Holocene Carbon Fluxes and Palaeoproductivity in Aquatic Ecosystems: a Multiproxy, Palaeolimnological Approach

Mackay, AW; Leng, MJ; Morley, DW; Piotrowska, N; Rioual, P; Swann, GEA.

Abstract

Inland waters act as an important control on the global carbon cycle. Deep tectonic lakes may provide a key link between short-term and long-term carbon cycles as buried carbon is essentially locked away from the atmosphere over geological timescales. Here we investigate Holocene carbon dynamics in one of the world's most important lake ecosystems, Lake Baikal, Siberia. We test the hypothesis that multiple factors play a significant role in determining long-term carbon dynamics in central Asia, and that these factors change in importance over time. Carbon isotopes (^{13}C), percentage total organic carbon (%TOC) were analysed during combustion in a Carlo Erba 1500 on-line to a VG Triple Trap and dual-inlet mass spectrometer. A multi-decadal organic geochemistry record (%TOC; ^{13}C, C/N ratios) was determined on Holocene sediments extracted from a slope terrace c. 600 m deep. Age-depth modelling on radiocarbon-dated pollen extracts was undertaken using Bacon, which takes into account variable sediment accumulation rates. Carbon mass accumulation rates (CMAR; g cm-2 yr-1) were estimated at a centennial scale resolution. ^{13}C values were routinely higher during cool glacial periods (-26) than during warmer climates (-28) linked to changes in carbon sources. Diatom productivity & boreal forest expansion were strongly associated with 13Cvariability during the early Holocene, but after 8 kyr BP, no relationships are apparent. CMAR were highest during the early Holocene (11.7 8 kyr BP) although rates fluctuated considerably. Peak values of 12.5 g cm-2 yr-1 were observed at 10.35 kyr BP before a rapid decline to c. 5.2 g cm-2 yr-1 at 10.05 kyr BP. CMAR declined to lowest Holocene values of 3.5 g cm-2 yr-1by 3.9 kyr BP at the same time asmaximum ^{13}C values (-27.0), indicative of low palaeoproductivity. Our data show that measures of palaeoproductivity in Lake Baikal are complex, and during the early Holocene are strongly associated with allochthonous inputs mediated by taiga forest expansion and fluvial input into the lake. Minima in Holocene palaeoproductivity are coincident with peaks in hematite stained grains in North Atlantic sediments, a proxy for ice-rafted debris, highlighting tight linkages via teleconnection processes between changes in the North Atlantic and remote central Asia.