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ABSTRACTS OF PRESENTATIONS

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TWO CENTURIES
OF THE ARAL SEA INVESTIGATIONS

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The Aral Sea: Already Dead, Dying, or Alive?

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In the first half of XX century, the Aral Sea was a single closed terminal water body of two rivers in the arid zone. Its water area was mostly brackish with specific native brackish water ecosystems. Since 1960s, the decrease of water level and the increasing salinity have started. Depending on the bottom relief the Aral Sea began to split into several water bodies. In 1989, when level fell by 13 m, the Aral Sea was divided into 2 polyhaline terminal lakes with marine ecosystems. It is possible to say that Aral disappeared as a geographical object and instead of it appeared two new ones: the Large and Small Aral. It was one lake with 2 tributaries, but since 1989 appeared 2 lakes with one tributary each. So, from geographical point of view Aral Sea disappeared 20 years ago. In the fauna of the new 2 lakes only widely euryhaline species remained due to water increasing salinity and introduction of salt tolerant exotic species. Fish fauna consisted of introduced species of marine origin. In spring 1990, level of the Small Aral increased and a water flow to the Large Aral appeared. In August 1992 a dike to stop it was built in Berg's Strait. Salinity in the Small Aral stopped growth and began to fall what was favorable to the fauna. Transitional brackish-marine salinity zone were formed. In April 1999 the dike was destroyed by storm. Construction of new solid dike started in 2004 and was finished in autumn 2005. Since that date it is possible to say that so called Small Aral Sea should now be considered as a regulated brackish-water reservoir. After Aral division in 1989, increasing salinity and level fall in the Large Aral became faster and now it is divided into western and eastern basins and Tschebas Bay. Salinity in the

eastern basin is growing faster than in the western one. In the late 1990s, the Large Aral became hyperhaline with specific fauna. Some invertebrates from local saline water bodies were moved to the Large Aral by natural way. Brine shrimp became predominating in zooplankton. Next year Eastern Large Aral should disappear. From the biological point of view residual water bodies of Aral Sea are definitely alive. It is possible to say that ecosystem of a lake behaves like transformer: from brackish type to marine one and finally to hyperhaline and vice versa.

Geoinformational Mapping and Landscape-Ecological Monitoring Support in the Southern Aral Sea Region

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Landscape-ecological or geoecological monitoring (GM) is one of the important parts of complex program solving the Aral Sea disaster problem. Complex landscape methods and application landscape studies in common with landscape-ecological mapping are being the secure basis of scientific data receipt for the geoecological estimation and GM. Spatial landscape structure and conditions analysis for the geoecological remote sensing assisted monitoring is the most effective for the using of consecutive series of models: verbal, portrait, block and cartographic. The contemporary level of regional cartographic monitoring is being achieved on the ground of complex of methods: field nature research, remote sensing data and GIS technologies.

The landscape map of the southern Aral Sea region was created as the basis of cartographic support for the geoecological monitoring. Landscapes are the complex systems with the internal structure and functioning features in common with external relationships (vertical and horizontal interconnections). Component-specific landscape maps and the map of exogenous processes have been created on the ground of spatial analysis of these interconnections. For the complex geoecological estimation within GM tasks the series of maps was supplemented with the map which was reflected the character and intensity of anthropogenic influence on landscapes. The map of nature management is the key to estimate the degree and direction of the anthropogenic influence on territory's landscape structure. The series of analytical maps (estimating and forecasting maps are the most valuable) is the basis of geoinformational support of landscape dynamics analysis. Finding positive and negative feedback cause-effect relations between forms of anthropogenic influence and landscape conditions is the requirement of landscape changes discovery.

Rehabilitation of Degraded Ecosystems Using Innovative Technologies for Sustainable Economic Development and Stabilisation of Ecological Situation in Priaralye

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Drying up inner lakes is a specific to arid zone with growing population and economy. But, scale of desertification on 8 mln.ha area, including dried the Aral Sea bed, fertile deltas of Amu Darya and Syr Darya rivers have no analogies in world. Ecological situation uncontrolled worsening in the Priaralye and in the Aral Sea Basin, which conform of unsustainable using natural resources, non balanced growing economy, using 80-90% of water reserves for extensive irrigations. Poor water management, absence of adequate drainage and irrigation systems followed by water logging, soil salinisation, declining crop yield. Damage to economy reached
1.0-1.4 bln.USD. About 80 thousand hectares of irrigated land annually excluded from using in the basin. Alarming mobilization of salt from deep geological strata took place in new and all irrigated systems. Common volume of salt forming here reached 120-140 mln. tons, which exceed 4-5 times volume of salt discharged to Aral Sea by rivers. Huge volume of return and drainage water are forming in basin (30-40 km^3), half of them run off to rivers spoiling drinking and irrigation water quality downstream, others release to depressions with non-stable water regimes. Water logging resulted by evaporative concentration of toxicants on upper part of soil-persistent organic pesticides, trace and heavy metals, which migrate to agricultural crops, evaporates under high temperature, transfer under wind activity and impact of human, child and animals health. On this reason morbidity of population in Khorezm and south Karakalpakistan with bronchial asthma, bronchitis, and allergic diseases 2-3 time exceed average in Uzbekistan and whole Karakalpakistan. 70-80% of woman and child suffer from Anemia in all Priaralie.

It is a high potential of efficient using water resources in Central Asia, conforming data were

presented by UNESCO report on water Vision- 2025 (Water Forum, 2000, Hague), if innovative
natural resources and energy saving local and international technologies would be implemented in practice. That is way, we are trying to use integrated approach to elaborate differential nature protection measures on the base of long – rang fulfilling full scale environmental monitoring. Project for creating artificial landscapes, productive pastures, to built "green barrier" on the whole dried the Aral Sea bed were proposed for realizing them during 15 years (1990 - 2005).

Efficiency of these measures proved by time, 10 thousand cow are grazing round year in artificial wetlands created near Muinak city, 60 thousand cow are grazing from May to November from all Karakalpakistan, and harvesting young reed as hay for stoking for winter period, lake Sudochy became reservoir for fish breeding and reservation for international
birds migration. In wet years, area of wetlands increase to 250 thousand ha with potential reed biomass 800 000 tons, which after fermentation became feed material for animals, cellulose for processing paper, construction material for preparing Hardboard and chipboard. Many other technologies were implemented in the Priaralie on pilot sites: cash crop Licorice on saline soils gave 10-15 t/ha root with supplementary irrigation; treatment on different bioplateau big volume of drainage and sewage water and reusing them for irrigation of sandy soils in desert zone; bioengineering methods of rural drinking water supply; biotechnology cultivation of valuable microalgae, shrimp Artemia, getting salt product($MgSO_4$, $Mgcl_2$, $NaSO_4$,Kcl) on brine lakes; drip irrigation of orchards on sandy soils by saline water, combined with biological drainage; hydroponics and gun sprinkler irrigation; restoration of

tugay forests on riverine water protection zone; using thermal artesian water for intensive growing fish Tilapia, vegetables in greenhouse and use sewage water for irrigation of fodder crops, etc. In parallel large scale monitoring of Priaralie was done, including dynamic of landscapes for 25 years, using remote sensing materials and its deciphering by using helicopter, with preparing thematically maps of plant coverage, hydro geological situation, forming barchans and wetlands, soil types, solonchaks, migration and destruction of pollutants, etc. Unique and detail data collected in field experience on quality and quantity of transferring and deposition of dust-salt aerosols, its impact to natural and cultural plants during 1981-1991, 2002-2007. Methodology of ecological zoning of Uzbekistan worked out and implemented for 13 districts,178 rayon's of Uzbekistan on 20 selected indicators with preparing 12 thematically maps for each district. Innovation world technologies could restore any kind land degradation and getting high income.

Peculiarities of Biodiversity Monitoring in Nature Reserve Barsakelmes in Conditions of Ecological Crisis

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Nature Reserve Barsakelmes is only one in the world located in a zone of ecological crisis of global scale.
Monitoring studies is a basis for long-term observation of natural processes. It is important for Barsakelmes to monitor the territory of the Aral Sea dry seabed. It represents the great scientific importance as a unique world-wide nature laboratory for study of global desertification processes.
Ecosystem approach is a modern method for research, monitoring and preservation of the environment.

Ecosystems of the new land should be distinguished as the area of extraordinary scientific interest. Mapping in a large scale will give spatial pattern of ecosystems' distribution.
The most important aspect of nature chronicle should be selection key species and communities. Each protected area existing in isolation from human impact is automatically compared with similar contiguous ecosystems, first of all with vegetation. Key subjects should be chosen according to their significance, value of resources. Rare, vulnerable, zonal, representational species are selected according to global, national, local importance.
Advanced ecological monitoring has related to reorganization of Nature Revere into Biosphere Reserve as the most efficient form of regulation of nature conservation and socio-economic activities in the territory. Direction towards assessment and realization of sustainable functioning of wetlands will best meet the requirements of Ramsar Convention after joining core area in the Syr Darya river delta.

Archaeology and its Relevance to the History of Climate and Hydrology

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A brief review of archaeological data is given and their relevance to the reconstruction of climate and lake level changes is discussed. Research began in the 19th century and has established a good database, especially for the southern Aral Sea region (ancient Khorezmia).
Human occupation of the region first began during the Late Pleistocene, but was probably interrupted by the last glaciations. The Aral Basin was re-settled by Neolithic populations after the 8.2 ky event and continued until now.

A humid climate is indicated for the early period, several large lakes in the Kyzylkum sustaining the Neolithic population, however, the lake level of the Aral Sea may have been low, since the Amu Darya drained to the Caspian Sea via the Uzboy at this time. At the end of the 3rd Millennium BC the northern Aral region carried a forest-steppe vegetation, which is indicated by cultural and economic change in archaeological culture. Around 2000 BC the Amu Darya stopped flowing to the Caspian Sea, changing its course to the Akcha Darya channel now densely settled for the first time. The Aral water level may have reached 40-45 m a.s.l. Climate change in Siberia is indicated as one important factor causing the Scytho-Saka migration at the beginning of the 1st Millennium BC. From the 6th Century BC onwards irrigation activity could have influenced the hydrological balance and perhaps the Uzboy was active for part of this period. A major regression in the 4th Century AD was probably caused by climate, but aggravated by extensive irrigation systems. In the 10th Century the water level of the Aral Sea was below 53m a.s.l., although both Amu Darya and Syr Darya drained to the Aral Sea. An extreme regression in the early 13th Century and a lesser one at the end of the 14th Century were presumably caused by war, possibly also influenced by earthquakes. They are well documented in medieval written reports. In both cases dams were destroyed and the Amu Darya drained to the Sarykamysh depression and/or the Uzboy, thus withdrawing water supply from the Aral Sea. A transgression at some time after the 14th century is documented by marine sediments overlying archaeological sites and may have existed as late as the 19th century.

The collaboration between different disciplines is very fruitful to all partners. In this respect archaeology can provide dating and a cultural context, sometimes helping to explain processes in the geosciences. Archaeologically obtained data sometimes provides further proxies for vegetation and/or climate change. Besides, some proxies identified by the geosciences can receive a different meaning when connection with the cultural-historical processes.

Although the present ecological crisis of the Aral Sea is certainly regrettable, it also offers new possibilities. All previous research was carried out only on areas of dry land (excepting coring of course) and features under water could not be studied. Therefore many aspects remained uncertain. The present exposure of the former lake bed can be seen as a chance to analyse both geomorphologic features and archaeological remains directly. Such research should be carried out soon, as it can help to understand past human reactions to extreme situations. A recovery of the Aral Sea, again blocking, or at least seriously complicating such studies, could occur fairly quickly as has happened in the past.

The Aral Sea yesterday and today, and appropriate measures for stabilization of the ecological situation in the region

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The Aral Sea is one of the world's largest inland brackish water bodies. Located in the heart of the Central Asian deserts, at + 53m abs., the Aral Sea has long functioned as a huge evaporator, with a total annual evaporation of about 60 km3. Until 1960, the Aral Sea represented the fourth largest inland lake in the world.

