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Article

Current trends in biodiversity change in the kazakh sector of the Caspian sea

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Abstract. A comprehensive analysis of the dynamics of hydrobiological communities in the Kazakh sector of the Caspian Sea for the period 2010-2024 was carried out. The study covers three key components of the marine ecosystem: phytoplankton, zooplankton and macrozoobenthos. It was found that the species diversity of phytoplankton decreased by 3.7 times (from 74 to 20 taxa), with the dominance of diatoms (*Cyclotella choctawhatcheeana*) and blue-green algae (*Phormidium angustissimum*). Zooplankton is characterized by a sharp increase in biomass – 47.7 times by 2024. This growth is due to an increase in the number of facultative plankters that are resistant to pollution and hypoxia. Macrozoobenthos communities, on the contrary, demonstrate a pronounced decrease in biomass - 5.2 times compared to the initial values. The most significant reduction was recorded among polychaetes (*Hediste diversicolor*), which may be associated with the deterioration of conditions in the bottom horizons, including pollution, oxygen deficiency and siltation. The obtained data indicate a profound transformation of the trophic structure of the ecosystem associated with a complex of natural and anthropogenic factors, including climate change, oil pollution and invasion of alien species. The results emphasize the need to adapt existing environmental protection measures and develop new approaches to monitoring the state of the Caspian Sea.

Keywords: Caspian Sea; phytoplankton; zooplankton; macrozoobenthos; biodiversity; anthropogenic impact; long-term dynamics.

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1. Introduction

The Caspian Sea, as the largest enclosed body of water in the world, represents a unique ecosystem subject to significant natural and anthropogenic pressures. In recent decades, intensified industrial activity-including oil extraction and shipping-as well as climate change, have exerted complex impacts on hydrobiological communities. Particular attention in ecosystem assessments is given to phytoplankton, zooplankton, and macrozoobenthos, which serve as key indicators of biodiversity and trophic interactions (Krupa, 2019; Heydari et al. 2018).

One of the most important components in the study of aquatic ecosystem health is phytoplankton. Phytoplankton refers to a collection of microscopic plants (primarily algae) that, through the process of photosynthesis, absorb phosphates, nitrates, and dissolved carbon dioxide, while releasing oxygen, serving as the primary source of productivity that supports all higher trophic level organisms (consumers) (Domingues, 2022; Naselli-Flores et al., 2023).

Phytoplankton also exhibits the highest species diversity among aquatic organisms, develops in large biomass, and is well adapted to a wide range of environmental parameters (Li et al., 2002). Due to the short life cycle of algae and their ability to be the first to respond to even minor changes in environmental conditions through alterations in community structure and quantitative indicators, they are highly suitable for bioindication studies (Sugianti et al., 2024).

Zooplankton communities play a crucial role in aquatic ecosystems by acting as intermediaries in the transfer of matter and energy within trophic chains. They serve as a vital food source for aquatic invertebrates, fish larvae, and planktivorous fish. Zooplankton responds relatively quickly to environmental changes and can thus serve as an effective indicator of ecosystem health. Its distribution is closely associated with hydrological factors (Tomljanović et al., 2025).

Macrozoobenthos constitutes the primary food source for most sturgeon and semi-anadromous fish species in the Caspian Sea. The species composition, abundance, and biomass of macrozoobenthos are subject to considerable fluctuations under the influence of both natural and anthropogenic factors.

The aim of this study is to analyze the long-term dynamics (2010–2024) of the structural and quantitative characteristics of aquatic biota in the Kazakh sector of the Caspian Sea, including changes in species composition and abundance of phytoplankton, trends in the distribution of zooplankton and macrozoobenthos, and to identify potential correlations between anthropogenic pressures and the condition of benthic communities.

The relevance of this study is supported by previous research conducted by the authors (Modabberi et al., 2020; Beaumont et al., 2022; Aubakirova et al., 2023; Abdurahmanov et al., 2010; Vostokov et al., 2023; Tabari et al., 2022), which reported a decline in biodiversity in coastal zones. The present study expands upon these findings by providing updated data covering the period up to 2024.

2. Materials and methods

Sampling was carried out using vertical and horizontal toning, and species were identified using atlases (McCauley et al., 2003; Kight et al., 2011). The abundance (million cells/m³) and biomass (mg/m³) of zooplankton and macrozoobenthos were calculated. Zooplankton was collected using a Juday net, and benthic samples were obtained with a Petersen dredge. Taxonomic analysis was conducted using microscopy and genetic methods (Schwarz et al., 1984). Statistical processing included biodiversity indices (Shannon, Simpson) (Seregin et al., 2023) and correlation analysis with hydrochemical parameters (salinity, temperature).

3. Results

To assess the state of phytoplankton in the northern part of the Caspian Sea, data from the summer period of 2010 to 2024 are presented in Table 1 (Hitrova et al., 2019; Guseinova, 2012; Kostyanoi, 2024). Summer is a representative period for evaluating the taxonomic and quantitative composition of phytoplankton, as it corresponds to the vegetation season. The species composition of phytoplankton in the Kazakh sector of the Caspian Sea includes the following groups: *Bacillariophyta* (diatoms), *Chlorophyta* (green algae), *Cyanophyta* (cyanobacteria), and *Dinophyta* (dinoflagellates).

