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Biodiversity, the present ecological state of the Aral Sea and its impact on future development

Vrstna pestrost, sedanje ekološko stanje Aralskega jezera in njegov vpliv na prihodnji razvoj

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Abstract : The Aral sea used to be the fourth largest lake in the world. Its catchment area is huge, two main rivers (Amu Darya and Syr Darya) feed the lake. The balance of hydrological regime changed drastically after 1960 due to regulation of both main rivers and diversion of water for agricultural irrigation and intense cotton production. Salinity increased and most of invertebrate and fish species disappeared. A significant drop of water level has been recorded in the past 20 years and Aral Lake is presently divided into a small northern lake basin and a larger south basin. Kokaral dam construction resulted in increased water level and decreased salinity. Many invertebrate species reappeared in Small Aral and fish returned from Syr Darya river. Ecological situation in Large Aral is different, eastern part of this basin is completely dried out. The data on salinity levels, some chemical characteristics and above all the data about zooplankton, zoobenthos and fish in Small Aral have been recorded and presented in the article. Salinity ranges between 1 and 8 g/L, the lowest is near the river inlet. Five species of zooplankton (*Keratella quadrata*, *Brachionus plicatilis*, *Evadne anonyx*, *Calanipeda aquaedulcis*, *Cyclops vicinus*) and rotifers from the genus *Synchaeta* are very abundant, ten species are less numerous and seven summer species very rare. Different zoobenthos species are present, but only four abundant (*Hediste diversicolor*, *Chironomus plumosus*, *Syndosmya segmentum* and *Cyprideis torosa*). Zoobenthos mainly consist of Polychaeta, Mollusca, Crustacea and Diptera. The highest diversity was found near the Kokaral dam. Many fish species are commercially important: 14 of them are abundant, including endemic bream *Abramis brama orientalis*, *Chalcalburnus chalcoides aralensis*, carp *Cyprinus carpio aralensis*, and Aral roach *Rutilus rutilus aralensis*. White-eye bream *Abramis sapa aralensis*, silver carp *Hypophtalmichthys molitrix*, orfe *Leuciscus idus oxianus*, and snakehead *Channa argus warpachowskii* are less numerous. Aral barbel *Barbus brachycephalus brachycephalus* and Turkestan barbel *Barbus capito conocephalus* remain very rare. It can be concluded that significant positive changes occurred after Kokaral dam construction. Particularly, biocenoses and the Aral lake environment have been improved and fisheries returned. Today Kazakhstan Government is discussing an idea to improve this dam and dike

and we support this discussion and advise to make it higher. All can lead to improve ecological state of the Small Aral.

Keywords: Aral Sea, biodiversity, ecological state, zooplankton, zoobenthos, fish

Izvleček: Aralsko jezero je bilo četrto največje jezero na svetu. Njegovo prispevno območje je zelo veliko, dve glavni reki sta pritekali v jezero, Amu Darja in Sir Darja. Hidrološko stanje jezera se je drastično spremenilo po letu 1960 po regulaciji in preusmeritvi obeh glavnih rek za namakanje bombažnih nasadov. Povečala se je slanost, številne vrste nevretenčarjev in rib so izginile. V 20 letih se je gladina vode v jezeru opazno znižala in jezero se je razdelilo na dva dela, manjši severni bazen in večji južni bazen. Po izgradnji jezu Kokaral se je gladina vode zvišala in slanost znižala. Mnoge nevretenčarske vrste so se vrnile v Mali Aral, iz Sir Darje so prišle tudi ribe. Ekološko stanje v Velikem Aralu je drugačno, vzhodni del tega bazena je popolnoma suh. V članku so zbrani podatki o slanosti, nekateri kemijski parametri in predvsem združbe zooplanktona, zoobentosa in rib v Malem Aralu. Slanost variira med 1 g/L in 8g/L, najnižja pri rečnem vtoku. Zelo pogostih je pet zooplanktonskih vrst (*Keratella quadrata*, *Brachionus plicatilis*, *Evadne anonyx*, *Calanipeda aquaedulcis*, *Cyclops vicinus*), ena nedoločena vrsta kotačnika *Synchaeta*. Deset vrst je manj pogostih, zelo redkih pa je šest vrst pomladnih zooplantontov. Prisotnih je tudi več različnih vrst zoobentosa, le štiri vrste pa so pogoste (*Hediste diversicolor*, *Chironomus plumosus*, *Syndosmya segmentum*, and *Cyprideis torosa*). Zoobentos sestavljajo Polychaeta, Mollusca, Crustacea in Diptera. Največja pestrost je bila ugotovljena ob jezu Kokaral. Mnoge ribje vrste so gospodarsko pomembne, 14 od njih je pogostih, vključno z endemnimi taksoni *Abramis brama orientalis*, *Chalcalburnus chalcoides aralensis*, *Cyprinus carpio aralensis*, *Rutilus rutilus aralensis*. Manj številčne so *Abramis sapa aralensis*, *Hypophtalmichthys molitrix*, *Leuciscus idus oxianus*, *Channa argus warpachowskii*. Zelo redki sta dve vrsti mrene *Barbus brachycephalus brachycephalus* in *Barbus capito conocephalus*. Ugotavljamo, da so se opazne in pozitivne spremembe zgodile po izgradnji jezu Kokaral. Zlasti se je izboljšala vrstna pestrost združb in jezersko okolje nasploh, zato se je vrnilo ribištvo. Danes Kazahstanska vlada razmišlja o izboljšanju jezu in nasipa. To razmišljanje podpiramo in obenem svetujemo povišanje jezu, kar bi prineslo izboljšanje ekološkega stanja Malega Arala.