In the past times, the unique isolation of the Aral Sea contributed to extraordinary diversity of its biota, which could be compared with that in Africa. The Aral Sea region featured half of the total species number listed for the former Soviet Union, of which most have disappeared, or are currently on the verge of extinction. The regional species diversity listed 500 bird species, 200 mammals, 100 fish species; insects and invertebrates were widely represented, as well.

The situation started changing rapidly in 1960-s – 1070-s, which expressed in water level drop and, consequently, shrinking of the Aral Sea. A large-scale human intervention is believed to trigger these processes. In 1988-1989, the Aral Sea was divided into two reservoirs – the Large and the Small Seas connected via the Berg strait. In 2001, the Vozrozhdenie island (the largest island in the Aral Sea) became connected with the southern sea, which was followed by the further gradual separation of the Big Sea into 2 sections - the deep western part and the eastern shallow part. In 2009, the eastern part of the Big Sea dried completely. The Aral Sea ecosystem was destroyed and its climate-regulatory function was lost. Concurrently, a number of coupled processes intensified: increased air dryness, sand storms frequency, wind-induced removal of sand, dust and salt from the dried seabed (which transformed into a salt marsh). All these phenomena intensified desertification processes in the Aral Sea region.

Since the 1990-s, a number of projects have been implemented with the purpose of environmental rehabilitation of the Aral Sea basin. In accordance with the priorities under the Aral Sea Program, artificially-flooded landscape ecosystems are being created in the Syr Darya and Amu Darya River deltas.

In 1999-2002, a pilot project “Rehabilitation of Lake Sudochye infrastructure” (funded by GEF, Governments of the Netherlands and Uzbekistan) was implemented. As a result of project activities, the lake almost completely restored its former area and resumed its habitat importance for rare and endangered bird species (as per International Red Data Book): European white pelican, little egret, spoonbill, glossy ibis, mute swan, Dalmatian pelican, little cormorant, white-headed duck, etc.

Another project under ASBP priority is “Creation of local reservoirs in the Amu Darya delta and the dry bottom of the Aral Sea”. After implementation of priority interventions, the water surface area made about 150.0 thousand hectares (at the normal water level) that enabled biodiversity rehabilitation at the delta lakes, contributed to development of fish and livestock farming, significantly reduced transfer of salt and dust. However, frequent low-water years occurring in recent decades in the Amu Darya delta hamper sustainability of these wetlands.

In 2005, the project on infrastructure development of the Small Sea was resumed. The main objectives are as follows: increasing the Small Sea area, rehabilitation of delta lakes for fisheries purposes, improving water supply to irrigated lands, hayfields and pastures, improving health of the population, etc. By now, the project is nearly completed, stocking valuable fish species is initiated, and activities under the project II-nd stage (increasing the surface area of the Small Sea) are scheduled.

With view of negative impacts of current processes in the Aral Sea on the habitat conditions of people, animals, and plants, the following actions should be envisaged:

- To guarantee sanitary water discharges to the delta lakes, upon development of regionally-agreed legal tools ensuring this process;
- Implement design and construction works for collector and drainage water discharge into the Aral Sea;

- To optimize the operational retime of interstate water reservoirs and water management ensuring water supply to the riverine ecosystems.

Aral Sea Level Variability

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A method of wetland mapping and flood event monitoring has been developed on the basis of a satellite multi-sensor data combination. This includes radar altimetry in a multi-mission framework (Topex / Poseidon, Jason-1, Jaon-2, GFO and Envisat), laser altimetry (Icesat), and surface reflectance measurements from different sensors: the MODIS instrument onboard Terra satellite, optical imagery on Landsat satellites. It has been applied to the monitoring of Aral Sea basin water bodies: North and Small Aral, and the Sarykamish Lake.
MODIS data provide every 8 days, surface extension of free water, from 2000 to 2009, with a spatial resolution of 500 meters, and individual Landsat images allow to detect shoreline with a much better precision (28 meters), which is usefull in term of calibration of MODIS imagery and for the estimation of level versus surface rating curve. Altimetry provides level variations of the water bodies studied. Some in-situ data were also taken into account in the study that provided external forcing for total water budget of the basin (river runoff, precipitation, evaporation). A precise Digitized elevation model, and results from field campaign carried out by other groups are also used to determine volume variation of Aral Sea.
Based on these different techniques we have determined the extent of water within the Aral Sea basin, as well as volume

variations, which is key parameter in the understanding of hydrological regime in ungauged basin, where this type of information may be used as input of hydrodynamical model.

The Vertebrates of Barsakelmes Nature Reserve: Expedition Studies at Russian State Pedagogical University

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The studies on vertebrate animals have been introduced into the RSPU expedition program starting from the second half of the 1970-s. Under this program, observations on phenology, population dynamics, and habitat distribution were conducted for almost all vertebrate species. In addition, a number of species have been subjected to specific research. Vertebrate colonization of the desiccated Aral Sea bottom is being under targeted research since 1980.

<u>Amphibians</u>

No specific studies were conducted for the single amphibian species, the green toad, resident in the reserve area.

<u>Reptiles</u>

Out of the total 9 reptile species ever recorded on the island, one species, the water snake, has not actually occurred since the start of the expedition. The other species, the gray gecko, has been only discovered on the island by the members of the expedition. The targeted studies on the temperature conditions and food composition have been conducted for the most abundant species, takyr toad agama, the squeaky gecko, and the cottonmouth.

<u>Birds</u>

In early 1990-s, i.e., in the last years of Barsakelmes island existence, 38 bird species nested at its territory. According to the observations of 2005-2008, the number of nesting species reduced to 16-17 through this period. Ornithological expedition research peaked in 1980-1992. At that time, biological features of 15 bird species were investigated in details including their feeding, breeding and parental behaviour patterns, temporal budget, postembryonic development, food composition, etc.

The impact of extreme desert conditions on certain components of reproduction cycle, as well as the avian influence on the abundance of several insect species were the topics of targeted research.

Mammals

Four mammal species, the yellow gopher, the small jerboa, lesser five-toed jerboa, and kulan were scrutinised by the participants of the expedition. They studied, in particular, the annual cycle, diurnal activity, and the food composition, as well as the impact of the above species on the ecosystem constituents. In addition, the first three species were studied separately for the presence of helminth fauna and the temperature conditions in the holts; additionally – the endobiont protozoans in the digestive tract of kulan.

To date, the results of research conducted at Barsakelmes reserve in the course of RSPU expeditions are published in over 50 scientific papers related to various aspects of the vertebrate biology; however, certain materials still await their publication.

Changes in the Aral Sea Fish Communities and Fisheries in the Period of Ecological Crisis

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Fish fauna of Aral consisted of 20 species from 7 families. It was presented by generative-freshwater species. After introductions in 1927-1963, the number of species has increased up to 34, while composition of commercial fish species changed a little. Regulation of Syr Darya and Amu Darya flow and increasing water withdrawal led to the level fall and increase of water salinity changing habitation conditions, especially for reproduction. With the level fall spawning areas have reduced to the middle of 1960s almost by 5 times. In the end of 1970s – beginning of 1980s income of fresh water was stopped. Since 1975 there are no spawning areas in the sea. Fish fauna in coastal waters was presented only by silverside, gobies, and sometimes by ninespined stickleback. Because of worsening conditions for natural reproduction catches in 1961-1976 fell more than by 4 times. First signs of salinization negative impact on fishes appeared in mid 1960s at salinity 12-14 ‰. In the mid 1970s salinity exceeded 14 ‰ and natural reproduction stopped. In the end of 1970s indigenous commercial fish fauna was lost. To 1981 when salinity has exceeded 18 ‰, Aral has lost meaning for fishery. Only indigenous stickle-back and acclimatized gobies, atherine and Baltic herring remained. Commercial fishes of higher ages can be caught only in the mouths of rivers. In order to preserve fishery in 1979-1987 flounder-gloss from the Sea of Azov was acclimatized. In 1991-2000 it was in Aral the only commercial fish. Aral due to level fall divided in 1989 into Large and Small. In the end of 1990s salinity in Large Aral reached 60-70 ‰, and flounder became extinct as other fishes. Since 1988, runoff of Syr Darya began to enter in Small Aral creating freshened zone where indigenous fish fauna came from lacustrine systems and the river. In 1989-2008 ecological state of Small Aral has improved. Recession in agriculture has allowed a stable runoff of Syr-Darya. Construction of Kokaral dam allowed accumulating it. Area of freshened zone increased significantly and natural habitat of indigenous commercial fishes became wider. Some valuable commercial fishes reached trade number.

Water level decline in lakes: the difference between disaster and welfare

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Exceptional decline of water level in lakes is the outcome of natural and/or anthropogenic changes. The natural impact is commonly reduction of precipitation and/or enhancement of evaporation whilst man made effect is varied between source diversion and water inputs reduction, enhanced pumping or any other method of water withdraw from lakes. The anthropogenic changes are mostly aimed at agricultural development or improvement of water supply. The hydrological difference between natural and anthropogenic change is mostly the rate of water level decline and the amplitude: under natural conditions decline is commonly slower than those initiated by man made intervention. On the contrary, man made intervention in lake water budgets followed by long term decline of water level are accompanied by irreversible disturbances of the limnological conditions which sometimes terminated by catastrophic expression. Anthropogenic short term enhancement of water withdraw aimed at increase water

supply which cause temporal water level decline must precautiously analyzed to indicate either improvement nor deterioration of water quality. Moreover, the short term changes are possibly reversible whilst long term modification probably not. Two predominant parameters are considered: duration and amplitude of the change. Within these rationalities case studies will be comparatively investigated: Lake Chad in Africa, Lake Kinneret in Israel, Aral Sea in Kazakhstan and Uzbekistan, Lake Qarun in Egypt, Lake Sevan in Armenia and Lake Tai-Hu in China.

The Aral Sea basin: the time for trial and activity

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The Aral Sea basin includes two major watersheds - the Amu Darya and Syr Darya Rivers. These rivers are the main transboundary waterways across 6 countries: Kyrgyzstan, Tajikistan, Uzbekistan, Kazakhstan, Turkmenistan, and Afghanistan.

Prior to 1961, the Aral Sea featured the average area of water surface equal to 67.800 m^2, water volume –1064.0 km^3 (at 53-m sea level mark). Shrinking of the sea started in the second half of 1960-s. At present, the Aral Sea is split into three separate reservoirs.

Due to the shrinking processes, the Aral Sea area reduced by 33.0 km^2, and the shoreline receded by 100 km. Water mineralization in the southern part of the sea increased up to 90 g/l. More than 3 million hectares of the seabed and coastal delta became dry land. These large-scale processes led to decreased warming effect of the sea on its surrounding areas in winter, and cooling effect – in summer,

accompanied by climate changes (increased aridity and climate continentality).
The main problem concerned with the use of water resources in the Aral Sea is represented by conflicting interests of agriculture (irrigation regime in the countries of the lower reaches – Uzbekistan, Kazakhstan, and Turkmenistan) and power engineering (the energy use of the rivers by the upstream countries – Tajikistan, Kyrgyzstan). Prior to 1991, 70% of the river runoff was accumulated in the reservoirs of the upstream countries and was discharged to the lower reaches during the vegetation season. This situation has changed dramatically in the following years. In order to produce more electric energy, the upstream countries are forced to discharge up to 70% runoff during winter. This led to disastrous floods in winter and summer droughts in the lower river reaches, thus threatening the food security of the downstream countries. Disparity in the seasonal water demands has formed a major dispute between these two regional groups of countries in regard to the use of transboundary rivers.
To jointly address emerging water problems, the Republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan signed an agreement on joint management, use, and protection of transboundary water bodies, on 26 March 1993, and established the International Fund for Saving the Aral Sea (IFAS). The primary IFAS goal was defined as suspension and mitigation of the Aral Sea crisis, involvement of funds from the five states of the region, as well as from international organizations and donors for the sake of improving the environmental and socio-economic situation in the Aral Sea basin.
Since its inception, International Fund for Saving the Aral Sea has implemented a lot of activities towards improving regional conditions and stability in the Central Asia. Within

the IFAS framework, the Heads of the States of the Central Asia adopted relevant declarations, statements, and decisions; 2 intergovernmental programs, ASBP-1 and ASBP-2, were developed and implemented (ASBP-2 is still under implementation); as well as a number of other activities at various level have been undertaken. These efforts provided a solid background to cope with the complex issues of improving the regional water governance. However, the emerging problems outpace the implemented actions.

