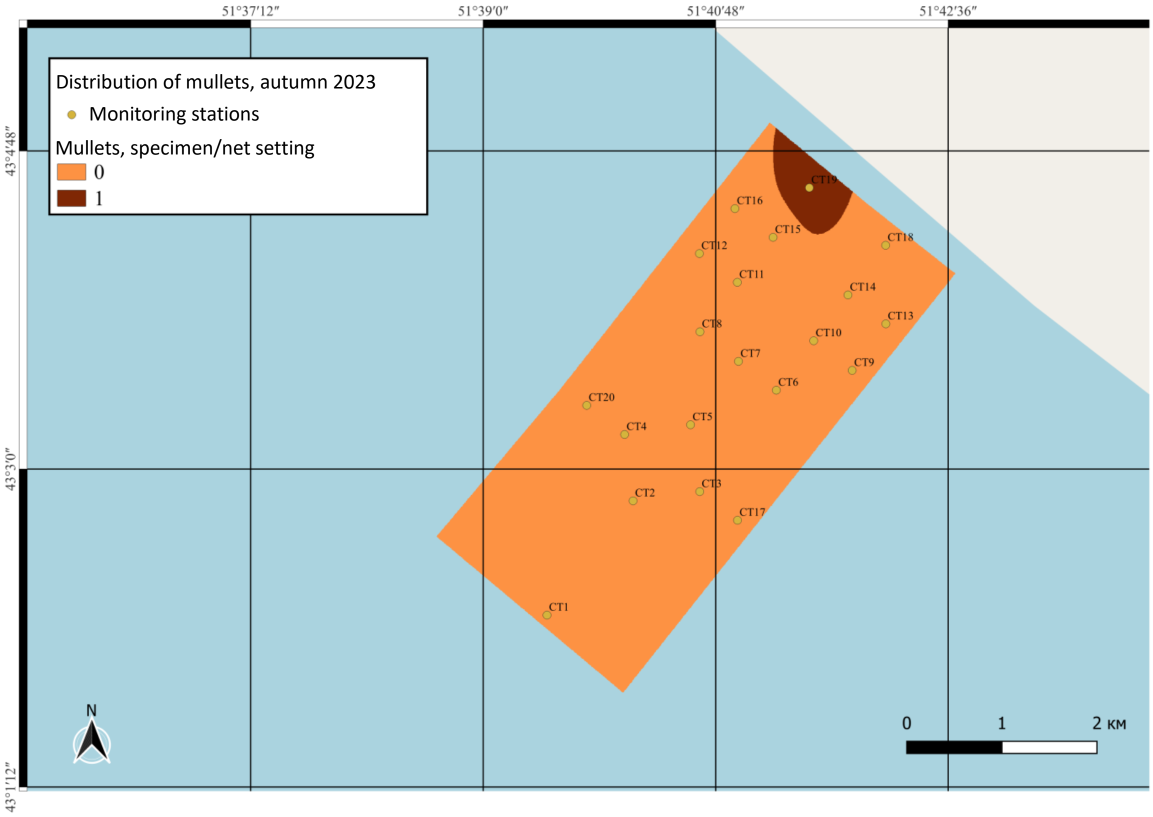

Figure 2.2.2.2.9 Distribution of mullet within the survey area in autumn 2023, specimen/net setting

The length of individual was 42 cm, its weight was 0.56 kg. It was over 2 years old. The mullet was caught at station 19 in the northeastern shallow area of the survey area.

In autumn 2023, population of mullets in the survey area amounted to 800 specimen/km^2, their biomass was 0.448 t/km^2.

In winter 2023, representatives of mullets were not recorded.

In spring 2024, mullets were observed in the northern and northeastern coastal areas of the survey area (stations 13 and 19) in the amount from three to seven specimen per net setting (Figure 2.2.2.2.10).

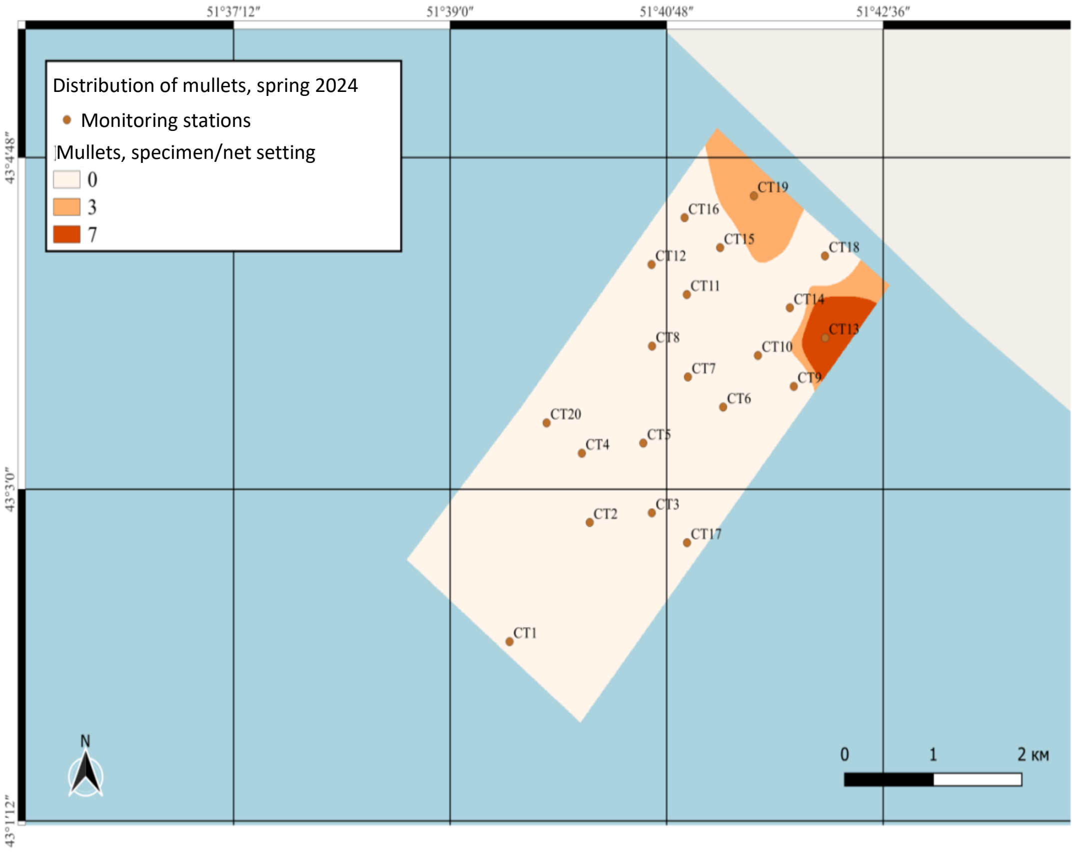

Figure 2.2.2.2.10 Distribution of mullet within the survey area in spring 2024, specimen/net setting

Caught individuals were at the age of more than 2 years. Their average length was 43.3 cm; average weight was 0.596 kg. Mullets were caught at stations 13 and 19 in the northern and northeastern shallow areas. Concentration of mullets at the site amounted to 8,000 specimen/km^2; biomass was 23.296 t/km^2.

In summer, mullets were observed at stations 13, 16 and 19 in the northern and northeastern parts of the survey area. Mullets were observed in amount from one to six specimen/net setting (Figure 2.2.2.2.11).

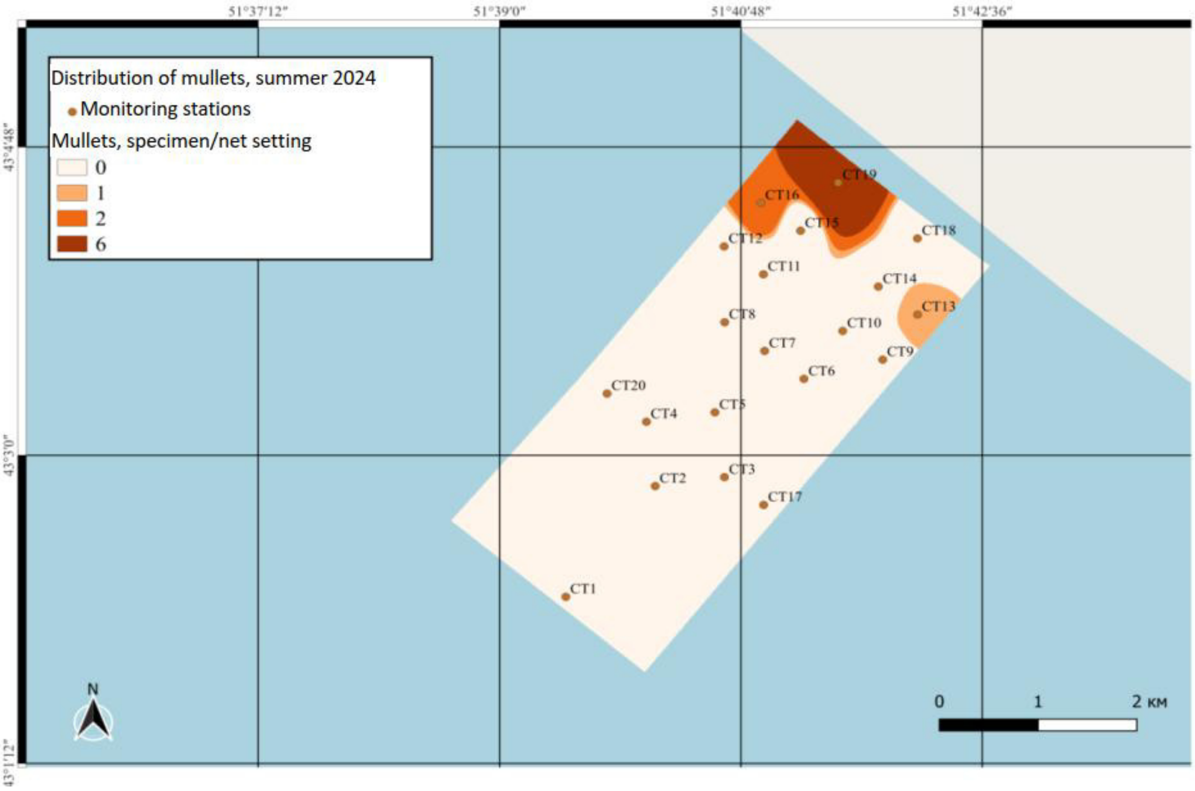

Figure 2.2.2.2.11 Distribution of mullet within the survey area in summer 2024, specimen/net setting

Average length of individuals caught was 44.2 cm; average weight was 0.522 kg. The age of mullets was more than 2 years. The largest catch was taken at station 19 and amounted to six specimen per net setting.

Concentration of mullets within the survey area amounted to 7,200 specimen/km^2; biomass was 17.9 t/km^2.

