



LIETUVOS ŽEMDIRBYSTĖS INSTITUTAS  
LITHUANIAN INSTITUTE OF AGRICULTURE

# **DIRVOŽEMIO STABILUMO UŽTIKRINIMAS EKOLOGIŠKAI IRSOCIALIAI JAUTRIUOSE REGIONUOSE**

## **SOIL STABILITY IN ECOLOGICALLY AND SOCIALY VULNERABLE REGIONS**

Tarptautinė mokslinė konferencija  
International Scientific Conference

**2009 m. birželio 10-12 d., Perloja, Varėnos r.  
June 10-12, 2009, Perloja, Varena Municipality, Lithuania**

Mokslinių straipsnių rinkinys / Scientific articles

Akademija, Kėdainių r., 2009

## **ENVIRONMENTAL PROBLEMS OF HYBRID MARINE/ LACUSTRINE SEAS AND LAKES (ARAL SEA AND BALTIC SEA ARE TAKEN AS AN EXAMPLE)**

Nikolai V. ALADIN, Igor S. PLOTNIKOV

Zoological Institute of RAS

Universitetskaya emb. 1, 199034 St. Petersburg, Russia

E-mail: [aral@zin.ru](mailto:aral@zin.ru)

### **Abstract**

The Aral Sea was terminal water body in arid zone. The main part of its water area was brackish. Since 1960s, decrease of level and salinization began. Original ecosystem has nearly totally gone. The only hybrid marine / lacustrine sea that could be compared with Aral is Baltic. Here there are 4 basic and 3 intermediate salinity zones and 3 barrier salinities.  $\delta$ - horohaliticum divides freshwater and brackish water ecosystems,  $\alpha$ - covers brackish-water area. ( $\beta$ - is located in the area influenced by full-saline waters. Redirection of riverine waters from Aral Sea for irrigation allowed increasing harvesting of cotton and rice, but salinization of these lands did not allow having sustainable agriculture. Aral desiccation has brought severe consequences. Commercial fisheries were lost. The climate also changed. Strong windstorms blow salt, dust and contaminants. In the case of Baltic Sea the main threat is eutrophication.

Key words: Baltic Sea, Aral Sea, salinity, salinization.

### **Introduction**

In the first half of the 20th century, the Aral Sea was a single terminal water body of two rivers in the arid zone. The main part of its water area was brackish with specific aboriginal brackish water ecosystems. Since 1960s, decrease of level and salinization of the Aral Sea have begun. Due to the structure of its depression the Aral Sea began to split into several residual water bodies. In 1988-1989, when level decreased by 13 m, the Aral Sea was divided into 2 polyhaline terminal lakes with marine ecosystems - the Large and Small Aral. In the fauna, only widely euryhaline species remained due to water salinization and introduction of exotic species. Piscifauna 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. The threat appeared of moving the Syrdarya River mouth to the Large Aral. In August 1992 a dike was built in the Berg's Strait. Salinity growth in the Small Aral stopped; the salinity began to decrease which was favourable to the fauna. Conditions of transitional brackish water-marine salinity zone were formed. In April 1999, the dike was destroyed by a storm. Construction of new solid dike started in 2004 and was finished in autumn 2005. After Aral Sea division, salinization and level fall in the Large Aral became faster. The Large Aral was divided into the Western Aral, Eastern Aral and Tschebas Bav. 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 invertebrate species inhabiting saline water bodies in the Aral Sea region moved into the Large Aral by natural way. Among them, the brine shrimp (*Artemia parthenogenetica*) became predominating in zooplankton /Аладин, Плотников, 2008/.

### Results and discussion

As you could see original brackish-water ecosystem of the Aral Sea has nearly totally gone due to its salinization. The only hybrid marine / lacustrine sea that could be compared with Aral Sea is Baltic Sea. In our unique Baltic brackish-water ecosystems cover up to 60%. In the Aral Sea they covered up to 90%.



**Figure 1.** Ecosystems in relation to salinity

Baltic Sea is a young sea and in glacial time it was a cold lake. Baltic Sea until now retains many features of lake. Baltic Sea is semi-closed, shallow, brackish water body having smooth salinity gradient and unique fauna and flora. Biodiversity of Baltic Sea is relatively low while in its own way is unique and needs special measures for its preservation.

Riverine waters are giving considerable contribution practically to the whole water areas of the Baltic Sea.

In the Baltic Sea there are oligohaline and mesohaline water areas, and each of them has its own specific flora and fauna. The most freshened areas there are Gulf of Finland and Gulf of Bothnia. Central water area of Baltic Sea has pronounced mesohaline character. Only in Kattegat and Sound can polyhaline conditions be found.

Above-mentioned scientists from Baltic Sea states have demonstrated that biodiversity of this young sea was formed in the postglacial time and is highly heterogeneous by its composition. It consists of three main components:

- 1 - marine,
- 2 - freshwater,
- 3 - brackishwater (*sensu stricta*).

