Water Research Institute

Annual Technical Report

FY 1999

Introduction

Research Program

Maine is the 'blue water' state as described by final report of the Great Pond Task Force in 1997, a reference to the clean, clear, oligotrophic condition of many of our surface waters. However, our water resources are not problem-free. Indeed, as the visible condition of previously impacted waters has improved during the past three decades, we have become increasingly aware of invisible impacts such as mercury, dioxin, arsenic, and acid rain. The Maine Water Research Institute is a central player in the overall research program to address these and other issues in Maine.

1998 was the last year of the USGS WRRI regional competition. All three of the proposals submitted by Maine in 1998 were funded, and indeed were ranked 1, 2 and 4 by the regional panel. These projects, plus the two proposals funded in 1997, comprised the USGS-funded research program of the Institute in 1998. These projects are summarized below.

We are particularly pleased to report that three activities of the WRI involved collaboration with social scientists. The largest effort is the project by Kevin Boyle (UMaine) and John Halstead (UNH) on valuations of lake front property. The second is our EPA/NSF Water and Watersheds grant which closely involves the University of Maine Smith Center for Public Policy (see 'Oher Institute Research' below). Finally, the WRI secured the funding and participated in a graduate student project and publication on the contributions of Maine lakes to the state economy (Boyle et al, 1997 in the 'Reports' section).

Other Institute research in 1998 included the following:

· *Collaborative Research on Maine Surface Water Toxics* (NSF 1996-98 $298,000 to Kahl, Katz, Courtemanch (DEP), and Bushway; and Maine DEP 1996-98; $740,000 to Kahl, Katz, and Bushway). The Maine Surface Water Ambient Toxics (SWAT: LD 1042) Program, initiated in 1994, is designed to determine the extent and magnitude of toxic contamination in Maine surface waters. The overall program involves fish and sediment monitoring for toxic substances, and other special studies as suggested by data collected. This cooperative agreement between DEP and the Institute provides analytical support for SWAT and the related Dioxin monitoring program in Maine, and provides new input from University of Maine researchers who have substantial expertise in Maine with the environmental chemistry of these compounds. This project constructed new 'clean room' facilities necessary to conduct low-level organic toxic and heavy metal analyses, and acquired the instrumentation to analyze for trace level organic toxic compounds. The facilities expanded the existing inorganic WRI laboratory capabilities to create a state-of-the-art organic and inorganic environmental research facility for the State of Maine.

· *Long Term Monitoring of Maine Lakes and Streams* (EPA, 1991-99; $680,000 to J.S. Kahl and S.A. Norton). The University of Maine was a founding participant in the EPA LTM program begun in 1983. The program has expanded in recent years to include spring sampling of outlets on selected lakes, and now includes lakes sampled in the 1980s by the High Elevation Lake Monitoring project conducted by Kahl and Matt Scott of Maine DEP.

· *Surface water data analysis, Environ. Monitoring & Assessment* (EPA 1992-98; $960,000 to J.S. Kahl and S.A. Norton). Since 1991, the WRI laboratory has been the national surface water chemistry laboratory for the EPA flagship monitoring program EMAP. Activities of this project have included modifying new analytical methods for total nitrogen and aluminum speciation, developing interpretative methods for data validation and assessment, and publishing regional statisitical data in conjunction with EPA scientists.

· *Development of a Water Resource Management Plan, Acadia N.P.* (NPS, 1994-98; $66,000), to Kahl and Houtman. A

comprehensive plan does not exist for management of water resources in Acadia National Park. The 1990 Acadia General Management Plan identified a Water Resources Management Plan (WRMP) as an important part of future management efforts. Kahl and Houtman were funded in 1994 to develop a WRMP to guide management of the lakes, ponds, streams, and groundwater into the next century. An Oversight Committee was assembled to review progress and provide input to the plan. Committee members included local town admin-istrators, business people, MDI water suppliers, and staff from several state agencies. We solicited public input, and sent out a questionnaire to interested persons to help identify key issues. A series of focus group meetings in the win-ter provided forums for various state and local interest groups to discuss their concerns. We have reviewed literature and documents pertaining to Acadia water resources. A complete draft of the plan will be available in 1999.

· *Linking Watershed-scale Indicators of Changes in Atmospheric Deposition to Regional Response Patterns*. (EPA, 1997-2000, $636,000 to Kahl and 7 others). This research is part of a program addressing scientific and societal needs by investigating the processes and indicators of response and recovery at the Bear Brook Watershed in Maine (BBWM). We are using the geochemical model MAGIC to predict site specific results and will then scale the results from BBWM to the regional level by re-examining the parallel spatial and temporal chemical trends in the High Elevation Lakes in Maine (HELM) and their watersheds. These lakes had the highest concentrations of nitrate of any known lake population in the northeastern US in the 1980s. Concurrently, we are developing the mechanisms to present these findings in a practical format for state and federal resource managers and decision-makers, guiding them to information relevant to their goals. This latter objective is especially relevant in Maine, because of the importance of the forest products industry to the state economy.

This information is fundamental for EPA to meet the Congressional mandate in the Clean Air Act Amendments (CAAA) to ascertain trends in ecological response, and to determine the effectiveness of the CAAA in influencing these trends. Site specific data from BBWM scaled to the regional HELM population will also provide a template for the recognition and under-standing of possible N-saturation and base cation depletion that may be occurring in watersheds in the region. This information will be presented and evaluated for use in management and policy decisions by industry, and at the local, state and federal level.

· *Inferring Regional Patterns and Responses in N and Hg Biogeochemistry Using Two Sets of Gauged Paired-watersheds* (EPA, $475,000 to Kahl et al.). This project is part of long-term ecological research using two gauged-watersheds to be implemented at Acadia National Park through collaborative funding by USGS and this proposal to EPA. The focus is atmospheric deposition of N and Hg, and their ecological consequences. Both elements are of major concern, both regionally and to the Park Service at Acadia. This location offers the advantages of a) co-funding for cost-effectiveness; b) a natural experimental design for the two watersheds because of a major forest fire in part of the Park in 1947; c) parallel design with the acidic deposition experiment on paired-watersheds at the nearby Bear Brook Watershed, Maine (BBWM); and d) prior research at Acadia and BBWM that supply background data, and provide the basis for ecosystem indicators to be applied at Acadia. Our objectives are addressing N cycling and saturation, and Hg input and bioavailability, in paired watersheds with different forest types. We are using the natural landscape contrasts provided by fire to compare patterns and processes in N and Hg sequestration and mobility. N loading to estuaries is being addressed by periodic sampling of estuary tributaries as ‘satellite’ locations, whose N-loading will be extrapolated from occasional sampling by using the more intensively monitored main watersheds as index sites.

The results will provide new information for Acadia and for the New England region on the ecological consequences of high N deposition at Acadia, and the loading of N to estuaries in the region. We lack an explanation of the high accumulation rates of Hg in sediment and peat cores compared to wet-only deposition, and have not explained why Acadia has some of the highest Hg concentrations in biota in the world. The general representativeness of Acadia forests for the New England region, combined with the fire history to be included in our experimental design (fire also being ‘typical’ of the historical New England landscape), offers the opportunity to understand some key issues for Acadia, while providing insight into these issues at the regional scale.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Effects of Lake Water Quality on Prices of Lakefront Property Prices in New Hampshire and Vermont
Project Number	HQ-96-GR-02674
Start Date	09/01/1997
End Date	08/31/1999
Research Category	Social Sciences
Focus Category #1	Economics
Focus Category #2	Management and Planning
Focus Category #3	Conservation
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kevin Boyle	Professor	University of Maine	01
John Halstead	Professor	University of New Hampshire	02
Roy Bouchard	Professional Staff	Maine Department of Environmental Protection	03

Problem and Research Objectives

New Hampshire Project Abstract/Summary

New England's lakes are aging at an extremely rapid rate. Between the years 1986 and 1996, the number of eutrophic lakes (those with high nutrient levels) in New England doubled to 32% (White, 1997). Fully 23% of New Hampshire's lakes have reached the eutrophic stage. It is estimated that cultural eutrophication has caused as much aging of New Hampshire's lakes in the last 30 years as took place in the previous 10,000 years. Policy makers often face the problem of evaluating water quality affects a region's economic well-being. Using water clarity as a proxy for eutrophication levels (as a lake becomes inundated with nutrients, water clarity decreases markedly), analysis was performed on sales data collected over a six year period. Results indicated that water clarity had a significant effect on prices paid for residential properties. Effects of a one meter change in clarity on property value were also estimated. Thus, policy makers have access to information which provides part of the cost of water quality degradation as measured by changes in water clarity.

Vermont Project Abstract/Summary

Vermont's lakes are threatened by decreasing levels of water quality. Nutrient loading, or eutrophication, from human sources poses a significant threat to the health of Vermont lakes. Water clarity in affected lakes is noticeably reduced and in many instances, aquatic macrophyte growth is drastically accelerated. The Vermont Department of Environmental Conservation estimates that 90% of the state's impaired water bodies is caused by nonpoint source pollution. It is estimated that approximately 80% of the state's 228,915 acres of lakes and ponds have been impacted by nutrients while another 3% are threatened (Vermont DEC, 1996).

Current lake protection policies and restoration efforts tend to be evaluated by the physical and biological benefits they provide such as increased water clarity. However, little information is known about the economic benefits of improved water quality resulting from such policies and projects. Information on the economic benefits of improving lake-water quality would be helpful to the Vermont Department of Environmental Conservation when weighing the costs and benefits of various lake-protection policies and projects and to prioritize projects where benefits do exceed costs.

Methodology

New Hampshire Project Methods

This study used the hedonic method to estimate the effects of water clarity on housing prices. The general form of the hedonic price equation used in this study is HP = f (S, L, lnWC), where:

HP = home price

S = structural characteristics

L = locational characteristics

WC = water clarity

Sixty-nine public access lakes in fifty-nine towns were selected for this study. In consultation with the New Hampshire DES and others familiar with New Hampshire's Lakes regions, the lakes were broken into four market areas in central and southern New Hampshire. Lakes were grouped into markets due to close proximity to each other and the probability that they share common characteristics.

Information on the selected variables was taken from public assessment and transaction records available in the towns where the properties are located. In New Hampshire, water bodies with surface area larger than 10 square acres are considered available for public use.

The original number of usable observations collected was 742. Ninety eight observations were removed due to inconsistent town records or unrecoverable gaps in the secchi disks readings. Also, those observations that had no information on plumbing were discarded.

Lake area (**LKA**) was incorporated into the equation via an interaction variable, lake area ***** ln(water clarity), or **LKALWC**. The derivative of this interaction variable weights changes in water clarity by lake area:

(1) ¶HP95/¶WC = b * LKA * WC^{-1}

LKALWC was chosen for use in this study because its use incorporates more of each lakes' characteristics into the equation which makes the estimated coefficients more robust. The combination variable **LKALWC** also removes the price bias that results from using one regression coefficient for lakes of all sizes within a single market.

Vermont Project Methods

This study used the hedonic property value model to estimate the implicit value of water clarity and aquatic weed density on Vermont lakefront properties. The general forms of the hedonic models used in this study are specified as:

hp=f**(S, L, ln(WC))**

and

hp=f(**S, L, exp(WD)**)

where;

hp=is the actual sales price of property

S=is the structural characteristics of the property

L=is the locational characteristics of the property

ln(WC)=natural log of water clarity

exp(WD)=is the exponential of total aquatic weed density

This study incorporated lakefront property sales from twenty-one lakes and twenty-six organized towns and territories throughout Vermont. The lakes were selected by representatives from the Vermont DEC and grouped into three separate markets. Each market consists of a group of lakes that are in close proximity with one another and have a common urban center. The purpose of separating the lake groups into separate markets is to examine cross-market variations in the estimates of the implicit price of water clarity.

Information on property sales and property sales price were collected from transfer tax records held in town offices. Transfer tax records are considered public information and can be obtained from the town office to identify lakefront property sales within the town. Property tax cards were used to provide information on the structural and locational characteristics of the properties. A total of 236 observations were used in the estimates for water clarity.

An interaction variable of the natural log of lake-water clarity multiplied by total lake surface area is used in this study because of the collinearity between water clarity and lake area. This implies that water clarity is more important to consumers of lakefront property located on larger lakes while consumers of lakefront properties located on smaller lake may be willing to forgo improved water quality for less boating traffic.

Principal Findings and Significance

New Hampshire Results/Principal Findings

Lake water clarity was found to have a statistically significant, and positive effect on property values in the areas studied. The application of these results on a lake by lake basis can be illustrated by examining a single water body, Sunset Lake in market area 4. For this lake, **LKA** = 31, **WC** = 3.2, and β_9 =149.6. Thus,

$$\partial \mathbf{HP95} / \partial \mathbf{WC} = \beta_9 * \mathbf{LKA} * \mathbf{WC}^{-1} = 149.6 * 31 * (1/3.2) = \$1,449.25$$

so that a one meter improvement in water clarity would result in just under a $1,500 increase in property value. The mean property value in this region is $167,100, so the one meter change represents approximately a one percent change in property value. Similar calculations are performed for "average" lakes in the four market areas in Table 6, indicating that there is a wide variation in the effects of one meter water clarity improvements on property values.

This study shows that water clarity is a concern to consumers who own lakefront property on those lakes. Mail survey results (a related effort of the overall study) show that water clarity is an important factor in purchase decisions of waterfront property in New Hampshire; 76% of respondents made the effort to inquire about water clarity prior to purchasing their property. Also, of those who responded, 96.9% said clean water is a very important while 98.5% said clear water is a very important. Clarity of the water influenced the purchasing decision of 45.5% of survey respondents. This result shows that marginal changes in water clarity do affect lakefront residential property prices (Gibbs, 2000).

Decreasing property values will affect both state and local tax revenues. It is important for the fiscal health of both the State of New Hampshire and individual towns that water clarity be protected. The results of this study can be used to determine where the most effort needs to be concentrated for the improvement or protection of water clarity.