The main IFAS objective for the future lies in improving its organisation, enhancing the efficiency of IFAS activities, raising its image, and attracting donors to address the regional problems. A new Program for practical actions on improvement the social, environmental, and economic situation in the Aral Sea region, for 2011-2015 (ASBP-3), should be developed and implemented. Based on the analysis of the overall situation in the Aral basin, as well as IFAS functioning (including its branches), a number of key challenges in the regional water resources management – political, organizational, and logistics, are defined.

Transboundary Issues of the Aral Sea Basin and the Ways to Their Integrated Solution

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The issues of international watercourses, or transboundary rivers, claim for further strengthening of interstate cooperation in water resources management. It is of primary importance that the decisions to be adopted in this area should apply an integrated approach to maintaining the river systems' capacity, since their depletion would lead to the decrease in regional food and energy security, and, ultimately, to the reduction of social security in the region. New approaches to transboundary river management aimed at their safe use in public water supply, irrigation and hydropower need to be developed; and international actions for the prevention of environmental crises in transboundary watersheds should be initiated.

The cumulative shortage of water resources, as well as expected growth in water demand may trigger transnational political and legal conflicts concerned with the joint exploitation of water resources, which require strengthening of international cooperation, improvement of legal tools, and implementation of preventive measures at the international watercourses. The regional water security has shifted to the social security level, which, in turn, may transform to a human disaster in the region.

Natural hazards (earthquakes, floods, mudslides, and landslides) present another grave problem, particularly, the mountain areas of Kyrgyzstan, Tajikistan, and Uzbekistan are much more at risk, since the majority of the regional river runoff is formed in these areas and, therefore, the flood probability there is very high.

The shrinking Aral Sea, the insecure Sarez Lake, other natural objects may become the large-scale epicenters of environmental disasters threatening all countries in the Central Asia.

Despite certain progress achieved in shaping the new socio-economic system, the states of the Central Asia are still facing a number of common problems and difficulties that hinder the national and regional development.

Based on the assessment of the current situation in the region, the paper lists the main issues and ways to cope with those through international cooperation in the Central Asian region and the aid of the World community.

The Forecast of Parasitological Situation in the Aral Sea in Compliance with Possible Options of Future Environmental Condition of This Water Body

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There are four main ways of the preservation and restoration of the Aral Sea ecosystems. The general provisions of parasitological situation's forecasts in the Aral Sea, which can be in case of each of these ways choosing, are shown below.

First way. Total insulation of north part of the water body ("Small Aral"); increasing of water level and its mineralization by using of the tributary from the Amu Darya River.

Parasitological prognosis: the number of freshwater parasite species, which will come mainly from the Amu Darya River. However, many rheophilic forms will not ecize here and as result of this, the number of parasite species will be significantly less than in the river now or in the Aral Sea many years ago.

Second way. Partial irrigation of south part of this water body ("Large Aral"); conservation of salt resistance species.

Parasitological prognosis: the fauna of the parasites will be very depauperated. The water animals will be very low infected with parasites, therefore from the parasitological view points these animals quite suitable for an introduction. In connection with presence of free ecological niches for marine parasites, sea forms which are new for this fauna will easily acclimatize here.

Third way. The restoration of delta and near-delta freshwater and brackish-water bodies at lower reach of the

Syr Darya River and near the "Small Aral"; increasing of the number of freshwater fishes and waterfowls.

Parasitological prognosis: the number of parasites, which use waterfowls as definitive hosts, will significantly increase. An appearance of parasites, which are dangerous for human health, is possible.

Fourth way. The restoration of delta and near-delta freshwater and brackish-water bodies at lower reach of the Amu Darya River and near the "Large Aral"; increasing of the number of freshwater fishes and waterfowls.

Parasitological prognosis: the species composition of the freshwater and brackish-water parasites will sharply increase. In the desalinated areas an appearance of parasites, which are dangerous for human health, is possible.

Collector and Drainage Waters in the Aral Sea Basin and Their Possible Recycling

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Return water flow (including collector and drainage waters/ CDW) make a significant proportion in the total water resources of the basin, being, at the same time, an appreciable pollution source. Data on return flow presented by the national workgroups, as well as other materials obtained over the last decade, allow for unbiased comprehensive assessment, which illustrates formation and the use of return waters in the Aral Sea basin.

Return waters, i.e., the combined total CDW from irrigated areas and industrial wastewater, are estimated at 45.8 km3 per year, or 40% of the natural river flow in the region. This is a huge figure, to be yet analyzed under the new "PBAM-3" program. Within this value, wastewater contributes to 6,9% only. The rest part is represented by CDW coming from irrigated areas, which makes 42.7 km3 per year, or more than 40% of irrigation intake. Notably, more than a half of the drainage discharge is characterized by the mineralization value less than 3.0 g/l, i.e., is suitable for the local recycling. This indicates clearly that the autumn and winter quota for the Aral Sea could be composed entirely by the drainage discharge during inter-vegetation flushing period.

Preliminary synthesis of data on return water and its use in the Aral Sea basin shows the following pattern. Of the total accounted volume, 6.0 km3, or 13.0%, is used within irrigation perimeter; 23.5 km3, or 51.0%, is discharged into the rivers (recycled); and 16.3 km3, or 36.,0%, is diverted to the locked depressions. Thus, in general, 64.0% of various return waters is recycled; in the Syr Darya watershed this value makes 80.0%, in the Amu Darya watershed -56.5%, respectively. The use of return water (including discharges into the rivers and tributaries) in Central Asia differs between the states: 100% in Kyrgyz Republic and Tajikistan, 63% - in Uzbekistan, 55.5% in Kazakhstan, and 45.2% in Turkmenistan.

At the same time, return waters represent the main source of regional water pollution. Collector waters are highly mineralized and polluted by the residues of chemical fertilizers and pesticides used in the irrigated zone. According to the data from Russian Institute for Hydrochemistry, up to 13% of fertilizers are washed out during irrigation. Data from the Institute of Hydrobiology, Academy of Sciences of Ukraine, indicate that the average nitrogen and potassium washout via collector discharge amounts to 30% of applied fertilizers, whereas phosphorus - 1 kg per hectare. Water with high nitrate concentration presents a potential threat to human health. Under intestinal metabolism, certain bacteria induce transformation of nitrates into high-toxic nitrites.

In terms of regional geography, in the watershed upper part CDW are diverted, as a rule, into the rivers, whereas in the middle and lower parts – into the various semi-arid/ desert depressions and pockets, where they form the so-called irrigation fault lakes (backwater basins). This water is practically unused for the economic purposes due to its high mineralization and pollution. Water mineralization in these lakes varies from 7.0 to 15.0 g/l, prevailing water chemical types are: "chloride-sulfate" and "calcium-magnesium-sodium".

Under conditions of the total deficit of the Aral Sea water resources, exploitation feasibility of mineralized lakes should be addressed in the national economies. Solution of this problem should be linked with the solution on partial dumping of CDW into the Aral Sea. In this case, all the lakes should be considered as an integral part of the single drainage basin of the Aral Sea.

Monitoring process as the basis for environmental regulation of water quality

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To date, the world practice is lacking a unified methodology to environmental valuation of water quality, including scientific quality standard for the surface waters. Different ways are applied to environmental regulation in EU, USA, Japan, CIS, and other countries and regions.

Conceptual approaches to water quality management in the Republic of Kazakhstan, as well as in the other Central Asian countries, have remained unchanged since the Soviet Union period. They were based on sanitary regulations, which required compliance with the fixed values of pollutants' water content (maximum permissible concentration, MPC) in the water bodies. The maximum allowable discharges (MADs) into the water bodies are still calculated upon the MPC values; whereas environmental possibilities for self-purification are not considered. MAD parameters are established upon the baseline status of the certain aquatic object (environmental quality), with the assumption that environmental quality standards (MPC) remain unchanged.

Among the major shortcomings of MAD approach, we should mention the disregard of regional conditions, which determine chemical composition of surface waters. Moreover, the process of natural water self-purification (self-purification rate coefficients were developed *in vitro* for various water body models) is frequently disregarded. Due to the above-mentioned defects, pollution standards of water quality, based on scientific evaluation, prove to be impracticable, and the users obtain the authorized ecological permissions for over- or underrated MADs. At the same time, requirements for planning water conservation measures, as well as their effectiveness remain rather nominal.

The main prerequisite to cope with these problems is establishing a unified methodology for water quality standards and assessment of the environmental status of water bodies. Apart from setting the relevant standard parameters, this methodology should envisage conversion of environmental parameters in force under current practice, as well.

During transition to the unified methodology for integrated water resources management in Central Asia, European and Russian approaches to water quality evaluation may be considered as prototypes for development of a mathematical model of water management in the Aral Sea region.

Sustainable Cotton – an Achievable Goal in the Aral Sea Area?

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Cotton is an annual crop with a high demand for water and high temperatures throughout the almost six-month long growing season. It also requires specific soil conditions, crop and water management, crop protection chemicals and labour for harvesting. High energy inputs and efficient management skills are necessary for this crop, which is much more complex than most other agricultural crops. Climatic advantages, large supplies of water and low-cost labour have given Central Asia countries such as Uzbekistan and Turkmenistan advantages as producers of cotton.

The rapidly disappearing Aral Sea in Central Asia is an example of the consequences of conventional cotton production in low income countries. More than 90% of what used to be the world's fourth largest water body has disappeared due to water mismanagement. The area that the Aral Sea used to occupy is now mainly a saline desert that is the source of toxic airborne pollutants. These poisonous chemicals and soil particles affect the health of local people, especially mothers and young children. The area's surface water has been salinized and people in the downstream areas of Uzbekistan have very little drinking water. The countries in the Aral Sea basin (Uzbekistan, Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan and Afghanistan) compete for the water feeding into the former Aral Sea via the rivers Amu Darya and Syr Darya. The leaders of these countries have had great difficulties in agreeing on fair allocation and utilisation of the water resources.

What can be done? Organic cotton grown without fertilisers and pesticides would be a more environmentally friendly option with fewer adverse side-effects on health and biodiversity – but it is not feasible. Organic cotton still needs irrigation, and the costs of production and the land requirement are both at least 50% higher. In addition, the soils and waters are already heavily polluted – the future is certainly bleak!
One conclusion is that cotton production needs to be decreased on a global scale. This could be achieved by replacing cotton with synthetic fibres or by reusing cotton fibres from recycled materials – and by a change in global consumption patterns. Such conclusions have already been drawn by international environmental organisations but it is also supported by many researchers. Consumers are also becoming increasingly aware of these facts.

Development of Student Initiatives and Ecological Education Aimed at Protection of Avifauna in Karakalpakstan

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Effective work with young people is a problem for most of ecological NGOs of Uzbekistan. Important bird areas (IBA) program directed to identification and conservation of territories important for birds in Uzbekistan. In 2007 IBA program opened 4 student ornithological clubs in universities in regions of Uzbekistan. One of them is “Otus” club at Karakalpakstan State University. Creation of NGO “Uzbekistan Society for the Protection of Birds” made us recognize strengths and weaknesses of student activities.

139 people are members of UzSPB now. 40% of them are students. “Otus” joins least number of students – 13% of total number of UzSPB members. In 2008 clubs got support from Rufford Fond project and researched 23% of all IBAs in Uzbekistan. “Otus” club carried out monitoring of IBA “Zhyltyrbas Lake”. Other clubs researched in threes and more IBAs.

