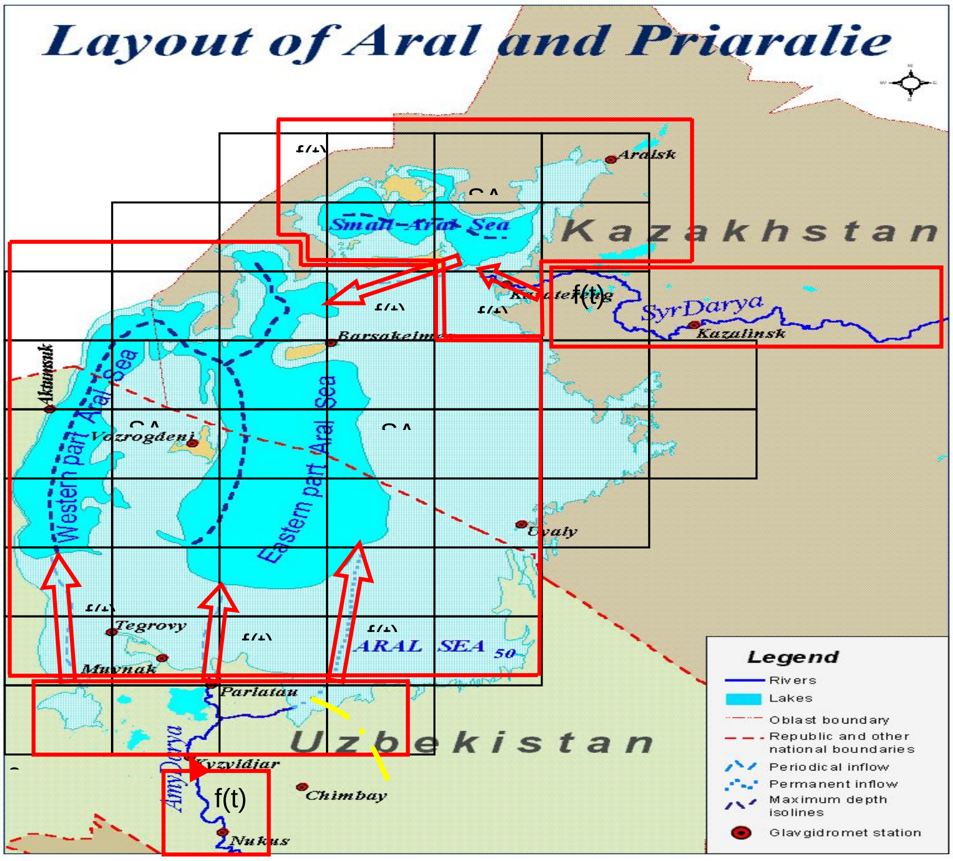
International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union

INTAS Project – 0511 REBASOWS

Summary Report

December 2006/revised August 2007

"The rehabilitation of the ecosystem and bioproductivity of the Aral Sea under conditions of water scarcity"



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Summary Report REBASOWS

1. Background

The shrinking process of the Aral Sea is a well-known example of an ecological disaster which is seen as a result of an unbalanced water consumption in the Aral Sea catchment, mostly for irrigation in the last 40 years of the 20th century. It led to a reduction of 70% of the volume of water in the sea and 50% of the initial surface, the increase of mineralisation of water from 8 to 50-60 g/l and above, full loss of freshwater fish productivity, the desertification of almost 4 million ha of dried bed of the Sea and Sea coast, and the annual transfer of almost 2-3 million tons of salt and dust from the former seabed to the landscape of the Aral Sea shore. As a consequence of overexploitation of the water resources the shrinking of the Aral Sea continued and three water bodies were formed:
(1) the Northern Sea with a water capacity of approx. 30 km^3, with a temporal dam between it and the big Central Sea,
(2) the Central Sea with shallow water and a huge quantity of evaporation, and
(3) the Western part – deep and narrow, which is now almost separated from the Central Sea. The former Lasorev island is now connected with the mainland near Muynak and the western part of the sea has interchange of water with the Central Sea only in the northern part.

2. Objectives and Tasks

This project had the following objectives based on an integrated approach analysing different management options with respect to hydrological, ecological and economic goals. The major tasks of the project were

- to forecast the Aral Sea water and salt balance under different scenarios of water inflow to the Aral Sea coastal zone
- to define a sustainable ecological profile of a closed water body
- to develop a strategy for restoration of the ecosystem, biodiversity and bio-productivity in a part of the Aral Sea.

To achieve these general objectives the following steps were executed:

1. A set of mathematical models and software for integrated investigation of the Aral Sea water surface development was elaborated
2. The water and salt inflow to the Aral Sea was analysed with respect to different development scenarios of the Central–Asian states and three alternatives of the delta's water supply.
3. The influence of water and salt input on the water-salt dynamics in the East and Western water bodies was analysed for different alternatives of the delta's watering.
4. The requirements for a sustainable ecological profile of the Aral Sea remainder and biological parameters for full or at least partial restoration of its Western or central part were defined.
5. An optimal integrated management strategy was to be developed to increase the bio-productivity in a selected part of the sea under possible fluctuations of water inflow.

3. Methodology

The general approach was based on the analysis of possible scenarios in the catchment which have impacts on the water balance and subsequently on the ecosystems and on alternatives to distribute the remaining discharge among the water bodies of the Aral Sea.

3.1 Development of Water Use Scenarios

Three basic scenarios were developed for the whole region and their impacts on the water balance and on the ecosystem were studied. These scenarios are based on development plans of the region, water use efficiency and agricultural development and they are characterised by water and salt input to the Aral Sea and the Pre-Aralie region. Also, the linkages of water use and productivity were analysed. The scenarios covered a period of about 20 years (2005-2025) and each years was subdivided in seasons (at least growing and non growing season). Each scenario considered also different hydrological or meteoro-logical conditions (dry-wet) to gain insight into the sensitivity of the outcomes.

The **optimistic scenario** assumes that the regional integrated development is supported by all the states, including:

- mutually beneficial use of transboundary water resources on the basis of water conservation and common environmental approaches;
- mutually beneficial agricultural development with maximum focus on regional specialization in agricultural production;
- efficient use of natural resources (water and land)
- economic growth, mainly, through industrial and services development.

By 2020, population growth rates will decrease to 0,98 % per year, the regional population being about 54 million; the mean annual GNP growth will be 4-6 % per year in the long term. Moreover, GNP is expected to be about 86 billion $ or more than 1600 $ per capita a year.

Power sector will be developed mainly on the basis of hydropower stations to establish sustainable energy production.