Ključne besede: Aralsko jezero, vrstna pestrost, ekološko stanje, zooplankton, zoobentos, ribe

Introduction

The Aral Sea is a terminal lake, lying amidst the vast deserts of Central Asia. From the 1600's to the 1960's, the hydrological regime of the Aral Sea was in reasonable balance. This lake is Transboundary Lake and 7 countries (Afghanistan, Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan) are contributing water into it. Since 1960 the anthropogenic regression and salinization of the Aral Sea has begun. This has resulted in the disappearance of most of invertebrates and fish species. Some of them have become extinct. At the end of the 1980's due to the fall of water level, the Aral Sea was divided into northern Small Aral and the southern Large Aral having different hydrological regimes.

Regression and salinization of Large Aral continues. After the construction of the Kokaral dam (Aladin, 2014) Small Aral Sea level has increased and a gradual decline in its salinity has began. Because of this dam lake restoration is possible. To date, salinity of the Small Aral Sea has become lower than it was before the 1960's.

There is a process of restoration of former biodiversity. Many invertebrate species are reappearing due to salinity decrease. Commercial freshwater fish species returned into the Small Aral from Syr Darya River and lakes in its lower reaches where they survived. Their populations are in good state. Fisheries are restoring and catches are growing (Aladin and Plotnikov, 2012; Aladin et al., 2012; Plotnikov et al., 2012).

At present Aral Sea is divided to the number residual parts (lotic and lentic). Large Aral Sea is currently the most suffering part of the lake. In the beginning of 21st century it was divided in 3 parts: Western Large Aral Sea, Eastern Large Aral Sea and Tsche-Bas Bay. Since last few years appeared a new fourth part of Large Aral Sea – New Central Aral Sea.

Summer 2014 marked another milestone for the Large Aral Sea. For the first time in modern history, the Eastern Large Aral Sea has completely dried. So we have again currently only 3 parts Western Large Aral Sea, Tsche-Bas Bay and New Central Aral Sea.

In autumn 2009 some people without any calculations and without direct observations reported that Eastern Large Aral Sea dry up completely (http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php). Next year 2010 Eastern Large Aral Sea came back because it was a very wet year and a lot of water came from Amu Darya River delta.