2.2.2.3 Semi-anadromous and river fish species

The species composition of the semi-anadromous fish was represented by Caspian vimba and estuarine perch. Juveniles were represented by the yearlings of estuarine perch, which were encountered mainly in the northern part of the survey area. Poor distribution of the semi-anadromous fish species at the site is explained by the peculiarities of their migratory behavior, namely, by the beginning of feeding migration. The surveyed area is a traditional feeding ground for estuarine perch and its yearlings. Distribution of juveniles of the other species of semi-anadromous and river fish in this area is limited due to the high salinity of the water. The number and biomass of adult fish were low. The absence of semi-anadromous fish at the survey in winter is explained by their pre-winter and winter migrations into the shallow water areas.

Caspian vimba

Caspian vimba is a semi-anadromous fish species. The largest populations of the species are found along the western and southern coasts of the Caspian Sea and in the rivers of this region. Fish spawning takes place in fresh water, where it migrates from the seawaters, in not-stagnant areas. Eggs are laid on vegetation and soil. After spawning, mature adults return to the sea for feeding. Caspian vimba is a valuable species, but its stocks are small, and its commercial value is very low.

In autumn, it was encountered in the surveyed area as a single specimen (1 specimen/net setting). Length of individual was 22.3 cm; its weight was 0.15 kg. It was over five years old. The Caspian vimba was caught at station 13 in the northeastern part of the survey area (Figure 2.2.2.3.1).

Figure 2.2.2.3.1 Distribution of Caspian vimba within the survey area in autumn 2023, specimen/net setting

In autumn 2023, the population of Caspian vimba in the survey area amounted to 800 specimen/km^2, its biomass was 0.056 t/km^2.

In winter 2023, as well as in spring and summer 2024, representatives of Caspian vimba were not recorded.

Estuarine perch

Estuarine perch is an actinopterygian fish belonging to the perch family (*Percidae*). Its body can reach lengths of up to 62 cm, though it is usually around 50 cm, and its body weight can be up to 2 kg. The body is elongated and somewhat compressed from the sides. The mouth is large, though smaller compared to that of a regular perch.

Estuarine perch is a marine fish that avoids desalinated areas and is a predator. Adults primarily feed on fish. They reach puberty at the age of 2-5 years and spawn in April-May. The fertility of estuarine perch ranges from 83-126 thousand eggs, which are spawned on rocky substrates. Males guard the eggs to protect them. Estuarine perch was encountered at station 13 in the northeastern part of the survey area, where overall catch amounted to one specimen/net setting. A single representative of perch was also recorded at station 5, in the central shallow area of the site, where overall catch amounted to one specimen/net setting (2.2.2.3.2).

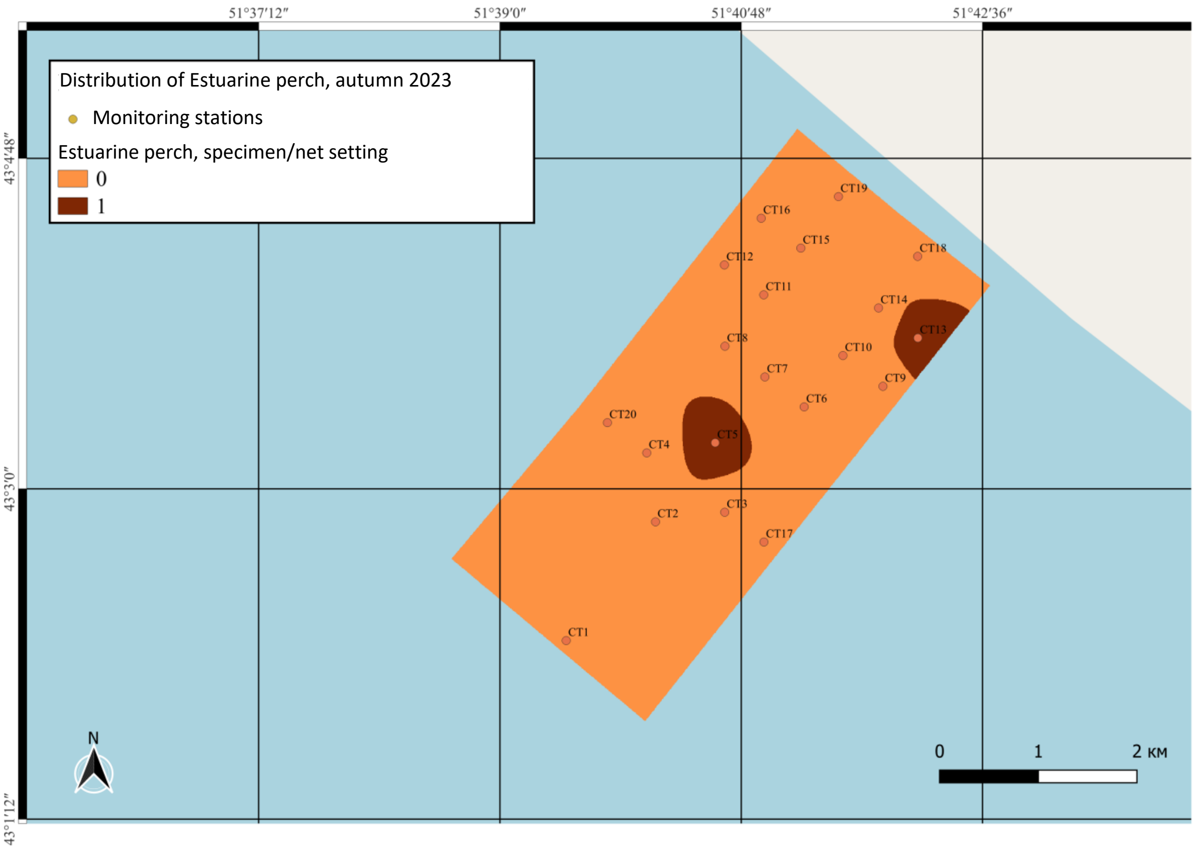

Figure 2.2.2.3.2 Distribution of Estuarine perch within the survey area autumn 2023, specimen/net setting

Average length of the individuals was 38.0 cm; their weight was 0.87 kg.

In autumn 2023, population of Estuarine perch in the survey area amounted to 1,600 specimen/km^2, its biomass was 1.392 t/km^2.

In winter 2023, representatives of Estuarine perch were not recorded..

In spring 2024, Estuarine perch was observed in the gill net catches at stations 13, 18 and 19 in the northern and northeastern part of the survey area. The number of individuals varied from two to five specimen per net setting. The largest catch was recorded at station 13 in the northeastern shallow water area. It included five specimen per net setting (Figure 2.2.2.3.3).

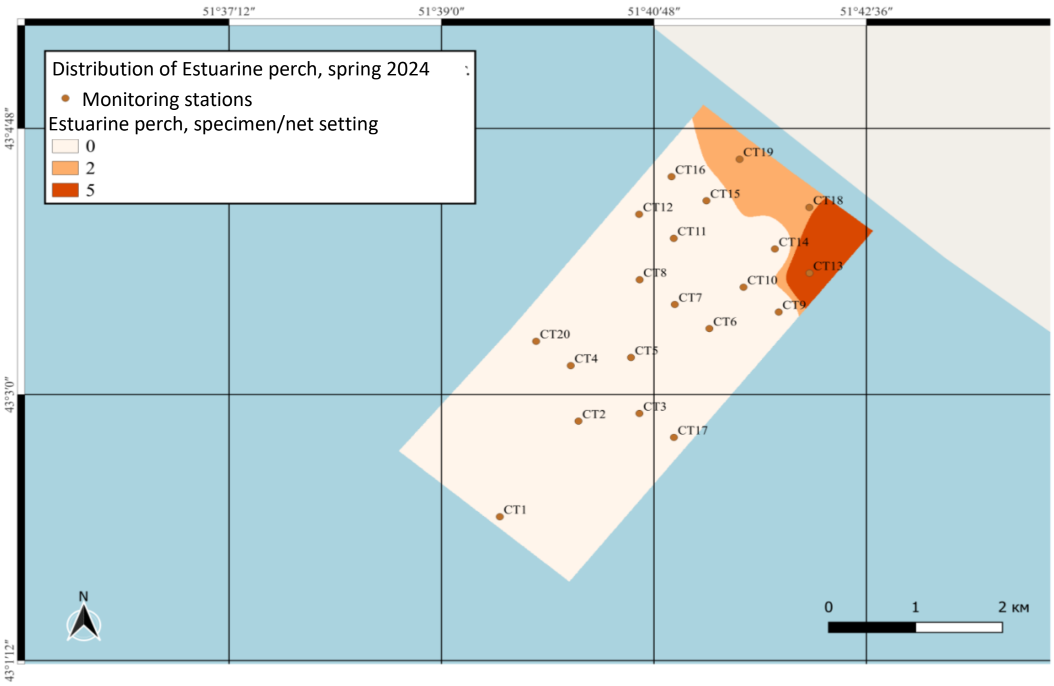

Figure 2.2.2.3.3 Distribution of Estuarine perch within the survey area in spring 2024, specimen/net setting

Average length of the caught individuals was 48.38 cm; weight was 1.422 kg. Concentration of Estuarine perch at the site was 7,200 specimen/km^2; biomass was 18.56 t/km^2.

During the summer period, Estuarine perch were observed in the gill net catches at stations 13, 18 and 19 in the northern and northeastern parts of the site. The number of individuals varied from two to five specimen per net setting. It should be noted that the stations, where large concentrations of Estuarine perch were observed in the catches in summer, coincided with those in the spring period. The largest catch was recorded at station 18 in the northeastern shallow area of the survey area. It included 13 specimen per net setting (Figure 2.2.2.3.4).

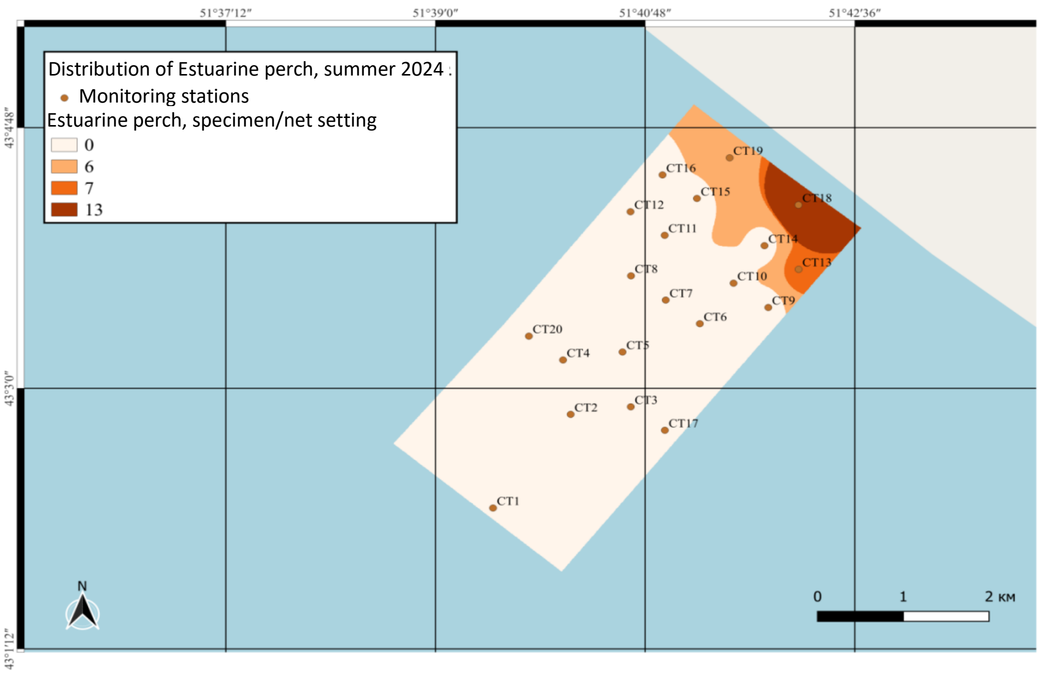

Figure 2.2.2.3.4 Distribution of Estuarine perch within the survey area in summer 2024, specimen/net setting

Average length of caught individuals amounted to 38.0 cm; their weight was 0.52 kg.

