Paleolimnological investigations of anthropogenic environmental change in Lake Tanganyika: I. An introduction to the project

Andrew S. Cohen¹, *, Manuel R. Palacios-Fest², James McGill³, Peter W. Swarzenski⁴, Dirk Verschuren⁵, Robert Sinyinza⁶, Tharcisse Songori⁷, Bombi Kakagozo⁸, Mutanga Syampila⁶, Catherine M. O’Reilly⁹ and Simone R. Alin¹, ⁰

¹Department of Geosciences, University of Arizona, Tucson, AZ 85721, USA; ²Terra Nostra, Tucson, AZ 85741, USA; ³P.O. Box 7, Embangweni, Malawi; ⁴US Geological Survey 600, 4th Street South, St. Petersburg, FL 33701, USA; ⁵Research Group Limnology, Department of Biology, Ghent University, Ledeganckstraat 35, Ghent, Belgium; ⁶Department of Fisheries, P.O. Box 55, Mpyungu, Zambia; ⁷Ministry of Geology and Mines, Bujumbura, Burundi; ⁸Centre de Recherche en Hydrobiologie, Uvira, DRC c/o P.O. Box 254, Bujumbura, Burundi; ⁹Department of Biology, Vassar College, Poughkeepsie, NY 12604, USA; ¹⁰School of Oceanography, University of Washington, Seattle, WA 98195, USA; *Author for correspondence (e-mail: acohen@geo.arizona.edu)

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Abstract

We investigated paleolimnological records from a series of river deltas around the northeastern rim of Lake Tanganyika, East Africa (Tanzania and Burundi) in order to understand the history of anthropogenic activity in the lake’s catchment over the last several centuries, and to determine the impact of these activities on the biodiversity of littoral and sublittoral lake communities. Sediment pollution caused by increased rates of soil erosion in deforested watersheds has caused significant changes in aquatic communities along much of the lake’s shoreline. We analyzed the effects of sediment discharge on biodiversity around six deltas or delta complexes on the east coast of Lake Tanganyika: the Lubulungu River delta, Kabesi River delta, Nyasanga/Kahama River deltas, and Mwamgongo River delta in Tanzania; and the Nyamuseni River delta and Karonge/Kirasa River deltas in Burundi. Collectively, these deltas and their associated rivers were chosen to represent a spectrum of drainage-basin sizes and disturbance levels. By comparing deltas that are similar in watershed attributes (other than disturbance levels), our goal was to explore a series of historical “experiments” at the watershed scale, with which we could more clearly evaluate hypotheses of land use or other effects on nearshore ecosystems. Here we discuss these deltas, their geologic and physiographic characteristics, and the field procedures used for coring and sampling the deltas, and various indicators of anthropogenic impact.

Introduction

Understanding the history and timing of disturbances caused by anthropogenic alteration of watersheds is an essential element in lake management. This task is difficult even in small, closely monitored lakes; but in large lakes with poor historical documentation, the task is particularly
daunting. Under these circumstances, a paleolimnological approach may be the only means of reconstructing the cause and effect relations between human activities and lake-ecosystem change.

In this introductory paper and companion papers (McKee et al. 2005; Palacios-Fest et al. 2005a, b; Msaky et al. 2005; O’Reilly et al. 2005; Dettman et al. 2005; Nkotagu 2005; Cohen et al. 2005), we document the first detailed and well-dated records of paleolimnologic change linked to human activity for Lake Tanganyika, the largest of the African rift lakes. Lake Tanganyika houses an extraordinarily rich and complex ecosystem, which may be under threat from a variety of human activities, particularly those related to rapid deforestation in the lake’s surrounding catchment (Coulter 1991; Cohen et al. 1995). Lake Tanganyika supports one of the most species-rich lacustrine biotas on the planet, with over 1500 species of organisms, at least 600 of which are endemic to the lake.

Our principal objective was to determine the timing and magnitude of changes in impacted watersheds and probable linkages between these changes and ecosystem changes in the lake. Paleolimnology provides a powerful approach for investigating ecosystem dynamics and anthropogenic impacts at Lake Tanganyika and its catchment, where only limited historical data are available to assess the timing of human impacts to lake watersheds and their relations to ecological changes in the lake. Most ecological investigations of sedimentation impacts on the lake to date have been of short duration and of limited regional scope. This impedes our ability to draw conclusions about the probable causes of observed differences in ecosystems between regions of the lake that are highly disturbed by human activities today, vs. those showing lesser or no signs of watershed disturbance, since chronologies linking the putative causes and effects cannot be obtained from modern data alone.

To conduct this research we identified, mapped, and cored a series of representative river deltas around the northeastern and east-central margins of the lake, a region that includes both some of the most highly impacted watersheds surrounding Lake Tanganyika, and some areas that have experienced very limited human impacts over the past few hundred years. Using \(^{210}\text{Pb}\) and \(^{14}\text{C}\) dating techniques (McKee et al. 2005), we determined changes in sediment accumulation rates, as well as changes in sedimentological (Palacios-Fest et al. 2005a), palynological (Msaky et al. 2005), lacustrine paleoecological (ostracodes, mollusks, fish sponges) (Palacios-Fest et al. 2005b), and geochemical archives (O’Reilly et al. 2005; Dettman et al. 2005) in the study areas over the last several hundred years. We further assessed the ecological impact of excess sedimentation on the benthic environment of Lake Tanganyika by comparing the species diversity and distribution of chironomid larvae (non-biting midges) adjacent to pristine and disturbed tributary drainages (Eggermont and Verschuren 2003a). In this particular study, spatial patterns in the modern fauna were surveyed using recently buried chironomid remains (Eggermont and Verschuren 2003b and c) rather than live larvae, to avoid the logistic difficulties associated with live monitoring of aquatic invertebrate populations in large lakes and more easily obtain the sample sizes needed for robust statistical analysis. Recently deposited death assemblages reflect the general distribution of suitable habitat, rather than local microhabitat conditions at (a statistically small number of) sampling sites (Frey 1988). They thus permit investigation of the ecological impacts of excess sedimentation at the appropriate spatial scale, and in a study design that controls for influences of natural habitat diversity and gradients on the distribution of benthic biota. All studies were conducted as a subcomponent of the Special Study on Sedimentation of the Lake Tanganyika Biodiversity Project, a Global Environmental Facility (UNDP-GEF) program (www.ltbp.org) designed to develop conservation and resource management strategies for Lake Tanganyika and its watersheds, in cooperation with the NSF-GEF funded Nyanza Project research training program on tropical lakes.

**Purpose and general approach of the study**

The main purpose of this study was to identify the timing and magnitude of ecological and environmental changes along the eastern shore of Lake Tanganyika over the last several hundred years. The conceptual approach we have taken is to compare the historical records of offshore delta environments adjacent to watersheds representing a spectrum of modern disturbance levels, from