Report as of FY2008 for 2007ME152B: "Response of a linked lake-stream system to dam removal and restoration of migratory fish."

Publications

Project 2007ME152B has resulted in no reported publications as of FY2008.

Report Follows

Progress Report

Project Title: Response of a linked lake-stream system to dam removal and restoration of migratory fish.

Current Status: A no-cost extension was used on this project for 2008 to take advantage of external funding for a graduate student in that year. A complete season of data collection was conducted in 2008 and will continue in 2009.

1. Problem and Research Objectives:

Maine represents the last stronghold of federally endangered Atlantic salmon in the United States and is home to a variety of other migratory fish including alewives, blueback herring, American shad, rainbow smelt, and sea lamprey. However, these fish and the stream communities they interact with have been altered by habitat fragmentation through the construction of dams and other barriers that block the access by migratory fish, especially those other than salmon, to inland waters. The ecological consequences of the loss of these fish are not well known, but may be important considering the strong effects of migratory fish loss, particularly Pacific salmon, in western North America. For example, failure to successfully recover Atlantic salmon may, in part, lie in the loss of migratory fish that were historically abundant, but are now absent in many watersheds because of the barriers to their migration. When inland access is available, migratory fish are likely to interact directly in food webs with stream organisms and may serve as vectors of marine-derived nutrients, yet little is known about the historical or current role of migratory fish in Maine's rivers.

Nationwide, barriers to migratory fish passage are being removed in effort to restore freshwater-marine connectivity. For example, the Community-Based Restoration Program of the National Oceanic and Atmospheric Administration helped facilitate 53 restoration projects targeted to restore migratory fish access to rivers between 1996 and 2002 alone. While there is good reason to believe such efforts will improve river health, there are few data about the outcome of such activities. Indeed, few river restoration projects in general are monitored for success. Our proposed research is targeted to address two basic questions that are critical for guiding the successful restoration of inland waters in Maine that have become disconnected from marine systems: 1) what role do migratory fish play in lake and stream communities, and 2) what are the outcomes of river restoration efforts targeted towards the reestablishment of marine-freshwater connectivity?

This project is centered around an ongoing dam removal on a relatively small lake-stream system (Sedgeunkedunk Stream) that feeds the Penobscot River, Maine. The replacement of one dam with a rock ramp and planned removal of a second dam on this stream in 2009 provides an opportunity to collect pre- and post-removal data in a tractable system prior to much larger, complicated dam removals in the Penobscot River. We have collected on year of pre-dam removal data in this system. We complement the pre-post monitoring on the Sedgeunkedunk system with a comparative study of other systems with and without current barriers to migratory fish.

Objectives:
Our primary objective is to evaluate the response of stream and lake communities to dam removal and the subsequent restoration of migratory fish. In particular we are:

- measuring key biological (phytoplankton, zooplankton) and physical (water chemistry and habitat structure) indicators of ecosystem health before and after dam removal and in a comparative study of systems with and without migratory fish
- testing for evidence of delivery of marine-derived nutrients by migratory fish to a restored watershed and in a series of systems with and without migratory fish access

This project is designed to provide a set of pilot data about stream and lake response to restoration efforts and the utility of stable isotope methods for detecting the delivery of MDN by migratory fish to inland waters in Maine. We expect this information to be useful for more comprehensive evaluations of river restoration efforts in Maine and other east coast rivers.