Concentration of Estuarine perch in the survey amounted to 20,800 specimen/km^2; its biomass was 30.6 t/km^2.

2.2.2.4 Marine crayfish

The eastern shelf of the Middle Caspian Sea, where the survey area is located, is inhabited by two species of crayfish: *Pontastacus eichwald Bott* (narrow-clawed crayfish) and *Caspiastacus pachypus Rathke* (thick-clawed crayfish). During the last sea level rise, which peaked in the mid-1990s, an increasing trend in the abundance of thick-clawed crayfish was observed on the eastern shelf. However, the Caspian Sea crayfish populations were not monitored for the following 20 years. Research on these populations was resumed only in the period from 2015 to 2019 by Russian scientists (Ushivtsev, 2021; Ushivtsev et al., 2020). A bottom trawl with a length of 4.5 m was used in the shallower waters of the survey area to determine population and distribution of Caspian crayfish. In total, 67 specimens of marine crayfish were caught by the trawl during the survey period. Crayfish were also caught by other fishing gear and were biologically analyzed to obtain size-weight and sex structure of the population.

The survey area is characterized by the presence of stone ridges, which serve as the hiding places for crayfish. Bottom sediments here have various mineralogical composition and consist of sand, broken shell and silt. The coastal zone of these sites is rich in benthic organisms that serve as food for crayfish, but plant food is limited to algae. Changes in the abundance of benthic organisms and algae greatly reduce the biological productivity of the area.

In autumn, the trawl catches showed accumulations of crayfish in the central (station 7) and northeastern (stations 11, 15) parts of the area at depths from 16.0 to 18.3 m (Figure 2.2.2.4.1).

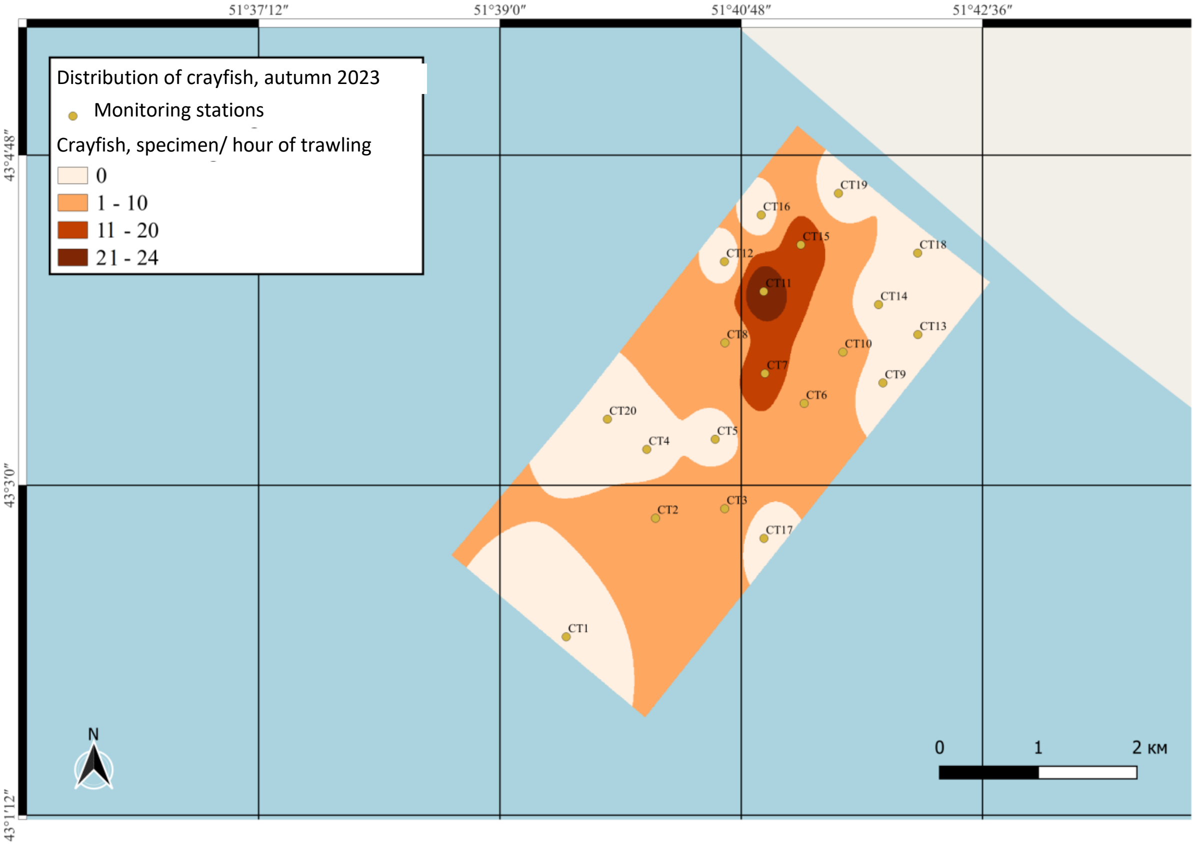

Figure 2.2.2.4.1 Distribution of marine crayfish within the survey area in autumn 2023, specimen/trawling

Length of marine crayfish varied from 5.6 to 12.3 cm; their weight varied from 3 to 57 g. Males prevailed in sex ratio (69.5 %). Average length of crayfish was 8.5 cm; average weight was 15.4 g (Table 2.2.2.4-1).

Table 2.2.2.4-1 Size and weight parameters of crayfish within the survey area, autumn 2023

Parameter	Size				Average
Length, cm	5-8	9	10	11	8.5
Weight, g	13.8	24.7	33.7	37.8	15.4
Number, specimen	25	20	15	7	67
Number, %	37.3	29.85	22.38	10.45	100

Population of crayfish in the survey area of the site amounted to 52,000 specimen/km^2, their biomass was 0.801 t/km^2.

A single representative of thick-clawed crayfish (*Pontastacus eichwald Bott*) was recorded in the research catches in winter 2023.It was caught by a 4.5-meter trawl at station 11 in the northern part of the survey area at a depth of 18.6 m (Figure 2.2.2.4.2).

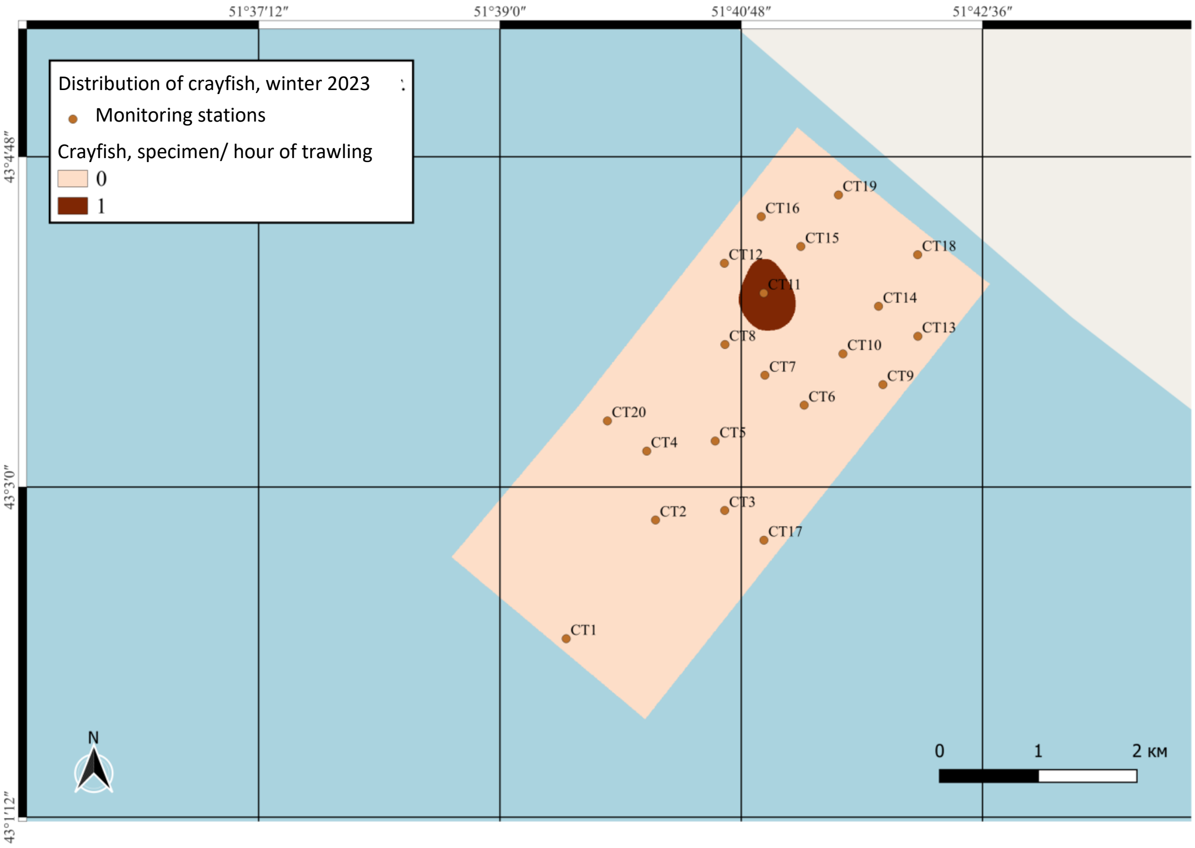

Figure 2.2.2.4.2 Distribution of marine crayfish within the survey area in winter 2023, specimen/trawling

The length of individual was 9.3 cm; its weight was 28 g. It was male.

In winter 2023, population of crayfish in the survey area amounted to 156.5 specimen/km^2, their biomass was 0.004 t/km^2.

In spring, aggregations of crayfish were observed in the trawl catches at stations 1, 2, 7, 9, 17 and 20 (Figure 2.2.2.4.3).

