Global Change Biology (2007) **13,** 1314–1326, doi: 10.1111/j.1365-2486.2007.01364.x

Large-scale climatic signatures in lakes across Europe: a meta-analysis

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Abstract

Recent studies have highlighted the impact of the winter North Atlantic Oscillation (NAO) on water temperature, ice conditions, and spring plankton phenology in specific lakes and regions in Europe. Here, we use meta-analysis techniques to test whether 18 lakes in northern, western, and central Europe respond coherently to winter climate forcing, and to assess the persistence of the winter climate signal in physical, chemical, and biological variables during the year. A meta-analysis approach was chosen because we wished to emphasize the overall coherence pattern rather than individual lake responses. A particular strength of our approach is that time-series from each of the 18 lakes were subjected to the same robust statistical analysis covering the same 23-year period. Although the strongest overall coherence in response to the winter NAO was exhibited by lake water temperatures, a strong, coherent response was also exhibited by concentrations of soluble reactive phosphorus and soluble reactive silicate, most likely as a result of the coherent response exhibited by the spring phytoplankton bloom. Lake nitrate concentrations showed significant coherence in winter. With the exception of the cyanobacterial biomass in summer, phytoplankton biomass in all seasons was unrelated to the winter NAO. A strong coherence in the abundance of daphnids during spring can most likely be attributed to coherence in daphnid phenology. A strong coherence in the summer abundance of the cyclopoid copepods may have been related to a coherent change in their emergence from resting stages. We discuss the complex nature of the potential mechanisms that drive the observed changes.

Keywords: climate variability, coherence, European lakes, meta-analysis, nutrients, phytoplankton, water temperature, zooplankton

Received 26 June 2006; revised version received 17 January 2007 and accepted 26 January 2007

Introduction

Lake ecosystems are strongly influenced by many stressors (e.g. eutrophication, climate change, acidification, and pollution). Physically, the most important drivers are the local meteorological variables air temperature,

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