

# 15th Annual Maine Water Conference

*a combined meeting with the  
Northeast Geological Society of America*

March 24, 2009  
Holiday Inn by the Bay  
Portland, Maine





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## Session T10

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### *Habitat Restoration in North Atlantic Watersheds*

*Stream restoration projects, ranging from bank protection to dam removals to watershed-scale regional planning efforts, are common throughout eastern North America. Many of these projects are motivated by the need to restore migration pathways and habitat for diadromous fish species. In 2008, the University of Maine and USM received NSF funding to create the Diadromous Species Restoration Research Network (DSRRN), a research coordination network designed to develop and sustain facilitated interactions of multiple research, government and stakeholder entities focused on restoring diadromous fish populations throughout the North Atlantic region. The strength of this network is in its connection to and integration with the Penobscot River Restoration Project. This session will explore current research and management efforts in stream and river restoration across the North Atlantic region, with the goal of fostering the interdisciplinary dialogue central to the DSRRN.*



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### SESSION CHAIRS

Karen Wilson, University of Southern Maine, [kwilson@usm.maine.edu](mailto:kwilson@usm.maine.edu)

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8:00AM

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#### **FRESHWATER - MARINE LINKAGES: THE ROLE OF SMALL COASTAL RIVER SYSTEMS AS A SOURCE OF FALL FORAGE FISH (RIVER HERRING) IN THE NEARSHORE MARINE ENVIRONMENT IN MAINE**

*WILSON, Karen A., Department of Environmental Science, University of Southern Maine, Gorham, ME and WILLIS, Theodore V., Aquatic Systems Group, University of Southern Maine, Portland, ME*

Throughout their range, river herring (alewives and blueback herring) spawning runs are depressed. In Maine, river herring spawning runs are tiny in comparison to descriptions of historical runs in the 1700-1800s, where fish were harvested by the ship-hold. Decreases in these harvests have been attributed to the construction of innumerable small and large dams on nearly every coastal river and stream and, within the last 40 years, more efficient harvest methods in the marine environment. Today there is an unprecedented rate of dam removal and efforts to re-invigorate alewife runs in larger rivers. We will discuss these activities in the context of nearshore marine food webs and what may be missing from these food webs under current river herring production. Diet data collected from two Maine estuaries in 2007 and 2008 demonstrated that young-of-year (YOY) alewives can

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compose a large proportion of the diet of a diversity of predatory fishes when YOY alewives are abundant in the estuary and nearshore region. However, in 2007, alewives were only present during one 2 week period, suggesting that although alewife represent high-quality food late in the growing season, when juvenile and adult groundfish are in need of energy prior to the onset of winter, the resource is only available in short-lived pulses as YOY migrate out of freshwater nursery habitat. We argue that the limited number of river herring runs active today may be contributing to the pulse nature of this potentially important resource, and that in the past many runs from a diversity of freshwater systems may have resulted in what was effectively an extended out-migration period. This result argues for a regional approach to river herring restoration that takes into account the cumulative potential for YOY production.

8:20AM

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### **GEOMORPHIC COMPARISON OF TWO ATLANTIC COASTAL STREAMS: TOWARD A BETTER UNDERSTANDING OF ANTHROPEGENIC IMPACTS ON ATLANTIC SALMON SPAWNING AND REARING HABITAT**

*WILKINS, Benjamin C. and SNYDER, Noah P., Geology and Geophysics, Boston College, Chestnut Hill, MA*

Substrate size and mobility is important to Atlantic salmon (*Salmo salar*) spawning and rearing success. Channel geometry is a control on bedload mobility in streams. It is believed that channel morphology in many Maine rivers has been altered by land use practices, creating wider and shallower channels, and lowering stream competence. If correct, these changes may be partially responsible for the limited number of returning salmon currently observed in Maine coastal rivers. To evaluate the magnitude of these changes, we performed a statistical comparison of channel morphology between two Atlantic coastal streams: the Narraguagus River in Downeast Maine and the Jacquet River in New Brunswick, Canada. Compared to the Narraguagus, the Jacquet has relatively healthy returns of adult salmon. Both watersheds have similar drainage areas and mean annual precipitation, but differing average channel gradients (0.16%; 0.51%) and longitudinal profiles. During the summer of 2007, we surveyed a 13.6-km section of the Narraguagus with a drainage area range of 129-247 km<sup>2</sup>, and a 10.4-km section of the Jacquet with a drainage area range of 94-265 km<sup>2</sup>. We made measurements of active and bankfull width and depth, and channel gradient at 100-m intervals, and performed grain-size counts at 200-m intervals. We also measured gradient and width in a GIS-based analysis. Results of our analysis show that channel gradient is likely the most influential factor on Atlantic salmon habitat as it relates to sediment size. The two rivers exhibit no significant difference in width-to-depth ratio, when low-gradient outliers are removed. Measured and predicted grain sizes reveal finer river-bed sediments on the Narraguagus, however, Shields parameter calculations show that sediment should be mobile in both streams. We compare these predictions to field-based habitat mapping on the Narraguagus. Based on predicted grain size, we expect nearly continuous Atlantic salmon rearing habitat on the Jacquet. In contrast, the Narraguagus habitat is segmented into reaches of steeper gradient (>0.002) with potentially good habitat, and flatter reaches (<0.0005) of poor habitat. The long flat reaches likely act as sediment sinks, preventing the continuity of downstream sediment transport and causing sediment to be sourced from localized glacial deposits.

8:40AM

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### **DAM REMOVAL AND ROCK RAMP FISH PASSAGE TO RESTORE SEDGEUNKEDUNK STREAM ALEWIFE AND ATLANTIC SALMON POPULATIONS**

*SHEPARD, Steve, Aquatic Science Associates Inc, Brewer, ME and BERNIER, Matt, NOAA Fisheries, Maine Field Station, Orono, ME*

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Sedgeunkedunk Stream, a tributary of the lower Penobscot River, drains a watershed of 54 square kilometers, including two mainstem lakes impounded by dams. These two dams, and a third dam that diverts water from a location near the stream mouth, were used to regulate and divert water for paper-making processes. These three dams and several historic mill dams contributed to the loss of alewife and Atlantic salmon populations from the Sedgeunkedunk watershed. Because these dams currently have no provisions for upstream fish passage, restoration of alewife and salmon is precluded. This restoration project addresses fish passage at the lower two dams. The City of Brewer will remove the Lower Dam as part of a mitigation agreement thereby providing Atlantic salmon with access to suitable habitat upstream of the dam. The Town of Orrington and their partners have replaced the Meadow Dam (located five kilometers upstream at the outlet of Fields Pond) with a rock ramp fishway. Alternatives analyses demonstrated that a rock ramp fishway best met the goals of fish passage efficacy, wetlands protection, social acceptability, reasonable cost, and engineering feasibility. An intensive outreach program provided information to stakeholders and documented support from natural resource agencies, non-governmental organizations, local government, abutting landowners, recreational users and the general community. Stakeholder support was fostered by the efforts to include stakeholder issues in the alternatives analyses and implementation of the preferred alternative. The structure includes an innovative use of a liner to retain baseflows in the channel. Baseline biological sampling suggested by the Gulf of Maine Council's Barrier Removal Monitoring Guide is currently underway to assess changes in the aquatic community after restoration. Adult alewife will be stocked in 2009, and passively reintroduced from the Penobscot River over time. Restoring alewife runs to the watershed will reinforce the key trophic link of a littoral/pelagic zooplanktivore in the pond (currently represented by only one species, golden shiner), potentially allowing for increased diversity and resilience within the fish community. Furthermore, the hypothesized increase in energy and nutrient fluxes due to alewife migrating within the pond and stream should increase diversity, production, and carrying capacity of stream fishes, including juvenile Atlantic salmon.

9:00AM

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### **RESTORATION OF FLUVIAL PROCESS AND AQUATIC HABITAT IN THE SANDY RIVER AND TRIBUTARIES TO THE KENNEBEC RIVER, MAINE**

*HAYES, Benjamin R., Environmental Center, Bucknell University, Lewisburg, PA, FIELD, John, Field Geology Services, Farmington, ME and RICHTER, Robert C. III, FPL Energy Maine Hydro LLC, Lewiston, ME*

Stream restoration efforts in northeastern North America have limited success because many channels remain in a disequilibrium condition after a century of widespread logging in these watersheds. By the mid-1800s sediment deliveries to most streams were greatly increased and many channels were straightened and cleared of trees or large boulders to facilitate log drives. Hydraulic geometries were altered as splash dams, berms, cribbing, and other structures were built. Aquatic habitats were further degraded by channel widening, loss of water depth and velocity variations, and deposition of large bars at artificial constrictions or other areas of energy loss. Today these streams remain in a protracted phase of fluvial adjustment, with the episodic creation of meanders where artificially straightened channels become clogged with wood, sediment, or ice.

Considering these factors, an adapted restoration approach is being used to improve fisheries habitat in the Sandy River and upper Kennebec River basins in Maine. Ecological and hydrogeomorphic studies are conducted to assess aquatic conditions and guide restoration efforts. Relic logging features such as berms and splash dams are removed to enable the stream to reconnect with its floodplain, increase habitat complexity, improve flow in abandoned side channels, and permit more uniform distribution of energy throughout the fluvial system.

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Rather than constrain the channel in a static position using a traditional Rosgen-based Natural Channel Design methodology, in-stream structures are designed to encourage the stream to naturally create new meanders, bars, or pools and develop a new equilibrium condition on its own.

9:20AM

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### **A RESTORATION FRAMEWORK FOR OPTIMIZING HABITAT CONNECTIVITY IN GULF OF MAINE WATERSHEDS**

*WRIGHT, Jed R., Gulf of Maine Coastal Program, US Fish and Wildlife Service, Falmouth, ME and HANLEY, Jesse O., Kent Business School, University of Kent, Canterbury, United Kingdom*

Interest in restoring access to historic habitat for diadromous fish in the Gulf of Maine has led to the development of a framework for identifying and implementing barrier removal and river restoration projects. Numerous studies have identified how stream barriers disrupt ecological processes, including hydrology, passage of large woody debris and movement of organisms. Thousands of barriers exist in Maine streams and rivers, which block the passage of fish and many other aquatic and terrestrial species, as well as the natural movement of sediment and woody debris. These barriers are in the form of both dams and road-stream crossings. Recent analysis in the lower Penobscot River watershed found that barriers block access to over 70% of the historic habitat for alewife and Atlantic salmon. Using geographic information systems we have developed predictive habitat models and other datasets that are used as inputs for optimization models that maximize potential benefits from barrier removal projects while minimizing costs.

9:40AM

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### **HUDSON RIVER FLOODPLAIN CHANGE OVER THE 20TH CENTURY**

*COLLINS, Mathias J., NOAA Restoration Center, Gloucester, MA and MILLER, Daniel, Hudson River National Estuarine Research Reserve, Staatsburg, NY*

Detailed surveys of the Hudson River and its floodplain from the early 1900s, and high-resolution mapping of the same areas today, provide an opportunity to evaluate changes over the 20th century. This study uses GIS to quantitatively compare water areas and islands mapped by the United States Army Corps of Engineers in 1907-11 along an approximately 37-mile reach from Athens to Troy, New York, with the same features mapped in the early 21st century. The comparison shows a substantial decrease in the acreage of total water area (~30%) with secondary channels disproportionately affected (~70%). The number and total area of islands has also dramatically decreased: ~65% and ~85%, respectively. These changes primarily reflect the success of navigation improvement projects undertaken since the 19th century whereby the river has been transformed from a shallow, island-braided river in the study reach to a deeper, single-thread channel. Dredge spoils from the main channel were used to fill secondary channels and other backwater areas, with important implications for native aquatic species that rely on these areas for feeding, nursery, and rearing habitat. Restoring secondary channels is an opportunity to restore important habitats and environmental functions critical to the productivity of the Hudson River Estuary ecosystem.