One of the factors complicating development of student environmental initiatives in Karakalpakstan is language barrier. Only 50% of inhabitants of Uzbekistan speak Russian. These figures in Karakalpakstan are several times lower. Ignorance of Russian doesn’t let students and teachers work with special literature. In Karakalpakstan State University is acute shortage of professional tutor ornithologists. Remoteness from Tashkent and difficult access to IBAs is also a big problem. “Zhyltyrbas Lake” - the nearest Karakalpakstan IBA is 150 km away from Nukus. Absence of stable Internet access renders relation of “Otus” club members with members of other clubs and their coordinator impossible. Only one member of “Otus” club indicated his e-mail in UzSPB members form. UzSPB will realize educational program for clubs leaders and members to increase effectiveness of student work. A leader of “Otus” will be chosen and taught. Agreement between UzSPB and Karakalpakstan university administration will allow fitting student expeditions to university’s summary. Status of UzSPB’s branch let “Otus” propose initiatives to local administration.

One of the real actions for conservation of avifauna in Karakalpakstan is a count of Khiva (black-and-goldish) Pheasant *Phasianus colchicus chrysomelas* in Esbergen-Sheganak riparian forest (protected area of future Lower-Amu Daryia biosphere reserve in Karakalpakstan). It was possible thanks to initiative of “Otus” club and support of project of the Government of Republic of Karakalpakstan, UND and GEF "Conservation of Tugai Forests and Strengthening Protected Areas System in the Amu Darya Delta of Karakalpakstan". Thanks to International Fund for Aral Saving in Uzbekistan (IFAS) support in July, 2009 on Zhyltyrbas Lake was carried out ornithological training for 5 active members of "Otus". In 2009 UzSPB prepares project proposal "Development and implementation of mechanism of biodiversity conservation on globally important key territories of Uzbekistan by scientific community, students and local communities" to GEF Small Grants Program. With the assistance of "Otus" club on Zhyltyrbas Lake will be carried out state value of biodiversity and developed action plan for it conservation.

Current Status and Problems of Conservation of Avifauna of Southern Priaralye

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Wetlands of of Amu Darya delta and southern coast of Aral Sea were historically characterized by rich fauna. The drying of their significant part has threatened existence of many species. The situation in the region was very dynamical during last 10 years. Water area was widened in the framework of the Program of Pool of Aral Sea - 2, but acute shortage of water resources and instability of a hydrological regime of restored and new reservoirs destroy populations of their inhabitants. 24 rare species of birds were registered on key wetlands of the region (Sudochye, Zholdyrbas, Akpetki and Sarbas Gulf) in 2007-2009, 11 from them are included in the Red List of IUCN. Thus reservoirs of Southern Priaralye have not lost the global importance for conservation of biodiversity. 4 other water systems (Domalak, Makpalkol, Muinak gulf, Mezhdurechie (lakes Koksu and Shege) are very unstable or completely dried up. This causes degradation of habitats and a low level of biodiversity.

One of the local threats is fishery and littering reservoirs by prohibited kapron fishing nets; many waterfowl perish as a result. One more threat is burning out last year reed thrickets by shepherds with the purpose of young growth reception for cattle feeding. As a result not only laying and young birds perish, but also places of nesting and feeding become unsuitable before the following vegetation of a reed. The basic problem of the region is instability of hydrological regime. Problems of local threats can be solved by forces of the local nature protection organizations and propaganda of careful relation to the nature. Problems of drying of reservoirs are directly connected to distribution of water resources. They are already in the competence of certain ministries and departments. Long-term strategy of conservation unique Aral biota should be based on development of modern approaches to conducting agriculture and its radical all levels reconstruction. This includes preparation of forages, improvement of cattle breeds, modern methods of irrigation and a choice of economically sound agricultural crops. This will allow regulating needs of the region in water resources and finding necessary volumes of water for maintenance of existing water-marsh complexes of Southern Priaralye.

New Data on the Aral Sea Level Changes in the Holocene And Pre-Holocene Times

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Changes of the Aral Sea lake level have been observed in three sediment boreholes, two outcrops and associated archaeological sites. The obtained results are supported by 25 radiocarbon dates. Major trends of lake level changes have been reconstructed in some detail for the last 2 ka BP, and additional data provides an outline of changes throughout the Holocene. Several distinct changes are shown to precede the modern, human-induced regression of the Aral Sea. These include: 1) the latest maximum in the AD 16th-20th centuries (53 m a.s.l.), 2) a medieval "Kerderi" minimum of the AD 12th-15th centuries (29 m a.s.l.), 3) the early medieval maximum of the AD 4th-11th centuries (52 m. a.s.l.), and 4) an AD/BC lowstand, whose level is not well-established. Since then events are only inferred from sparse data. The studied cores contain several sandy layers representing the lowering of the lake level within the Holocene, including the buried shore-bar of ca. 4500 cal. BP (38 m a.s.l.) and shallow-water sediments of

ca. 5600 cal. BP (44 m a.s.l.), 7200 cal. BP (28 m a.s.l.), and 8000 cal. BP (26.5 m a.s.l.). Data on the pre-Holocene lake level changes currently are rather poor. We refer to the ^{14}C date 19,900 ± 140 (AA-83399) BP obtained at the depth of 634 cm of an 11-m long core, which also has several sand layers. Those in the core's bottom contain typical Aral Sea mollusks (*Hypanis vitrea* (Eichw.), *Caspiohydrobia conica* Logv. et Star., and *Cerastoderma glaucum* Poiret. The optimistic evaluation for the age of the bottom layer is about 40,000 BP.

Effects of Human Activities on the Hydrological Processes in Arid Regions of Central Eurasia - a Multi-Disciplinary Research Project

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In this paper, a multi-disciplinary research project for understanding historical interactions between humans and the natural environment in a semi-arid region in Central Asia will be outlined.

Historically and geographically, Central Asia has been a key area of interaction, transit and exchange between East and West. While many Central Asian peoples are well recognized in historical records as skilled nomads, merchants and traders, it is more recently acknowledged that these peoples also assimilated the ideas and artifacts passing through their territories into their own cultures, often with material effect on landscapes and livelihoods. At the same time, Central Eurasia is an excellent location for tracing human reactions to both past climate changes and anthropogenic activities. In this climatically sensitive area, which alternates between semi-arid and arid conditions, human influence can be historically traced. The area with extended arid and semiarid deserts has potential agricultural plains along rivers, flowing from high mountains with many glaciers, which were actively cultivated far back in historical time. These border regions could record both natural environmental and anthropogenic changes very sensitively.

Although interactions between environmental changes and human reactions have rarely been studied in Central Eurasia, agricultural development in the Aral Sea basin has caused the severe lake-level regression that started in the 1960's. Recent agricultural development in arid to semi-arid regions, especially in the latter half of the 20th century associated with modern irrigation technology, has contributed to increasing agricultural production. However, considerable environmental issues have resulted. It is important, therefore, to balance resource development and preservation in arid and semi-arid regions.

This project aims to study and clarify the historical interaction between human activities and natural systems in the semi-arid region of Central Eurasia, The project attempts to clarify historical changes, the rise and fall of nomadic groups and countries, their removal, changes in subsistence, the use of natural resources, and climate change through the analysis of historical documents and archaeological investigations as well as various natural proxies such as ice cores, lake sediment samples, tree rings and wind-blown deposits. At the same time, we will investigate the present status of the area and the effects of human activities on the natural environment, with particular emphasis on their social, religious and cultural background.

Influence of Change of Climate and Soils at Artificial Formation of Halophytes Vegetation in Aral Sea Region

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The analysis of trends of daily meteorological data WMO (for 2008 inclusive) has shown, that in Priaral'e authentic significant changes of a climate are observed. Increasing tendencies are: increase of temperatures and reduction of precipitation in warm half-year, in the summer and in the autumn, and also a cold snap in an annual cycle due to cold half-year and a winter season.

Now in the South Priaralya sharp fast climatic fluctuations of a geothermal regime year by year, especially appreciable in the cold season are precisely secreted. Here tendencies are marked:

- the general annual warming a climate due to its significant warming in vernal-aestivo-autumnal the season (from May till October);
- periodic (i.e. in a year) sharp fluctuations of temperatures (maximal and monthly average) in the winter from very low (t_{av}= –15.1°C, t_{min}= –32.2°C) up to high (t_{av}= –1.0°C, t_{min}= –12.3°C);
- periodic (in 2-3 years) sharp fluctuations in a moisture from maximal (240-314 mm in 2002-2003) up to minimal (90 and 89 mm in 2005 and in 2007) rainfall amounts.

Data on temperature and relative humidity of air, given by the nearest meteorological stations Chimbay and Kungrad do not reflect real climatic conditions of our local experimental sites on drying bottom land of Aral sea. Real climatic conditions in field have appeared much more continental.

Summer irrigation of the plantings on solonchaks improves the soil moisture indices both in the 40-110 cm root horizon and in deeper soil layers, 200-300 cm, without affecting the upper (0-20 cm) soil layers.

For a good survival of seedlings of *Haloxylon aphyllum* and *Salsola richteri* on solonchaks of the drying bottom land of Aral sea are necessary congenial weather and climatic conditions: first of all it is the increased amount of rainfall (140-220 mm) in comparison with norm, and also not so cold winters (with average temperature in the coldest month – –1–2°C), not so hot summer (with average temperature in the coldest month 26-27°C) and absence of frosts in the vernal season.

Lessons and Outlooks (about the Program of Studies in the Barsakelmes Reserve)

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The reserve is nearing its jubilee with a new quality. It is not the previous protected natural territory, but a quite new structure. What are the reasons for this?

1. The island is turning into an ostanets, a remainder of an ancient elevated territory which is to be explained by its geological genesis. It originated as an ostanets as far as the pre-Aral history. It would be a mistake to regard it as a peninsula, for it is separated from the remains of the retreating sea by a wide strip of dry sea bottom.
2. The boundaries of the reserve have changed principally, thus depriving its territory of its natural form. The reserve has added some genetically alien territories, - aqual, hydromorphous, - and a huge area of previous bottom – an ancient alluvial-deltaic plain.

3. The main objective of the reserve has changed. It includes now not only bioecological aims, but social and economical ones as well. The Barsakelmes Reserve was established as a typical at that time wildlife reserve for protection of saiga, Persian gazelle, later onager, and for their domestication, hybridization, etc. The realization of the idea of combined ecological studies was initiatively started in mid-sixties. The newest aims obviously lead the reserve away from its ecological essence. Quite another way is the investigation of the reserve's history, its geology, including the anthropogenic component of past eras.

The utmost scientific significance of Barasakelmes was determined not only by its biogeographic situation but by its convenience as of a specific natural laboratory. Such eminent zoologists as A. Bannikov, A. Sloudsky, B. Grzymek and others noted the fact for various reasons. Researchers from the USA, Germany, Japan, Turkey and other countries were showing interest in the Aral Sea, and Barsakelmes in particular later on. It is not a matter of chance that some scientists came up with the idea of giving the statute of biospheric reserve to Barsakelmes Reserve as early as 1960's (S. Neronov, L. Kuznetsov). The proposal was repeated and came to the stage of real project (Tursinbayev, Dimeyeva, Alimbetova, 2007) after a lapse of thirty years. The previously predicted changes of the territory related with the drying of the sea became real by that time, thus enhancing the monitoring sufficiency of the reserve.

For different reasons protected natural territories were isolated in the world, but rarely their borders matched with natural and historical boundaries. Mountain chains, river deltas, islands were often such boundaries. Barsakelmes became one.

The contemporary extension of its borders can be explained organizationally but not ecologically. The reserve has lost its ecological integrity, so the situation demands building of a new program of its scientific activity. The Kaskakulan area and the more so the planned territory of the Syr Darya avant-delta are quite different in ecosystem composition. Aside from common, predominantly monitoring aims, each of these territories should have a program consistent with its ecosystematic peculiarities. This diminishes the significance of common quantitative characteristics of flora and fauna in general, their systematic and bioecological groups, etc. It should be realized that the natural historical characteristics do not match with organizational and administrative ones.

Having the aforesaid in mind, the methodological basics of the future activity of the Barsakelmes Reserve are defined by the necessity of ecosystematic approach. It is the only approach to provide the solution to the problems faced by biospheric reserves of international class. As it is known, the classic idea of ecosystem (Tensley, 1935) supposes dimensionlessness of the subject. The successful studies of ecosystems on this basis during three fourth of a century does not permit us to accept its neo-revision, the substitution of “ecosystem” by the specific term “biogeocenosis” particularly in the case of Barsakelmes, where the cenotic role of mammals (especially rodents and ungulates) and various insects is sufficient.

