Introduction

The Mission of the New York State Water Resources Institute (WRI) is to improve the management of water resources in New York State and the nation. As a federally and state mandated institution located at Cornell University, WRI is uniquely situated to access scientific and technical resources that are relevant to New York State's and the nation's water management needs. WRI collaborates with regional, state, and national partners to increase awareness of emerging water resources issues and to develop and assess new water management technologies and policies. WRI connects the water research and water management communities. Collaboration with New York partners is undertaken in order to: 1) Build and maintain a broad, active network of water resources researchers and managers, 2) Bring together water researchers and water resources managers to address critical water resource problems, and 3) Identify, adopt, develop and make available resources to improve information transfer on water resources management and technologies to educators, managers, policy makers, and the public.
Research Program Introduction

The NYS WRI's FY2012 competitive grants research program was conducted in partnership with the NYS Department of Environmental Conservation (DEC) Hudson River Estuary Program (HREP). The overall objective of this program is to bring innovative science to watershed planning and management. In FY2012 research was sought that fit within the context of New York State’s growing concerns about aging public infrastructure, economic constraints on public investment, and the recent requirement for State planning agencies to incorporate principals of “smart growth” as promulgated in the 2010 Smart Growth Public Infrastructure Policy Act (http://smartgrowthny.org/index.asp). The specific areas of interest for the FY2012 grants program solicitation were: 1) Water-related infrastructure including water supply and wastewater treatment facilities, distribution networks, decentralized treatment installations, dams, constructed wetlands, etc., and their current state and effectiveness at providing water services regionally at reasonable cost; 2) Regional economic vitality with respect to water infrastructure and its effect on private and public investment and industrial development; 3) Integration of scientific, economic, planning/governmental and/or social expertise to build comprehensive strategies for public asset and watershed management; 4) Smart growth and its implications for water related infrastructure development, regional water quality, and regional economy; 5) Novel outreach methods that enhance the communication and impact of science-based innovation to water resource managers, policy makers, and the public; 6) The economics and benefits of source watershed protection strategies and the use of ecological services to meet water supply and quality needs, as opposed to treatment at point of delivery. Projects were evaluated by a panel consisting of representatives of the US Geological Survey, the NYS DEC, and faculty from Cornell University. Two research projects were supported in FY12 through the 104(b) competitive grants program with a total funding level of $39,840. These projects included:

1. Relative abundance of blueback herring in relation to permanent and removable dams on the Mohawk River. PIs: Dr. Karin Limburg & Dr. Neil Ringler, SUNY Environmental Science & Forestry.

2. Pollution trade-offs associated with the use of riparian zones as best management practices. PI: Dr. Philippe Vidon, SUNY Environmental Science & Forestry.

We also report here on two projects that received no-cost extensions beyond FY2011. The two projects listed below were completed in February, 2013, and December, 2012, respectively:


4. Two-dimensional river model for predicting bacterial contamination of bathing beaches in the St. Lawrence. PI: Dr. Michael Twiss, Clarkson University.

Lastly, we include information on a supplemental award:

USGS Award No. G11AP20223 Flood Frequency Research for California

and also on a 104(g) project that has just begun:

2012NY189G The Remote Monitoring of Surface Velocity, Bathymetry, and Discharge
NITROGEN (N) AVAILABILITY AS DRIVER OF METHYLMERCURY PRODUCTION IN FORESTED SOILS AND STREAM SEDIMENTS

Basic Information

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Publications

There are no publications.
NITROGEN (N) AVAILABILITY AS DRIVER OF METHYLMERCUER PRODUCTION IN FORESTED SOILS AND STREAM SEDIMENTS

Start / End dates: 03/11-02/13
(a 1-year no-cost extension was granted to SUNY-ESF in May 2012)

Principal Investigators: P. Vidon and M. Mitchell.

Objectives

Atmospheric deposition of nitrogen (N), sulfur (S) and mercury (Hg) is ubiquitous in the Northeastern United States and has a major impact on forested lands and the water quality of this region. However, although recent research suggests significant interactions exist between the N, S and Hg cycles in forested landscapes, the exact nature of the complex interactions between these cycles is still poorly understood. For this project, the objectives were to: 1) Determine what variable or combination of variables regulate S, Hg and MeHg export at the watershed scale across a range of seasonal and hydrological conditions (e.g., low flow versus high flow); and 2) Determine to what extent nitrate availability in forest soils and associated wetland sediments regulate S, Hg and methylmercury (MeHg) availability across a range of redox conditions, from headwater locations (oxic) to stream hyporheic zones, and lowland wetland soils (anoxic). Addressing these objectives is critical to the management of our forests as climate and rates of N, S and Hg atmospheric deposition are constantly changing. Understanding what variables affect S and Hg cycling in these watersheds in relation to changes in hydrological and redox conditions in soils and streams will help 1) better predict how future changes in climate and atmospheric deposition might affect N, S, and Hg dynamics, and 2) identify areas of the landscape that are especially sensitive to N, S or Hg contamination and where management should be focused.

Activity Report

Because FY2011 funds did not become available to the PIs before the middle of August 2011, it was decided that the project would be delayed one year in order to capture N, S and Hg dynamics in spring, a critical time of year for Hg export. A one-year no-cost extension was granted by the NYWRRI to SUNY-ESF in May 2012 until 02/2013.

To date, all fieldwork has been completed, and total mercury (THg), methylmercury (MeHg), nitrate (NO$_3$), dissolved organic carbon (DOC) concentrations, and sulfate / sulfide ratios were determined for a total of 12 dates between April and October 2012 (growing season).

THg concentrations in the study streams typically varied between 1 ng/L and 5 ng/L, and were significantly positively correlated to DOC (p<0.05). Similarly, THg was positively correlated to a variety of fluorescence indices (FI, HIX, Humic A) suggesting, that together with DOC, the fluorescence properties of organic matter may be good indicators of Hg concentrations in the stream.

