Doctor of Sciences, Professor ***N. V. Aladin***
(*Zoological Institute of RAS, St. Petersburg*)
PhD ***Ph. Micklin***
(*Western Michigan University, Kalamazoo, US*A)
PhD ***I. S. Plotnikov***
(*Zoological Institute of RAS, St. Petersburg*)

THE PARTIAL RESTORATION OF THE ARAL SEA AND THE BIOLOGICAL, SOCIO-ECONOMIC AND HEALTH CONDITIONS IN THE REGION

An article describes the project of the partial restoration of the Aral Sea and how it can influence biological, social, economical and health conditions in the region. History of the lake is analysed, biological diversity of the water body is shown in progress, influence of shoaling on health of people, living in the region is explained. Measures to make situation better are shown, as well as their potential influence on all aspects of life in the region, including political relationships of countries of the region.

Keywords: *Aral sea, Middle Asia, lake, biological diversity, health, foreign policy*.

ILBM is a way of thinking that assists Lake Basin managers and stakeholders in achieving sustainable management of lakes and their basins[1]. It takes into account that lakes have a great variety of resource values whose sustainable development and use require special management considerations for their lentic (static) water properties. In our studies of the Aral Sea we are using the IL_2BM platform (Integrated Lotic/Lentic Basin Management).

Fifty years ago the Aral Sea was the 4th largest lake in the world by surface area. The main parameters of the Aral Sea in the middle of 20th century were: area: 67,499 km^2 (Large Aral 61,381 km^2 and Small Aral 6118 km^2), volume: 1089 km^3 (Large Aral 1007 km^3 and Small Aral 82 km^3), level: +53.4 m above sea level, maximal depth: 69 m, salinity: about 10 g/l (Table 1) [1]. In those days, the Aral Sea was inhabited by about 20 species of fishes (Table 2) and about 200 species of free-living invertebrates. In the Aral Sea, there were the following numbers of aboriginal free-living animals species (without Protozoa and some small Metazoa): fishes – 20, Coelenterata – 1, Turbellaria – 12, Rotatoria – about 90, Oligochaeta – 10, Cladocera – 14, Copepoda – 7, Harpacticoida – 15, Ostracoda – 11, Malacostraca – 1, Insecta larvae – 25, Hydracarina – 7, Bivalvia – 9, Gastropoda – 3 [10].

Between the middle of the 19th century and 1961, the shape and salinity of the Aral Sea practically did not change. We must note, however, that due to both the intended and the accidental introductions that started in the 1920s, the number of free-living animals grew substantially. In the Aral Sea appeared (Table 3, 4): fishes – 17, Mysidacea – 5, Decapoda – 2, Copepoda – 1, Polychaeta – 1, Bivalvia – 1 [9; 10]. Originally fishes and invertebrates were introduced in order to increase the number of commercial fish species and in order to increase food resources for them. Later, when the salinity of the Aral Sea began to rise, fishes and invertebrates were introduced which were capable of adapting to the increasing salinity. The most successful was the introduction of the salt tolerant flounder (*Platichthys flesus*). The most successful introduction of invertebrates was the introduction of the bivalve mollusk *Syndosmya segmentum* and the polychaete worm *Hediste diversicolor* [9; 10]. Both of the invertebrates introduced are of great importance for flounder nutrition. We also should note that during the introduction of fishes and invertebrates, some accidental introductions took place, too. Some accidentally introduced fishes and invertebrates had negative impacts. About 100 years of introduction activities allow us now to conclude that in the case of the Aral Sea the introductions of fishes and invertebrates have had more negative than positive consequences.

[1] Integrated Lake Basin Management (ILBM). – URL: http://www.ilec.or.jp/en/activity

Table 1

Hydrological and Salinity Characteristics of the Aral Sea, 1960–2015*

Year and portion of sea	Level (meters asl)	Area (km²)	% 1960 area	Volume (km³)	% 1960 volume	Average depth (meters)	Avg. salinity (g/l)	% 1960 salinity
1960 (all)	53,4	67,499	100	1,089	100	16,1	10	100
Large	53,4	61,381	100	1,007	100	16,4	10	100
Small	53,4	6,118	100	82	100	13,4	10	100
1971 (all)	51,1	60,200	89	925	85	15,4	12	120
1976 (all)	48,3	55,700	83	763	70	13,7	14	140
1989 (all)		39,734	59	364	33	9,2		
Large	39,1	36,930	60	341	34	9,2	30	300
Small	40,2	2,804	46	23	28	8,2	30	300
Sept 22, 2009 (all)		7,146	10,6	83	7,7	10,8		
W. Basin Large	27	3588	26,2	56	17,9	15,1	>100	>1000
E. Basin Large	27	516	1,1	0,64	0,07	0,7	>150?	>1500
Tshche-bas Gulf	28	292		0,51	7,1	1,4	~85	850
Small	42	3200	52	27	33	8,4	8	100–130
8/29 and 11/25, 2014 (all)		6,990	10,4	48,2	4,4	6,9		
W. Basin Large	25,0	3,120	22,8	54	17,2	15,4	>150	>1000
E. Basin Large	25	0	0	0	0	0	0	0
Tshche-bas Gulf	28,5	372		0,72		1,4	89	890
Small	41,9	3197	52,3	27	33,2	8,5	6–8	0,6–0,8

* *Sources:* Values for 1960-1989 from Micklin, Philip (2010), «The past, present, and future Aral Sea», *Lakes & Reservoirs: Research and Management*, 15, Table 1, p. 195; Area data for 2009 and 2014 calculated from MODIS 250 meter resolution natural color images and Landsat 8 natural color images (30 meter resolution) using ImageJ software; Volume data for 2009 and 2014 calculated from area changes; Salinity data for 2009 author estimates based on measurements taken with a YSI-85 electronic meter during an expedition to the Aral Sea in September 2007 and data provided by Dr. N. Aladin of the Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia, on salinity measurements taken in 2008; Salinity data for 2013 based on measurements taken with the YSI-85 meter and an optical refractometer during an expedition to the Aral Sea in August and September 2011; Salinity data for 2014 based on data provided by Dr. Aladin from an expedition to the Aral in 2014.