Table 1. Characteristics of Phytoplankton in the Kazakh Sector of the Caspian Sea During the Summer Period (2010–2024)

Year	Number of species	Number, million cells/m^3	Biomass, mg/m^3
2010	74	423.5	423
2011	91	946.7	758
2012	94	810.3	484
2013	129	3326.7	737
2014	128	2643.0	916
2015	95	3363.0	1115
2016	89	1390.6	272
2017	128	1724.1	908
2018	64	1552.4	212
2019	126	1507.0	1440
2020	33	559.6	308
2021	83	1574.1	212
2022	21	223.9	250
2023	25	241.9	215
2024	20	230.1	210

Figure 1 shows a comparative overview of the average number of phytoplankton species from 2010 to 2024. In 2024, species diversity decreased 3.7 times compared to 2010. However, the highest species richness was recorded in 2013, reaching 129 taxa, and in 2014 and 2017, with 128 taxa each.

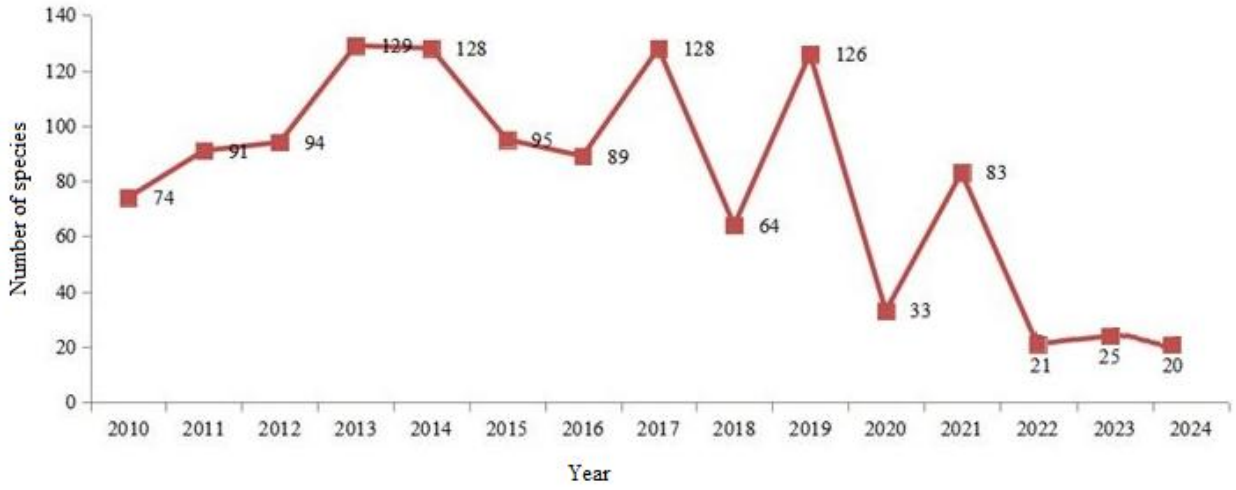

Figure 1. Number of phytoplankton species in the Kazakh part of the Caspian Sea, summer period 2010-2024

When comparing the quantitative indicators of phytoplankton in 2024 with 2010, the number decreased by 1.4 times, and the biomass increased by 1.6 times (Figure 2). There are also years with maximum growth rates of phytoplankton biomass in 2019 (1,440 mg/m^3) and abundance in 2015 (3,363 million cells/m^3).

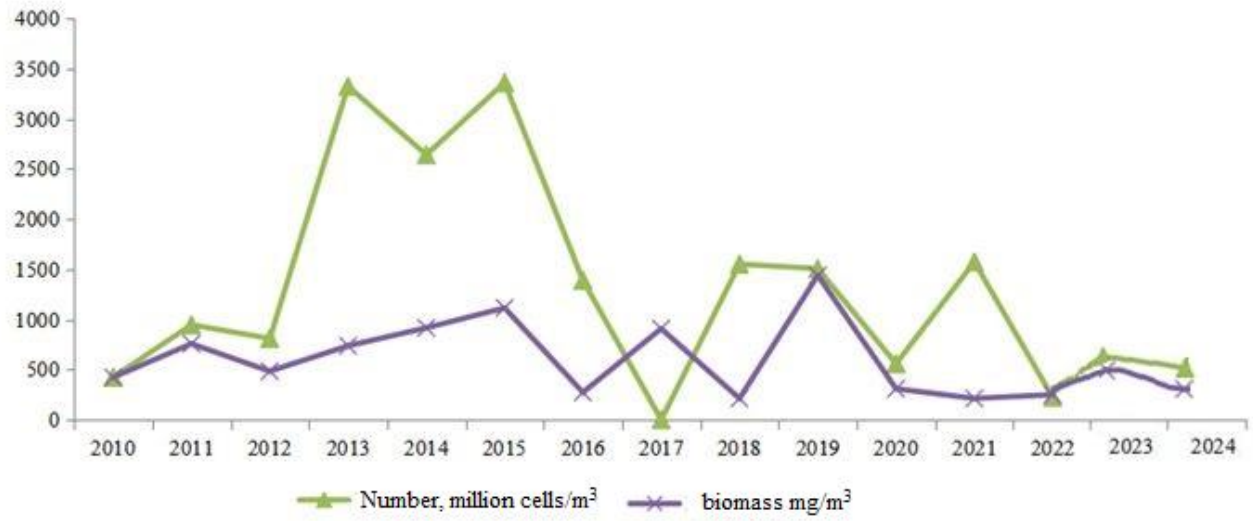

Figure 2. Comparative characteristics of the phytoplankton state of the Kazakh part of the Caspian Sea, summer period 2010-2024

According to the 2024 summer study by LLP "SED", 26 taxa were identified at the Abai site (Table 2).

