

## **Shallow Mediterranean Lakes: Variation in the Theme – Workshop Conclusions**

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Studies on shallow lakes from north temperate climate clearly demonstrate that they alternate between clear and turbid water states in response to some control factors. However, ecology of semi-arid to arid shallow Mediterranean lakes is less explored. A workshop held in Dalfsen, The Netherlands in June 2005 formed a step towards compiling existing data and experience on shallow Mediterranean lakes to evaluate the variation in the theme. In accordance with the state of art of the ecology of shallow lakes and food web theories, hypotheses to be tested arose.

Hydrological variation (e.g. water level fluctuations, water residence time) on major ions and nutrients dynamics and processes and ecology of submerged macrophytes appeared to have crucial role for food webs in shallow Mediterranean lakes. There is evidence that shallow Mediterranean lakes shift forward and backward between clear and turbid water in response to water level fluctuations. Furthermore, hydrological dry years are associated with increase salinity, conductivity and concentration of total phosphorus. The latter is probably due to drought induced decrease in water level and increase in water residence time that may provide longer contact with sediment that may enhance internal processes such as increase in internal P loading. However, at the same time the loss of N by denitrification was favoured causing N limitation

Experience from northern temperate shallow lakes suggests that shallow lakes alternate between turbid water and macrophyte-dominated clearwater in response to nutrient levels. The influence of nutrient appears to increase southward from the north temperate regions and this was probably manifested through naturally greater annual macrophyte abundance in warmer locations as a consequence of longer plant-growing seasons. Critical nutrient

thresholds for warmer lakes to maintain vegetation dominated clear water state are still unknown, but there are evidence from the Mediterranean zone showing that nutrient concentrations for oligotrophication and the recovery of submerged macrophyte are lower than in northern temperate shallow lakes. This also will be relevant for the implementation of the European Water Framework Directive and conservation and management of these ecosystems.

Furthermore, in shallow Mediterranean lakes strong trophic cascade of fish resulting from dominance of generalist and opportunistic fish species, whose diversity is usually high, together with frequent spawning and absence of strong piscivores seem to be the reason for the lack of strong large-bodied grazers that could control phytoplankton. However, such effects may even vary within the region. Therefore, these factors need elaborating in order to allow shallow lake ecologists and managers to develop better restoration strategies for eutrophicated shallow Mediterranean lakes.

Modifications for the implementation of the European Water Framework Directive for determining ecological status in shallow Mediterranean lakes appeared to be necessary due to strong hydrological variations, relatively smaller size of the lakes in the region. Furthermore, indices that were developed in the high latitudes cannot be used in the south because of wide variations in the climatic and hydrological conditions.

Furthermore, global climate warming can be even more challenging for shallow Mediterranean lakes than that of high latitude lakes since the shallow lakes in the region are among the most sensitive areas regarding the extreme changes in climate.

Limited data and experience presented on shallow Mediterranean lakes highlights that there seems to be a strong variation on the theme of shallow lake ecology from that of the high latitudes. In determining the ecology of shallow Mediterranean lakes role of hydrology especially in relation with global warming, the requirement for lower TP levels for obtaining and conserving macrophyte-dominated state and the inefficiency of zooplankter for clearing water probably due to strong top-down effect of diverse and omnivorous fish fauna have to be included in the framework of a research aiming to test their importance and to present variation.

As the ecology of shallow Mediterranean lakes clearly form a regional and international issue, regional scale research and exchange of information among scientists and managers would be highly desirable in the future. To enhance cooperation between shallow lake scientists in the Mediterranean climate regions, an e-mail based discussion group named “warm lakes discussion group” addressed [warmlakes@sulakalan.org](mailto:warmlakes@sulakalan.org) has already been activated following the workshop of “ shallow Mediterranean lakes: variation in the theme”.

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