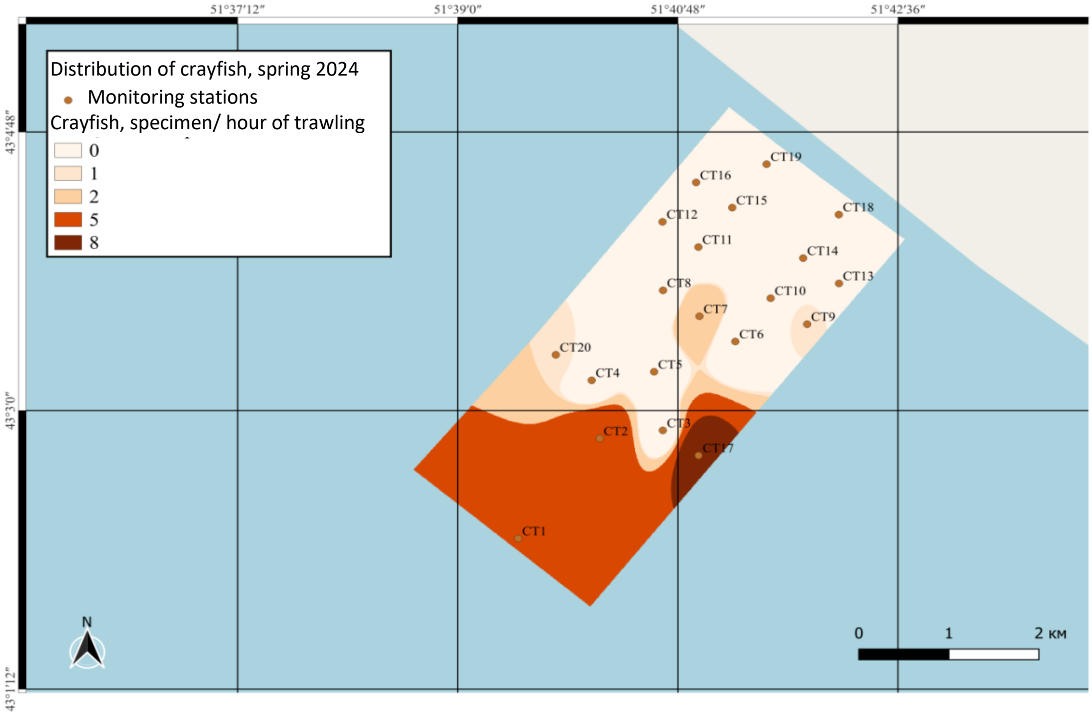

Figure 2.2.2.4.3 Distribution of marine crayfish within the survey area in spring 2024, specimen/trawling

Length of marine crayfish varied from 2.6 to 14.5 cm; their weight varied from 1 to 60 g. Males prevailed in sex ratio (66.7 %). Average length of crayfish was 7.0 cm; average weight was 14.9 g (Table 2.2.2.4-2).

Table 2.2.2.4-2 Size and weight parameters of crayfish within the survey area, spring 2024

Parameter	Size				Average
Length, cm	2-5	5-8	9	10-15	7.0
Weight, g	2.0	10.1	23.7	51	14.9
Number, specimen	4	15	6	2	
Number, %	14.8	55.6	22.2	7.4	

Concentration of crayfish in the survey area amounted to 5,700 specimen/km^2, their biomass was 0.679 t/km^2.

In summer, aggregations of crayfish were observed throughout the whole surveyed area. Maximum concentrations were recorded at stations 1, 3, and 6 (Figure 2.2.2.4.4).

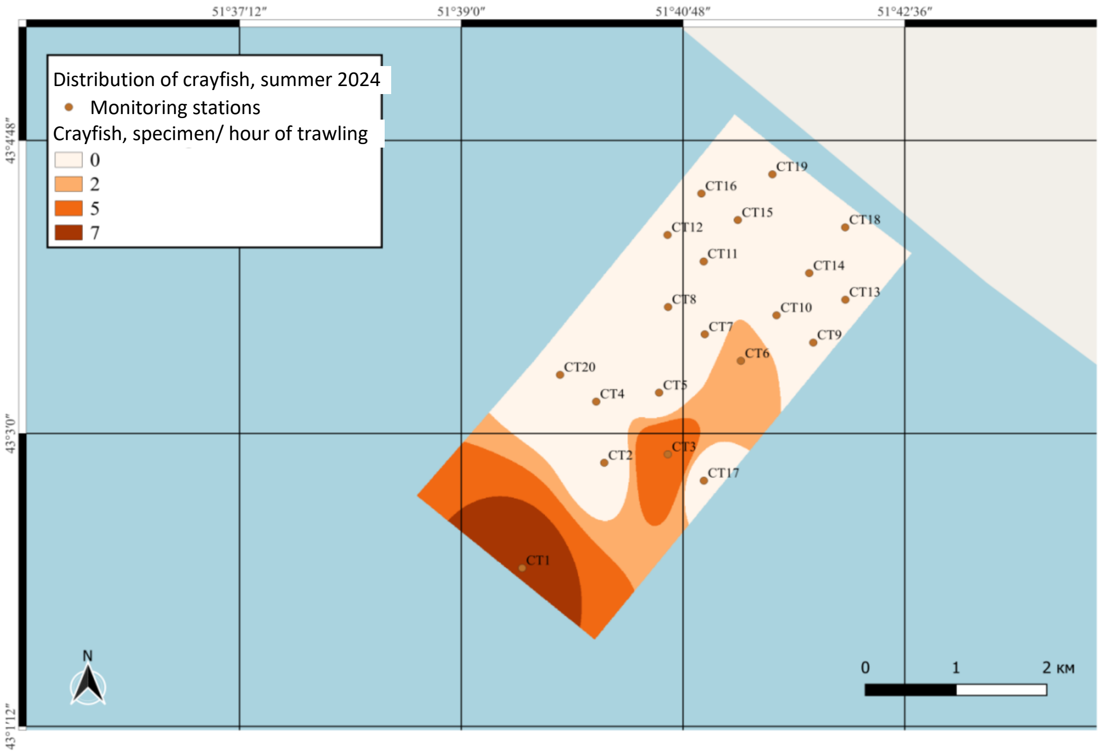

Figure 2.2.2.4.4 Distribution of marine crayfish within the survey area in summer 2024, specimen/trawling

Length of marine crayfish varied from 3.1 to 13.8 cm; their weight varied from 1 to 72 g. Males prevailed in sex ratio (100 %). Average length of crayfish was 8.9 cm; average weight was 27.5 g (Table 2.2.2.4-3).

Table 2.2.2.4-3 Size and weight parameters of crayfish within the survey area, summer 2024

Parameter	Size				Average
Length, cm	3-5	5-8	8-9	9-15	8.9
Weight, g	1.5	16.6	23.6	34.3	27.5
Number, specimen	4	7	28	41	
Number, %	5	8.7	35	51.3	

Concentration of crayfish in the survey amounted to 53,600 specimen/km^2, their biomass was 2.521 t/km^2.

2.2.3 Caspian seal

The Caspian seal, *Pusa caspica* (Gmelin, 1788), is the only mammal species found in the fauna of the Caspian Sea. The population of the Caspian seal is in a depressed state and has been declining in number over the past decade. This situation necessitates constant, all-season monitoring of the Caspian seal population across all parts of the Caspian Sea. A route survey was conducted in autumn, covering a distance of 26.6 km. In total, 13.3 km² was surveyed, with an average survey route width of 500 meters. During this survey, only one representative of the Caspian seal was recorded, with no dead animals observed. The seal was encountered at station 1 (Figure 2.2.3.1).

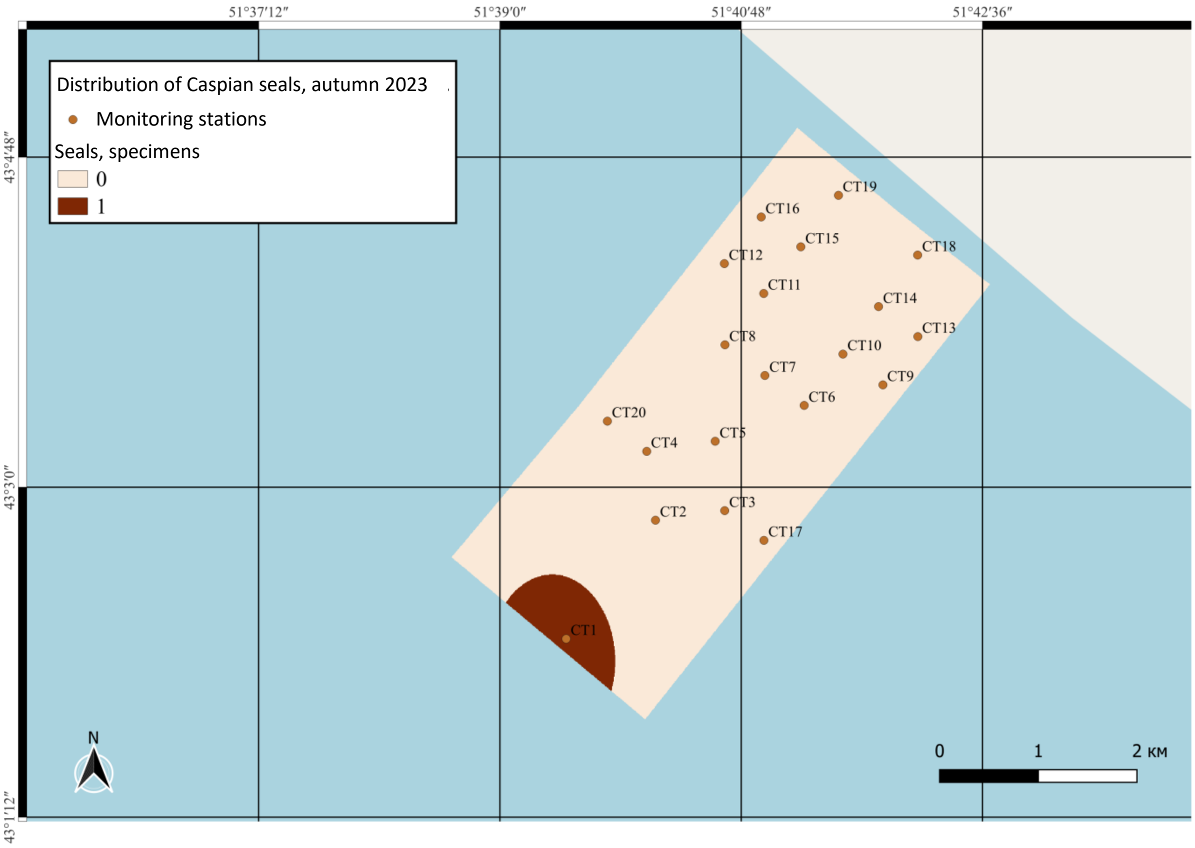

Figure 2.2.3.1 Distribution of the Caspian seal within the survey area in autumn 2023, specimen

Occurrence rate was 3.76 animals per 100 km of route. Average distribution density was at a level of one specimen/km^2 (Table 2.2.3-1).

