Analysis of Cougar Lake, Illinois, food chain using stable isotopes of nitrogen and carbon.

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Introduction

The most abundant isotopes of nitrogen and carbon are ^{14}N and ^{12}C, but two other stable isotopes of these elements also exist, ^{15}N and ^{13}C. The abundances of these isotopes in organic matter are low, but measurable. Ratios of ^{13}C and ^{15}N to ^{12}C and ^{14}N are presented as per mil differences from a reference material (δ ‰). Values of $\delta^{13}C$ and $\delta^{15}N$ vary as a result of biological processes.

^{15}N has been used in recent years to reconstruct the food chains of lakes. ^{15}N is favored in amino acid formation. Chemical bonds containing ^{15}N are stable and harder to break allowing it to be conserved in tissue and concentrated up the food chain. Studies have shown that $\delta^{15}N$ concentrates up the food chain at ~3.4‰ at each trophic level (Cabana 2006; Post 2002).

Carbon-saturated photosynthesis discriminates against ^{13}C, but under conditions of carbon limitation this discrimination breaks down and ^{13}C is used by plants. Thus, in shallow water macrophytes where photosynthetic rates are high, one might expect organic matter to have high $\delta^{13}C$ values. Thus, the heavier isotope of carbon, can be used to determine feeding locations of animals within a lake because shallow water plants tend to have higher $\delta^{13}C$ than open water phytoplankton. The organic matter produced by phytoplankton or macrophytes retains its unique source isotopic signature as it moves through the food chain. (France 1995; Vander Zanden 1999).

In 2001, largemouth bass were released in Cougar Lake on the Southern Illinois University Edwardsville campus in an effort to reduce the sunfish population and to establish a bass fishery. By 2004, it was assumed that largemouth bass had become the top level predator (Cronin, unpubl.). By using stable isotope analysis of samples taken from the lake, we were able to reconstruct the food chain and test whether largemouth bass are the top level predators of Cougar Lake. In addition, stable isotopes should indicate the presence of other food webs in the lake.

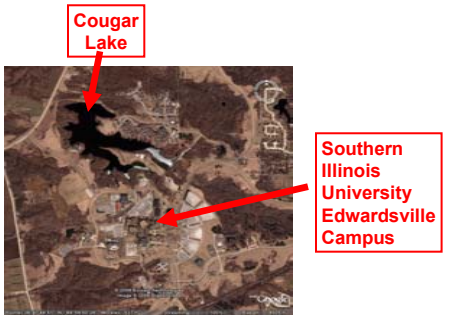

Figure 1: Aerial Photo of Cougar Lake

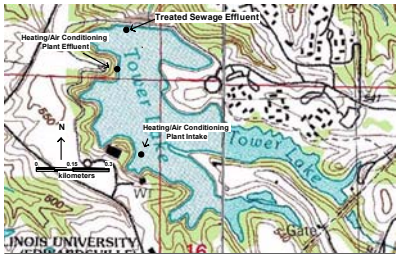

Figure 2: Map of Cougar (Tower) Lake

Cougar Lake

Cougar Lake (previously known as Tower Lake) is an 11m deep, 34 ha. lake located on the Southern Illinois University Edwardsville campus (38°48"N, 90°00"W, Fig 1 & 2). It is highly eutrophic with an anaerobic hypolimnion (>5m depth, Brady and Brugam 2002). The lake receives a tertiary-treated sewage effluent from the University Campus. A recent biotic change has been the stocking of bass in 2001. At about the same time the littoral zone of the lake began to support dense growths of aquatic macrophytes (mostly *Myriophyllum spicatum*).

Results

Plants:

Both phytoplankton and *Myriophyllum* have similar $\delta^{15}N$ values (Fig. 3), but *Myriophyllum* has considerably higher average $\delta^{13}C$ (-16.5±3.6‰ for *Myriophyllum* versus -29.3±3.1‰ for phytoplankton)

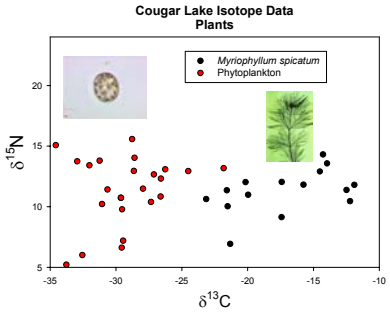

Figure 3: Isotopic composition of Cougar Lake plants

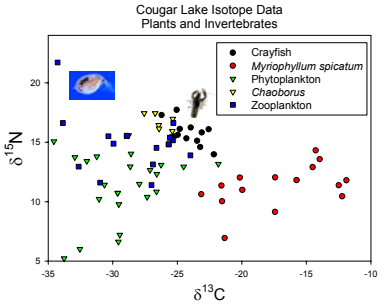

Figure 4: Isotopic composition of Cougar Lake Invertebrates

Zooplankton:

Zooplankton have a slightly higher $\delta^{15}N$ value (+14.8±2.2‰) than phytoplankton (+11.2±2.9‰). The $\delta^{13}C$ values for zooplankton are similar to phytoplankton – not *Myriophyllum* (Fig.4)

Materials and Methods

All samples were collected over 12 months from Feb 2005 to Feb 2006. Fish samples were collected using minnow traps and angling. The fish were euthanized with Tricaine (a fish anesthetic) at a lethal dose. The fish were returned to lab where they were weighed and measured, tissue samples were taken, and gut contents were analyzed. Benthic invertebrates, zooplankton, and phytoplankton samples were collected approximately every two weeks. Benthic invertebrates were collected using an Ekman dredge and sieved *in situ*. Samples were sorted in lab and dried. Phytoplankton were collected by filtering one liter of water through a GF/C glass fiber filter designed to filter cells from water. Zooplankton were collected with a zooplankton net and filtered through a glass fiber filter in lab. All samples were dried for 24-48 hours in a 60°C drying oven. Dried samples were ground using a cryogenic impact grinder. Samples were sent to Cornell Isotope Labs and analyzed for $\delta^{15}N$ and $\delta^{13}C$ using an Isotope Ratio Mass Spectrometer.