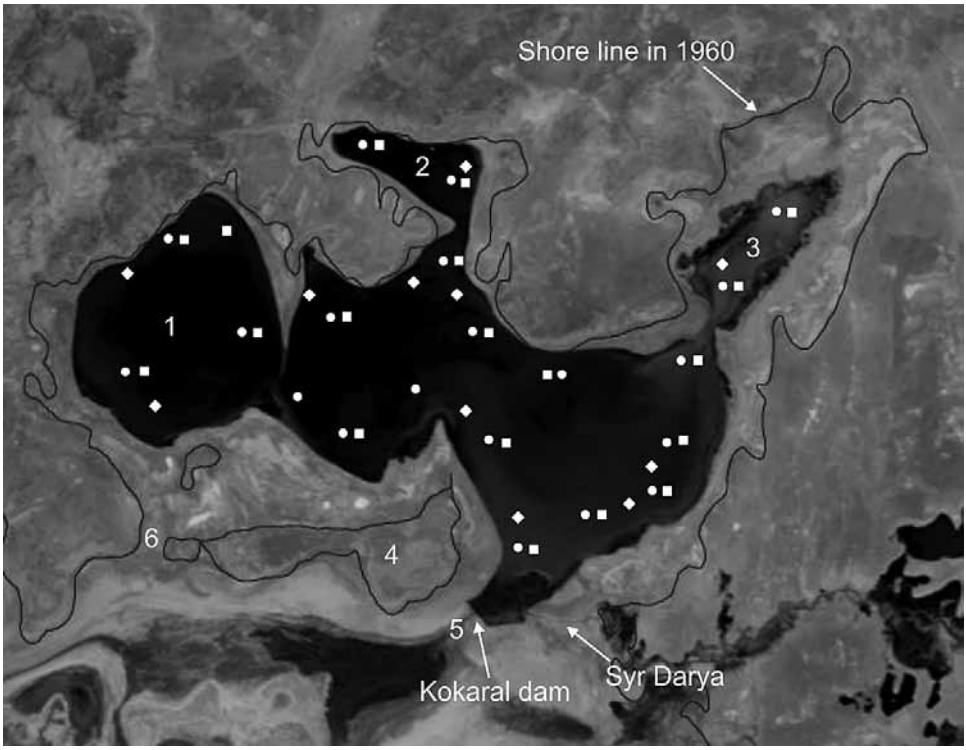

Figure 1. Map of sampling places in Aral Sea. 1 – Saryshiganak Bay; 2 – Butakov Bay; 3 – Shevchenko Bay; 4 – Kokaral island; 5 – Berg Strait; 6 – Auzy-Kokaral Strait. Standard stations: ◆ – ichthyological, ● – hydrobiological, ■ – hydrochemical.

Slika 1. Označena vzorčna mesta v Aralskem jezeru. 1 – zaliv Saryshiganak, 2 – zaliv Butakov, 3 – zaliv Shevchenko, 4 – otok Kokaral, 5 – ožina Berg, 6 – ožina Auzy_Kokaral. Standardne postaje: ◆ – ihtiološka, ● – hidrobiološka, ■ – hidrokemijska.

Material and Methods

Number of field trips around Aral Sea were made. We studied the following places: Small Aral Sea, Tsche-Bas Bay; Western Large Aral Sea (Only Chernyshov Bay); New Central Aral Sea. Small Aral Sea level is 42.0 m a.s.l. with a volume of 27.1 km^3. Water covers an area of 3288 km^2. Basin has maximal depth of 15.5 m (average depth of 8.2 m).

In our studies of Aral Sea we are using IL^2BM platform (Integrated Lotic/Lentic Basin Management) (http://www.ilec.or.jp/en/).

Salinity was measured using YSI-85 and conductometer LF-330. Other chemical parameters were determined using standard methods. Oxygen concentration and pH were measured at the sampling points. Parameters such as COD (permanganate method), NH_4^+, NO_2^-, NO_3^- and PO_4^{3-} were analysed in the laboratory.

Plankton samples were collected according to standard methodology using plankton net (mesh size 60μm). Invertebrates (zoobenthos) were sampled using Petersen bottom sampler (0.025 m^2) and sediments were washed through the sieve No 36. All samples were fixed with formalin (4%) and investigated using stereo microscope (MBS-10). All collected animals were taken to the Aral branch of Kazakh Research Institute of Fishery and Zoological institute of RAS. For species identification Atlas of the Aral Sea invertebrates was used.

Fish were sampled several years. They were caught with fixed fishing nets (mesh size 18-65 mm).

Results and discussion

Chemical data

Oxygen concentrations, COD, concentrations of NH_4^+, NO_2^-, NO_3^-, PO_4^{3-} and pH were measured in different years and very little changes were found. More changes were detected in salinity (Table 1).

Salinity in different parts of Small Aral Sea was from 1 g/L up to 8 g/L. The lowest level of salinity was observed in May 2014 near the Kokaral dam (near Syr Darya delta) and the highest in August in Butakov Bay near Akespe village. The level of Small Aral in investigated period was from 42.1 to 42.6 m a.s.l. The lowest was in August, the highest in May (unpublished data by Ermakhanov from institutional report).

Much higher salinity was measured in Tsche-Bas Bay, ranging from 78 g/L up to 89 g/L. The lowest level of salinity was observed in May near connection to New Central Aral Sea and the highest – in August near the northern coast of Tsche-Bas Bay. The level of Tsche-Bas Bay was from 28.7 to 29.1 m a.s.l. The lowest was in August, the highest was in May.

In Western Large Aral Sea (Only Chernyshov Bay) salinity was very different compared to Small

Table 1: Selected chemical data from Small Aral Sea in the years 2007 – 2013.
Tabela 1: Izbrani kemijski podatki o malem Aralu v letih 2007 – 2013.

Year	pH	O_2, mg/dm^3	COD mg/dm^3	Salinity, ‰	Biogenes, mg/dm^3			
					NH^+_4	NO^-_2	NO^-_3	PO^{3-}_4
2007	7.90-8.30	6.71-13.63	4.3-12.0	6.3	0.65-1.25	0.003-0.055	0.00-0.60	0.005-0.068
2008	6.85-7.20	5.32-11.42	1.5-12.2	12.1	0.05-1.23	0.002-0.135	0.02-0.59	0.008-0.050
2009	6.93-7.32	6.20-12.51	1.4-11.7	12.9	0.38-0.83	0.012-0.101	0.05-0.43	0.010-0.025
2010	7.20-7.30	7.84-12.30	5.8-7.0	11.0	0.23-0.37	0.003-0.039	4.17-5.94	0.000-0.040
2011	7.20-7.45	7.62-12.74	2.4-4.6	9.9	0.36-0.39	0.028-0.032	4.35-5.30	0.022-0.036
2012	7.20-7.25	7.74-9.28	3.2-3.9	5.7	0.37-0.39	0.022-0.029	3.99-4.97	0.017-0.025
2013	7.10-8.15	7.70-9.20	3.1-3.5	5.3	0.12-0.24	0.009-0.027	3.22-3.33	0.015-0.019

Aral with very high values, from 143 g/L up to 169 g/L. The lowest level of salinity was observed in May 2014 near sampling camp of Mangistau Bioresource Company and the highest in August near the northern coast of Chernyshov Bay. The level of Western Large Aral Sea in investigated period was from 24.9 to 25.5 m a.s.l. The lowest was in August, the highest was in May.