The realization of ecosystematic approach supposes the description of statics and dynamics (monitoring) of the main components of principal ecosystems.

1. The abiotic component should be described not on the general level only, but on the level of ecosystem. So, the description of meteofactors should be made not on the level of not only local climate (weather report data), but ecoclimate, thus reflecting the real ecological situation the

organisms are facing. Soils should be characterized not only by their types or their difference but by analyzing the elements of their structure.

2. The biotic component should be studied, aside from the common inventory, on organismic, populational and cenotic levels. It is a necessary way of studying the biological diversity providing the systematic completeness of research methodology. “Natural chronicles” with their specific approach to studies of particular animal or vegetable objects are in the past. It is clear today that preservation of specific species under natural conditions is impossible outside their ecosystems. Even the best world zoos and botanical gardens cannot solve this problem. Their successes are short-termed and illusory. That is why each of the described further levels of studying should be connected with a specific ecosystem.

We intendedly did not focus on the program of studies of aquatic ecosystems, newly formed (including the so-called “aquatic-paludal” ones) as well as earlier ones. They are a subject for a special discussion.

Let us regard the biotic component in more details.

A. The conditions of the reserve permit studying of bioecological peculiarities of the principal species. The brilliant monographic studies of ungulates (V. and V. Rashek, V. Zhevnerov) prove it. The multiple observations of insects by D. Piriulin, birds by D. Eliseev and M. Ismagilov, reptiles and aquatic invertebrates (N. Aladin) were a serious contribution into the research of animals. Many species of spermaphytes were objects of investigations (biology of reproduction, aquatic regime, mineral metabolism, structural adaptations, etc.). Phenological observations were brilliantly organized (Burambayev). Such observations are impossible under conditions other than stationary. It would be intolerable to stop them in the renovated Barsakelmes Reserve.

B. Population studies are extremely necessary in the general program of biota monitoring. Barsakelmes as an ideally isolated territory has always been favorable for such works. Unfortunately, such studies of ungulates were incomplete – in accordance with the scientific management level of those times. A surprising thing is that nobody was interested in a small population of mustangs that existed on the island for not less than 20 years (the population was literally eaten in the early 90's). As to onager and, to lesser extent, saiga and Persian gazelle, such studies are quite expedient nowadays. But they are possible only under the conditions of artificial isolation which are necessary for general tasks of ungulates' preservation in the reserve as well.

Our examination of national parks and reserves in Africa, Europe and Latin America has demonstrated that the protected areas are isolated (fenced) in necessary cases to avoid emigration of large animals (ungulates first of all) and, to some extent, to hinder the penetration of poachers. It is a necessary measure for new territories described by M. Tursinbayev, L. Dimeyeva, Z. Alimbetova (2007).

Studies of ground squirrel, jerboa, mocassin snake, *Rhrynocephalus helioscopus, Eremias velox, Alsophylax pipiens* on population level are possible. They are ancient inhabitants of the area, and making of patterns of their population and, later, of their changes caused by possible migrations is especially interesting.

As to population studies of insects and other invertebrates, they are necessary but demand specifically trained specialists.

It is also necessary to restore studying of populations of spermaphytes. First of all it must be done with dominant species of various stages of succession process. Partially, such studies have been begun already, and it is advisable to continue them. Naturally, such works should be initiated on the new territories.

C. Studying of natural systems on cenotic level supposes the inventory of ecosystems of the new territories, as well as of the basic core of the reserve. Such studies on Barsakelmes have already been made, long-term observations on stationary sites (composition, ecosystem structure, various types of dynamics, productivity, some functional characteristics, etc.) are performed now. It is necessary to continue them and to begin such studies on the new territories.

The stationary monitoring sites should include or be accompanied by studies on previous levels. The new observations should provide studying the biota dynamics on daily, seasonal, annual (fluctuations, including the "detection time" for specific components) and in long-standing cycles. The directed (successional) changes should be especially focused on. They take place first of all in azonal ecosystems. Successions in zonal ecosystems occur under external influence only. The cenotic level of studies should include the problem of existence and functioning of phytocenotic complexes of both clay and sandy desert. The understanding of the character of the complex structure would allow to differentiate it from other forms of organization of vegetative cover. The ecosystematic approach would permit studying one of the most important problems of ecology, the problem of ecotones. Ecotones are considered differently and irregularly in the modern literature. The Aral dry bottom (the so-called "ecological corridor") is a naturally developed and evolving ecotone between territories of different origin. It is a unique area that gives a chance to solve both specific questions of monitoring and fundamental problems. The observation of this territory may allow (not in the nearest future) to see the sources and stages of formation of vegetation.

The organization of at least isolated studies of biological productivity and minor biological turnover is absolutely urgent for creating a biospheric reserve.

It is clear that the above-described quite voluminous program cannot be realized completely, as it demands adequate equipment and personnel. On the other hand, the extension of the program through solving of applied problems (pasturing, phytomeliorative, sociological and other ones) is hardly reasonable, for it shakes the foundation of the ecosystematic idea. The principle of "he who pays the piper calls the tune" is conjunctural and hardly may be applied to the unique situation of the Barsakelmes Reserve. The principles of the proposed program are not undeniable, but they have a theoretic base and are oriented on studies on the historical initial territory of Barsakelmes with provision for the future development of the area.

Different approaches to programs of activity of the Barsakelmes Reserve have been worked out. A part of them has been published in 2007 ("Works of the Barsakelmes Reserve") and demonstrate a large variety and controversity. They are often based on the experience of various national and international projects carried out under the aegis of the Academy of Sciences, UNESCO, UNEP, World Bank, etc. in the second half of the 20th century. Most of these projects have not reached the ecosystematic level, first of all because of lack of methodical background. The level of ecology in the beginning of the 21st century, having in mind the compactness of the Barsakelmes Reserve and the possibility of modeling many ecosystems, permits the elaboration of a modern program of its scientific activity at the turning point of its development. All this is possible only in case of serious discussion of various programs on a proper methodological base.

The Future of the Aral Sea: is the Glass Half Full or Half Empty?

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The Aral Sea, a once vast brackish water terminal lake in the heart of Central Asia, has been rapidly drying since the 1960s. This process by Sept. 2009 led to a level drop of more than 26 meters, a surface area decrease of 88%, a volume reduction of 92%, and a 10 to 20 fold increase in salinity. The lake's recession led to a panoply of severe negative ecological, economic, and human welfare consequences. A key question is what does the future hold in store for this once magnificent water body? In this PowerPoint presentation we first briefly examine the Aral's past and present and then turn at more length to its future. The Aral over its modern geological incarnation (approximately the last 10 millennia), has receded and advanced a number of times. The main causative factor until the 1960s was the periodic westward diversion away from the lake of its main tributary the Amu River and its subsequent return. Climate change and perhaps irrigation development played a much smaller, secondary role. A key point in looking to the past as a guide to the future is that the Aral has recovered a number of times from very deep recessions.

The modern recession initiated in the early 1960s. The lake had been in a high standing phase since the dawn of the 20th Century, so some "natural," cyclical drop in level would be expected. But this should not have been more than 4 or 5 meters, bringing its level from 53.4 meters asl in 1960 to

perhaps 48 meters today. The main cause of recession (more than 80%) has been expansion of irrigation well beyond the point of sustainability, which led to a huge drop in inflow from the seas two influent rivers (Amu and Syr). Climate change (Global Warming) has, so far, not been a major contributor to the sea's demise, although it will play a much more important role in the future. The sea's recession by Sept. 2009 was the greatest for several thousand years and soon will be the most severe for the last 10,000 years.
What of the future for this once "Great Lake"? It is a case of the "Glass Half Full" and at the same time "Half Empty". To restore the lake to its former (1960s) condition would be very difficult in the foreseeable future. It would not only require very expensive improvements to irrigation efficiency to free water for the sea, but also a substantial (40 to 50%?) reduction in the irrigated area. The latter would devastate the region's agricultural economy. The sea by Sept. 2009 had broken into four pieces and, without question, portions of the sea are amenable to partial rehabilitation.
Rehabilitation of the Small (northern) Aral Sea is underway. The first phase was completed in Fall 2005. So far it has been a marked success and a second phase of further restoration is near implementation.
Partial restoration of the Large (southern) Sea is also possible. It is in much worse shape than the Small Sea was prior to its rehabilitation. The Eastern Basin is nearly gone and improvement efforts for it make no sense. The Western Basin, on the other hand, could be preserved and partially rehabilitated. This would require improving irrigation efficiency in the Amu River Basin to free water for the Western Basin and the sending of any "excess" water to it rather than to the Eastern Basin. The benefits and costs of such a project need careful investigation and analysis to

determine if the project is economically and ecologically feasible.

An effort to rehabilitate and preserve what is left of the deltas of the Syr and Amu rivers is essential. These entities are biologically rich and economically valuable. They serve as “gene pools” to preserve both faunal and floral species of the region. Valuable efforts have been underway to protect and preserve the wetlands and lakes of the Amu since the late 1980s and more recently for the Syr. These are to be applauded.

Diversions from Siberian rivers (Irtysh and Ob’) to Central Asia and the Aral Sea have also been put forward as a way to save the Aral. The project *(“Sibaral”)* to send 27 km^3 southward was nearly begun in the mid 1980s, but was halted by Gorbachev in 1986, much to the consternation of the, at that time, Central Asian Republics of the Soviet Union. Since 2000, this project has again been promoted by the new nations of Central Asia with some support from various people and groups in Russia. However, in the final analysis, diversions from Siberian Rivers to Central Asia are very unlikely. The cost would be enormous, complicated agreements would be necessary between Russia and the Central Asian nations, there is strong public opposition in Russia, international donors have clearly stated they will not contribute to the financing of such projects, only part of the water diverted would reach the Aral, and less expensive and complicated alternatives for dealing with water problems in Central Asia exist.

Genetic Identification of Aral *Artemia* Populations

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The genus *Artemia* is globally distributed (except from Antarctica) and comprises six well-defined bisexual species and numerous parthenogenetic strains. *Artemia* inhabits coastal or inland saline and hypersaline waters. According to recent reports, parthenogenetic *Artemia* strains were first detected in the Large Aral Sea in 1998 and until 2002 they represented ~99% of total biomass of the zooplankton community. *Artemia* individuals collected from two sites of Aral Sea (sample A: Northern Aral Sea, sample B: the Strait) are genetically identified for the first time. Genetic analysis was based on 16S mtDNA sequence data and genotyping five microsatellite loci. Comparisons of obtained with GenBank 16S mtDNA sequences confirm that the individuals from the two Aral sampling sites belong to the parthenogenetic group of the *Artemia* genus (maximum likelihood and parsimony methods). For microsatellite analysis, more than 75 individuals (belonging to 8 parthenogenetic populations, Aral populations included) were genotyped. Pairwise genetic distances between individuals were calculated by Cavalli-Sforza's chord measure. Microsatellite analysis showed that the individuals of sample A are grouped separately from those of sample B, indicating that the two samples comprise different clones. More specifically, *Artemia* individuals from the Northern part of Aral Sea (sample A) are grouped together with the

diploid parthenogenetic population from Namibia while the individuals from the Strait (sample B) are grouped with the parthenogenetic populations from Polychnitos and M. Embolon (Greece) and Jiangsu (China). Although preliminary, our results provide strong evidence for a distinct genetic make-up of the two Aral Sea samples, i.e. they should be considered as two different parthenogenetic *Artemia* populations.

Social, Economic and Political Consequences of the Aral Ecological Crisis

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The environmental crisis in the Aral Sea basin has proved catastrophic for the five Central Asian countries and its influence extends far beyond the boundaries of the region. The drying up of the Aral Sea was a result of errors committed under the command economy over many decades; now this disaster is having an extremely negative impact on the socioeconomic and environmental situation in the region.

The basin is in the heart of a vast landmass and its remoteness from any ocean means it has an extremely dry continental climate, a particular feature of the region.