10:00AM BREAK

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10:20AM

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### **THE SIMULATION OF POOL-RIFFLE MORPHOLOGIES IN NORTHEAST CHANNELS WITH DIFFERENT DENSITIES OF LARGE WOODY DEBRIS AND BOULDERS**

*THOMPSON, Douglas M., Physics, Astronomy and Geophysics, Connecticut College, New London, CT*

Large woody debris (LWD) provides important habitat for aquatic species and is often associated with formation of pools and scour holes. Studies on forced pools include many reports of over 80 or 90 percent of pools being associated with structural controls and large obstructions that include boulders, bedrock outcrops and LWD. A computer model was developed that attempts to predict the percent area covered by pools, riffles, glides and runs based on input data that include channel slope, width, the number of small and large boulders, and the number of small, medium and large pieces of wood. The statistical-empirical model is founded on the idea that boulders, bedrock outcrops and LWD provide a physical framework that then controls local hydraulic conditions and the locations of pools and riffles. The spacing of individual obstructions approximate and are modeled as log-normal distributions with separate distributions for different size and types of obstructions. Pools are assigned different probabilities of development depending on the obstruction type. Subsequent pool and riffle lengths follow their own slope-dependent, log-normal trends. A minimum distance develops between successive pools because of the backwater conditions and turbulent conditions needed for pool formation. The total number and spacing of pools, riffles, glides and runs thus reflects the characteristics of the distribution of obstructions and characteristics of the pool-riffle couplet. Statistical results provide evidence that the number of pools at over 30 field sites is influenced by the number of log jams, the number of large boulders, the number of pieces of wood and channel width. The number of scour holes also showed some statistical relation to channel width, slope, number of pieces of wood, and number of boulders.

10:40AM

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### **CASCADE BROOK SALT MARSH RESTORATION PROJECT**

*RIVARD, Linda and WATTS, Sarah C., Tetra Tech, Inc, Portland, ME*

The U.S. Fish and Wildlife Service contracted Tetra Tech, Inc. (formerly Northern Ecological Associates, Inc.) to conduct pre-construction and post-restoration monitoring within an 88-acre portion of the Cascade Brook salt marsh area located within the Scarborough Marsh Wildlife Management Area, Scarborough, ME, in response to a culvert failure along Old Blue Point Road. The goal of the restoration and monitoring effort was to restore the native marsh surface elevation to allow native salt marsh vegetation to repopulate the marsh; reduce the constriction of tidal flow to the marsh, thereby increasing salinity and reducing freshwater pooling on the marsh surface; and, remove or control the large populations of common reed (*Phragmites australis*), an invasive plant, from central areas of the marsh that were historically dominated by salt meadow grass (*Spartina patens*) or other native salt marsh species. Pre-restoration monitoring was conducted in 2002, restoration activities were conducted in 2003, and post-restoration monitoring occurred annually between 2004 and 2008. A combination of qualitative and quantitative assessments was used to monitor changes associated with restoration activities. Results of the five-year post-restoration monitoring effort documented a positive vegetative response in the spoil removal areas, with desirable salt marsh species rapidly repopulating the areas exposed during restoration activities, emerging from the uncovered, intact seed bank. A review of the water quality data collected over the five-year period revealed a high degree of variability both spatially and temporally, but no clear trend of increased salinity. In the common reed control and removal areas, reestablishment of common reed was documented, however the

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extent has been reduced in comparison to pre-restoration conditions, and it appears that the reestablishment of native species has slowed the regrowth of common reed. Long-term predictions for the site include the continued expansion of common reed in those areas where it has become reestablished, however it appears that native vegetative species will persist within the targeted restoration areas, resulting in an overall increase in diversity and restoration of native salt marsh species at the site.

11:00AM

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### **RIVER RESPONSE TO DAM REMOVAL: INITIAL RESULTS FROM THE SOUHEGAN RIVER AND THE MERRIMACK VILLAGE DAM, MERRIMACK, NEW HAMPSHIRE**

*PEARSON, Adam Jeffrey<sup>1</sup>, SNYDER, Noah P.<sup>1</sup>, and COLLINS, Mathias J.<sup>2</sup>, (1) Geology and Geophysics, Boston College, Chestnut Hill, MA, (2) NOAA Restoration Center, Gloucester, MA*

The Souhegan River is a tributary of the Merrimack River that drains a 443 km<sup>2</sup> watershed in southern New Hampshire. The lowermost barrier on the Souhegan River was the ~4-m high Merrimack Village Dam (MVD, ~500-m upstream of the confluence with the Merrimack River), which was breached and removed starting on August 6, 2008. The MVD impounded at least 62,000 m<sup>3</sup> of sediment, mostly sand. After the breach, the Souhegan River immediately began to incise a new channel into these legacy sediments. We use 12 monumented cross-sections, longitudinal profiles, repeat photography, and sediment samples to document the response of the Souhegan River to the removal of the MVD. Our study is part of the first full application of a newly published guide to stream barrier removal monitoring. Prior to dam removal, in August 2007 and June 2008, we surveyed the cross-sections and longitudinal profile, and collected thalweg sediment samples. After removal, in August 2008, we surveyed 11 cross-sections and the longitudinal profile, and collected sediment samples. We surveyed 10 of the cross-sections again in October 2008. Comparison of the August 2008 cross-sections with those from June 2008 showed that, in a 495-m reach upstream of the former location of the MVD, the Souhegan River eroded a relatively narrow channel 0.6 to 3.0-m into the legacy sediments, in some places exposing bedrock and boulders likely from the pre-dam riverbed. Downstream of the former dam location, a sand deposit up to 1.0 to 3.5-m thick prograded almost to the confluence with the Merrimack River. Between the August and October 2008 surveys, upstream of the former dam, the river continued to incise (up to 1.0-m) and began to widen its channel. Downstream, the river began removing the initial pulse of stored sediment, with up to 1.2-m of incision. Our ongoing work in this dynamic system will document and analyze longer-term response of the channel to the removal.

11:20AM

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### **MODELING THE HYDROLOGICAL IMPACTS OF STREAM RESTORATION IN RED BROOK, A SMALL COASTAL STREAM IN SOUTHEASTERN MASSACHUSETTS**

*FRADKIN, Barry<sup>1</sup>, DOUGLAS, Ellen M.<sup>1</sup>, LAMBERT, Beth C.<sup>2</sup>, and PURINTON, Tim A.<sup>2</sup>, (1) Environmental, Earth & Ocean Sciences, University of Massachusetts, Boston, MA, (2) Massachusetts Riverways Program, Department of Fish & Game, Boston, MA*

New England has a long history of anthropogenic modification of stream channels. Many fluvial systems have been drastically altered from their natural state, whether for flood control, power generation, or navigation purposes. In the case of Red Brook, a small coastal stream in southeastern Massachusetts, the channel and bank morphology has been significantly modified for cranberry bog operations and recreational fishing. Concrete

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flumes and earthen berms remain along the lower reach of the stream, but a cooperative restoration effort is currently underway. Started in 2006, the project is being coordinated by Massachusetts Riverways Program, with help from the property's caretakers, The Trustees of Reservations, as well as other interested stakeholders. Restoration plans include removal of the concrete structures, regrading and replanting the banks, and emplacement of large woody debris. Ultimately, the goal of this project is to restore habitat for the endemic sea-run brook trout population, which prefer a gravel bed, and the cool, spring-fed waters of Red Brook.

Monitoring of the stream restoration has been ongoing since spring of 2008, using a combination of in-situ measurements, geophysical techniques and a remotely-accessed environmental sensor network to monitor flow and sediment movement in the Brook before and after the flume removal. The monitoring program also includes the development of a computer model of the Brook using HEC-RAS, a one-dimensional water surface profile model developed by the U.S. Army Corps of Engineers. The purpose of this model is to simulate streamflow conditions before and after flume removal, and to predict the overall impact of stream restoration activities on the flow and sediment transport regimes of Red Brook. Some of the challenges involved with modeling Red Brook include a strong tidal influence within the lower reaches and cranberry bog operations in the upper reaches of the brook. Modeling these unique aspects will provide insight into the sensitivity of coastal streams to natural and artificial flow controls, as well as evaluating the success of the restoration project in terms of channel morphology, flow conditions, and sediment transport.

11:40AM

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### **INCLUDING BEAVERS IN THE RIVER RESTORATION BASELINE**

*BURCHSTED, Denise, Center for Integrative Geosciences, University of Connecticut, Storrs, CT, DANIELS, Melinda, Department of Geography, Kansas State University, Manhattan, KS and THORSON, Robert, Geoscience, Univ of Connecticut, Storrs, CT*

Goals for river restoration, particularly dam removals, are often based on the model of a free-flowing, single-thread, rocky substrate channel. When considering precolonial conditions of headwaters in the northeastern U.S., additional complexity associated with beavers (*Castor canadensis*) should be included. By historical accounts, beavers were pervasive at the time of European colonization. Examination of modern watercourses re-colonized by beavers reveals features that counter the free-flowing baseline model.

Observations of forested headwater streams in northeastern Connecticut show a beaver dam density of up to three dams / 100m, with check-dams located downstream of larger dams. This creates a patchy diversity of habitats including large impounded ponds, "check-dam" impoundments, and beaver meadows interspersed with free-flowing reaches. In turn, this provides potential to alter the natural flow regime due to increased storage and saturated areas. It also dramatically affects biogeochemical cycles through alternating high- and low-oxygen reaches.

Sediment distribution is patchy in beaver-created habitats. The major impoundments are sites of deposition, with organic and fine-grained mineral sediments. Downstream of beaver dams, the river channel has multiple threads. These channels are actively eroding downstream of new dams and in beaver meadows. Of the ten beaver dam complexes examined in this study, 80% are drained by multiple channels. A new dam, less than one year old, effectively diverts a portion of the watercourse into the riparian forest downstream of the dam. The diverted water shallowly floods 722 m<sup>2</sup> of the forest, eroding and altering that soil. By comparison, only 214 m<sup>2</sup> is newly flooded upstream of the new dam. The flooded forest downstream of the dam is drained by five separate side-channels newly scoured in the forest soil, 117m in combined length adjacent to 60m of the primary channel.

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Given the recognition of beavers as ecosystem engineers, their landscape alteration should be included in the river restoration baseline. In headwater systems this includes patchy distribution of habitats and sediments, alternating high- and low-oxygen conditions, alternating sediment mobilization and deposition, and multi- and single-thread channels.

## Session T12

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### *Land Conservation and Management Strategies for Protecting Water Quality*

*Water quality depends upon both unique physical and social settings and in order to protect this resource, the two must be integrated. This session will explore a wide range of approaches to protect or improve water quality, from bottom-up community action to top-down watershed-scale policy. This session starts with applications of community-based conservation models as management tools then moves to a larger landscape scale- watershed level strategies to protect water quality.*



### SESSION CHAIR

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David Hart, Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, david.hart@umit.maine.edu

10:40 AM

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#### **COLLABORATION AND LOCAL NATURAL RESOURCE PLANNING**

*JANSUJWICZ, Jessica. Dept. of Wildlife Ecology, School of Forest Resources, University of Maine, Orono, ME*

Managing natural resources for the common good is a thorny issue, particularly when private lands are involved. All levels of government and the private sector continue to grapple with this issue, struggling to find the right balance between public and private interests in land. To reconcile these diverse interests, there has been a growing trend toward more inclusive, participatory efforts to involve multiple stakeholders in local-land use planning decisions. This collaborative, community-based model has become an important cornerstone for a rapidly increasing number of federal, state, and local natural resource and environmental programs addressing wetlands, wildlife, endangered species, water quality and other watershed management concerns. In theory, a collaborative approach is a logical framework for decision-making and action, and the benefits of this approach are touted in the academic literature and popular press. As the practice of participatory planning accelerates, however, it must be matched by rigorous evaluation “on-the-ground.” Responding to this call for better empirical analysis, a grow-

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ing number of studies offer criteria against which collaborative efforts can be evaluated in practice. While recent studies have led to a better understanding of the process of collaboration, few empirical studies focus on both the social and environmental outcomes of collaborative natural resource planning. To bridge this gap between theory and practice, my research will use an integrated performance evaluation framework to investigate and link the process and outputs of the Vernal Pool Working Group, a government-initiated collaborative planning effort in Maine, with social and environmental outcomes. Determining whether collaborative efforts yield the results modeled, planned, and anticipated is critical, and evaluation is necessary both to guide future efforts and policies and to identify variables associated with success and failure.