Table 2. Taxonomic composition of phytoplankton, summer 2024

№	Taxa	Frequency of occurrence, %
Bacillariophyta (diatoms)		
1	*Amphiprora paludosa*	10
2	*Coscinodiscus jonesianus*	35
3	*Cyclotella choctawhatcheeana*	85
4	*Cyclotella meneghiniana*	20
5	*Diploneis interrupta*	20
6	*Discoplea comta*	35
7	*Gyrosigma acuminatum*	10
8	*Nitzschia acicularis*	15
9	*Navicula cryptocephala*	10
10	*Navicula minima*	20
11	*Nitzschia reversa*	10
12	*Nitzschia tryblionella*	5
13	*Podosira parvula*	5
14	*Pseudosolenia calcar-avis*	45
15	*Thalassiosira incerta*	5
Cyanophyta (Blue-green algae)		
16	*Gomphosphaeria lacustris*	5
17	*Merismopedia punctata*	80
18	*Microcystis aeruginosa f.flos-aquae*	50
19	*Oscillatoria brevis*	5
20	*Phormidium angustissimum*	90
21	*Spirulina laxissima*	65
Chlorophyta (Green algae)		

22	*Ankistrodesmus acicularis*	15
23	*Planctonema lauterbornii*	45
Pyrrophyta (Pyrophyte algae)		
24	*Peridinium subsalsum*	2
25	*Prorocentrum cordatum*	16
Euglenophyta (Euglenic algae)		
26	*Euglena acus*	10

Diatoms and cyanobacteria are widely distributed across the waters of the northern Caspian Sea. Among the diatoms, *Cyclotella choctawhatcheeana* is noted as the dominant species. Diatoms and dinoflagellates form the main part of the biomass, while cyanobacteria dominate in terms of abundance.

A decline in quantitative indicators was observed across all surveyed transects. Overall, the phytoplankton community in the studied area was dominated by small-celled algae, which serve as a preferred food source for invertebrates, creating favorable conditions for the development of planktonic and benthic organisms.

The phytoplankton studies revealed that the Middle Caspian Sea can be classified as a beta-mesosaprobic waterbody, with waters considered moderately polluted. The average value of the species diversity index in 2021 reached 2.84 bits/specimen and characterized the low level of diversity of the phytoplankton community in the study area during the summer period.

The zooplankton species composition is mainly dominated by crustaceans, including copepods (*Copepoda*), cladocerans (*Cladocera*), and barnacles (*Ctenophora*). The second largest group is rotifers (*Rotatoria*). Other species grouped as “various organisms” include all planktobenthic forms and their larvae, ciliates, hydrozoans, nematodes, flatworms, polychaetes, bell-shaped ciliates, leeches, insects, water mites, etc.

Table 3 presents the results of interannual studies on the number of species, abundance, and biomass of zooplankton during the summer period from 2010 to 2024 (Kostyanoi, 2024; Sharipova, 2012; Akbari, 2020).

Table 3. Characteristics of zooplankton in the Kazakhstan sector of the Caspian Sea during the summer period 2010–2024

Year	Number of species	Abundance, individuals/m^3	Biomass, mg/m^3
2010	32	41054	252
2011	37	38046	489
2012	47	31570	205
2013	51	80853	1814
2014	38	48068	2668
2015	46	86896	1662
2016	48	51354	6227
2017	46	40751	520
2018	29	22149	5510
2019	34	49625	396
2020	21	14779	122
2021	29	21943	5772
2022	12	42253	13576
2023	18	34542	12785
2024	11	181224	12021

When comparing the species composition of 2024 with that of 2010, a decrease of 2.9 times is observed (Figure 3). The highest species diversity of zooplankton was recorded in 2013. Throughout all studied years, widespread representatives from the following families were noted: copepods - *Acartia tonsa*, rotifers - *Brachionus plicatilis*, and, among others - polychaete worms *Hediste diversicolor*.

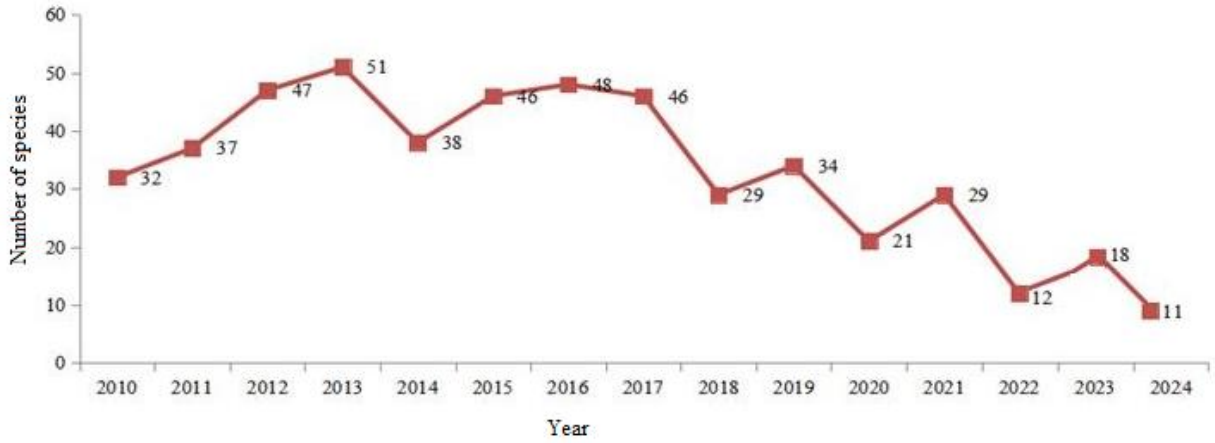

Figure 3. Number of zooplankton species in the Kazakhstan sector of the Caspian Sea, summer period 2010–2024

Analysis of the quantitative composition of zooplankton in 2024 compared to 2010 shows an increase in abundance by 1 time and in biomass by 47.7 times (Figure 4).