It is assumed that by implementing a rigorous water conservation policy at the national level the water use efficiency will be substantially improved. The irrigation demand will be 9,4 thousand m3/ha; the unit water consumption will decrease to 0,08 m3/capita/year.

Further it is assumed that the improved water use efficiency will support the development of new irrigated areas from 7,85 Mha (current level) to 8,5 Mha. The increase in irrigated area is mainly expected due to the improvement of the general economic situation in the region by about 2010 and the availability of adequate funds for implementation of large-scale water conservation measures.

Substantial GNP growth will be ensured through outstripping industrial growth rates. Taking into account industrial development, on the one hand, and introduction of water recycling in industrial plants, on the other hand, it is assumed that industrial water use will reach 3,3 billion m^3/year against 1,9 billion m^3/year in 2000.

Under planned figures of water use efficiency in various economic sectors, the total water use will be 91,1 km^3/year. At the same time, 80,1 km^3/year will be used for irrigation and 11 km^3/year for industry and household and drinking water supply.

The second scenario **("Business as usual")** assumed that transboundary water management will develop as usual in the region. This implies that the integration processes in transboundary water resources management will be developed slowly. The regional integration in agricultural production progresses poorly and each country tends to rely on food self-provision.

Major national efforts are aimed at maintaining current infrastructure while paying little attention to water conservation.

Population growth rates are constant at a level of 1,9 % per year, and the population is about 61 million. The mean annual GNP growth is not more than 4 % per year. The regional GNP is expected to be 44,7 billion $ or about 800 $ per capita/year.

According to current tendencies, water use efficiency figures will be as follows: irrigation demand 12 thousand m^3/ha; population - 0,1 m^3/capita/year. The total water use will be 108,4 km^3/year, of which: irrigation 96 km^3/year; industry 3,05 km^3/year; and, household and drinking water supply 6 km^3/year.

The irrigated area will remain practically unchanged until 2020.

The third scenario was based on the **"National Development Strategies"** of the countries in the catchment and these individual development plans were analysed in detail in a previous GEF project. There, various development scenarios, from worsening of the situation to strengthening and rehabilitation were suggested. The main positions of these scenarios for a period of 2000-2020 are given below in Table 1 and served as input for the various model simulations. One should note that the considered plans/strategies did not provide the full volume of input information and therefore in case of missing information indicators of the optimistic scenario were used.

Table 1: Major indicators of the national development plans

Indicator	Year	Unit	South. Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Population growth rate	2010	%	1.30	1.50	4.20	3.20	1.95
	2020	%	1.30	1.50	3.00	3.20	1.95
Population	2010	*million*	2.77	2.72	8.84	8.52	30.08
	2020	*million*	3.16	3.15	12.15	11.68	36.48
GNP	2010	*billion $*	6.5	2.4	2.9	12.2	33.8
	2020	*billion $*	11.3	4.2	5.5	64.1	65.2
GNP growth rate	2010	%	6.0	6.0	6.1	18.0	8.0
	2020	%	5.0	5.0	6.0	18.0	6.5
Agricultural share in GNP	2010	%	34	50	30	15	24
	2020	%	32	50	30	15	24
Industrial share in GNP	2010	%	24	20	26	32	25
	2020	%	26	22	26	32	25
Irrigated land	2010	1000 *ha*	809.5	447.5	822.6	1897.5	4712.9
	2020	1000 *ha*	881.8	479.7	959.7	2343.9	4915.0
Irrigated land per capita	2010	ha/capita	0.29	0.16	0.09	0.22	0.16
	2020	ha/capita	0.28	0.15	0.08	0.20	0.13
Unit water use for household and drinking water supply	2010	*1000m3/man/year*	0.06	0.04	0.08	0.07	0.09
	2020	*1000m3/man/year*	0.07	0.06	0.08	0.08	0.09

The water distribution in the Pre-Aralia region and among the remaining water bodies of the Aral Sea was analysed for the recent situation, an alternative which has been developed within a former NATO grant, and for the case that the discharge of the Amudarya will mainly feed the Wetsren lake and some water bodies in the Delta region.

3.2 Models and Simulations

For the whole Aral Sea catchment a simulation tool was adapted to analyse the flows of water and the salt load in the basin and to study the socio-economic consequences of water use in the region. The whole area was subdivided into 42 planning zones and in each planning zones the major water consumers were identified. The water resources model (Fig. 1) reflects formation, regulation and use of water resources in transboundary rivers of the Syrdarya and the Amudarya basins, and with respect to the three scenarios defined above simulations were executed for a time horizon of about 20 years.

