CURRENT STATUS OF LAKE ARAL – CHALLENGES AND FUTURE OPPORTUNITIES

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ABSTRACT

The Aral Sea was the fourth largest lake in the world before 1960. However, it is now four separate water bodies, fed mainly by collector-drainage waters because of excessive upstream irrigation water withdrawals from the two main influent rivers, the Syr Darya and Amu Darya, which is clearly shown on satellite images. The resulting rapid increase in salinity has caused a dramatic decrease in the lake biodiversity and loss of a once thriving fishery. Only a small part of the indigenous biota has survived. The regression of the Aral Sea also has had profound socioeconomic and human impacts on the lake riparian populations. Accordingly, it is encouraging to note the reversal of the degradation of the Northern (Small) Aral Sea after the erection of a dike at Berg's Strait in 1992. This first dike was washed out in 1999, but was replaced with the new structurally-sound Kok-Aral dam in 2004-2005. The water level in the Northern Aral has increased several meters and its salinity has returned to levels that can sustain the pre-1960 ecosystem. The biodiversity also has been somewhat rehabilitated, and the commercial fisheries have revived. The remnants of the hyperhaline Southern (Large) Aral continue their retreat and salinization. The Large Aral contains no fish species, and almost all the invertebrate species have been lost. To restore the Aral Sea to its former state would be very difficult, if not impossible, in the foreseeable future. However, a partial restoration of its separate parts is possible. Plans for further rehabilitation of the Small Sea and possible restoration of some parts of the Southern (Large) Aral Sea are discussed.

Keywords: Aral Sea, salinity, biodiversity.

INTRODUCTION

The Aral Sea is a terminal, or closed basin (endorheic) lake, lying amidst the vast deserts of Central Asia. Its drainage basin encompasses more than two million km^2 (**Fig. 1**). As a terminal lake, it has surface inflow but no outflow. Therefore, the balance between inflows from its influent rivers, the Amu Dar'ya and Syr Dar'ya and net evaporation (evaporation from the lake surface minus precipitation on it) fundamentally determine its level. In 1960 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 the 20th century: 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 (actually above the Kronstadt gage near St. Petersburg, Russia, maximal depth: 69 m, salinity: about 10 g/l (Aladin, et al., 2008).

Figure 1. The Aral Sea basin

Prior to the modern desiccation, the Aral Sea was inhabited by about 20 species of fishes and about 200 species of free-living invertebrates (Plotnikov et al., 2014a). 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 10 species of new invertebrates and 17 species of new fishes (Plotnikov et al., 2014b).

METHODS

The results presented here are based on data gathered in annual expeditions to the shores of the Aral Sea, conducted since 1960. Zoological and botanical samples were taken and the hydrological parameters measured. Additionally, satellite images have been used to monitor the changing geographical features. The results of different projects conducted around and on the Aral Sea have been critically evaluated and incorporated into this paper. Also, available official information and data concerning the Aral Sea and its surrounding have been used.

RESULTS AND DISCUSSIONS

Since 1960 the Aral Sea has steadily shrunk and become shallower (**Fig. 2**) owing overwhelmingly to irrigation withdrawals (**Fig. 3**) from its influent rivers (Amu Dar'ya and Syr Dar'ya). At the end of the 1980s, when the water level had dropped by about 13 m and reached about +40 m, the Aral Sea divided into two lakes – the Large and the Small Aral. At that time, the total area of the Aral Sea (Large Aral and Small Aral) was 40,000 km^2 with a volume of 333 km^3 and a salinity of 30 g/l (Aladin et al., 2008). By September 2009, the total Aral area was only 8410 km^2, with a volume of 85 km^3. The Large Aral area had a surface of 4922 km^2 with a volume of 58 km^3 and a salinity >100 g/l. The Small Aral area at that date was 3487 km^2, volume 27 km^3 and salinity 10-14 g/l.