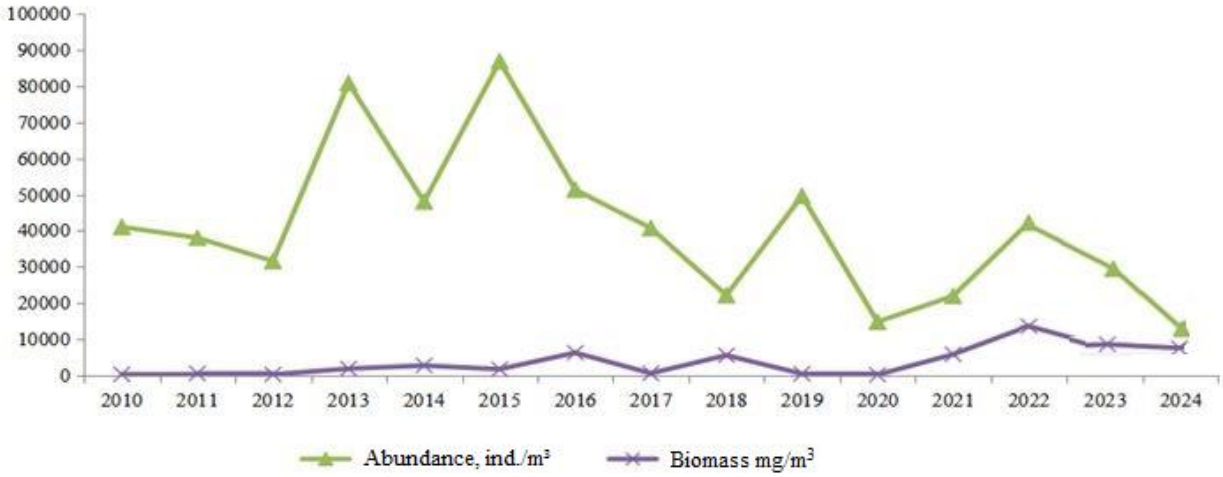

Figure 4. Comparative characteristics of the zooplankton status in the Kazakhstan sector of the Caspian Sea, summer period 2010–2024

The basis of zooplankton abundance at all stations was formed by copepods (*Copepoda*), while facultative planktoners (*Others*) dominated in terms of biomass.

According to the research by LLP "SED" in 2024 (summer), 26 taxa were identified at the Abay site (Table 4).

Table 4. Taxonomic composition of zooplankton at the Abai site, summer 2024

№	Taxa	Frequency of occurrence, %
The family of rotifers *(Rotifera)*		
1	*Hexarthra fennica (Levander)*	5
2	*Brachionus plicatilis (Muller)*	100
3	*Brachionus quadridentatus (Hermann)*	90
The family of branchiopods *(Cladocera)*		
4	*Podonevadne camptonyx (G.O. Sars)*	35
	The family of oar-footed crustaceans *(Copepoda)*	
5	*Acartia tonsa (Dana)*	100
6	*Calanipeda aquae-dulcis (Kritschagin)*	100
7	*Ectinosoma abrau (Kritschagin)*	5
8	*Halicyclops oblongus (Lindberg.)*	5
9	*Harpacticoida gen.sp.*	20
Optional planters *(Others)*		
10	*Bivalvia gen.sp.*	60
11	*Blackfordia virginica (Mayer)*	100
12	*Cirripedia gen.sp.*	95
13	*Hediste diversicolor (O.F.Müller)*	70
14	*Mnemiopsis leidyi (A. Agassiz)*	25
15	*Rhithropanopeus harrisii (Gould)*	10
16	*Moerisia pallasi (Derzhavin)*	5

The benthic fauna of the Caspian Sea is poor in species number but diverse in their origin. In the Kazakh sector of the Caspian Sea, the zoobenthos community includes three main systematic groups: worms (Vermes), mollusks (Mollusca), crustaceans (Crustacea), and other groups (Others). Among the worms, annelids (Annelida) dominated in frequency of occurrence, represented by the classes Oligochaeta and Polychaeta. Oligochaetes were found at all studied stations, with a 100% frequency of occurrence. Polychaetes were represented by the species Hediste diversicolor and Hypaniola kowalewskii.

Table 5 presents data from LLP "Kazekoproject" for 2010–2023 and LLP "SED" for 2024, providing an interannual comparison of the number of species, abundance, and biomass of macrozoobenthos during the summer period.

Table 5. Characteristics of Macrozoobenthos in the Kazakh Sector of the Caspian Sea during the Summer Period, 2010–2024

Year	Number of species	Abundance, individuals/m^3	Biomass, mg/m^3
2010	39	9474	33090
2011	27	3719	7307
2012	41	7810	19216
2013	44	5029	8246
2014	40	5905	11167
2015	30	6123	13354
2016	59	6313	17642
2017	53	9232	16393

Year	Number of species	Abundance, individuals/m³	Biomass, mg/m³
2018	38	3442	11986
2019	46	6149	11873
2020	33	1129	10570
2021	38	3527	13262
2022	18	3153	6412
2023	21	3072	6403
2024	17	3011	6321

The state of species diversity shows a decrease of 2.3 times in 2024 compared to 2010 (Figure 5). The maximum species composition of macrozoobenthos was recorded in 2016, with 59 taxa.