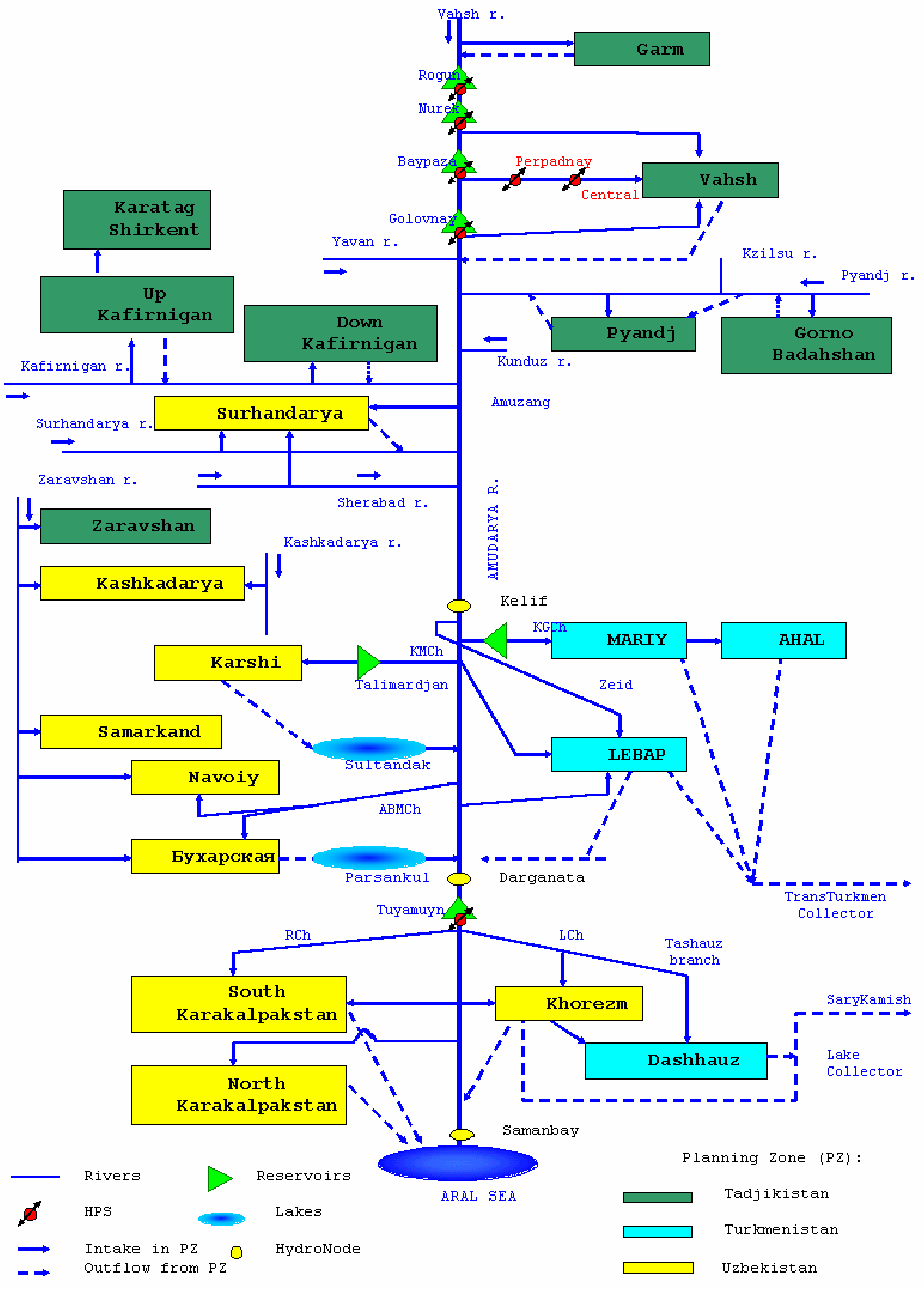


Fig. 1: Flow Paths of Water and Major Consumers

The socio-economic modul (Fig. 2) was based on the following parameters and yielded information about agricultural and industrial productivity under different development scenarios:

- population (rural and urban)
- economy (GNP, GNP per capita, contribution of economic sectors to GNP)
- water (demand of economic sectors; availability is calculated in the hydrological model)
- agriculture (irrigated land productivity by crops, including technical and food crops)
- investments (investments in agriculture, direct foreign investments)
- energy (production and consumption)
- food (calories production and consumption, with regard to food basket)

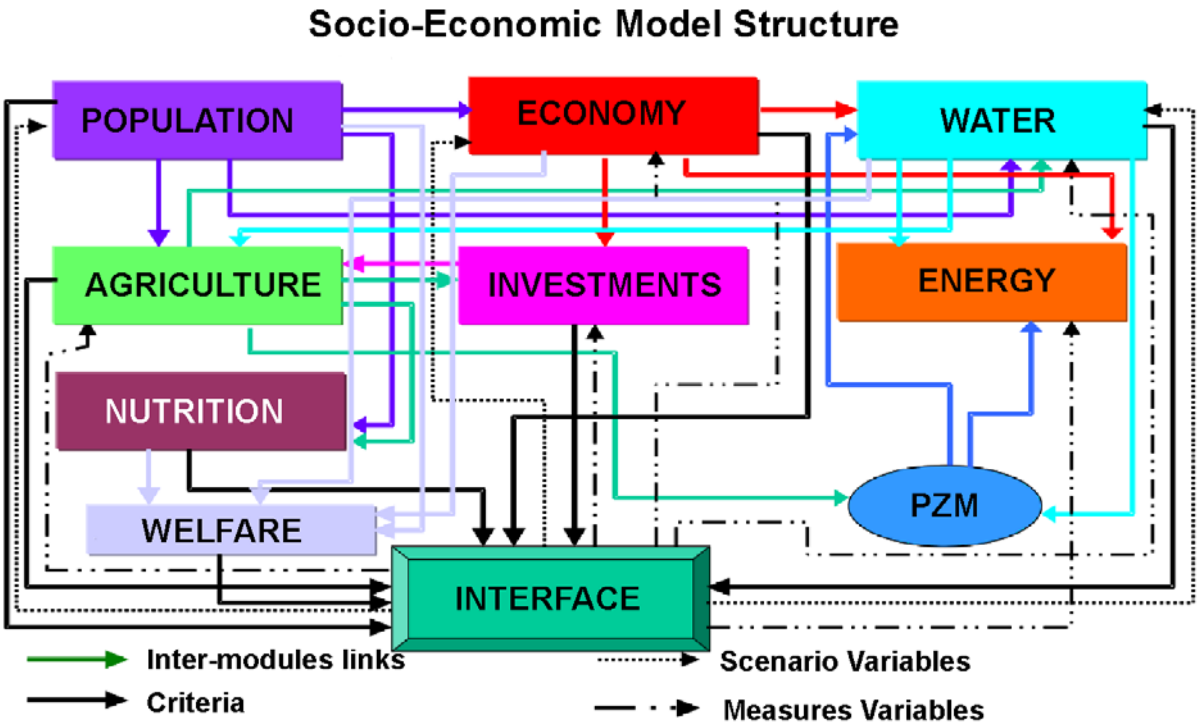


Fig. 2: The Coupling of the Modules

The final recipient of all the flows of water, salt and other pollutants is the Aral Sea, or what has remained from the former large water body. Three mathematical models were used to represent various aspects of the sea behavior and development. These are the hydrological, the hydro-dynamic and the environmental model. Mixing processes, stratification, sediment-tation and interaction among the water body and the atmosphere required the analysis at different spatial and temporal scales. At the higher hierarchic level the Aral Sea is considered as a system consisting of four interconnected objects: Amudarya delta, Aral Sea's Western bowl, Aral Sea's Eastern bowl and Aral Sea's Northern bowl referred to as the Small Aral Sea with its own economic and ecological indicators. A subdivision of the system into four components was necessary due to the water exchange among the different water bodies. The exchange process itself is dependent on the difference between water transfer from the Amudarya Delta to the Aral Sea's Western part and their transfer firstly to Eastern part and then to the Western part of the Sea.

The second hierarchic level is comprised of three simulation models, two of which describe water movement and mixing dynamics within Eastern and Western parts, while the third one refers to the formation and development of biological populations. The boundary conditions for this model are derived from the previous hierarchic level and reflect the water resources distribution strategy, the current situation in Eastern and Western parts of the Aral Sea and external climatic factors of the Aral region. Model outputs (statistical characteristics of Eastern and Western parts) form ecological conditions for the environmental model, which is based on ordinary differential equations, simulating the dynamics of biological populations in the Sea.