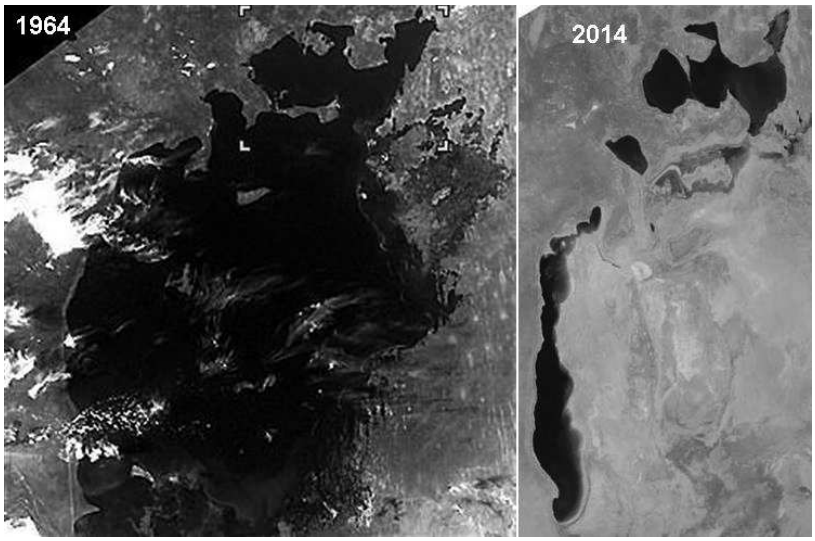

Figure 2. Since 1960 the Aral Sea has steadily shrunk and become shallower (left image from Corona spy satellite right from MODIS 250-meter sensor).

After the division of the Aral Sea, the Northern/Small Aral Sea started to have a positive water balance. Therefore, water from the Syr Dar'ya River, ground inflow, and precipitation on the sea's surface have contributed 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, there was a flow of excess water from it to the Large Aral Sea at that time. 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 River. Consequently, it was decided to build a dam on the Berg Strait (**Fig. 4**) to keep the water in the Northern/Small Aral Sea. In August 1992, a basic dam was built. (Aladin et al., 1995). This dam helped preserve the Small (Northern) Aral and rehabilitate its biodiversity.

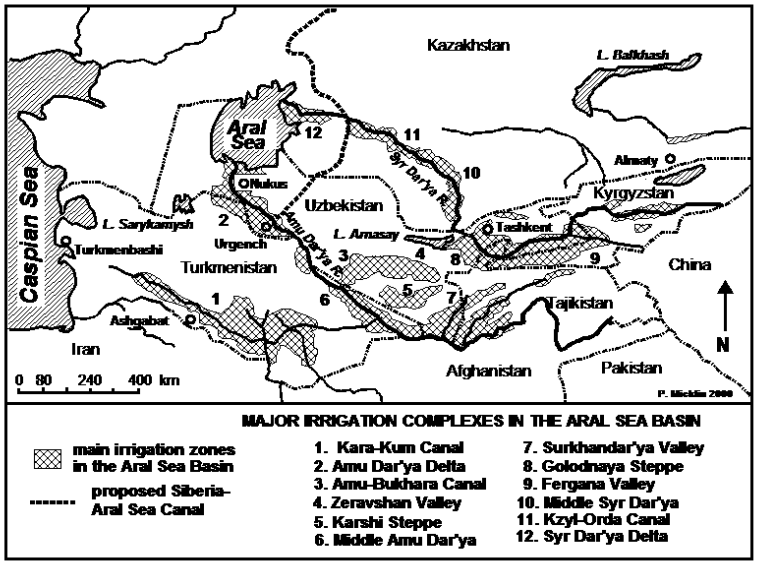

Figure 3. Irrigation development in the Aral Sea basin.