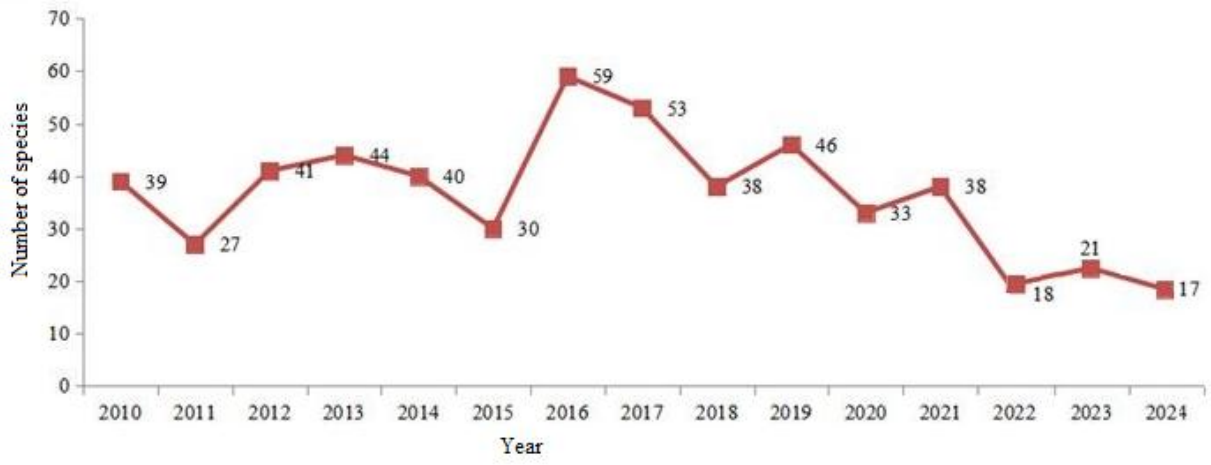

Figure 5. Number of macrozoobenthos species in the Kazakhstan sector of the Caspian Sea, summer period 2010 - 2024

Quantitative indicators of macrozoobenthos in 2024 compared to 2010 decreased by 3 times in abundance and by 5.2 times in biomass (Figure 6). Considering the annual trends in benthos abundance and biomass, a sharp decline is observed in 2011, a periodic increase in 2012, followed by a steady decrease until 2024. The abundance and biomass of the benthic fauna were mainly formed by representatives of the "soft" benthos, specifically annelid worms (Annelida) - oligochaetes and polychaetes.

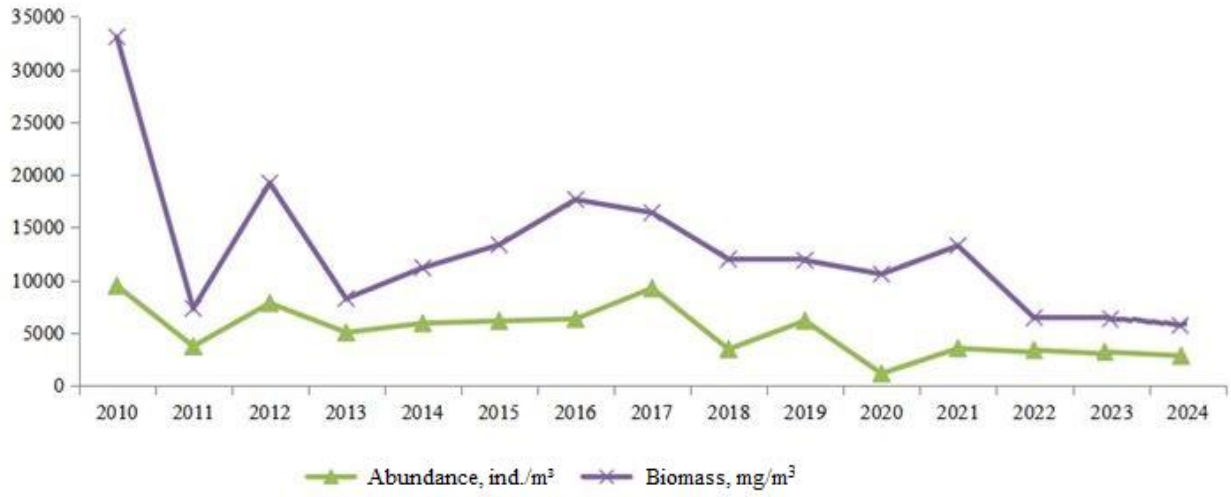

Figure 6. Comparative characteristics of the state of macrozoobenthos in the Kazakhstan sector of the Caspian Sea, summer period 2010–2024

According to the SED study, 14 macrozoobenthos taxa were identified in the Abai site in 2024 (summer) (Table 6).

Table 6. Taxonomic composition of the macrozoobenthos of the Abai site, summer 2024

№	Taxa	Frequency of occurrence, %
Worms (Vermes)		
1	*Hediste diversicolor*	100
2	*Spionidae gen.sp.*	90
3	*Oligochaeta gen.sp.*	100
4	*Manayunkia caspica*	80
5	*Turbellaria gen. sp.*	10
Shellfish (Mollusca)		
6	*Abra ovata*	15
7	*Cerastoderma lamarcki*	55
Crustaceans *(Crustacea)*		
8	*Balanus improvisus*	30
9	*Schizorhynchus bilamellatus*	45
10	*Stenocuma graciloides*	90
11	*Stenogammarus (S.)similis*	5
12	*Pterocuma pectinata*	10
13	*Rhithropanopeus harrisii*	60
Others		
14	*Moerisia pallasi*	5

An interannual comparison of the state of phytoplankton, zooplankton, and macrozoobenthos is presented in Table 7.