The subunits (Western, Eastern and Northern part of the Aral Sea) have quite different topographic features and especially the deeper Western part required a 3-D for simulating properly the hydro-physical and hydro-chemical processes. For a few cases a full 3-D model was applied but due to the computational efforts a 1-D vertical model was complementary applied. The simulation of mixing, sedimentation, ice cover was modeled based on the previously estimated exchange of water among the water bodies. As a result the currents within the water body, the stratification processes and the salinity were obtained for each scenario.

The model simulations provide an input for the Pre Aralie region and the Aral Sea mostly originating from Amu- and Syrdaria. The subdivision of this region is given in Fig. 3, below.

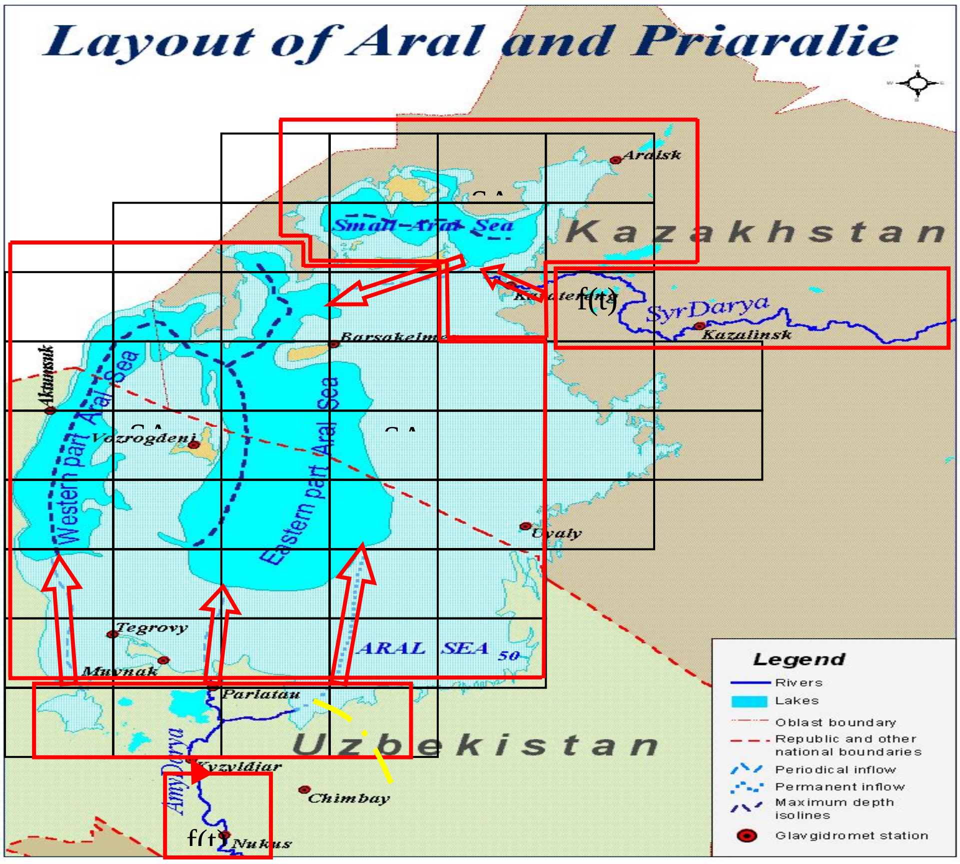


Fig. 3 Zonation of the Prearalie and Aral Sea region

4. Results

First, the results from the scenario runs are described by discussing the inflows to the Prearalie region and into the Aral Sea. Then the hydro-physical and hydro-chemical consequences for the water bodies of the former Aral Sea are analysed. Thirdly, the ecological consequences are presented.

4.1 Scenario runs

The water balance and flow model was calibrated for the Northern Sea water level and water salinity for the period from 1988-1998 using monthly intervals. The correlation coefficient between observed and simulated water balance was 0.98, while the salinity showed even a higher correlation of 0.99 (see Fig. 4 - 6). The uncertainty in the simulation is smaller than the error in estimating the water volume from bathymetric data and water table measurements. The models are therefore considered as appropriate to simulate the period from 2005 to 2025 for different scenarios. In some cases the simulations have been extended up to 50 years but these results are classified as less relevant.