Table 2

Species composition of the Aral Sea aboriginal ichthyofauna*

Species	Status
Ship sturgeon *Acipenser nudiventris*	C-, E
Aral trout *Salmo trutta aralensis*	C-, E
Pike *Esox lucius*	C-
Aral roach *Rutilus rutilus aralensis*	C
Orfe *Leuciscus idus oxianus*	C-
Asp, zherekh *Aspius aspius iblioides*	C
Rudd *Scardinius erythropthalmus*	C-
Turkestan barbel *Barbus capito conocephalus*	C-, RB
Aral barbel *Barbus brachycephalus brachycephalus*	C-, RB
Bream *Abramis brama orientalis*	C
White-eye bream *Abramis sapa aralensis*	C-
Aral shemaya *Chalcalburnus chalcoides aralensis*	C-
Sabrefish *Pelecus cultratus*	C-
Crucian carp *Carassius carassius gibelio*	C-
Carp *Cyprinus carpio aralensis*	C
Wels *Silurus glanis*	C-
Nine-spined stickleback *Pungitius platygaster aralensis*	NC
Pike perch, zander *Stizostedion lucioperca*	C
Perch *Perca fluviatilis*	C-
Ruff *Gymnocephalus cernuus*	NC

* *Note*: C – commercial; C- – commercial but low stocks; NC – not commercial; RB – in Red Book; E– extinct.

Since 1960 the Aral Sea has steadily shrunk and shallowed owing overwhelmingly to irrigation withdrawals from its influent rivers (Amu Dar'ya and Syr Dar'ya) (Table 1). At the end of 1980s, when the water level dropped by about 13 m and reached about +40 m, the Aral Sea divided into the Large and the Small Aral. In those days the total area of Aral Sea (Large Aral and Small Aral) was 40,000 km^2 (down 60% from 1960), volume: 333 km^3 (down 33% from 1960) and salinity: 30 g/l (10 g/l in 1960) [1]. After the division of the Aral Sea, the Northern/Small Aral Sea started to have a positive water balance. Thus, water from the Syr Dar'ya River, ground inflow, and precipitation on the seas surface were contributing in total more water than evaporated from the surface of the Small Aral. In the case of the Large Aral Sea, the water balance continued to be negative. Thus, evaporation from its surface continued to be significantly higher than the total amount of water reaching it. Due to the positive water balance in the Northern/Small Aral Sea, a flow of excess water from it to the Large Aral Sea commenced. This discharge of water from the Small Aral occurred primarily in spring-early summer and corresponded to the high flow period on the Syr Dar'ya.

.

Table 3

Introduced fish species in the Aral Sea*

Species	Years of introduction	Source	Way	Status in the 2000s
Baltic herring *Clupea harengus membras*	1954–1959	Baltic Sea	A	R
Grass carp *Ctenopharyngodon idella*	1960–1961	China	A	C-
Silver carp *Hypophtalmichthys molitrix*	1960–1961	China	A	C-
Spotted silver carp *Aristichtys nobilis*	1960–1961	China	A	C-
Black carp *Mylopharyngodon piceus*	1960–1961	China	A+	C-
Black-striped pipefish *Syngnathus abaster caspius*	1954–1956	Caspian Sea	A+	?
Caspian atherine *Atherina boyeri caspia*	1954–1956	Caspian Sea	A+	R, NC
Bubyr goby, transcaucasian goby *Pomatoschistus caucasicus* [= *Knipowitschia caucasica*]	1954–1956	Caspian Sea	A+	NC
Sand goby *Neogobius fluviatilis pallasi*	1954–1956	Caspian Sea	A+	NC
Round goby *Neogobius melanostomus affinis*	1954–1956	Caspian Sea	A+	NC
Syrman goby *Neogobius syrman eurystomus*	1954–1956	Caspian Sea	A+	NC
Tubenose goby *Proterorchinus marmoratus*	1954–1966	Caspian Sea	A+	NC
Bighead goby *Neogobius kessleri gorlap*	1954–1956	Caspian Sea	A+	NC
Snakehead *Channa argus warpachowskii*	1960s	Kara-Kum canal	A+	C
Black Sea flounder *Platichthys flesus*	1979-1987	Sea of Azov	A	N, C

* *Way of introduction*: A – acclimatization, A+ – incidentally at planned introduction.
Status: R – rare, N – numerous, C – commercial, C- – commercial but low stocks, NC – not commercial.

River. This being the case, it was decided to build a dike on the Berg Strait to keep the water in the Northern/Small Aral Sea. In August, 1992, a basic dike was built [3].

The construction of this basic dike was reported in Geneva during the UNEP meeting in September, 1992, as a conclusion to the results of the UNEP Diagnostic Study for the Aral Sea. During this meeting, four primary paths to the conservation and rehabilitation of the Aral Sea and its ecosystems were discussed for the first time [1].