Nitrate was only poorly correlated to THg suggesting that differences in nitrate levels in the watershed were not tied to clear differences in THg export at the watershed scale. However, THg was strongly negatively correlated to Sulfide. Although the methylmercury data are still being analyzed at this report is being written, these results are consistent with our understanding of Hg chemistry. Indeed, as sulfate reduction occurs in the summer, and therefore as more sulfide is
produced, a large fraction of THg is converted into MeHg, therefore leading to a drop on THg concentration.

Water quality analysis also revealed a large increase in DOC concentration in the lower section of the watershed where a wetland is present. As MeHg data become available, we will explore in more details the relationship between nitrate level, DOC, and MeHg. Specifically, we will investigate the spatial and the temporal variability of MeHg production, in relation to nitrate dynamics in particular.

Graduate and Undergraduate Student Training (1 Graduate Student, 3 Undergraduate Students)

This research project forms the basis of the MS Thesis for Whitney Carleton, graduate student in the Department of Forest and Natural Resources Management at SUNY-ESF under the supervision of PI Vidon. Whitney started her MS project in Fall 2011, and is expected to graduate from SUNY-ESF after completion of this research project in Summer 2013.

In addition to Whitney, three undergraduate students (Joshua Enck, Mario Alciati, and Angela Marcoccia) were directly involved in this project.
Conference Presentations


Abstract # B31C-0432. \textit{American Geophysical Union Annual Meeting}, San Francisco, California, December 2012.

In addition, two manuscripts are currently in preparation for submission to peer-reviewed journals in fall 2013.
Two-Dimensional River Model for Predicting Bacterial Contamination of Bathing Beaches in the St. Lawrence River

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Publications

There are no publications.
Final Report: Use of Two-Dimensional River Modeling for Predicting Bacterial Contamination of Bathing Beaches in the St. Lawrence River

Michael Twiss, Department of Biology
Clarkson University, Potsdam NY

Introduction

Human health concerns stemming from recreational bathing are an important issue in the St. Lawrence River (over 100 miles in length) and throughout New York State. Despite high water quality in the main channel of this major river, bathing beaches are affected by tributary inputs that carry agricultural and urban effluents and have profound impacts on near shore water quality for considerable distance downstream; this is a concern for municipalities (e.g., Clayton, Alexandria Bay, Massena) and the NYS Office of Parks, Recreation & Historic Preservation who are responsible for beaches in this area, as well as those in Canada. At present there are no viable protocols in place to forecast beach closures in this region. Decisions on bathing risk are made >24 h after sampling due to the time required for water sampling and processing (incubation) to measure fecal indicator bacteria, typically *E. coli*.

Objectives

We conducted a combination of computer modeling, field sampling during the summer bathing season, and field experimentation to develop the basis for a predictive model of beach health assessment. The investigation focused on the International Section of the St. Lawrence River (the section of the St. Lawrence shared by Canada and the United States from its headwaters in Lake Ontario downstream to the Moses-Saunders Power dam at Massena NY/Cornwall, ON. The scope was refined to examine two beaches of interest: one in New York at Coles Creek State Park and one in Ontario at Crysler Beach.

Personnel involved

Dr. Michael R. Twiss, Professor of Biology/Director of Great Rivers Center at Clarkson University, Potsdam, NY, 13699, email: mtwiss@clarkson.edu; tel. 315-268-2359
Dr. Joseph Skufca, Associate Professor of Mathematics & Computer Science, Clarkson University, email: jskufca@clarkson.edu; tel. 315-268-2399
Dr. Jeffrey J. Ridal, St. Lawrence River Institute of Environmental Sciences, 2 Belmont Street, Cornwall, ON, Canada K6H 4Z1, email: jridal@riverinstitute.ca; tel. 613-936-6620

Students:
1. Anthony Harvey, Master of Science candidate, Environmental Science and Engineering, Clarkson University
2. Nicholas Marshall (2011), Bachelor of Science candidate, Applied Mathematics, Clarkson University

Completed Work Overview

Our work was conducted over two field seasons (2011, 2012). In 2011, fecal coliform in nearshore waters was determined at specific locations along the NY side of the St. Lawrence River with the objective of developing a predictive model for fecal contamination at Coles Creek State Park Beach. In 2012, we were not able to continue with this sampling design since the New York State Department of
Transportation began work in June on a culvert under Route 37. This culvert was the fecal coliform contaminated tributary (“Red Mills Tributary”) that we identified, through hind casting of water flow using a 2D hydrodynamic model, as being 24 hours upstream. The construction created a dam upstream of the tributary and a pumped diversion. Due to the high impact we decided to invest our remaining efforts on the project to obtain rate constants on fecal coliform growth and loss rates in river water and further observations of fecal coliform distribution in the St. Lawrence River. These will be used to develop a mechanistic model of fecal bacteria transport in the St. Lawrence River.

Summary of Results from Work Completed

**2011**

Experiment 1A: Monitoring Coles Creek State Park Beach

**Description:** A 10 week study (16 June 2011 to 18 August 2011; day of year 167-230) was performed in order to gain information about water quality and fecal coliform presence at specific locations along the St. Lawrence River. These locations were selected based on a 2D river flow model of the St. Lawrence River that showed how water interacted with the near shore of the U.S. side of the river from Red Mills Tributary to Coles Creek State Park Beach. Petri-Film (3M Corp.) plates were used to enumerate *E. coli* and fecal coliform bacteria.

**Result-Expt.1A:** Rainfall does not appear to have a significant effect on total coliforms or *E. coli* at Coles Creek State Park Beach (Fig. 1). However, rainfall may affect other parameters that affect *E. coli* levels or the rainfall may not have an immediate effect due to lag time in runoff.