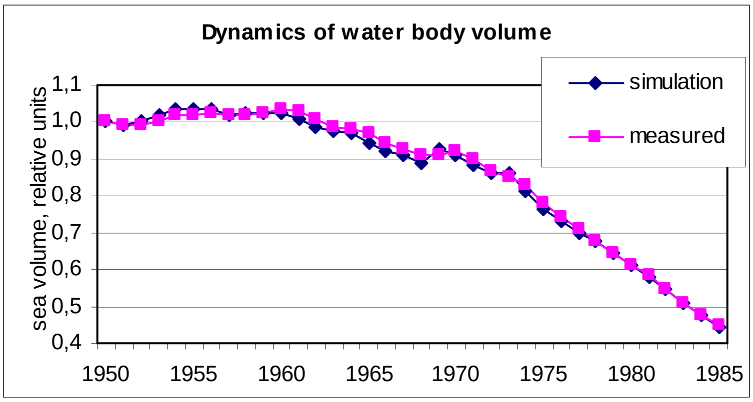


Fig. 4 Dynamics of Water Body Volume of Aral Sea

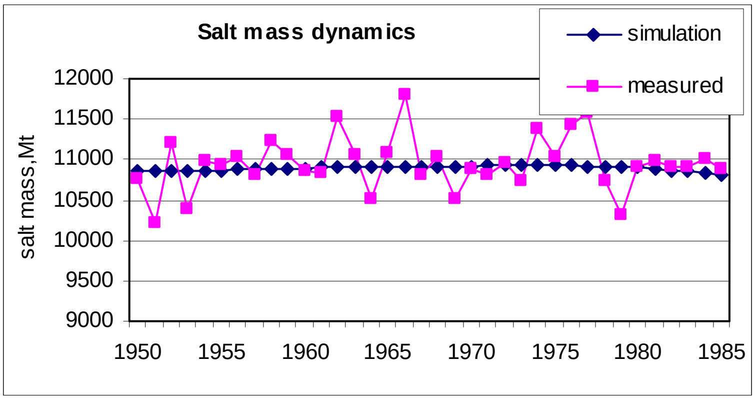


Fig. 5: Salt Mass Dynamics of Aral Sea

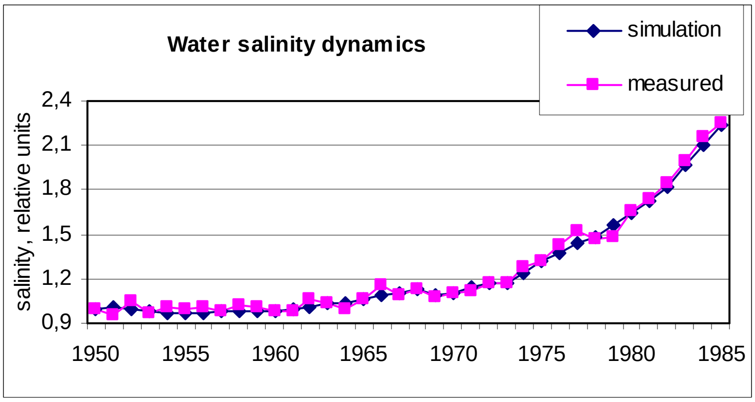


Fig.6: Water Salinity Dynamics of Aral Sea

According to **optimistic scenario**, inflow to Syrdarya delta (Kazalinsk) is estimated as 7.9 km^3/yr with average annual salinity 1.0 g/l. The average annual Amudarya (Samanbai) runoff is 12.65 km^3 that is 6.0km^3 more compared with business as usual scenario and 8.8 km^3 more compared with national vision scenario. Average annual salinity by Samanbai is 0.95 g/l.

Calculations show that under **business as usual** scenario the average release to Syrdarya delta is 4.96 km^3/yr with an average annual salinity 1.37 g/l. The average release to the Amudarya delta is 6.6km^3/yr with an average annual salinity 1.32 g/l. Inflow to Amudarya delta varies within 16 - 16.2 km^3 during growing season and 0.8 - 7 km^3 during non-growing season. Average salinity (at Samanbai) varies within 0.8 – 2g/l.

According to the **national vision scenario**, at expense of winter releases to Syrdarya delta (Kazalinsk) inflow to delta is maintained at the level of 4.0 km^3/yr with sharp fluctuations: during non-growing season 5.5 km^3, during growing season 0.1 km^3 and salinity varying within 1.2 - 2.2g/l. Average annual Amudarya runoff is 3.9 km^3, average salinity is about 1.55 g/l. Inflow to the Delta varied within 0.2 - 8.6 km^3 (during season) because it depends on reservoirs management practice. Major influence originates from Nurek dam serving power generation and Tuyamuyun and other reservoirs serving irrigation purposes. Maximum seasonal salinity (at Samanbai) reaches 3.0 - 5 g/l, while its minimum is about 1.0 g/l.

Table 2: Average of Syrdarya and Amudarya design flow (km^3) and water salinity (g/l) for three scenarios. (seasons (X-III, IV-IX) and for year (X-IX))

Scenarios	Indicator	X-III	IV-IX	X-IX
Syrdarya - Kazalinsk				
1. Business as usual	River flow	4.30	0,66	4,96
	Water salinity	1.38	1.33	1.37
2. Optimistic	River flow	4.71	3.21	7,92
	Water salinity	1.06	1,00	1.03
3. National vision	River flow	3,81	0.31	4.12
	Water salinity	1.45	1.36	1.44
Amudarya - Samanbai				
1. Business as usual	River flow	2,74	3,84	6,58
	Water salinity	1.52	1.19	1.32
2. Optimistic	River flow	3.75	8,90	12.65
	Water salinity	1.22	0.90	0.95
3. National vision	River flow	2.39	1.52	3,91
	Water salinity	1.64	1.40	1.55

The sensitivity of the inflows to different climatic conditions is given in Table 3.

Table 3: Average of Syrdarya and Amudarya design flow (km^3) and water salinity (g/l) for three scenarios under different climatic condition (Max=wet, Min=dry, seasons (X-III, IV-IX) and for year (X-IX))

Scenarios	Indicator	X-III Max/Min	IV-IX Max/Min	X-IX
Syrdarya - Kazalinsk				
1. Business as usual	River flow	4,43/3,50	0,79/0,62	
	Water salinity	1,36/1,50	1,30/1,46	
2. Optimistic	River flow	4,76/3,17	2,51/1,86	
	Water salinity	1,05/1,12	1,00/1,10	
3. National vision	River flow	3,46/2,61	0,49/0,43	
	Water salinity	1,47/1,61	1,1,35/1,51	
Amudarya - Samanbai				
1. Business as usual	River flow	3,00/1,46	4,77/5,02	
	Water salinity	1.45/1,80	1,28/1,27	
2. Optimistic	River flow	3,61/2,32	7,55/6,58	
	Water salinity	1,25/1,35	0.90/0.95	
3. National vision	River flow	3,98/2,29	3.06/3,21	
	Water salinity	1,40/1,77	1,34/1,36	

4.2 Simulation of the Aral Sea

For testing the models for the water body of the Aral Sea and the Prearalie region the period until 1960 is considered as the stationary state of the sea (in long-term dimension), the period from 1961 - 2002 is used as a reference period to describe the unsteady state of the sea, the years 2000 - 2005 have been selected as a testing period, while 2005 – 2025 define the forecasting period.

The first two periods form the basis for estimating values of phenomenological parameters for all groups of mathematical models. The forecasting period is about 20 years but it can be also seen as unlimited since at present one can estimate a stabilization period of the Aral Sea through the water factor, i.e. water surface elevation and volume of water body under different water inflows; however, time of stabilization of hydro-chemical and biological processes cannot be determined at the given stage. The testing period within the framework of the given project allows to evaluate the accuracy of forecasts.

Since 1986, the Aral Sea consists of two independent objects – the Large Sea and the Small Sea - with their own bathymetry and hydrology. Small sea (Northern part of Aral Sea) is recharged by the Syrdarya river from south-east. The volume of the small Sea at 42,0 m is ~ 27 km^3 with a water surface of 3105 km^2. The maximum depth equals 18m and the average depth has been estimated with 8,7m. Evaporation rates are similar in both lakes while the freezing conditions differ because winter temperatures in the small Sea are 4° C lower compared to the large Sea. The Syrdarya runoff is taken by small Sea within its capacity, excessive water flows to Large Sea. River and sea water mixing is slow because of small Sea topography(river water replaces sea water); that's why salinity of water inflowing to large

Sea is lower compared with water salinity in small Sea. Regarding the large Sea, small Sea plays a role of a pulse source, with salinity depending on the released volume.

Since 2000, an isthmus developped in the South of the Large Aral Sea and separated the water body into Eastern and Western bowls. Circulation of flow in the sea practically stopped but the small channel kept the water levels in the both bowls at a common level. This fact had dramatical effect on salinity dynamics. It has raised the intensity of salinity in the Eastern bowl, even despite the fact that it receives practically the whole runoff of the Amudarya river plus releases from the Small Sea. At present, the Western bowl is filled with water through the Northern channel, and its only source is Eastern bowl with highly saline water. Discharge in flow channel and its direction is determined from difference of water surface levels between the bowls and from the cross-section area of the channel. According to bathymetric curves, the Northern channel disappears at 29.0 m and both bowls start to develop independently from each other.

