Report as of FY2006 for 2006ND124B: "Classification of Macroinvertebrate Communities across Red River Drainage Basin"

Publications

- Conference Proceedings:
  - Zheng, W. and M. G. Butler,2007, "Composition and Seasonal Pattern of Invertebrate Drift in the Red River of the North near Fargo, ND", Third International Water Conference, International Water Institute, Grand Forks, March 13-15.
  - Anderson, Ara and M. G. Butler,2006, "The life history of Hexagenia limbata (Serville) (Ephemeroptera:Ephemeridae) in two Minnesota streams,North American Benthological Society (NABS) annual meeting. Anchorage, AK, June 6.

Report Follows

CLASSIFICATION OF MACROINVERTEBRATE COMMUNITIES ACROSS RED RIVER DRAINAGE BASIN

REGIONAL WATER PROBLEM

Changes in environmental conditions in running waters lead to changes in benthic macroinvertebrate communities. Therefore, many indicators of stream or river pollution focus on macroinvertebrates. Species richness, evenness, and abundance tend to exhibit great correlation with in-stream habitat conditions. If relationships between benthic invertebrates and their habitats are deterministic, it should be possible to predict macroinvertebrate distribution. The distribution of invertebrates in any river is likely to depend on multiple habitat features. Multivariate relationships between invertebrates and habitats are associative and do not indicate causes and effects, so these relationships should be tested with specific field experiments. Also, variables found to be important descriptors of invertebrate composition may be location specific. A more complete understanding of relationships between habitat structure and community variables is needed to identify ecological patterns, and to devise improved strategies for maximizing diversity, abundance and production of commercially and ecologically important species. Appropriate spatial and temporal scales of measurements are equally required for determining cause-and-effect relationships between habitat structure and community variables.

There is increasing recognition of the need for biological information on the Red River of the North. Recently (Nov. 2-3, 2005) the International Water Institute (IWI), in collaboration with the International Red River Board (IRRB), and the International Joint Commission (IJC), sponsored a workshop to develop approaches for assessing and monitoring the health of this important aquatic ecosystem. Following two days of discussion, there was consensus that too little biological information currently exists for certain goals of the workshop to be met. Specifically, hopes of identifying targeted biological communities for monitoring, and of establishing common sampling methods, were premature, as so little biological research has been conducted on the main stem and the lower tributaries of the Red River. A recent report (Laidlaw 2004) by the Energy & Environmental Research Center (EERC) at UND serves as a starting point for development of appriopriate biological monitoring tools for the Red River Basin. I propose research to help fill this information need, by inventorying macroinvertebrate communities in major habitats of the main-stem Red River, and assessing suitable sampling techniques for monitoring these communities. Such information will make a valuable contribution toward the development of a comprehensive research proposal for the Red River main stem that is the IJC's charge to the Aquatic Ecosystem Committee of the IRRB (Fritz 2005).

LITERATURE REVIEW

The structure and composition of benthic macroinvertebrate communities in freshwater ecosystems are very often used for the biological assessment of water quality and to evaluate the impact of chemical and other pollutants (Wiens & Rosenberg, 1984; Hellawell, 1986; Mance, 1987; Rosenberg & Resh, 1993).

Stream community structure changes with variation of in-stream habitat (Gorman & Karr, 1978; Huryn & Wallace, 1987). Macroinvertebrate abundance and taxonomic richness are generally highest in stream environments where stones, woody debris, plants and other forms of habitat structure are abundant (Downes et al, 2000; Matthaei et al, 2000; Voelz & McArthur, 2000). Species richness, evenness, and abundance tend to exhibit great correlations with instream habitat (Simley et al, 2005).

Habitat structure is defined as physical objects in an environment that provide habitat (e.g., rocks, trees, shells of sessile animals). Habitat structure promotes greater biomass, abundance and diversity of organisms by enhancing the abundance and variety of resources and creating multiple substratum types and variable hydrodynamic regimes (Bertness & Leonard, 1997; Lenihan, 1999; Downes et al, 2000; Syms & Jones, 2000). For example, increased colonizable surface area and microhabitat diversity created by habitat structure reduces the intensity of competition for living space (Downes et al, 2000; Ellner et al, 2001). Habitat structure also reduces the frequency of localized species extinctions due to chance by providing refuges from predation and physical disturbance, like wave force and strong currents (Bertuness & Leonard, 1997; Lipcius et al, 1998). Additionally, habitat structure indirectly benefits organisms by increasing the abundance and diversity of food resources by increasing particulate matter abundance (Fournier & Loreau, 1999; Siler et al, 2001).

That habitat structure generally has positive effects on biological communities is well established, but a more complete understanding of relationships between habitat structure and community variables is needed to identify ecological patterns and devise improved strategies for predicting macroinvertebrate distribution, maximizing diversity, abundance and production of commercially and ecologically important species (Lipcius et al,1998; Lenihan, 1999). Identification and consistent use of biologically meaningful measures of habitat structure are considered critical in attaining these goals (Commito & Rusignuolo, 2000; Downes et al, 2000). Appropriate spatial and temporal scales of measurements are also required for elucidating cause-and-effect relationships between habitat structure and community variables (Downes et al, 1998; Attrill et al, 2000).