Table 7. Characteristics of the species composition of phytoplankton, zooplankton and macrobenthos of the Kazakh part of the Caspian Sea, summer period 2010-2024

Year	Number of types, pcs.			Number, million cells/m^3			Biomass, mg/m^3		
	Phyto -	Zoo -	Benthos	Phyto -	Zoo -	Benthos	Phyto -	Zoo -	Benthos
2010	74	32	39	424	41054	9474	423	252	33090
2011	91	37	27	947	38046	3719	758	489	7307
2012	94	47	41	810	31570	7810	484	205	19216
2013	129	51	44	3327	80853	5029	737	1814	8246
2014	128	38	40	2643	48068	5905	916	2668	11167
2015	95	46	30	3363	86896	6123	1115	1662	13354
2016	89	48	59	1391	51354	6313	272	6227	17642
2017	128	46	53	1724	40751	9232	908	520	16393
2018	64	29	38	1552	22149	3442	212	5510	11986
2019	126	34	46	1507	49625	6149	1440	396	11873
2020	33	21	33	560	14779	1129	308	122	10570
2021	83	29	38	1574	21943	3527	212	5772	13262
2022	21	12	18	224	42253	3153	250	13576	6412
2023	19	11	21	215	41232	3145	215	12785	6403
2024	20	10	23	232	39211	3159	210	12021	6321

Figure 7 shows an interannual comparison of the number of phytoplankton, zooplankton, and macrozoobenthos species. When comparing, it was found that representatives of phytoplankton dominate in terms of species composition.

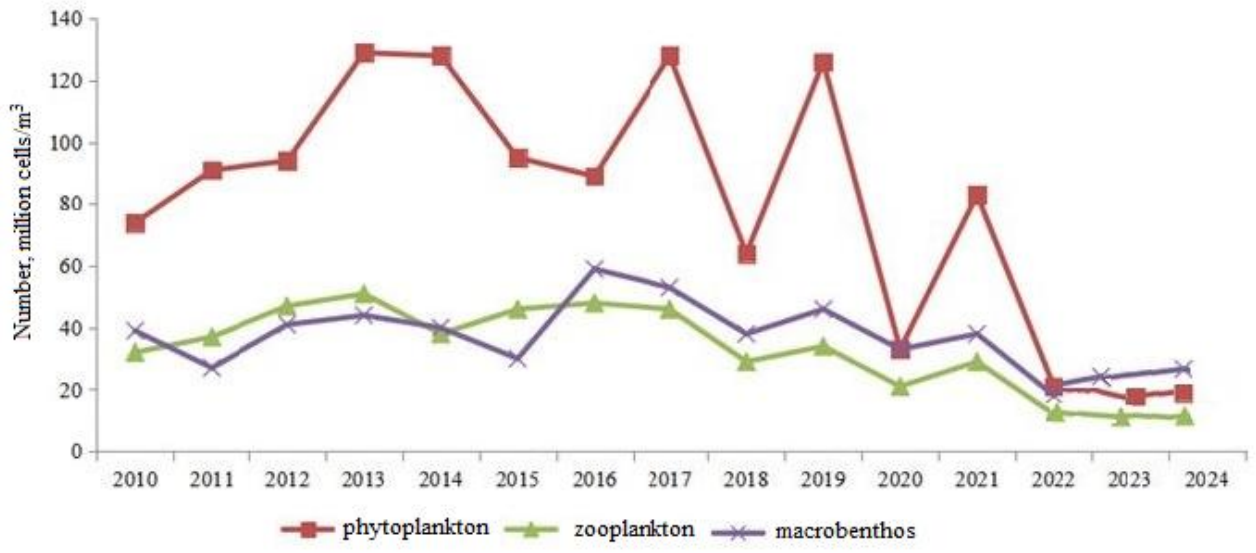

Figure 7. Average number of phytoplankton, zooplankton, and macrozoobenthos species in the Kazakh part of the Caspian Sea, summer period 2010-2024

Figure 8 shows an interannual comparison of phytoplankton, zooplankton, and macrozoobenthos abundance. When comparing, it was found that zooplankton representatives dominate in terms of numbers.

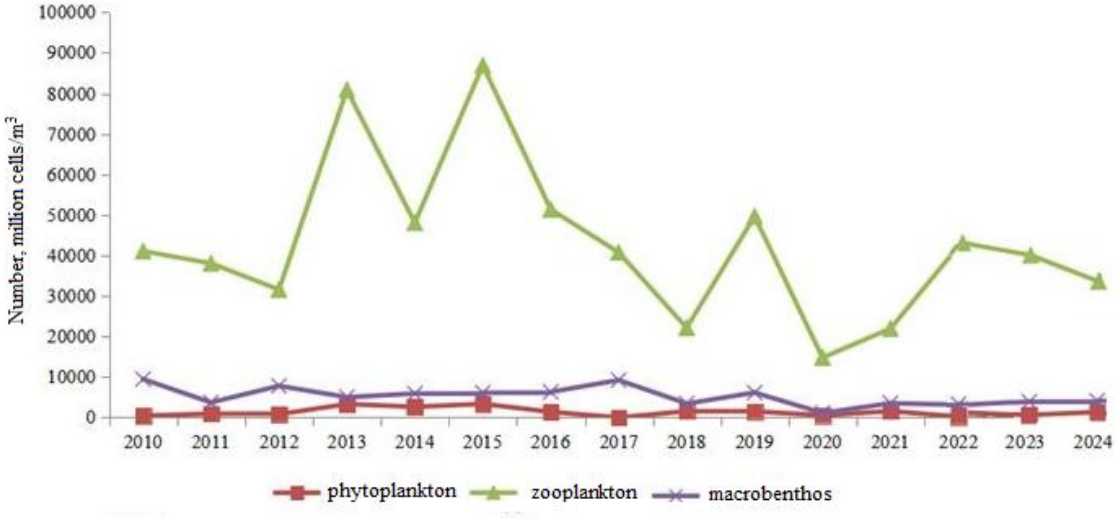

Figure 8. Average abundance of phytoplankton, zooplankton, and macrozoobenthos in the Kazakh part of the Caspian Sea, summer period 2010-2024

Figure 9 shows an interannual comparison of phytoplankton, zooplankton, and macrozoobenthos biomass. When comparing, it was found that representatives of macrozoobenthos dominate in terms of biomass.