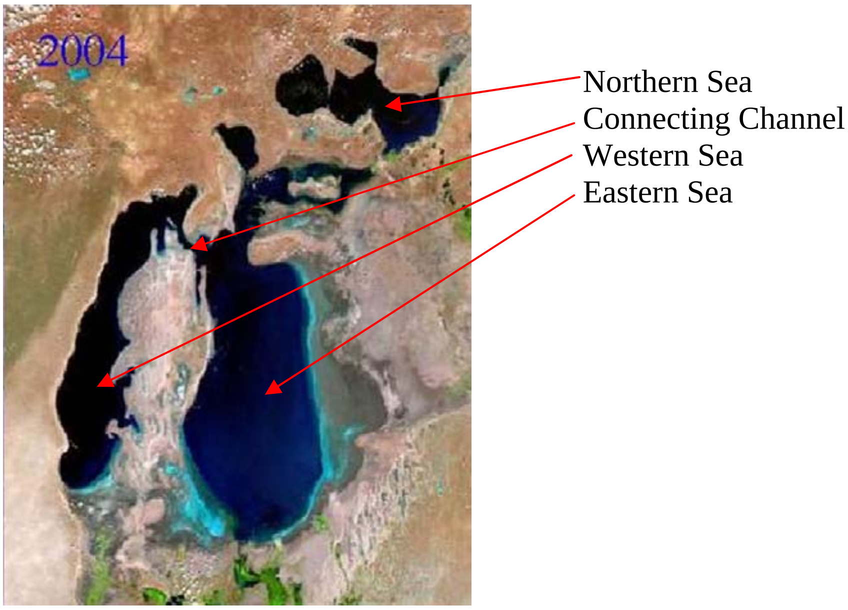
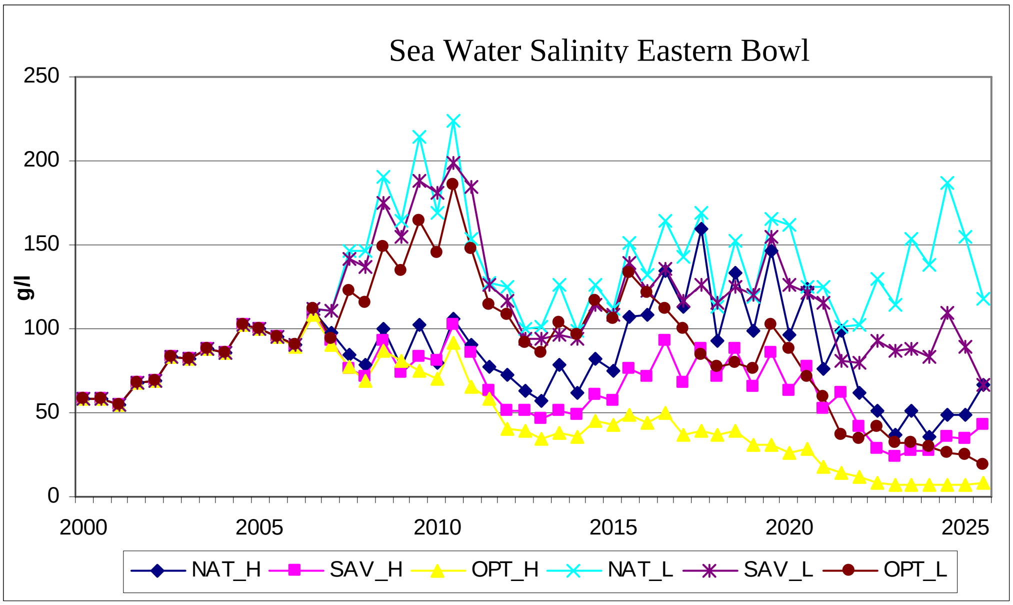


Fig. 7: Different Water Bodies of Lake Aral

Simulations show that water level stabilization in the Northern Sea at the altitude of 41.5 - 42.0m is possible under all scenarios only for the next 3-5 years. For the national vision scenario the level will fall down soon to 40m. A water level stabilization at the altitude of 47m is found only for two scenarios: business as usual scenario after several decades (2040) and for optimistic scenario after 2020.

The scenarios differ with respect to water salinity dynamics in Northern Sea. Under level stabilization at 42 m salinity in first 5 years (2010) decreases under all scenarios to 16 - 17 g/l and then: under business as usual scenario increases to 18 g/l, under national vision scenario – decreased to 15 g/l, under optimistic scenario – decreases to 12 g/l by 2025 and to 6 g/l by 2050.

The Southern part is expected to be separated soon into two water bodies as it was already the case in 2004 (Fig. 7). This will happen when the water level drops below 29 m which is expected in all scenarios until 2010. Only a series of wet years might delay this process. In the long term a water table between 28,0 and 31,0 is expected. Additionally, the salinity is already extremely high ranging among 50 – 80 g/l. The development of the salinity, crucial for any ecological system, is given in Fig. 8 for the different scenarios considering also H (wet) and L (dry) climatic conditions.