![Figure 1](image-url)  
*Figure 1.* Total coliform detected at Coles Creek State Park Beach over a 60 day period in 2012 that encompassed the peak bathing period. Statistical predictive modeling showed no ability to predict total coliform or *E. coli* contamination in the water based on any ancillary measured parameters, including rainfall.
Samples collected during this project at Coles Creek State Park Beach were notably greater in *E. coli* than samples taken by the State Park personnel, which were analyzed by a separate lab (Fig. 2). This will be communicated to the NYSDOH in order to notify them of what is considered to be an important discrepancy. One possible explanation of this is that samples collected (independently) in our study were placed in a darkened cooler at ambient river water temperature and processed within an hour at the laboratory. In contrast samples collected by the State contractor were kept cool and processed up to 24 hours after collection; we suspect that that protocol adversely affected *E. coli* survivorship in the sampled river water.

![Figure 2](image.png)

**Figure 2.** A comparison of *E. coli* detected in samples collected in this study (independent) versus those collected by contractors sampling water for the State at Coles Creek State Park Beach.

**Experiment 1B: Mathematical Modeling Techniques for predicting fecal Coliform Contamination at Coles Creek State Park Beach**

**Description:** As our foundational mathematical goal, we wanted to develop a methodology that could be used to predict *E. coli* levels at a beach, where we specifically intend for this methodology to allow for either now casting (based on immediately available factors) or forecast (based on previous days values). As such, we take as explanatory variables a number of measured quantities deemed to be biologically relevant, measured at the beach site. Additionally, we used river flow models to estimate “day-ahead” sources of water at the beach, and made water quality measurements at these specified upstream locations. As a third source of available explanatory measurements, we consider weather information (wind, rainfall, temperature). Mathematically, our goal was to determine a prediction function

\[ y = f(x_1, x_2, \ldots, x_n) \]

that could predict beach e-coli level \( y \) as a function of the explanatory variables.

Our general approach was to consider both regression models (linear and nonlinear), which could predict a bacteria level, logistic regression models, predicting a likelihood of exceeding a safe level, and classifiers – predicting whether we are above or below some threshold. For each models explored, we had to make a selection of which predictor variables to include in the model. Although it might seem that better models could be achieved through inclusion of all the variables, it is reasonably easy to
imagine that if a predictor variable was not very important, it could add “noise” to prediction without
adding much power to the predictive performance. As such, we desired to determine which predictor
variables are most important to the modeling process. Our algorithm in evaluating these models is
outlined as follows:

1. Assume a basic model structure
2. Choose a subset of explanatory variables
3. Choose model parameters (regression coefficients, for example) that minimize model
   error and measure performance
4. Evaluate performance of that subset of variables by using a cross-validation procedure.
5. Repeat steps 2-4 to exhaustively search all subsets of explanatory variables to determine
   the most robust set of variables for that model structure
6. Repeat steps 1-6 for other model structures.

Result-Expt.1B: From our preliminary modeling effort, we draw the following main conclusions:
- Linear Regression performed very poorly, indicating likely non-linear dependence on
  explanatory variables.
- K-Nearest Neighbor classifier (a simple, non-linear approach) appears to be the most robust of
  the models studied.
- For the beaches under study, upstream tributaries are the likely source of the bacterial
  contamination.
- Key variables in predicting next day beach levels are conductivity and bacteria level at the
  upstream tributary, along with current and previous day rainfall.

Our initial analysis was based on data measured within this funded study. Additionally, we applied
a similar result on collaborator data collected at Canadian beaches during a previous summer (2010). The
approach to identify a good model seems to have worked well on these datasets. However, the approach
must be viewed as “exploratory data analysis” in that we are considering all possible models before
evaluating performance.

● 2012 ●

Experiment 2: The Effects of Tributary Inputs on Water Quality on Crysler Beach, St. Lawrence River.

Description: Crysler Beach is located 7 km northeast from Coles Creek State Park. Owing to the issue
with road work affecting the tributary sampling related to our initial study site, Coles Creek, we applied
the same type of hind casting to determine that water impinging on Crysler Beach was in the vicinity of Hoasic
Creek, 24 hours previously. Since we could not conduct the same type of thrice-weekly sampling as done at Coles Creek
State Park Beach in 2011, we coordinated with personnel from the St. Lawrence River Institute of Environmental
Science (SLRIES) to conduct an intensive survey, on 22 June 2012 of the river from Crysler Beach to 8 km upstream.
Water was sampled for E. coli and fecal coliform bacteria, temperature, specific conductivity, turbidity, and
chromophoric dissolved organic matter (CDOM). Sampling was conducted from a depth of 0.3 m to 2 m using a zodiac
boat of the SLRIES and from 2 m to the mid-channel using
the coastal research vessel of the Great Rivers Center at Clarkson University. The investigative survey was performed to gain information regarding tributary outputs and if they cause a significant amount of *E. coli* to enter the near shore and main channel of the river.

**Result-Expt.2:**
The results of the investigative survey show that there are major water quality differences in the tributaries and low flow areas of the river compared to the main channel area (Fig. 4A-D). These trends can be seen with all water quality parameters that were measured. However, there did not appear to be elevated bacteria at the mouth of the tributary or in low flow areas as indicted by water quality. Instead, the near shore water more closely resembles the main channel water (Fig. 4E-F). This may be due to the low flow from the tributaries into the St. Lawrence River, which causes gradual mixing. One possible reason for the lack of abundant coliform bacteria from the tributaries may be the lack of precipitation in the days prior to the day of sampling, as reported by the City of Cornwall water filtration plant’s climatological station report which stated that there was a total of 0.5 mm of rainfall in the 10 days prior to the survey date.