Salinity in New Central Aral Sea varied from 6 g/L up to 77 g/L. The lowest level was observed in May near the Kokaral dam and the highest in August near the connection to Tsche-Bas Bay. The level of New Central Aral Sea at the place of planned southern dike was from 28.5 to 28.9 m a.s.l. and at Kokaral dam from 29.5 to 31.6 m a.s.l. The lowest level was in August, the highest was in May.

Zooplankton

Zooplankton biocenoses in Small Aral Sea mainly consist of three Rotifera, Cladocera and Copepoda (Table 2). Only few species of freshwater and brackish planktonic Protozoa were detected (Plotnikov et al., 2014; Smurov, 1995).

Five species of zooplankton were numerous: *Keratella quadrata* (Müller), *Brachionus plicatilis* Müller, *Evadne anonyx* Sars, *Calanipeda aquaedulcis* Kritchagin, *Cyclops vicinus* Uljanin and one undeterminated species of rotifers from the genus *Synchaeta* (unpublished data by Ermakhanov from institutional report).

Less numerous were ten species: *Brachionus quadridentatus* Hermann, *Brachionus calyciflorus* Pallas, *Hexarthra oxyuris* (Zernov), *Bosmina longirostris* Müller, *Chydorus sphaericus* Müller, *Ceriodaphnia reticulata* (Jurine), *Podonevadne camptonyx* (Sars), *Phyllodiaptomus blanci* (Guerne et Richard), *Mesocyclops leuckarti* (Claus), *Acanthocyclops viridis* (Jurine). Copepod taxa from order Harpacticoida were also less numerous (unpublished data by Ermakhanov from institutional report).

Seven species of zooplankton mainly from rotifers group were very rare and all of them were observed only in summer time: *Asplanchna priodonta* Gosse, *Keratella cochlearis* (Gosse), *Notholca acuminata* (Ehrenberg), *Filinia longiseta* (Ehrenberg), *Moina mongolica* Daday, *Diaphanosoma brachyurum* Lievin, *Podonevadne angusta* groups: (Sars) (unpublished data by Ermakhanov from institutional report).

In Tsche-Bas Bay only two species of zooplankton were numerous: brine shrimp *Artemia parthenogenetica* Bowen et Sterling from May till September, and halophilic ciliate *Fabrea salina* Henneguy during all summer months from June till August (Plotnikov et al., 2014).

Zooplankton species *Moina mongolica* was very rare and only few individuals (parthenogenetic females) were observed only in summer time.

In Western Large Aral Sea (Only Chernyshov Bay) only one species of zooplankton brine shrimp *Artemia parthenogenetica* was numerous due to high salinity. It occurs from May till September. One species of halophilic ciliate *Fabrea salina* was observed only at the end of summer in August and was very rare (Plotnikov et al. 2014).

Near the Kokaral dam the biodiversity of zooplankton is the highest. Three species were numerous: *Keratella quadrata*, *Brachionus plicatilis*, *Calanipeda aquaedulcis*, seven species were less numerous: *Brachionus quadridentatus*, *Bosmina longirostris*, *Chydorus sphaericus*, *Ceriodaphnia reticulata*, *Phyllodiaptomus blanci*, *Mesocyclops leuckarti*, *Acanthocyclops viridis*.

Near connection to Tsche-Bas Bay the biodiversity of zooplankton are the lowest. Only three species of zooplankton were numerous: brine shrimp *Artemia parthenogenetica* Plotnikov et al., 2014, euryhaline *Moina mongolica* from May till September, and halophilic ciliate *Fabrea salina* during all summer months from June till August.

Zoobenthos

Zoobentic biocenosis in Small Aral Sea mainly consists of groups: Polychaeta, Mollusca, Crustacea, Insecta/Diptera (Table 3). Only few species of Foraminifera and Nematoda were found in samples (Filippov et al. 1993; Plotnikov et al. 2014).

Four species of zoobenthos were numerous: *Hediste diversicolor* (Müller), *Chironomus plumosus* (L.), *Syndosmya segmentum* Récluz, *Cyprideis torosa* (Jones) (Plotnikov et al., 2014; unpublished data by Ermakhanov from institutional report).