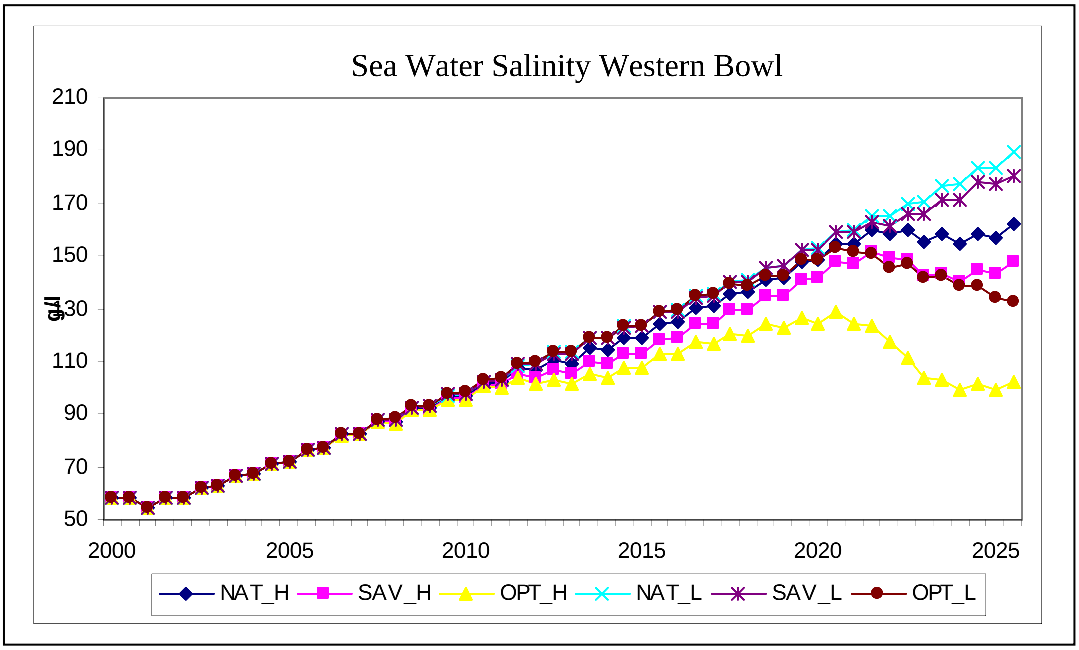
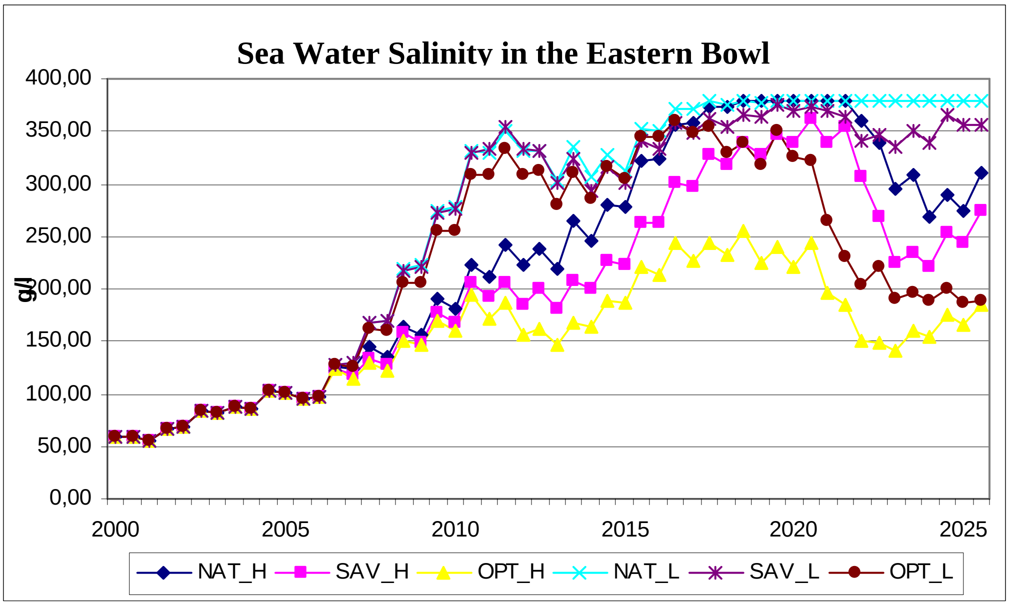


Fig. 8: Water Salinity in Eastern and Western Bowl for recent situation and different scenarios

It can be easily concluded that even in the optimistic scenario the ecological situation of the Aral Sea will continue to deteriorate. Under the recent conditions the Western part, which is deep and has a larger water volume, will suffer most. Therefore, further alternatives were investigated for the Prearalia region. The are based on

- the recent situation,
- a previous NATO study and
- a new water project transferring most of the discharge from the Amudarya directly to the Western bowl.

The simulation results for the proposed water transfer system are given in Fig. 9.



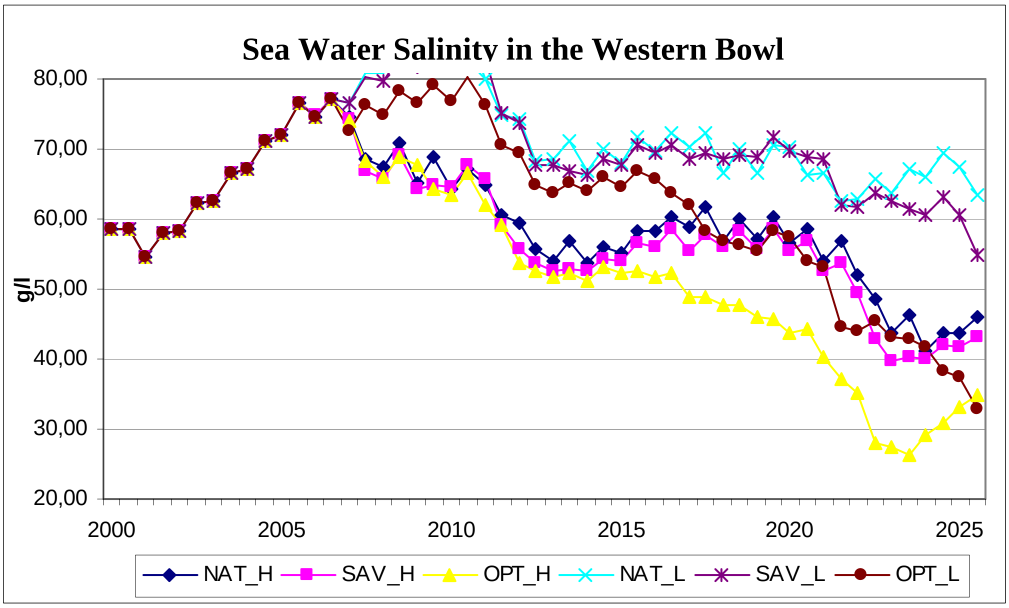


Fig.9: Sea Water Salinity for the New Transfer System and different scenarios

The two water bodies will be separated and the inflow to the Western part will slowly reduce the salinity while the Western part will more or less dry up and the remaining water body will exhibit extremely high salt concentration.

4.3 Consequences for the Ecosystem

The ichthyofauna of the Aral Sea originally was relatively poor. There were only 20 species of fishes from 7 families. For comparison, in the similar land locked Caspian Sea, the fish fauna comprised 130 species of 19 families. Of 20 Aral fish species, 10 or 12 were commercial; these were mainly valuable large fishes of high commercial quality. Later, due to introductions in 1950-1960’s, the number of species rose up to ca. 30 species. As salinity raised in 1970’s most aboriginal freshwater species vanished. In 1981 fishery was stopped in the Aral Sea. During 1980’s all aboriginal and most introduced species became extinct in the Aral Sea due high salinity. By 1990, only 5 species survived in the Large Aral: baltic herring *Clupea harengus membras* (Linnaeus), flounder *Platichthys flesus luscus* (Pallas), atherine *Atherina boyeri caspia* (Eichwald), and bullheads *Neogobius fluviatilis* Berg and

Potamoschistus caucasicus (Kewrajsky). During 1990's both bullheads vanished. In 1990's the feeding of flounder consisted mainly on shrimp, crabs, nereis, mollusks and bullheads. Currently, artemia constitutes the main food source for flounder. In 2001 only 2 species of fishes survived in the Aral Sea: atherine and flounder.

