

# ***What don't we know about dying and dead seas ?***



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Aral Sea

Caspian  
Sea

**As conclusions of this NATO Advanced Research Workshop on Dying and Dead Seas, numerous questions remains concerning the studied water bodies, all along their hydrological cycle and along their anthropic perturbations.**

No compilation work was yet shown to allow an observation on common trends in the evolution of all large inland bodies of the world? ie : plotting dynamic evolution of volume, salinity, composition, oxygen, level changes, solar activity, global change (NAO,...), history of primary production recorded in sediments, ...

- What classification should we use for such investigation (watersheds, climate, human impact)? How to address generally the issue?

**Modern period threats**

**Toxicity**

**Water depletion**

**Eutrophisation / anoxia**

**Overfishing**

**Climate change**

**Loss of biodiversity**

**Water bodies**

**Caspian, Issyk Kul**

**Aral, Dead Sea, Kinneret, KBG, Chad**

**Louisiana current, Black Sea, Manyas, Mayrout**

**African lakes**

**White sea**

**most...**

## **Water balance Indeterminations:**

- How could a model consider automatically separate water balance for each successive subdivisions of the former Aral Sea along the drying process?
- Aral Sea: how should we account for the occasional water discharge through the Berg Strait Dam. Differently, how can we solve precise separate water balance accounting after 1989 for the sub-bodies?
- The complex role of the deltas (enhancing evaporation, infiltration, ..) in endangered seas remains a very important question, either for problems of water diversion and/or contaminated river discharge.

## Ground water

- Little is known about potential impact of neotectonics on changing water and chemical interactions in the history of studied water bodies (except for lake Manyas).
- Measurements and knowledge about ground water remains incomplete and doesn't allow any solid estimation of net underground water and salt exchanges.
- Could we map the water table level elevation all around the water body to get a view of overall flow direction (as given for lake Corangamite), and make a first estimate of inflow with simple gradient Darcy law?
- How does ground water pumping affects these transfers all around the Aral Sea(s), is it well accounted for (is the critical  $4\text{m}^3/\text{sec}$  already overpassed?), and how should it be managed?

- Some localized springs were reported in the dried Aral sea bed. Is there some also underwater? What is the extent of their contribution to the Sea's mass balances?
- In the Aral, the observed level drop and salinity raise do overpass worse estimated scenario by the Russian Hydrological and Meteorological Institute (RHMI), what are the sources of these discrepancies?
- As expected, salinity raises slower than simple concentration factor due to drying remanent water body (worse scenario). Many classical logical explanations exist (new precipitations equilibrium reached), as some less investigated ones, including the proposed accumulation of highly saline waters in the western Aral deeper basin.
- What is the correct evaporation rates from the Aral Sea, between the two limit hypothesis given by G. Destouni: 1000 and 2000 mm/year? (cfr. 35th Int. Liège Colloquium on Ocean Dynamics, May 2003)  
Precise estimation of evaporation as function of salinity are required.

# **As suggested by different authors: part of the sea level drop of the Aral remains unexplained:**

## **1. Is there some other forgotten phenomena:**

- Intense saline stratification allowing increased SST leading to increased evaporation rate
- Does the net ground water flow correspond to an outflow?  
Additional loss by evaporation due to export to lagoons are driven by wind driven tides (also indicated by larger deposits of salts on the southwestern regressing shoreline of the Eastern basin, corresponding to RHMI description of wind driven sea level oscillation).
- Additional loss by evaporation and infiltration within an increasing loss of River Discharge trough expanding and desertifying deltas  
Accumulation of highly saline waters in the western deeper basin
- Neotectonism : are some fault active below the Amu Darya and Syr Daria river beds, or below the sea bed? Can they allow increased ground water transfert?

## **2. Is there simply some bias in the estimation of the factors entering the simple water balance equation?**

**An important synthesis is required concerning the water balance of endangered water bodies:**

- How can we unify these works?
- Can we solve part of our indeterminations by joining efforts devoted on the evolution of the salinity balance and composition to the water balance studies?
- We are missing past and present data, i.e. we are unable to give true forecast of the Caspian sea level changes, as the whole drainage basin of the Volga river is too large comparatively to available data.

## **Hydrodynamics (circulation & water masses formation)**

- In the Aral Sea, a shift from anticyclonic to cyclonic dominant circulation was suggested several times, but no clear evidence was given. Can we say that the general circulations switched from anticyclonic to cyclonic pattern as consequence of the drying process?
- How should the equation of state be adapted to account correctly for the large range of salinity (both total and detailed composition) encountered in drying or strongly fluctuating water bodies, and in the case of fresh or sea water discharge over a hypersaline water ? Could such adaptation reproduce the incomplete winter mixing of southern Aral sea shallow water column (20 m), as suggested by recent measurements?
- What is the complete history of the different water masses formation within the drying process (stratification changes during “anthropogenic period”) and what is the circulation today in the Aral Seas?