However, sometimes large spatial and temporal variations in community structure are observed in both impaired and unimpaired sites. Variation in distribution and abundance of benthic organisms may be caused by differences among sites in flow-rate (Newbury, 1984), stream size and distance to the source (Minshall, Petersen & Nimz, 1985), substrate (Minshall & Minshall, 1977), vegetation (Vincent, 1983), and temperature and stream discharge (Bournard et al, 1987; Boulton & Lake, 1992). Seasonal variability of such factors at a site (e.g. Wade et al, 1989) is one of the prominent causes of temporal variation in the community. The phenology of species within a community will also alter the observed composition of the community throughout the year. The degree to which phenology affects the observed taxonomic richness, diversity or calculated biotic indices of a community depends on the species involved (Rosillon, 1987). In the context of bioassessment and monitoring, temporal variation may influence judgement as to whether or not a site is degraded (Linke et al, 1999). It is clear that the time scale of sampling, particularly when it is carried out over more than one season, can significantly affect results of a bioassessment. A predictive model incorporating time would have higher predictive power and result in a more sensitive bioassessment. A closer look at the nature of structural changes within the community between the seasons might give evidence of whether or not human impact caused the site to fail.

The distributions of many macroinvertebrates vary both spatially and temporally, such that collecting representative samples that are representative of the natural community structure is extremely difficult or impossible (Resh & Jackson, 1993; Merritt et al, 1996). The method chosen should collect representative and relatively comprehensive samples of the benthic community (Resh, 1995). The data used for biological assessment should be acquired by a variety of sampling techniques, which have been developed and modified over time (Flannagan & Rosenberg, 1982; Mackay et al, 1984; Rosenberg & Resh, 1993; Merritt et al, 1996).

SCOPE AND OBJECTIVES

The objectives of this research are to 1). Inventory the macroinvertebrate communities of different habitat conditions in the main stem Red River 2). Explore the temporal changes of these benthic communities through the open water season and 3). Compare the results of outcomes provided by different sampling techniques. These objectives will allow me to evaluate potential relations between aquatic invertebrate communities and environmental conditions.

METHODS

Sites will be randomly selected in three reaches of the main stem Red River: above Fargo (Oxbow), within Fargo (Oak Grove), and below Fargo (Harwood). Sampling periods will be chosen from May to September, during which different sampling techniques will be applied to each site according to habitat: main-channel using a Ponar sampler, channel slopes using a core sampler, and sweep net to collect from snags. If possible, drift nets will be deployed during the night time, and retrieved them the next day. Site variables will be measured on each sampling occasion using meters, water samplers, direct observations or visual estimations. Water quality samples will be taken back and analyzed by chemistry laboratory. Macrobenthic invertebrate samples will be preserved in 70% ethanol and separated from river sediments using a surcrose-floatation procedure (Anderson 1959). Organisms will be identified to the lowest practicable level by a stereoscope and with appropriate taxonomic keys. The identification results will be compared and complied with published and known records.

My advisor, Dr Malcolm.Butler will provide field facilities for all field data collection (i.e., equipment storage, sampling process). Lab analysis of samples will be conducted at NDSU.

DELIVERABLES

The macroinvertebrate faunas of large, rivers throughout the world have been poorly studied by comparison to the vast literature on smaller, upland streams. There has been a handful of studies on large rivers around the world, including rivers in Australia (Schulze & Walker, 1997; Sheldon & Walker, 1997, 1998), Austria (Humpesch & Elliott, 1990), France (Cogerino et al., 1995; Bournaud et al., 1996, 1998), North America (Wells & Denmas, 1979), Spain (Muñoz & Prat, 1994), and Russia (Zhadin & Gerd, 1970; Mordukai-Boltovskoi, 1979). Very little research has been done to benthic marcroinvetebrates in the Red River. The anticipated results of this study will comprise my Ph.D. dissertation, and will be presented at conferences, and submitted for publication to peer-reviewed journals. Ultimately, this work will be available for use in developing large scale international monitoring assessment of Red River, and advance our understanding of aquatic ecology to the benefit of biomonitoring and water resources in North Dakota and Minnesota.

PROGRESS TO DATE

Literature reviewing has been partly finished. Solicitations have been made to the North Dakota Department of Health (NDDH). A list of macroinvertebrates taxa collected from the Red River in a recent study is available from the Energy & Environmental Research Center (EERC). We have inquired and confirmed the ability of the North Dakota State University (NDSU) Chemistry Department to aid in analysis of water parameters. We have taken a preliminary survey on the Red River in September 2005. We have attended the International Water Institute (IWI) Red River of the North Assessment Workshop on November 2~3, 2005.

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