Geophysical Research Abstracts
Vol. 13, EGU2011-3563, 2011
EGU General Assembly 2011

Lake sediment biochemistry influences food web structure

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Aquatic ecosystems play an important role in the global carbon cycle. The quantity and quality of sedimented organic matter (SOM), through carbon and nutrient cycling, are of particular importance in lake ecology and biogeochemistry. In a recent study, we showed that a biomanipulation (presence or absence of a planktivorous fish) influenced the elemental (C:N:P ratios) and biochemical (sugars, proteins, lipids) composition of biotic compartments (phytoplankton, zooplankton and SOM). In turn, SOM biodegradability could have a bottom-up effect by influencing the turnover of nutrients and their availability for biotic compartments. This biodegradability is expected to be higher when SOM contains more labile compounds such as sugars, proteins or unsaturated fatty acids. To our knowledge, the interactive effects of trophic cascades (top-down control) and sediment (bottom-up control) on food web structure and biogeochemistry have never been studied.

We compared here the influence of different sediments on biotic compartments, in presence or absence of fish. We used 24 experimental mesocosms immersed in lake Créteil (France). Bottom-up control was studied by comparing 3 different sediment treatments: a control treatment without sediment added (S0), and two treatments with sediment added in the bottom of the mesocosms. These sediments had respectively low (S1) and high (S2) contents of organic matter (OM). Indeed, elemental and biochemical analyses revealed that S2 contained roughly 10-fold more organic carbon, proteins, sugars and unsaturated fatty acids (10, 1.53, 0.72 and 0.51% respectively) than S1 (0.7, 0.11, 0.06 and 0.01% respectively). After 6 months, we added planktivorous fishes (roach, *Rutilus rutilus*) in half of the mesocoms to compare three-level food webs (phytoplankton - zooplankton - fish), with two-level ones (phytoplankton - zooplankton). Monthly (from winter to summer 2010), biomass of recently deposited sediment, zooplankton and particulate organic matter (POM; particle size 0.7-50 μm) were measured. 0.7-50 μm POM is generally considered to comprise mainly phytoplankton. Lipid biomarkers (fatty acids and sterols) of these different biotic compartments were analysed.

Before fish addition, POM and zooplankton biomass were significantly lower in S0 and S1 treatments than in S2. Sedimentation rates were slightly lower in the S0 enclosures than in the enclosures with sediment.

After fish addition, POM biomass was significantly lower in S0 than in S1 and S2, in both fishless and fish enclosures. Moreover, the differences between enclosures without and with sediment were greater in fish enclosures than in fishless ones. In fish enclosures, zooplankton biomass was higher in enclosures with sediment. Moreover, zooplankton biomass was higher in S2 than in S1 treatment. In both fishless and fish enclosures, sedimentation rates were significantly lower in S0 than in S1 and S2. Moreover, the difference between enclosures without and with sediment was greater in fish enclosures than in fishless ones.

Our results suggest the existence of a sediment bottom-up effect, leading to an increase of the biomass of both phytoplankton and zooplankton, and, in turn, in sedimentation rates. This effect is especially pronounced when the OM content of sediment is high. Thus, sediment quality appears to influence the release and availability of nutrients for aquatic food webs. The magnitude of this bottom-up effect depends upon fish presence. Thus, trophic cascades from predator to prey species within food webs influence the effect of sediment on the functioning of freshwater systems. Analyses of potential lipid biomarkers are underway to characterise more precisely these processes.