

BIODIVERSITY OF THE ARAL SEA AND POSSIBLE WAYS OF REHABILITATING AND CONSERVING ITS REMNANT WATER BODIES

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The Aral Sea was the 4th largest lake in the world by water surface area in 1960. At that time its area was 67,499 km² (Large Aral 61,381 km², Small Aral 6118 km²) volume was 1089 km³ (Large Aral 1007 km³, Small Aral 82 km³). The Aral Sea was +53.4 m above ocean level with maximum depth 69 m. It was a slightly saline lake with average salinity about 10 g/l.

The Aral Sea was inhabited by about 12 species of fishes and about 150 species of free-living invertebrates excluding Protozoa and small-size Metazoa.

Since 1960 the Aral Sea has steadily become shallower, owing overwhelmingly to water withdrawals upstream for irrigation. In January 2006 the Aral was around 17000 km² (25% of 1960), volume – 108 km³ (10% of 1960). The Large Aral was 14,325 km² (23% of 1960) and had a volume around 81 km³ (8% of 1960). Salinity of the Large Aral ranged from 70+ to more than >100 g/l. The values for the Small Aral are 3000+ km² (50%), 21 km³ (26%), average salinity about 13 g/l.

Prior to introduction of fishes and free-living invertebrates to the Aral Sea that started in the 1920s, the following aboriginal free-living animals were present: Fishes – 12, Coelenterata – 1, Turbellaria – 12, Rotatoria – 58, Oligochaeta – 10, Cladocera – 14, Copepoda – 7, Harpacticoida – 15, Ostracoda – 11, Malacostraca – 1, Hydracarina – 7, Bivalvia – 9, Gastropoda – 3. Total – 160. Protozoa and some other small Metazoa are not included.

Until 1961 the shape and salinity of the Aral Sea practically didn't change since the middle of the 19th century. We have to note that due to intended and accidental introductions, that started in the 1920s, the number of free-living animals grew. In the Aral Sea the following new fishes and invertebrates introduced by man appeared: fishes – 21, Mysidacea – 5, Decapoda – 3, Copepoda – 3, Polychaeta – 1, Bivalvia – 4. Total – 37. *Abra ovata* and *Nereis diversicolor* introduced by man are of great importance for flounder nutrition.

Since the end of 1980's, when the level dropped by about 13 m and reached about +40 m, the Aral Sea divided into the Large and Small Aral with area 40,000 km² (60% from 1960); volume 333 km³ (33% from 1960); salinity 30 g/l (3 times higher than in 1960).

In both newly borne lakes salinity increased and under these new conditions the following free-living animals could survive: Fishes – 10; Rotatoria – 3; Cladocera – 2; Copepoda – 2; Ostracoda – 1; Decapoda – 2; Bivalvia – 2; Gastropoda – >2; Polychaeta – 1. Total: >25.

After the Aral Sea division its volume has decreased from 1000 km³ to 400 km³ by year 2001 and to 108 km³ by year 2005 with the Large Aral Sea volume (2005) at 85 km³ and the Small Aral Sea volume (2005) at 23 km³.

After the Aral Sea division salinity in the Large Aral continued to rise and reached 90 g/l (western part) and 160 g/l (eastern part) in 2005, while in the Small Aral it decreased and reached 17 g/l in 2005.

The zooplankton of the Aral Sea just after its separation (1989) under average salinity about 30 g/l was composed of the following invertebrates: Rotatoria – *Synchaeta vorax*, *S. cecilia*, *S. gyrina*; Cladocera – *Podonevadne camptonyx*, *Evadne anonyx*; Copepoda – *Calanipeda aquaedulcis*, *Halicyclops rotundipes aralensis*; larvae of Bivalvia – In zoobenthos there were Bivalvia – *Abra ovata*, *Cerastoderma isthmicum*; Gastropoda – *Caspiohydrobia* spp.; Polychaeta – *Nereis diversicolor*; Ostracoda – *Cyprideis torosa*; Decapoda – *Palaemon elegans*, *Rhithropanopeus harrisi tridentatus*. Fishes were represented by *Pungitius platygaster*, *Clupea harengus membras*, *Platichthys flesus*, *Atherina boyeri caspia*, *Knipowitschia caucasicus*, *Neogobius fluviatilis*, *N. melanostomus*, *N. syrman*, *N. kessleri*, *Proterorchinus marmoratus*.