![Water quality and bacterial content in water samples collected on 22 June 2012. Sampling locations furthest east (right) are immediately downstream of Crysler Beach; samples furthest west (left) are immediately upstream of Hoasic Creek.](image)

**Experiments 3, 4 & 5:** Experiments to assess the die-off of *E. coli* in river water.

Water of “Red Mills Tributary” upstream of the construction area was collected and from it *E. coli* was cultured and isolated. This culture of *E. coli* was maintained at laboratory temperatures (21°C) in sterile culture media prepared using St. Lawrence River water. Several experiments were conducted to determine the fate of bacteria entering the river from tributaries. A measurement of the UVR extinction in the nearshore water of the St. Lawrence River revealed a UVR extinction coefficient of 2.24·m⁻¹; this indicates that 1% of UVR incident at the surface will found at a depth of 2.1 m.

Three day-length long experiments (from sunrise [approx. 06h:00] to sunset [approx. 20h:30]), were conducted on 30 July, 7 August, and 10 August to determine the effect of ambient ultraviolet (UVR) on *E. coli*. These experiments used both polycarbonate and Teflon bottles, each set being exposed to direct light and covered by foil to block light as a control. The experiment were deployed at a depth of 10 cm in the river water for in situ incubations. These experiments used filtered (0.4-µm) and unfiltered river
water collected from the nearshore zone and inoculated with cultured *E. coli* to achieve an estimated 100 CFU/mL.

**Result-Expt. 3, 4 & 5:** Based on the day long exposures, it appears that die-off of *E. coli* is greatest when the sun is directly overhead and is less inhibitory to growth at sunrise and sunset.

**Experiments 6, 7, 8, 9 & 10:** Dilution assays to measure *E. coli* growth and grazing rates as affected by light exposure.

The daylong exposures (Expts. 3-5) proved the impact of light exposure and revealed that there was additional losses of *E. coli* in unfiltered river water. The loss of bacteria in the unfiltered river water in the dark was due to microzooplankton grazing, wherein small metazoans and unicellular flagellates (generally < 200 µm) consume bacteria as prey items. Microzooplankton grazing is an active trophic activity amongst the plankton in the Upper St. Lawrence River (Twiss and Smith, 2012).

One technique to determine loss rates due to grazing is to conduct dilution assays (Landry and Hassett, 1982) using light and dark exposures. A 4 hour long experiment, from 10h:00 to 14h:00, to determine the effect of UV radiation and grazing on *E. coli*. This experiment used both polycarbonate and Teflon bottles, each set being exposed to direct light and covered by foil to block light as a comparison and a dilution series assess the effects of grazing versus light inhibition. Six dilutions were conducted for each experimental treatment. *E. coli* concentration was determined at the beginning of the experiment and in each replicate after the 4 hour exposure time. The intrinsic specific growth rate was determined as the intercept with the ordinate of a linear least squares regression of specific growth rate in each dilution versus the respective dilution factor; specific grazing rate was determined as the slope of this regression (Landry and Hassett, 1982). Here we consider any grazing rate to be the sum of *E. coli* a specific loss due to microzooplankton grazing, viral lysis, or other cell death. The following rules were applied to accepting estimated rates. In cases where there was a statistically non-significant (*P* > 0.10) regression, the growth rates in all dilutions was averaged rather than using the intercept to predict the specific growth rate (per Chen et al., 2009) and no grazing rate was determined (i.e., not applicable [NA]). In addition, grazing rates were considered to be undeterminable (NA) in assays that resulted in a positive slope (theoretically impossible), in which case growth rates in all dilutions were averaged.

**Results- Expts. 6-10**

A summary of the experiments in Table 1 proves the detrimental impact of light on survivorship of *E. coli* in river water. One experiment (Expt. 6) provided valid estimates of both growth and loss rates of *E. coli*. Loss rates were similar (0.15 ± 0.02 ·h^−1^) despite light regime or the type of container used. However, the experiments show a strong adverse effect of light on *E. coli* survivability. For example, in all 5 experiments, growth rates of *E. coli* in the dark was far greater than exposed to ambient sunlight, which would have both visible and UVR components, since Teflon is nearly UVR transparent. A reduction of UVR by using a Mylar-D coating reduced the adverse impact of light exposure on *E. coli* growth in 2 of 3 instances (Expts. 8 & 9, Expt. 10 shows no difference compared to full light exposure).
Table 1. Dilution assay results for experiments on *E. coli* fate in St. Lawrence River water using various light exposures due to various containers (Teflon or polycarbonate [PC]) or coatings, none (light), reduced (Mylar) or dark (aluminum foil). Values are specific rates of growth (μ) or loss (g) in each treatment.

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**Anticipated Impact and Outcomes**

Despite the setback with the loss of our primary sampling site (“Red Mills Tributary”) in 2012, we have been able to design and carry out meaningful experiments in 2012 that provide us with rate constants so that we can derive a mechanistic model. The mechanistic model requires identification of polluted inputs, in this case tributaries. Based on two-dimensional hydraulic modeling, we can predict, with a high degree of reliability, where water will be transported.

The basic equation governing transport of water parcels is given by
\[ \frac{\partial c}{\partial t} = D \nabla^2 c - \vec{v} \cdot \nabla c + q(t), \]

where \( c \) represents the concentration of \( E. coli \) bacteria. On the right hand side, the first term gives the effect of diffusion, the section is the advection (caused by the velocity of the fluid), and \( q \) is a source or sink term. Since the velocity field in the Upper St. Lawrence is known, this equation can be used to determine concentrations as a distribution in both space and time. As first approximation, we may ignore the source term and assume diffusion to be small, such that spatial changes in concentration are governed by the velocity field. For determining the fate of \( E. coli \) in the river water we can, assume a given concentration at one location and evoke growth and loss terms, such as those measured in our field experiments. This approach may be suitable for assessing risk of contaminated tributaries, with respect to the anticipated impact they might have downstream.