Table 2.2.3-1 Results of the count of live Caspian seal individuals, autumn 2023

Length of route, km	Width of route, km	Counting area, km^2	Quantity, specimen	Population, specimen/km^2	Occurrence rate, specimen/100 km
26.6	0.5	13.3	2	0.1	3.76

Caspian seal was recorded at station 1 in the southwestern part of the site. The approximate estimate of the number of live Caspian seal individuals within the area was one individual.

In winter 2023, as well as in spring and summer 2024, representatives of the Caspian seal were not encountered.

3. Conclusion based on the results of the marine flora and fauna survey

With regards to the hydrobiology of the surveyed area, in autumn, the qualitative composition of phytoplankton was represented by four divisions: *Cyanophyta*, *Bacillariophyta*, *Dinophyta*, *Euglenophyta*. In winter period, it was represented by three divisions: *Bacillariophyta*, *Dinophyta*, *Chlorophyta*. In spring and summer periods, there were five divisions: *Cyanophyta, Bacillariophyta, Dinophyta, Euglenophyta* and *Chlorophyta*.

The taxonomic structure of phytoplankton in both the surface and bottom horizons was dominated by diatoms, which formed the basis of quantitative indicators. This is typical for the algocenosis of the survey area. The maximum values of phytoplankton biomass were recorded in the summer, attributable to the full vegetation of diatoms, dinophytes, green algae, and blue-green algae.

The species diversity of phytoplankton increased to 51 species, influenced by the prevailing abiotic conditions, particularly the temperature regime. Small-celled blue-green algae, diatoms, and partly dinophytic forms of algae developed quite intensively, which positively affected the formation of the fodder base in this part of the sea. The phytoplankton community in all seasons was represented by all ecological groups common for the Caspian Sea.

Distribution of the biomass of algal flora was uneven in the surface and bottom horizons of the site.

According to the survey results, zooplankton in the survey area was characterized by low diversity in all periods. *Acartia tonsa* dominated in the zooplankton zoocenosis across the survey area. The role of the other groups of zooplankton was insignificant. Abundance and biomass of zooplankton community depended mainly on the development of *Acartia tonsa*. The temperature drops in winter have affected the quantitative indicators of zooplankton (the lowest values).

Distribution of quantitative indicators of planktonic invertebrates in the survey area was uneven.

During all survey sessions, the minimum concentrations of phytoplankton in the surface and bottom horizons and the maximum concentrations of zooplankton at the same stations were caused by a trophic pressure produced by plankters on the plant cells.

In all seasons of the survey, the abundance of benthic fauna was formed mainly by "soft" benthos, namely by crustaceans, which is common for the soils in the surveyed area (sandy soils with broken shells). The biomass values were composed of the representatives of "hard" benthos - bivalves.

The abundance of zoobenthos in both periods have varied depending on the development of crustaceans.

Distribution of the biomass of zoobenthos at the surveyed site was of local character in all survey periods.

The survey of aquatic vegetation in autumn and winter periods has revealed the presence of two species of algae: *Laurencia caspica* and *Polysiphona caspica*. Rocky ridges inhabited by macrophytes appear as separate inclusions on a surface of sandy-shell soils. Biomass of aquatic vegetation was low due to the low temperatures and wave activity. It is known that the optimal development of macrophytes requires a salinity of 8-10 ‰ and depth (well-warmed shallow water with a depth from 0.5 to 4.0 m).

The concentrations of phytoplankton, zooplankton, zoobenthos and aquatic vegetation decreased from autumn to winter and then increased in spring and summer, which corresponds to the natural cycle of development of these organisms.

With regards to the fishery conditions in the surveyed area, the catches of sturgeons depend on the migration processes that affect the number of fish and thereby predetermine the possible catch. Only young sturgeons were found in the trawl and gill net catches. The main biological parameters of the sturgeon fish were at the level of long-term dynamics and corresponded to these age groups. The absence of starry sturgeon and beluga in the catches indicates small populations of these species. At present time, sturgeon fish species belong to the prohibited types of aquatic biological resources for commercial and recreational fishing in the Republic of the Kazakhstan in compliance with the fishery regulations.

Marine ichthyofauna at the site was distinguished by the species diversity in all seasons. The catches included Caspian tulka, marine migratory herrings, gobies and mullets. By the end of the growing season, the number of goby species was significant. From autumn to winter, the migration processes were observed at the site, which were expressed in a multiple decline in the number of marine fish, as well as in the redistribution of their concentrations in the survey area. At the same time, favorable feeding conditions were observed at the site during nursery period (spring, summer, autumn), which was confirmed by the high linear weight of fish, stability of the age and sex structure of the species populations.

Semi-anadromous fish in the survey area were represented by Caspian vimba and estuarine perch, whose populations were insignificant due to the small populations of these fish species.

Marine crayfish were actively feeding on almost the entire survey area in all seasons.

The only individual of the Caspian seal was encountered in the survey area in autumn.

The survey results showed a decrease in the abundance and biomass of hydrobionts inhabiting the survey area during the transition from autumn to winter season. The largest concentrations of aquatic biological resources at the site were recorded in the summer, which is explained by the maximum development of water areas used for feeding.

At the same time, low concentrations of hydrobionts and absence of the most species of ichthyofauna at the site in winter are the result of winter migration. The absence of ichthyofauna in the research catches is also explained by the reduced level of fish activity in the winter period.

Thus, the survey area is used by aquatic biological resources for feeding, spawning, wintering and pre-winter migrations throughout the whole year.

4. Recommendations for prevention and mitigation of adverse effects, restoration and improvement of natural environment

4.1. National and International Legal Framework

Water quality standards, pollution prevention measures, and national strategies for the protection of water resources and bodies in Kazakhstan are based on the following national and international legal acts, where survey, monitoring (baseline and regular monitoring surveys to measure pollutants, including physical, chemical, and biological factors, and compliance with water quality standards), studies (baseline and regular studies to assess the quality of water bodies and identify pollution sources, including through the Environmental Impact Assessment (EIA/ESIA) process) and modelling (use of water quality models to predict the effects of pollution on aquatic ecosystems and human health) requirements as well as key provisions related to water resources and bodies are defined:

a. **The Water Code of the Republic of Kazakhstan** (2003, amended in 2021)
   - **Monitoring and Surveys:** The Water Code mandates the creation of a water monitoring system to track the quality of surface and groundwater. This includes regular surveys and analysis of water quality in various water bodies, such as rivers, lakes, reservoirs, and the Caspian Sea.
   - **Pollution Prevention:** The Code provides for the development of strategies to control and reduce pollution in water bodies. It requires pollution studies, including environmental impact assessments (EIAs) for projects that may affect water quality.
   - **Water Quality Standards:** It sets standards for water quality that must be adhered to by industries and other stakeholders. The Water Code also mandates the development of modelling systems for predicting the impact of pollution on water bodies.
   - **Pollution Fees:** The Code outlines a system for levying fees and penalties for the discharge of pollutants into water bodies, thereby creating incentives for pollution prevention.

b. **Environmental Code of the Republic of Kazakhstan** (2021)
   - **Environmental Impact Assessment (EIA):** The Environmental Code requires that major projects potentially affecting water bodies undergo an EIA. This assessment must include studies on water pollution risks and modelling to predict long-term environmental impacts.
   - **Monitoring and Reporting:** The Code mandates regular environmental monitoring and reporting for water bodies, especially in relation to pollution. This includes studies on pollutants' sources, concentrations, and the ecological health of water bodies.
   - **Pollution Limitation:** The Environmental Code provides the legal basis for limiting emissions and effluents that pollute water bodies. It outlines requirements for the installation of monitoring systems to assess the levels of contaminants in water bodies.
   - **Water Pollution Monitoring:** The law calls for the monitoring of water bodies to detect pollution levels. It also emphasizes the importance of preventive measures to reduce contamination.
   - **Regulations on Waste Disposal:** It includes provisions for managing the disposal of industrial and municipal waste, which may affect water quality. Pollution modeling techniques must be applied to assess the impact of such waste on water bodies.
   - **Surveys and Reporting:** The law requires regular surveys of water bodies to detect pollution and to provide detailed reports on the environmental quality of water.

c. **Code of the Republic of Kazakhstan from 7 July 2020 № 360-VI "On the health of the people and the health care system"** (with amendments and additions as of 16.03.2025) **and Law of the Republic of Kazakhstan dated 21 May 2022 № 122-VII "On Biological Security of the Republic of Kazakhstan"** (with amendments and additions as of 08.06.2024)
   - **Water Quality Surveys:** The law requires surveys of water bodies to assess the safety and quality of water supplies and discharge.
   - **Pollution Control Measures:** It establishes guidelines for controlling the pollution of water sources and mandates regular water quality testing and reporting.

d. **Government Decrees and Orders (Various)**
These decrees and orders provide specific technical regulations and methodologies for the monitoring, study, and modelling of water pollution in Kazakhstan, for example:
- **The Order № 250 on "State Monitoring of the Environment"** (2021) outlines specific requirements for the collection, analysis, and reporting of water quality data, including for pollutants like heavy metals, nitrates, and pesticides.
- **The Order on Water Protection Zones No 19-1/446** (2015) specifies buffer zones around water bodies where pollution control measures must be enforced.
- **The Order on approval of requirements for fish protection devices of water intake and discharge structures No. 221** (2019) defines requirements for fish protection devices of water intake and discharge structures.
- **The Order on approval of the Sanitary and epidemiologic requirements to water sources, places of water intake for the economic and drinking purposes, economic drinking to water supply and places of cultural and community water use and safety of water objects, No. 26** (2023), including, Sanitary and Epidemiological Requirements for Water Bodies (para. 4), Sanitary and Epidemiological Requirements for the Protection of Coastal Waters of Reservoirs from Pollution in Places of Water Use by the Population (para. 5), Sanitary and Epidemiological Requirements for the Sanitary Protection Zone and Sanitary Protection Strip (para. 6) of Chapter 2.

e. **Regulations on Water Quality Standards and Pollution Control**
- **Water Quality Standards (various sanitary and hygienic Standards):** These standards, outlined by the Kazakhstan Ministry of Health and Social Development, establish maximum permissible concentrations (MPC) of pollutants in water bodies. They serve as a reference for pollution studies and modeling efforts.
- **Pollution Load Calculations:** Regulations also require modeling of the "pollution load" in water bodies, which helps predict how pollutants affect the water quality over time and under different conditions.

f. **Strategic Environmental Assessment (SEA) Regulations**
- SEA studies include comprehensive water quality modelling, risk assessments, and surveys to predict the potential impacts of development projects on water bodies.
- They require the assessment of cumulative impacts from multiple sources of pollution (e.g., industrial, agricultural, and municipal).

g. **Caspian Sea Environmental Management and Pollution Control (Regional Agreements)**
- **Tehran Convention (Caspian Sea):** Kazakhstan, as a Caspian Sea littoral state, is required to conduct pollution studies and modeling under the **Tehran Convention** and its protocols ((i) Protocol Concerning Regional Preparedness, Response and Co-operation in Combating Oil Pollution Incidents ("Aktau Protocol"); (ii) Protocol on the Protection of the Caspian Sea against Pollution from Land based Sources and Activities ("Moscow Protocol"), (iii) Protocol for the Conservation of Biological Diversity ("Ashgabat Protocol"), (iv) Protocol on Environment Impact Assessment in a Transboundary Context). This includes research on pollution sources, the distribution of contaminants in the Caspian Sea, and the development of action plans to reduce pollution levels.

h. **International Cooperation and Reporting Obligations**
Kazakhstan is a signatory to several international environmental agreements that provide guidelines for water pollution monitoring and modelling, such as:
- **Convention on Biological Diversity (CBD).** This Convention mandates the sustainable use of marine and freshwater resources.
- **The Ramsar Convention on Wetlands.** While the Ramsar Convention primarily deals with wetlands, it has relevance for fish protection in the context of aquatic habitats.
- **United Nations Convention on the Law of the Sea (UNCLOS).** UNCLOS obligates states to protect and preserve the marine environment.
- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).** CITES may indirectly influence water intake infrastructure by regulating activities that could harm endangered marine species.