Vermont Results/Principal Findings

Preliminary results show that Lake-water clarity and total aquatic macrophyte density have statistically significant positive and statistically significant negative effects on lakefront property prices in Vermont, respectively. The results of this study will be forthcoming as a master's thesis at the University of Maine at Orono in August 2000.

References

Vermont Department of Environmental Conservation. (1996). Lake Water Quality Assessment, 1996. Agency of Natural Resources. Department of Environmental Conservation, Water Quality Division. Waterbury, Vermont.

Descriptors

Lakefront property value, water quality, hedonic methods, New Hampshire, Vermont

Articles in Refereed Scientific Journals

Boyle, Kevin J., P. Joan Poor, and Laura O. Taylor. 1999. Estimating the Demand for Protecting Freshwater

Lakes from Eutrophication. American Journal of Agricultural Economics 81(5): forthcoming.

Gibbs, Julie P., John M. Halstead and Kevin J. Boyle. 1999. An Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties. Agricultural and Resource Economics Review 29(2).

Book Chapters

Dissertations

Gibbs, Julie P. 2000. The Influence of Water Clarity on Marginal Prices for Residental Lake Front Property in New Hampshire. Unpublished Thesis. University of New Hampshire, Durham, N.H.

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Discussion Papers Presented at Professional Meetings

Gibbs, Julie P., John M. Halstead and Kevin J. Boyle. 1999. "An Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties." Northeastern Agricultural and Resource Economics Association, Rhode Island.

Boyle, Kevin J. 1999. "Estimating the Demand for Lake Water Quality with a Hedonic, Property-Value Model: Objective versus Subjective Measures of Quality." Department of Economics, University of Wyoming, Laramie, Wyoming.

Taylor, Laura O., Kevin J. Boyle, and P. Joan Poor. 1999. "Subjective versus Objective Quality Measures in Hedonic Demand Models: Implication for Valuing Water Quality." Selected paper, annual meeting of the Southern Economic Association, New Orleans, LA.

Taylor, Laura O., Kevin J. Boyle, and P. Joan Poor. 1999. "Subjective versus Objective Quality Measures in Hedonic Demand Models: Implication for Valuing Water Quality." 7th Annual Triangle Camp Resources, Wilmington, NC.

Boyle, Kevin J., P. Joan Poor, and Laura O. Taylor. 1999. "Estimating the Demand for Protecting Freshwater Lakes from Eutrophication." Invited paper, Association of Environmental and Resource Economics session on "Frontiers of Applications of Hedonics to Environmental Issues," annual meeting of the American Agricultural Economics Association. Nashville, TN.

P. Joan Poor, Kevin J. Boyle, and Laura O. Taylor. 1999. "Objective versus Subjective Measures of Environmental Quality in Hedonic Property Value Models." Selected paper, annual meeting of the Northeastern Agricultural and Resource Economics Association, Morgantown, WV.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Differentiating Local Contributions of Mercury from Regional Inputs
Project Number	HQ-96-GR-02674
Start Date	09/01/1998
End Date	08/31/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Toxic Substances
Focus Category #3	Water Quality
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Stephen A. Norton	Professor	University of Maine	01
David L. Courtemanch	Professional Staff	Maine Department of Environmental Protection	02
Jeffrey S. Kahl	Associate Professor	University of Maine	03

Problem and Research Objectives

Hypotheses

1. Local sources of Hg emissions contribute significantly to atmospheric deposition of Hg (both wet and dry) on a local scale.
2. Atmospheric deposition rates of Hg from a point source is inversely related to distance from that source and directly related to the prevailing wind direction.
3. The response of lake biota and the sediment record to changes in atmospheric deposition of Hg is inversely related to the (watershed/lake) area ratio.

Approach

Our research focuses on hypotheses 1 and 2 by determining the chemistry of dated sediment cores from lakes and bogs at varying distances from, and compass directions around, these Hg sources. We will determine the relative contributions of the local sources versus the regional background and the timing of changes in comparison to the onset and changes of local emission sources. The third hypothesis will be evaluated by the three PIs at the conclusion of the analytical phase of the research.

Methodology

Methods

We will collect single sediment cores from the deep area of each of 8 lakes near Orrington, Maine. For these lakes, we already have data on Hg in fish and surface sediments that show that Hg concentrations are higher near and downwind of the local Hg sources (DEP, 1996). Two cores will be from a) a lake further downwind to determine how far the signal from the local sources is (or is not) measurable, and b) a lake significantly upwind of the sources to establish the regional baseline resulting from the continental Hg signal from the atmosphere. Cores will also be collected from at least two peat bogs where the influence of a canopy on dry deposition of Hg is effectively zero. It is essential that all these cores be dated by ^{210}Pb (Norton et al., 1997; Binford et al., 1994) so that the chronology of Hg stratigraphy can be correlated with the emission history of the industrial sources. Total Hg concentrations will be determined from intervals of sediment. Fluxes of Hg to the coring site (μ g Hg/cm^2/yr) will be calculated based on the sediment chronology, mass accumulation rates, and concentrations of Hg. These fluxes will then be compared to the emission history for the local area, region, and continent.

Principal Findings and Significance

Progress

Early in the project, we recognized the possibility of establishing a gamma spectrometry laboratory for the purpose of conducting the radionuclide analyses proposed in the original grant proposal. With supplementary funding provided by the Office of the Vice Provost for Research at the University of Maine, in combination with rearranged budgeting for the ^{210}Pb analyses (approved by the U. S. Geological Survey), we have established a functioning gamma laboratory providing the services needed in support of this research. ^{210}Pb dating has been completed on 8 of 10 cores (see Table 1, below) and is underway on the last two. Start-up and calibration of the various steps in dating took longer than anticipated, setting back our schedule about 4 months.

All tasks of the project are under control and proceeding well. We expect to complete tasks on the schedule indicated in Table 1.

Site	Coring	Water concentration	Loss-on-ignition	^{210}Pb	Chronology	Hg concentration
Caribou Bog	Done	Done	Done	Done	Done	Done
Eddington Bog	Done	Done	Done	Done	Done	Done
Brewer Lake	Done	Done	Done	Done	7/00	Done
Goose Pond	Done	Done	Done	7/00	8/00	7/00
Jacob Buck's Pond	Done	Done	Done	Done	Done	Done

Long Pond	Done	Done	Done	Done	7/00	Done
Swetts Pond	Done	Done	Done	Done	Done	Done
Thurston Pond	Done	Done	Done	Done	7/00	Done
Trout Pond	6/00	7/00	7/00	8/00	8/00	8/00
Williams Pond	Done	Done	Done	Done	Done	Done

Table 1: Status of tasks on the project, as of June 1, 2000, with estimated date of completion

Data analysis will continue in July and August of 2000. Re-analysis of any samples, suggested by data analysis, has been on-going. A final report and manuscripts will be prepared during the late summer and fall of 2000, respectively.

Field work has been conducted by Professor Stephen Norton (PI), Amy Benoit (Undergraduate Student in charge of the two bog cores), John Cangelosi (Technician), Ewan Whitaker (Graduate Student), and Ethan Perry, Kate Mahaffey, and Amy Winkle (undergraduate students). ^{210}Pb laboratory work has been conducted under the supervision of Professor C. Tom Hess primarily by Amy Benoit and Mary-Jo Norris (Graduate Student), with assistance from Perry. Chemical laboratory work has been supervised by Norton and Michael Handley (Laboratory Manager), and conducted by Cangelosi and Perry.

Products to Date

Benoit, Amy, 1999, A history of atmospheric mercury deposition derived from an ombrotrophic peat bog in Maine: Evidence for a local industrial source?: Honors Thesis, University of Maine, 28 p. plus Appendices.

Norton, S. A., Hess, C. T., Cangelosi, J. A., Norris, M. J., Perry, E. R., Kahl, J. S., and Courtemanch, D. L., 2000 (accepted for August oral presentation), Discrimination between regional and point source atmospheric Hg pollution using sediment records from drainage lakes, Maine, USA (abstract): Internat. Conf. On Heavy Metals in the Environ., Ann Arbor, MI.

Norton, S. A., Hess, C. T., Cangelosi, J. A., Norris, M. J., Perry, E. R., Kahl, J. S., and Courtemanch, D. L., 2000 (accepted for publication), Discrimination between regional and point source atmospheric Hg pollution using sediment records from drainage lakes, Maine, USA: Proc., Internat. Conf. On Heavy Metals in the Environ., Ann Arbor, MI., 4 p.

Perry, E. R. and Norton, S. A., 2000, Human influences on biogeochemical cycles (oral presentation): 6th Annual Earth Sciences Teachers Workshop, University of Maine.

Progress on the research plan:

Installation of a gamma counting laboratory for dating sediment is complete.

Field work 90% complete

Chemical laboratory work 75% complete

Radiometric dating 80% complete

Data analysis 25%

Descriptors

Mercury, incinerators, chlor-alkali, paleolimnology, atmospheric emissions, atmospheric deposition, bog sediment

Articles in Refereed Scientific Journals

Norton, S.A., Hess, C.T., Cangelosi, J.A., Norris, M.J., Perry, E.R., Kahl, J.S. and Courtemanch, D.L. 2000 (accepted for publication). Discrimination between regional and point source atmospheric Hg pollution using sediment records from drainage lakes, Maine, USA: Proc., International Conference on Heavy Metals in the Environ., Ann Arbor, MI., 4 p.

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Norton, S.A., Hess, C.T., Cangelosi, J.A., Norris, M.J., Perry, E.R., Kahl, J.S. and Courtemanch, D.L. 2000 (accepted for August oral presentation). Discrimination between regional and point source atmospheric Hg pollution using sediment records from drainage lakes, Maine, USA: (abstract): International Conference on Heavy Metals in the Environ., Ann Arbor, MI., 4 p.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Using Semipermeable Membrane Devices for Detecting and Assessing Risks of Exposu
Project Number	HQ-96-GR-02674
Start Date	09/01/1998
End Date	09/30/2000
Research Category	Water Quality

Focus Category #1	Non Point Pollution
Focus Category #2	Toxic Substances
Focus Category #3	Hydrogeochemistry
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Howard H. Patterson	Professor	University of Maine	01
Touradj Solouki	Assistant Professor	University of Maine	02
Therese D. Anderson	Professional Staff	University of Maine	03
Jeffrey S. Kahl	Assistant Professor	University of Maine	04

Problem and Research Objectives

Abstract

Polychlorinated dibenzo-*p*-dioxins and furans (PCDD/F), collectively termed as dioxin, are two classes of che by scientists due to their carcinogenic and endocrine disruption characteristics (Fries, 1995). These contamina because they are produced from a variety of natural and anthropogenic processes. The hydrophobic nature an bioaccumulation in aquatic organisms. Bioaccumulation occurs when the organisms are exposed to dioxin thr dioxin-contaminated food sources, and direct dermal contact with contaminated water (Huckins *et al*, 1996).

Problem

Kraft paper mill effluents, historically one of the primary anthropogenic sources of dioxin, are under investiga Environmental Protection (DEP) because some of the fish consumption advisories effective in Maine Rivers a found in fish. In 1997, the Maine legislature passed the upstream-downstream bill; this law states that by the Kraft mill are not to exceed the levels above that mill. The current dioxin monitoring method in Maine involv fish annually. Unfortunately, this current method has drawbacks that make it difficult to use in determining up Semipermeable membrane devices (SPMDs) circumvent many of the current methods problems and potential robust, and accurate measure of the dioxin concentrations both above and below a Kraft paper mill.

Methodology

Purpose and Methods

Over the course of the 1999 and 2000 field seasons, SPMDs are being placed in two different Maine rivers fo to determine the feasibility of using these devices for monitoring the dioxin levels in surface waters. Since SP that may interfere with the monitoring process, water quality parameters are monitored at each site both in th comparability in site environmental conditions. In the laboratory, dioxins are extracted from the SPMDs throu dialysates are cleaned by gel permeation chromatography. This is followed by Florisil solid phase extraction a chromatography / high-resolution mass spectronomy (HRGC/HRMS).

Research Significance

The results of field investigations will determine when and where SPMDs are suitable for monitoring dioxin c method proves viable, the State could have the opportunity to monitor a variety of pollutant concentrations in fish species due to fish mobility. Most importantly, reliable development of the SPMD method for monitoring of Kraft mill compliance to the upstream-downstream law.

Research Objectives

- To develop both an accurate and cost-effective method of measuring dioxin exposure in aquatic system determinations for SPMDs:
    - How do SPMDs respond to a range of environmental conditions?
    - What method of extraction and cleanup of the SPMDs is feasible for analysis of the extracts by H
- To provide the State of Maine with the new tool of SPMDs for monitoring the dioxin levels above and measure mill compliance with government regulations. In order for an endorsement of the SPMD moni
    - SPMD results and DMP fish results for the same field season and relative locations will be exam trends in the dioxin levels between methods. Identical results between methods are not expected dioxin while the fish are indicators of bioaccumulation levels. However, the relationship between ratios of bioconcentration to bioaccumulation.
    - Environmental conditions among sites for a given deployment must be deemed comparable throu collected at both deployment and retrieval of the SPMDs.

Principal Findings and Significance

Progress

PHASE I: 1999 Field Season on the Penobscot River

OBJECTIVE: *SPMD Method Development*

- SPMDs were placed at nine sites on the Penobscot River in order to assess their biomonitoring potentia laboratory SPMD techniques. These sites were chosen both due to their range of environmental conditi used by DEP personnel for DMP fish collection.
- Each site chosen for a given deployment period was assessed for a suite of water quality parameters at deployment period.
    - Screening data, which included temperature, flow, and specific conductance measurements, was Temperature measured by a field thermometer aided in determining uniformity between sites sin pollutants. Flow was measured with a field flow meter for the same reason as temperature. Speci conductivity probe allowed for assurance that downstream sites were chosen within a wastewate
    - Water samples were collected in order to measure the following: Total Organic Carbon (TOC), Organic Carbon (DOC), Total Phosphorus, Chlorophyll a, apparent color, turbidity, and specific used in order to establish a more thorough comparison of the chosen sites for a given deploymen chosen sites during each deployment period (logger data was collected every hour of deploymen
- Each site had three SPMDs deployed and the three were combined to one sample for analysis.