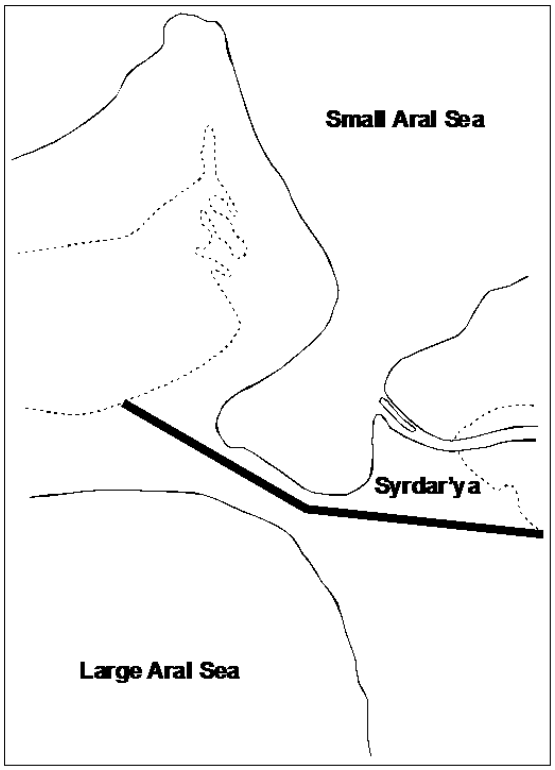

Figure 4. Dam in Berg strait.

The basic dam in the Berg Strait was partly destroyed a number of times by the high spring water levels but the broken parts of the dike were always 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 (**Fig. 5**), the dam completely failed with the loss of two lives (Micklin, 2010).

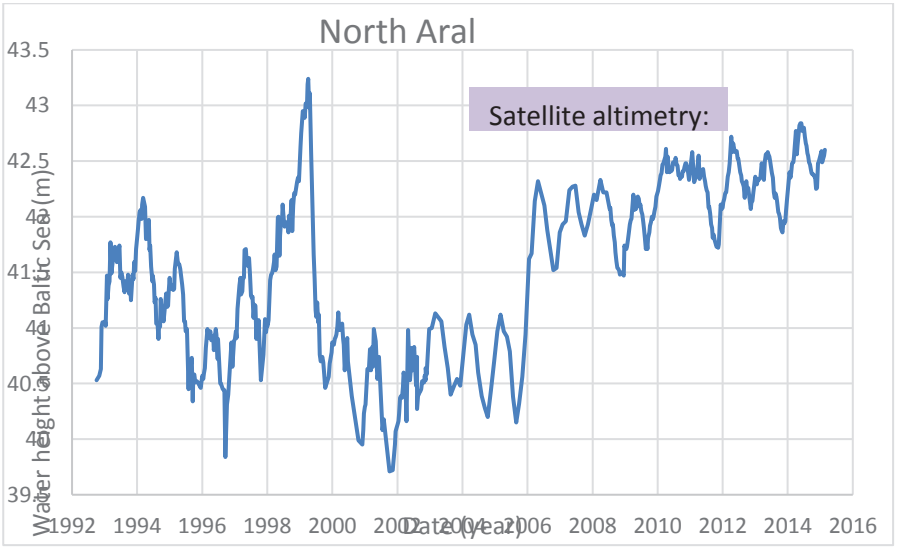

Figure 5. The Small Aral Sea level (data from satellite altimetry: Topex/Poseidon, Jason1, Jason2 and Jason3).

Figure 6. New Kok-Aral dam built by Russian company "Zarubezhvodstroy" in 2005

A new Kok-Aral dam (**Fig. 6**) was built by the Russian company "Zarubezhvodstroy". As a result, since August 2005, outflow has been controlled by a discharge structure (gates) in the dam. When the water gates are open at the Kok-Aral dam and there is heavy outflow, all the remaining southern water bodies of the Aral Sea are connected for a period of time (Micklin, 2014).

This dam on the Berg Strait was funded by the World Bank using funds from GEF (Global Environmental Facility) and the Kazakhstan government for the purpose of improving the brackish water environment of the Small (Northern) Aral Sea. Local people call this dam "Dam of life". The Kok-Aral dam has allowed an increase of the water level in the Small (Northern) Aral Sea in 6 months to +42 m a.s.l., and with "forcing" to 42.5 m (Cretaux et al., 2013). The present average salinity in the Small (Northern) Aral Sea is less than 10 g/l (Micklin, 2010). it will decrease even more in the near future.

It is possible to make the present dike higher and thus raise the water level to +45 m a.s.l. (recent research by P. Micklin, indicates it may even be possible to maintain the level at 48 m). 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 increases in the inflow from the Syr Darya, significant improvements in irrigation efficiency are needed.