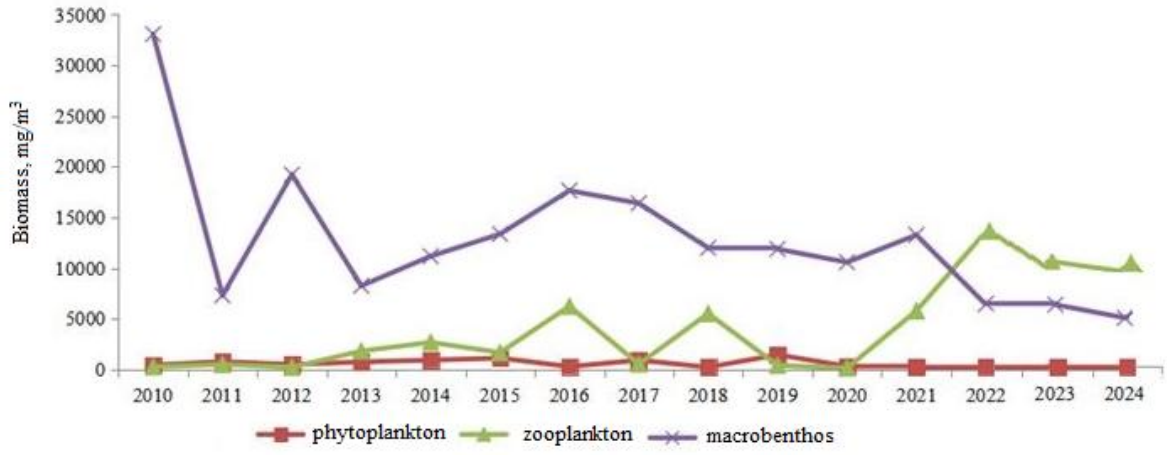

Figure 9. Average biomass of phytoplankton, zooplankton and macrozoobenthos of the Kazakh part of the Caspian Sea, summer period 2010-2024

4. Discussion

The results of long-term monitoring of hydrobiological communities of the northern Caspian Sea indicate significant transformations of the ecosystem associated with both natural climate fluctuations and increasing anthropogenic impact. The obtained data are consistent with the results of previously conducted studies [Akbari et al.,2020; Kostianoy, 2024; Court et al.,2025], which document the degradation of biodiversity in coastal zones and a decrease in the ecological sustainability of the water area.

The decrease in phytoplankton species diversity from 74 taxa in 2010 to 20 in 2024 is consistent with studies (Modabberi et al., 2020; Court et al.,2025) linking this trend to increased pollution by oil products. At the same time, the dominance of diatoms (*Cyclotella choctawhatcheeana*) and cyanobacteria (*Phormidium angustissimum*), indicative of eutrophic conditions, was observed (Xiao et al., 2018). Quantitative indicators of phytoplankton show

pronounced variability: the sharp increase in biomass in 2022 (13.576 mg/m³) was associated with the mass development of facultative plankters (*Bivalvia* gen. sp.), which may indicate invasive processes.

Zooplankton communities also underwent significant changes during the study period. A 40% decrease in the number of rotifers (*Brachionus plicatilis*) compared to 2010 and an increase in the proportion of individual dominant taxa indicate a shift in the ecological balance and a restructuring of trophic links. Such dynamics confirm the conclusions (Fedyaeva, 2024) about the transformation of the structure of plankton communities in the Northern Caspian.

Macrozoobenthos proved to be the most vulnerable component of the ecosystem. By 2024, its biomass had decreased 5.2-fold, particularly among polychaetes (Hediste diversicolor), which correlates with data on bottom sediment pollution (Shiganova, 2023). The predominance of oligochaetes and tolerant polychaetes can be regarded as an indicator of deteriorating environmental conditions and the degradation of the food supply for commercial fish.

Thus, the observed changes in the structure of hydrobionts reflect the general trend of biodiversity degradation and the transformation of trophic networks in the northern Caspian. These findings highlight the necessity of revising environmental measures, including enhanced monitoring of benthic communities and tracking the spread of invasive species.

5. Conclusion

A study of the long-term dynamics of phytoplankton, zooplankton, and macrozoobenthos in the Kazakhstan sector of the Caspian Sea from 2010 to 2024 revealed that the region's ecosystem is experiencing complex changes caused by a combination of anthropogenic pressures and natural and climatic factors. The analysis revealed a steady decline in the species diversity of all major aquatic organism groups, most pronounced in phytoplankton and macrozoobenthos. Simultaneously, structural shifts toward the dominance of more tolerant species are observed, reflecting increasing environmental degradation and consistent with the beta-mesosaprobic state of the waters.

Quantitative indicators of community development demonstrate different trends: phytoplankton is characterized by high interannual variability in abundance and biomass, zooplankton shows a tendency toward increasing biomass due to facultative forms and invasive species, while macrozoobenthos continues to decline in key parameters, indicating deteriorating conditions in benthic ecosystems. Significant qualitative and quantitative changes in benthic communities confirm the impact of economically and ecologically significant exploitation, as well as invasive processes, salinity changes, and sea level fluctuations.