- Early analyses revealed that cleanup methods were inadequate. Therefore, cleanup methods were altere
- Some retention time shifts still occurred after the cleanup method alterations, thus chromatographic tec
- Unfortunately due to a final sample volume of ten microliters, we are left with only small amounts of sa these adjustments. However, objectives for Phase I of the project have been met:
    - We have seen that surrogate recoveries are within acceptable ranges (Figure 1) and that the SPM
    - Appropriate cleanup methods have been developed and followed with success.

Figure 1. % Surrogate Recoveries for a Deployment S

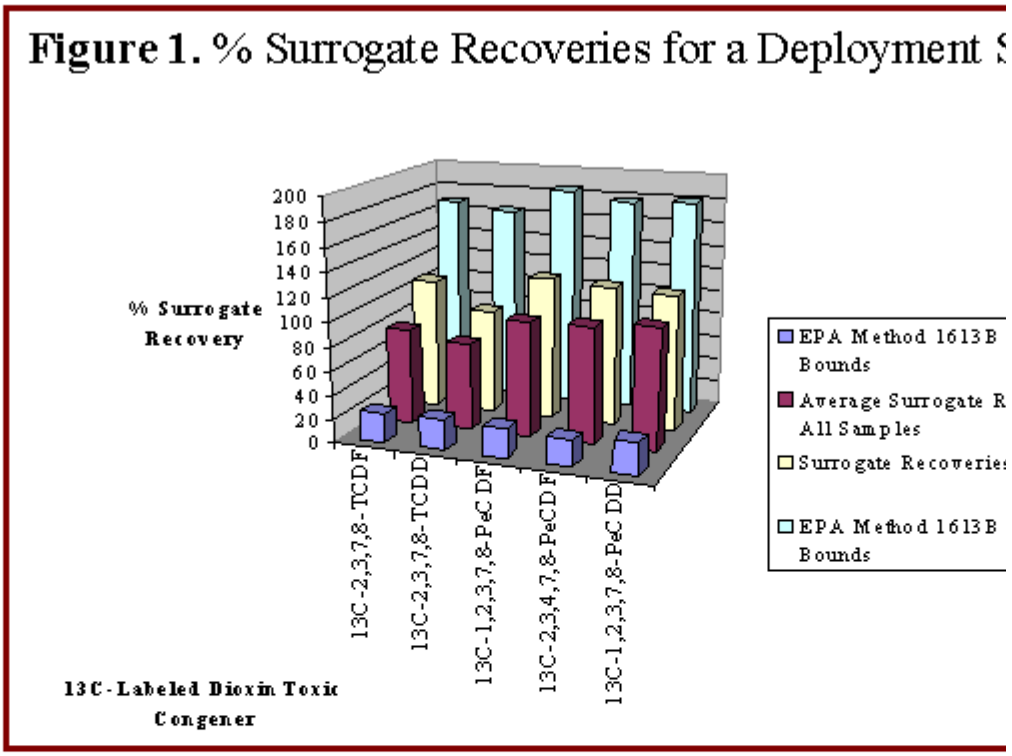

Figure 1 illustrates the surrogate recoveries from a deployment samp purposes, EPA Method 1613B provides lower and upper % surrogate boundaries which are shown in this figure. Surrogate recoveries for t samples were averaged for each congener listed in the graph. Site-9 s are also presented to show the recoveries for a deployment site. Figu that all of the surrogate recoveries fall within the boundaries set by th

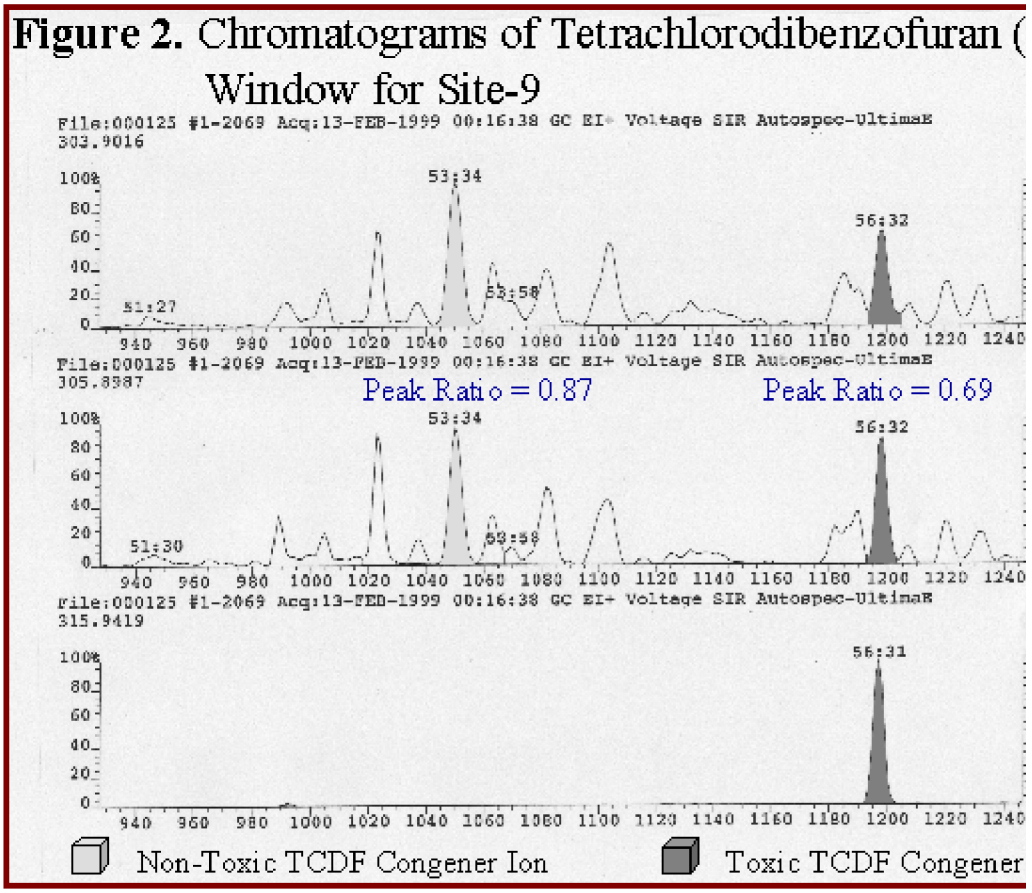

Figure 2 provides the TCDF window chromatograms for the three ions (m/z spectrometry detection. The first two ions, 304 and 306, are native TCDF fra corresponds to the 13C-labeled 2,3,7,8-TCDF surrogate. This latter fragment 56:31 (min:sec), allows us to identify the 56:32 native fragments as the toxic 2 this ID is substantiated by the peak ratio of 0.69 (for 304/306 at retention tim between the EPA Method 1613B theoretical ion abundance QC limits of 0.65 TCDF congener is identified because its peak ratio falls within these limits.

PHASE II: 2000 Field Season on the Androscoggin River

OBJECTIVE: ***To determine SPMD sampling variance and use SPMDs to monitor dioxin levels above a***

- Using the information gained from the 1999 field season investigations, two to four sites along the And help of the Maine DEP in order to determine the variations in dioxin concentrations above and below p

- In this field season the utility of the SPMDs for environmental dioxin monitoring will be tested:
    - This testing includes deployment of multiple SPMDs at a selected site in Dixfield, ME, in order
      the four-week deployment period as well as to determine if saturation of the SPMDs occurs (this
      deployment periods).
        - Twenty SPMDs were deployed at the Dixfield site on June 2, 2000. Every week, fiv
          extent of biofouling as well as the dioxin levels will be assessed.
        - This field experiment will be repeated in July; this setup was devised in the hope of
          flow with low flow in the SPMD sampling of dioxin levels in the river.
    - Deploying multiple SPMDs at sites both above and below a Kraft paper mill in order to determin
      is present will follow this time sampling (August and September deployment periods). The statist
      will aid in this determination.
- Water quality parameters tested at each site has been reduced to TOC, DOC, specific conductance, ten
  most crucial
- Laboratory experiments are being completed concurrently with this field season work in order to deterr
  dioxin that can be sampled by the SPMDs.

Analytical Considerations

- Trip blank concentrations are used to flag potential dioxin levels in the deployed SPMDs due to air exp
- Process blanks, dialysis blanks, and matrix spikes are used to monitor the analytical process and dioxin
  compared to those levels in site SPMDs as well.
- Dioxin peaks are interpreted through the use of EPA Method 1613B which provides theoretical ratio li
  high resolution mass spectrometer in order to insure the positive identification of dioxin peaks (Tellia
- Water quality data for each site is compared among sites for a given deployment to be assured that biof
  temperature were not statistically different among the sites.

Summary

The goal of this thesis project is to successfully complete two distinct phases in analyzing the dioxin-monitori
Determination of whether or not the use of SPMDs in dioxin monitoring is a reliable alternative to fish sampl
field, extraction, and cleanup methods. Therefore, determining viable SPMD techniques (1999 field season) a
environmental sites (2000 field season) will demonstrate the possible effectiveness of the SPMDs in monitorir
upstream-downstream law.

Products to Date

- Project Poster presented by H.A. Shoven at the Maine Water Conference (April, 2000) held in Augusta
- Invited Poster Presentation, Gordon Research Conference:*Environmental Sciences 2000: Water*, Plym
- The 6th International SPMD Workshop to be held in Columbia, MO (July, 2000).

- Pre-thesis Seminar presented by H.A. Shoven.

References

Fries, G.F. (1995). "A Review of the Significance of Animal Food Products as Potential Pathways of Human
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Huckins, J.N., J.D. Petty, *et al.* (1996). Semipermeable Membrane Devices (SPMDs) for the Concentration a
Contaminants in Aquatic Environments. Techniques in Aquatic Toxicology. G.K. Ostrander. Boca Raton, FL

Telliard, W.A. (1994). Method 1613: Tetra-through-octa-chlorinated Dioxins and Furans by Isotope Dilutior
D.C., United States Environmental Protection Agency.

Awards and Achievements

Honorable Mention, 2000 Maine Water Conference, April 3, 2000

UMGAA Nancy Morse Dysart '60 Student Travel Grant, April 2000

Invited Poster, Gordon Research Conference, June 26 - June 30, 2000

Individual Award, University of Maine Association of Graduate Students, June 2000

Descriptors

Pollution control, pollutants, contaminant transport, membranes, organic compounds, model studies

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Shoven, H.A., H. H. Patterson, T. Anderson, J.S. Kahl and T. Solouki. 2000. Poster presentation at MaineW
Conference on Environmental Sciences 2000: Water, and 6th International SPMD Workshop. *Monitoring Di*
Semipermeable Membrane Devices.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Association of Methymercury with Dissolved Organic Carbon - Implications for Bioacc
Project Number	HQ-96-GR-02674
Start Date	09/01/1998
End Date	08/31/2000
Research Category	Water Quality
Focus Category #1	Hydrogeochemistry
Focus Category #2	Toxic Substances
Focus Category #3	Water Quality
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aria Amirbahman	Assistant Professor	University of Maine	01
Terry A. Haines	Professor	University of Maine	02

Problem and Research Objectives

Statement of Critical Regional Problems

High concentrations of mercury (>0.5 mg/g wet weight) have been found in many species of freshwater fish i throughout the US. More fish consumption advisories resulting from mercury have been issued by state healt combined. This problem is especially acute in New England generally, and in Maine specifically. The Maine D Health has issued a blanket fish consumption advisory because of mercury for all fresh waters in the state. Th eliminates a source of high quality protein for residents. These high mercury concentrations also pose a threat source of the mercury is believed to be atmospheric deposition, but the mercury concentrations in biota are n mercury contamination of biota is highly variable and it is common for a lake containing fish with high mercu few hundred meters of another lake with relatively low fish mercury levels. In order to better target fish consu where mercury contamination of biota is most likely to occur, a better understanding of the environmental fac methyl mercury is needed.

Statement of Results and Benefits

The role of dissolved organic carbon (DOC) in the bioavailability of mercury (and other trace metals) is comp chemistry in fish mercury concentration nearly always identify DOC as an important variable, but have produ nature of the interaction. The mercury burden in higher organisms consists almost entirely of monomethyl me entirely through the diet, with a biomagnification factor of about 10 between trophic levels. However, uptake the food chain (e.g., algae) has a bioconcentration factor of ca. 105. Dissolved organic carbon is most likely t MeHg to algae rather than transfer through the food chain to fish. This proposed research focuses on the char

lakes and the interaction between DOC and CH3Hg as it relates to bioavailability of CH3Hg to algae. Throug parameters that control CH3Hg bioavailability, and thereby improve our ability to identify classes of surface v or low CH3Hg bioavailability. Our findings may be useful in improving the ability to predict CH3Hg concentr fish consumption advisories to exempt lakes where CH3Hg is unlikely to bioaccumulate, thereby increasing re

Methodology

Nature, Scope and Objectives of the Research

In freshwater systems, a strong correlation has been found between the aqueous concentration of different m may be positively, negatively, or unrelated to fish mercury concentration, which consists virtually entirely of C interaction of CH3Hg and DOC in freshwaters, due to its bioaccumulation and toxic effect on higher organis of DOC bind CH3Hg very strongly and compete with living cells for available CH3Hg. Alternatively, some fo and may serve to move CH3Hg from sediment reservoirs into the water column, making it more available for concentration has been determined in fish species from about 150 lakes and reservoirs in Maine. We will use span a wide range of CH3Hg and DOC concentrations. Laboratory studies will be designed to simulate the fi chemistry, nature and concentration of DOC and types of organisms are concerned. These studies will be dev that enhance the uptake of CH3Hg by the lacustrine organisms.This proposed research aims at elucidating th CH3Hg in lacustrine organisms. We expect that the findings of this study will enhance our ability to predict C The objectives of this study are as follows:

1. To examine the association of CH3Hg with the DOC from several lakes in Maine.

   The DOC from the selected lakes will be collected and their DOC will be concentrated. For one or mor fractionated based on physicochemical behavior. Acid-base properties and the elemental composition o Partitioning experiments using membrane dialysis technique will then be conducted to determine the re stability of CH3Hg-DOC complexes, with the use of chemical equilibrium modeling. The stability cons be correlated to the rate of uptake of CH3Hg by the organisms obtained by the following set of propos

2. To study the effect of DOC on CH3Hg uptake by a planktonic alga.

   Planktonic algae form the base of lacustrine food chains leading to fish. Algal cultures in the absence a of DOC isolated from the lakes will be amended with CH3Hg. The kinetics of uptake of CH3Hg by the different DOC samples and at varying solution chemistries and CH3Hg concentrations. It is expected t organisms will be inversely proportional to the stability of CH3Hg-DOC complexes as determined abo

Principal Findings and Significance

Complexation Studies

The purpose of the proposed complexation studies is to develop the energetics of interaction between several (DOC) and methylmercury (CH_3Hg). In the last fiscal year we were able to successfully design our experime involved and analyze CH_3Hg.

