Reaching into the Past for Future Resilience:

Recovery Efforts in Maine Rivers and Coastal Waters

by John Lichter

Ted Ames

John Lichter and Ted Ames discuss how analysis of environmental histories of human activities affecting Maine's estuary, river, and coastal marine ecosystems can shed light on the role key fish species may play. Through Maine's Sustainability Solutions Initiative, a group of researchers from Bowdoin, Bates, University of Southern Maine, and Penobscot East Resource Center have teamed up to examine ecological recovery in the state's waterways and coastal fisheries. Several river restoration efforts were already underway, and others are being planned as a direct result of this interdisciplinary project.

Many degraded ecosystems fail to recover populations of key biological species and functionality, or only move slowly toward recovery, despite the discontinuance of anthropogenic disturbance. The reasons are twofold: First, chronic disturbance can push ecosystems into alternative regimes in which recovery is opposed by natural resilience that develops within the altered ecosystem (Scheffer et al. 2001). Second, even where a regime shift has not occurred, ecosystem recovery may be slow because ecological processes operate on multiple time scales, some of which involve changes occurring so slowly that they are ponderous relative to the time scale of human activities and needs. Thus, in the first case, recovery may truly be stalled, and in the second, it may only seem to be stalled. That said, restoration efforts have accelerated ecosystem recovery when information about the key species and processes necessary for healthy functioning of a particular ecosystem is known. Reconstructing ecological history can provide such vital information and help managers develop reasonable goals for restoration. Over the last few decades, restoration ecology has developed as a scientific discipline seeking to renew degraded ecosystems by stimulating the natural processes that would eventually bring an ecosystem back to functionality. That is not to suggest that the original or pristine ecosystem state can be reestablished, but rather that a better understanding of the original ecosystem and the changes that occurred during the period of human disturbance can provide information about the key species and ecological processes that produced the original abundance and functionality of the ecosystem, with the goal of recovering what is recoverable.

Historical reconstructions of ecological systems have relied on documentary records, archeological studies, sedimentary records, and radiometric dating. Biological and chemical analysis of sediments from lakes, rivers, and nearshore marine environments can provide quantitative evidence of environmental change over thousands of years. For example, Köster and colleagues (2007) examined species of algae called diatoms that are preserved in the intertidal sediments of Merrymeeting Bay to reconstruct an 1,800-year record of natural variability and human-induced changes on the Kennebec and Androscoggin rivers. Radiometric methods including carbon-14 and lead-210 were used to provide approximate estimates of sediment age. Another study by Lotzi and Milewski (2004) examined archeological and historical evidence spanning two centuries of human impacts in the Quoddy region of coastal Maine and New Brunswick. This study documented overhunting of marine mammals and birds, overfishing of groundfish, and the damming of rivers and polluting of waterways that resulted in the collapse of diadromous fish species. However, it also documented the partial recovery of some species and improved water quality to reveal successful conservation and restoration efforts.

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Environmental histories of human activities affecting river, estuary, and coastal marine ecosystems can provide insights into the role key species may play and the ecological processes needed for restoring ecosystem functionality. Stocks of groundfish such as Atlantic cod, haddock, and pollock were harvested sustainably in coastal waters for centuries by Maine fishermen until industrialization and improvements in fishing technology enhanced harvest rates beyond sustainable levels (Baird 1874; Bolster 2008; Meyers, Hutchings and Barrowman 1996; Rosenberg et al. 2009). Altough overfishing is the conventional explanation for the decline of coastal fisheries, historical accounts by fisheries scientists in the late 19th century suggest a more complicated story of fisheries depletion. As U.S. Commissioner of Fisheries Spencer F. Baird (1874: xii) wrote:

> The general conclusions which have been reached as a result of repeated conversations with Captain Treat and other fishermen on the coast incline me to believe that the reduction in the cod and other fisheries, so as to become practically a failure, is due to the decrease off our

> coast of the quantity, primarily, of alewives; and, secondarily, of shad and salmon, more than to any other cause.