1. Conservation and rehabilitation of Small Aral.

2. Conservation and rehabilitation of the delta and deltaic water bodies of the Syr Dar'ya River.

3. Conservation and rehabilitation of the delta and deltaic water bodies of the Amu Darya River.

4. Conservation and rehabilitation of Large Aral.

Table 4

Alien free-living invertebrates in the Aral Sea*

Species	Source	Year	Way	Impact	Status
Branchiopoda					
*Artemia parthenogenetica***	Aral region	1990s–2000s	N	+	N, C
Ostracoda					
Eucypris inflata **	Aral region	1990s–2000s	N	+	N
Mysidacea					
Paramysis baeri	Don River	1958–1960	A	0	?
Paramysis lacustris	Don River	1958–1960	A	+	+
Paramysis intermedia	Don River	1958–1960	A	+	?
Paramysis ullskyi	Don River	1958–1960	AC	+	?
Limnomysis benedeni	?	?	AC	+	?
Decapoda					
Palaemon elegans	Caspian	1954–1966	A+	?	N
Rhithropanopeus harrisii tridentata	Sea of Azov	1965, 1966,	A+	+	N
Copepoda					
Calanipeda aquaedulcis	Sea of Azov	1965, 1966–1970	A	+	N
Polychaeta					
Hediste diversicolor	Sea of Azov	1960–1961	A	+	N
Bivalvia					
Syndosmya segmentum	Sea of Azov	1960, 1961, 1963	A	+	N

* *Way of introduction*: A – acclimatization, AC – by accident, A+ – incidentally at planned introduction, N – naturally. Status: R – rare, N – numerous, + – found, ? – no data. C – commercial. Impact: - negative, + positive, 0 no effect, ? unknown.

** – only in the Large Aral.

The concept paper to «Partially Preserve Small and Large Aral Seas» was proposed by M. I. L'vovich and I. D. Tsige'lnaya [6] for the Geneva meeting and was updated and modified by P. Micklin (Figure 1).

Way 1. Conservation and rehabilitation of the Small Aral and its ecosystems

The basic dike in the Berg Strait was partly destroyed a number of times by the high water level in spring but the broken parts of the dike were always later restored by local people. Unfortunately, in April, 1999, when the Small Aral Sea water level rose by more than 3 m and reached +43.5 m, the dam broke completely [8].

A new Kok-Aral dike was built by the Russian company «ZARUBEZHVODSTROY». As a result, since August, 2005, outflow has been controlled by a discharge structure (gates) in the dike. When the water gates are open at the Kok-Aral dike and there is heavy outflow, all the remaining southern water bodies of the Aral Sea are connected for some period of time [7].

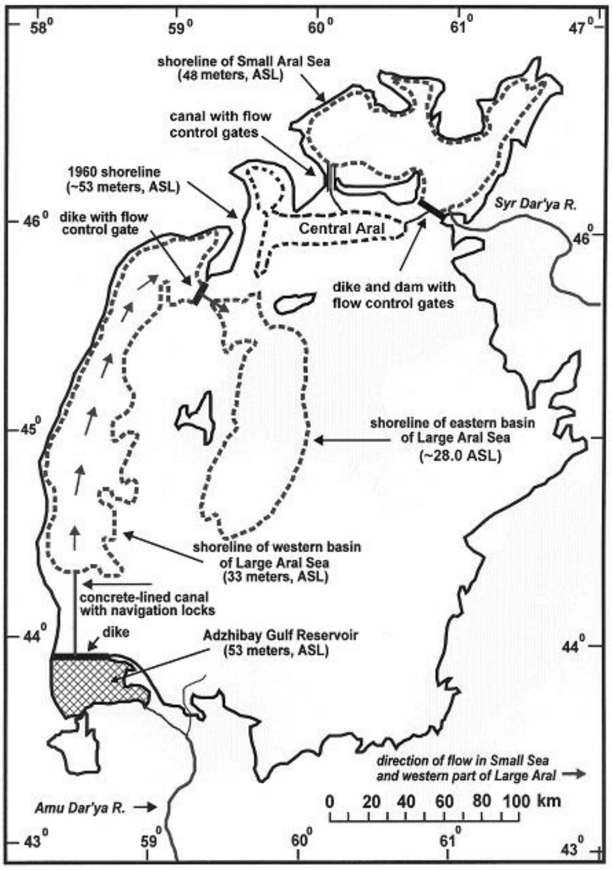

Figure 1. Optimistic Scenario of the Future Aral Sea (after 2030): Legend (figures are average annual values). *Small Aral Sea*: level = 48 m, surface area = 4 927 km^2, volume 54 km^3, river inflow = 5,0 km^3, net groundwater inflow = = 0,1 km^3, outflow = 1,0 km^3, salinity = 6–7 g/l. *Western Basin of Large Aral sea*: level = 33 m, surface area = = 6 200 km^2, volume = 85 km^3, river inflow = 6,4 km^3, net groundwater influx 2,0 km^3, avg. annual outflow to Eastern Basin of Large Aral = 3,6 km^3, salinity steadily decreasing reaching 42 g/l by 2 055 and 15 g/l by 2 110. *Eastern Basin of Large Aral Sea*: level ~28,0 m, surface area ~3,800 km^2, volume ~7,6 km^3, inflow from Western Basin of Large Aral = = 3,6 km^3, inflow from Central Aral highly variable, avg. annual salinity >200 g/l. *Adzhibay Gulf Reservoir*: level = = 53 m, surface area = 1 147 km^2, volume = 6,43 km^3, inflow = 8 km^3, outflow to Western Basin of Aral Sea = 6,6 km^3, salinity = 2g/l. ASL, above sea level, in this case is measured in relation to the Kronstadt gage near St. Petersburg, Russia.