Interaction between CH_3Hg and DOC was studied using membrane dialysis. We designed a set of glass reacti which a 500 Da membrane separates the two reaction vessels, one containing CH_3Hg and the other the DOC the membrane only. Methylmercury recovery in our system was usually above 90%. Mass balance was establi across the membrane, adsorption of CH_3Hg to the membrane, efficient mixing scheme and minimizing loss d

Experimental Results

Dialysis experiments were conducted to study the association of CH_3Hg with 5 well-characterized humic and consisted of peat humic (PHA), peat fulvic (PFA) and Suwannee River humic (SRHA) acids all supplied by tl Society. We also isolated humic and fulvic acid fractions of Baker Brook (BBHA and BBFA), which is a local wetland.

Adsorption isotherms involving CH_3Hg and each of these humic substances were obtained at different pH val The data obtained from these isotherms were used to estimate equilibrium binding constants of CH_3Hg to var experiments were also conducted at a fixed pH but at varying concentrations of DOC.

Typical adsorption isotherms developed using SRHA are shown in Fig. 1 at different pH values. The behavio very high affinity between CH_3Hg and SRHA. The equilibrium binding constants were obtained by fitting the experimental data using the computer program Fiteql:

Binding constants and total number of reactive sites for the association of methylmercury with IHSS Suwannee River humic acid.		
$RS_1H = RS_1^- + H^+$	$\log K_{a1} = -8$	$RS_{1T} = 7.68\times 10^{-11}$ M
$RS_2H = RS_2^- + H^+$	$\log K_{a2} = -10$	$RS_{2T} = 1.84\times 10^{-9}$ M
$CH_3HgOH + RS_1H = RS_1CH_3Hg + H_2O$	$\log K_{s1} = 12.58$	
$CH_3HgOH + RS_2H = RS_2CH_3Hg + H_2O$	$\log K_{s2} = 9.49$	
$CH_3HgOH + RSSR = RCH_3HgS^+SR + OH^-$	$\log K_{s3} = 14.81$	$RS_{3T} = 2.68\times 10^{-10}$ M

In modeling our data, we have used a discrete log K spectrum without explicit representation of electrostatic substances are represented as an assembly of monoprotic acids, with assumed acidity constants (K_{ai}), the anic complexes. Both Hg and CH_3Hg are known to bind favorably to the reduced sulfur containing functional gro evidence has shown that in the association between Hg and humic substances, these groups are thiol (RSH) a groups.

The first two reactions in the table characterize the dissociation of protons from the thiol/disulfane acidic site 10^{-10} are chosen to represent these groups on humics. These values are within the range of acidities of most t

using a "three-site model"; two acidic thiol/disulfane groups (RS_1 and RS_2) and a disulfide group. Due to the groups, binding of CH_3Hg to these groups is most effective at basic pH values. Conversely, binding of CH_3H at acidic pH values. Therefore, the adsorption isotherm data at pH 9.2 and 7.1 were used to estimate the bind functional groups (K_{s1} and K_{s2}) and the total number of these functional groups (RS_{1T} and RS_{2T}), since at th negligible. It was found that binding to two reactive thiol/disulfan groups modeled the data at pH 9.2 and 7.1 experimental data at pH 3.5 was used to estimate the equilibrium binding constant and the total concentration These values were then used to simulate association of CH_3Hg with SRHA at pH values of 4.6 and 5.2 as sho between the model and the experimental data are good indicating the validity of the proposed model. Similar humic substances have been performed. The results along with a more detailed discussion of our findings are preparation).

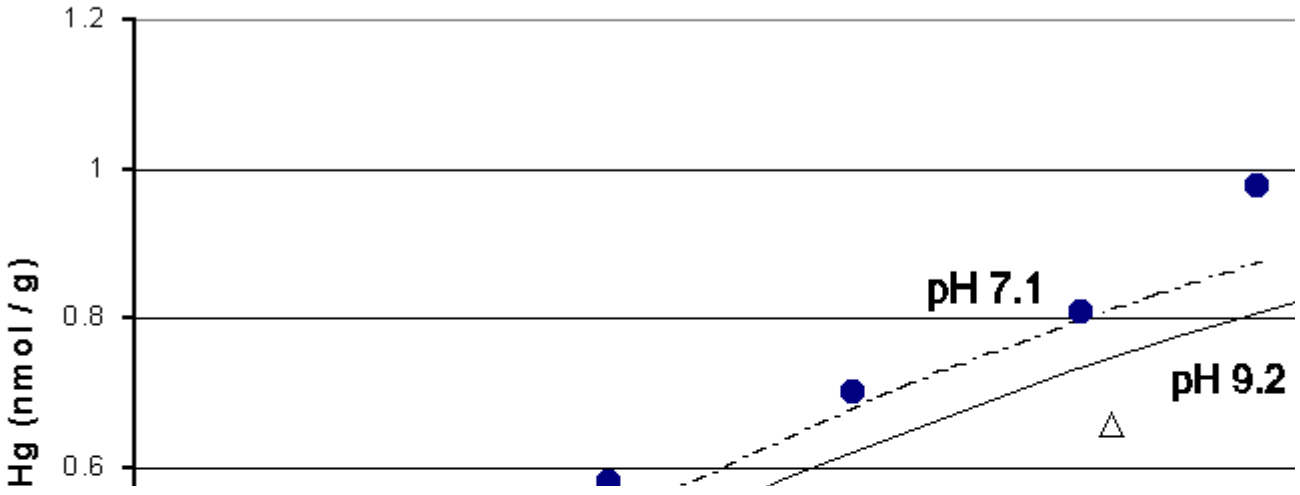
The parameters obtained in this study may be used to simulate speciation of CH_3Hg in natural waters. These models to predict fate of CH_3Hg. Concentration of total CH_3Hg in natural waters is usually in sub-nanomola that the dissolved organic carbon can indeed control the speciation of CH_3Hg in the aquatic environments.

Algal Studies

A culture of the planktonic green alga *Selenastrum capricornutum* was obtained from the University of Texas laboratory.

Preliminary experiments were conducted in the absence and presence of humic substances. The results from th expected, uptake of CH_3Hg increases with an increase in the total available CH_3Hg concentration. Addition (PFA) does not affect the uptake of CH_3Hg. A decrease in algal uptake is observed, however, at DOC concer binding affinity of CH_3Hg to humic substances even at low concentrations of the latter (Fig. 1), this behavior the algal cell surface and PFA.

Fig. 1a: Association of MeHg with Suwannee River Hu



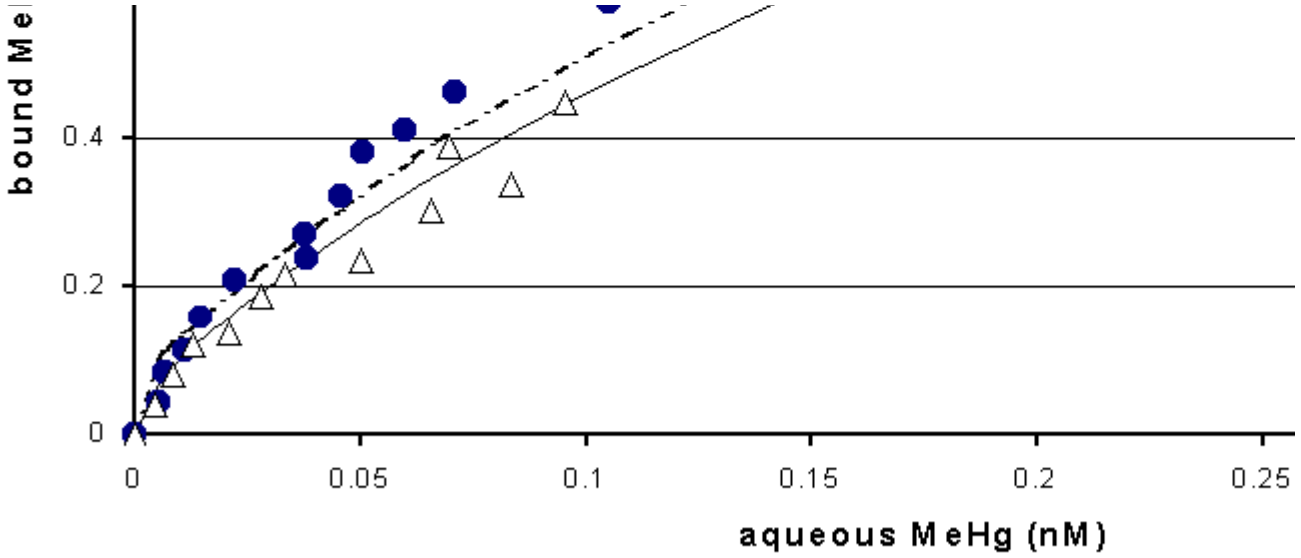
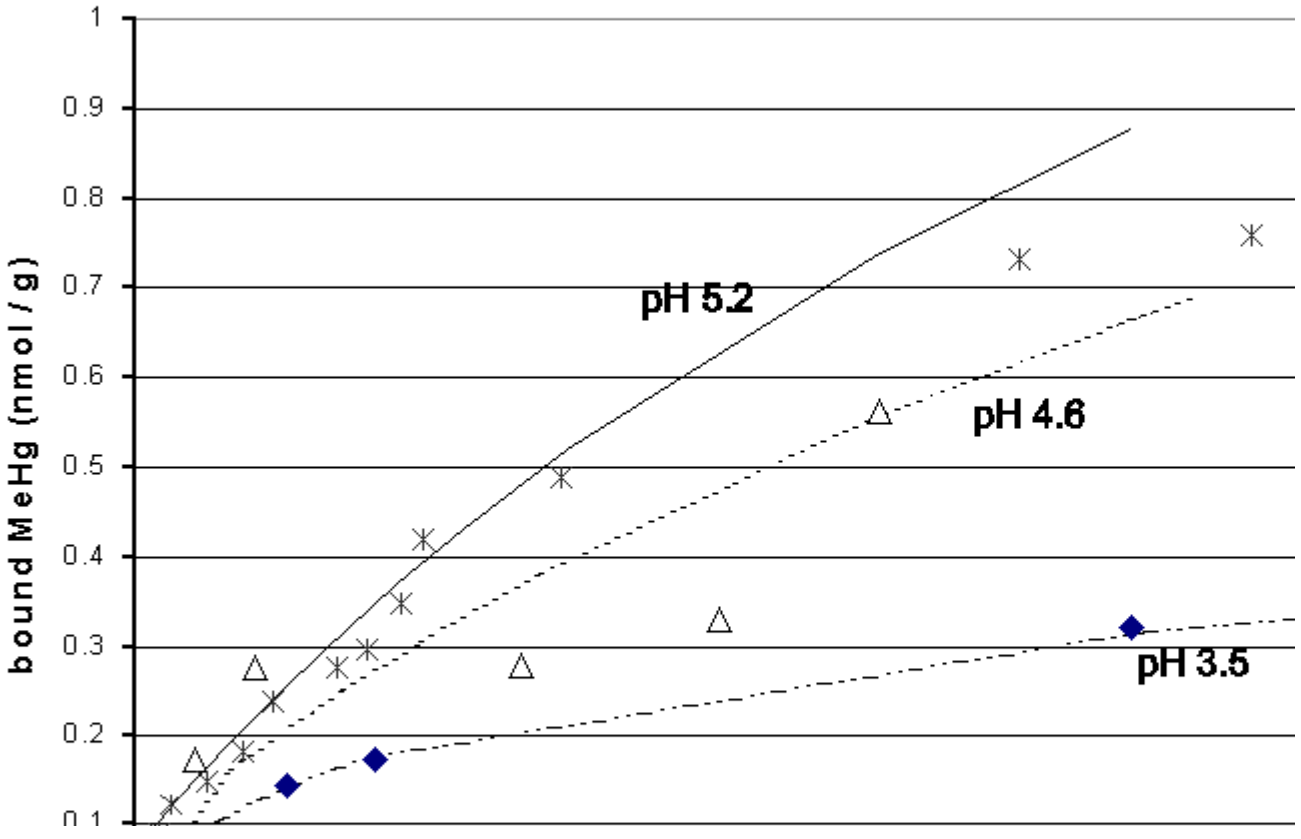