The first group is the main part of Baltic Sea biota. It includes relicts of previous geological times and immigrants from remote marine water bodies.

The second group includes large number of Baltic Sea inhabitants, which come together with freshwater inflow.

The third group is represented by a large number of species and is divided into 2 subgroups:

1. Ancient brackishwater arctic relicts (pseudorelicts-immigrants) formed in the glacial time in freshened areas of arctic basin that migrated into the Baltic Sea in postglacial time from the North-East and East possibly via fresh waters.

2. Brackishwater forms originated from freshwater ones.

While considering water area of modern Baltic Sea from position of brackish water hydrobiology it is possible to distinguish 4 basic and 3 intermediate zones in it. The basic zones are: freshwater, brackish water, marine and hyperhaline. The intermediate zones are: transitional between freshwater and brackish water, transitional between brackish water and marine, transitional between marine and hyperhaline. From the position of earlier published conception of relativity and plurality of barrier salinity zones /Аладин, 1986; 1988/ the following bounds of these zones for Baltic Sea were defined.

Below we shall consider these four barrier salinities:

- $\alpha$ - horohalinicum - for Baltic Sea brackish waters - 5-8‰,
- $\beta$ - horohalinicum - for polyhaline Baltic Sea waters - 22-26‰,
- $\gamma$ - horohalinicum - for hyperhaline Baltic Sea waters - 45-50‰,
- $\delta$ - horohalinicum - for fresh Baltic Sea waters - 0.5-2‰

Freshwater ecosystems in the Baltic Sea occupy mouths of inflowing rivers and also waste adjoining areas of shallow gulfs. Absence of pronounced high and low tides in the Baltic Sea contributes to stable existence of  $\delta$ - horohalinicum (0.5-2‰). This barrier salinity divides freshwater ecosystems from brackish water.  $\delta$ - horohalinicum is well distinguished in the eastern part of the Gulf of Finland and the Northern part of the Gulf of Bothnia. It is to note Vistula and Curonian lagoons which are divided by this barrier salinity into fresh and brackish water zones. In the South-Eastern area of the Gulf of Riga being constantly influenced by riverine water inflow  $\delta$ - horohalinicum zone is well distinguished also.

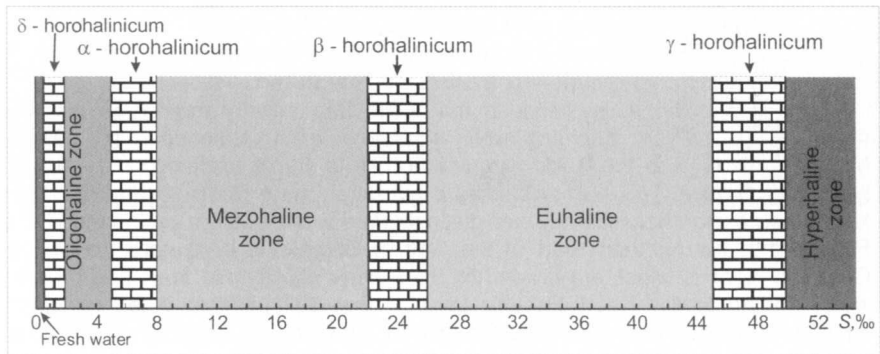
Area of the Baltic Sea occupied by freshwater zone is not large - only 6% of the total area. They are only small areas where fresh riverine waters are mixing with saline Baltic Sea waters. Salinity varies here from fresh water up to 2‰. However many freshwater plants and animals are living only here and never are found in the Baltic Sea proper. In Baltic freshwater ecosystems there are about 1200 species of fishes, free-living invertebrates and plants (without bacteria, protozoans and tiny metazoans). These water areas are shallow, maximal depths don't exceed several tens of meters. Special distinguishing of freshwater zones and ecosystems is important for forming universal conception of Baltic Sea biodiversity.  $\delta$ - horohalinicum is restricting zone for freshwater organisms invading Baltic Sea.

$\alpha$ - horohalinicum occupies the Baltic Sea proper, Bothnian Sea, Archipelago Sea and the Gulf of Riga. This boundary zone occupies the largest part of the sea area, about 62% of the total Baltic Sea. Salinity here varies between 5-8‰ and many scientists considered these salinities as the normal salinity of the Baltic Sea. In the Baltic Sea  $\alpha$ - horohalinicum is occupied by brackish water ecosystems which are the most poor in the species number. In them there are about 700 species of fishes, free-living invertebrates and plants (without bacteria, protozoans and tiny metazoans). Some of them are descendants of inhabitants of glacial lake

existed on the place of modern sea in the ice age. Zone of  $\alpha$ - horohaliticum occupies the deepest part of the Baltic Sea where depths are up to 500 m.

$\beta$ - horohaliticum (22-26‰) is located in the West of Baltic Sea and the Eastern water area of Danish Straits strongly influenced by inflow of full-saline waters from the North Sea. Salinity here varies from 22‰ up to 26‰. While the area is only about 4% of the total Baltic Sea area, number of species of fishes, free-living invertebrates and plants (without bacteria, protozoans and tiny metazoans) found here is about 3 000.