Atmospheric precipitation there does not exceed 100 mm per annum. The two largest rivers in the region empty into the Aral Sea: the Amu Darya (2,540 km) in the south and the Syr Darya (2,200 km) in the north-east; until 1960-1970, their total runoff was 55-60 km^3 per annum. This runoff allowed a stable water balance to be maintained. Extensive diversion of water from the Amu Darya and the Syr Darya, to irrigate newly cultivated areas, resulted in a dramatic decrease in the runoff of these rivers. In 1913, irrigable land in the Aral Sea basin totaled 3.25 million ha. By 1965 this figure increased to 5.13 million ha. Until 1960, water diverted for all the region's needs did not exceed 63 km^3.

The introduction of the concept of "cotton independence" and the economic policy that accompanied it required the area of irrigable land to be expanded. Irrigation systems in most of the region's republics were in an extremely poor condition and could not be relied on to provide any significant increase in cotton yields. In order to resolve this problem, however, it was decided to expand the area of irrigated land rather than to overhaul existing irrigation systems and improve soil fertility. During a relatively short period, the area of irrigated land was expanded to 8,3 million ha in 1990. As a result, water diverted for irrigation from the rivers of the Aral Sea basin exceeded the environmental limit, and runoff to the sea shrank dramatically, thus disrupting the sea's equilibrium and leading to excessive evaporation losses. In some of those years, no water reached the sea at all.

River runoff declined so rapidly that the sea ceased to be a natural, water-draining body. According to the At the beginning of 2008 the level of the Aral Sea was 28.6 m above that of the Baltic Sea, its volume had shrunk to 93.1 km3, less than a tenth of its volume in 1960, and its surface area shrank from 68,000 km2 in 1960 to 12,370 km2 over the same period, i.e. by five times.

The unrestrained development of irrigation in the Aral Sea basin was based in part on the erroneous of increasing water offtake, and the consequences this would have, were ignored. Moreover, in the plans and conceptual studies drawn up in that period, the Aral Sea was not considered as a natural water body into which a certain quantity of water must always be allowed to flow. Water management schemes for the Aral Sea did not include water input in the form of river runoff to compensate for evaporation from the surface. The runoff in the lower reaches of the rivers and water inflow to the sea were limited to sanitary water use in the rivers themselves. Since no regional environmental and sanitary limits were in place, the Amu Darya and the Syr Darya were viewed mainly as facilities for removing partially treated or untreated household and industrial wastewater, potentially contaminated with heavy metal salts and toxic chemicals. The environmental and social consequences of large-scale land development in the basin and the depletion and contamination of water resources were totally ignored. Moreover, no attention was paid to the fact that depletion of water sources results in increasing contamination of water and salinisation of irrigable land in the lower course of the rivers. These negative consequences and the poor design of irrigation systems severely undermined the region's water economy.

The rate at which the Aral Sea is drying up, and the desertification of the surrounding areas, lead us to conclude that the sea is likely to disappear altogether in 2015-2020. According to forecasts, the disappearance of the Aral Sea will lead to the formation of a new manmade desert which will become an extension of the Karakum and Kyzylkum deserts. Images recorded by the European Space Agency confirm this forecast. The rate at which the Aral Sea is drying up, and the desertification of the surrounding areas, lead us to conclude that the sea is likely to disappear altogether in 2015-2020. According to forecasts, the disappearance of the Aral Sea will lead to the formation of a new manmade desert which will become an extension of the Karakum and Kyzylkum deserts. Images recorded by the European Space Agency confirm this forecast.

The environmental consequences of the intensive utilisation of water and land resources have had a very negative impact on the region's socioeconomic situation and have undermined its natural potential. The region's ill-advised economic development strategy, particularly with regard to irrigation, has resulted in extensive secondary salinisation of soil. According to estimates, about 70% of irrigable land is subject to varying levels of salinisation, which reduces crop yields. Atmospheric and soil pollution results in unacceptable deterioration of the quality of drinking water from surface and underground sources.

In coastal areas, atmospheric precipitation and humidity have decreased, winter temperatures are lower whilst summer temperatures are higher. The fertility of soil exposed to the pollution has declined.

Water utilisation and distribution issues in Central Asian countries become especially acute during droughts. The droughts of 1998- 2001 and 2007-2008 in the Aral Sea basin were particularly severe and took a heavy toll on the economies of Tajikistan, Uzbekistan, Kazakhstan and Turkmenistan, seriously affecting agriculture and food security in the region.

The political consequences of the Aral crisis caused the decrease of the integration of cooperation in the region. Each country formulates its own water utilisation strategy, which increases competition for water and exacerbates water shortages and environmental problems. The lack of legal and economic instruments regulating the hydroelectricity sector impedes the resolution of problems associated with the shared use of cross-border water resources. It has prevented the creation of a hydroelectric energy consortium in the Syr Darya basin. In fact, the protracted consultations engaged in by Central Asian countries in recent years have failed to yield any positive results.

To encourage optimum distribution of limited water resources, especially in cross-border river basins, and amicable arbitration between competing economic sectors, regulation of all water use at national and regional level must be taken into consideration. The problem makes it necessary to change the old concepts of water use and the transition to an integrated water management. River basins must be used to their full potential, and properly coordinated regional and national water utilisation policies must be formulated taking into account the various organisational, financial and regulatory aspects of water economy based on systemic environmental and economic criteria.

Multi-Sensoral Remote Sensing of Land Cover and Wetland Habitats on the Desiccated Aral Sea Bed in Southern Prearalye

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Since the onset of the desiccation of the Aral Sea in the 1960s, the adjacent regions in Karakalpakstan / Uzbekistan and Kazakhstan are suffering from severe economic and ecologic degradation. The landscape is changing rapidly: by now, the newly emerged desert *Aral Kum* reaches over more than 40.000 km², and has altered the climate and whole environmental situation severely. Water scarcity is common in the downstream regions and large agricultural areas already had to be abandoned. Therefore, water management plays an essential role for sustaining livelihood in the region. While in Kazakhstan, the remaining run-off of the Syr Darya is redirected via the Kokaral dam into the small Aral Sea, the counterpart in the Amu Darya delta is a complex system of lakes and reservoirs, protected by embankments and connected through numerous canals and barrages. Many of the lakes are well known for their abundance of fish and the fertility of the adjacent reeds area for livestock breeding, such as Dzhyltyrbas lake, the Sudochie wetland complex or Ribachie (Sarebas) lake near Muynak.

The aim of this study is to apply satellite remote sensing data from a variety of high and resolution sensors (SPOT-5 HRG, ALOS Avnir-2 and PALSAR) for mapping and monitoring wetland habitats and the surrounding desert landscape units on the former Aral Sea bed. Object-based image analysis techniques are applied in a semi-automatic rule-set classifier in order to transfer the classification algorithm onto new datasets. The SPOT image data proved a highly suitable source of data for the land cover mapping of the dry-land areas, but has also its limitations in discriminating flooded and non-flooded reed habitats. Therefore, the PALSAR L-band radar data is integrated, due to its capability to detect the water surface underneath dense reed vegetation.

This paper presents preliminary results of an ongoing study. SPOT-5 data acquired in the years 2005 and 2007 have been segmented and classified into 11 land cover classes according to FAO LCCS. Accuracy assessment has been carried out based on field data acquired in the corresponding seasons. The method proved to be transferable from one time-step to another with only minor adjustments in the rule-set, retaining a high classification accuracy of 84% and 85%, respectively. This renders the applied method very suitable for the implementation into a continuous landscape monitoring system for a wide variety of applications, including water and land management, environmental protection, forestry and agriculture.

Scientific and Practical Problems of the Organization of Landscape-Ecological Monitoring in Southern Priaralye

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Southern Priaralie – the most dynamical part of the Aral region, distinguished by a variety of landscape-ecological conditions and connected in the functioning with the Aral sea. About 1,5 million person here lives. Landscape – ecological monitoring should pursue both scientific, and the practical purposes. Its task should include the operative control of a condition of the landscape environment and forward planning of its development on the basis of management of available and necessary water resources. Scientific base of monitoring – current theoretical understanding of successional dynamics of the landscape environment and it's stages of development, methods of landscape indication. A practical basis – the data of fieldwork and remote supervision with using GIS.

Socio-Economic Monitoring under the "Restoration of Lake Sudochye Wetlands" Project

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The "Restoration of Lake Sudochye wetlands" project (funded by the World Bank, Global Environmental Facility/ GEF, and International Fund for Saving the Aral Sea) was aimed at water resources and environmental management in the Aral Sea region. The project was implemented at the territory of the Republic of Karakalpakstan (Federal entity of the Republic of Uzbekistan).
The major practical outcomes under the project:

• Construction of hydraulic structures;
• Socio-economic and environmental monitoring.

The second project component included 4 phases:

- Perception: social structure, economic activities, and the environmental features of the area under studies;
- Awareness raising (workshops and discussions on the general project objectives and its socio-economic monitoring);
- Socio-economic monitoring of the project area;
- Processing/ analysis of monitoring results, development of recommendations.

Socio-economic monitoring was conducted at the project area/ Lake Sudochye, as follows:

• Importance of biological resources to the population welfare was defined;
• The project impact on socio-economic indicators (population structure, income rate and its composition, cultural and traditional institutions) was studied;
• Financial performance assessment for the industrial, agricultural, fishing and game enterprises and farms was forecasted.

Socio-economic monitoring provided a comprehensive assessment of current status and trends in the Amu Darya River delta for preparing proposals to the Project Implementation Unit. Monitoring methods tested under this pilot project are recommended as baseline for socio-economic monitoring activities at the Aral Sea coastal zone.

The Dying Dead Sea: the Microbiology of an Increasingly Extreme Environment

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The Dead Sea, located on the border between Israel and Jordan, currently contains around 348 g/l salts. Divalent cations (1.98 M Mg, 0.47 M Ca) dominate over monovalent cations (1.54 M Na, 0.21 M K), with Cl (6.48 M) and Br (0.08 M) as main anions (2007 values). Sulfate is low (4 mM), and the pH is about 6. The lake's water balance is negative, and during the past decade the level has dropped over one meter per year (May 2009: -422 m). The water is supersaturated with Na, and massive amounts of halite precipitate to the bottom. The lake has an area of about 630 km^2 and a maximum depth of 300 m. Biological monitoring since 1980 has shown that blooms of the unicellular green alga *Dunaliella* and halophilic Archaea of the family *Halobacteriaceae* develop only following significant dilution of the upper water layers after very rainy winters. Such events occurred in 1980 and even more dramatically in 1992, when up to $3.5x10^7$ Archaea per ml in the diluted upper 5-10 meters of the water column colored the lake red. Species isolated from the lake include *Haloferax volcanii*, *Haloarcula marismortui*, *Halorubrum sodomense*, and *Halobaculum gomorrense*. From 1996 onwards *Dunaliella* was no longer observed, and prokaryote numbers remained below $5x10^5$/ml. To characterize the residual microbial community in the lake we concentrated biomass from a large volume of brine in February 2007 for environmental genomic analyses. The results were compared to the metagenome of microbial bloom material collected in 1992, kept frozen for 16 years. The aims were to determine the

diversity of the Dead Sea microbial communities and to gain information about pathways enabling microbial survival in such a harsh environment. The 16S rRNA archaeal phylotypes recovered from the 2007 sample were diverse, with phylotypes distantly related to the genera *Halorhabdus*, *Haloplanus*, *Natronomonas*, and others. *Halorhabdus* sp. was also recovered in culture. However, the 1992 bloom sample was very homogeneous, with a single cluster related to *Halobacterium salinarum*. It is thus shown that even in one of the most extreme environments on Earth the microbial communities are dynamic, showing strong shifts in species composition as conditions for life become increasingly adverse.

Changes of Energetic Expenditures during Transpiration in Psammophylous Phytocenoses

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Functional peculiarities of phytocenoses during the process of *Atriplex sp. – Stipagrostis pennata – Haloxylon aphyllum* succession of vegetation on sandy coasts of the Aral Sea were studied. Short-living phytocenoses of *Atriplex sp.* are being replaced by monodominant communities of *Stipagrostis pennata*, then by two- or three-layer tree and shrub communities of the three-member complex of *Ephedra distachya – Calligonum aphyllum – Haloxylon aphyllum.* This is accompanied by stabilization of ecological regimes. Daily energetic expenditures change from 5-10 mjoule/t to 72-74 mjoule/t. This provides the increase of water content in green phytomass by 60 times and slowing down of water exchange by 4 times.