- **International Convention for the Prevention of Pollution from Ships (MARPOL).** While MARPOL is primarily focused on pollution prevention from ships, it sets standards that might affect water intake structures in terms of waste discharge.
- **Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).** Any intake/outlet structure could be subject to scrutiny if it results in the release of pollutants or disrupts marine habitats.
- The **Global Environment Facility (GEF)** and other international bodies also influence national regulations for water quality monitoring and pollution studies and reporting.

4.2. Recommendations based on legal requirements

Based on the national and international regulatory framework (see Chapter 4.1.), literature review and the results of this survey, the following recommendations and suggestions with their implementation timeframe are established.

The discharge of treated industrial wastewater into the marine environment must be thoroughly assessed during the FEED/Design and Pre-Construction Phases/ESIA phases to understand its impact on water quality, bottom sediments and marine hydrobiology baseline identified during this survey. This includes **conducting sedimentation and multiparameter modeling** to evaluate the potential effects of treated wastewater discharge on water quality (hydrochemical, hydrophysical parameters of marine water), on bottom sediments and respectively on marine hydrobiology.

Special attention should be given to water intake facilities, where fish protection devices must be designed and implemented in compliance with national and international legal standards[2]. When designing the fish protection devices, it is necessary to develop a "**fish-breeding and biological substantiation for water intake facilities**"[3], which justifies the chosen type of fish protection devices, their location depending on the main migration routes of fish, operating mode of the devices, and other. The “substantiation” should be prepared at the stage of selecting fish protection devices and then submitted separately for review and approval to the Committee of Fisheries of the Republic of Kazakhstan. The “substantiation” shall be done based on literature desk review, this baseline surveys results and based on modeling to be done as described above. The operational phase will require a monitoring of the effectiveness of the fish protection devices and a review of mitigation measures (if required). It should be noted that within the baseline marine life survey study area (the likely Project Impact Area with 20 sampling points, see Figure 2) fish main migratory routes have not been identified.

According to this baseline survey’s results, the bottom of the sea at the site is mostly rocky, which can cause certain difficulties at the stage of construction of the water intake and outlet facilities. It should be taken into account that construction, dredging and blasting operations are prohibited in the Caspian Sea water protection zones, and a **special authorization shall be obtained from responsible authorities[4] prior to the start of any dredging or blasting works**. Relevant mitigation measures need to be implemented (to be defined and provided within the permit by authorities) during the construction works.

2 (i) Order of the Minister of Agriculture of the Republic of Kazakhstan dated May 31, 2019 No. 221 „on approval of requirements for fish protection devices of water intake and discharge structures, (ii) Environmental Code of the Republic of Kazakhstan, Article 273 (to be applied as best practice) and (iii) international conventions requirements (see chapter 4.1. above)
3 Construction Regulations SP 3.04-110-2014 "Retaining walls, shipping locks, fish ladders (passing) and fish protection facilities"
4 article 223, clause 1, subclause 3 of Environmental Code of the Republic of Kazakhstan

According to the Environmental Code of Kazakhstan (Article 186, and Article 280 as best practice), companies operating in Kazakhstan and particularly in the Caspian Sea shall monitor the impact of emissions and the state of the marine environment and biological resources at the construction and operational phases of the facilities.

At the operational phase continuous monitoring (at least one year) of environmental parameters is mandatory. Within operational monitoring, it is recommended to also assess the impact imposed[5] by the discharge of treated industrial wastewater on phytoplankton, zooplankton and fish species in order to better determine the threshold (i.e., lethal concentration) for damage caused to fish resources. It should be noted that damage calculation is done mainly for valuable commercial, recreational, endangered and Red Book fish species. However, since no Red Book and endangered fish species have been identified at the surveyed area, the initial damage calculation at the ESIA/EIA phase[6] will be done mainly for commercial fish species.

The further occurrence and necessity of environmental monitoring at the operational phase can be defined only after the analysis and evaluation of at least one year of monitoring results and shall be based on national and international requirements (see chapter 4.1. above).

The summary table of recommended actions to be undertaken and their respective implementation phases are provided in the table 4.2.1 below. This table provides a clear outline of actions to be taken at each Project phase to ensure compliance with legal requirements and minimize the environmental impact due to treated wastewater discharge.

Table.4.2.1 Summary table of recommended actions to be undertaken

Implementation Phase	Actions/Recommendations
Pre-Construction	**Model sedimentation** of treated industrial wastewater (TIWW) discharge to assess its impact on bottom sediments and marine hydrobiology, using TIWW hydrochemical and hydrophysical parameters and baseline data acquired during this survey.
Pre-Construction	To assess the likely impacts of treated industrial wastewater discharge on baseline hydrophysical, hydrochemical, and hydrobiological parameters, conduct **multiparameter modeling** of water temperature, turbidity, transparency dynamics, salinity, and chemical dispersion. Use TIWW hydrochemical and hydrophysical parameters along with baseline data acquired during the survey to evaluate the effects on water quality, phytoplankton, zooplankton, and fish species.
Pre-Construction	Design **fish protection devices for water intake facilities** in accordance with national and international legal requirements and

5 impact assessment and damage evaluation, to sub-item 1, item 4 of Article 72 of the Environmental Code of Kazakhstan. The necessity to assess the damage to fish resources is also regulated by Article 17 of the Law of the Republic of Kazakhstan for Protection, Reproduction and Use of Wildlife as of July 09, 2004 under № 593-II..

6 initial damage calculation shall be done at ESIA/EIA level according to the Order on “approval of the Methodology for calculating the amount of compensation for damage caused to fish resources and other aquatic animals, including unavoidable, as a result of economic activity” August 21, 2017 No. 341."

Implementation Phase	Actions/Recommendations
	prepare a "fish-breeding and biological substantiation for water intake facilities".
Pre-construction	**Assess environmental impact** of treated industrial wastewater discharge on water quality, phytoplankton, zooplankton, and fish species. **Provide mitigation measures** to avoid or minimize impacts during the construction and operation phases.
Pre-Construction	Obtain **special authorization** from relevant authorities **prior to the start of any dredging and/or blasting works** in in the Caspian Sea water protection zones.
Construction	**Conduct continuous monitoring** of hydrophysical, hydrochemical and hydrobiological parameters. Ensure that any construction activities, including dredging or blasting, comply with restrictions (to be provided within the Authorization/Permit) in water protection zones[7].
Operation	Conduct continuous **monitoring of the effectiveness of fish protection devices** and **reassess damage to fish resources**, recalculating compensation if required.
Operation	Perform **continuous environmental monitoring** to assess the state of marine biological resources and environmental impact, adjusting frequency after analyzing initial monitoring results.

[7] It is stated in the Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 250 dated July 14, 2021 “On approval of the Rules of development of the program of industrial environmental control for the facilities of I and II of categories, conducting internal accounting, forming and provision of periodic reports on the results of production environmental control” (as amended on March 25, 2025). Reports are to be submitted on a quarterly basis.

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Appendix 1

Permission for using the wildlife resources (commercial fishing, recreational fishing, scientific and research fishing, reclamation fishing, reproductive fishing)

Қазақстан Республикасы Экология және табиғи ресурстар министрлігі

"Қазақстан Республикасы Экология және табиғи ресурстар министрлігінің Балық шаруашылығы комитеті" республикалық мемлекеттік мекемесі

Астана қ., Мәңгілік Ел Даңғылы, № 8 үй

Министерство экологии и природных ресурсов Республики Казахстан

Республиканское государственное учреждение "Комитет рыбного хозяйства Министерства экологии и природных ресурсов Республики Казахстан"

г.Астана, Проспект Мангилик Ел, дом № 8

Номер: KZ24VEP00163146

Дата выдачи: 16.10.2023 г.

РАЗРЕШЕНИЕ
на пользование животным миром
(промысловый лов, любительский (спортивный) лов, научно-исследовательский лов, мелиоративный лов, лов в воспроизводственных целях)

Выдано: Товарищество с ограниченной ответственностью "Казэкопроект"

Вид пользования: научно-исследовательский лов

Цель изъятия: проведение научных исследований по оценке состояния животного мира

Наименование водоема и (или) участка Каспийское море, Мангистауская область, участок "Курык"

Способы изъятия: Отлов

Ответственные лица за использование разрешения:

1. КАЛДЫБАЕВ САЛАУАТ КУАТОВИЧ
2. АЛТУРЕЕВ БАХЫТ БИСЕНБАЕВИЧ

Количество объектов, планируемых для изъятия из среды обитания:

№ п/п	Наименование объектов	Количество (килограмм, тонн, особей)
1	Вобла	100
2	Лещ	100
3	Судак	40
4	Кутум	40
5	сельди (пузанок, бражниковская, черноспинка)	60
6	Килька	20
7	Кефаль	30

Сроки изъятия с 20.10.2023 г. по 30.06.2024 г.

Район (территория) и границы участка предполагаемого изъятия: Мангистауская область

Орудия изъятия:

Наименование орудия изъятия	Количество штук
Объячеивающие орудия лова: сети ставные и плавные	24
Тралящие орудия лова: тралы и волокуши	4

Плавательные средства:

Название судна	Количество штук
Научно-исследовательское судно "Зайсан"	1
Научно-исследовательское судно "Акку"	1

Плавательные средства:

Название судна	Количество штук

Уполномоченное лицо: Бахиянов Аян Кайратович

Заместитель председателя

Appendix 2

Method of calculation of fish population using mullets as an example

Relative indicator of the average concentration of a species per one catch per unit of time (specimen per hour of trawling) is used as value characterizing population of juveniles and adult fish in the sea. Modern methods of calculation of fish stock require knowledge of their absolute population size. Calculation of the absolute population size of fish at the feeding grounds is based on the method of direct counting (Mesyatsev et al., 1935; Aksyutina, 1968; Russ, 1938; Stroganov, 1979; Belogolova, 2008).