**Conference Presentations**


**Student training**

Three students were involved with this project. The project comprises the primary thesis work of Anthony Harvey, a Master of Science candidate (anticipated completion date May 2013). Nicholas Marshall (Bachelor of Science candidate), was involved with developing statistical mathematical models. Heather Sprague (Biosystems Engineering, B.S. candidate, Clemson University) assisted with field work during summer 2012.

**References cited**


USGS Award No. G11AP20223 Flood Frequency Research for California

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Publications


Development of Regional Skews for Selected Flood Durations for the Central Valley Region, California, Based on Data Through Water Years 2008–9

By Jonathan R. Lamontagne¹, Jery R. Stedinger¹, Charles Berenbrock², Andrea G. Veilleux³, Donna L. Knifong², and Justin C. Ferris²

Abstract

Flood-frequency information is important in the Central Valley Region of California because of the high risk of catastrophic flooding. Most traditional flood-frequency studies focus on peak flows, but for the assessment of the adequacy of reservoirs, levees, other flood control structures, sustained flood flow (flood duration) frequency data are needed. This study focuses on rainfall or rain-on-snow floods, rather than the annual maximum, because rain events produce the largest floods in the region. A key to estimating flood-duration frequency is determining the regional skew for such data. Of the 50 sites used in this study to determine regional skew, 28 sites were considered to have little to no significant regulated flows, and for the 22 sites considered significantly regulated, unregulated daily flow data were synthesized by using reservoir storage changes and diversion records. The unregulated, annual maximum rainfall flood flows for selected durations (1-day, 3-day, 7-day, 15-day, and 30-day) for all 50

¹Cornell University, School of Civil & Environmental Engineering, 220 Hollister Hall, Ithaca, New York 14853
²U.S. Geological Survey, California Water Science Center, Placer Hall, 6000 J Street, Sacramento, California 95819
³U.S. Geological Survey, Office of Surface Water, 12201 Sunrise Valley Drive, Reston, Virginia
sites were furnished by the U.S. Army Corp of Engineers. Station skew was determined by using the expected moments algorithm program for fitting the Pearson Type 3 flood-frequency distribution to the logarithms of annual flood-duration data.

Bayesian generalized least squares regression procedures used in earlier studies were modified to address problems caused by large cross correlations among concurrent rainfall floods in California and to address the extensive censoring of low outliers at some sites by using the new expected moments algorithm for fitting the LP3 distribution to flood-duration data. To properly account for these problems and to develop suitable regional-skew regression models and regression diagnostics, a combination of ordinary least squares, weighted least squares, and Bayesian generalized least squares regression was adopted. This new methodology determined that a nonlinear model relating regional skew to mean basin elevation was the best model for each flood duration. The regional-skew values ranged from -0.74 for a flood duration of 1-day and a mean basin elevation less than 2,500 feet to values near 0 for a flood duration of 7-days and a mean basin elevation greater than 4,500 feet. This relation between skew and elevation reflects the interaction of snow and rain, which increases with increased elevation. The regional skews are more accurate and the mean squared errors are less than in the National skew map of Bulletin 17B.
Relative Abundance of Blueback Herring (Alosa aestivalis) in Relation to Permanent and Removable Dams on the Mohawk River

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Publication

Final Report to Cornell Water Resources Institute

“Relative Abundance of Blueback Herring (*Alosa aestivalis*) in Relation to Permanent and Removable Dams on the Mohawk River”

To: Water Resources Institute, Cornell University
From: Dr. Karin Limburg and Dr. Neil Ringler, SUNY – ESF
Date: April 15, 2012
Subject: Final report for blueback herring research on the Mohawk River

This report summarizes field and lab procedures as well as our findings.

**Field sampling:**

We conducted field sampling on the Mohawk River from May to July. The purpose of our field sampling was to determine the timing and distribution of the blueback herring spawning run. We used boat electrofishing gear to sample adult blueback herring at five sites on the Mohawk River. The sample locations were Locks 7, 9, 11, 15 and Little Falls, NY. All field sampling was done with assistance from the New York State Department of Environmental Conservation (NYSDEC). The sample dates, locations and personnel involved are summarized in the table below. No fish were collected on the final date (July 2) and so the sampling was terminated then.

<table>
<thead>
<tr>
<th>Date</th>
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<tr>
<td>May 22</td>
<td>Little Falls, NY</td>
<td>Christopher Legard (SUNY-ESF graduate student)</td>
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<tr>
<td></td>
<td></td>
<td>Dave Erway (NYDEC region 6)</td>
</tr>
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<td>May 23 - 24</td>
<td>Locks 7, 8, 9, 11 and 15</td>
<td>Christopher Legard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tiffany Evanchoff (SUNY-ESF Undergraduate)</td>
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<td></td>
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<td>Scott Wells (NYDEC region 4)</td>
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<td>June 12 - 13</td>
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<td>Tiffany Evanchof</td>
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<td></td>
<td></td>
<td>Scott Wells</td>
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<tr>
<td>June 14th</td>
<td>Little Falls, NY</td>
<td>Christopher Legard</td>
</tr>
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<td></td>
<td></td>
<td>Dave Erway</td>
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<tr>
<td>June 26th</td>
<td>Locks 7, 8, 9, 11 and 15</td>
<td>Karin Limburg (SUNY-ESF)</td>
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Sample Processing:

A sub-sample of 230 fish was retained for laboratory analysis at SUNY-ESF. The sub-sample will be used to determine demographic information about the population (length, weight, age, sex ratio, gonadosomatic index, diet, migration history, number of repeat spawners, genetic make-up, and stable isotope data). All fish were weighed, measured, and samples were taken of scales, otoliths, gonads, stomach contents, gill rakers, and muscle tissue. Within the scope of this project, length, weight, age, sex ratio, gonadosomatic index, diet, and degree of repeat spawning were quantified.