Due to high water transparency and shallow depths in the Aral Sea, most organics have been produced by phytobenthos, not phytoplankton, which made the ecosystem of this waterbody different from the ecosystems of other seas. In general, the stet biomass of phytobenthos reached 90%, while phytoplankton reached 10% (Karpevich, 1975). In 1990's almost all species became extinct in the Aral Sea. Presently the only benthic macroscopic plants in the Aral are *Cladophora fracta* and *Vauscheria sp.* In 1950-60's, in phytoplankton diatoms were dominant in the Aral Sea. According to Aladin and Kotov (1989) from 1972 to 1983 most species of brackish water planktonic algae vanished from the Aral Sea. In the 1980's, when salinity reached 24 ppt not only brackishwater species, but also some marine euryhaline species of algae began to disappear (Elmuratov, 1981). In 1999-2002, we recorded 159 species of algae in the periphyton and 167 species in the plankton. This is approximately half as much as recorded previously. So, in the 1920's, Kiselev (1927) recorded 375 species in the plankton of the Aral Sea, while in 1960-70's Pichkily (1981) and Elmuratov (1981) recorded 306 and 278 species, respectively.
With increasing salinity and transition of the Aral Sea from an oligohaline to a polyhaline water body its biota became drastically poorer. Almost all aboriginal species became extinct in the Large Aral, some still surviving (including some endemics) in some lakes (refugia) around the Aral Sea (Mirabdullayev et al., 2001). Revealing the remaining Aral biota in lakes of southern Aral Sea region is important not only from the view point of biodiversity conservation, but also for the increase of biological productivity of water bodies lying in Central Asia. Gaps in ecological niches in most of considered lakes result in their decreased biological productivity and eventually in lower fish yields. In this case, the introduction of some representatives of the Aral biota could prove an effective means for an increase of fish yields of major aquaculture ponds in Uzbekistan (Mirabdullayev et al., 1999).

To evaluate the consequences of a lower water table and higher salinity for the ecosystem of the Aral Sea the salt tolerance of various species has to be linked with the previous simulations. Developed fisheries based on freshwater species (mainly Cyprinidae) is only possible at levels of mineralization of 6-15 ppt. Fisheries based mainly on flounder and Acipenseridae on the Aral Sea are already possible at the level of water mineralization of 35-40 ppt. However, this is only possible in case of regular stocking of water bodies with juveniles and the use of the Aral Sea as the fattening water body (the so-called pasture aquaculture). At mineralization levels within 40-75 ppt, using bioresources of the Aral renders impossible to. However, if the mineralization levels grow higher than 75 ppt, a new type of bioresource, namely brine shrimp *Artemia*, will emerge. Cysts of artemia are widely used in aquaculture and are of commercial importance. Main factors limiting the development of artemia are forage (microalgae of phytoplankton), competitors (zooplankton) and predators (fishes). The development of phytoplankton is largely determined by the amount of nutrients in the sea. The availability of competitors and predators are mainly determined by their salt resistance. At mineralization reaching 70-80 ppt fishes vanish and the development of zooplankton significantly drops, which helps the artemia population to dominate in the water body ecosystem. This, in turn, enables the commercialization of catches of artemia cysts. The population of artemia preserves productivity at mineralization as high as 200-250 ppt. Artemia is capable of surviving at highest levels of mineralization (up to 300 ppt); however, its productivity decreases substantially.

With the existing infrastructure in the Amudarya delta, the Eastern water body will water supplies allow to maintain Eastern bed within 21 m and 31 m in almost all scenarios. At this variant, Western bed catastrophically falls to levels ranging between 20 and 26 m. In these same conditions, the expected mineralization in the Eastern bowl will widely range from 65 g/l to 100 g/l, while some extreme values may reach 250 g/l (see Fig. 8). The Western bowl shows a stable mineralization growth to 150-270 g/l and this implies that all scenarios are not profitable at all from the ecological view point. The volume of western basin drops significantly and its high mineralization unambiguously leaves no hope to rehabilitate the original ecosystem. As the mineralization continues to grow higher than 200 ppt the water body will loose also its importance for artemia catches. Enormous fluctuations of mineralization will prevent any stable biogeocenosis from developing there. Similarly, in the coastal zones of the Eastern water body the formation of stable arid and steppe biogeocenoses in part of the Aral Kums will hindered because periodical floods of saline waters will destroy the emerging vegetation and associated fauna. It can be concluded that the current inflow to the Eastern part is not satisfactory at al.

In the variant of water supply suggested in the NATO project, the ecological situation is perhaps similar: sharp fluctuations of volume, area and mineralization of eastern basin will prevent any stable or productive biocenoses from forming there. The water body will represent a trap for biota, in which mass extinctions of organisms will take place as a result of drying, flooding and mineralization fluctuations. This variant will not contribute to the rehabilitation of the original ecosystem of the Aral or even approach it ecological parameters.

From the ecological viewpoint, the water transfer scheme is most promising, in which the maximum flow reaches the Aral bed from the Amudarya delta along the western branches. In this variant, stabilization of water volume and area of western basin takes place and gradual drop in salinity to the level of a brackish water body, which with respective reintroduction measures enables a gradual restoration of the original biota and rehabilitation of fisheries. Considering the fact that the original fish productivity in the Aral Sea reached 5-6 kg/ha, western basin with the area of 5000 sq. km can potentially produce 2500-3000 tons of fish annually. Western basin is a narrow and prolonged water body stretching in meridian direction; therefore, due to a slow convection significant areas of fresh water are formed in the first years in its southern part, which is acceptable for introduction of hydrobionts including commercial fish fauna. Inflow of biogenic elements and organic matter to western basin will contribute to an increase in its overall productivity. A water regulating facility constructed on the canal connecting western and eastern basins could regulate water discharge to eastern basin and therefore control its volume. This, in turn, will enable the development of stable terrestrial biocenoses on the exposed bed of eastern Aral basin.
Another advantage of the realization of variant 3 is an opportunity to develop oil and gas complex. Intensive oil and gas prospecting is under way on the bed of the Aral Sea and production of limited explored deposits has been initiated. The drying and stabilization of Western basin could help to effectively conduct geological prospecting of oil and gas and if successful to begin developing their production.

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