Thus, absolute population size of fish in the sea (*N*) is assessed by the swept area method taking into account the average catch per hour of trawling (n_i), fish distribution area (S_i), swept area (*s*) and trawl catchability coefficient (*K*) (Aksyutina, 1968; Kushnarenko, 2003):

$$N = \sum n_i S_i / sK.$$

Total biomass is assessed by formula:

$$\mathbf{B = N\hat{w},}$$

where: N – estimated population size, mln.specimen;
ŵ – average weight of individuals, g.

Calculation of the population and biomass of the marine fish species (Caspian tulka, marine herrings, sand smelt) is performed using the similar formulas with the catchability coefficients for pelagic species (Caspian tulka, marine herrings, sand smelt) (*Stock assessment methods...* edited by Sudakova, 2011) and gobies (Stepanova, 1998).

Population of the sturgeon fish species in the sea is calculated according to the results of marine seasonal gill net and trawl surveys. Quantitative assessment of fish population is performed by formula:

$$\mathbf{N = Sx/Kg,}$$

where: N – Quantitative assessment of population, mln.specimen;
S – area of distribution, m^2;
g – area of one catch, m^2;
К – catchability coefficient of fishing gear;
x – average catch per one trawling/gill net setting, specimen.

Biomass of the sturgeon fish species in the Caspian Sea is calculated as the product of the estimated population and average mass of individuals (*Stock assessment methods...* edited by Sudakova, 2011):

$$\mathbf{B = N\hat{w},}$$

where: N – estimated population size, mln.specimen;
ŵ – average weight of individuals, kg.

Thus, for mullets:

Catch – 1 specimen
Swept area – 8.15 km^2
Catchability coefficient – 0.25
Number of gill net settings – 5
Individual weight of mullets – 560 g.

Relative population will be the following:

$N_{relative}$ = (8.15*(1/5))/0.25*1000 = 6,520 specimen.

Relative population will be the following:

$N_{absolute.} = 6{,}520/8.15 = 800$ specimen/km^2

Biomass will be the following:

B = 800 specimen/km^2 * 0.00056 t = 0.448 t/km^2

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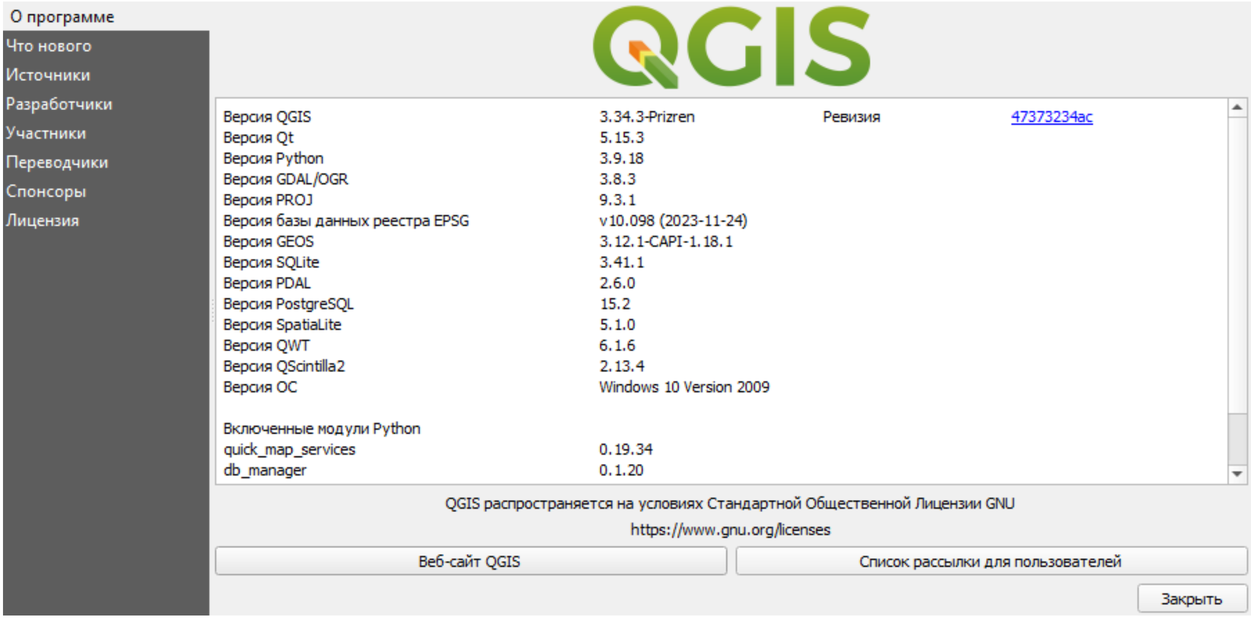
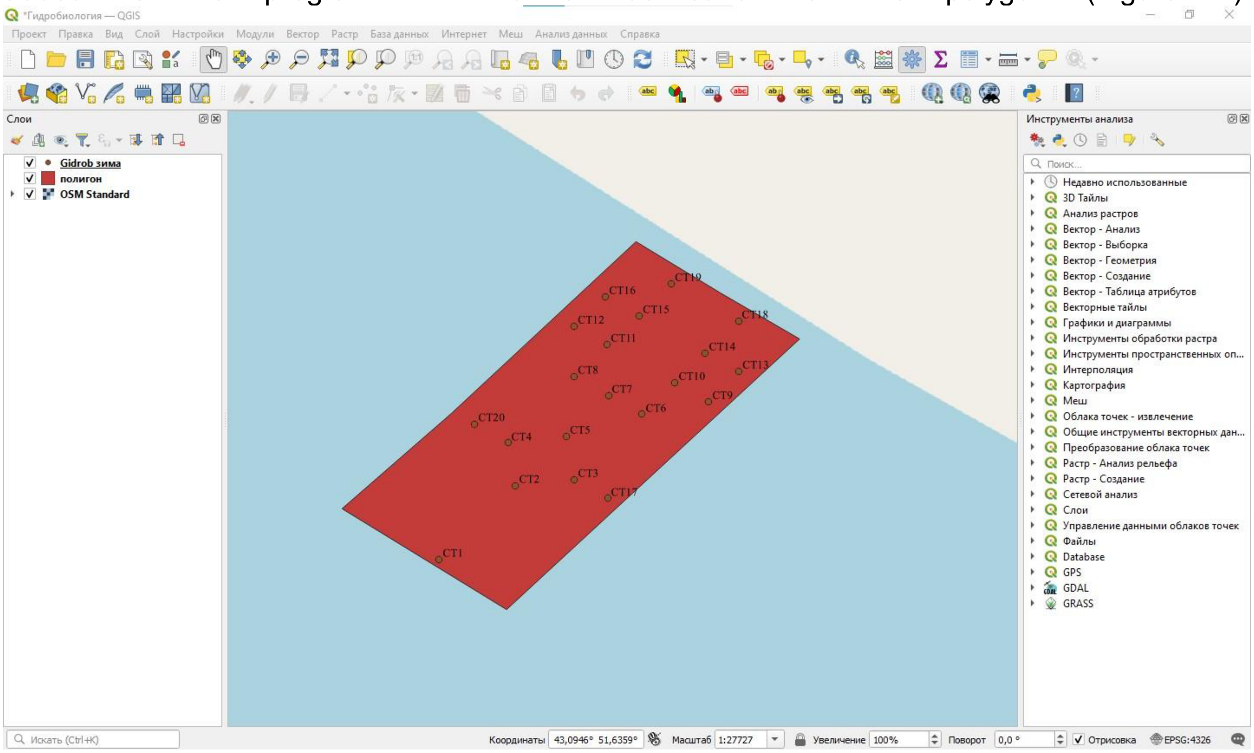
Appendix 3

Method of a spatial interpolation of distribution of forage organisms and aquatic biological resources within the planned construction site in the Middle Caspian Sea using QGIS 3.34 software when preparing the distribution maps

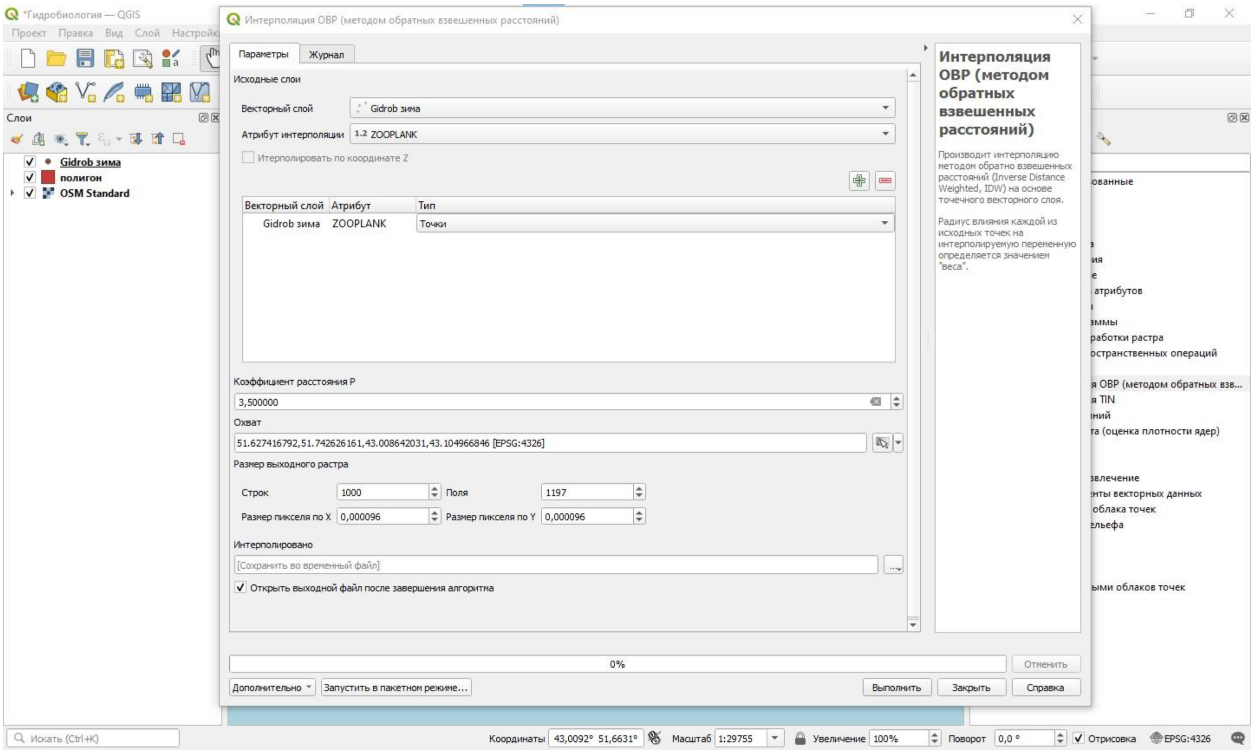
QGIS 3.34 software was used when preparing the maps of distribution of forage organisms and aquatic biological resources within the site of the planned construction in the Middle Caspian Sea (Figure 1).