- What are the different mechanisms linking human alteration of fresh river discharge and mixing regime changes?
- What was the changes in ice cover regime over the Aral Sea along with its dessication?
- What are the effects of ice cover changes on the water budget and hydrodynamics of the Aral Sea?
- How was the thermocline position affected by the drying process?
- Should we account for the impacts of indirect effect of new biogeochemistry on heat balance of the lakes in case of massive water (Case of the Peace conduit to the Dead Sea?).

## Geochemistry

- Much seems still to be searched about sulfate/chloride variation (expected reduction) observed in the Aral : what could explain their uneven distribution in the southern Aral?
- What is the influence of hot springs on lake chemistry (lake Manyas)?
- We have an idea of today's benthic biogeochemical fluxes in the Aral, but how were they affected by the drying process? What are the impacts of the hydrodynamical changes upon the Aral Seas biogeochemistry?
- How can we evaluate the salt deposition on the shores? What justify the large variation in the salt deposit pattern observed by remote sensing around the south-eastern Aral Sea?

## **Marine Biology & Ecosystem**

- What is the biological state of the Aral Seas today?
- What are the ecological consequences of a change in ice cover regime?
- When did the Aral Sea separated in two water bodies linked by a unidirectional (intermittent) flow trough dried Berg Strait? Can this limit be considered as a first limit for planctonic population isolation, whereas swimming fishes could still migrate until construction of the dam across Berg's strait?
- Could remote sensing distinguish between shallow benthic vegetation and phytoplankton blooms, in order to improve understanding of the evolution of primary production in the Aral Sea and other shallow aquatic environments?

- To what extent inland sea level variations can be considered as “breathing of the sea”, as suggested for the Caspian? What are the ecological implications of limited sea level oscillations? Being positive: in which way these variations of sea level would be of importance to the ecosystem functioning? Part of answer resides in the genetic diversity conservation or enhancement, key of ecosystem resilience to stronger water body variations.

- What are the large scale implications of the suppression of natural habitat on bird migrating routes?

- Is further efforts required to link observed abnormally high population mortalities (Caspian Sea) with particular toxic releases and bioaccumulation?.

## **Geomorphology**

- How much time is required for the transformation of the dried sea bed sediments in a soil (solonchacks), and for its following colonization by desert vegetation?
- How can we predict the consequences of sea level variations on coastal geomorphology (sinkholes, cutback tending to keep basins hydrological flow, destabilizing engineering structures).

## **Atmosphere**

- What is the interaction between atmosphere and surrounding arid vegetation dynamics?
- What are the impacts and feedbacks of both the increased irrigated agricultural areas and the decreased water body upon the local climate?
- What is the relative importance of overall climate warming versus changes in the climate seasonality (on-set and seasons length changes)?

## **Palaeo climatology/limnology/oceanography/ecology**

- Long term past variations of sea level and extension were presented for the Dead Sea - Kinneret, as well as for the Aral and the whole Paratethys.
- How can we estimate the potential parallel long term fluctuations of salinity and composition ?
- It is difficult to distinguish between natural climate variability and man induced impacts as the time scale of these events are different, and long term past records do not have the required resolution to allow this analysis.

## **Inland Hydrology and Anthropic influences:**

- A sustainable limit of water withdrawal of 35 km<sup>3</sup>/year was suggested for the Aral Sea watershed, under which no runoff losses change were observed. Can this limit be justified only by natural losses occurring during river transport through desert (evaporation, infiltration), or also by integrating changes in irrigation practices?
- An optimisation of the use of water reservoirs (using variable water qualities according to specific purpose) could allow an increase in (saltier) river discharge to the Aral Sea. What cumulated contribution can be expected if such practice were to be implemented in the whole basin?

## **Inland Hydrology and Anthropic influences:**

- How could we define the “anthropic period”, as an important raise of water diversion was already observed in the 1930s in the Aral watershed, as much earlier due to Hozerm civilizations, which might also have diverted very significative fluxes of water. We need to broaden temporal vue on anthropic influences.

- How can the tremendous loss of the Large Aral Sea can be prevented? Differently, what ACTIONS can be done to provide the annual volumes required for this?



## **Economics / Sustainable development**

- Negative water balance might in some case have “positive” (non dramatic) local consequences (Chad).
- What options exists concerning economic exploitations of the system (salt exploitation like for the Dead Sea, camel cattle in Aral and Chad )?
- What is the balance between what is gained thanks to agricultural water diversions and chemical treatments, and the lost due to long term degradation downstream? How to optimize this balance on the long term. Is it possible seeing the number of indeterminations?
- Should we wait to take large scale investments?

## Researchers

- A lot of measures were realised from 1998 until today, but with much variability in the methods used. More coordination is required.
- How can we increase data availability and easy accessibility to the whole scientific community? Multidisciplinary Databases should be compiled for each endangered sea.
- Will the open data base “Aral Sea Information System” remain relatively empty compared with the total information existing to date?

## **Conclusions ? : Emergency**

- How, in the various dramatic contexts presented, can scientific databases be considered as “potential commercial resources”?
- How can we pass from the valuable reports, meetings, frameworks and all the thinking and paper that it produces to...  
.....fast actions, oriented by these reflexions ?