Dynamics of Free-Living Invertebrate Fauna of the Aral Sea

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Till XX century the Aral Sea fauna remained stable during long time. All changes started in it were induced by men. Initially there were some unsuccessful attempts to enrich fauna with fishes valuable. In 1950s introduction of fishes continued and introduction of aquatic invertebrates has begun. Unfortunately scientific recommendations for introduction of aquatic organisms were not observed. Together with economically valuable species also there were some undesirable species what resulted serious disruptions in the ecosystem. In 1954-1956 Baltic herring was introduced and because of this pressure on zooplankton has increased. Its biomass has dropped more than by 10 times; number of large crustaceans has fallen significantly. Former dominant *Arctodiaptomus salinus* since 1961 became minor component. Shrimp *Palaemon elegans* was introduced incidentally and this species probably forced out and replaced indigenous amphipod *Dikerogammarus aralensis*. In 1960s there were acclimatized some euryhaline invertebrates: polyhaete *Hediste diversicolor*, bivalve mollusk *Abra ovata* and copepod *Calanipeda aquaedulcis*. It could be that the last species forced out and replaced still remained *Arctodiaptomus salinus*. In 1970s when salinity has exceeded 12-14 g/l, the death of freshwater and brackish-water species being the basis of fauna began. In decade after salinization has begun more than 50-70% of free-living invertebrate species disappeared. In the 2nd half of 1980s when salinity has exceeded 23-25 g/l, caspian brackish-water species have disappeared and remained only marine, euryhaline and halophilic ones. In 1989 because of level fall Aral has divided into 2 parts. In the northern part (the Small Sea) salinity began to drop, that allowed occurring again of caspian species (from resting eggs). In the southern part (the Large Sea) the level fall and salinity growth continue. This area to 2000 has become hyperhaline. Most species became extinct. New dominant in zooplankton became *Artemia*, naturally transferred from salty pools. The others some planktonic species are invaders or widely euryhaline species before lived in Aral but being very rare and not numerous.

GIS of Cadastres of Forestry and Especially Saving Territories, Objects of Animal World and Fish Cadastre

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The informational system, developed by us, on the basis of GIS-TECHNOLOGIES «State cadastres of natural resources of the Republic of Kazakhstan» represents databases on condition of wood fund, fish resources, fauna and specially protected areas (more than 2000 objects 2003-2008), maps (more than 1000 maps M 1: 1 000 000, M 1: 200 000, ArcGIS). Levels of information representation: local (wood economic, fish-breeding enterprises, hunting facilities, specially protected areas); regional and republic.
On the territory of Aral sea Wood cadastre includes the information on condition of wood fund of Aral official body on woods and fauna protection (wood pastures – 504571 hectares; not wood pasture – 69579 hectares, including black saxaul – 4,7 thousand м3); thematic maps of wood fund condition, its distribution on groups of wood owners, areas, breeds, types of woods.

Cadastre subsystem of specially protected Aral areas contains the detailed information on objects Barsakelmes state natural reserve: fauna, plant and wood fund, its nature protection, scientific, economic activities.
According to data of fish cadastre on the territory Kyzylorda oblast there are 196 reservoirs (Small Aral sea, reservoirs of local value), 12 reservoirs of South-Kazakhstan oblast (Shardarinskoye water basin, river Syr-Darya, reservoirs of local value). Kinds of fishes prevail: flounder, sazan, crucian, roach, bream, rudd, asp, pike, catfish, pike perch, perch, a silver carp.
Information from databases of cadastres allows to make reassessment of Aral natural resources, according to market condition; to develop the scheme of sustainable use and limits of withdrawal.

Saving of Biodiversity of terrestrial ecosystems of Kazakhstan Part of the Aral Sea

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The problem of saving of biodiversity of terrestrial ecosystems of Kazakhstani part of Aral sea is very important.
The area of reeds was reduced from 550 up to 18 thousand hectares, more than 30 large lakes in delta of the river of Syr-Darya totally disappeared and the part of tugay in flood plains of the river Syr-Darya were destroyed. From 178 species of the vertebrate animals lived on Aral region, remained 38.
We have made the detailed electronic maps of Aral region (Arc GIS -9,3 scale 1:1 000 000) on ecological-geobotanical

division; zones of rare and being under threat, kinds of plants and plant community, with dividing kinds of plants of the Red Book to characteristics and categories; to the areas of disappearance risk of vulnerable kinds of Flora and Plant communities: degrees of lands desertification. In the prepared national report on biological diversity in Kazakhstan and in particular, Aral region, ecological situation, a critical condition of biodiversity, the reason of degradation of natural systems are described in detail.

On the basis of information systems, "State cadastres of natural resources of the Republic of Kazakhstan" (GIS-TECHNOLOGY) we offer the assessment of biodiversity of surface eco-system with the use of potential index of the reserved territories: Barsakelmes natural reserve, Aral official body on protection of woods and fauna (scale 1:200 000 and 1:1 000 000).

The Effect of Oceanic and Aral Sea Water on Salinity Tolerance *Paramecia* ssp. (Ciliata)

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Differences in salinity tolerance of three paramecia species in water of oceanic and Aral Sea ionic composition were investigated. The obtained data allowed to support the hypothesis about absence of differences between upper limits of salinity tolerance in the same species in both Aral Sea and oceanic waters in terms of chlorinity. For the hypothesis's verification the linear variation in ranges of salinity acclimation were chosen. Salinity tolerances in *P. jenningsi* and *P. caudatum* ranged from fresh water to 4 ‰ in Aral Sea water and oceanic water while in *P. primaurelia*, these limits were fresh water - 3 ‰ in both types of water.

The procedure of calculation any equation for upper tolerant limits from another equation using an angular coefficient and a ratio of chlorinities of both types of water is developed.

Aral: the Blue Unknown Sea

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Let us go bask into the history of geographic discoveries. Prior to the late 1840s information about Aral was very scantly. Ptolemy's map compiled in the 2nd century, but published only in 1490, pictured Amu Darya and Syr Darya rivers flowing into the Caspian Sea, while the Aral Sea was not shown at all. In this way that part of Middle Asia was represented on the West European maps until the end of the 17th century.

Though in Russia they know about the existence of the Aral Sea long ago – since the merchant caravans pared their ways into the Caspian region to trade with Eastern peoples.

In 1552 Ivan the Terrible ordered to "…measure the land and draw the plan of state". Under Boris Godunov this plane was corrected, and in 1627 the "Big Plan" was compiled, which also covered the lands contiguous to the Russian State. The Aral Sea was named on this map as the Blue Unknown Sea.

In 1715 Peter I send an expedition to the eastern shore of the Caspian Sea headed by Bekovich-Cherkassky. In the course of that expedition in became clear that Amu Darya flows into the Blue Unknown Sea. "Aral" translated from Turkic means "island", i.e. a blue island in the middle of the boundless yellow sea of decert.

The first instrumental topographic data on Aral refer to the first half of the 18th century, the period of joining of Kazakhstan to the Russian State. In 1825 the topographic expedition of the colonel L.S. Berg reached the western shore of the sea, thus asserting the existence of big sea-type reservoir that required thorough geographic survey of dimensions and topographic situation. To execute that, in 1848, due to admiral F.F. Bellingauzen's solicitation, there was appointed an expedition to Aral under the command of lieutenant N.I. Butakov for the "survey and measurement" organization.
On March 5, 1848, Butakov and his crew of 18 men arrived to Orenburg and started building the sailing flat-bottomed schooner. On April 28, the schooner "Konstantin" was completed. On May 11, Butakov left Orenburg with his sailor crew, transporting the disassembled schooner in parts on one-horse carriages. The caravan counted 1500 carriages guarded by an infantry platoon, two Cossack squads and two guns. The Kazakh participants of the expedition were Dzhanges Kushinbaev, the caravan head of transport, and squad commanders – Illyaman Tyuleganov, Italmas Tlyamisov, Kubagan Usyanov and others.
After extremely difficult and long passage through the Aral region Karakum Desert "carriages transport" arrived at the newly founded in the lower reaches of Syrdaria fortification of Raim. On the 20th of Jule the schooner was assembled and in five days, on Jule 25, 1948, the geographic expedition for the first instrumental survey of the Aral Sea started.
Besides the commander lieutenant A.I. Butakov the expedition corps included navigators – ensign K.E. Pospelov and staff-captain of the general staff A.I. Maksheev, topographers – ensign A.A. Akishev, senior medical attendant A. Istomin, three corporals, fifteen sailors,

two orderlies and the private soldiers of the line battalion Tomas Verner (topographer) and Taras Shevchenko (staff drawer). According to other sources the expedition also included eight Polish exiled convicts. Together with Taras Shevchenko drawings were made by Bronislav Zalessky. In 1865 his works were published in Paris in the album "Life in Kirghis Steppe".

During summer and autumn of 1848 Butakov was describing the shores of the Aral Sea, made the depth measurements, topographic surveys, gathered samples of ground and sea flora. In latitude 45 North he discovered the group of Tzar Islands (called today the islands Vozrozheniya, Komsomolsky, Chagala, Konstantin) and the Island Obruchev. Because of strong storms at the beginning of October the survey had to be ceased. "Winds in Aral are suddenly growing strong, causing great waves, then they cease leaving after an unbearable ripple… Aral Sea numbers among the most choppy and troublesome".

The expedition passed the winter on the islands in the mouth of Syrdariya. In summer of 1849 Butakov has completed the survey of the biggest bays (Paskevicha and Tshche-Bas) and of Karatayup and Kuyaldy peninsulas. He also mapped the Chernyshev Bay and smaller islands of Menshikov, Tolmachev, Bellinsgauzen and Lazarev. Storms and head persisted and hindered work: "In summer… head was intolerable, without rains, the air being cleaned only by prevailing winds… These winds made sailing very difficult: they frequently incurred the worst danger upon us and forced to risks that often exceeded the reasonable limits". By the end of October the first survey of Aral was completed.

In winter of 1849-50, having moved to Orenburg, Butakov compiled a relatively precise map of Aral Sea. Shevchenko created the watercolor album of the sea and shores landscapes; almost every geographical name secured in the expedition report is accompanied by Shevchenko's special drawing.

The result of two-year labour of Butakov and his crew turned out to be the first navigator (mercator) map of the Aral Sea, published in 1850 by the Hydrographic Department of Marine Ministry. Besides that Butakov compiled the detailed navigational and hydrographic description of Aral. He was elected the Honorary Member of Berlin Geographic Society and decorated with foreign awards.

Simulation of the Expected Runoff into the Aral Sea

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1. Simulation and optimization modeling for the Aral Sea basin was contemplated as a basis for demonstrating possible alternatives to runoff exploitation and management of large HEPS reservoirs. Wide search was applied to management criteria (target functions) and economic indicators (impact assessment of runoff regulation and use).
2. Assessment of the expected runoff into the Aral Sea (for the next 30-50 years, via the Syr Darya and Amu Darya rivers) was carried out, as follows:
- Hydrological series for the natural riverine runoff into the sea were modeled, considering prediction scenarios of climate change (max, min);
- Water requirements and associated offtake distribution between the water management areas (planning zones) and ecosystems (Aral Sea region) were identified, according to the development scenarios of the countries (including Afghanistan):

(i) Optimal: established cooperation between the countries, in regard to runoff regulation and in compliance with water- and energy-saving obligations;
(ii) Current: maintaining of existent developmental trends;
- Probable situations (including conflicts) were plotted upon the *abstract model* involving risks and destabilizing factors:
(i) Considered regulation of the riverine runoff via internationally important reservoir hydrosystems– Toktogul/ the Naryn river, Rogun and Nurek / the Vakhsh River, and Dasht-i-Dzhum/ the Pyanj River, and others;
(ii) Considered/ ignored the long-term runoff regulation;
- Numerical studies on the long-term operational regime for reservoirs and HEPS were performed upon ASBmm complex model, in correlation with scenarios of hydropower and irrigation development, as well as preservation of ecosystems:
(i) The final result - distribution and use (including losses) of water resources, and water supply to the Aral Sea;
(ii) Considered possible loss of regulatory capacity of the Nurek, Rogun, and Tyuyamuyun reservoirs (due to siltation);

3. The Syr Darya River case analysis: energy production by Toktogul HEPS. Operational pattern is focused on the export of electricity during autumn and winter, and the annual flow regulation via reservoir; its consequences include:
- Drop of pressure and production at the Naryn HEPS cascade;
- Water supply deficit and losses to irrigation agriculture during the vegetation period;
- Occurrences of autumn and winter flash runoff (high water) on the Syr Darya River.