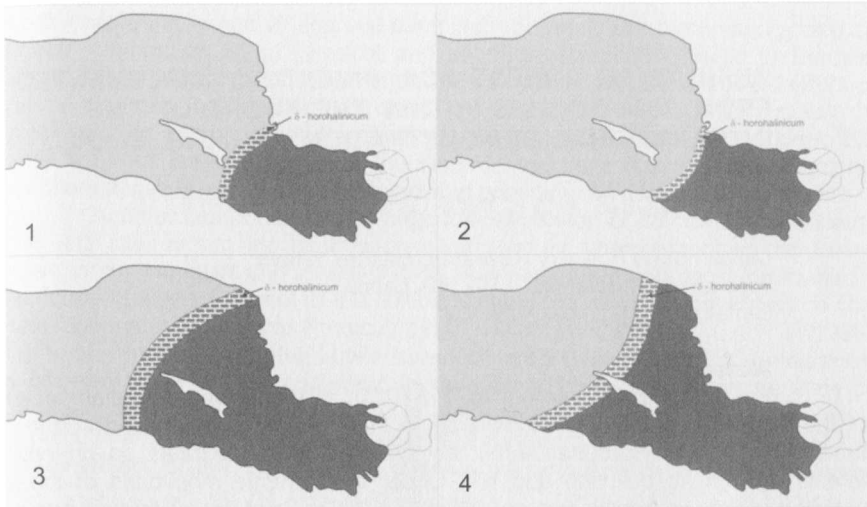
$\gamma$ - horohaliticum (45-50‰) is not directly found in the Baltic Sea. This zone in fact is outside of the sea or at its bounds,  $\gamma$ - horohaliticum can be found in rock pools or on salted shoals named "salt marshes". Hyperhaline ecosystems can be named seasonal ecosystems, which are formed in summer time when evaporation is highest,  $\gamma$ - horohaliticum divides inhabitants of full saline Baltic Sea waters from inhabitants of hyperhaline waters where maximal number of plant and animal species including unicellular ones does not exceed 100.



**Figure 2.**  $\alpha$ -,  $\beta$ -,  $\gamma$ - and  $\delta$ - horohaliticums in the waters classified by salinity

In the case of Aral Sea redirection of riverine waters for irrigation purposes allowed to increase harvesting of cotton and rice. Unfortunately salinization of irrigated lands did not allow having sustainable agriculture in this area.

Desiccation of the Aral Sea has brought severe consequences. Greatly reduced river flows ended the spring floods that sustained wetlands with freshwater and enriched sediment. Fish species in the lakes dropped from 32 to 6 because of rising salinity and loss of spawning and feeding grounds. Commercial fisheries were lost. Shipping on the Aral also ceased because the water receded many kilometers from the major ports. Groundwater levels dropped with falling lake levels, intensifying desertification. The climate also changed up to 100 kilometers beyond the original shoreline: today summers are hotter, winters are colder, humidity is lower (so rainfall is less), the growing season is shorter and drought is more common /Micklin, Aladin, 2008/.



**Figure 3.** Position of 6- horohaliniacum in the Gulf of Finland: 1 - prior to dike / dam construction in calm weather conditions, 2 - prior to dike / dam construction during cyclone and strong wind from the West, 3 - after dike / dam construction in calm weather conditions, 4 - after dike / dam construction during cyclone and strong wind from the West

The receding sea has exposed and dried 54 000 km<sup>2</sup> of seabed, which is choked with salt and in some places laced with pesticides and other agricultural chemicals deposited by runoff from area farming. Strong windstorms blow salt, dust and contaminants as far as 500 km. Airborne sodium bicarbonate, sodium chloride and sodium sulfate kill or retard the growth of natural vegetation and crops /Micklin, Aladin, 2008/.

In the case of Baltic Sea the main threat is eutrophication. This subject is excellently covered in the Baltic Sea Action Plan. We hope that environmental mistakes made by agricultural business around Aral Sea will not be repeated in the area around Baltic Sea /План действий..., 2008/.

### REFERENCES

- 1.Аладин Н. В. Концепция относительности и множественности зон барьерных соленостей // Журнал общей биологии. - 1988, т. 49, № 6, с. 825-833
2. Аладин Н. В. Особенности осморегуляции гемолимфы ракушковых и жаброногих ракообразных из морских и континентальных вод // Труды Зоологического института АН СССР. - 1986, т. 141, с. 75-96
3. Аладин Н. В., Плотников И. С. Современная фауна остаточных водоемов, образовавшихся на месте бывшего Аральского моря // Труды Зоологического института РАН. - 2008, т. 312, № 1-2, с. 145-154
4. Micklin P., Aladin N. Reclaiming the Aral Sea // Scientific American. - 2008, № 4, p. 64-71
5. План действий ХЕЛКОМ по Балтийскому морю // Диалог. - 2008. -

112с.