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

When the basic first dam in the Berg Strait was built in 1992, fishing on the Small Aral recommenced. After construction of the Kok-Aral dam, conditions for fishing improved tremendously (**Fig. 7**) (Ermakhanov et al., 2012).

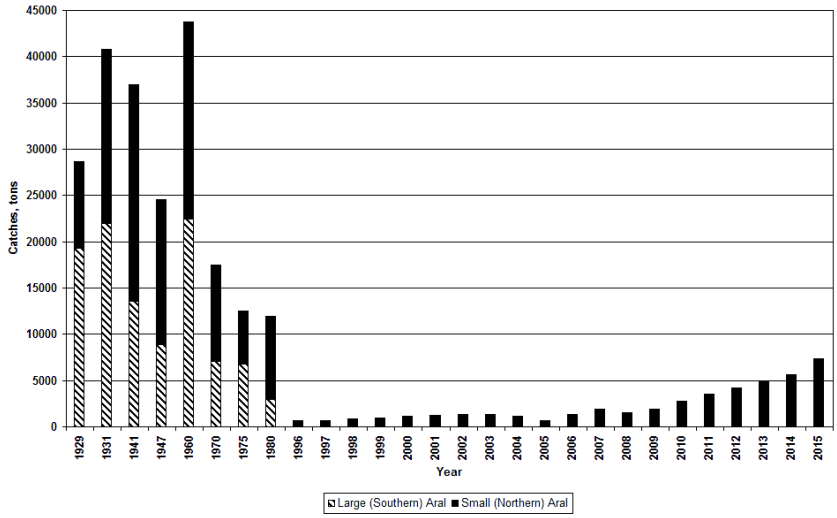

Figure 7. Commercial fish catches on the Small Aral Sea.

Since the Aral Sea divided into 2 lakes at the end of the 1980s, the level of the Large Aral Sea has declined intensively. 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 divided into the Eastern Large and Western Large Aral (**Fig. 8**). 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, whereas salinity in the Eastern part was >200 g/l (Micklin, 2014). The level of the Eastern Large Aral Sea is always higher than the level of Western Large Aral Sea. In both lakes, salinity increased so much that all the fish disappeared (**Fig. 7**) and only a few free-living invertebrates survived. In the Eastern part of the Large Aral only one species of invertebrates – brine shrimp *Artemia* (represented here by parthenogenetic clones) – has survived. At the end of the 20th century, this species appeared in the Large Aral Sea (Plotnikov et al., 2014b). Today, industrial harvesting of brine shrimp cysts has started. *Artemia* cysts (or eggs) is a semi-product and is nourishing food for fingerlings and small fish or shrimp.

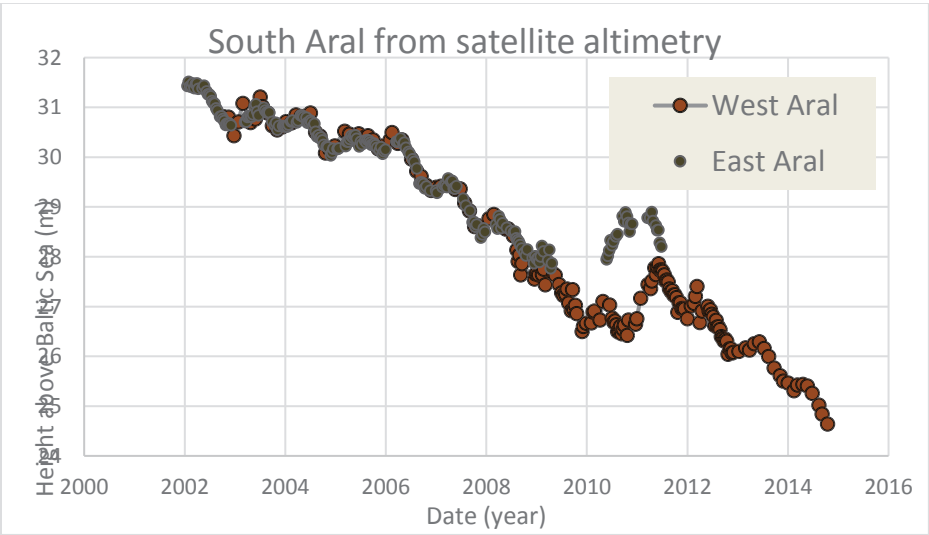

Figure 8. The Large Aral Sea level (data from satellite altimetry: Topex/Poseidon, Jason1, Jason2 and Jason3).