11:00 AM

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### **COMMUNITY BASED RESEARCH ALTERNATIVES FOR WATER QUALITY MONITORING IN THE NORTHEAST**

*THORNTON, Teresa<sup>1</sup>, Straub, Crista<sup>1</sup>, Leahy, Jessica<sup>1</sup>, Peckenham, John<sup>2</sup>, Wilson, Laura<sup>3</sup>, Jemison, John<sup>3</sup>, MacRae, Jean<sup>4</sup>. (1) Dept. of Forest Resources, University of Maine, Orono, ME, (2) George J. Mitchell Cntr for Environmental and Watershed Research, Orono, ME, (3) University of Maine Cooperative Extension, Orono, ME, (4) Dept. of Civil & Environmental Engineering, University of Maine, Orono, ME.*

What are the roles for communities in monitoring water quality? Within the scope of the “hard” sciences, Community Based Research (CBR) has primarily been a community workers model where researchers use the populace as a means of volunteer labor. Despite the questions raised about the quality of the data gathered by volunteers and mistrust of the researcher’s motives by communities, the top-down consulting model (where the community sets the agenda, but the professionals design and interpret the data) is seen as more scientifically reliable than a grass roots movement and is often the preferred method sought after by communities.

The consulting model has been preferred because it is more difficult for communities to possess the expertise to develop, implement, and interpret data. Yet this model lacks in the empowerment of the citizens within the research. They need to feel valued for the expertise they possess about the research site and they need to be informed on how to interpret the data they collect. This collaborative effort that empowers the community is especially important because it is their efforts that will provide the means of push for reform.

This presentation will discuss the interface between science and society, with an example using secondary students as researchers and reporters to the community. The public education system serves as a center point to connect citizens, local governments, community organizations, local businesses, and nearby colleges in a joint effort to create social capital that will increase the trust developed within the once separate stakeholder groups. These parties can then work on the dispersal of knowledge throughout the community in regard to land-use effects on water resources. The collaboration can encourage a platform for all stakeholders to work together to provide a sustainable means of policy enforcement or creation to safeguard drinking water.

11:20 AM

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### **USING WATERSHED-BASED MANAGEMENT PLANNING TO RESTORE THE WATER QUALITY OF DUDLEY BROOK IN AROOSTOOK COUNTY, MAINE**

*JESPERSON, Jennifer<sup>1</sup>, Evers, Melissa<sup>2</sup>, Tricia Rouleau<sup>1</sup>, Kailee Mullen<sup>1</sup>, Forrest Bell<sup>1</sup>. (1) FB Environmental Associates, Portland ME and (2) Maine DEP, Augusta, ME*

Results of macroinvertebrate sampling in Dudley Brook, a Class A stream in Aroostook County, Maine, show that

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the stream is impaired due to nonpoint source (NPS) pollution stemming from a history of agricultural land uses in the watershed. Following the development of a Total Maximum Daily Load (TMDL), FB Environmental Associates, in cooperation with Maine DEP, began working on the development of a Watershed-Based Management Plan (WBMP). The WBMP process is designed to help communities and regional planners better understand the effects of land-use at the watershed scale, and to take ownership of the problems by creating a long-term, locally driven, watershed management strategy. The success of the participation by watershed stakeholders is largely attributed to the small size of the watershed and the extent of outreach, including direct mail, press releases, public notices, personal communication by phone, and follow-up phone calls as the meeting date approached. As a result, local landowners, conservation groups, town managers, town planners, and government agencies came together for the first time to discuss Dudley Brook. Estimates of the extent of NPS loading and the required reductions needed to restore water quality (specifically N, P and sediment) were developed through the use of an integrated GIS-based watershed modeling tool called AVGWLF (ArcView Generalized Watershed Loading Function) which works hand in hand with a BMP cost estimating model called PRedICT (Pollutant Reduction Impact Comparison Tool). Target NPS reductions estimated by the model, as well as the types and costs of BMPs needed to reach these targets became informative tools used by local stakeholders to help set realistic goals for making improvements in the Dudley Brook watershed. Success of this initial WBMP meeting for Dudley Brook suggests that water quality improvements are well within reach. A second meeting has already been scheduled for 2009.

11:40 AM

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### **IF YOU REMOVE IT, WILL THEY COME? DIADROMOUS FISH RESTORATION EFFORTS IN A COASTAL MAINE WATERSHED**

*WILLIS, Theodore V., Aquatic Systems Group, University of Southern Maine and REARDON, Jeff, Trout Unlimited*

The last remaining obstruction along the St. George River to diadromous fish migration, Sennebec Dam, was removed in 2002 and replaced with a new low-head dam design (roughened ramp). Sennebec Dam was an 18 ft. high, 240 ft. long hydroelectric dam constructed in 1916; it was decommissioned and sold for \$1 in 1961 to the Sennebec Pond Association. Removal of the dam made the upper St. George River, including 17 miles of river and 1,100 acres of lakes, accessible to all diadromous species for the first time in 86 years. However, maintaining historic water levels was a critical point for the pond association. The roughened ramp satisfied Sennebec Pond home owners, removed a dangerous feature from the river (Sennebec Dam), and restored diadromous fish access. We will detail why, of the various passage options available, the roughened ramp was chosen. A number of obstacles stood in the way of completing the project, including opposition from upstream communities. The process of public hearings, winning over communities, and deflecting criticism of the project and alewives as part of the fish community, will be discussed. Current passage and efficiency statistics for the ramp were collected in 2007 and 2008 through a community monitoring effort at Sennebec Pond. We will discuss the process of continuing those efforts as an entirely community-based monitoring effort. Alewives have recolonized the upper St. George River but perceptions of alewives still present problems for continued restoration.

12:00 AM - 1:00 PM LUNCH BREAK

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# Session T12: Conservation and Management for Protecting Water Quality

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1:00 PM

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## **FROM THE HEADWATERS TO THE SEA, IMPLEMENTING A WATERSHED APPROACH IN SOUTHERN MAINE**

*FEURT, Christine, SMITH, Tin, and STEELE, Zack. Wells National Estuarine Research Reserve, Wells, ME*

Watersheds in southern Maine connect coastal and inland communities where diverse land-use practices and land conservation strategies create a complex mosaic of policies affecting water quality and quantity. This presentation shares lessons learned from a project designed to improve land-use decision making and overcome barriers to implementing a watershed approach in southern Maine watersheds.

The watershed approach mirrors the principles and practices of community-based ecosystem management. This project integrated the process of Collaborative Learning and land-use planning tools developed by the Ecosystem Based Management Network to connect the practice of ecosystem management to municipal land use decision-making. Desire to incorporate water quality and habitat protection into economic development strategies motivated the town of Sanford, Maine to examine existing resource conditions, ordinances, and Comprehensive Plan priorities. The Wells National Estuarine Research Reserve secured grant funding to support Sanford's efforts as part of a national project to improve land-use planning in coastal watersheds. Sanford's five watersheds are significant coastal headwaters that drain to two National Estuarine Research Reserves, one National Wildlife Refuge and a National Estuary Partnership. The source waters for a regional water district originate in Sanford as well. This collaborative partnership connected international and national scale initiatives with place based efforts to conserve land and protect water quality.

This project used Collaborative Learning to guide stakeholder engagement and use of geospatial tools and Community Viz technology to develop a Conservation Plan for Sanford that considered the value of headwater streams, aquifers and riparian buffers for water quality and quantity protection. Watershed values were considered along with habitat, recreation and land productivity values. Stakeholder engagement was supported by the use of key pad polling to gather information on community priorities.

This presentation addresses challenges and successes associated with the application of land use technology tools to improve decision making at the watershed scale and linking land conservation goals with water quality protection.

1:00 PM

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## **ALTERNATIVE LAND USE FUTURES IN THE LOWER PENOBSCOT RIVER WATERSHED: IMPLICATIONS FOR SURFACE WATER QUALITY AND AQUATIC BIOTA**

*CRONAN, Christopher S. , School of Biology and Ecology, University of Maine, Orono, ME, LILIEHOLM, Robert J., School of Forest Resources, University of Maine, Orono, ME, and TREMBLAY, Jill, Department of Anthropology, University of Maine, Orono, ME*

River and stream ecosystems play a critical role in the Maine landscape, linking upland watersheds with downstream aquatic and estuarine ecosystems through flows of water, matter, and energy. Increasingly, rivers and coastal waters are facing pressures and threats associated with human population growth, climate changes, land development, invasive exotic species, and non-point pollution. Given these environmental uncertainties, there is an important need for research aimed at monitoring the ecological health of these ecosystems and detecting changes and trends associated with degradation of aquatic resources. Our investigations indicate that rivers in Maine generally exhibit relatively low background levels of limiting nutrients such as nitrogen and phosphorus, implying that these waters are not currently at risk of eutrophication. These observations are very posi-

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tive and encouraging, but they also present an important challenge – how do we sustain our healthy river and stream ecosystems in the face of mounting pressures from the expanding human footprint in the Maine landscape? The answer to this question is that what happens in river and stream systems is largely a function of conditions in the surrounding watershed. In a watershed that is managed in a sustainable fashion, risks to surface waters are greatly diminished. We have applied a GIS-based alternative futures modeling approach to examine how different land use change scenarios may affect nutrient transfers from the surrounding watershed to surface waters in the lower Penobscot River. This information will permit improved planning and management for sustaining water quality and aquatic biota.

1:40 PM

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### **MAINE YARDSCAPING PARTNERSHIP - A SUCCESSFUL MODEL IN PUBLIC-PRIVATE COOPERATION**

*FISH, Gary, Maine Department of Agriculture, Food and Rural Resources, Board of Pesticides Control, Augusta, ME*

The Maine YardScaping Partnership is a successful example of public - private cooperation which includes state agencies, NGOs and private businesses all working towards implementation of ecological and sustainable landscaping practices.

The YardScaping partnership formed out of the rising concern among statewide organizations and agencies over the possible pollution caused by yard-care chemicals washing away into water bodies and the risks of pesticide exposure to people, pets and wildlife.

The mission of the partnership is to inspire Maine people to create and maintain healthy landscapes through ecologically based practices that minimize reliance on water, fertilizer and pesticides.

#### *Guiding Principles*

- \* Promote buffers
- \* Promote appropriate plants - native plants and non-invasive alien plants
- \* Reduce lawn area
- \* Reduce runoff
- \* Reduce reliance on pesticides, fertilizers and water
- \* Promote low-input lawns and landscapes
- \* Promote landscape diversity
- \* Create wildlife habitats
- \* Right plant, right place, right use
- \* Commonsense pest management (IPM)

This presentation will cover the origins of the partnership and how it has grown to be a resource and brand that Maine people have started to believe in. It will also highlight the successes and failures of the last 10 years and what the future has in store for Maine YardScaping.

2:00 PM

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### **NO DISCHARGE AREAS: ELIMINATING THE LAST MAJOR SOURCES OF SEWAGE DURING DRY WEATHER**

*LYONS, Regina, Environmental Protection Agency, Region 1, Boston, MA*

A No Discharge Area (NDA) is a federally approved state designation for a water body that prohibits the discharge of all sewage – treated or untreated – from any vessel. Under Section 312 of the Clean Water Act, a

## Session T12: Conservation and Management for Protecting Water Quality

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state can petition the Environmental Protection Agency (EPA) to approve a NDA designation for some or all of its waters. EPA's primary responsibility is to determine whether adequate facilities for the safe and sanitary removal and treatment of sewage from all vessels utilizing the proposed NDA are reasonably available. This designation provides an added layer of water quality protection because it is already illegal to discharge untreated sewage in the U.S. waters.

Boats equipped with toilets are required to have a Coast Guard-approved Marine Sanitation Device (MSD). MSDs are designed to either hold the raw sewage in a holding tank (Type III) or to treat the sewage and discharge this effluent into the coastal waters (Type I and II). A NDA designation is intended to prevent the discharge of MSD Types I and II within the designated area. (Discharges from Type III MSDs are already prohibited within state waters). Effluent from properly functioning Type I and II MSDs has bacteria concentrations well above water quality standards set for swimming or shellfish harvesting. If the MSD is not properly maintained or operated, the concentrations may be even higher. Sewage effluent from MSDs degrades water quality by introducing disease-causing microorganisms, nutrients, and chemicals. During dry weather, sewage discharges from vessels often represent the only possible source of sewage that can cause beaches and shellfish beds to be closed.

Maintaining pumpout infrastructure and educating boaters and marina operators are the foundation for the success of any NDA. In fall 2008, an evaluation of the Casco Bay NDA program was performed. At the time of this study, Casco Bay was the only NDA in Maine. The methodology for the evaluation was a multi-method approach utilizing three program evaluation instruments 1) a mail-survey of Casco Bay boaters, 2) an in-person survey of pumpout facility operators, and 3) site visits of the Casco Bay pumpout facilities. Recommendations for the Casco Bay NDA program were made based on the overall research findings. The results from this study can be applicable to NDAs in any area – whether one wants to improve an existing program or to establish a new designation.