The dike on the Berg Strait was funded by GEF and the Kazakhstan government to allow the improvement of the brackish water environment of the Small (Northern) Aral Sea. The dike on the Berg strait has allowed an increase of the water level in the Small (Northern) Aral Sea to +42 m a.s.l., and with «forcing» to 42.5 m. The present average salinity in the Small (Northern) Aral Sea is less than 10 g/l [8]. In the near future, it will decrease more. It is possible to make the present dike a bit higher and thus raise the water level to +45 m a.s.l. This increase will allow the enlargement of the volume and area of the Small (Northern) Aral Sea. An alternative 2nd phase of the project would raise the level only of the Saryshaganak Gulf. For further improvement of situation, improvements in irrigation efficiency are needed to increase the inflow from the Syr Dar'ya River.

The second phase of the project would allow further improvement in the health of the local people, a decrease in unemployment and an increase in living standards as well as income for the local families. The local economy also will be improved (fishery, shipping, etc.). The local microclimate around the Small (Northern) Aral Sea would be much better than now.

When the basic first dike in the Berg Strait was built in 1992, fishing on the Small Aral recommenced (Figure 3). After construction of the New Kok-Aral dike, conditions for fishing improved tremendously [4].

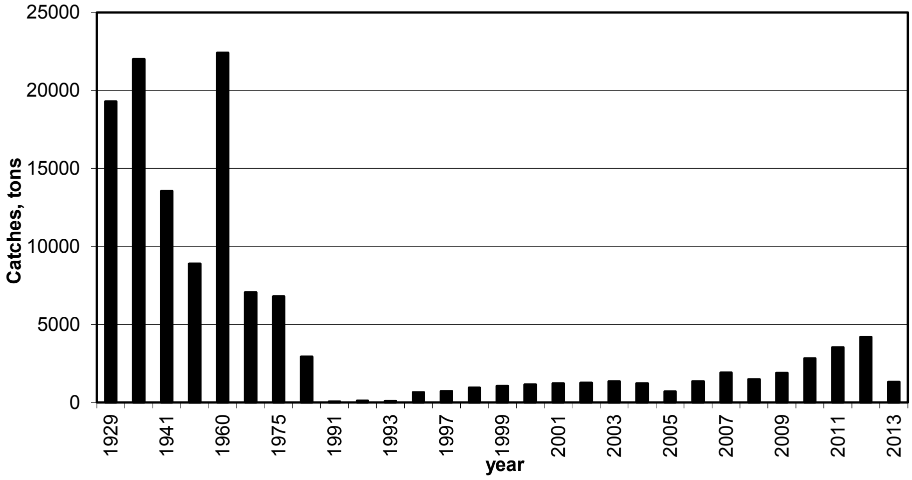

Figure 2. Commercial fish catches on the Small Aral Sea

Way 2. Conservation and rehabilitation of the Large Aral and its ecosystems

Since the Aral Sea divided into 2 lakes at the end of the 1980s, the level of the Large Aral Sea has declined. In early 2003, when the level of the Large Aral Sea dropped by 22 m and fell to about +31 m, the Large Aral Sea was practically divided into the Eastern Large and Western Large Aral. In September, 2009, the area was 4922 km^2 (8% from 1960), the volume 58 km^3 (6% from 1960), and the salinity in the Western part of the Large Aral Sea and Tschebas Bay – >100 g/l, Eastern part – >200 g/l [8]. In both lakes, salinity increased so much that all the fish disappeared and only a few free-living invertebrates survived. In the Western part and Tschebas Bay of the Large Aral Sea are to be found today: Infusoria – 2, Rotatoria – 2, Copepoda – 1, Ostracoda – 2, Branchiopoda – 1, Gastropoda – 2. In the Eastern part of the Large Aral only one species of Branchiopoda – brine shrimp *Artemia parthenogenetica – has survived*. At the end of the 20th century, this species appeared in the Large Aral Sea [9]. Today, industrial harvesting of brine shrimp cysts has started. *Artemia* cysts (or eggs) is a semi-product and is nourishing fodder for fingerlings and small fish or shrimp.

A special waterway and water discharge gates were built in 2004–2005 to supply the eastern depression of the Large Aral from the Mezhdurechensky reservoir via the Akdarya river bed. Unfortunately, the completed spillway and water gates failed soon after being put into operation in autumn, 2005. A new waterway and water discharge gates were built and water from the Amu Dar'ya River via the Mezhdurechensky reservoir and via the Akdarya river bed is coming to the Eastern Large Aral Sea.

Health problems of the local people

Salt, sand and dust are being blown from the dried Large Aral seabed and are adversely affecting the health of the local people. Health experts say the local population suffers from high levels of: 1) respiratory illnesses; 2) throat and esophageal cancer; 3) digestive disorders; 4) high blood pressure due to breathing and ingesting salt-laden air and water; 5) liver and kidney ailments; 6) eye problems. The loss of fish in Large Aral Sea has also greatly reduced dietary variety, worsening malnutrition and anemia, particularly in pregnant women.

Vozrozhdeniya (Resurrection) Island poses an unique problem

This Island was once a small, remote outcrop in the middle of the Aral Sea.