Since the completion of the Kok-Aral dam in 2005, excess water has been released southward creating a large lake that extends westward and southward and in some years extend sufficiently far south to aid in refilling the Eastern Basin of the Aral Sea. This lake also reaches what was formerly Tschebas Bay and supplements its water balance. It also provides some water through the connecting channel to the Western Basin of the Aral Sea. Fish from the Small Sea are carried into it by outflow from the Kok-Aral dam. This water body has been named the Central Aral by some experts (**Fig. 9, 10, 11**).

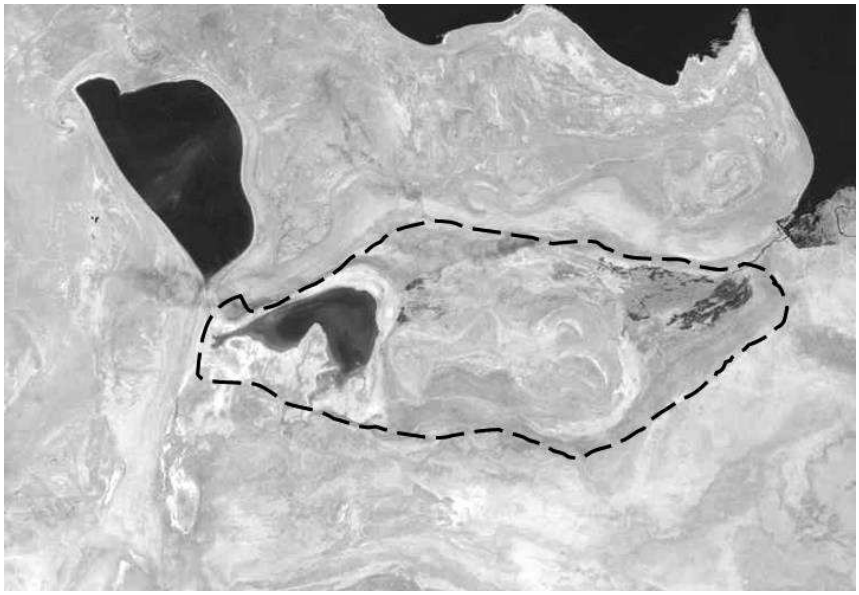

Figure 9. The Central Aral (Oct. 10, 2015).

However, the Central Aral is large, very shallow (the eastern part is now more a wetland than a true lake) and has extensive areas of reeds contributing to high rates of evapo-transpiration and thus significant water loss. Also, the western part has salinity levels too high (~70 g/l) for fish to survive. Finally, the area of the lake experiences great annual variation (**Fig. 9, 10**): enlarging greatly during the winter/spring period of heavier inflow from the Syr Darya and shrinking rapidly during the summer and autumn (and some years entirely disappearing).

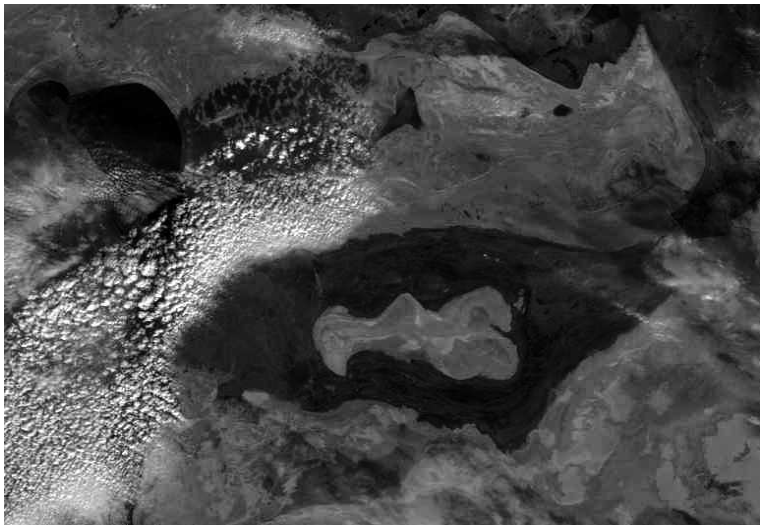

Figure 10. The Central Ara (Jan. 23, 2016)