Six species of zoobenthos were less numerous: *Chironomus behningi* Goetghebuer, *Glyptotendipes gripekoveni* Kieffer, *Limnocythere aralensis* Schornikov, *Limnocythere inopinata*

Table 2: Taxonomic composition of zooplankton in the Small Aral Sea in in the years 2011 – 2013 (species only found in the samples are indicated).
Tabela 2: Taksonomska sestava zooplanktona v Malem Aralu v letih 2011 – 2013 (naštete so le vrste, ki so bile najdene v vzorcih).

Taxon	Occurrence, %		
	2011	2012	2013
Rotifera			
Asplanchna priodonta Gosse	-	5	5
Synchaeta spp.	50	60	74
Keratella quadrata (Gosse)	68	77	74
Keratella cochlearis (Gosse)	-	-	5
Brachionus quadridentatus Hermann	41	40	26
B. calyciflorus Pallas	-	9	26
B. plicatilis Müller	23	40	68
Notholca acuminata Ehrenberg	5	5	5
Filinia longiseta (Ehrenberg)	23	27	-
Hexarthra oxyuris (Zernov)	5	36	37
Cladocera			
Bosmina longirostris (Müller)	10	18	21
Chydorus sphaericus (Müller)	15	23	26
Moina mongolica Daday	10	9	-
Ceriodaphnia reticulata (Jurine)	15	36	21
Diaphanosoma brachyurum (Lievin)	-	-	5
Podonevadne angusta (Sars)	5	5	-
P. camptonyx (Sars)	10	5	37
Evadne anonyx Sars	73	73	79
Copepoda			
Phyllodiaptomus blanci (Guerne et Richard)	14	14	11
Calanipeda aquaedulcis Kritschagin	100	100	100
Cyclops vicinus Uljanin	60	86	79
Mesocyclops leuckarti (Claus)	20	23	26
Acanthocyclops viridis (Jurine)	28	36	32
Harpacticoida gen. sp.	25	14	26

(Baird), *Tyrrenocythere amnicola donetziensis* (Dubowsky),

Amnicythere cymbula (Livental), unspecified species from genera *Chironomus*, *Candona* and family Ceratopogonidae were also less numerous (Plotnikov et al. 2014; unpublished data by Ermakhanov from institutional report).

Four species of zoobenthos were very rare and all of them were observed from May till September: *Dreissena polymorpha aralensis* (Andrusov), *Cerastoderma isthmicum* Issel, *Paramysis intermedia* (Czerniavsky), *Palaemon elegans* Rathke. Unspecified species from genus *Chironomus* and family Ceratopogonidae were also less numerous (Plotnikov et al., 2014; unpublished data by Ermakhanov from institutional report).

Unspecified species from genera *Cryptochironomus*, *Cladotanytarsus*, *Tanytarsus*, *Caspiohydrobia* were very rare and all of them were observed from May till September (unpublished data by Ermakhanov from institutional report).

Table 3: Taxonomic composition of zoobenthos in Small Aral Sea in in the years 2012 – 2013 (species only found in the samples are indicated).

Tablela 3: Taksonomska sestava zoobentosa v Malem Aralu v letih 2012 – 2013 (naštete so le vrste, ki so bile najdene v vzorcih).

Taxa	Occurrence, %	
	2012	2013
Polychaeta		
Hediste diversicolor (Müller)	86	80
Insecta: Diptera		
Chironomus behningi (Goetghebuer)	25	18
Chironomus sp.	-	36
Ch. plumosus (Linne)	50	50
Glyptotendipes gripekoveni (Kieffer)	-	10
Cryptochironomus sp.	30	5
Cladotanytarsus sp.	-	8
Tanypus villipennis (Kieffer)	-	8
Tanytarsus sp.	17	8
Ceratopogonidae gen. sp.	-	18
Mollusca: Bivalvia		
Syndosmya segmentum Récluz	60	46
Dreissena polymorpha aralensis (Andrusov)	5	4
Cerastoderma isthmicum Issel	25	4
Mollusca: Gastropoda		
Caspiohydrobia spp.	5	-
Crustacea		
Paramysis intermedia (Czerniavsky)	-	4
Palaemon elegans Rathke	5	-

In Tsche-Bas Bay three species of zoobenthos were numerous from May till September: salt tolerant halophilic ostracod *Eucypris inflata* (Sars), euryhaline ostracod *Cyprideis torosa* (Jones) and halophilic larvae of *Chironomus salinarius* Kieffer (Plotnikov et al. 2014).

Two species of zoobenthos were very rare: euryhaline Turbellaria *Mecynostomum agile* (Beklemischev) and large ciliate *Frontonia marina* Fabre-Domergue. Unspecified species of foraminifers and nematodes were also were very rare (Plotnikov et al. 2014).

In Western Large Aral Sea (Only Chernyshov Bay) only one species of zoobenthos halophilic larvae of *Chironomus salinarius* were numerous and present from May till September. One rare species of zoobenthos was found: large ciliate *Frontonia marina*. Very rare were unspecified species of foraminifers and nematodes (Plotnikov et al. 2014).