Beginning in 1952 the Soviet Union used the island as a testing ground for super-secret biological weapons. Genetically modified and weaponized pathogens were tested on horses, monkeys, sheep, donkeys and laboratory animals, including: anthrax, tularemia, brucellosis, plague, typhus, Q fever, smallpox, botulinum toxin, and Venezuelan equine encephalitis. Fishermen and local residents worried about reports of mass deaths of animals and fish, as well as infectious diseases among the people who worked on the island.

Upon the Soviet Union's collapse in 1991, the military allegedly decontaminated the island. However, due to receding waters, by 2001 Vozrozhdeniya had become part of the mainland to the south. Health experts feared that weaponized organisms such as anthrax had survived and could escape to the mainland via fleas on infected rodents, which are numerous on the now dry lands, or that terrorists might gain access to the organisms. In 2002, the U.S. sent $6 million and a team of experts to help Uzbekistan destroy any remaining pathogens.

Evidences of the previous desiccations of the Aral Sea

There is much evidence of previous desiccations of the Aral Sea. Remnants of medieval saxauls were found on the dried seabed. Remnants of medieval saxauls were also found under the water. Coring in the Aral Sea and paleolimnological analysis of available cores showed not only medieval dedication but also much earlier desiccations. Archeological studies also confirmed previous desiccations of the Aral Sea. The ruins of a medieval mausoleum (Kerdery) were found on the dried bottom. Bones of *Homo sapiens* and domestic animals were found near the mausoleum. Millstones were found on the bottom of the Aral Sea not far from Kerdery mausoleum. Elements of ceramics, needles and arrow-heads were found on the bottom of the Aral Sea again not far from the Kerdery mausoleum [2; 5].

Paleo hydrographic studies also revealed evidence of the previous desiccations of the Aral Sea. Remnants of Medieval river beds are clearly seen on the former Aral Sea bottom [5] (Figure 3). A fossil (probably Medieval) canal between the Western and Eastern Large Aral Seas was discovered by Prof. Dr. Rene Letolle and predicted by Dr. David Piriulin.

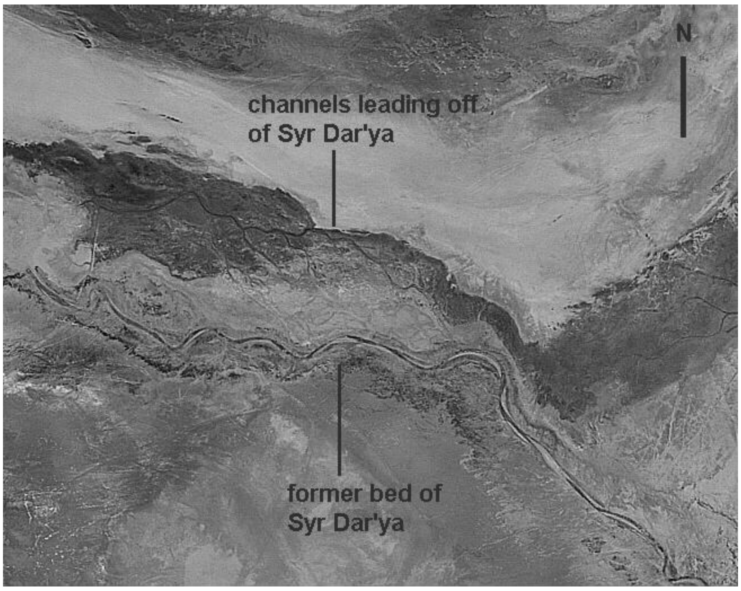

Figure 3. Landsat 5 band 5 Image of September 11, 2007 showing former channel of Syr Dar'ya on dried bottom of Eastern Basin of the Large Aral with sub-channels leading off to the northwest

Source: U.S.G.S. Global Visualization Viewer (Glovis). – URL: http://glovis.usgs.gov

The modern desiccation of the Aral Sea is changing the names of the separated areas of it

The Small (Northern) Aral Sea acquired a common name – in its short form, the «Kazaral Sea» or «Kazakhstan Aral Sea». While the correct scientific name is – Northern Aral Sea derived from the brackish-water regulated reservoir.

The Western Large (Southern) Aral Sea also acquired a common name – in short, the «Western Uzaral» or «Uzbekistan Aral Sea». The correct scientific name is – Aral Sea derived from the southwest hyperhaline non-regulated lake.

Likewise, the eastern Large (Southern) Aral Sea acquired a common name – in short «Eastern Uzaral» or «Eastern Uzbekistan Aral Sea». The correct scientific name is – Aral Sea derived from the southeast hyperhaline non-regulated lake.

The former Tschebas Bay also acquired a common name – «Tschebas-Kul». The correct scientific name is – Aral Sea derived from Tschebas hyperhaline non-regulated lake.

The strait between the Eastern and Western Large Aral has a common name – «Uzun-Aral». The correct scientific name is the natural channel between the Eastern and Western Large Arals.

Eastern Large (Southern) Aral («Eastern Uzaral») periodically receives inflow from the Amu Darya during high flow years on that river (e.g. 2010). Unfortunately, the newly reborn Eastern Large Aral is very shallow and dries up soon after water inflow from the Amu Darya ceases. It is unfortunate that this event is occasional and is not repeated annually.

At present the Aral Sea is divided into a number residual parts (lotic and lentic). The Large Aral Sea currently is the most ecologically devastated part of the lake. In the beginning of the 21st century, it was divided into three parts: Western Large Aral Sea, Eastern Large Aral Sea and Tsche-Bas Bay [9; 10]. The future of the Large Aral Sea is connected with oil and gas extraction from the dry seabed and with brine shrimp cysts harvested in the Western Large Aral Sea. Currently only the Small (Northern) Aral Sea can be used for fishing.