Results:

Size, sex ratios, and GSI.

Table 1 shows mean size, weights, gonadal weights, and gonado-somatic (GSI) indices in May and June 2012. Males ranged in size (total length, TL) from 205 to 262, and females from 220 to 280 mm.

<table>
<thead>
<tr>
<th>Date</th>
<th>N</th>
<th>Sex ratio (M:F)</th>
<th>Mean Total Length, mm</th>
<th>Mean Fork Length, mm</th>
<th>Mean wet weight, g</th>
<th>Mean Gonad weight, g</th>
<th>Mean GSI</th>
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<td>May 23-24</td>
<td>124</td>
<td>79-45</td>
<td>239</td>
<td>212</td>
<td>119</td>
<td>9.6</td>
<td>0.086</td>
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<tr>
<td>June 12-13</td>
<td>98</td>
<td>75-23</td>
<td>235</td>
<td>209</td>
<td>100.1</td>
<td>4.9</td>
<td>0.049</td>
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<tr>
<td>June 26</td>
<td>7</td>
<td>5 to 2</td>
<td>246</td>
<td>218</td>
<td>111.9</td>
<td>5.4</td>
<td>0.050</td>
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<tr>
<td>Total</td>
<td>229</td>
<td>159-70</td>
<td>238</td>
<td>211</td>
<td>110.6</td>
<td>7.5</td>
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GSI was highest in May and stabilized in June, indicating that most spawning went on in May. This is consistent with previous observations.

Compared to an earlier study of Mohawk River blueback herring conducted by KL and Ian Blackburn in 1999-2001, adult spawners have declined in size significantly (Figure 1) and sex ratios have skewed toward males (Figure 2). This may reflect selective fishing at sea. Note that there are no directed marine fisheries on blueback herring, but bycatch is a well-known problem (ASMFC 2012).
Diet.

Blueback herring were also observed to be feeding on benthic macroinvertebrates during the 2012 spawning run. This is consistent with earlier observations by Simonin et al. (2007), who reported feeding by blueback herring in the Hudson/Mohawk watershed, but only when fish were captured in unidirectional flow. Fish captured in the tidal Hudson River estuary were not observed to feed. Simonin et al. (2007) concluded that feeding occurs in unidirectional flow to subsidize the energy required to reach spawning grounds in the Mohawk and other tributaries.
Possible effects of dams.

No effects of dams was detected on size of spawning blueback herring in 2012, irrespective of sex or sampling date (p > 0.2). However, female GSI was significantly lower (p < 0.05) at Lock 15, the farthest upstream location at Little Falls, NY, suggesting that most spawning took place downstream of that location. Again, this is in agreement with earlier studies.

Anticipated products of this research: A manuscript will be developed over the summer. Also, the results will be disseminated to the Mohawk River and Hudson River Estuaries Programs of the NYS DEC.
Conclusions.

Although this was a preliminary study, the findings thus far do indicate some substantial changes in the Mohawk River component of the Hudson River watershed's blueback herring stock; in particular, size of fish has declined over the past decade and the sex ratio is skewed toward males. If more funding can be found, then more demographic analysis (age, growth, and provenance via isotopic and trace elemental chemistry) could be performed on otoliths and tissues archived from these samples. This could help identify not only the origin of these fish (Mohawk, Hudson, or elsewhere), but also could shed light on marine habitat use. Given the parlous state of river herring (blueback herring and alewife), such information could be very useful for conservation management.

Literature cited.


POLLUTION TRADE-OFFS ASSOCIATED WITH THE USE OF RIPARIAN ZONES AS BEST MANAGEMENT PRACTICES

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Publications

POLLUTION TRADE-OFFS ASSOCIATED WITH THE USE OF RIPARIAN ZONES AS BEST MANAGEMENT PRACTICES

Start / End dates: 03/12-02/13

Principal Investigators: P. Vidon.

Objectives:

Riparian zones (near stream zones) are widely recommended best management practices (BMP) to mitigate the impact of agriculture on the quality of our waters owing to their inherent ability to remove nitrate from subsurface flow. However, recent research suggests that the strong biogeochemical gradient often observed in riparian zones as water moves from the upland environment to streams also influences the fate and transport of many other redox sensitive elements such as phosphorus, sulfate and iron, as well as the production and/or consumption of greenhouse gases (GHG) ($\text{N}_2\text{O}, \text{CO}_2, \text{CH}_4$)$^{[3,4,5]}$. These elements affect the quality of our water and air, and it is critical to determine to what extent the promotion of riparian zones as BMPs for nitrate removal is done at the expense of air quality (greenhouse gas production), or at the expense of water quality vis-à-vis phosphorus, sulfate and/or iron, and associated contaminants?

Addressing these questions in the context of stream/riparian zone restoration is extremely important both nationally and regionally. Every year, millions of dollars are spent to restore streams and adjacent riparian zones (including in the Hudson River Watershed), primarily to restore fish habitat, reduce sediment load in streams and prevent stream erosion. However, stream restoration often fails to recognize the importance of stream channel geomorphology and evolution on riparian zone hydrological and biogeochemical functioning. As a result of this, many stream restoration projects use homogenous stream restoration designs that are in fact far remote from the complexity of natural systems (Figure 1). Stream geomorphology (including meander curvature) nevertheless impacts surface water – groundwater interactions in the near stream zone, and in turn, regulates riparian zone hydrology (e.g. water table level, water table gradient) and biogeochemistry (e.g. dissolved oxygen availability, organic carbon availability, oxidation-reduction potential). There is therefore a critical need to quantify potential
pollution trade-offs associated with the use of riparian zones as BMPs within the context of stream restoration.