2. Methodology:

Study Sites

A total of five lakes were selected for biweekly sampling from May to October of 2008. Table 1 provides a summary of some important physical and chemical characteristics of each lake. These lakes were selected based on differences in migratory fish access. Brewer Lake and Fields Pond are part of a lake-stream system that is drained by Sedgeunkedunk Stream. Sedgeunkedunk is a 3rd order stream that drains into the Penobscot River at Brewer, Maine. A small scale dam removal project on Sedgeunkedunk Stream has been initiated with hopes of restoring migratory fish access to Fields Pond. The first phase of this restoration project was completed during the summer of 2008, when a dam at the outlet of Fields Pond was bypassed to allow migratory fish passage. An additional dam ~1km from the confluence of Sedgeunkedunk Stream with the Penobscot River currently blocks access of migratory fish into the catchment and is scheduled for removal in late summer 2009. The removal of this dam coupled with the dam bypass at the outlet of Fields Pond will restore access by migratory fish, primarily alewives but also Atlantic salmon and other fish, to Fields Pond and the lower portion of Sedgeunkedunk stream, although the fish aren't expected to return until 2010. Migratory fish will not be able to access Brewer Lake and upstream segments of Sedgeunkedunk stream because of a dam below Brewer Lake that will remain intact. Swetts Pond, located near Orrington, Maine, is inaccessible to migratory fish and is expected to remain that way. Alamoosook Lake and Toddy Pond are located near the town of Orland, Maine and are part of a linked lake-stream system, where they are the two most downstream lakes in the chain respectively. Outlets at both lakes are fitted with fish ladders to allow migratory fish passage, and both receive sizable alewife runs each spring.

Sampling was conducted on a biweekly basis for each lake from May to October in 2008 to assess temporal changes in several key physical, chemical, and biological parameters. In each lake we quantified zooplankton community structure (species composition and size distribution), phytoplankton biomass (chlorophyll *a*), and nutrient concentrations (total and dissolved fractions of N and P) from samples taken at two

replicate stations. Additionaly, secchi disk transparency and depth profiles of dissolved oxygen and temperature were recorded at each lake. Biweekly lake sampling will continue in 2009 following the same procedures used during 2008, providing us with two years of pre-restoration data for the Fields Pond/Sedgunkedunk Stream system.

Stream sampling and stable isotope analysis are planned for the 2009 field season in addition to a continuation of the lake sampling implemented in 2008. Seston quantity, quality (N and P concentrations), and composition (particle size distribution), as well algal biomass (chlorophyll *a*) will be measured at outlet streams of each lake to assess seasonal variation in export patterns and possible migratory fish influence. Invertebrate community composition (species composition, density, and biomass) will also be assessed in each outlet stream in order to determine the extent to which seston export and marine nutrient delivery influences invertebrate assemblages in lake outlet streams. Samples of seston, algae, zooplankton, invertebrates, alewives, and other predatory fish will be collected from each lake and outlet stream and analyzed for stable isotopes (^{15}N, ^{13}C, and ^{35}S). Sampling will provide insight into the influence of migratory fish on linked lake-stream systems by providing data prior to inland migration by key anadromous fish species, and after the establishment of young of the year migratory fish populations in receiving lakes.

3. Principal Findings

Biweekly lake sampling conducted during 2008 revealed several interesting patterns. Mean zooplankton body length decreased dramatically over the course of the summer in both alewife lakes while it remained relatively stable in the three non alewife lakes (Figure 1). These results are consistent with size-selective predation by alewives. Seasonal chlorophyll *a* patterns from Toddy Pond and Alamoosook Lake are indistinguishable from those at the three non alewife lakes (Figure 2), suggesting that zooplankton suppression by alewives is not a significant influence on phytoplankton dynamics in the study lakes. The extent to which migratory fish act as vectors of MDN in these systems remains unclear. There are no obvious increases in total N or P in the alwive lakes during spring when the fish arrive to the lakes (Figure 2). Any early season pulses of nutrients resulting from inland fish migration might be obscured by spring mixing and P re-suspension, which strengthens the need for more detailed stable isotope analysis to separate these potential processes.

4. Student support: One graduate student was supported on a combination of research and teaching assistantships through the Maine Agricultural and Forestry Experiment Station and the School of Biology and Ecology at the University of Maine. The graduate student will be funded in 2009-10 by WRRI funds.

Table 1. Summary of several important physical and chemical characteristics of the five study lakes.

