Disrupted seasonal clockwork in the population dynamics of a freshwater copepod by climate warming

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Limnol. Oceanogr., 54(6_part_2), 2009, 2493-2505 | DOI: 10.4319/lo.2009.54.6_part_2.2493

ABSTRACT: Life history responses are expected to accompany climate warming, yet little is known how long-term effects of climate and environmental change affect the seasonal dynamics of planktonic organisms. We used an historical data set from Lake Washington (U.S.A.) to quantify population responses of a calanoid copepod (*Leptodiaptomus ashlandi*) to long-term changes in temperature and resource availability and explore potential mechanisms for the responses. Increasing water temperatures (annual mean increase of 1.5° C in the upper 10-m water volume) and longer stratification periods (about 4 weeks) were observed between 1962 and 2005, coincident with a pronounced decline in *Leptodiaptomus* densities. However, production was maintained because of an increase in the production to biomass ratio and a life cycle shift in Leptodiaptomus from an annual to a 6-month cycle. Cross-wavelet analyses demonstrated that the annual thermal forcing of copepod recruitment observed during the first two decades of the study weakened substantially, leading to more stochastic population dynamics during the past two decades. This shift from one to two generations per year was most likely produced by a longer and warmer growing period combined with changing fluctuations in resource (phytoplankton) availability. Climate change can lead to higher-frequency voltinism in ectothermic organisms and to temporal reorganization of their population dynamics.

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