In the Central Aral at the end of the dry season (July-November) (**Fig. 9**), when it receives little water from the Small Aral Sea, salinity is probably quite high. The Central Aral during the winter/spring season (from December to June) (**Fig. 10**) has a large surface area when large volumes of water discharge into it from the Small Aral Sea due to the large winter water releases into the Syr Darya through the Toktogul dam on the Naryn River in Kyrgyzstan for power generation and normal spring flooding (Cretaux et al., 2015). Mineralization of the lake at this time is low. The lake is covered with ice during winter as a result of the diminished salinity.

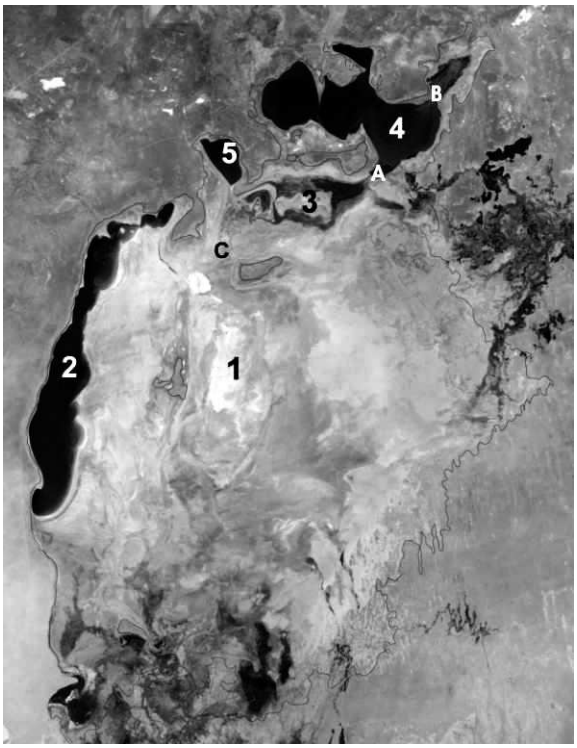

Figure 11. The Aral Sea on August 19, 2014. 1 - dried Eastern Basin of the Large Aral Sea; 2 - Western Basin of the Large Aral Sea; 3 - New Central Aral Sea; 4 - Small Aral Sea; 5 - Tsche-Bas Bay; A - Kokaral dam (Central dam) B – Proposed Northern dam; C – Proposed Southern dam.

The Small (Northern) Aral Sea (**Fig. 11**) 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 (**Fig. 11**) also acquired a common name – in short, the “Western Uzaral” or “Uzbekistan Aral Sea”. The correct scientific name is Western Basin of the Southern Aral Sea derived from the southwest hyperhaline non-regulated lake. Likewise, the Large (Southern) Aral Sea (**Fig. 11**) acquired a common name, in short, “Eastern Uzaral” or “Eastern Uzbekistan Aral Sea”. The correct scientific name is Eastern Basin of the Southern Aral Sea derived from the southeast hyperhaline non-regulated lake. The former Tschebas Bay (**Fig. 11**) also acquired a common name – “Tschebas-Kul”. The correct scientific name is – Southern Aral Sea derived from Tschebas hyperhaline non-regulated lake. The strait between the Eastern and Western Large Aral (**Fig. 11**) has a common name – “Uzun-Aral”. The correct scientific name is the natural channel between the Eastern and Western Large Arals.

The Eastern Large (Southern) Aral 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.

The Large Aral Sea is the most ecologically devastated part of the lake. In the beginning of the 21st century, it divided into three parts: Western Large Aral Sea, Eastern Large Aral Sea and Tsche-Bas Bay (Plotnikov et al., 2014a, 2014b). The future of the Large Aral Sea is most 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.