The new Kok-Aral dike could be made a bit higher. In this case, the volume of this reservoir would increase and more fish could be caught. To the north of the New Kok-Aral dike in the entrance to Saryshaganak Gulf one more dike could be built, too [7]. Moreover, to the south of the New Kok-Aral dike a third dike could be made. If in the future 2 more dikes were built, it would be possible to have year round fishing in all reservoirs controlled by these dikes, as we have now year round fishing in the Small (Northern) Aral Sea. Three dike systems: Kok-Aral dike (Central dike), Saryshaganak Gulf dike (Northen dike) and the proposed third dike (Southern dike) would help not just the fishermen live better. Construction of the Saryshaganak Gulf dike (Northen dike) would allow water to be brought back to the large city of Aralsk (town of Aralsk district). Construction of the third dike (Southern dike) would allow both residual water and fishing in the so-called Central Aral Sea. At present, due to the lack of this dike, the Central Aral Sea dries up during periods of water shortage.

Future of the Aral Sea also depends on the prevailing political trends in the countries of the Aral Sea basin

Near the city of Muynak in the delta of Amu Darya River it was a monument to the soldiers who died in the Great Patriotic War during the 2nd World War. This monument was built in Soviet time and after collapse of USSR it was renovated. On the stele were painted Uzbek and Karakalpak flags. Near the stele was built an additional small pedestal with a slogan in Uzbek language «Feats of the fathers – the heritage for future generations» . Unfortunately, in April 2008 marble slabs with the names of the dead soldiers were removed. On stele instead of flags – the images of the Aral Sea were painted. Luckily in September 2008, in the Central park of Muynak, the district administration erected a new monument in memory of those who died in the Great Patriotic War. Thanks to the demand of the people the war memorial not only has been recreated on the new place, but also a list of the dead has been supplemented with new names.

The main driving force for regional cooperation in the Aral Sea region is International Fund for saving the Aral Sea (IFAS)[1]. Founders of the IFAS are: the Republic of Kazakhstan, the Kyrgyz Republic,

[1] IFAS. – URL: http://ec-ifas.org/

the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan. Since 1993, as the Presidents of IFAS were elected:

1. The President of the Republic of Kazakhstan N. Nazarbayev – from 1993 to 1996.
2. The President of the Republic of Uzbekistan I. Karimov – from 1997 to 1999.
3. The President of Turkmenistan S. Niyazov – from 1999 to 2001.
4. The President of the Republic of Tajikistan E. Rakhmon – from 2002 to 2008.
5. The President of the Republic of Kazakhstan N. Nazarbayev – from 2008 to 2012.

In August 2013, the President of the Republic of Uzbekistan I. Karimov was again elected as the President of IFAS and continues to serve in that position.

The ICWC (Interstate Commission for Water Coordination) was the first regional institution set up after independence. Its main tasks are to control the regulation, efficient use and protection of the waters, to develop a regional common water management policy and to determine annual limits of water use for each state. Its members are the heads of the respective national water ministries or departments, who meet every quarter to determine the exact water distribution – i.e. the translation of the general quotas into exact amounts based on water flow measurements and weather forecasts. Meetings of the ICWC are chaired by the member countries on a rotating basis. All decisions are made unanimously. Operative bodies of the ICWC are the secretariat in Khujand (Tajikistan), a scientific information centre in Tashkent (SIC ICWC) with branches in all member countries and the two river basin organizations (BVOs), which had already been established by the Soviet government. The headquarters of the BVO Syr Darya is in Tashkent (Uzbekistan); the one of the BVO Amu Darya is in Urgench (Uzbekistan)[1].

In 1993, ICAS (Interstate Council for the Aral Sea Basin Problems) was founded with the EC (Executive Committee) as its executive agency. It consisted of five members per republic who met every half year and decided about the plans developed by the EC, which formulated principles, projects and measures. The ICWC was integrated into ICAS. Also in 1993, the International Fund for Saving the Aral Sea (IFAS) was set up in Almaty. All member states were expected to pay 1% of their state expenses to this fund per year. Its Executive Committee (EC IFAS) consists of two representatives for each of the five states. Initially, the role of IFAS was primarily to generate funds from member state fees and donor assistance, while EC ICAS was in charge of the Aral Sea Basin Program[2] (ASBP, see below).

In 1994, a new ecological commission was created, the ICSDSTEC (Interstate Commission for Socioeconomic Development and Scientific and Ecological Cooperation), later renamed the Interstate Commission on Sustainable Development (ICSD). Its main objective is the coordination and supervision of cooperation in the field of environmental protection and sustainable development in Central Asia. The ICSD meets twice a year with the chair rotating among its member states. A Scientific Information Centre (SIC ICSD) is based in Ashgabat[3].

In 1997, the regional institutions were restructured following an evaluation of the first phase of the ASBP that advised a strengthening of the regional institutions. Because of overlapping responsibilities, ICAS and IFAS were combined under the name IFAS. The chairmanship of IFAS has since then rotated among the presidents of the five member states. The EC IFAS is accordingly located in the respective country. Thus, the Executive Committee has been located in Almaty (1993–1997), Tashkent (1997–1999), Ashgabat (1999–2002), and Dushanbe (2003–2009); the planned move to Bishkek did not take place due to political turmoil in 2005. From 2009 until 2013, it has been based in Almaty. Since 2013, it has been based in Tashkent. Another decision concerned the fees of the member states. As it became obvious that none of the states had fulfilled its financial commitments, contributions were lowered to 0,3% of the state expenses for the richer countries downstream

[1] IFAS: organizational structure. – URL: http://www.waterunites-ca.org/themes/17-ifas-organizational-structure.html?view=booktext

[2] Ibid.