Lake	Area (ha)	Perimeter (m)	Max. Depth (m)	Mean Depth (m)	Volume (m^3)	Secchi Depth (m)	pH	Alkalinity (mg/L)	Conductivity (uS/cm)	Chl *a* (ppb)	TP (ppb)	TSI
Alewife												
Alamoosook Lake	403	14820	8.5	4.9	$2.0x10^7$	4.7	9.7	42	7	3.5	9	53
Toddy Pond	975	50344	37.2	8.2	$6.2x10^6$	6.1	4.4	30	6.52	3.4	5	41
Non-alewife												
Brewer Lake	388	14521	14.6	7.9	$2.8x10^7$	5.3	6.6	32	6.74	4	9	52
Swetts Pond	50	4260	7.3	3.4	$1.1x10^6$	4.6	7.3	40	6.84	4.3	15	16
Restoration												
Fields Pond	210	16178	9.4	4.0	$2.4x10^6$	4.5	4.8	32	6.89		17	50

Data from Pearl environmental database; http://pearl.maine.edu

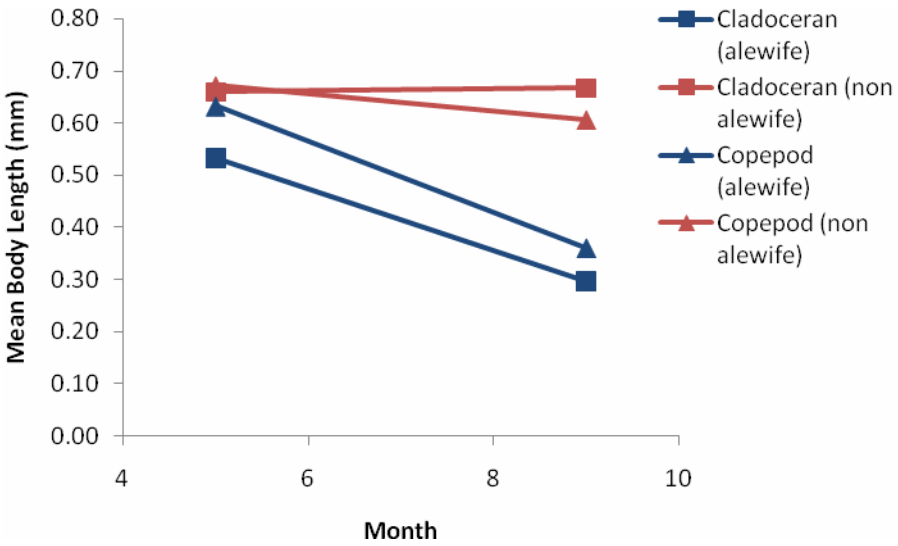

Figure 1. Mean cladoceran and copepod body lengths in lakes with and without alewives in spring and late summer. Values are means across ponds (alewife *n*=2, non-alewive *n*=3).