There are 4 main ways of conservation and rehabilitation of Aral Sea and its ecosystems that were first discussed in Geneva (September 1992 - UNEP meeting):

1. Conservation and rehabilitation of Small Aral;
2. Conservation and rehabilitation of Large Aral;
3. Conservation and rehabilitation of delta and deltaic water bodies of Syr Darya;
4. Conservation and rehabilitation of delta and deltaic water bodies of Amu Darya.

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

Dike in Berg strait will allow conservation of the Small (Northern) Aral and rehabilitation of its biodiversity. The old dike was built by our proposal in August 1992. It existed, with periodic partial breaches, until April 1999, when after the water level rose to +43.5 m, a catastrophic breach occurred that destroyed the dike. The number of free-living animals increased. Even such a short period allowed partial rehabilitation of biodiversity in Small Aral.

Since separation of the Small Aral Sea from Large Aral at the end of 1980s number of free-living animals increased because salinity in this lake fell 50% and in 2005 reached about 17 g/l. At that time, the Small Aral's area was 2,804 km² (47% from 1960), volume 23 km³ (28% from 1960), and level +40.4 m asl.

Our survey last year on Small Aral showed the following number of species: fishes – 12; Rotatoria – 3; Cladocera – 2; Copepoda – 2; Ostracoda – 2; Decapoda – 2; Bivalvia – 2; Gastropoda – >1; Polychaeta – 1. Total: >27.

Zoobenthos of the Small Aral Sea today consist of the following: Bivalvia – *Abra ovata*, *Cerastoderma isthmicum*; Gastropoda – *Caspiohydrobia* spp.; Polychaeta - *Nereis diversicolor*; Ostracoda - *Cyprideis torosa*, *Eucypris inflata*; Decapoda – *Palaemon elegans*; Insecta: Chironomidae larvae. Fishes of the Small Aral: *Clupea harengus membras*, *Platichthys flesus*, *Atherina boyeri caspia*, *Knipowitschia caucasicus*, *Neogobius fluviatilis*, *N. melanostomus*, *N. syrman*, *N. kessleri*, *Pungitius platygaster*, *Proterorchinus marmoratus*, *Ctenopharyngodon idella* (reappeared in 2004), *Sander lucioperca*. After the first dike in Berg strait was built, fishing on the Small Aral was restarted.

The Russian company “Zarubezhvodstroy” built the new dike in Berg strait. It was completed in autumn 2005. In 2006 spring the level of Small Aral reached the design level of 42-42.5 m, well ahead of schedule. The Small Aral area now is about 3,382 km², volume 29.5 km³, inflow from Syr Darya 3.5 km³/year, outflow via Berg strait 1.15 km³.

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

Since Aral Sea divided into 2 lakes at the end of 1980s level of Large Aral Sea is constantly declining. Since beginning of 2003, when the level in the Large Aral Sea dropped by 23 m and reached about +30 m, the Large Aral Sea is practically divided into the Eastern Large and Western Large Aral. Area 14,293 km² (23% from 1960); volume 85 km³ (8% from 1960); salinity: Western part – 80-90 g/l, Eastern part – 150-160 g/l (excluding Tsche-Bas bay where salinity is 80-90 g/l).

In both lakes salinity increased so high that practically all fishes are gone and only a few free-living invertebrates could survive: Fishes – 4?; Infusoria – 2; Rotatoria – 3; Cladocera – 2; Copepoda – 2; Ostracoda – 2; Branchiopoda – 1; Decapoda – 2; Bivalvia – 2; Gastropoda - >2; Polychaeta – 1?. Total: >29?

Zooplankton of the Western Large Aral Sea (2005. Average salinity 80-90 g/l): Infusoria – *Fabraea salina*; Rotatoria – *Brachionus plicatilis*, *Hexarthra fennica*; Cladocera – *Moina mongolica* ?; Copepoda – *Halicyclops rotundipes aralensis*; Branchiopoda – *Artemia salina*. Zoobenthos: Infusoria – *Frontonia* sp.; Turbellaria – *Mecynostomum agile* ?; Gastropoda – *Caspihydrobia* spp.; Bivalvia – *Abra ovata*; Polychaeta – *Nereis diversicolor*; Ostracoda – *Cyprideis torosa*, *Eucypris inflata*.

Zooplankton and zoobenthos of the Eastern Aral Sea (2005, average salinity of 150-160 g/l): Zooplankton – *Artemia salina*; zoobenthos – alive macro- and mezo- Metazoa are not available. Only in Tsche-Bas bay due to much lower salinity (80-90 g/l) zooplankton and zoobenthos resembles those of the Western Large Aral Sea.