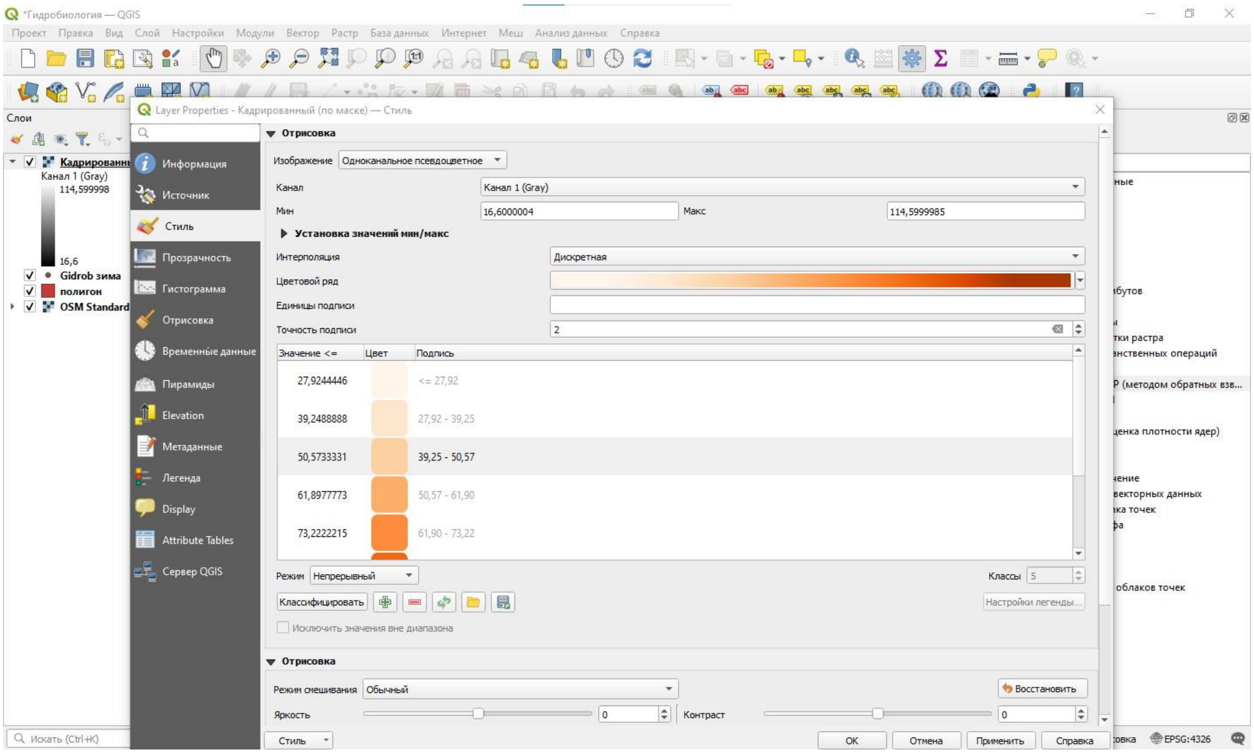
In order to build the polygon of the planned construction site, coordinates of all stations were added to the program with further delineation of the polygon (Figure 2).



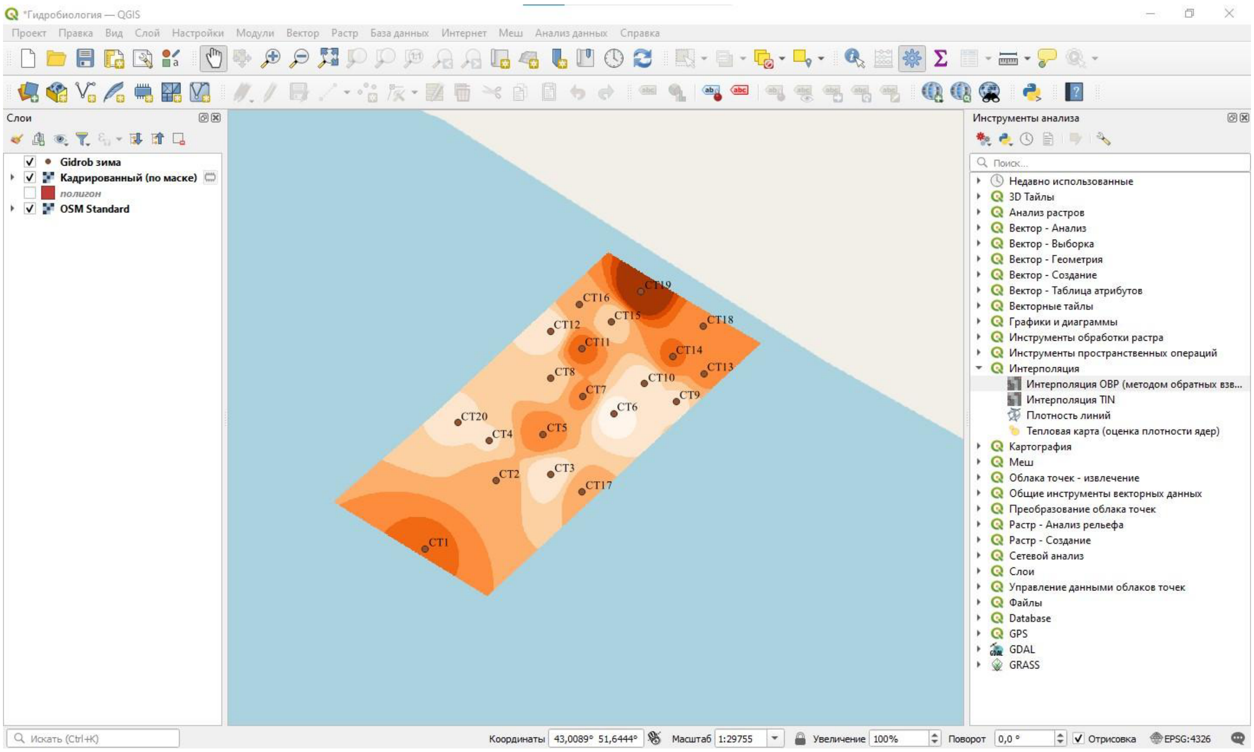
The following indicators were used for a relative assessment of distribution of forage organisms and aquatic biological resources depending on their biology and methods of collection of biological materials: mg/m^3 for phytoplankton and zooplankton; g/m^2 for zoobenthos, specimen per net setting for sturgeons; specimen per hour of trawling for gobies; and other. Data on each type of forage organisms and aquatic biological resources obtained for each station during the survey were added to the special layers of the program. As a next step, the data was interpolated using the method of inverse distance weighted interpolation with the specified parameters (coefficient of distance and size of an output raster) (Figure 3).



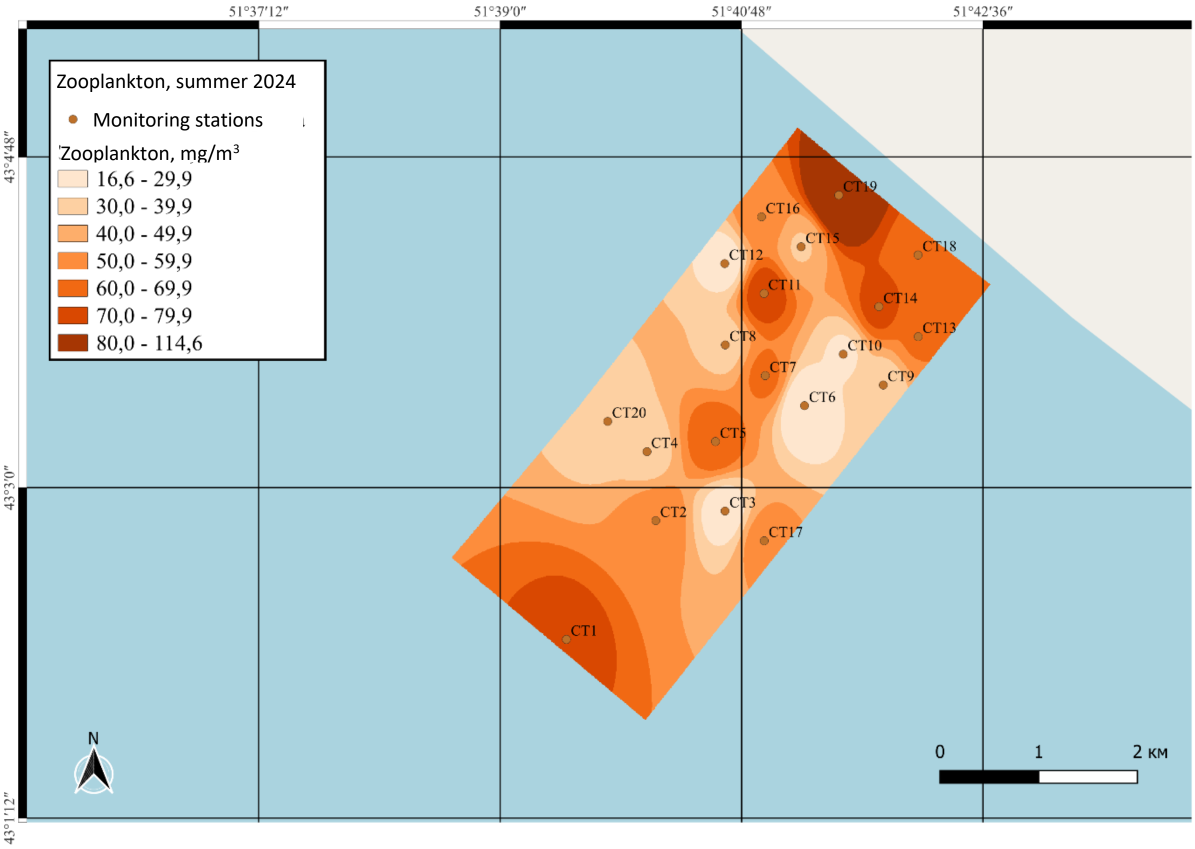
After the spatial interpolation, a style of distribution map (color scheme, font, and range of values) was built in the program (Figure 4).



At the end of interpolation, the program provides the interpolated distribution map created according to the specified parameters of a relative distribution of forage organisms and aquatic biological resources and the selected style (Figure 5).



The resulting interpolated distribution map is laid on the layout with the grid of geographical coordinates indicating latitude and longitude of the planned construction site, and with the legend indicating the distribution step for the forage organisms and aquatic biological resources with a range bound to the color scheme (Figure 6).


51°37′12″
51°39′0″
51°40′48″
51°42′36″
43°4′48″
43°3′0″
43°1′12″
Zooplankton, summer 2024
Monitoring stations
Zooplankton, mg/m³
16,6 - 29,9
30,0 - 39,9
40,0 - 49,9
50,0 - 59,9
60,0 - 69,9
70,0 - 79,9
80,0 - 114,6
CT19
CT16
CT15
CT18
CT12
CT11
CT14
CT13
CT8
CT10
CT7
CT9
CT6
CT20
CT5
CT4
CT3
CT2
CT17
CT1
N
0
1
2 км