Fig. 1 b: Association of MeHg with Suwannee River H



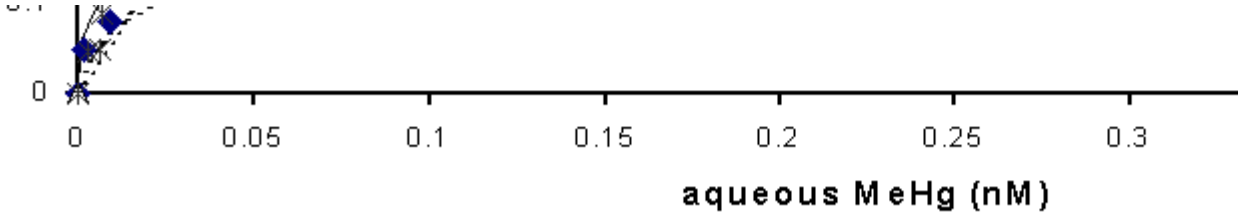
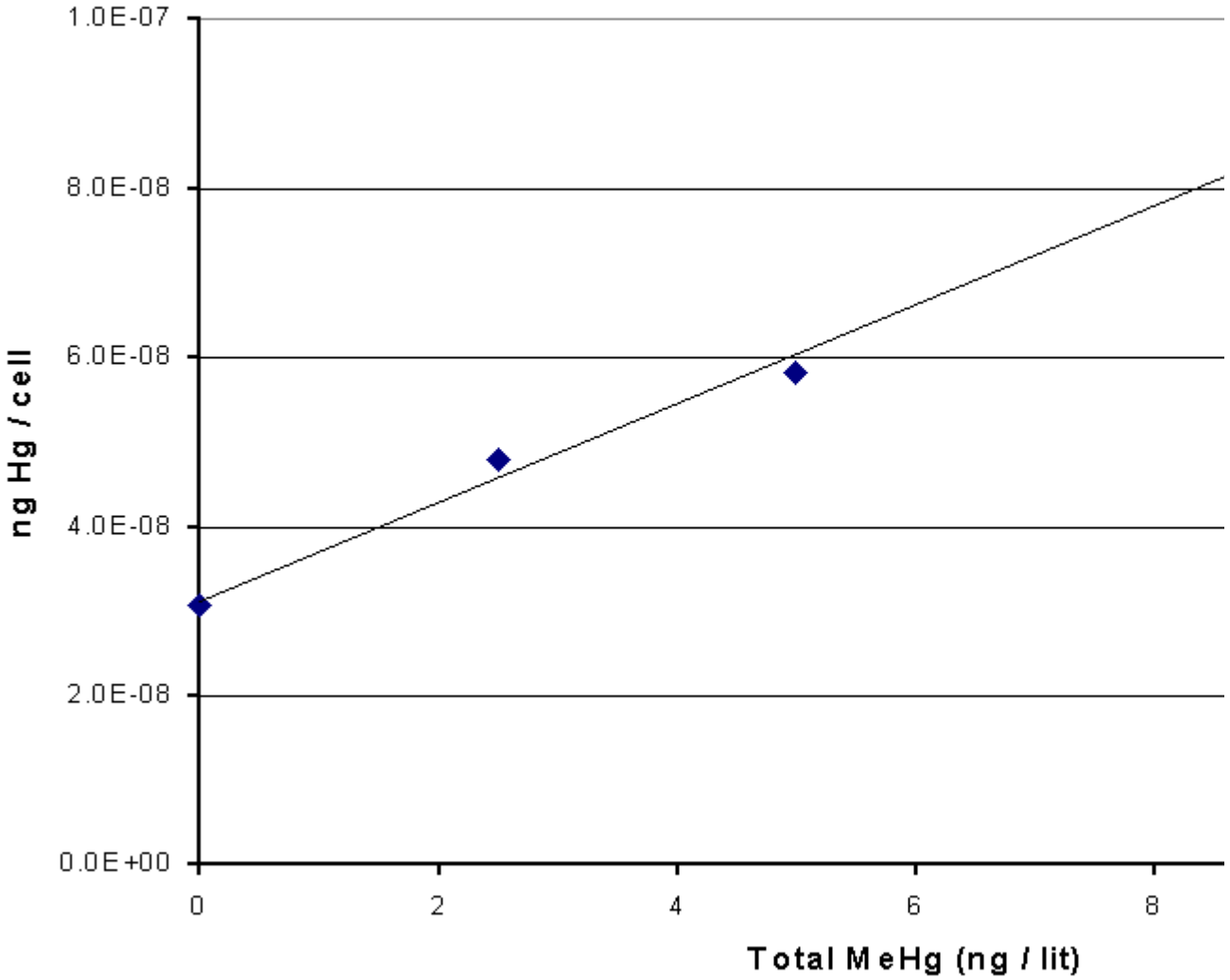
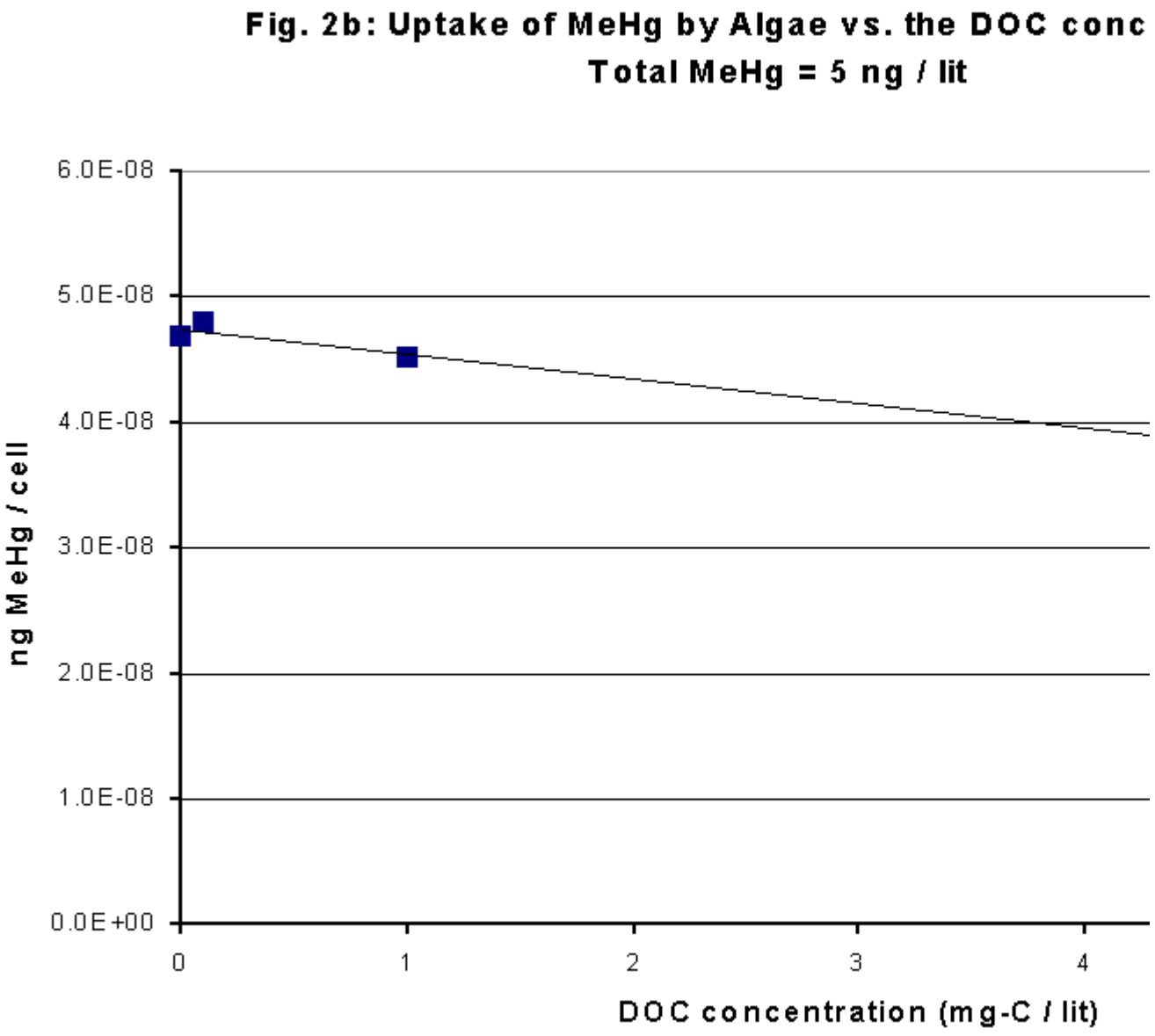


Fig. 2 a: Uptake of MeHg by Algae with no DO





Descriptors

Dissolved organic carbon, organometallic compounds, contaminant transport, fish ecology, lakes

Articles in Refereed Scientific Journals

Amirbahman, A., Reid, A., Haines, T. and Arnold C. 2000. Association of methymercury with dissolved hum
To be submitted for publication to Environmental Science and Technology.

Book Chapters

Dissertations

Reid, A. Association of methymercury with dissolved organic carbon. M.S. Thesis, University of Maine, Oro

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Reid, A., Amirbahman, A., and Haines, T. 1999. Complexation of methymercury by peat humic acid. Poster
Environmental Engineering and Science Professors, Research Frontiers Conference. University Park, PA.Reic
1999. Association of methylmercury with dissolved humic acids. Poster presentation: Maine Water Conferen

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Impact of Manure on Stream Water Quality
Project Number	HQ-96-GR-02674 - Project #4
Start Date	04/01/1999
End Date	03/20/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Surface Water
Focus Category #3	Waste Water
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
John M. Jemison, Jr.	Professional Staff	University of Maine	01
Ron Mack	Professional Staff	University of Maine	02
Kathryn Hopkins	Assistant Professor	University of Maine	03

Problem and Research Objectives

Hypotheses

1. Local manure nutrients and organic matter loading to streams will cause a shift in the benthic macroinvertebrate (BMI) communities between the above and below input samples.
2. Water quality samples downstream from the manure input should have higher nutrient and bacteria concentrations than the samples obtained at the upstream sites.
3. Once the manure source is removed, BMI community structure above and below the previous input area will not be significantly different.

Approach

Our research focuses on hypotheses 1 and 2 by comparing water quality and macroinvertebrate samples above and below two sources of manure runoff. We will determine the differences in abundance and species diversity of the BMI communities, water chemistry, and fecal coliform counts between the upstream and downstream sites. We will evaluate the third hypothesis if the analytical phase of the study warrants the implementation of measures to correct the manure problems on the source farms.

Methodology

Methods

We will collect BMI community and water quality samples from two streams near Skowhegan, Maine. Using methods developed by the Maine Department of Environmental Protection (MDEP) (Davies and Tsomides, 1997), we will place rock baskets above and below two dairy farms located on the Wesserunsett Stream and one of its tributaries, Cold Brook, during the fall of 1999 and 2000. In addition, we will place rock baskets a quarter mile below the confluence of the two streams. The baskets will be left for 28 days to facilitate colonization; we will remove the baskets after the colonization period and identify the macroinvertebrates to the genus level. Differences in total abundance, species diversity, and changes in feeding-group composition will be analyzed with the MDEP statistical model. We will conduct a habitat analysis of each stream reach and describe the surrounding watershed to ensure that the sampling sites are similar. To support the BMI data, we will collect duplicate water quality samples at the five sites following at least four storm events. The water samples will be used to determine the concentration of coliform bacteria in the streams since this is an indication of organic pollution.

Principal Findings and Significance

Progress

Four water samples were collected from the five sites after storm events during 1999; of these, the sample obtained in September was not run by the laboratory so the data set contains only three sets. The 1999 BMI rock baskets were placed in the streams above and below the two farms, but rapids at the site where the two streams join prevented the placement of baskets at this location. Identification of the macroinvertebrates in the 12 samples has been completed to the genus level for all families except Chironomidae (Diptera), which is currently underway (see Table 1, below). All tasks of the projects are proceeding well and we expect to complete tasks on schedule as listed in Table 1.

Site	Coliform	Coliform	BMI ident.	BMI ident.	Data analysis	Data analysis
	counts-99	counts-00	1999	2000	1999	2000
1A-Above RL	Done	10/00	7/00	12/00	8/00	1/01
1B-Above RL	Done	10/00	7/00	12/00	8/00	1/01
1C-Above RL	N/A	N/A	7/00	12/00	8/00	1/01
2A-Below RL	Done	10/00	7/00	12/00	8/00	1/01
2B-Below RL	Done	10/00	7/00	12/00	8/00	1/01
2C-Below RL	N/A	N/A	7/00	12/00	8/00	1/01
3A-Above DC	Done	10/00	7/00	12/00	8/00	1/01
3B-Above DC	Done	10/00	7/00	12/00	8/00	1/01
3C-Above DC	N/A	N/A	7/00	12/00	8/00	1/01
4A-Below DC	Done	10/00	7/00	12/00	8/00	1/01
4B-Below DC	Done	10/00	7/00	12/00	8/00	1/01
4C-Below DC	N/A	N/A	7/00	12/00	8/00	1/01
5A-DS	Done	10/00	N/A	N/A	8/00	1/01
5B-DS	Done	10/00	N/A	N/A	8/00	1/01

Table 1. Status of tasks on the project as of June 1, 2000, with estimated date of completion. (N/A = not applicable)

Macroinvertebrate identification and data analysis for the 1999 sampling season will continue in July and August of 2000. Because the 1999 fecal coliform counts did not consistently indicate the presence of excessive organic inputs, we will supplement this parameter with additional water chemistry analyses. We will determine the pH, total suspended solids, nitrogen, phosphorus, alkalinity, and dissolved oxygen levels of each water sample during the 2000 season. Sample processing and data analysis for the 2000 season will be conducted during the fall and winter of 2000, respectively. A final report and manuscripts will be prepared in the spring of 2001.

Field work has been conducted by John Jemison, Jr. (PI) and Claire Belisle (Graduate Student). Macroinvertebrate identification has been conducted by Belisle. Coliform samples have been processed by the Kenebeck Sanitation Treatment Facility.

Progress on the research plan:

Field work 50% complete

Coliform laboratory work 50% complete

BMI laboratory work 45% complete

Data analysis 25% complete

Descriptors

Water quality, nutrient runoff, non point pollution, macroinvertebrate impact

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A CD Version for PEARL - Public Educational Access to Resources on Lakes
Project Number	HQ-96-GR-02674 - Project #5
Start Date	04/01/1999
End Date	02/01/2000
Research Category	Social Sciences
Focus Category #1	Education
Focus Category #2	Conservation
Focus Category #3	Recreation
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Mary Beard-Tisdale	Associate Professor	University of Maine	01
Jeffrey S. Kahl	Associate Professor	University of Maine	02

Problem and Research Objectives

Project Objectives

1999

With over 5700 lakes and ponds in Maine (Williams, 1998), and with different state and local agencies responsible for collecting and distributing lake data, it is often difficult for scientists, educators, and community organizations to find related information. Untimely, inaccurate, and incomplete data can be reduced by storing lake data-sets in one location and distributing them over the Web. PEARL is designed to serve this need, in addition to assisting with public education on water conservation and natural resource issues. The Internet is on its way to becoming the primary platform for GIS, where data publishing, display, and query have been most successfully implemented (Longley, et. al., 1999). Eventually, a broader user base will be reached as advances in moble computing and wireless communications enable remote access to PEARL. Currently, an alternative, stand-alone method of accessing Maine's lake data is being developed for distribution on Compact Disk.