Near the Kokaral dam the biodiversity of zoobenthos is the highest. Four species were numerous: *Hediste diversicolor* (Müller), *Chironomus plumosus* (L.), *Syndosmya segmentum*, *Cyprideis torosa*. The following four species such as *Chironomus behningi* Goetghebuer, *Limnocythere aralensis*, *Tyrrenocythere amnicola donetziensis*, *Amnicythere cymbula* were less numerous, while species *Cerastoderma isthmicum* and *Palaemon elegans* were very rare.

Near the connection to Tsche-Bas Bay the biodiversity of zoobenthos was the lowest. Three species of zoobenthos from May till September were numerous and occurred from May till September: salt tolerant halophilic ostracod *Eucypris inflata* (Sars), euryhaline ostracod *Cyprideis torosa* and halophilic larvae of *Chironomus salinarius*. Euryhaline large ciliate species *Frontonia marina* was very rare. Unspecified species of foraminifers and nematodes were also were very rare (Plotnikov et al. 2014).

Fish

In Small Aral Sea 14 species of commercial fish were numerous: pike *Esox lucius* Linnaeus, bream *Abramis brama orientalis* Berg, asp (zherekh) *Aspius aspius iblioides* (Kessler), crucian carp *Carassius carassius gibelio* Bloch, Aral shemaya *Chalcalburnus chalcoides aralensis* (Berg), carp *Cyprinus carpio aralensis* Spitshakow, grass carp *Ctenopharyngodon idella* (Valenciennes), sabrefish *Pelecus cultratus* (Linnaeus), Aral roach *Rutilus rutilus aralensis* Berg, rudd *Scardinius erythropthalmus* (Linnaeus), wels *Silurus glanis* Linnaeus, perch *Perca fluviatilis* (Linnaeus), pike perch or zander *Stizostedion lucioperca* (Linnaeus), Black Sea flounder *Platichthys flesus* (Linnaeus) (Ermakhanov et al. 2012) (Table 4).

Less numerous were 4 species: white-eye bream *Abramis sapa aralensis* Tjapkin, silver carp *Hypophtalmichthys molitrix* (Valenciennes), orfe *Leuciscus idus oxianus* (Kessler), snakehead *Channa argus warpachowskii* Berg (Ermakhanov et al. 2012).

Only 5 species of commercial fish were very rare: Baltic herring *Clupea harengus membras* (Linnaeus), spotted silver carp *Aristichtys nobilis* (Richardson), black carp *Mylopharyngodon piceus* (Richardson), Aral barbel *Barbus brachycephalus brachycephalus* Kessler, Turkestan barbel *Barbus capito conocephalus* Kessler (Ermakhanov et al. 2012). Fishery is under control by authorities.

Nine fish species in the lake are not commercial. Six of them are numerous: ruff *Gymnocephalus cernuus* (Linnaeus), nine-spined stickleback *Pungitius platygaster aralensis* (Kessler), Caspian atherine *Atherina boyeri caspia* Eichwald, bubyr goby, transcaucasian goby *Pomatoschistus caucasicus* Berg [= *Knipowitschia caucasica* (Berg)], sand goby *Neogobius fluviatilis pallasi* (Berg), round goby *Neogobius melanostomus affinis* (Eichwald) (Ermakhanov et al., 2012). Three species of not commercial fish are rare: syrman goby *Neogobius syrman eurystomus* (Kessler), tubenose goby *Proterorchinus marmoratus* (Pallas), bighead goby *Neogobius kessleri gorlap* Iljin (Ermakhanov et al. 2012).

In Tsche-Bas Bay and in Western Large Aral Sea (Only Chernyshov Bay) fish are not living now due to high salinity (Ermakhanov et al. 2012).

The highest biodiversity of fish was found near the Kokaral dam. Nine species of commercial fish were numerous: pike *Esox lucius* Linnaeus, bream *Abramis brama orientalis* Berg, Aral shemaya *Chalcalburnus chalcoides aralensis* (Berg), carp *Cyprinus carpio aralensis* Spitshakow, Aral roach *Rutilus rutilus aralensis* Berg, wels *Silurus glanis* Linnaeus, perch *Perca fluviatilis* (Linnaeus), pike perch or zander *Stizostedion lucioperca* (Linnaeus), Black Sea flounder *Platichthys flesus* (Linnaeus).

Two species of commercial fish were less numerous: silver carp *Hypophtalmichthys molitrix* (Valenciennes) and snakehead *Channa argus warpachowskii* Berg.

Near connection to Tsche-Bas Bay the biodiversity of fish is the lowest. Only one species of commercial fish was very rare in this part of the New Central Aral Sea. Black Sea flounder *Platichthys flesus* was caught several times from May to June (Ermakhanov et al. 2012).

Table 4: Species composition of ichthyofauna in the Small Aral Sea.
Tabela 4: Vrstna sestava ihtiofavne v Malem Aralu.