These results indicate a continuing decline in the ecological resilience of the northeastern Caspian Sea and the increasing complexity of trophic interactions. Under these conditions, predicting targeted ecosystem changes under the influence of anthropogenic and natural factors is particularly important. Strengthening hydrobiological monitoring, including monitoring of invasive species (e.g., *Mnemiopsis leidyi*), the implementation of regional biodiversity assessment standards based on updated data, and the use of satellite-based methods to predict eutrophication are recommended.

6. Supplementary Materials. No Supplementary materials.

7. Author Contributions

Conceptualization - S.K., Y.P.; methodology - L.T.; investigation - S.S., Y.P; resources - A.Zh., D.A.; data curation - Y.P.; writing - original draft preparation - S.K., L.T.; writing - review and editing - S.K., S.S.; visualization - D.A.; supervision - S.S.

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Каспий теңізінің қазақстандық секторындағы биоалуантүрліліктің өзгеруінің қазіргі тенденциялары

Сымбат Койбакова, Ербол Панғалиев, Самал Сырлыбекқызы Ляйлим Тайжанова, Дастан Аманкешұлы, Айнур Жидебаева

Аңдатпа. 2010–2024 жылдар аралығында Каспий теңізінің қазақстандық секторындағы гидробиологиялық қауымдастықтардың динамикасына кешенді талдау жүргізілді. Зерттеу теңіз экожүйесінің үш негізгі компонентін қамтиды: фитопланктон, зоопланктон және макрозообентос, олар трофикалық байланыстардың негізін құрап, биотаның тұрақты қызметін қамтамасыз етеді. Анықталғандай, осы кезең ішінде фитопланктонның түрлік әртүрлілігі 3,7 есе азайған - 74 таксоннан 20 таксонға дейін. Қауымдастық құрамында диатомды балдырлардың (*Cyclotella choctawhatcheeana*) және цианобактериялардың (*Phormidium angustissimum*) айқын басымдығы байқалады, бұл эвтрофтанған және антропогендік әсерге ұшыраған су айдындарына тән құбылыс. Зоопланктондар үшін 2024 жылға қарай биомассаның күрт өсуі - 47,7 есеге артуы тіркелді. Бұл үдеріс ластануға, оттегі тапшылығына және тұрақсыз гидрологиялық жағдайларға жоғары төзімді факультативті планктердің сандық басымдығымен түсіндіріледі. Оларға қарағанда, макрозообентос қауымдастықтары биомассаның айтарлықтай төмендеуін көрсетіп отыр - бастапқы көрсеткіштермен салыстырғанда 5,2 есе азайған. Ең елеулі қысқару көпқылтанды құрттарда (*Hediste diversicolor*) байқалды, ол түптік қабаттардағы жағдайдың нашарлауымен: ластану деңгейінің артуымен, оттегінің жетіспеушілігімен және субстраттың лайлануымен байланысты. Алынған мәліметтер жиынтығы табиғи және антропогендік факторлардың, соның ішінде климаттық өзгерістердің, мұнаймен ластанудың және бөгде түрлердің енуінің әсерінен каспий экожүйесінің трофикалық құрылымының терең трансформациясын көрсетеді. Зерттеу нәтижелері қолданыстағы табиғат қорғау шараларын қайта қарау және теңіздің жағдайын мониторингтеудің жаңа тәсілдерін әзірлеу қажеттігін айқындайды.

Түйін сөздер: Каспий теңізі; фитопланктон; зоопланктон; макрозообентос; биоалуантүрлілік; антропогендік әсер; көпжылдық динамика.

Современные тенденции изменения биоразнообразия в Казахстанском секторе Каспийского моря

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Аннотация. Был проведён комплексный анализ динамики гидробиологических сообществ в казахстанском секторе Каспийского моря за период 2010–2024 гг. Исследование охватывает три ключевых компонента морской экосистемы: фитопланктон, зоопланктон и макрозообентос, которые в совокупности формируют основу трофических связей и обеспечивают устойчивое функционирование биоты. Установлено, что видовое разнообразие фитопланктона за данный период сократилось в 3,7 раза - с 74 до 20 таксонов. При этом в сообществе чётко прослеживается доминирование диатомовых водорослей (*Cyclotella choctawhatcheeana*) и цианобактерий (*Phormidium angustissimum*), характерных для эвтрофированных и подвергшихся антропогенному воздействию водоёмов. Для зоопланктона отмечен резкий рост биомассы - увеличение в 47,7 раза к 2024 году. Данный процесс объясняется численным преобладанием факультативных планктеров, обладающих высокой устойчивостью к загрязнению, кислородному дефициту и нестабильным гидрологическим условиям. В отличие от них, сообщества макрозообентоса демонстрируют выраженное снижение биомассы - в 5,2 раза по сравнению с исходными значениями. Наиболее значительное сокращение зафиксировано у полихет (*Hediste diversicolor*), что связано с деградацией условий в придонных горизонтах: повышением уровня загрязнения, дефицитом кислорода и заилением субстрата. Совокупность полученных данных указывает на глубокую трансформацию трофической структуры каспийской экосистемы, вызванную сочетанием природных и антропогенных факторов, включая климатические изменения, нефтяное загрязнение и проникновение чужеродных видов. Результаты подчёркивают необходимость пересмотра существующих природоохранных мер и разработки новых подходов к мониторингу состояния моря.

Ключевые слова: Каспийское море; фитопланктон; зоопланктон; макрозообентос; биоразнообразие; антропогенное воздействие; многолетняя динамика.