In 2005 fishes of the Western Large Aral Sea, with salinity 80-90 g/l, consisted of *Pungitius platygaster*?, *Platichthys flesus*, *Atherina boyeri caspia*, *Neogobius melanostomus*. Fishes were not found in the Eastern Large Aral. In Tsche-Bas Bay flounder (*Platichthys flesus*) was observed in water with salinity 80-90 g/l. In the remnants of the strait between Small and Eastern Large Aral *Atherina boyeri caspia* was found in water with salinity 60-80 g/l. Flounder (*Platichthys flesus*), introduced in 1970s, now is about to disappear from the Large Aral Sea. It already is absent from the Eastern depression.

At the end of 20th century brine shrimp *Artemia salina* (*A. parthenogenetica*) appeared in the Large Aral Sea. Industrial harvesting under the aegis of the international company INVE Aquaculture is under study, including a pilot project on the shores of Chernishev Bay. However, last year (2005) the company postponed activities due to slow salinity increase.

Last year a special water discharge facility (dike and control structure) was constructed in order to supply the Eastern depression of Large Aral with Amu Darya water from Mezhdurechensky reservoir via Akdarya river bed. Unfortunately the completed spillway and water gates were damaged by water in autumn 2005. This now complex is under restoration.

In our view, it is desirable to provide more water to the Eastern Large Aral from Small Aral via Berg strait dike and water discharge from Mezhdurechensky reservoir via Akdarya river bed. Western Large Aral Sea could, perhaps, maintain its level using ground water flow from Amu

Darya delta and Ustjurt plateau. Realization of this project will help protect biodiversity of salt tolerant species of hydrobionts.

Way 3. Conservation and rehabilitation of delta and deltaic water bodies of Syr Darya.

After the collapse of the USSR, discharge of Syrdarya slightly increased and reached about 5 km³ per year. After making a first dike in Berg strait in summer 1992 some other rehabilitation projects were initiated. Syrdarya delta shifted slightly northwards and some fresh water reservoirs were built. Along lower Syrdarya near the Small Aral several fresh water lakes have been rehabilitated: Tuschibas, Kamyslybas, Zhalanashkol, Karasholan, etc. These small projects allow to restore freshwater fisheries and hunting. Fish farms were also renewed and more young fish are released to the local water bodies. Fish farms are also planned for use in reintroduction of sturgeon to the Small Aral.

Way 4. Conservation and rehabilitation of delta and deltaic water bodies of Amu Darya.

In the lower reaches of the Amudarya several freshwater and brackish water reservoirs and lakes were established. One of the most successful projects is Sudochie Lake. Sudochie Lake is completely filled up and via underground flow is giving some water to the Western Large Aral Sea. Reeds, aquatic birds and hydrobionts are almost recovered in Sudochie Lake. Other former Aral Sea bays could also be rehabilitated, including Sarbas, Muynak, Adjibay and Zhiltyrbas. Fisheries and hunting activities came back for the areas mentioned above.

Some evidences of medieval desiccation of the Aral Sea.

During desiccation of the Aral Sea remnants of saxauls were found on its former bottom. Some stumps were also found under water close to the modern shore line. Radiocarbon analysis dated these to Medieval times. For more paleoenvironmental reconstruction of medieval desiccation special corings in the Aral Sea were made under the CLIMAN project (INTAS).

At the end of 20th century, Kazakh hunters found ruins of medieval mausoleum (Kerdery) on the dried bottom. In 1960, the area was under about 20 m of water. Bones of Homo sapiens and domestic animals, millstones, elements of ceramics, and other artifacts were found near the mausoleum. All these findings were studied by international team of archeologists also under CLIMAN project.

Recently remnants of Medieval river beds on the former Aral Sea bottom were also detected on satellite images. Preliminary investigations on this matter were made by D. Piriulin.

In our opinion, the future of the Aral Sea is connected with oil and gas extraction. Oil and gas drilling rigs are now wide spread on the former Aral Sea bottom. A gas condensate plant was built not far from Muynak. Local decision-makers even permanently closed channel that formally gave water to Muynak reservoir. Gate is closed in order to decrease groundwater level in the area. A high water table level promotes softening of ground that endangers drill towers. They could fall over or start to lean.

Finally, we would like to note that citizens of Kazakhstan like to call Small (Northern) Aral Sea "Kazaral" that means "Kazakh Aral". People in Uzbekistan also sometimes instead of Large (Southern) Aral Sea like to use name "Uzaryl" that means "Uzbek Aral". We believe that on future maps will be 4 main water bodies at the place of former Aral: Kazaral, Western Uzaryl, Eastern Uzaryl, and remnant of Tshebas bay.