Basin- and global-scale environment alternately drive diatom community structure in ancient Lake Ohrid

Aleksandra Cvetkoska1,2, Dedmer B. Van de Waal1, Timme H. Donders2, Elena Jovanovska3, Zlatko Levkov4, Torsten Hauffe3, Jane M. Reed5, Alexander Francke6, Hendrik Vogel7, Thomas Wilke3, Bernd Wagner8, and Friederike Wagner-Cremer2

1Netherlands Institute of Ecology, NIOO-KNAW, Department of Aquatic Ecology, Wageningen, The Netherlands
2Palaeoecology, Department of Physical Geography, Utrecht University, Utrecht, The Netherlands
3Department of Animal Ecology & Systematics, Justus Liebig University Giessen, Giessen, Germany
4Institute of Biology, Faculty of Natural Sciences and Mathematics, University Ss Cyril and Methodius, Skopje, North Macedonia
5Department of Geography, Geology and Environment, University of Hull, Hull, UK
6School of Earth, Atmosphere, and Life Science, University of Wollongong, Wollongong, Australia
7Institute of Geological Sciences & Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
8Institute of Geology and Mineralogy, University of Cologne, Cologne, Germany

Evidence for global environmental and climate change-related loss of biodiversity is accumulating. Understanding the causes of species community change is thus essential for effective management and conservation policies. Nonetheless, disentangling the relative influence of the individual or multiple drivers determining the species communities is challenging, as ecosystems are simultaneously affected by variable drivers acting on different spatial and temporal scales. To this end, paleolimnological data may provide critical information on long-term community changes, species dominance shifts, and their underlying drivers. Natural forced changes in the aquatic environments can be used to study the response of biota to repeated fluctuations in essential key variables. In this study, we investigated the planktonic diatom communities in a continuous, 1.36 Ma sedimentary succession from ancient Lake Ohrid (North Macedonia/Albania). This is the oldest, continuously existing freshwater lake in Europe, acknowledged as a site of exceptional biodiversity and endemic species richness. An extended biogeochemical dataset from the DEEP site sedimentary record and previously-published variables representing global climate variability was used to: i) quantify the relative influence of individual environmental variables in governing species communities, and ii) disentangle the contribution of basin-scale environmental processes and global-scale climate variability in driving community patterns over time. The results show that the structure of planktonic communities was primarily determined by the basin-scale environment, particularly, nutrient availability, water temperature and water column mixing, but also local tectonic processes, since lake ontogeny. However, since the onset of the penultimate glacial period 0.185 Ma ago, global-scale climate variability became the principal drivers of the diatom community structure. Our proxy time-series illustrates how various factors at different
spatial scales may determine the freshwater planktonic communities over geological time-scales. Extended periods of stable communities can be terminated by changes in climate, environmental conditions and/or lake ontogeny, leading to species extinctions and community turnovers. Thereby lake ecosystem structure and functioning are affected and effective management and conservation policies are required to minimize additional anthropogenic change-related loss of biodiversity.