In other words, Baird was certain that coastal cod populations were disappearing because their forage base had been decimated by events occurring on land and on the major rivers, that is, dam building and overfishing of forage species. Baird identified a potentially pivotal ecological linkage between coastal groundfish and anadromous fish species that may have generally been known by fishermen at the time, but has since been underappreciated by scientists and managers. Other fisheries experts following Baird corroborated a connection between groundfish and anadromous fish runs (Atkins 1887; Belding 1921; Fields 1914). Baird's conclusion that inshore groundfish populations depended on river herring (i.e., alewife and blueback herring) returning to their natal rivers to spawn along with their young-of-year emigrating from the rivers to coastal waters might prove to be a vital piece of information to stimulate the ecological recovery of nearshore fisheries. Further examination of the link between freshwater and marine ecosystems can be achieved today by examining historical patterns of fishing activity and the seasonal movements of groundfish in relation to extant populations of river herring along the coast of Maine.

Historical information suggests that river herring populations were a vital resource for nearshore cod populations and without a substantial recovery of river herring, coastal fisheries will remain depleted.

Fisheries scientists have long relied on the empirical knowledge of fishermen to understand the spatial patterns of groundfish habitat and movement patterns. In the late 19th century, George Brown Goode (1887) interviewed fishermen to map fishing grounds in the Gulf of Maine. Following Goode, Walter H. Rich (1929) added the accounts of many fishermen active in the early 20th century to produce a more complete picture of fishing grounds from Cape Cod to the Bay of Fundy. Trying to understand why fish disappeared from the once bountiful grounds along Maine's coast, fisherman and fisheries scientist Ted Ames has continued the tradition of Goode and Rich by interviewing retired fishermen who were active in the era before the rapid introduction of new technologies to New England fishing fleets placed severe pressure on coastal fish stocks. Ames's objective was to understand the ecology of groundfish populations when they were still relatively abundant with the hope of discovering fundamental ecological processes that might aid restoration efforts (Ames 1997, 2004, 2010, 2012). To this end, he interviewed fishermen who were active prior to 1950 to supplement the historical database of Goode and Rich.

The resulting spatial database provides a unique opportunity to piece together vital information about groundfish ecology in the Gulf of Maine. But because fish stocks are so depleted today, modern field studies may not be useful for detecting or evaluating many important ecological connections needed for successful restoration. To date, Ames's work has supported the conclusion of Baird and his contemporaries about the importance of river herring to coastal groundfish populations. For example, the spatial array of former fishing grounds and seasonal movement patterns in the 1920s and 1930s indicate that cod moved inshore during the spring and fall in mid-coast Maine, where substantial alewife runs still occurred in the Damariscotta, Medomak, and St. George rivers. Presumably, cod preyed on the adult alewives returning to their natal river in the spring and on juvenile alewives emigrating from the rivers in the fall. The seasonal movement patterns observed in the Damariscotta region contrast sharply with most other rivers along the Maine coast where alewife runs had collapsed and coastal cod had moved further offshore (Ames and Lichter in review). Historical studies of the Inner Kettle Bottom and Outer Kettle Bottom fishing grounds near the mouth of the Kennebec River may provide additional ecological insights. With more than 400 known fishing grounds described in the Goode-Rich-Ames database, these two fishing grounds were reported to be among the best for year-round cod fishing throughout the study period. Although the Kennebec and Androscoggin rivers had been dammed much earlier (i.e., 1837 and 1815, respectively), the tidal waters of Merrymeeting Bay and its small tributaries may have afforded sufficient spawning and nursery habitat to maintain river herring populations before the raw industrial and municipal wastes of the mid-20th century caused the complete collapse of anadromous fish stocks (Köster et al. 2007; Lichter et al. 2006; Taylor 1951).

Historical information suggests that river herring populations were a vital resource for nearshore cod populations and without a substantial recovery of river herring, coastal fisheries will remain depleted. This insight is profound, because in addition to overfishing groundfish populations in the Gulf of Maine, human activities have undermined the marine food web to the extent that once bountiful coastal fishing grounds no longer produce any fish. Recognizing this historical connection, Ted Ames has taken the next logical step by linking historical coastal spawning areas of groundfish that were near rivers to the availability of juvenile river herring as forage for both young and adult groundfish. Young river herring do not join migrating schools of adult fish, but remain in coastal waters until their second year (Collette and Klein-MacPhee 2002). Ames's hypothesis suggests that recovery of coastal cod populations, along with other groundfish species, may depend as much on river restoration as on implementing fishing regulations to maintain sustainable harvests.