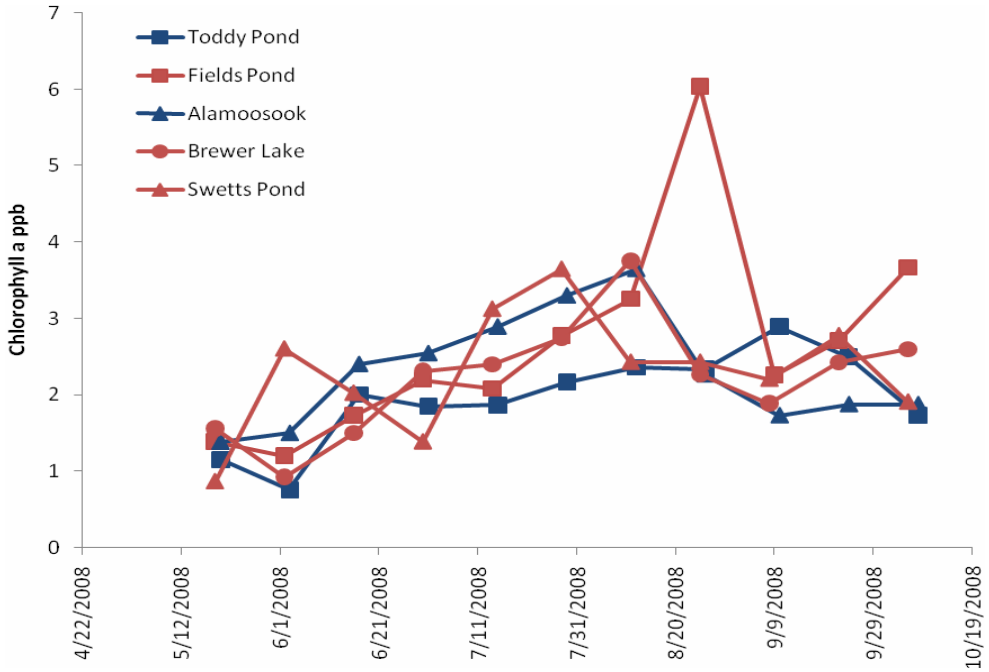

Figure 2. Chlorophyll a concentration in lakes with (blue, Toddy/Alamoosook) and without (red, Fields/Brewer/Swetts) alewives.

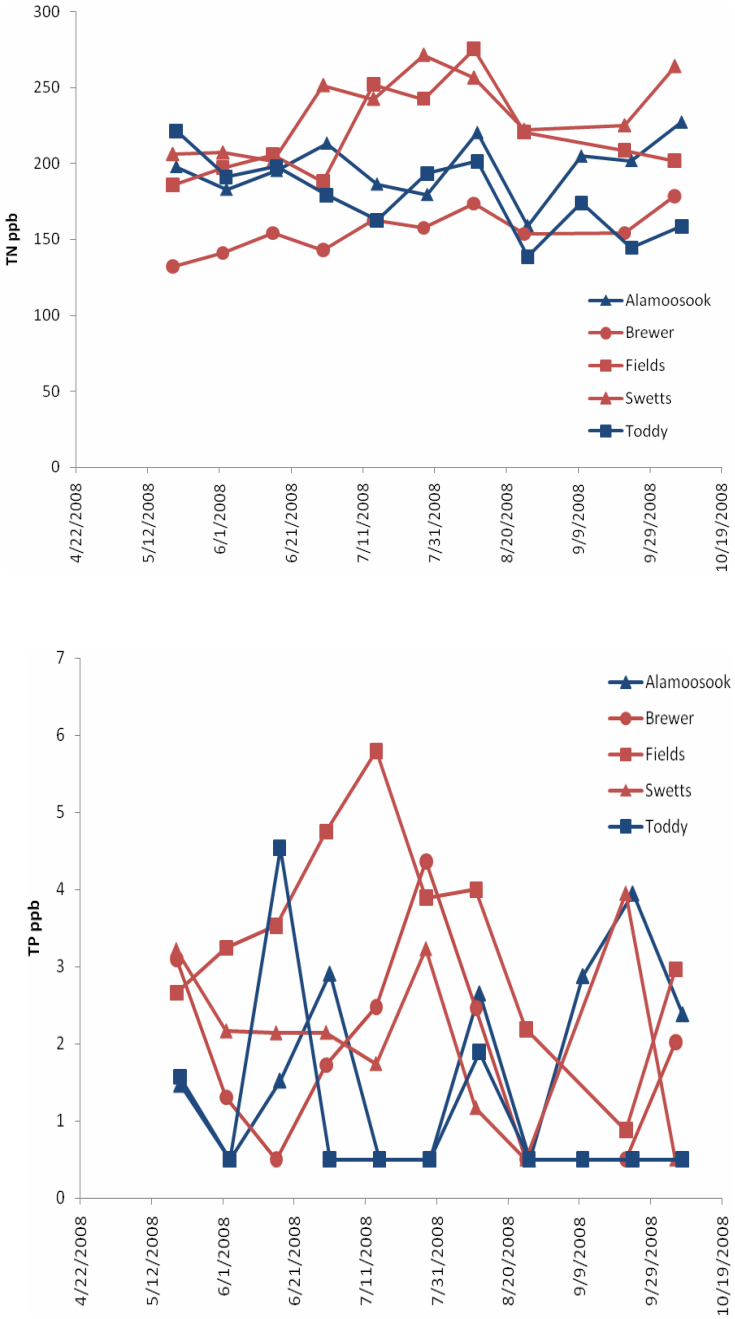

Figure 3. Seasonal patterns in total nitrogen (TN) and total phosphorus (TP) concentrations in lakes with (Alamoosook, Toddy) and without (Fields, Brewer, Swetts) alewives.