The **three primary objectives** for this project include:

1) Determine the concentration of soluble reactive phosphorous (SRP), the Sulfate/Sulfide and FeII/FeIII ratios in groundwater, and fluxes of N\(_2\)O, CO\(_2\), CH\(_4\) gases at the soil-atmosphere interface in relation to nitrate (NO\(_3^-\)) concentrations and fluxes in a series of three riparian zones located along a stream reach with contrasting stream curvatures in Central NY.

2) Determine the impact of stream curvature (outer bend and oxbow, inner bend, straight section) on riparian zone functioning with respect to N, P, S, Fe, and GHG fluxes.

3) Quantify potential water and air quality trade-offs associated with the use of riparian zones as BMPs for N removal.

**Activity Report**

As of today, all fieldwork has been completed, and most of water and air samples collected for this project have been analyzed. Although data analysis is underway, some preliminary conclusions have been reached:

Water quality and hydrological measurements have primarily focussed along a series of 3 riparian sections (inner meander (IM), straight section (SS), outer meander with oxbow depression (OX)) on the banks of a 600 m long agricultural floodplain section of Fall Creek, near Freeville, NY (Figure 2).

Hydrological data indicate overall contrasting groundwater flow directions and water table depth depending on location and stream meander curvature (Figure 3, next page).

Biogeochemical data indicate significantly (\(\alpha=0.05\), \(p<0.05\)) greater NO\(_3^-\) concentrations (1.45 mg N/L) at the IM site than at the OX site (0.2 mg N/L). In the oxbow depression at site OX, mean N\(_2\)O and CH\(_4\) fluxes in the oxbow (N\(_2\)O: 1.26 mg N / m\(^2\) / day (+/- 1.94); CH\(_4\): 24.50 mg C / m\(^2\) / day (+/- 0.36)) were significantly (\(\alpha=0.05\), \(p<0.05\)) higher than at locations on higher ground at the field edge (N\(_2\)O: 0.18 mg N / m\(^2\) / day (+/- 0.38); CH\(_4\): -0.67 mg C / m\(^2\) / day (+/- 0.48).

Together, these data indicate clear differences in hydrological conditions, N dynamics, and GHG production/consumption between the various landscape elements found in the

---

**Figure 2: Description of the studied stream reach and of its main features.**

- Existing well, piezometer, and static chamber transects
- Field / Riparian Zone boundary
- Oxbow Depression # 1
floodplain. Ultimately, sites exhibited different biogeochemical conditions, with elevated \( \text{NO}_3^- \) loss, \( \text{N}_2\text{O} \) and \( \text{CH}_4 \) emissions within the oxbow formation, suggesting the geomorphology and the meander setting significantly influenced subsurface biogeochemistry and associated pollution trade-offs.

Additional analyses are underway to fully address all the questions posed in the objectives. As indicated below, several manuscripts are in preparation for submission to peer-reviewed journals as this report is written.

*Figure 3*: Riparian water table level and typical groundwater flow direction at key locations throughout the floodplain.

**Graduate and Undergraduate Student Training** (1 Graduate Student, 3 Undergraduate Students)

One graduate student (Sara Marchese) was supported by this award in Summer 2012. This award also partially supported additional data collection for Pat Rook (MS2012). Three undergraduate students participated in fieldwork, and one of them, Angela
Marcoccia, used some of the data collected as part of this project to complete her undergraduate thesis (see details below).

**Conference Presentations**


**Thesis partially supported by work conducted under this award**


**Peer Reviewed Publications**

One MS Thesis (Sara Marchese) and three (3) manuscripts are currently in preparation. The manuscripts will be submitted to peer reviewed journals in summer or fall 2013.

PI Vidon will present results from this work at the American Geophysical Union conference in December 2013, while graduate student Sara Marchese will present results from this work at the Soil Science Society of American meeting in November 2013.
The Remote Monitoring of Surface Velocity, Bathymetry, and Discharge

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Publications

There are no publications.
Traditional methods of measuring river flow rates are relatively expensive and often require field technicians to work in hazardous conditions. Under high flow conditions, during which the bathymetry changes widely, the use of extrapolated rating curves can result in errors of up to 70%. In an effort to develop a reliable, continuous and efficient method of remotely monitoring volumetric flow rate, an initial series of surface particle image velocimetry (SPIV) experiments were conducted in a wide open channel flow facility to measure the surface velocity field and study the physics connecting the surface turbulence metrics to bathymetry. The experiments were carried out in fully developed flows at a range of non-dimensional flow depths ($B/H = 8 – 20$, where $B$ is the channel width and $H$ is the flow depth), Reynolds numbers ($Re_H = 8,000 – 59,000$, based on the mean velocity and flow depth) and Froude numbers ($Fr = 0.1 – 0.5$). Both mean and turbulent velocities and integral length scales were calculated from the surface PIV data. It was found that the mean surface velocity is linearly related to the depth-averaged velocity. This result, which has been noted by several other researchers, is a consequence of the self-similarity of wall-bounded flows. The slope of the best-fit line was found to be 0.94, which is consistent with the 0.90 value indicated by Rantz (1982) for concrete-lined channels.
Figure 1. Mean Centerline Velocity vs. Depth-Averaged Velocity

The integral length scale, calculated from the surface turbulent velocity field, varies predictably with the flow depth as seen in figure 2a and clearly demonstrates a Reynolds number dependence (figure 2b).

Figure 2. (a) Transverse integral length scale, $L_{22,2}$ vs. flow depth, $H$. (b) Transverse integral length scale, $L_{22,2}$ vs. Reynolds number, $Re$.

Figure 3. Integral length scale ($L_{22,2}$) normalized by the flow depth, $H$ vs. the turbulent Reynolds number, $Re$.