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### **SUNDAY RIVER OUTWARD BOUND PROJECT AND MILL BROOK STREAM BANK STABILIZATION & HABITAT ENHANCEMENT PROJECT: A NEW APPROACH FOR CONTROLLING RIVERBANK EROSION IN MAINE**

*STERN, Jeff, Fiddlehead Environmental Consulting, Harrison, ME; WILLIAMS, Betty, Cumberland County Soil & Water Conservation District, Windham, ME; FIELD, John, Field Geology Services, Farmington, ME; MILOT, Jay, Caribou Springs, LLC, Gilead, ME; and SYSKO, Jim, Town of Newry, Newry, ME*

Sunday River: In July, 2008 the Town of Newry and partners installed an innovative project to stabilize 400ft of severely eroding riverbank where the Sunday River threatened to wash out the Sunday River Road. The Sunday River Road is the only access to logging, year-round residences, summer camps, a school and recreation in the Upper Sunday River Watershed. The project included installing rock vanes that protrude into the river facing upstream, and "bar buddies" which consist of an anchor tree driven into the riverbed and cabled to additional trees placed horizontally at the toe of the bank. Vanes and bar buddies deflect flows from vulnerable banks. Newry received an \$87,000 grant from FEMA's Hazard Mitigation Grant Program. The grant was matched with \$29,000-worth of locally-donated cash and volunteer labor.

Mill Brook: The Cumberland County Soil & Water Conservation District, in collaboration with numerous partners, conducted a unique stream bank restoration and habitat enhancement project in September 2007. The project stabilizes the bank, protects a home that was close to collapsing into Mill Brook due to bank erosion, and improves stream habitat and function. Rock vanes were installed and angled upstream to deflect flows away

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from the bank. Woody debris was anchored to the base of the bank and log deflectors were angled upstream, helping to turn water away from the bank during high flows.

Both the Sunday River and Mill Brook Projects are models for a new approach to stream bank stabilization in Maine. Rip-rap which was commonly used to protect eroding banks in the past has been discredited. Rock vanes provide more effective protection than rip-rap for eroding banks and are embedded in river systems so they don't wash out. Installation of vanes and bar buddies/woody debris improve aquatic habitat in ways rip-rap does not.

## Session T14:

### *Using Monitoring Data to Influence Management and Conservation of Aquatic Ecosystems*

*This session will focus on the importance of using monitoring data to inform and improve the management and conservation of aquatic ecosystems. This session will provide examples of well-designed integration of sound science into management decisions leading to tangible improvements in aquatic ecosystems. Large or long-term studies, in particular, can be difficult to sustain, but can provide invaluable information to base difficult management decisions. In other cases, discrete datasets can be the basis of good management decisions or can be used to determine if previous decisions led to desired environmental results.*



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#### SESSION CHAIR

Tom Danielson, Bureau of Land and Water Quality, Maine Dept. of Environmental Protection,  
Thomas.J.Danielson@maine.gov

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1:00 PM

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#### **SENECA LAKE, AN IDEAL NATURAL LABORATORY FOR RESEARCH, EDUCATION AND OUTREACH**

HALFMAN, John D.<sup>1</sup>, O'NEILL, Kerry<sup>1</sup>, BRIDGEMAN, Stina<sup>2</sup>, VAN STEEN, William<sup>2</sup>, and BROWN, Meghan<sup>3</sup>,  
(1) Department of Geoscience, Hobart & William Smith Colleges, Geneva, NY (2) Department of Mathematics and Computer Science, Hobart and William Smith Colleges, 3 Geneva, NY (3) Department of Biology, Hobart & William Smith Colleges, Geneva, NY

Seneca Lake, in central New York State, is an ideal natural laboratory because its major tributaries drain different basin areas, land use, bedrock geologies, physiographies, and other characteristics. Educational, research and outreach activities have provided limnological and hydrogeochemical data from the lake and its tributaries since the early 1990's. The bulk of the data were collected weekly from April through October at four sites in the northern end of the lake, and near the terminus of six major tributaries. The onsite lake data included CTD (Sea Bird SBE-25) profiles, plankton tows, secchi disk depths, and collection of surface and bottom water samples. The water was analyzed for nutrients, chlorophyll, turbidity and major ions back in the laboratory. Identical data as well as stream discharge was collected from the tributaries. We utilize this data to delineate sources of

## Session T14: Using Monitoring Data to Influence Management

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impairment, land use and water quality connections, and facilitate scientific arguments to protect, preserve and hopefully improve water quality in the lake.

Near real-time and achieved data are now available online (<http://fli-data.hws.edu>) through the purchase and deployment of an air and water quality monitoring buoy (YSI). The buoy has been deployed at a mid-lake site in 60 meters of water from April through November since June 2006. It records hourly mean meteorological data (air temperature, barometric pressure, relative humidity, light intensity, wind speed and direction) and twice-daily water quality profiles (temperature, conductivity, turbidity, and fluorescence), recording data every 1.5 m along the entire water column, and relays the data to a computer on campus. Prepackaged programs display current conditions and annual summaries. Raw data can also be user selected by date range and parameters of interest, and either viewed in tabular form or downloaded as a CSV file suitable for importing into data processing programs. Future plans include expanding the data and visualization offerings to include interactive data visualization capabilities, include earlier CTD and other data, and incorporate an expanded monitoring network to be deployed in Seneca Lake in 2009. The new equipment includes Doppler current profilers, recording thermistors and turbidity sensors, and time-series sediment traps.

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### **THE FINGER LAKES OF NEW YORK: AN IDEAL NATURAL LABORATORY FOR RESEARCH, EDUCATION AND OUTREACH**

*O'NEILL, Kerry and HALFMAN, John D., Department of Geoscience, Hobart and William Smith Colleges, Geneva, NY*

The Finger Lakes of central and western New York provide an ideal natural laboratory for research and education because they provide a range of watershed areas, water residence times, land use activities, bedrock geologies, degree of water quality protection, and other characteristics. Despite being critical sources that provide Class AA drinking water to the surrounding communities, these lakes are threatened by a variety of pollutants, most notably nutrient loading from human and agricultural sources. Thus, limnological and other water quality data are essential to monitor the health and well-being of these aquatic systems and provide recommendations to maintain the water quality in these lakes.

Monthly limnological data has been collected from the eight largest and most eastern Finger Lakes, Honeoye, Canandaigua, Keuka, Seneca, Cayuga, Owasco, Skaneateles, and starting in 2008 Otisco, from at least two mid-lake sites from May through October over the past four years. This effort is part of a water quality monitoring effort by the Finger Lakes Institute, Hobart and William Smith Colleges. The data include CTD casts (Sea Bird SBE-25) of temperature, conductivity, depth, pH, dissolved oxygen, photosynthetically active radiation, fluorescence, and turbidity, plankton tows, secchi disk depths, and collection of surface and bottom water samples. The water samples are analyzed for nutrients (total phosphate, soluble reactive phosphate, nitrate, silica), chlorophyll, total suspended solids, and major ion concentrations back in the laboratory.

The data reveal water quality trends in each lake, and comparisons between the lakes. Annual mean data from each lake are ranked, where a low ranking means small concentrations or deep secchi disk depths. Mean rankings from each lake, fortuitously, correlate with the degree of water quality protection in the watershed and most likely reflect the degree of agricultural runoff and associated nutrient loading from the watershed. Projects in Owasco, Cayuga and Seneca Lakes are examples where overall poor rankings precipitated detailed analyses of the watershed to assess sources of and propose methods to reduce water quality impairments.

## Session T14: Using Monitoring Data to Influence Management

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### **RELATIONSHIP BETWEEN CHANGES IN URBAN LAND COVER AND TRENDS IN WATER CLARITY IN FOUR TIME PERIODS FOR MAINE'S GREAT PONDS**

*TYLKA, Megan, Ecology and Environmental Science Program, University of Maine, Orono, ME and VAUX, Peter, Senator George J. Mitchell Center for Environmental & Watershed Research, University of Maine, Orono, ME*

Current studies have shown the importance of past land uses on current water quality. More information is needed to understand the relationship between water clarity and urban land cover. Changes in land use is one potential driver of changes in water clarity. Recent increases in seasonal, lakeshore development have sparked concerns regarding the management of lakeshore development and the impacts of such development on water clarity. Secchi disk trends for 2,065 Maine Great Ponds, lakes greater than 10 ha, are analyzed using Seasonal Kendall tau for four time periods (1975-2007, 1975-1986, 1987-1996, 1997-2007). Secchi trends for lakes in all time periods are mapped using ARCGIS to investigate spatial trends across broader spatial extents. We used the Retrofit Change Layer (1992-2001) NLCD to characterize changes in residential development in drainage areas surrounding the Great Ponds. Results indicated that Secchi data over 30 years may impede finding significant changes to trends because of shifting trends over time. Decade Secchi data was able to find more significant trends. Most drainage areas surrounding the Great Ponds showed no change or increases in percent urban land cover over the nine years. To better understand the importance of lagged effects of urban land cover on water clarity, the change in urban land cover is used to explain Secchi trends in different time periods. This dynamic view of water clarity integrated with changing urban land cover complements more static views of lake water quality and may provide useful tools for management.

2:00 PM

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### **DOES PALEOLIMNOLOGICAL EVIDENCE SUPPORT THE FISH REMOVAL PROJECT IN EAST POND?**

*LAKE, Bjorn, Dept. of Civil and Environmental Engineering, University of Maine, Orono, ME, AMIRBAHMAN, Aria, Dept. of Civil and Environmental Engineering, University of Maine, Orono, ME, and SAROS, Jasmine, School of Biology and Ecology, University of Maine, Orono, ME*

The frequency of nuisance algal blooms in East Pond, Smithfield Township, Maine has been increasing in the past two decades. Meanwhile, the trophic status of the hydrologically-linked, North Pond, has remained relatively constant, even though both ponds have similar morphometry and geology. In the spring of 2007, a biomanipulation project involving the removal of white perch, yellow perch, and black crappie in East Pond was started to reverse the trend of decreasing water quality. The purpose of our study was to provide a longer-term assessment (>100 years) of the trophic status of these two lakes through the use of chemical and biological components in lake sediments. A 45-cm sediment core was collected from each pond in January 2008. The cores were sectioned in 0.5-cm increments, dated by  $^{210}\text{Pb}$  analysis, and analyzed for isotopic carbon and nitrogen, diatom assemblages, and chemical phosphorus speciation. The chemical speciation data suggests that both ponds contain roughly equal amounts of phosphorus in the sediment. However, East Pond has more potential for internal loading of phosphorus than North Pond because there are higher concentrations of labile and reducible phosphorus in the top few centimeters of sediment. At the time of submission, the results from the diatom assemblages and isotopic work are still pending.

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### **RELATIONSHIPS BETWEEN CLADOCERAN SIZE STRUCTURE AND HYDROGEOMORPHIC AND TROPHIC FEATURES OF MAINE LAKES**

*WHITMORE, Elizabeth A*, School of Biology and Ecology, University of Maine, Orono, ME, *WEBSTER, Katherine E.*, Antrim, United Kingdom, and *BACON, Linda C.*, Maine Dept. of Environmental Protection, Augusta, ME

Due to their position in the middle of aquatic food chains, cladocerans are influenced by both top-down (predation) and bottom-up (nutrient) pressures. These two trophic pressures shape the size structure of the cladoceran community. In addition, hydrogeomorphic (HGM) features such as depth have also been found to influence size structure. In order to study the relationships between cladoceran size structure and lake trophic and HGM features, we looked at the size structure of cladoceran communities in 76 Maine lakes. These lakes were chosen to represent a range of depth, surface area, and location in the state. The cladoceran samples and water chemistry data came from the Maine Department of Environmental Protection. We measured the body length of adult cladocerans and calculated size spectrum metrics such as quartiles, size frequency and the Stemberger Index. The cladoceran body size spectra for our lakes varied both in size (median from 0.25 to 1.30mm and 75th quartile from 0.25 to 1.63mm) and in inter-quartile range (0.02 to 0.51mm). Size metrics were produced using non-metric multidimensional scaling (NMDS) on three sets of measures from each lake: (1) the 10th, 25th, 50th, 75th and 90th quartiles of adult cladocerans, (2) the quartiles of *Daphnia* and bosminid body length, and (3) size frequency within 0.2mm interval bins. We calculated correlations between the resultant NMDS axes and HGM features (depth, elevation, and pH) and trophic status (TP and chlorophyll). The only significant correlations between body size NMDS axes and the lake features were for elevation and depth ( $p < 0.05$ ). We will further investigate the effects of HGM and trophic features (including invertebrate predator density and fish community characteristics) through multiple linear regression. Our results will be used to develop a tool that allows lake managers to use cladocerans as an indicator of how food web configuration influences lake trophic status of Maine lakes.