Taxa	Status
Esocidae	
Esox lucius Linnaeus (Pike)	A, C-
Cyprinidae	
Rutilus rutilus aralensis Berg (Aral roach)	A, C
Leuciscus idus oxianus (Kessler) (Orfe)	A, C-
Aspius aspius iblioides (Kessler) (Asp, zherekh)	A, C
Scardinius erythropthalmus (Linnaeus) (Rudd)	A, C-
Barbus capito conocephalus Kessler (Turkestan barbell)	A, C-, RB
Barbus brachycephalus brachycephalus Kessler (Aral barbell)	A, C-, RB
Abramis brama orientalis Berg (Bream)	A, C
Abramis sapa aralensis Tjapkin (White-eye bream)	A, C-
Chalcalburnus chalcoides aralensis (Berg) (Aral shemaya)	A, C-
Pelecus cultratus (Linnaeus) (Sabrefish)	A, C-
Carassius carassius gibelio Bloch (Crucian carp)	A, C-
Cyprinus carpio aralensis Spitshakow (Carp)	A, C
Ctenopharyngodon idella (Valenciennes) (Grass carp)	I, C-
Hypophtalmichthys molitrix (Valenciennes) (Silver carp)	I, C-
Aristichtys nobilis (Richardson) (Spotted silver carp)	I, C-
Mylopharyngodon piceus (Richardson) (Black carp)	I, C-
Siluridae	
Silurus glanis Linnaeus (Wels)	A, C-
Gasterostidae	
Pungitius platygaster aralensis (Kessler) (Nine-spined stickleback)	A, NC
Percidae	

Stizostedion lucioperca (Linnaeus) (Pike perch, zander)	A, C
Perca fluviatilis Linnaeus (Perch)	A, C-
Gymnocephalus cernuus (Linnaeus) (Ruff)	A, NC
Clupeidae	
Clupea harengus membras (Linnaeus) (Baltic herring)	I, C--
Atherinidae	
Atherina boyeri caspia Eichwald (Caspian atherine)	I, NC
Gobiidae	
Pomatoschistus caucasicus Berg (Bubyr goby, transcaucasian goby) [= *Knipowitschia caucasica* (Berg)]	I, NC
Neogobius fluviatilis pallasi (Berg) (Sand goby)	I, NC
Neogobius melanostomus affinis (Eichwald) (Round goby)	I, NC
Neogobius syrman eurystomus (Kessler) (Syrman goby)	I, NC
Proterorchinus marmoratus (Pallas) (Tubenose goby)	I, NC
Neogobius kessleri gorlap Iljin (Bighead goby)	I, NC
Channidae	
Channa argus warpachowskii (Berg) (Snakehead)	I, C
Pleuronectidae	
Platichthys flesus (Linnaeus) (Black Sea flounder)	I, C

Abbreviations: A – aboriginal; I – introduced; C – commercial; C- – commercial but low stocks C-- – while commercial but stocks very low for fishery; NC – not commercial; RB – in Red Book.

All above mentioned data collected from May till September is the evidence of great practical and commercial importance of all four Aral Sea Areas in Republic of Kazakhstan: Small Aral Sea, Tsche-Bas Bay, Western Large Aral Sea (Only Chernyshov Bay), New Central Aral Sea.

As it is said in the introduction to this paper big positive changes in Aral Sea environment and in Aral Sea fisheries happened immediately after construction of a Kokaral dam in the Berg strait. Today local people and Kazakhstan Government are discussing an idea to improve this dike. We are supporting this discussion and we advise to make it higher from 42-43 meters above ocean level up to 46 - 48 meters as it was advised by us in 1992.

We also propose to build two more dams in addition to this Central dam:

1) The Northern dam could be build in the entrance to the Bolshoy Sarychaganak Bay near Trekhgorka place (three-headed mountain place in English). The canal from Kamyslibash Lake to Bolshoy Sarychaganak Bay should be build too. The dam should be as high as 49-50 meters a.s.l. Geographical coordinates of future dike could be N 49°29’16”, E 61°15’51”.

2) The Southern dam could be build at the southern edge of New Central Aral Sea where it unites with Tsche-Bas Bay. This dam will enable keeping the water that is running away from Kokaral dam in Republic of Kazakhstan via its spillway. Geographical coordinates of future dike could be N 45°55’37”, E 59°40’15”.

New Central Aral Sea which appeared in 2005 - 2006 after new Kokaral dam was built in

comparison to the other three parts of the Aral Sea described in the article is studied very poor. Fauna is not studied yet so more studies should be done as soon as possible.

Povzetek

Usoda četrtega največjega jezera na svetu do leta 1980, je sicer poznana tudi svetovni javnosti, veliko manj pa je bilo objav o spremembah ekološkega stanja, življenjskih združb in posebno gospodarsko pomembnih rib. Članek govori o kemizmu in slanosti, biodiverziteti planktonskih, bentoških in ribjih združb v različnih letih, ekološkem stanju in hidrološkem režimu ter možnosti ohranjanja in izboljšanja trenutnega stanja predvsem v severnem delu nekdanjega jezera, danes imenovanega Mali Aral.