[3] Ibid.

and to 0.1% of state expenses for the poorer countries upstream[1].

In 2002, the IFAS Board decided to establish a Regional Centre of Hydrology (RCH) and attach it to EC IFAS. Its main purpose is to improve the system of hydro-meteorological forecasting, environmental monitoring and data exchange among the national hydro-meteorological agencies in the region[2].

The next very important organization for regional cooperation in the Aral Sea region is International Lake Environment Committee Foundation (ILEC). ILEC is a public interest incorporated foundation/NGO based in Japan[3]. Its history dates back to 1986, following the Shiga Conference on Conservation and Management of World Lake Environment of 1984, which was held in Otsu, Japan. The Shiga Conference was the event at which then Executive Director of the United Nations Environment Program (UNEP) M. K. Tolba proposed the establishment of an international committee to realize the trans-generational succession of the Conference and to help the world develop rational management plans for lakes and their catchment basins. Ever since then, ILEC has been promoting rational and sound management of world lakes (natural and anthropogenic) and their catchment areas consistent with sustainable development policies. It has an advisory body known as the Scientific Committee, composed of internationally renowned scientists and experts on lake and reservoir management and conservation[4].

ILEC created the ILBM platform. Good basin management of a lake can be realized only through ILBM, or continuous improvement of lake basin governance, that integrates Institution, Policy, Participation, Science, Technology and Finance. ILEC promotes ILBM globally, with long-term and strong political commitment, in order to improve the state of world lakes[5]. Prof. Dr. Tatuo Kira (1919–2011), Prof. Dr. Masahisa Nakamura and Prof. Dr. Walter Rast did a lot for saving the Aral Sea. Prof. Dr. Tatuo Kira participated as a leading expert in preparation of UNEP Diagnostic Study for the Aral Sea in 1986–1992.

International scientific cooperation is very important for regional cooperation in the Aral Sea region. We would like to give only 2 examples. The first example is the fact that the leading scientists in studying of salinity and osmoregulation were from Germany and Russia: Prof. Dr. Adolf Remane (1898–1976), Prof. Dr. Vladislav Khlebovich, and Prof. Dr. Otto Kinne (1923–2015). All of them did a lot for understanding of the leading role of salinity in Aral Sea studies. The second example is the leading scientists in studying of physiology and ecology of the Aral Sea animals and plants. All of them were from Russia: Prof. Dr. Nikolai Gerbilskiy (1900–1967), Prof. Dr. Andrey Polenov (1925–1996) and Prof. Dr. Lev Kuznetzov (1934–2015). These three scientists did a lot for predicting influence of environmental change in the Aral Sea on local animals and plants.

Unfortunately due to new global economic crisis risk of a new stagnation period in saving the Aral Sea is quite possible. Lack of funding forces international donors IFAS, and Central Asian governments to reconsider existing plans for saving the Aral Sea that were made before. Shallow reservoirs on the Aral Sea bottom are loosing too much water from evaporation. In connection with this, Amudarya water in excess of that needed to maintain existing wetlands and lakes in the lower delta of the Amudarya should be redirected to the Western Large Aral Sea rather than being allowed to flow to the Eastern Large Aral Sea and evaporate. This will allow in the distant future to save not only Small/Northern Aral but also Western Large Aral Sea (Figure 1). The Central Aral Sea should be connected to Tsche-Bas Bay. In our opinion the Aral Sea in the 21st century will be a chain of human operated reservoirs. The rest of Amudarya water will be used only for Western Large Aral and the rest of Syrdarya water will be used only for Small/Northern Aral and Central Aral connected to Tsche-Bas Bay (Figure 1).

---

[1] IFAS: organizational structure. – URL: http://www.waterunites-ca.org/themes/17-ifas-organizational-structure.html?view=booktext

[2] Ibid.

[3] International Lake Environment Committee Foundation (ILEC). – URL: http://www.ilec.or.jp/en/

[4] Ibid.

[5] Integrated Lake Basin Management (ILBM). – URL: http://www.ilec.or.jp/en/activity

Conclusions

1. Prior to the beginning of anthropogenic regression and salinization of the Aral Sea its ecosystem survived consequences of new species introductions that began at the end of the 1920s.

2. The main and only cause of modern desiccation and salinization of the Aral Sea is withdrawal of Amu Darya and Syr Darya waters for irrigation.

3. It is possible to distinguish 3 main stages of Aral Sea biodiversity decrease process owing to its salinization [9]:

– in 1971–1976 when salinity exceeded 12–14 g/l, brackish-water species of freshwater origin disappeared;

– in 1986–1989 when salinity exceeded 23–25 g/l, brackish-water species of Caspian origin disappeared;

– in the end of 1990s and beginning of 2000s in the Large Aral Sea when its salinity exceeded 80–100 g/l, species of marine origin disappeared.

4. In 1987–1989 the Aral Sea because of desiccation has divided into 2 parts: Small Aral in the north and Large Aral in the south. On the place of one lake were formed 2 water bodies.

5. After division of Aral Sea in 1989, Small Aral has positive water balance and its salinity began to decrease. After construction of a new dike in Berg's strait there has been a recovery of biodiversity and revival of fishery.