2:40 PM BREAK

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3:00 PM

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### **APPLICATION OF LONG-TERM BIOLOGICAL MONITORING DATA IN MANAGING WATER QUALITY OF MAINE'S STREAMS AND RIVERS**

*DANIELSON, Thomas J.*, Bureau of Land and Water Quality, Maine Dept. of Environmental Protection, Augusta, ME

The Maine Department of Environmental Protection (MDEP) is responsible for managing the water quality of the State's stream and rivers. MDEP has accumulated 35 years of data on benthic macroinvertebrate communities from across the state. Macroinvertebrates are animals without backbones that can be seen without magnification, such as crayfish, snails, mayflies, stoneflies, and caddisflies. Over the years, MDEP has used the data to identify waterbodies that did not attain water quality goals, develop restoration plans, and document the recovery

## Session T14: Using Monitoring Data to Influence Management

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of waterbodies. MDEP has also used the data to adjust pollution discharge limits, flow requirements downstream of dams, and other permits. Long-term data have been used to propose upgrades in class for waterbodies that exceed water quality goals. The accumulation of hundreds of samples led to the development of a statistical model that predicts attainment of class AA/A, B, or C water quality goals based on macroinvertebrate community composition. More recently, MDEP has used the large data set to build statistical models to infer water quality parameters, such as total phosphorus, based on the composition of biological communities. The inference models will be useful for determining likely causes responsible for impairing streams and rivers and documenting incremental improvements in water quality.

3:20 PM

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### **RECREATION TRAILS AND WATER QUALITY: ARE RECREATION TRAILS DEGRADING STREAM QUALITY?**

*WILKERSON, Ethel, Manomet Center for Conservation Sciences, Brunswick, ME*

The U.S. Forest Service identified public recreation as one of the four greatest threats to forested landscapes. To quantify the ecological impact of recreation trails we sampled 112 trail segments (55 motorized, 26 non-motorized, 31 non-mechanized) in Maine and New Hampshire. Where recreation trails crossed stream channels we recorded the crossing structure (culvert, bridge, or ford) and assessed sediment inputs and habitat connectivity. Sediment inputs were classified as none, trace (visible, but minor), measurable (forms sediment fan), and catastrophic (significantly alters stream morphology). We found that 38% of stream crossings had no sediment inputs, 29% of crossing had trace sediment inputs, and 24% had measureable inputs. The 9% of stream crossings with sediment additions classified as catastrophic included trails of all use types- non-mechanized (2%), non-motorized (2%), and motorized (5%). The majority of trails (7%) with catastrophic sediment additions were on streams 1-2m in width. Stream crossing structures (bridges and culverts) can cause interruptions in natural stream substrate, abrupt changes in stream elevation, or significant reductions of water depth or flow that would interrupt or impede movement of aquatic organisms. On the recreation trails we sampled 26% of stream crossings were classified as restricting habitat connectivity. Of the crossings with connectivity issues the majority (24%) occurred on streams less than 5m wide. The results of this study have direct implications for trail managers and land owners. All trail types (motorized, non-motorized, and non-mechanized) were found to contribute sediment to streams and degrade stream quality. Small streams were found to be particularly vulnerable to sediment inputs and migration blockages. These streams may be simply overlooked by managers and/or financial resources may be directed to infrastructure on larger streams. However, they are a critical part of aquatic ecosystems and must be managed appropriately.

3:40 PM

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### **INVENTORYING AND PRIORITIZING FISH PASSAGE BARRIER REPLACEMENTS**

*KANOTI, Keith, Maine Forest Service, Augusta, ME and ABBOTT, Alex, Gulf of Maine Coastal Program, Falmouth, ME*

Tens of thousands of miles of streams flow throughout the State of Maine. Most of these streams are intersected by a network of thousands of miles of roads crossing over bridges and culverts. Culverts at road-stream crossings have the potential to limit the movement of fish just as much as dams and both can have a significant impact on natural processes. In order to reconnect riverine habitats for many aquatic and terrestrial species across Maine, efforts are underway to survey and remove barriers to their movement.

## Session T14: Using Monitoring Data to Influence Management

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Replacement and upgrading of culverts that are barriers to fish passage can be very costly. To effectively restore fish passage, managers of road systems not only need to know which crossings are blocking passage but where to target resources so that maximum habitat benefit can be obtained from each replacement. This project developed a Maine Road-Stream Crossing Survey protocol that was used by Maine Forest Service field crews and volunteers to survey over 1,000 road crossings in the lower and mid-Penobscot River watershed to assess barriers to fish passage. Field data was imported to an ESRI Personal Geodatabase (a spatially-aware Microsoft Access database) as a table, and then reformatted and edited to correct errors and make records consistent. Based on field and other data sources, crossings were rated as severe barriers, moderate barriers or adequate fish passage crossings. Barriers were then prioritized for removal based on their position in the stream (the lowest barrier on the stream was considered highest priority), the potential length of stream that would be restored by barrier removal, and whether the stream supported diadromous fish habitat. An atlas with all surveyed sites and barrier rankings was produced and priority data were provided to towns in the survey area.

4:00 PM

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### **WATER QUALITY INFORMATION FOR DECISION SUPPORT: A TALE OF TWO DATASETS**

*PECKENHAM, John, Senator George J. Mitchell Center for Environmental & Watershed Research, University of Maine, Orono, ME*

Water quality data can be collected from diverse sources to inform decision making. Two examples are presented: (1) surface water chemistry for drinking water sources, and (2) groundwater chemistry for rural towns relying on private water sources. Public water suppliers are obligated to monitor water quality and collectively have generated an extensive and high-quality time-series for geographically unique locations. In Maine there are 45 water utilities that use 49 surface water sources (lakes, ponds, rivers, and streams). A sub-set of these sources has been analyzed to demonstrate the presence of regional water chemistry gradients that are associated with watershed processes and the formation of disinfection by-products. This knowledge can be used by utility managers to help manage finished water quality. The second project uses groundwater quality results generated from a current citizen-scientist project (GET WET!). Students analyzed drinking water from their home wells to develop a spatial analysis of water chemistry at a town scale. The local community has applied this knowledge in local land use management. Repeated testing in specific towns will lead to the ability to analyze the time varying nature of groundwater chemistry.

## Session T15

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### *Competitive Demands for Groundwater Resources in the Northeast Survey*

*Groundwater issues have increased in scope and complexity as competing demands on the resource have grown. As these demands continue to increase in the Northeastern US and Eastern Canada, water managers, regulators, and municipalities are under increasing pressure to provide equitable management strategies for these resources. Increasingly important to effective management is the analysis of cumulative withdrawals of ground water within a watershed or regional aquifer system, and the balancing of these withdrawals with instream flow needs, for aquatic life and the dilution of point and nonpoint pollution sources. This session will focus on the analysis of cumulative withdrawals within a watershed or aquifer system, particularly in complex hydrogeologic environments, and the development of tools and strategies for the management of competing ground water uses.*



### SESSION CHAIR

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Martha Nielsen, USGS , Maine Water Science Center, [mnielsen@usgs.gov](mailto:mnielsen@usgs.gov)

8:00AM

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#### **GROUNDWATER MANAGEMENT IN THE LIVE FREE AND DIE STATE**

*KERNEN, Brandon M., New Hampshire Department of Environmental Services, Concord, NH*

The State motto for New Hampshire is “Live Free or Die.” Despite its motto, nobody in New Hampshire may develop a new groundwater withdrawal that exceeds 57,600 gallons a day without initiating a public participation process and completing extensive and sometimes costly testing. New Hampshire also receives approximately 44 inches of rain a year, and has more than 1,300 lakes, ponds and reservoirs which cover approximately 280 square miles of the State. Yet, even in New Hampshire, the management of water resources to protect competing water users, the environment and future water needs of the state is one of the most hotly debated topics in the State.

Proposed large groundwater withdrawals from stratified drift aquifers with limited extents and crystalline bedrock aquifers in close proximity to private residential wells, community water supplies, sensitive wetlands resources and stressed rivers have required that the State to develop laws, regulations, and procedures for detailed impact assessments. State laws and regulations have developed a process whereby any entity developing a new large

## Session T15 : *Competitive Demands for Groundwater Resources*

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groundwater withdrawal must identify all potential water users and resources that may be adversely impacted by a large groundwater withdrawal and complete extensive testing to assess the potential for adverse impacts to occur. This talk will describe New Hampshire's past, present, and possibly future approach to managing groundwater withdrawals and water resources.

8:20AM

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### **EMPIRICAL METHODS FOR ESTIMATING AND PROJECTING WATER USE IN THE SEACOAST REGION, SOUTHEASTERN NEW HAMPSHIRE**

*HORN, Marilee A., U.S. Geological Survey, Pembroke, NH*

New methods were developed to estimate water use in the Seacoast region in southeastern New Hampshire for 2003 and project future water demand in 2017 and 2025 as part of a regional ground-water availability study. The methods focused on estimating 2003 water demand as the basis for determining withdrawal, delivery, consumptive use, release into sewers, return flow, and transfer by users at the census-block and town scales. Measurements of withdrawal and return flow, where available, were used to check the validity of the demand estimates.

Domestic water demand was estimated using a per capita water demand model that related metered deliveries to domestic users with census block and block-group data. The model was used to predict annual, summer, and winter per capita water-demand coefficients for each census block. Using data from the 2000 U.S. Census, significant predictors of domestic water demand include population per housing unit, median value of owner-occupied single family homes, median year of housing construction, population density, housing unit density, and proportion of housing units that are in urban areas. The mean annual domestic per capita water-demand coefficient in the Seacoast region was 75 gal/d; the coefficient increased to 91 gal/d during the summer and decreased to 65 gal/d during the winter. Domestic consumptive use was estimated as the difference between annual and winter domestic water demand. Estimates of commercial and industrial water demand were based on coefficients derived from reported use and metered deliveries. A relation was established between current commercial and industrial employee numbers and water demand. Projections of domestic, commercial, and industrial water demand in 2017 and 2025 were determined by using the housing and employee projections for those years developed through a privately-developed Transportation Demand Model and applying current domestic and non-domestic coefficients.

Domestic water demand is projected to increase by 54 percent from 19.0 Mgal/d to 28.7 Mgal/d from 2003 to 2025 based on projection of future population growth. Non-domestic (commercial, industrial, irrigation, and mining) water demand is projected to increase by 66 percent from 7.3 Mgal/d to 11.8 Mgal/d from 2003 to 2025.

8:40AM

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### **DECISION-SUPPORT TOOL TO ASSESS WATER AVAILABILITY AT UNGAGED SITES IN MASSACHUSETTS.**

*ARCHFIELD, Stacey A.<sup>1</sup>, VOGEL, Richard M.<sup>2</sup>, STEEVES, Peter A.<sup>1</sup>, BRANDT, Sara L.<sup>1</sup>, WEISKEL, Peter K.<sup>1</sup>, and GARABEDIAN, Stephen P.<sup>3</sup>, (1) Massachusetts-Rhode Island Water Science Center, U.S. Geological Survey, Northborough, MA, (2) Civil and Environmental Engineering, Tufts University, Medford, MA (3) Silvio O. Conte Anadromous Fish Research Laboratory, U.S. Geological Survey, Turners Falls, MA*

Federal, State and local water-supply, regulatory, and planning agencies require easy-to-use, technically defensible decision-support tools that can evaluate the effects of existing and proposed water withdrawals, compute

## Session T15 : *Competitive Demands for Groundwater Resources*

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flow statistics, evaluate baseline streamflow conditions needed for sustaining the health of the ecosystem, and estimate inflows to drinking-water-supply reservoirs for safe yield analyses at ungaged locations. In cooperation with the Massachusetts Department of Environmental Protection, an interactive, point-and-click decision-support tool was developed in combination with a geographic-information system to address these needs.