4. The Amu Darya River case analysis: an impact study based on scenarios of the joint runoff regulation by the Rogun and Nurek reservoirs, risks included:
- Losses to irrigation agriculture and ecosystems of the South Aral Sea region, the Amu Darya River delta, under conditions of joint energy production at Rogun and Nurek HEPS. The best option, as shown by our calculations, is represented by the combined pattern (energy operation mode for the Rogun HEPS, compensatory irrigation mode – for the Nurek HEPS).

5. Assessment of the expected runoff into the Aral Sea is made upon the scenarios, which consider:
(i) A number of risks: increased water consumption, climate change, loss of regulatory capacity of the reservoirs due to siltation, commissioning of new HEPSs and reservoirs of regional importance, etc.;
(ii) Requirements for environmental discharges into the Aral Sea and its adjacent territories, depending on the scenarios for the water level stabilization in the North Aral Sea and the Great Aral Sea (its western part).

6. The top priorities, both current, and in the future are the issues of water saving and sustainable water use. Their solution will enable minimizing regional water deficit and releasing water for the Aral Sea recharge (upon the optimal scenario - up to 12 km3, by 2050).

Adding Insult to Injury: Climate Change Exacerbates Adverse Effects of Irrigation Practices in the Aral Sea Basin

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Central Asia, especially the Aral Sea region, is a critical area for water resource management. Irrigation practices have had an adverse impact on the ecology of the Aral Sea Basin. Loss of habitat and reduction of biodiversity in this region are well documented. At the same time that irrigation practices have exerted their influence, climate change has exacerbated some of the negative effects. The record of the past, compiled from instrumental and proxy data (Tingley, 2009) is incomplete, yet the overall picture is fairly clear, and includes recent regional warming. Projections for the future require assumptions about controlling climate parameters, as well as understanding of the uncertainties in these assumptions. This paper reviews some of these factors.

The hydrologic budget of the Aral Sea Basin may be expressed as the difference between outputs and inputs. The Aral Sea itself is shrinking simply because the outputs exceed the inputs. Outputs are dominated by diversion of water for irrigation and desalinization of soil in the basin and by evaporation from the sea itself. Inputs are dominated by flows from rivers draining into the Aral Sea, most importantly the Amu Darya and the Syr Darya. These rivers in turn have their own hydrologic budgets.

The source region for these river systems lies in the glaciated portions of the Pamirs, Tien Shan, and other associated mountain ranges. Increasing temperature and decreasing precipitation are causing the glaciers to shrink, ultimately reducing the available water in the two watersheds. However, the nonlinear relationship between melting glaciers and stream flow is not well understood. Climate models predict both increasing temperatures and decreasing precipitation in the Central Asia region, due in part to changes in the Hadley circulation and expansion of low-latitude desert belts to higher latitudes. However, uncertainties in the climate models due to incomplete understanding of feedback mechanisms and to paramaterization of sub-gridscale processes must be kept in mind in applying these models.

Economic and ecological benefits from sustainable use of the Aral Sea Artemia resources: results and experiences from a field sampling campaign conducted in the Uzbek part of the Aral Sea (2005-2007)

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The brine shrimp *Artemia* is an essential and highly priced live food item in marine aquaculture worldwide. Field

observations over the past decade suggest that this halophilic zooplankton organism is gradually colonizing the desiccating Aral Sea. Through a NATO Science for Peace Project (2005-2007) conducted on the Uzbek part of the Aral, the potential sustainable exploitation of this expanding population was assessed. This was achieved through a systematic field sampling campaign (covering abiotic factors, primary production and *Artemia* population parameters), complemented with laboratory culture tests.
As a result of their virtual separation, the Western and Eastern parts of the Large Aral have evolved into water bodies with different hydrological characteristics, but in view of potential *Artemia* exploitation they both show low productivity, prohibitive for large-scale commercial investment in the present conditions. However, the resource may be approaching the threshold to justify a small-scale and economically efficient commercial operation, where the logistics of harvesting and transport nevertheless remain problematic. Moreover, the continuing uncertain situation regarding the future water management of the tributary rivers, which affects the productivity, is a fundamental problem for any conceivable medium- and long-term Aral *Artemia* exploitation plan.

Regional Features of Modern Environmental Problems in Central Asia

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The Central Asian region is a new geopolitical structure within the modern global political system and consists of five independent states. The term “Central Asia”

traditionally denotes a geographical area which extends far beyond the borders of these states. However, in a political context, this region is understood as being confined to the territories of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Its natural and geographic unity has been forged in the basins of its cross-border rivers.
Climatic conditions in mountainous areas directly influence cyclical river flows and the utilisation of water. High temperatures during the growing season and a saturation deficit result in a high evaporation capacity. Therefore, irrigation, which is vital to this region, has the greatest influence on water utilisation and international relations in cross-border river basins. This in turn has determined the historic and cultural homogeneity of Central Asian nations, and is a key factor in strengthening their economic integration. Given their economic and social interdependence, resolving the region's environmental problems, which are generally cross-border in nature, and ensuring the sustainable development of Central Asian countries, will depend upon accelerated integration based on the joint management of water resources in cross-border river basins.
Central Asia's fragile ecosystem, its water shortages and arid climate act as serious impediments to the socioeconomic development of the region's countries. Cross-border atmospheric pollution in industrial and urban areas is one of the most acute environmental problems in Central Asia. The main causes of air pollution are the metallurgical, chemical, building, energy and transport industries. Wastewater from farms and industrial facilities contaminates cross-border rivers. Runoff water contains pesticides, nitrogen and phosphates, which threaten river ecology and water safety. Neither an efficient recycling infrastructure nor an adequate waste management strategy is

in place. There is also a potential threat from radioactive and toxic metallic waste burial sites. Eventually, a considerable percentage of waste disposed of within the drainage basin reaches the rivers.

Another serious problem for the region is desertification. For example, more than 66% of Kazakhstan's land is desertified. About 40% of pasture land in Kyrgyzstan is depleted. In Tajikistan, the cultivation of steep slopes and deforestation of the mountains has destabilised the natural mountain habitat. About 80% of Uzbekistan's territory is desert or semi-desert. Mountainous ecosystems are especially sensitive to external influences.

The region is widely exposed to natural disasters, including earthquakes, floods, mudslides and landslides. These pose a huge threat to the safety of dams, water reservoirs, villages and towns along the rivers. Any major dam burst threatens the population of all countries in the region. This threat is especially pronounced in the mountainous areas of Kyrgyzstan, Tajikistan and Uzbekistan, where most of the region's runoff is generated, and where the risk of destructive flood tides is highest.

In addition to the problems mentioned above, there are several large-scale environmental crises which threaten all the Central Asian countries: the drying up of the Aral Sea, the unstable rock-dammed Lake Sarezskoye, etc.

According to statistics, about 36.1 million people (64% of the region's population) have access to centralised water supply. In Kazakhstan, Tajikistan and Turkmenistan, water supply systems in cities are better than in rural areas. Access to sewage systems is restricted to 22% of the population (11.4 million people), mainly in cities.

The absence, inefficiency or poor state of repair of water supply and sewage systems are the main obstacles to improving public health and raising living standards, especially in rural areas. All these problems in turn impede the sustainable development of the region. Most oblast centres have no sewage treatment systems, and untreated wastewater is being discharged directly to filtration fields or storage ponds. The existing treatment facilities are overloaded, and there is a permanent threat of dam breakage.

The construction of many hydraulic environmental protection facilities has been discontinued or is never planned due to a lack of funds. The generally accepted "polluter pays" rule is barely applied, and no fee is charged for the use of freshwater resources, which is required to encourage efficient natural resources management. Common pollutants are oil products, phenols, heavy metal salts, fertiliser, and pesticides. As a result, cities and other areas are unable to supply drinking water that complies fully with public health requirements.

The existing water supply systems in Central Asian countries do not meet requirements for reliability and drinking water quality, nor do they have all the required treatment facilities; protective sanitary zones are not in place at many water collection sites. Up to 70% of water distribution networks are obsolete, and this figure is increasing, which results in frequent accidents and contamination of water. Over 20-30% of water is lost due to leakages in household water supply systems and pipe corrosion or obsolescence. Existing pipeline capacity is not sufficient to provide an uninterrupted water supply because of its poor state of repair and the obsolete water treatment technology in use. The situation is exacerbated by the fact that a large proportion of wastewater from industrial facilities is being directed to municipal treatment works which are not designed for such wastewater. Most cities have no storm drainage able to treat excess water; as a result, large quantities of contaminated water end up in water bodies. Contamination of drinking water sources and the inefficiency of treatment facilities lead to the deterioration of the quality of drinking water consumed by the public. The safety of drinking water has to be a key element of a comprehensive environmental policy for Central Asian countries. A package of urgent legal, economic and organisational measures must be implemented to protect water resources from contamination, increase the use of properly protected underground freshwater, reduce the load on water treatment plants, minimise drinking water losses, and improve water treatment technology.

To conclude, it is clear that Central Asia's environmental problems all relate directly to the stability of river ecosystems. If these countries fail to take concerted action to stop the depletion and contamination of water resources, these trends may have a negative impact on socioeconomic development, environmental protection and security in Central Asia.

The availability and adequacy of water resources is an essential precondition for the stable functioning of all economic sectors. The efficient regulation of shared water utilisation, especially in agriculture and the hydraulic power industry, is key to international co-operation between Central Asian countries. water utilisation needs a comprehensive approach and joint measures should be considered on the basis of the basin in with the integration of cooperation between countries.

Aquatic flora composition and distribution of macrophytes in the Aral Lake: comparison for the present and the past

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The first herbariums of aquatic plants have been collected by A.N.Butakov from the Aral Lake in 1849. Since that time the Aral Lake has turned from mezohaline oligotrophic lake into hyperhaline mesosaprobic one. There were collected sixty macrophytes' species during the period of 1949-1985 from the Aral Lake. Among there species the hydrophytes were prevailing group that was represented by 35 species of macroalgae and 17 species of vascular plants and there, while the helophytes were represented by only 7 species of vascular plants.

During the first period of the Lake's investigations (1849-1903) the homogeneous dominant communities of *Phragmites australis* and *Nanozostera noltii* have been registered as covering most of shallow water coastal areas of this brackishwater basin. Seven species of higher plants and 30 species of macroalgae (Charophyta-1, Rhodophyta - 10 and Chlorophyta – 19) constituted these plant associations. Then at the initial stage of salification (1903-1960) the distribution of above mentioned associations has become patchy, their structure have changed dramatically in terms of species composition and increase of species diversity. Charophytes and green macroalgae became dominant among submerged macrophytes. During this period 24 species of higher plants as well as 6 Charophytes and about 40 species of other macroalgae were registered in Aral Lake. Catastrophic drying of the Aral Lake during the 1960-1980s has led to subdivision of the Lake into two basins: Big Aral

and Small Aral as well as has caused degradation of the most of aquatic macrophytes associations.
Finally at the end of the 1990s the Big Aral has turned into a hyperhaline basin from where macrophytes are absent. The Small Aral is a brackishwater eutrophic basin with freshwater input from the Syr-Darya River, due to this it has been gradually populated by widespread euryhaline, mesohaline and oligohaline, cosmopolitic and extremely polymorphic species of hydrophytes, which are penetrating into the Aral Lake from other continental brackishwater reservoirs of Central Asia.