River restoration efforts are underway in the Kennebec and Penobscot watersheds. Dam removal and improvements in fish passage are being implemented at some locations, while other restoration projects are in the planning stages. In 2011, approximately three million alewives and blueback herring returned to the Kennebec during their spring spawning migration, thanks to the efforts of the Maine Department of Marine Resources (MDMR) and dam owners. The resulting number of juvenile fish leaving the Kennebec should exceed the adult abundance by many multitudes. This is a terrific start, but historically tens of millions of river herring returned to Maine rivers and lakes each year to spawn (Hall, Jordaan and Frisk 2011). Their young-of-year may have numbered in the tens of billions. This huge influx of fish into coastal waters each year was likely the reason the Gulf of Maine was once so bountiful with cod and other predatory fish species (Baird 1874).

History can tell us what was lost over the centuries, but perhaps more importantly, it can also help us

STUDENT SPOTLIGHT

Miguel Barajas

SSI Undergraduate Researcher
Environmental Science major, University of Southern Maine

When Miguel Barajas began interning with USM's Aquatic Systems Group last summer, he never imagined he'd be rising before dawn to hop aboard fishing boats, where his task was to figure out what cod had eaten for breakfast. When fish were captured, he flushed out their stomachs, collected the contents, weighed and measured the cod, and released them back to the sea. "Making fish throw up is definitely an experience this research is giving me that I wouldn't otherwise have had," he wryly observes.

Barajas is part of a team studying the role of river herring, or alewives, in the cod's diet. An important food source for cod and many other species, alewives have been on the decline over the past century due largely to human activity on rivers, including dams and pollution from factories.

It's not clear what happens to groundfish such as cod when alewife populations decline. To help solve one piece of the puzzle, Barajas is using computer modeling to simulate how consuming fewer alewives affects their growth. His findings could yield clues to help revive Maine's decimated groundfisheries.

"If the computer models suggest that reductions in river herring negatively affect groundfish growth, it may be possible that future efforts to restore river herring could positively affect groundfish growth," Barajas says. "This would have many economic implications for the Gulf of Maine groundfish industry as well as the surrounding coastal communities."

Barajas is working with Karen Wilson, assistant research professor, and Theo Willis, adjunct assistant professor, both of USM's Department of Environmental Science. They are members of an SSI research team at Bowdoin, Bates, and USM studying alewife restoration in the Kennebec and Androscoggin rivers, and the ecological and economic impacts of these efforts on fisheries and economies from the headwaters to the coast.

Led by John Lichter, Samuel S. Butcher Associate Professor in the Natural Sciences at Bowdoin, the project will help communities and groups make more informed decisions about the costs and benefits of river restoration efforts. It also will contribute to a better understanding of the effects of river restoration on fisheries and economies at the basin and town scales.

Now a junior at USM, Barajas is already hooked on doing research that helps solve sustainability challenges. "Through my experiences working on the SSI research, I have come to the realization that I want to continue studying marine and freshwater systems," Barajas says. "I want to focus on the management of these resources for future generations in Maine."

—Kim Ridley

Eileen Johnson

STUDENT SPOTLIGHT

Graduate Research Assistant, Sustainability Solutions Initiative; Ph.D. Student, Ecology and Environmental Sciences; Program Manager/GIS Analyst and Adjunct Lecturer in Environmental Studies, Bowdoin College

Eileen Johnson has a unique perspective on SSI: she is a Ph.D. student at the University of Maine and a staff person and lecturer at Bowdoin College, where she facilitates community-based research projects in the Environmental Studies Program. She brings this experience to SSI, which she chose for her doctoral work because of its focus on connecting knowledge with action and its emphasis on developing effective strategies for engaging stakeholders.

What problem are you working to solve?

I am currently a member of an SSI team comprised of researchers from Bates, Bowdoinm and the University of Southern Maine. Our research focuses on river systems and seeks to understand barriers to restoration.

What progress are you making toward solutions?

My research focuses on the role of institutions and the incorporation of stakeholders in the research process. Through my research, I have come to have a fuller understanding of how stakeholders characterize "restoration," what questions and concerns they have about the two river systems in our study, along with understanding opportunities for engaging stakeholders throughout the research process, including effective ways of sharing our results.