The results are fully characterized when the integral length scale is normalized by the flow depth and plotted versus the turbulent Reynolds number, $Re_{f} = u_{rms} L_{22,2} / v$ as seen in figure 3. This relation thus enables direct calculation of the flow rate from the measurement of only the surface...
velocity field. Initial estimates of volumetric flow rate as compared to an independent measure prove quite promising (Table 1).

<table>
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<th>Uc, Centerline Velocity [cm/s]</th>
<th>Q, SPIV Results [m³/s]</th>
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<td>23</td>
<td>0.0311</td>
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Table 1. Measured and estimated values of volumetric discharge.

In the upcoming year we intend to carry out additional experiments where the channel cross-section will be modified to a trapezoidal shape and where the bed roughness will be increased with the addition of gravel. The gravel experiments have already been initiated. Our goal in the upcoming year is to carry out field measurements at prototype scale at one or more of the local USGS gaging sites. To this end we have made multiple field site visits in coordination with the Ithaca USGS to begin to design these prototype experiments.
The Director and staff of the NYS Water Resources Institute undertake public service and partnership activities. Most are conducted through multidisciplinary projects funded outside the Water Resources Research Act (WRRA) context. In order to couple WRRA activities to other NYS WRI activities, a portion of WRRA resources are devoted to information transfer through a partnership program with the Hudson River Estuary Program, dissemination of information related to emerging issues, and student training.
NY Water Resources Institute Information Transfer

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Publications

New York State Water Resources Institute FY2012

The mission of the New York State Water Resources Institute (WRI) is to increase awareness of emerging water resources issues and to identify creative ways to improve the management of water resources in New York State and beyond. Additionally, WRI acts as a bridge to foster communication and knowledge exchange between the various stakeholder groups, government agencies, and research institutions that are engaged with water resources management in New York State.

During FY2012, staff research and information transfer focused on the following major areas:

1. **Responding to potential shale gas development and associated hydraulic fracturing**
2. **Assessment and funding of public water resource infrastructure**
3. **Long-term resilience to extreme weather events and climate change**

Additional research and information activities on various topics were conducted as appropriate and needed.

**Shale Gas & Hydraulic Fracturing**

- Published a peer-reviewed study “Toward strategic management of shale gas development: Regional, collective impacts on water resources,” in *Environmental Science & Policy*, January 2012 (most downloaded ES&P article on the internet from June to November, 2012)
- Submitted commentary on USEPA’s “Draft investigation of ground water contamination near Pavillion, Wyoming,” February 2012
- Participation on expert panel for “Municipal law & planning: A local perspective on hydrofracking,” organized by the Albany Law School, September 2012

**Public Water Infrastructure**

**What we do**
Replacing and upgrading aging water infrastructure throughout the State will require investment of billions of dollars from both public and private entities over the coming decades. This infrastructure is critical to maintaining and improving environmental and public health. The Smart Growth Public Infrastructure Policy Act of 2010 prioritizes the funding of public infrastructure projects that promote smart growth.
Above: New York watersheds in the Hudson and Mohawk basins, the location of WRI analyses of infrastructure function, efficiency, and funding

Using data from state and federal agencies, as well as local municipalities and utilities, WRI is investigating the state of public infrastructure and exploring strategies for investing in capital projects. The goal of these analyses is to aid planners and public decision makers at various levels of government, and to generate insight with respect to strategic management of state funds and the maintenance and improvement of public health and New York’s environmental assets. In the past year WRI has:

- Submitted a manuscript entitled “A watershed-scale goals approach to assessing and funding wastewater infrastructure,” to the Journal of Environmental Management
- Initiated multidisciplinary research with experts in city and regional planning, business management, natural resources, environmental engineering, and policy analysis
- Conducted a national survey (via Cornell) investigating issues related to public perception of water and wastewater infrastructure
- Published a study, “Desalination in northeastern U.S.: Lessons from four case studies” in Desalination

A more complete list of NYSWRI activities follows. For more information please email Director Susan J Riha at nyswri@cornell.edu, or call (607) 255-3034, Website: wri.eas.cornell.edu
New York State Water Resources Institute FY2012 Activity

Peer Reviewed Publications


Outreach and non-Refereed Publications


Policy Related Outreach
1. NY Assemblywoman Ellen Jaffee cites NYSWRI article "Desalination in northeastern U.S.: Lessons from four case studies" in a letter to the New York State Public Service Commission. August 5 [link].

Conference Presentations & Invited Talks


Press

1. NYSP2I announces recepients of 2012-2013 Community Grants Program, NYSP2I Press Release, February 22 [link].

2. As India grows, water supply shrinks, Asia Pacific Defense Forum, December 6 [link].

3. DEC, Cornell and local stakeholders to work together on improving the Cayuga Lake water quality, NYSDEC Press Release, October 19 [link].

4. 'A Day in the Life of the Hudson River' event to celebrate ten years of exploring the estuary, NYSDEC press release, October 2 [link].

5. Simple and cheap solution to India's grave water crisis: Waste water recycling, The Economic Times (India), September 23 [link].

6. Where are the herring? Day out seeks answers, The Daily Gazette, June 27 [pdf].

7. Studing impact of Irene, Lee can lessen future storm damage, Poughkeepsie Journal, June 24 [link].

8. Another wastewater treatment facility proposed, Morning Times (Sayre, PA), June 6 [link].


10. Eagle Scout plants Trees for Tribs, Your News Now, May 20 [link].


12. DEC again hosts 'Trees for Tribs' potting, Poughkeepsie Journal, April 24 [link].


USGS Summer Intern Program

None.
## Student Support

<table>
<thead>
<tr>
<th>Category</th>
<th>Section 104 Base Grant</th>
<th>Section 104 NCGP Award</th>
<th>NIWR-USGS Internship</th>
<th>Supplemental Awards</th>
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Notable Awards and Achievements
Publications from Prior Years