6. Large Aral Sea having negative water balance continues to dry up and salinity is increasing; at the end of the 1990s it turned into a hyperhaline water body. Recovery of its biodiversity and fishery is not a real possibility. The only possibility of economic activities on Large Aral is harvesting of brine shrimp.

7. To the present, Large Aral has divided into 3 separate water bodies: the Western and Eastern basins connected by channel, and Tschebas Lake.

8. The significant raising of irrigation efficiency in the basin of Aral Sea could save significant amounts of water, which could replenish the water balance. However it requires comprehensive and very expensive reconstruction of irrigation systems and also essential changes in the social and economic sphere that are improbable at the present time.

9. The volume of underground water reaching the Aral Sea is essentially larger than was assumed earlier.

10. Vozrozhdeniya Island being during Soviet time proving ground for exploring and trial of biological weapons now is peninsula. In 2002 the U.S. sent $6 million and a team of experts to help Uzbekistan to destroy any remaining pathogens. Meanwhile some people still believe that this island remains «delayed-action bomb» since preserved there active pathogens can get on the continent.

11. Plans for oil and gas extraction on the dried bottom of the southern Aral Sea can reduce interest of Uzbekistan authorities in taking actions to restore that part of the Aral Sea.

12. Only International Cooperation and International Financial Support could help to find a better future for the Aral Sea and for the people who are living in its catchment area.

References

1. Aladin N., Micklin P., Plotnikov I. Biodiversity of the Aral Sea and its Importance to the Possible Ways of Rehabilitating and Conserving its Remnant Water Bodies, NATO Science for Peace and Security Series. *C: Environmental Security. Environmental Problems of Central Asia and their Economic, Social and Security Impacts.* Edited by Jiaguo Qi, Kyle T. Evered, Springer, 2008, pp. 73–98.

2. Aladin N. V., Plotnikov I. S. Changes in the Aral Sea level: Palaeolimnological and archaeological evidences, *Proc. Zool. Inst. Russian Acad. Sc.,* 1995, Vol. 262, pp. 17–46. (In Russ.).

3. Aladin N. V., Plotnikov I. S., Potts W. T. W. The Aral Sea Desiccation and Possible Ways of Rehabilitating and Conserving its Northern Part, *Int. J. Environmetrics*, 1995, Vol. 6, pp. 17–29.

4. Ermakhanov Z. K., Plotnikov I. S., Aladin N. V., Micklin P. Changes in the Aral Sea Ichthyofauna and Fishery During the Period of Ecological Crisis, *Lakes & Reservoirs*: *Research and Management*, 2012, No. 17, pp. 3–9.

5. Krivinogov S. Changes of the Aral Sea Level, Part I, Chapter 4. The Devastation and Partial Rehabilitation of a Great Lake Series. *Springer Earth System Sciences*, Vol. 10178. Eds. P. Micklin; N. V. Aladin; I. Plotnikov, 2014, No. XII, pp. 77–108.

6. L'vovich M. I., Tsigel'naya I. D. Managing the Water Balance of the Aral. *Izvestiya Akademii Nauk SSSR*, Seriya Geograficheskaya, 1978, No. 1, pp. 42–58. (In Russ.).

7. Micklin P. Efforts to Revive the Aral Sea. The Devastation and Partial Rehabilitation of a Great Lake Series. *Springer Earth System Sciences*. Eds. P. Micklin; N. V. Aladin; I. Plotnikov, 2014, Part III, Chapter 15, Vol. 10178, pp. 361–379.

8. Micklin P. The Past, Present, and Future Aral Sea. *Lakes & Reservoirs: Research and Management*, 2010, No. 15, pp. 193–213.

9. Plotnikov I. S., Aladin N. V., Ermakhanov Z. K., Zhakova L. V. The New Aquatic Biology of the Aral Sea, Part II, Chapter 6. The Aral Sea. The Devastation and Partial Rehabilitation of a Great Lake Series. *Springer Earth System Sciences*, Vol. 10178, Eds. P. Micklin; N. V. Aladin; I. Plotnikov, 2014, No. XII, pp. 137–170.

10. Plotnikov I. S., Aladin N. V., Ermakhanov Z. K., Zhakova L. V. Biological Dynamics of the Aral Sea Before Its Modern Decline (1900–1960), Part I, Chapter 3. The Aral Sea. The Devastation and Partial Rehabilitation of a Great Lake Series. *Springer Earth System Sciences*, Vol. 10178. Eds. P. Micklin; N.V. Aladin; I. Plotnikov, 2014, No. XII, pp. 41–76.

Аладин Н. В., Миклин Ф., Плотников И. С.

ЧАСТИЧНОЕ ВОССТАНОВЛЕНИЕ АРАЛЬСКОГО МОРЯ И ЕГО СВЯЗЬ С СОСТОЯНИЕМ ЗДОРОВЬЯ, БИОЛОГИЧЕСКИМИ И СОЦИО-ЭКОНОМИЧЕСКИМИ ХАРАКТЕРИСТИКАМИ РЕГИОНА

В статье рассматривается проект восстановления Аральского моря и то, как это может повлиять на биологические, социальные и экономические характеристики региона.

Проанализирована история региона и водоема, показано биологическое разнообразие региона в прошлом и в настоящем. Показано воздействие обмеления водоема на здоровье населения региона. Предложены меры по улучшению ситуации и показаны потенциальные результаты этого воздействия.

Ключевые слова: *Аральское море, Средняя Азия, водоем, биологическое разнообразие, здоровье, политика*.