2000

Many solutions have been devised to create an Internet GIS that meets the technical requirements of the original project mission. However, new tools, new ideas, and new collaborations are being built on the existing framework to better meet the evolving needs of a diverse research and education community. Once the project grew from a concept to an application, much interest was generated to not only improve the existing site capability, but to increase the range of environmental information accessible through the site. This need to move beyond the original concept that focused on one isolated geographic feature (lakes) is a natural evolution that more realistically captures the natural ecological interactions in the real world. Although one project can not be expected to adequately address all areas of environmental research, it is appropriate—and is within the focus of PEARL—to better represent the rich and changing environmental conditions that are important to the researchers and educators using the PEARL Internet GIS.

Methodology

Methods

1999

We used ESRI Arc/View GIS software to spatially join statewide lake information in a standard database format (dbf) to an extensive statewide lake polygon layer. The subsequent theme became the interactive search/display layer for a *server side* application created with Microsoft (MS) Visual Basic and ESRI MapObjects (ESRI, 1996). Additional lake data was stored in relational databases using MS Access.

MS FrontPage was used to create a WebSite that serves this Visual Basic / MapObjects application to the client (individual users). By using Active Server Pages—which combine HTML code and vbscript that contain structured query language statements (SQL)—we provided visual- and text-based search tools that allow access to the lake data.

Lake data consists primarily of secchi depth measurements (Williams, 1998). Some phosphorus and trophic data are available. Data were gathered and compiled by the Water Research Institute, the Volunteer Lake Monitoring Program, and Department of Environmental Protection.

All data are available to the user in text format, and secchi data are also available through an interactive graphing tool using ChartFx by SoftwareFx. Other options to develop custom graphing capabilities are in development.

2000

To increase access speed and allow more user control, an additional map application was created with the existing tools to provide views with different degrees of detail. The user may select which mode to use—more detail or less detail—while searching and displaying geographic information.

New data layers such as contours, boat access sites, and roads, were acquired from U.S. Census Tiger vector data, and from the Maine Office of GIS. These were modified using ESRI ArcView and ArcInfo GIS software packages. As new lake chemistry data was added, structured query language (SQL) statements were redesigned to more efficiently access the data from the relational database.

Principles of human computer interaction (HCI) were employed to design and implement an improved interface for the site, search maps, and data display results. Dynamic watershed links were created with Visual Basic script to provide a unique web address that directs the user to region-specific information. Identifying a lake in a different watershed automatically changes the watershed link's destination through a single URL.

Principal Findings and Significance

Principal Findings

1999

This project provides an efficient means for different groups to gain access to an extensive amount of lake-data in Maine, and serves to educate the public about conservation and natural resource issues. It provides a tool for researchers to better understand the problems of using GIS over the Internet. Further research through PEARL may lead to new developments in using the Internet as a means to support Web based GIS in a social, educational, and technical context.

1. The site has been beneficial to scientists, researchers, educators, students, lake monitors, and land developers.
2. Data can be accessed quickly and can be updated very efficiently.
3. The full utility of the site is not yet achieved -- new chemistry and biological data need to be compiled and incorporated.
4. It is a cost effective means for information access.

5. Client incompatibilities with program components, Internet bandwith restrictions, and user unfamiliarity with the computers are important factors to consider when designing an Internet GIS.

2000

The release of new GIS tools, based on a more interoperable, component technology (Zeiler, 1999) provide methods for more efficient development of Internet GIS applications. Not readily available from a box, Internet GIS development still requires strong technical and theoretical GIS skills. But emphasis on *software* development can be replaced by *solution* development; that is, it is easier for GIS application developers and experts closer to their unique field of research to understand and contribute to the creation and use of component based applications (Hartman, 1997). They can, for example, spend more time building and using the new and existing PEARL components for research, education, and analysis. Data access will also be improved, reducing the reliance on stockpiled information. Rather, specific experts can more efficiently maintain and update their own spatial and attribute data and then provide access to it, possibly through remote connections. This will, however, increase the need for cooperation among contributors to adhere to consistent formatting and data exchange standards.

1. Client access to advanced browser technology is more common and the trend increases. PEARL developers will be more able to take advantage of advanced programming techniques and more complex interface components.
2. PEARL's concept extends beyond a technology; it is a program of collaboration, education, and information that uses advanced technology to meet established goals.
3. The growing public user base for Internet GIS, and the increasing ability of field-specific research experts to use custom GIS applications, increases the value of PEARL while placing higher demands on its services.

Future Work

1999

Revisions and data additions to the WebSite are ongoing, as is the development of a separate CD ROM application to provide the same, or better, tools in a stand alone environment. Future efforts include:

1. Current tools (especially ESRI MapObjects and MS Visual Basic) will be used to create an interactive CD application. A prototype is available of the Mount Desert Island region (not yet on CD).
2. Addition of new data layers (e.g. soils, vegetation) to Web and CD.
3. New educational tools and links for elementary through college level.
4. Addition of links or communication space for VLMP members and Lake Associations.
5. Publication of VLMP reports and data summaries on the PEARL Web-site, and possible inclusion in CD application.
6. More complete documentation and metadata; improved online user instruction and educational tutorials.

This project provides an efficient means for different groups to gain access to an extensive amount of lake-data in Maine, and serves to educate the public about conservation and natural resource issues. It provides a tool for researchers to better understand the problems of using GIS over the Internet. Further research through PEARL may lead to new developments in applying the Internet as a means to support

Web based GIS in a social, educational, and technical context.

2000

Technical improvements are necessary to increase the usefulness of the site to accommodate new sources of information. The natural evolution of the PEARL project has led to new communications with agencies and organizations interested in capitalizing on the potential of the existing site. Future efforts include:

1. Building collaborative relationships to encompass a more appropriate representation of environmental data.
2. Completion of interactive CD application. The PEARL-CD ver. 1.0 application is scheduled for completion by September 2000.
3. Creating watershed based geographic representation; the focus shifts from lakes to watersheds; addition of rivers and streams, potentially wetlands.
4. Continue to add and updata lake chemistry data and revise query and data capture methods.
5. Creation and addition of interpretive information to extend educational component beyond the research level.
6. Spatial data: correcting errors and improving accuracy (GIS software upgrades: ArcInfo 8, MapObjects 2.0; updating to NAD83).
7. Adding spatial analysis components.
8. Additional documentation and metadata; more online user instruction.

Appendix

Comments

The following e-mail message is reprinted in its entirety with permission by its creator. Comments about the activities of other states or organizations are not intended as criticism, but rather, are intended to emphasize the importance of the PEARL Program and other similar projects.

> From: BetGailor@aol.com
>
> Date sent: Wed, 19 Apr 2000 18:49:54 EDT
>
> **Subject: your website**
>
> To: pearl@spatial.maine.edu
>
> Hi! My son, Knute, is doing a science fair project in which he is comparing
>
> the water quality of a few lakes in Maine with a few lakes in Connecticut,
>
> where we live. My family lives in Harrison, Maine, and Knute was interested
>
> in why Maine lakes are so much cleaner than those in Connecticut. Barbara
>
> Welch, who works for Maine DEP (and with whom I went to college), gave us

your website address. We are writing to tell you what a terrific resource your website is! Connecticut's website pales in comparison! You have presented so much helpful information, and we have both learned so much! Knute collected samples and tested for phosphate levels, nitrogens, sulfates, and chlorides in Long Lake in Bridgton, Highland Lake in Bridgton, and Sebago Lake in Raymond. It was so great to be able to compare our results with those reported on your website.

Thanks for putting together such a wonderful resource. It is truly outstanding and we are most appreciative. Sincerely, Bet Gailor

References

1999

ESRI, 1996, Building Applications with MapObjects^{TM}: Environmental Systems Research Institute, Inc., 1-201.

Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W., 1999, Geographical Information Systems: Principles and Technical Issues: John Wiley & Sons, Inc., 1-16.

Williams, Scott., 1998, Volunteer Lake Monitor Program Annual Report, 1-9.

2000

Hartman, R, 1997, Focus on GIS Component Software: Onward Press, 1-330.

Zeiler, M, 1999, Modeling Our World: ESRI Guide to Geodatabase Design: ESRI Press, 1-195.

Descriptors

GIS, Maine lakes, conservation, education

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Professional Presentations

1999

Maine Water Conference -- PEARL demonstration and exhibit. 15 April 1999, Augusta, Maine

Maine GIS Users' Group—Pearl Project overview and public use. EMTC, Bangor, Maine

Atlantic Institute—Technical development and application issues. 8 June 1999, Laval Université, Quebec, PQ

2000

SIE Graduate Seminar—Research potential for data models and advanced query methods. 30 March 2000, Orono, Maine

Maine Water Conference—PEARL demonstration and exhibit. 18 April 2000, Augusta, Maine

Department of Spatial Information Science and Engineering (SIE) Alumni Event—PEARL as a research platform for Internet GIS. 21 April 2000, Orono, Maine

University Open House. Various demonstrations for college bound high school students.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Ecosystem-wide Effects of Roadway Runoff on Headwater Streams in Maine
Project Number	HQ-96-GR-02674 - Project #3
Start Date	09/01/1999
End Date	08/31/2001
Research Category	Water Quality
Focus Category #1	Ecology
Focus Category #2	Surface Water
Focus Category #3	Non Point Pollution
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Alexander D. Huryn	Associate Professor	University of Maine	01

Problem and Research Objectives

Predictions

1. Concentrations of heavy metals will increase in stream sediments downstream of the Maine turnpike.
2. Changes in invertebrate and vertebrate community structure, as measured by richness, abundance, biomass, and secondary production will be correlated with concentration of heavy metals and/or other chronic disturbances associated with the presence of the turnpike.
3. Periphyton standing crop will increase downstream of the turnpike because of a reduction in the richness and production of grazing invertebrates in reaches affected by heavy metals and/or other chronic disturbances associated with the turnpike.
4. Rates of detritus processing by invertebrates will decrease in reaches affected by heavy metal levels and/or other chronic disturbances associated with the turnpike because of a general reduction in the richness and production of detritus-feeding invertebrates.

Approach

This research is based upon five streams that flow beneath the Maine Turnpike in the general vicinity of Saco. Five 50-m study reaches have been established upstream and downstream of the turnpike in each stream. Each study reach is considered a statistical replicate. This design will be used to quantify how the presence of the turnpike affects longitudinal gradients of physical habitat variables, water chemistry, and concentrations of heavy metals in the sediments of these streams, and how longitudinal gradients of these factors affects population- to ecosystem-level variables.

Methodology

Methods

The following variables will be measured in each study reach. Variables are categorized into physical and chemical or biological attributes. Biological attributes are further subdivided in those that most closely reflect ecosystem structure, and those that reflect ecosystem function.

Physical and chemical attributes of study reaches

- Water and sediment chemistry
- Suspended sediments
- Reach channel form and discharge
- Catchment land-use

Ecosystem structure

- Community structure (abundance, biomass) for invertebrates and fish

- Spatial and temporal patterns of primary producers (chlorophyll *a*)
- Spatial and temporal patterns of benthic organic matter accumulation and storage

Ecosystem function

- Annual macroinvertebrate production and resource demand
- Transported organic material
- Leaf detritus processing

Principal Findings and Significance

Progress

Data collection is ongoing for the test of Predictions 1, 2, 3. Data required to test Prediction 4 will be collected in Autumn 2000. Sampling has been proceeding according to the original proposal, with the exception of (1) the elimination of spring sediment sampling for heavy metal content due to expense and to weather-related delays in the winter sampling period, and (2) the addition of a sampling date for benthic invertebrates due to concerns about the temporal resolution required to accurately determine growth rates of invertebrates from field data. Progress (as of June 2000) toward the quantification of the variables outlined in Methods is detailed below.

Physical and chemical attributes of study reaches

- Water chemistry (sampled on 7 dates; 2 additional dates are planned).
- Sediment chemistry (sampled on 2 dates – October 1999, March 2000; 1 additional date is planned).
- Suspended sediments (sampled on 7 dates; 2 additional dates are planned).
- Reach channel form (mapped July 1999; riparian habitat mapping is scheduled for Autumn 2000).
- Catchment land-use (assessment using GIS scheduled for Autumn 2000).

Ecosystem structure

- Invertebrates (sampled on 7 dates, 2 additional dates are planned).
- Fish (scheduled for July 2000).
- Periphyton (sampled on 3 dates; 1 additional date is scheduled).
- Benthic organic matter (sampled on 7 dates, 2 additional dates are planned).

Ecosystem function

- Invertebrate production (cannot be assessed until all invertebrate sampling is completed).
- Transported organic material (sampled on 7 dates, 2 additional dates are planned).
- Leaf detritus processing (scheduled to coincide with leaf fall during Autumn 2000).

Several months of sample processing will be required in the laboratory following completion of all sampling in Autumn 2000. Data analysis is expected to be completed during Autumn 2001.

Field work has been conducted primarily by Thomas S. Woodcock (Ph.D. Candidate) with additional

assistance by Alex Huryn (Associate Professor , PI), Michael A. Chadwick (Ph.D. Candidate) and Damon Ely (undergraduate student). Laboratory work has been conducted primarily by Thomas S. Woodcock (Ph.D. Candidate) with assistance by Damon Ely and Jake Mongrain (undergraduate students). Chemical laboratory work has been supervised by William Cook (Maine State Analytical Laboratory).

Products to Date

Preliminary data generated by this research have been included in the following products:

Davies, S.P., L. Tsomides, J.L. DiFranco, and D.L. Courtemanch. 1999. Biomonitoring Retrospective: Fifteen year summary for Maine rivers and streams (See pp. 114-117). Maine Department of Environmental Protection, Augusta, Maine. DEPLW1999-26.