How could your findings contribute to a more sustainable future in Maine and beyond?

Our research will help communities to better understand the value of restored river systems and help us to understand how we can collaborate more effectively with stakeholders. I hope that our work will help to forge collaborations among all of the different individuals and groups currently connected with our two rivers of study, the Androscoggin and Kennebec.

—Kim Ridley

understand how to recover what is recoverable of our once bountiful natural resources. To this end, researchers at Bowdoin and Bates colleges and the University of Southern Maine have teamed up with Ted Ames of the Penobscot East Resource Center to examine ecological recovery in Maine's waterways and coastal fisheries. Through Maine's Sustainability Solutions Initiative (SSI), they are investigating the ecological and social influences on further ecological recovery of our rivers, estuaries, and nearshore marine habitats and are estimating the potential economic benefit that further ecological recovery would bring neighboring communities. Working with individual stakeholders and stakeholder organizations, they seek to understand the best steps that can be taken to stimulate recovery and to develop a vision of functioning, rich coastal ecosystems that benefit people as well as wild populations. (See sidebars for student spotlights related to this project.)

To date, the Bowdoin-Bates-USM collaboration has presented several public lectures and has partnered with the Kennebec Estuary Land Trust (KELT) and the Merrymeeting Bay Trust to organize a stakeholder symposium titled, *Many Rivers, One Estuary*. These events brought together hundreds of interested people from a variety of organizations to discuss ecological recovery in the Kennebec and Androscoggin watersheds, their common estuary, and the coastal fisheries that once depended on the river-estuary complex. In response to these unusual, open discourses between academic scientists, state scientists, and concerned stakeholders, several local restoration projects have been initiated. For example, the Bath water district, the Woolwich fish commission, KELT, and Woolwich residents are examining options for restoration of their fish ladder on the Nequasset River. Experts from Wright-Pierce Engineering, the U. S. Fish and Wildlife Service, and the MDMR provided technical information, and this group recently submitted a grant proposal to help fund repairs of the Nequasset fish ladder. Another important collaboration has emerged between NextEra Energy, the MDMR, the Androscoggin River Alliance, and the Bowdoin-Bates-USM research team to address ecological concerns in the Androscoggin River. Their goal is to determine whether fish-lift technology would improve passage of American shad at the Brunswick hydroelectric dam. These efforts are a direct consequence of the novel discourse and collaborations generated between groups that generally have not interacted in the past.

Reconstructing ecological history can play an important role in understanding the vital ecological relationships that once resulted in truly bountiful resources supplied by our rivers, estuaries, and coastal waters. Understanding and sharing that history can play an equally important role in generating public support for ecological restoration. Harvest of the annual alewife, blue-back herring, shad, salmon, and sturgeon runs was an important source of food and an important export commodity during the Colonial era throughout coastal Maine. Embracing restoration of fish passage today is in many ways embracing the pioneer history and traditions of our coastal communities. As Maine's coastal economy depends critically on tourism, embracing a historical narrative focused on the connection between the unique character of Maine's people, their communities, and the unique ecology of coastal Maine seems well advised. Restoration of historic fish runs can only benefit Maine's coastal economy with increased fish harvests as well as enhanced tourism based on working waterfronts and restored spawning runs. Over the long run, resilience of coastal communities may depend on a diversity of economic activities that better weather external disturbances in our increasingly interconnected world.

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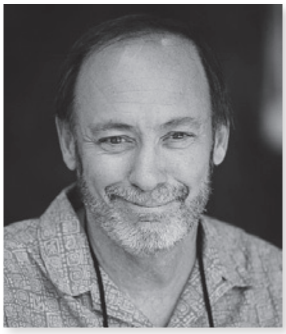
Ted Ames, a founding board member of Penobscot East Resource Center, is a visiting Coastal Studies Scholar at Bowdoin. He fished commercially for 28 years and was vice-chair of Maine Department of Marine Resources Hatchery Technology Committee, executive director of the Maine Gillnetters Association, and director of Alden-Ames Lab. He has authored several peer-reviewed articles on historical fisheries ecology, fishermen's ecological knowledge, and related subjects. Ames is the recipient of a 2005 MacArthur Award.



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