This decision-support tool estimates unregulated and regulated daily streamflow at any user-selected location along a perennial stream in Massachusetts. Users can estimate water availability and test water-management scenarios for an ungaged basin by comparing estimated streamflows to user-specified, time-varying ecological-flow targets or by simulating changes in water use at individual withdrawal points. A spatially-referenced database of ground- and surface-water withdrawals, ground-water discharges, and National Pollutant Discharge Elimination System (NPDES) return flows was populated statewide. For a user-selected basin, the effects of ground- and surface-water withdrawals and discharges are subtracted and added, respectively, from the unimpacted, daily streamflow to obtain a time series of regulated, daily streamflow at an ungaged location. Users also have the option to apply an analytical solution to time-varying ground-water withdrawals and discharges that considers the effects of the aquifer properties on the timing and magnitude of streamflow alteration by water use. New methods were developed to estimate unregulated, daily flow-duration curves and time series of streamflows at ungaged sites. Estimated unregulated and regulated daily streamflows show good agreement with observed unregulated daily streamflows and compare reasonably well with the results obtained from a calibrated rainfall-runoff model.

9:00AM

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### **ESTIMATED EFFECTS OF GROUND-WATER WITHDRAWALS ON STREAM-WATER LEVELS OF THE PLEASANT RIVER NEAR VREBO FLATS, MAINE, JULY 1 TO SEPTEMBER 30, 2005**

*DUDLEY, Robert W. and STEWART, Gregory J., U.S. Geological Survey, Augusta, ME*

In 2006 the U.S. Geological Survey (USGS) analyzed available surface-water data collected at two USGS streamflow-gaging stations located on the Pleasant River near Crebo Flat, Maine to determine whether withdrawals from an irrigation well near the river were affecting streamflows. The study demonstrated how streamwater levels measured at the nearby streamflow-gaging stations related to ground-water withdrawals during the summer of 2005 and provided a way to estimate the related short-term streamflow depletion. The data, methods, and results presented are a case study in the consideration of the effects of irrigation withdrawals on streamflows from wells in similar stream-aquifer systems in Maine. This study is documented in USGS Scientific Investigations Report 2006–5268 available online at <http://pubs.usgs.gov/sir/2006/5268/pdf/SIR2006-5268.pdf>

9:20AM

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### **LAND USE ASSESSMENT OF HIGH YIELD SAND AND GRAVEL AQUIFERS IN MAINE**

*HOLDEN, Mark,, and HOPECK, John; Bureau of Land and Water Quality, Maine Department of Environmental Protection, Augusta, ME*

This study assesses the cumulative impact of residential, commercial, and industrial development on 300 of the significant (>50 gpm) sand and gravel aquifers defined and mapped by the Maine Geological Survey. The method provides a relative comparison of the risk of adverse impact through the Aquifer Quantitative Use Assessment, or AQUA, Index. Non-point source risks due to population and travel corridors are treated as a function of the density of impervious surface in the aquifer polygon, by subtracting the total road covered or road

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salt influenced acreage (75 foot buffer from centerline) from the total number of acres of an individual aquifer. The balance of the remaining acreage was divided by a factor based on the presence and relative risk of petroleum tanks (underground/aboveground storage tanks (USTs or ASTs)), former tank locations (i.e. possible legacy of contamination) and potential or actual sources of contamination to groundwater (as derived from Environmental Geographic Analysis Database (EGAD) Site Data). The resulting number, still in units of acres, is divided by the original acreage to give the dimensionless AQUA index, which can also be expressed as a percent. An AQUA index of 1 or 100% means no impact. In general, larger overall acreage in combination with remoteness or other limits on development result in a higher AQUA index. This index may be used to assess the relative risk to future or present municipal, private, or commercial drinking water uses and to identify those aquifers most at risk from commercial/industrial development or residential pressures. Overall, 77 high yield aquifer locations (26%) are non-impacted (4,881 acres or 16% of total acres), 145 (48%) are less than 50% impacted (8,540 acres or 29% of total acres), and 78 (26%) are more than 50% impacted (13,325 acres or 55% of total acres (29,746)). Of the non-impacted high yield sand and gravel aquifers, 18% have public water supply wells. Of the aquifers with AQUA values between 1.0 and 0.5, 28% have public water supply wells, while of those with AQUA values less than 0.5, 38% have public water supply wells.

9:40AM

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### **GROUNDWATER FLOW MODELS AS A WATER RESOURCE MANAGEMENT TOOL**

*HOUSE, Jason, Woodard & Curran, Portland, ME*

In many regions facing much tighter groundwater supplies than the northeastern U.S. and eastern Canada groundwater flow models are routinely developed to help water managers, regulators and municipalities better understand the demands placed on groundwater resources. Some water-poor states in the southern U.S. have even implemented permit and annual reporting requirements for withdrawals, which allows them to continually update the models. While this is an extreme approach that may not be appropriate for every region, it does illustrate the power of groundwater flow models to help balance competing demands for water resources.

Groundwater flow models are used to understand the following:

1. The water budget for a groundwater basin.
2. The interaction of groundwater and surface water using data on all water bodies and their behavior, including seasonal water gains and losses.
3. Natural resources' dependency on water levels.
4. The impact of withdrawals on other water users.
5. The nature and amounts of recharge to an aquifer.

Together, understanding these and other aspects of the model allow the modeler to create a detailed picture of how groundwater moves within a watershed, and how it interacts with natural resources, water bodies, and human users who rely on it. Once established, the model can be used to understand the effect of a change in conditions, such as diversion of flows or changes in precipitation.

This presentation will discuss the data required to develop a groundwater flow model, best practices for keeping the model up to date, and lessons from water-stressed regions that can be applied in the northeast U.S. and Eastern Canada.

## Session T15 : *Competitive Demands for Groundwater Resources*

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10:00AM

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### **FIPY FOR HYDROLOGISTS? A FLEXIBLE TOOL FOR COMPUTER MODELING OF HYDROLOGIC PROCESSES**

*REEVE, A.S., Department of Earth Sciences, University of Maine, Orono, ME , WHEELER, Daniel, Center for Theoretical and Computational Materials Science, National Institute of Standards and Technology, Gaithersburg, MD and GUYER, Jonathan E., Center for Theoretical and Computational Materials Science, National Institute of Standards and Technology, MD*

FiPy is a computer simulations library that solves partial differential equations using the finite volume method. FiPy was developed at the National Institute of Standards and Technology to simulate material science processes, but can be used to simulate a variety of hydrologic processes including surface-water flow, ground-water flow, and solute transport. While most ground-water practitioners interested in computer modeling rely on a small set of software developed specifically for ground-water flow, FiPy represents a flexible alternative to these 'canned' packages that bridges a gap between writing computer code to solve a problem and using one of the common ground-water modeling systems. FiPy has been applied to three different ground-water problems, providing an overview of the utility of FiPy to the hydrologic community. In the first example, a flownet for a simple two-dimensional ground-water flow problem is created to highlight the basic components of a FiPy model. The simulation of a pumping test and calibration to associated field data is used in the second example to estimate hydraulic conductivity in an aquifer. Solute transport and ground-water flow are simulated in the last example to assess results from an ongoing tracer test within a Maine peatland. These examples showcase FiPy's ability to solve a wide variety of hydrologic problems and its capability to link different hydrologic processes within a multi-physics framework.

## Session T16: State of Maine's Environment

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### *State of Maine's Environment*

*This session highlights ongoing water-related research in Maine, including presentations on the consequences of climate change on water resources, practices for restoring the quality of Maine's urban impaired streams, and a comparison of brook trout populations in Maine's lakes and streams from a regional perspective.*



### SESSION CHAIR

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John Peckenham, Senator George J. Mitchell Center for Environmental & Watershed Research, University of Maine, [jpeck@maine.edu](mailto:jpeck@maine.edu)

10:20 AM

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#### **CLIMATE CHANGE AND PRACTICES AT MAINEDOT**

*GATES, Judy, and HEBSON, Charles, Environmental Office, MaineDOT, Augusta, ME*

It is now generally accepted that climate is changing. Regardless of the “how” and “why” of climate change, it is becoming apparent that a variety of MaineDOT practices should be reviewed for continued viability in a changing climate. The science of climate change can provide some indication of potential changes in Maine's precipitation climate, but it is up to MaineDOT policy makers and engineers to adjust MaineDOT practices accordingly. One area of concern is the effect of climate change on MaineDOT's hydraulic structures. Anecdotally we hear that we have been experiencing 100-year events annually for the past few years. MaineDOT is working with U.S. Geological Survey to see if, in fact, design events are getting bigger. Hydraulic design and associated policies may change as a result. An on-the-ground reality is that most transportation drainage structures and bridges are designed to last from 20 to 100 years, so in many cases the opportunity to size for long-range increased flows is immediate while specific environmental outcomes are still unknown. Without knowing for sure whether projections are conservative or extreme, MaineDOT needs to use the best available science to estimate the need to change current practice in anticipation of increased duration, volume, or frequency of flows. We have opted to go forward with assessing whether our current practices and policies are adequate to respond to a range of future hydrologic changes.

## Session T16: State of Maine's Environment

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10:40 AM

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### **PLANNING FOR CLIMATE CHANGE IN THE CASCO BAY REGION**

*BOHLEN, Curtis, Casco Bay Estuary Partnership, University of Southern Maine, Portland, ME*

Planners, engineers, developers and local officials make decisions that shape our landscape for decades to come. Despite consensus among scientists about the existence of anthropogenic climate change and a growing understanding of its indirect impacts, those local decisions are often made without taking climate change into consideration. Decisions made today that fail to consider climate change risk inadvertently increasing both environmental and social costs of adaptation to climate change. Casco Bay Estuary Partnership has initiated an effort to support climate-aware decision making at the local level. The first steps in this effort consists of gathering information on both documented changes in climate and predicted changes for the future, and beginning to look at the probable impacts of sea level rise on coastal communities and coastal resources. As the program evolves, the focus will turn increasingly towards developing outreach mechanisms to better incorporate an awareness of climate change into present-day decisions.

11:00 AM

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### **IMPERVIOUS SURFACE ANALYSIS FOR SELECT URBAN IMPAIRED WATERSHEDS IN MAINE**

*CANNON, LaMarr, Maine NEMO Program, Partnership for Environmental Technology Education, South Portland, ME and HAZELTON, Eric L.G., Hazelton Ecological Associates, Portland, ME*

The Maine Non-Point Source Education for Municipal Officials Program (NEMO) is part of the national NEMO network protecting natural resources in 31 states. NEMO educates decision-makers on the relationship between land use, natural resource protection and water quality. A major focus of the NEMO outreach program conveys the impacts of impervious surfaces (IS) on water quality. Here we present the results of IS buildout assessments from four watersheds in Maine conducted for the Maine Department of Environmental Protection as part of the impervious cover TMDL. We discuss data collection and creation, analysis methods and results. Data quality and availability varied by town and watershed, and we adapted our methods according to what was available. Towns with well developed GIS infrastructures (zoning and planning data) and complete cadastral data were easy to assess. Our methods also depended on the size of the watershed, smaller watersheds required greater positional accuracy and resolution. Large watersheds could be assessed using satellite-derived data (from MEGIS). Smaller watersheds required digitizing existing IS. We determined the average IS for each zoning type and, using potential buildout scenarios provided by each town, we predicted the watershed IS after future development. Where possible, we considered potential subdivisions, development proposals and other community-provided information (at times hand-drawn). Town cooperation and data availability heavily influence our assessments. The completed IS analysis was integrated into town presentations to educate municipal officials on the impacts of IS on water bodies and water quality, and methods of low impact development (LID) that can be used to mitigate impacts. The presentation includes the effects of extending the channel forming flow with traditional detention basin treatment of stormwater, examples of LID, and cost comparisons between traditional development and LID.

11:20 AM

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### **A COMMUNITY-BASED COLLABORATIVE APPROACH TO RESTORING LONG CREEK**

*DILLON, Fred, FB Environmental Associates, Portland, ME and HENDERSON, Zach, Woodard and Curran, Portland, ME*

## Session T16: State of Maine's Environment

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The Long Creek watershed is located in the communities of South Portland, Westbrook, Scarborough and Portland in one of the most heavily urbanized areas of the state. Impervious cover (IC) in some of Long Creek's subwatersheds exceeds 50% and overall IC in the watershed is nearly 30%. Consequently, Long Creek and its tributaries do not meet water quality classification standards. The types of stream classification violations include metals, chloride, dissolved oxygen, macroinvertebrates, and brook trout. Reports by the Maine DEP in 2002 and EPA in 2007 both identified IC as the primary factor in Long Creek's degradation.