Tsomides, L., T.S. Woodcock, and S.P. Davies. 2000. Use of Biological Monitoring to Track Nonpoint Sources in Goosefare Brook, York County, Maine. Maine Dept. Environmental Protection and University of Maine , Orono. (ORAL PRESENTATION) New England Interstate Water Pollution Control Commission (NEIWPCC) Annual Nonpoint Source Meeting held May 23-25,2000 at URI Narragansett Bay Campus, Narragansett,RI.

Maine Department of Environmental Protection. 2000. Surface Water Ambient Toxic Monitoring Report, 1998 Final Data Report. Section 3.3 Urban Non-point Source Investigation (See pp 1-19). Maine Department of Environmental Protection, Augusta, Maine. DEPLW2000-6

Progress on the research plan

Field work 75% complete

Sample processing 50%

Chemical laboratory work 60% complete

Data analysis 10%

Descriptors

Benthos, bioindicators, biomonitoring, ecosystems, heavy metals, insects, land use, pollutants, runoff, streams, water quality, water quality monitoring

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Davies, S.P., L. Tsomides, J.L. DiFranco, and D.L. Courtemanch. 1999. Biomonitoring Retrospective: Fifteen year summary for Maine rivers and streams (See pp. 114-117). Maine Department of Environmental Protection, Augusta, Maine. DEPLW1999-26.

Maine Department of Environmental Protection. 2000. Surface Water Ambient Toxic Monitoring Report, 1998 Final Data Report. Section 3.3 Urban Non-Point Source Investigation (See pp 1-19). Maine Department of Environmental Protection, Augusta, Maine. DEPLW2000-6.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Cycling and Speciation of Mercury and Methylmercury in the Soil of Acadia National P
Project Number	HQ-96-GR-02674 - Project #2
Start Date	09/01/1999
End Date	05/31/2001
Research Category	Water Quality
Focus Category #1	Hydrogeochemistry
Focus Category #2	Toxic Substances
Focus Category #3	Water Quality
Lead Institution	University of Maine

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aria Amirbahman	Assistant Professor	University of Maine	01
Jeffrey S. Kahl	Assistant Professor	University of Maine	02
Terry A. Haines	Professor	University of Maine	03

Problem and Research Objectives

Abstract

The primary goal of the project last year was to perform preliminary studies on both the Canon Brook and H develop a focused research strategy for the 2000 field season. Efforts were directed at perfecting analytical te methylmercury in soils, as well as identifying potential soil sampling sites at each watershed. Significant prog

months with regards to completion of preliminary analyses, as well as development of field sampling and anal
These analyses appeared to indicate that methylation of mercury in organic soils from each watershed was no
preliminary findings, efforts have now been directed at completing a more thorough study of total Hg and Me
well as organic soils. These results will help provide a better understanding of the overall mercury budgets fo
Brook watersheds.

Methodology

Methods

Preliminary selection of sampling sites was limited to areas in each watershed that had the greatest potential c
More specifically, methylation generally takes place under anaerobic conditions, and therefore most of the sar
soils. These are areas in which ponding might occur with a higher potential for anoxia. Several well-drained s
at the Hadlock Brook watershed and eight sites at the Canon Brook watershed were selected. The differences
watersheds were quite distinct. Attempts were made to distribute the sampling sites evenly throughout each w
accurate distribution of MeHg. However, this proved to be difficult especially in the Canon Brook watershed
steep slopes.

Samples were taken in August, September and October, representing a variety of conditions. August and earl
very dry conditions due to the lack of rain over the summer months. However, the late September and Octob
due to the heavy rains received during that period. Multiple cores of the organic layer were taken from each s
also made in April 2000, after the ground thawed, from a reduced set of four of the Hadlock Brook sampling
were during periods of heavy stream flow.

Principal Findings and Significance

Results

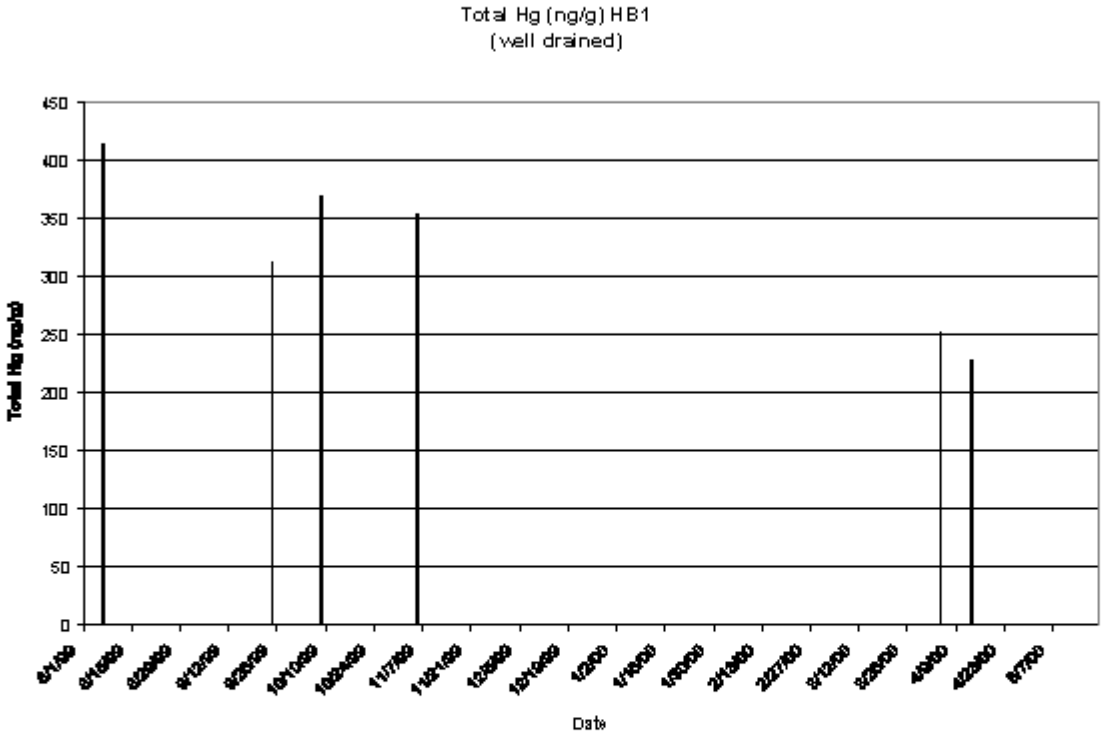
Soil samples from the 1999 and early 2000 field seasons were analyzed for MeHg and total Hg. The results fr
as to how the concentrations of MeHg and Hg might change at a particular site over a period of time. Prelimi
to be no significant changes in MeHg and Hg in the organic layer of soil for the samples that were analyzed (
concentrations for the soil cores taken at Canon Brook for the two collection dates (8/18/99 and 10/15/99) sh
change between collections. Similarly, total Hg concentrations showed no significant changes. The data show
concentrations in well-drained soils from the Canon Brook watershed for one of the eight plots from the upp
plots for CB5).

The poorly drained soils collected from the Hadlock Brook watershed appeared to show higher concentration
Brook watershed. However, the concentrations of MeHg and total Hg still do not seem to show any significa
The data shown represents MeHg and total Hg concentrations in one poorly drained soil plot (HB2) and one

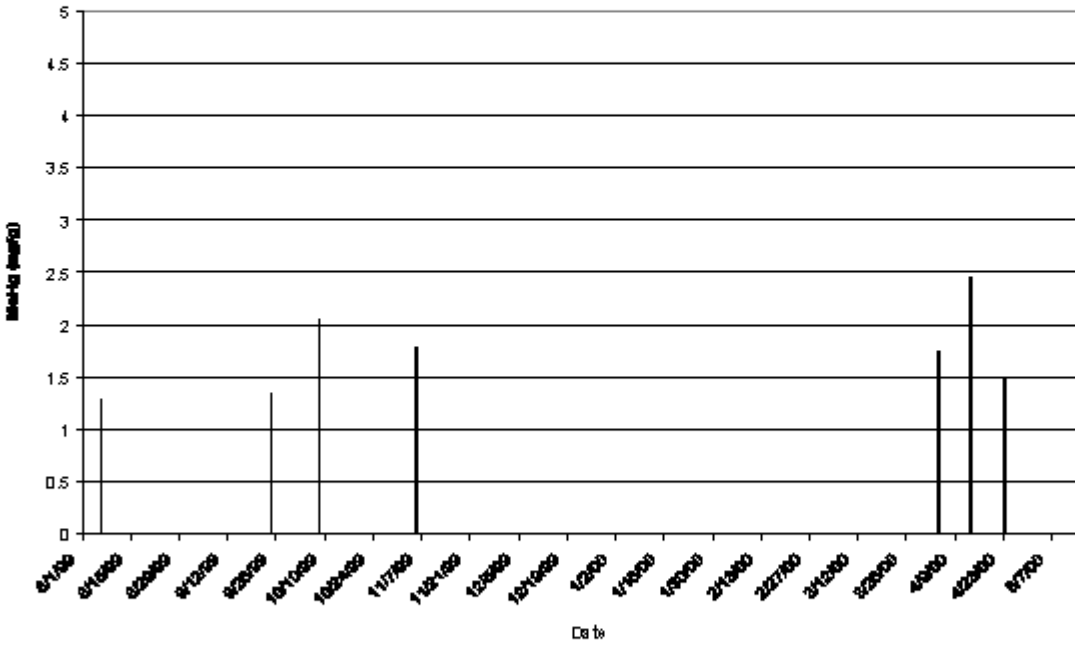
The increase in MeHg seen in the Hadlock Brook soil samples that were collected up to this point is not nece
scenario originally put forth in this proposal, but can be due to many other factors. More specifically, the phy
could play a more significant role than the reduced organic material in the Canon Brook watershed as a resul
hydrology of the Canon Brook watershed could possibly result in less methylation of Hg.

In order to more accurately assess the role of soils in the speciation of Hg at both the Canon Brook and Hadl
this project is to expand the analysis of soils to include mineral horizons, as well as the organic horizon. This

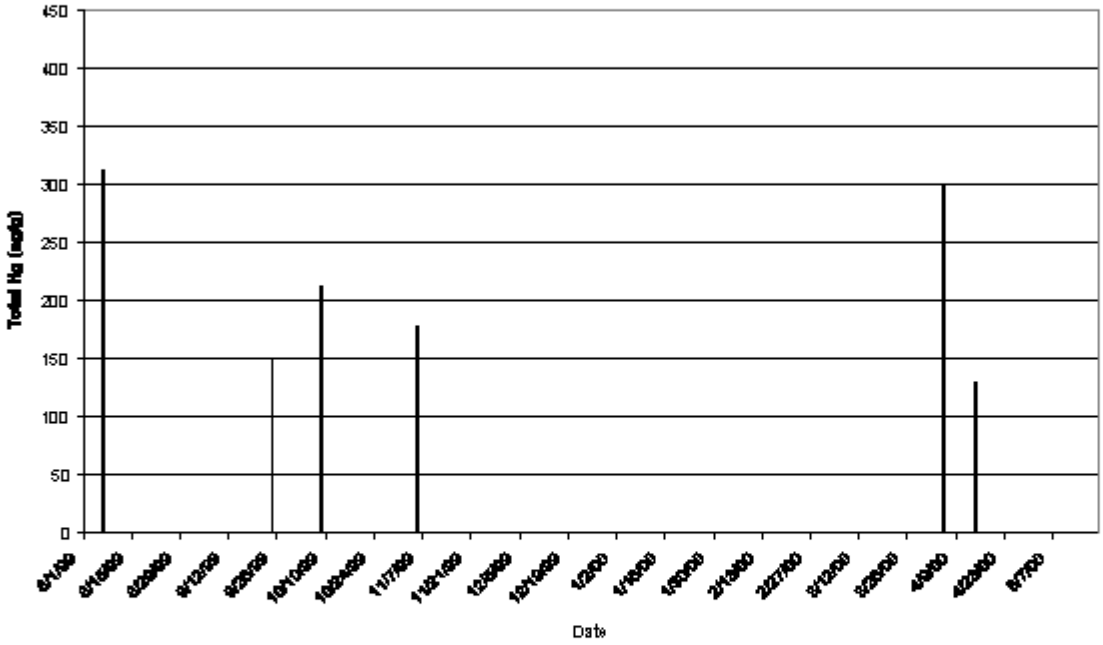
complete picture of how soil contributes to the overall Hg budget in these two watersheds. Soil samples that
analyzed for MeHg and total Hg. These samples were collected as part of the PRIMENET Project. Three dif
plots at each watershed: 1) the organic horizon 2) the top 5 cm of the B-horizon, and 3) the remaining B-hor
soils, monthly soil collections (for the three depths) will be made from two well drained plots from both wate
the remainder of the 2000 field season. This data will supplement the results of the August 1999 MeHg and t

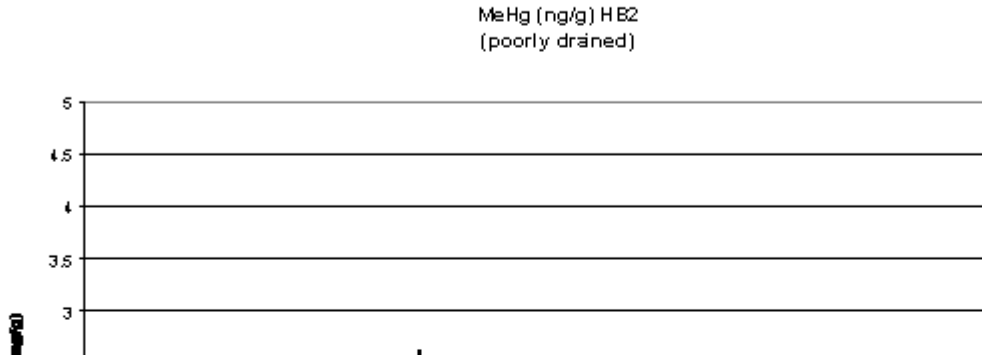


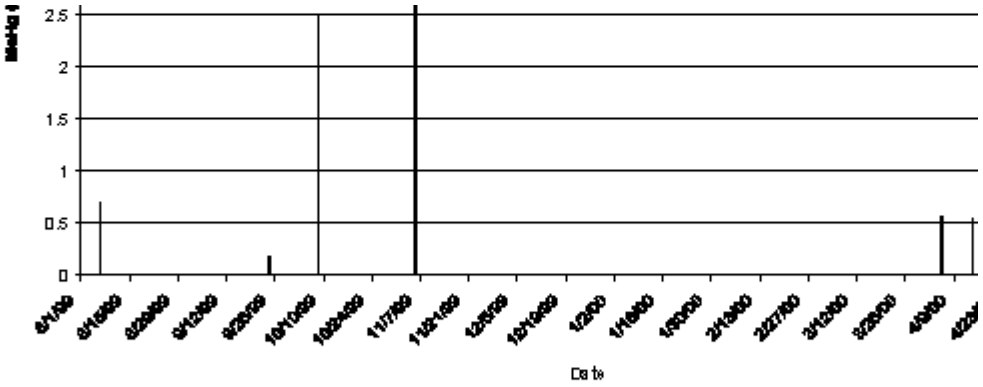
MeHg (ng/g) HB1
(well drained)



Total Hg (ng/g) HB2
(poorly drained)


450
400
350
300
250
200
150
100
50
0
Total Hg (ng/kg)
Date


MeHg (ng/g) HB2
(poorly drained)
5
4.5
4
3.5
3



Descriptors

Mercury, methymercury, cycling, speciation, Acadia National Park

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Ruck, P., Kahl, J.S., Haines, T. and Amirbahman, A. Cycling and speciation of mercury in the soil of Acadia Augusta, ME. April 2000.