Hidrološki režim jezera se je drastično začel spreminjati že kmalu po letu 1960, ko so Sovjeti z regulacijami preusmerili dve veliki reki, Syr Darjo in Amu Darjo, ki sta sicer polnili veliko Aralsko jezero. Razlog preusmeritve rek je bilo namakanje velikih površin posajenih z bombažem v nekdanjih sovjetskih republikah Uzbekistanu in Kazahstanu. Vode je jezeru je pričelo primanjkovati, gladina se je hitro zmanjševala in že v 80. letih prejšnjega stoletja se je veliko jezero razdelilo v dva bazena, severni Mali Aral in južni Veliki Aral s povsem drugim hidrološkim režimom. Slanost v teh bazenih se je izjemno povečala, marsikje je dosegla vrednost prek 100 g/L soli. To je bil začetek vrstnega siromašenja življenjskih združb, izumiranja nekaterih vrst, med njimi tudi gospodarsko pomembnih rib. Jezersko dno je postalo puščavsko območje, ki je vsebovalo tudi različne toksične snovi, posledice kemijskih in bioloških poskusov v času hladne vojne. Biotsko izjemno diverzitetni otok Barsakelmes je postal puščavski.

Raziskovalci so skušali rešiti preostanek severnega dela z izgradnjo večjega nasipa in jezu imenovanega Kokaral v bližini delte Syr Darje, ki je preprečeval odtekanje vode v puščavo. Nivo vode se je nekoliko zvišal, predvsem pa se ni več zmanjševal. Največji učinki so se pokazali v slanosti, ta se je zmanjšala pod 10 g/L, zato so se vrnili mnogi nevretenčarji v planktonu in bentosu in z njimi tudi nekatere ribje vrste predvsem iz porečja in manjših jezer prispevnega območja. Ribje populacije v Malem Aralu so danes v dobrem stanju in omogočajo tudi kontroliran in za nekatere vasi gospodarsko pomemben ribolov. Usoda južnega Velikega Arala pa je še naprej negotova, v suhem letu 2014 je v del te kotanje povsem presušil.

Planktonska združba je danes v Malem Aralu zmerno pestra, prevladujejo vrste iz skupin Rotifera, Cladocera in Copepoda, nekaj je protozojskih vrst. Pet vrst je zelo pogostih, med njimi rotatorija *Keratella quadrata* in *Brachiounus plicatilis*, vodna bolha *Evadne anonyx* in dve vrsti kopepodov *Calanipeda aquaedulcis* in *Cyclops vicinus*. Poleg teh je manj pogostih še deset vrst in zelo redkih, ter še vedno ogroženih sedem vrst, med njimi nekatere, v drugih jezerih sicer zelo pogoste vrste, npr. *Keratella cochlearis*, *Filinia longistea* ter *Moina mongolica*.

Podobno pestra je tudi združba nevretenčarjev v bentosu, sestavljena predvsem iz skupin Polychaeta, Mollusca, Crustacea in Diptera. Zelo pogosta vrsta je *Chironomus plumosus*, ki je značilen predstavnik občasno anoksičnih jezerskih sedimentov in obenem dobro prilagojen na večjo slanost. Zelo pogost je tudi polihet *Hediste diversicolor*, ki kaže na slan tip celinskega vodnega telesa. Marsikje invazivna vrsta *Dreissena polymorpha aralensis* se v Malem Aralu sporadično pojavlja in je zelo redka.

Posebna pozornost je bila v naših raziskavah dana ribjim združbam. Kar 14 vrst gospodarsko pomembnih rib je danes v Malem Aralu, med njimi bi izpostavili ščuko *Esox lucius*, krapa *Carassius carassius gibelio*, aralsko vrsto rdečeoke *Rutilus rutilus aralensis* in *Platichthys flesus*, ki velja za eno najbolj okusnih rib. Manj pogosta je vrsta aralskega ploščiča *Abramis sapa aralensis*. Izlov dveh redih, sicer gospodarsko pomembnih vrst poher, aralske pohre *Barbus brachycephalus brachycepahlus* in turkestanske pohre *B. capito conecephalus*, je strogo kontroliran. V jezeru je kar devet vrst gospodarsko nepomembnih rib, med njimi tudi endemne. Njihov obstoj ni vezan na ribištvo, ampak na ekološke razmere v malem Aralu.

Kazahstanska vlada si močno prizadeva vzdrževati pridobljeno ekološke stanje v Malem Aralu in ga celo izboljšati z nadgradnjo in obnovo jezu Kokaral ter gradnjo dveh novih pregrad. Veliko bolj negotova je usoda Velikega Arala, kjer

nižanje vodostaja in slanostne razmere omogočajo preživetje le nekaterim zelo specializiranim nevretenčarskim vrstam.

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