A watershed management plan was completed recently for Long Creek to serve as a road map for restoration by addressing numerous specific impacts on the aquatic environment from the surrounding built environment. Restoration recommendations include retrofitting and installing a variety of structural stormwater treatment systems; implementing nonstructural Best Management Practices (BMPs) to improve pavement and landscape management; encouraging local ordinance revisions to provide greater protection of water resources; re-vegetating extensive areas along the riparian corridor; improving geomorphology through floodplain restoration; and partnering with local land conservation organizations to publicly promote the "greening" of the watershed, among others. To lay the groundwork for this ambitious effort, an extensive (and intensive) stakeholder involvement process was employed over the course of 18 months culminating in the completion of the Watershed Management Plan. A community-based collaboration collectively referred to as the "Long Creek Restoration Project" engaged individuals from a wide variety of interests and perspectives. Participants included representatives from state and municipal government, local businesses and property owners, state transportation agencies, and conservation organizations, among others. In addition to being primary authors of the Watershed Management Plan, the presenters were both closely involved with the stakeholder process through the coordination of the Technical Advisory Committee, which was charged with helping to guide the development of restoration recommendations.

11:40 AM

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### **CURRENT STATUS OF NATIVE/WILD BROOK TROUT IN NEW ENGLAND FRESHWATERS**

*HALLIWELL, David, Maine Dept. of Environmental Protection, Augusta, ME and GALLAGHER, Merry, ME Dept. of Inland Fisheries and Wildlife, Bangor, ME*

According to the EBT-Joint Venture (2005), brook trout were once plentiful in North America's aquatic habitats from Georgia to Newfoundland (Canada), and as far west as Ohio. We surveyed state fishery biologists in New England to determine their current status within large rivers, wadeable streams, coastal streams, and lakes/ponds. Brook trout appear to have declined from larger rivers, and primarily persist in several larger Maine rivers. Brook trout are still found in hundreds of smaller wadeable streams in all six New England states, ranging from 15% (CT) to 75% (NH) of surveyed streams (average 39%: 50% VT, 30-36% ME, MA, RI). Anadromous (*salter*) brook trout in coastal streams are less common, occurring in only five streams in Massachusetts, 10 streams in Rhode Island, and 65 (historical) streams in Maine. With the exception of less than a dozen Vermont lakes, wild brook trout still persist in 706 Maine lakes/ponds (10% of surveyed waters). The presence of native brook trout in numerous Maine lakes, and their overall absence in New England lakes, is a topic for further investigation. Brook trout declines within New England aquatic habitats are due to a combination of logging, land use change, development, warmer water temperatures and the deleterious effects of introduced fish species.

## Session T18

### *Poster Session*

*The Senator George J. Mitchell Center for Environmental and Watershed Research and the U.S. Geological Survey have sponsored a juried student poster exhibition at the Maine Water Conference since 2000. Winners receive a cash award and their names are engraved on a plaque housed at the Mitchell Center. There are separate competitions for high school, undergraduate and graduate students.*

*Abstracts for this session will address the chemical, biological, hydrological, and geochemical aspects of surface and ground waters, and their policy and economic implications.*

*Student presenters are indicated in bold type.*



### SESSION CHAIR

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Ruth Hallsworth, Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, hallsworth@maine.edu

### BOARD 1 - Graduate

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#### **HYDRAULIC AND GEOMORPHIC EFFECTS OF LARGE WOODY DEBRIS ADDITIONS TO THE NARRAGUAGUS RIVER WATERSHED, COASTAL MAINE**

**JOHNSON, Elizabeth A.**, Department of Geology and Geophysics, Boston College, Chestnut Hill, MA, and **SNYDER, Noah P.**, Geology and Geophysics, Boston College, Chestnut Hill, MA

Maine coastal rivers are important to current ecologic and geomorphic research because they host the last remaining runs of endangered anadromous Atlantic salmon in the U.S. Atlantic salmon populations have declined over the last few hundred years with returning adults decreasing from ~500,000 in the 1880s to ~1,000 in 2000, and presently occur only in Maine from the Kennebec River to the Canadian border. Recent restoration studies have added large woody debris (LWD) to small tributaries to improve salmon rearing habitat. We study the effects of LWD additions in early August 2008 on hydraulics and substrate in Baker Brook, a west-flowing

## Session T18: Poster Session

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tributary of the Narraguagus River. We focus on the treatment reach nearest the confluence with the Narraguagus River (Baker1). The study site is divided into two reaches, treatment (Baker1-T) and control (Baker1-C). These are further divided into four sub-reaches based on channel gradient (~1% in Baker1-C-Flat and Baker1-T-Flat; >2% in Baker1-C-Steep and Baker1-T-Steep). The control sub-reaches allow us to quantify uncertainty because the degree of observed post-treatment changes will not depend on added LWD; changes in the treatment sub-reaches must be larger than those in the control sub-reaches to be deemed significant. We seek to answer three research questions: (1) how much does mean velocity through the study sub-reaches change as a result of additions; (2) how much does hydraulic roughness change; and (3) does sediment storage and sorting result from the LWD additions? We measured reach-average velocities ( $U_{reach}$ ) using the salt dilution method in May, July and August 2008. We use rating curves to compare the post-treatment to the pre-treatment  $U_{reach}$ -stage relationship. Preliminary results on treatment-related changes in  $U_{reach}$  are inconclusive because we do not yet have enough post-treatment velocity data collected at the same stage as the pre-treatment measurements. We quantified sub-reach substrate median grain size with intensive clast counts in July 2008; these will be repeated post-treatment in May 2009. Analysis of pre-treatment substrate size show that the flat sub-reaches have a finer substrate size (34-38 mm) than the steep sub-reaches (88-134 mm). Comparison analysis of data gathered in May-August 2008 with additional post-treatment data collected in May 2009 will allow us to assess the effects of added LWD in Baker Brook.

### BOARD 2 - Undergraduate

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#### **USING "LEGACY SEDIMENTS" TO DETERMINE PAST LAND USE CHANGES AND FUTURE SEDIMENT RELEASE IMPACTS ON DOWNSTREAM ECOSYSTEMS: YELLOW BREECHES CREEK WATERSHED, CUMBERLAND COUNTY, PA**

*HAYNES, Courtney E. and NIEMITZ, Jeffrey W., Dept. of Geology, Dickinson College, Carlisle, PA*

Over the last 250 years, thousands of mill dams in south central PA have accumulated sediments and included pollutants (nutrients and trace elements) due to changes in land-use over time. Ironically these so-called "legacy sediments" (Walter and Merritts, 2008) are currently being released back into streams by dam removal to improve stream ecology. Depending on surrounding land use, these sediments can contain elevated levels of nutrients, organic compounds, and/or bio-available trace elements. Here we present comparative geochemical and sedimentological data at two legacy sediment sites within the Yellow Breeches Creek (YBC) watershed, Cumberland County, PA. The Eaton-Dikman Pond (EDP) site is contained within forested land use and the Wittlinger Dam (WD) site within agricultural land use.

Thirty-one sediment cores were collected from the 91,000 m<sup>2</sup> EDP site, and ten cores from the 15,000 m<sup>2</sup> WD site. Using core depths and GIS, total volume of legacy sediments at the two sites is estimated. Magnetic susceptibility, inorganic and organic carbon, and grain size analyses reveal two very different stratigraphies. The EDP site has large volumes of sand with iron ore slag and charcoal derived from forest clear cutting for the local iron industry in the late 18th and early 19th centuries. These sand bodies are between overlying silty clays and soil horizons and underlying basal wetland hydric soils and sandstone and metavolcanic bedrock. The WD site contains exclusively silty clay on sandstone colluvium and underlying carbonates. XRD analyses of core facies mirror bedrock sources. XRF analyses show significant differences in nutrient and trace elements. Total phosphorus is double at WD over EDP confirming agricultural inputs. REE's are enriched over average shale in both sites. Transition metals (Cd, Co, Cu, Ni, Pb, Zn) are 2-3 times more enriched at WD than EDP especially in the upper half of the cores suggesting airborne as well as agricultural sources of pollution.

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Weekly water samples were collected at both sites to determine the dissolved and suspended load release relative to discharge after dam removal. Preliminary data indicate that the majority of stream load release is caused by episodic discharge events and stream bank slumping. These data are compared to an 11-year record from another site on the YBC.

### BOARD 3 - Undergraduate

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#### **ZOOPLANKTON POPULATION ANALYSIS AND BODY LENGTH MEASUREMENT IN DAMARISCOTTA LAKE, MAINE IN RELATION TO ALEWIFE POPULATIONS**

**BLAIR-GLANTZ, Spencer**, *Department of Environmental Science, University of Southern Maine, Portland, ME*, **WILSON, Karen**, *Department of Environmental Science, Univ. of Southern Maine, Portland, ME* and **WILLIS, Theodore V.**, *Aquatic Systems Group, University of Southern Maine, Portland, ME*

The purpose of the study was to analyze the impact of predation from juvenile alewives (*Alosa...*) on zooplankton population numbers and overall body size, to determine if predation primarily affects the larger-bodied zooplankton groups, driving down their populations and allowing other groups to flourish. Zooplankton groups in Damariscotta Lake, Maine, collected on 5 monthly sampling dates (June to October 2008) and identified, counted, and measured for body length. Eight zooplankton groups were identified and measured: *Cyclopoida*, *Calanoida*, *Daphniidae*, *Bosmina*, *copepod nauplii*, *Asplanchnidae*, *Conochilus*, and *Holopedium spp.* All zooplankton groups changed in abundance over the duration of the study period. *Daphniidae* in particular were affected by alewife predation; initially abundant, their populations dropped dramatically soon after the appearance of alewife juveniles. Average body length also dropped somewhat over the five month span. *Copepod nauplii* had a large population increase, as well as a small increase in average body size. Interestingly, zooplankton dynamics in Damariscotta Lake varied by lake basin, with zooplankton consistently more abundant and larger in the main (north) basin than in the Muscongus basin (south).

Changes in zooplankton abundance and length correspond to the time of the summer that juvenile alewives would be expected to consume larger zooplankton. Differences between basin may be related to basin morphology, differential usage by juvenile alewives, or productivity.

### BOARD 4 - Graduate

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#### **MERCURY AND METHYLMERCURY DYNAMICS IN THE SEDIMENTS OF THE GREAT BAY (NH) AND PENOBSCOT RIVER (ME) ESTUARIES**

**BROWN, Lauren E.**<sup>1</sup>, **AMIRBAHMAN, Aria**<sup>1</sup>, **VOYTEK, Mary A.**<sup>2</sup>, and **CHEN, Celia Y.**<sup>3</sup>, (1) *Dept. of Civil and Environmental Engineering, University of Maine, Orono, ME* (2) *US Geological Survey, Reston, VA* (3) *Department of Biological Sciences, Dartmouth College, Hanover, NH*

Due to the significant sedimentation of river-borne particulate matter in estuarine systems, these zones act as repositories for particulate contaminants including Hg. The sediments of estuaries and salt marshes have a high degree of geochemical variability, especially with respect to sulfate and organic matter, and are subject to significant fluctuations in water level, oxygen and salinity that result in redox transitions in the zone close to the sediment-water interface (SWI). We performed pore water and sediment chemical and molecular analyses to study Hg cycling in the Penobscot River estuary (ME) and Great Bay (NH) sediments. In Penobscot we studied the mudflats, and in Great Bay we studied the mudflats and a salt panne. We observed a correspondence between the abundance of sulfate-reducing bacteria (SRB) and solid-phase and pore-water MeHg concentrations. These

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concentrations and the SRB density reached a maximum close to the SWI in the mudflats. In addition, intact sediment cores were collected from Penobscot River and the location of the redoxcline was manipulated by altering the ponding regimes of the overlying water on the cores. Induced shoaling of the redoxcline was observed in the absence of any active aeration, which corresponded to the shoaling of the net MeHg production zone. These results corroborated our field observations in the salt panne, where ponded water resulted in the shoaling of the redoxcline as well as the maximum sediment MeHg concentration. Based on this, environments such as salt pannes are likely to be Hg methylation and release hotspots in estuaries.

### BOARD 5 - Undergraduate

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#### **INVESTIGATING HUMAN INFLUENCE ON NUTRIENT LEVELS IN THE MACHIAS RIVER ESTUARY IN MACHIAS, ME**

**CORBETT, Jacqueline** and **OTTO, William**, *University of Maine at Machias, Machias, ME*

Estuaries are diverse habitats, supporting fisheries important to the economy of Maine. Pollution caused by water treatment plants can threaten the water's quality. A municipal waste water treatment plant dumps into the mouth of the Machias River estuary. This study investigates whether this plant is affecting the growth of biota downstream. One component was to measure soft-shell clam (*Mya arenaria*) growth rates over time, tidal height, and exposure to predation. The second component was to determine nutrient levels to which the clams were exposed.