Information Transfer Program

Information Transfer Program

A major goal of the Water Research Institute is to foster increased cooperation and communication between the

academic community, state agencies, environmental organizations, and private companies. Using portions of staff time and substantial non-USGS funding, the WRI has maintained an active program of dissemination of research results, conferences and meetings, service on committees dealing with water resource issues, working with teachers and conducting special projects.

The main Information Transfer project separately funded during the regional competition was PEARL (Public Educational Access to Resources on Lakes), the Maine lakes database. It is listed under research because of the mechanism of funding. Other Information Transfer activities in 1998 are described below:

Conferences and Workshops

The WRI is the lead organization in organizing and conducting the annual Maine Water Conference. This conference in Augusta provided expanded technical sessions, in addition to the issues orientation that has been part of previous MWCs. The conference now consists each year of a morning plenary session, 4 to 6 afternoon concurrent sessions, and in 1999 will expand to include a field trip.

Water Resources Education

The WRI administers Project WET (Water Education for Teachers) in Maine under a formal agreement signed with national WET in 1996. This program was new to the State of Maine in 1994, and continues to expand in scope. Instructional workshops for teachers are day-long, hands-on workshops for 20 to 25 teachers. Each teacher receives the hardbound WET curricula and activity guide covering over 90 activities, paid for by the WRI and outside donors.

Testing the Waters – Building A Maine Watershed Alliance. This educational program provided a hands-on, minds-on water quality monitoring and educational experience for more than 1,000 schoolchildren and teachers along the Kennebec River in Maine. Participants were encouraged to become active environmental stewards, gathering a snapshot of their community watershed by collecting water samples simultaneously at over 40 stations along the Kennebec River and its tributaries. Funding support for the 1998 TTW program was provided by U.S. EPA Environmental Education Grants Program, and Maine Project WET. The Institute received the 1999 Governor's Award for Environmental Excellence in acknowledgement of the TTW program.

Data Dissemination and Access

The WRI developed a web page for the Maine Volunteer Lake Monitoring program in 1998. This augmented the PEARL web page, and provided the VLMP with its first web presence.

Newsletter and Digests

The WRI publishes its newsletter Waterlines on a irregular quarterly schedule. This newsletter contains information on ongoing and upcoming grants, developments in the WRI laboratory, news releases from the University on water resources related issues, and announcements for our conferences. Our regular contributors include the USGS in Augusta and other water resource professionals on campus and in Maine.

In 1998, the WRI published an information digest on Maine's Wellhead Protection Program, in collaboration with the state Drinking Water Program. In 1999, an informational digest entitled: Safe Drinking Water was published. Collaborators included the Maine Department of Human Services, Division of Health Engineering; Cooperative Extension Servie, University of Maine; and the Maine Groundwater Assocation.

A report by the Resources Economics group at UMaine was commissioned by the WRI to support the activities of the Great Pond Task Force. The conclusions of the report were that Maine lakes are indirectly Maine's second largest employer (after forest products), and contribute more to the state economy that Bath Iron Works, the state's single largest employer.

Committees and Commissions

Graduate Education. The Director of the Institute served on 13 graduate student committees in environmental science and water resources in 1998.

Co-chair, Council on Environ. Monitoring and Assessment (Gubernatorial appointment). The Institute Director is the co-chair of CEMA, which was formed by executive order on Earth Day, 1998. CEMA will work to increase coordination among volunteers and agencies which collect environmental data. This work will include a web page and on-line database of monitoring activities in Maine.

Maine Great Pond Task Force. The enabling legislation establishing the GPTF included several named members, including the director of the WRI. Since 1996, this activity has included monthly meetings of the entire task force, numerous meetings of the water quality subcommittee and the finance subcommittee, and several public hearings statewide. The WRI director has prepared two working papers for the task force as well. The WRI digest on Maine Lakes has been widely circulated in Maine as a result of the GPTF activities.

Board of Directors, Maine Volunteer Lake Monitoring Program. The WRI Director is a member of the board of the Maine Volunteer Lake Monitoring Program. The WRI has had a long standing involvement with the VMP, including technical and analytical contributions. The Penobscot Institute is the host organization for Penobscot Riverkeepers 2000, described above in the general public service section.

Corporate Affiliate Program. The University of Maine CAP involves more than 40 companies in a cooperative program to foster collaboration and information exchange between the University and business. The CAP involves workshops and meetings among the various partners and the University.

Scientific Advisory Panel, Maine Forest Biodiversity Project. The Institute is serving as a scientific advisor on watershed issues for the FBP, an interagency/private sector task force to define, among other things, how to set up a natural areas reserve system in Maine.

River Flow Management Commission. (Gubernatorial appointment). The RFAC is an advisory group comprised largely of state agency representatives which deals with stream flow and storm flow, especially in the context of potential spring flooding. A statewide snow-survey is conducted each spring by the Commission.

Maine Forest Advisory Team. This interagency/industry/environmental advisory group was established to evaluate forest practices and BMPs, to define compliance and set compliance goals, and to refine BMPs and guidelines for other forest practices.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	8	N/A	N/A	N/A	8
Masters	16	N/A	N/A	N/A	16
Ph.D.	2	N/A	N/A	N/A	2
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	26	N/A	N/A	N/A	26

Awards & Achievements

Research Achievements

The Maine Institute serves on the New England Governors/Eastern Canadian Premiers working group on acid rain, which is helping guide the present debate and influence possible lawsuits involving EPA and air emissions from mid-western states.

Maine Institute research was the centerpiece of a 1998 report to the EPA OAR acid rain division on the impacts and trends on surface waters in Maine. This report was funded by OAR as they prepare to report to Congress on the effectiveness of the 1990 Clean Air Amendments.

Related to the Clean Air Act, the Maine Institute, via IAG through the WRRI, has assumed responsibility for the 1999-2003 EPA acid rain monitoring program in the northeastern US (Adirondacks to Maine).

USGS-funded research in Maine (by a geologist and a historian) established that arsenic in groundwater was as likely to be from anthropogenic uses as from bedrock sources. This concept was a change from conventional wisdom in northern New England, and the idea has slowly been accepted and investigated by state agencies and NAQWA as we continue to investigate the issue.

Acid rain research based in the Maine WRI was published as an entire special issue of Environmental Monitoring and Assessment in March: The Bear Brook Watershed in Maine: A paired watershed experiment--the first decade, 1987-1997.

Information Transfer and Public Service

The Director served on the Maine Great Ponds Task Force from 1996 to 1998, as a result of which the Institute published a report to the legislature entitled 'The Impact of Lakes on Maine's economy' (conclusion: state's second largest 'employer'). This report was a centerpiece of the Task Force recommendations to the legislature, and helped pass legislation re-establishing the Lakes Division (at 500K/yr) in the Maine DEP in 1998 after the legislature had abolished it in1991. Several pieces of lake protection legislation were also passed in 1998. The Director testified to the legislature twice during the process.

The current and former directors of the Maine Institute were lead-author and co-author of the 1998 draft Water Resource Management Plan for Acadia National Park, the first such document ever done for the park. It is a planning document intended to guide management and research at Acadia for the next decade.

Staff of the Maine Water Research Institute were highlighted during a Maine Public Television program – "Maine Watch" on June 6, 2000. This television broadcast contained interviews with Therese Anderson, WRI Laboratory Manager and Steve Kahl, Director covering the UMaine role in dioxin research. The institute plays a critical role with the State of Maine agencies in monitoring dioxin compliance within the framework of the 1997 Maine dioxin reduction law.

UMaine graduate students, Sarah Vidito and Ken Johnson hosted a seminar entitled: A Tale of Two Streams - A comparison of two different Acadia watersheds on May 15, 2000. Acadia National Park staff joined this forum in discussing the status of current research at Acadia National Park.

The Institute hosted the Acadia Water Quality and Watersheds Research Workshop on March 13,2000. Participants included staff from Acadia National Park, Maine USGS and a variety of concerned groups and citizens. Workshop topics included a wide variety of presentations including: 1) The Mercury Issue at Acadia , 2) Nitrogen cycling and 3) Watershed-Scale Research: Major Ions.

Staff from the Institute participated in the program entitled: Expanding Your Horizons. EYH program goals include encouraging 7^{th} and 8^{th} grade girls from Maine to consider career options in the Science and Math fields. Institute staff conducted tours in our state-of-the art laboratory facilities.

The Maine Water Research Institute was voted a provisional seat on the University of Maine Association of Graduate Students on 5/11/2000. This increased visibility will foster a wider audience for project information transfer for research activities at the Maine Water Research Institute.

Awards

The Maine Institute won the 1998 EPA New England Environmental Merit award for 'developing on the premier environmental chemistry programs in the nation'.

The Maine Institute was awarded the Governor's award for Excellence in Environmental Education for implementing Testing the Waters via an EPA grant, anew outreach and educational program in Maine.

A travel award from the University of Maine Professional Employee Advisory Council was awarded to John Peckenham, Senior Scientist from the Institute supplementing his travel to the National Institute for Water Research meeting on March 18 – 21, 2000.

Three graduate students from the Institute were awarded a University of Maine Alumni Association Group Travel Award: Ken Johnson, Sarah Vidito, and Heather Shoven. Invited poster presentations were presented at the Gordon Research Conference: Environmental Science 2000:Water on June 25-30 2000.

The Maine Water Conference 2000 premiered the MWC Best Presentation Awards during the annual conference. Three awards were presented to UMaine/Institute graduate students on April 13, 2000. Sarah Vidito received the Best Presentation Award for her poster presentation highlighting the PRIMENet research at Acadia National Park. Heather Shoven and Andrea Pearce received Honorable Mention for their contributions.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Kahl, J., S. Norton, I. Fernandez, L. Rustad, and M. Handley. 1999. Nitrogen and sulfur input-output budgets in the experimental and reference watersheds, Bear Brook Watershed in Maine (BBWM). Environ. Monitoring and Assessment 55:113-131.

David, M., G. Vance, and J. Kahl, 1999. Chemistry of dissolved organic carbon at Bear Brook Watershed, Maine: Stream water response to (NH4)2SO4 additions. Environ. Monitoring and Assessment 55: 149-163.

Norton, S., J. Kahl and I. Fernandez, 1999. Altered soil-soil water interactions inferred from stream water chemistry at an artifically acidified watershed at Bear Brook Watershed, Maine USA. Environ. Monitoring and Assessment 55:97-111.

Stoddard, J.L., J.S. Kahl (8th co-author), and 21 others, 1999. Recovery of lakes and streams from acidification: regional trends in North America and Europe. Nature, in press.

Norton, S.A., J.S. Kahl, I.J. Fernandez, L.E. Rustad, T.A. Haines, S.C. Nodvin, J.P. Scofield, T.C. Strickland, P.J. Wigington, and J. Lee, 1999. The Bear Brook Watershed in Maine (BBWM). Envir. Monitoring and Assessment 55:7-51.

Roy, S., S.A. Norton, I.J. Fernandez, and J.S. Kahl, 1999. Linkages of P and Al export at high discharge at the Bear Brook Watershed in Maine. Environ. Monitoring and Assessment 55:133-147.

Stoddard, J.L. C.T. Driscoll, J.S. Kahl, and J. Kellogg, 1998. Can site-specific trends be extrapolated to the regional level? Ecological Applications, 8:288-299.

Stoddard, J., C. Driscoll, J.S. Kahl, and J. Kellogg, 1998. A regional analysis of lake acidification trends for the northeastern US, 1982-94. Environ. Monit. and Assess. 51:399-413.

Norton, S.A., Evans, G.C., and Kahl, J.S., 1997. Comparison of Hg and Pb fluxes to hummocks and hollows of ombrotrophic Big Heath bog and to nearby Sargent Mt. Pond, Maine, USA: Water, Air, and Soil Pollut. 100:271-286.

Book Chapters

Dissertations

Kahl, J.S., 1998. Controls on the geochemisty of headwater systems in Maine. Ph.D Dissertation, Dept. Geological Sciences, University of Maine, Orono, ME. 359 p.

Water Resources Research Institute Reports

Peckenham, J. and S. Hasbrouck, 1999. Safe Drinking Water. Informational digest prepared in cooperation with the Maine Department of Human Services, Division of Health Engineering; Cooperative Extension Service, University of Maine; Maine Groundwater Association and the Water

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