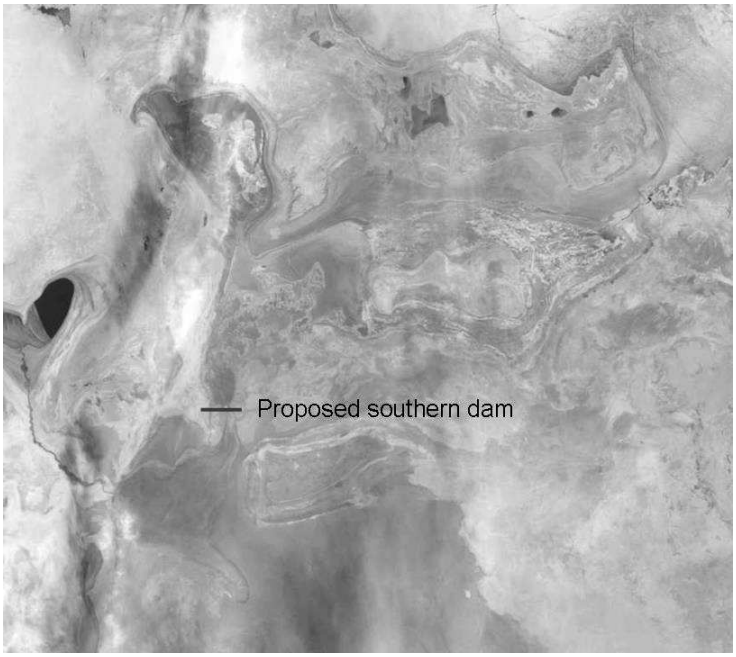

Figure 12. Discharge of Syr Darya water to the Eastern Large Aral (May 5, 2015)

The new Kok-Aral dam (**Fig. 11**) could be made 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 dam in the entrance to Saryshaganak Gulf one more dam could be built (**Fig. 11**), too (Micklin, 2014). Moreover, to the south of the New Kok-Aral dam a third dam could be constructed (**Fig. 11**). If in the future two more dams were built, it would be possible to have year-round fishing in all reservoirs controlled by these dams, as we have now year round fishing in the Small (Northern) Aral Sea. Three dam systems: Kok-Aral dam (Central dam), Saryshaganak Gulf dam (Northern dam) and the proposed third dam (Southern dam) would help not just the fishermen, but everyone live better. Construction of the Saryshaganak Gulf dam (Northern dam) would allow water to be brought back to the large city of Aralsk (town of Aralsk district). Local people would like to call it Dam of Happiness. Construction of the third dam (Southern dam) (**Fig. 11, 12**) would prevent the escape of residual water southward and improve fishing in the so-called Central Aral Sea. Local people would like to call it Dam of Despair. Currently, due to the lack of this dam, the Central Aral Sea dries up during periods of water shortage.

CONCLUSIONS

Considering the positive effect of the Kok Aral dam for the wildlife and for the population inhabiting this area what should be done for the additional conservation of biodiversity and biological resources of the Aral Sea? First, as soon as possible a raising rise of the dam by 2-3 m would increase the water level throughout the Small Aral. This will improve the fishery and the husbandry as well. It also will give the population easier access to the lake and the settlements will be closer to the sea.

A further suggestion is to build in the next few years a dam in the entrance to Saryshaganak Gulf. After that is finished, a simple dam to the south of Kulandy peninsula is needed to keep the water from the Central

Aral from overflowing to the vast area of the big Aral, where it only evaporates and increases the salinity of the former seafloor.

Regarding the Southern Aral Sea and Amudarya River delta region in accordance with ideas of some leading Aral researchers (Lvovich, Tsigelnaya, Micklin and some others), we should not refill shallow reservoirs in Amu Darya delta, but redirect the residual Amu Darya flow to the Western Large Aral Sea. However, most of Uzbek researchers have an opposite position, i.e. they consider using excess of river water for the watering of former sea bays (Jiltirbas, Sarbas, Muynak, Adjibay) and Lake Sudochye, as well as Mejdurechye reservoir on the delta of Amu Darya river. It must be noted that in the Republic of Karakalpakstan these water bodies are viewed as environmentally and economically vital. These measures will allow improving local microclimate and partly rehabilitating Southern Aral fishery and animal husbandry, create ecological conditions for the conservation of flora and fauna, and generate additional jobs and income sources for the local people.

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