To determine water quality, one-liter samples were collected at three sites down stream from the plant May through December of 2008. Samples were also collected at sites in a control estuary from the Pleasant River in Addison, Maine. The samples were vacuum filtered, and total suspended solids were determined. Salinity was measured using a hand refractometer. The samples were then analyzed for phosphates, nitrates, and nitrites using a Lachat Quick Chem 8500.

Our results show low levels of phosphates, nitrites, and nitrates for all sampling. The recommended level of phosphorous in estuaries is below 0.01 mg/L and below 0.1 mg/L of nitrogen (NOAA/EPA,1988). Our concentrations never exceeded these levels, but were below for several samples. Samples at varying tidal heights were analyzed, however no significant difference was detected.

Early salinity measurements were lower than expected. Our initial working hypothesis was that a lateral separation between fresh and salt water existed in these estuaries. Based on salinity data during the summer, this hypothesis was questioned. Depth samples were collected and analyzed and salinity was much higher in both estuaries. This vertical separation of fresh and salt water caused us to revise our hypothesis. Since early samples were surface water samples, they were not representative of the water the clams experienced. Further investigation needs to be conducted to determine the best technique for sampling; seasonal circulation and mixing of water could vary. Since salinity levels varied vertically in the water column, nutrients were likely to vary as freshwater is phosphorous-limited, and saltwater is nitrogen-limited. However, results show little depth variation in nutrient concentrations.

### BOARD 6 - High School

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#### **DETECTION OF ARSENIC IN GROUND WATER USING SURFACE PLASMON RESONANCE: FIELD VERIFICATION OF A NEW ANALYTICAL TECHNIQUE FOR ARSENIC**

**KING, Carin P.**, *Waterville Senior High School, Waterville, ME*

Arsenic is a known toxin found in water throughout the world. Arsenic contamination is a particular problem in

## Session T18: Poster Session

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developing countries where drinking water is often drawn from shallow, unmonitored wells. The WHO has determined that “simple, reliable, low cost equipment for field measurements” is an urgent requirement for arsenic detection (WHO 2001). Our past work developed a single beam surface plasmon resonance method for detecting arsenic at 20 ppb in pure water. We now describe the extension of this method to lower arsenic detection limits in a ground water sample matrix. Arsenic samples were obtained from ground water wells at over 20 locations in central Maine. An analytical intercomparison study was performed on these samples using SPR and an ICP- optical emission spectroscopy. This work provides the next step towards an analytically robust method for detecting arsenic in ground water using a single beam SPR instrument.

### BOARD 7 - Graduate

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#### **FACTORS INFLUENCING LAKE ASSOCIATION FORMATION IN MAINE**

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Physical properties of lakes create market failures and contribute to management challenges. Lakes valued as scenery or part of an ecosystem could be considered a public good, while lakes used for drinking water or recreational resources could be considered a common pool resource (CPR), as would fisheries and the properties of remoteness and solitude found at lakes. Theory suggests that organizations and institutions can help reduce correct these market failures. A tradition of small local level associations centered around lakes has emerged in Maine to attempt to solve the management problems related to CPR/public goods. These groups could be called road associations, camp/ property owners' associations, lake associations or watershed associations. The objectives of these groups vary from narrow, with road associations focusing on private road maintenance, to more broad with watershed organizations expanding their view to an entire watershed to protect the lake's water quality. Similar groups also provide a voice to seasonal property owners and work as lobbying groups to maintain the character of a lake. This research examines what factors encourage the formation of lake associations in Maine through the use of binary logit regression. Factors influencing the costs and benefits organization formation as well as properties of the lake and surrounding communities are included. Lake associations can spread information efficiently and allow members to be more certain about their neighbors' values. The costs of programs (invasive species prevention, erosion control, etc.) can be spread throughout the community. Informal constraints are locally based and make up the majority of lake associations' institutions. Implications for the social and ecological sustainability of lakes will be discussed with a focus on recommended actions to support lake management in Maine.

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#### **DISTRIBUTION OF NATIVE AND INTRODUCED CRAYFISH IN MAINE: AN ONGOING EFFORT TO DEVELOP BASELINE DATA BEFORE NEW SPECIES INVADE**

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Invasive crayfish are an increasing problem in North America, and can threaten freshwater resources through consumption of aquatic insects, snails, plants and fish eggs, or by displacing native crayfish species. Based on past research, Maine's low crayfish diversity along with little habitat overlap could lead to vulnerability with non-

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native invasions. Detecting crayfish invasions is difficult unless there is reasonable knowledge of native distributions. This project's goals are to identify and update distributions of native and non-native crayfish in Maine and identify crayfish "hot spots" that may indicate an invasion. Crayfish samples were collected as part of the Department of Inland Fisheries and Wildlife's brook trout stream surveys in 2007 and 2008 and by University of Southern Maine in western Maine in summer of 2008. In some cases we revisited sites sampled previously by other researchers to confirm the presence of invasive crayfish. The presence of crayfish was assessed in 1,061 stream sites (IF&W) and 13 other locations checked by USM. We found *O. virilis* a native species to be most common at 94% of the total catch, followed by *O. limosus* (5.0%) and *O. immunis* (1.0 %). Non-native crayfish are suspected in select locations throughout the state by human introductions including bait buckets and harvesting attempts. This is an ongoing effort that depends in part on tips from lake shore owners, anglers, and other outdoor enthusiasts.

### BOARD 9 - Graduate

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#### **DEVELOPING NON-LETHAL BIOMARKERS FOR WATERBORNE ORGANIC CONTAMINANTS**

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Expression of cytochrome P4501A (CYP1A) in the liver is a well-established, but lethal biomarker for organic contaminant exposure in vertebrate species. A non-lethal biomarker using scales and gill filaments to measure CYP1A enzyme activity (measured as ethoxyresorufin o-deethylase, EROD) would present an alternative method for detection of water-borne contaminant exposure in endangered or threatened fish species. This analysis would also provide an inexpensive technique (compared to whole body chemical analysis) to determine acute organic contaminant exposure and help identify specific geographical areas for chemical analysis to aid in implementing restoration plans for contaminated sites.

We are evaluating the sensitivity, reliability, and time course of the induction and duration of CYP1A activity in gills, scales, and livers in Atlantic salmon (*Salmo salar*). Atlantic salmon are indigenous to Maine and are currently listed as an endangered species. We exposed salmon parr to two aqueous concentrations of PCB-126 (0.01  $\mu\text{M}$  & 0.001  $\mu\text{M}$ , static exposure), acetone (32.25 ppm, vehicle), and untreated water for 24 h before transferring the fish to clean, flow-through water. Throughout several time points (during and post exposure) we collected gill filaments and scales (non-lethally) and whole livers (lethally).

Gill EROD activities in fish treated with 0.01  $\mu\text{M}$  PCB-126 were elevated at 6 h during exposure and remained significantly elevated (compared to untreated and acetone controls) throughout the experiment. The 0.001  $\mu\text{M}$  PCB-126 treated fish showed an elevated gill EROD activity at 6 h which declined at 24 h exposure before reaching untreated activity levels by 48 h post exposure. Scale EROD activities were elevated for 0.001  $\mu\text{M}$  PCB-126 treated fish at 6 h, but not significantly elevated in the 0.01  $\mu\text{M}$  PCB-126 treated fish until 24 h. After 48 h post exposure, scale EROD activities became highly variable in all groups.

Gill and scale CYP1A activity show encouraging results as non-lethal biomarkers of contaminant exposure and response for use with endangered fish species. Liver EROD activities are currently undergoing analysis. Future investigations include optimizing scale and gill EROD protocols to reduce variability.

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#### **CITIZEN SCIENCE: SOLVING GROUNDWATER ISSUES IN NEW ENGLAND**

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Although the U.S. Environmental Protection Agency (EPA) regulates public water systems, private drinking water wells are monitored by the landowner. Approximately 15% of Americans use private drinking water. This number increases to approximately 20% in New England (EPA 2008). Without state and federal regulations, maintenance and testing does not always occur. Water quality is difficult to determine by sight, taste, or smell which makes testing critical. Some contaminants of concern include the following: microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides (EPA 2008). Specifically, studies in New England have indicated the following contaminants: methyl-tertiary-butyl ether (MtBE), radon, and arsenic (EPA 2008). This poster presents efforts to address these concerns. Four watersheds in New England were selected to investigate water quality in drinking water wells. Testing will proceed via a comprehensive groundwater quality curriculum, Groundwater Education through Water Evaluation & Testing (GET WET!). GET WET! will be implemented in K-12 schools and 4-H afterschool programs. These students will evaluate and test private well waters for nitrates, hardness, chloride, pH, salinity, conductivity, and iron bacteria. The poster will present a comprehensive evaluation plan to examine the differences in knowledge, attitude, and behavior pre- and post- GET WET! participation among household members, students, teachers, and administrators. Overall, this research project will provide a new well water monitoring program to communities, and determine the effectiveness of citizen science within the study sites.

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#### **GROUNDWATER MAPPING AND ANALYSIS IN A COASTAL ENVIRONMENT USING GIS**

**WOOD, Eric**, *Geosciences, University of Southern Maine, Gorham, ME*

By combining resources from many diverse fields the ability to accurately reconstruct the three dimensional shape of the saltwater/freshwater interface in the coastal environment of Long Island, Maine can be achieved with reproducible and accurate results. GIS software creates a workspace that allows input of data in different formats to be analyzed, structured, converted, and drawn into a visual environment that can be manipulated into a user friendly graphical interface. To build the maps in this project, data from well boring logs had to be geocoded to existing homes using aerial photography and tax parcel maps. Water table and geologic features data had to be taken from existing PDF files and georeferenced into the projected coordinate system to provide accurate spatial representations of interpreted physical features. Data such as well depth, well yield, surficial geology, bedrock geology, potentiometric elevation and surficial topography are combined to create a multilayered three dimensional digital map.

To get the most accurate data for surface elevations, raw LiDAR files had to be broken down and clipped into usable formats and then loaded into ArcMap software. The surface topography was then rebuilt in the GIS environment to create a 3D model from which all subsurface features could be measured from. Features such as well location, depth, yield, surface elevation, potentiometric elevation, bedrock elevation, water body elevation,

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and freshwater cell interface could all be mapped in a projected coordinate system with accepted tolerances applicable to the data being entered. GPS data logging was also employed to improve the accuracy of individual well locations, but the data proved to be only as accurate as the homeowner's recollection of well location and well specifics.

### BOARD 12 - Graduate

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#### **MONITORING THE RESTORATION OF RED BROOK, A SMALL COASTAL STREAM IN SOUTHEASTERN MASSACHUSETTS**

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The removal of flow barriers has increased greatly over recent years as a form of stream restoration. Often there is little effort, money or guidance available for the long-term post-removal monitoring, hence it is difficult to assess the overall success of these projects. If monitoring is done, it is typically on an annual basis following restoration activities. We are monitoring the restoration of Red Brook, a 4.5 mile long, spring-fed, coastal stream which is currently on the priority projects list of the Massachusetts Riverways Program. The long-term goal of the Red Brook Restoration project is to naturalize the stream and restore its function by removing man-made flumes, eliminating sources of unnatural sedimentation, and enhancing habitat for sea-run brook trout. We are using a combination of in-situ measurements (for channel geometry and bedload sampling), geophysical techniques (ground penetrating radar) and a remotely-accessed environmental sensor network to monitor flow and sediment movement in the brook before and after the flume removal. We have based our monitoring approach on the Stream Barrier Removal Monitoring Guide, recently published by The Gulf of Maine Council (GoMC) on the Marine Environment. During the summer of 2008, we quantified the extent of sediment deposits that had built up behind the three existing flumes. The upper flume was removed in September 2008 and we are currently in the process of monitoring changes in the channel geomorphology in response to this removal. By using multiple techniques and sub-annual sampling intervals we will be able to compare monitoring methods and assess the effectiveness of aquatic habitat restoration within the first year after flume removal. To our knowledge, we are the first to implement the monitoring strategy outlined in the GoMC guidance document, hence we will be able to make recommendations with respect to this approach.



# ❧ *thank you* ❧

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