

New Jersey Water Resources Research Institute Annual Technical Report FY 2001

Introduction

The New Jersey Water Resources Research Institute is a Federally-funded program of research, training and information transfer concerning all aspects of fresh and estuarine water in the state. Its mission is to:

* sponsor research on all aspects of water quality, water quantity, water use, and the management of water resources * train students at the undergraduate, graduate and postgraduate levels to become the next generation of water resource professional for NJ * facilitate the transfer of information from researchers to the public and to water

Based at Cook College, on the New Brunswick campus of Rutgers University, the Institute's activities are guided by an Advisory Council, which consists of representatives of the academic community, of government agencies, and of the private sector.

NJWRRI has funded research on topics ranging from pollutants in ground and surface waters to the behavior of estuarine fish to the ecology of wetlands. With funds provided by Congress and Rutgers University, the NJ Water Resources Research Institute supports a program of research each year which addresses a periodically-updated list of priority issues developed by the Advisory Council in consultation with a wide range of water resource professionals and includes:

I. Integrity of aquatic and water-associated ecosystems II. Analysis, assessment, and management of water quantity, water quality and water sources III. Predictive capabilities for protection and restoration IV. Methods of analysis and methods of detection of contaminants V. Impacts of land-use practice and change on water resources VI. Socioeconomic and information transfer problems in water management

Research Program

A Continuation Proposal: Factors controlling methylmercury degradation in Pine Barrens lakes and the Meadowlands

Basic Information

Title:	A Continuation Proposal: Factors controlling methylmercury degradation in Pine Barrens lakes and the Meadowlands
Project Number:	2001NJ941B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	6
Research Category:	
Focus Category:	Toxic Substances, Water Quality, Non Point Pollution
Descriptors:	lakes, Pine Barrens, atmospheric deposition, degradation, ecosystem, mercury, methylmercury
Principal Investigators:	Tamar barkay, John Reinfelder

Publication

Factors controlling methylmercury degradation in Pine Barrens lakes and the Meadowlands

Problem and Research Objectives: Mercury concentrations in fish of the Pine Barrens lakes are elevated as a consequence of the atmospheric deposition of mercury (Hg) and in-lake methylation processes (NJ DEP, 1994; Ruppel *et al.*, 1994). A range of tissue concentrations of Hg in fish collected from different lakes suggests that the production of methylmercury (MM) is affected by factors that are unique to each lake. Recent work (Pak and Bartha, 1998) showed similar production rates of MM in the sediments of three Pine Barrens lakes suggesting that transport to, and/or MM degradation in, the water column, may be responsible for between-lakes variability. Availability of MM to the aquatic food chain might be controlled by degradation (and possibly production) of MM in the water column following the flux of MM from sediments. Our research addresses the degradation of MM in water samples and how it is affected by the physical-chemical and biological parameters in Pine Barrens lakes. Samples collected at the Meadowlands, a highly contaminated site where low MM/total Hg (Hg_T) concentration ratios in the water were detected, are included for the sake of comparison.

Two objectives address the hypothesis that MM production is controlled by its degradation in the water column:

- (i) To relate the MM concentration and rate of its degradation to the MM/ Hg_T ratio.
- (ii) To determine if the abundance and expression of bacterial mercury resistance (*mer*) genes in the microbial communities of the lakes control MM production by stimulating its degradation. Enzymes encoded by these genes are known to degrade MM to volatile $Hg(0)$.

Procedures and Methods

Mercury analyses: Total Hg is measured water samples (200 - 500 ml) in Dr. Reinelder's lab by the cold vapor atomic fluorescence spectrometry (CVAFS) technique (Bloom and Fitzgerald, 1988) using a Tekran 2500 CVAFS mercury detector. Dr. Reinfelder is currently setting up his lab for MM analysis. Data for MM concentrations reported here was obtained through a contract with Flett Laboratories, Inc., (Winnipeg, Manitoba).

Physical-chemical parameters: Hand held probes are used to measure pH, temperature, salinity, dissolved O_2 , and conductivity in the field during sample collection. Total organic carbon is measured at the laboratory of Dr. Seitzinger at IMCS.

Microbiological and molecular parameters: Routine protocols are used for the enumeration of heterotrophic bacteria and assessment of community diversity (Barkay, 1987). The presence of *mer* genes and their expression are detected by protocols developed in our laboratory (Nazaret *et al.*, 1994). We are currently developing quantitative approaches for gene and transcript detection using a recently purchased quantitative PCR instrumentation.

Principle findings and significance

Samples were collected during Aug. 2000 and Apr. 2001 from four Pine Barrens Lakes and from four sites in Berry's Creak in the Meadowlands. The most significant findings are summarized below:

I. An inverse relationship between the proportion of MM in total Hg (Hg_T) and Hg_T concentration has emerged from data collected to date (Fig. 1). It resulted from a large discrepancy in Hg_T concentrations ($\mu\text{g/L}$ for Meadowlands and ng/L for Pine Barrens) with similar MM concentrations (ng/L in both study sites). Others have demonstrated this trend with samples collected from numerous environments. To the best of our knowledge, our hypothesis regarding the role of inducible microbial transformations in MM degradation, is, at present, the only plausible explanation for this “paradox”.

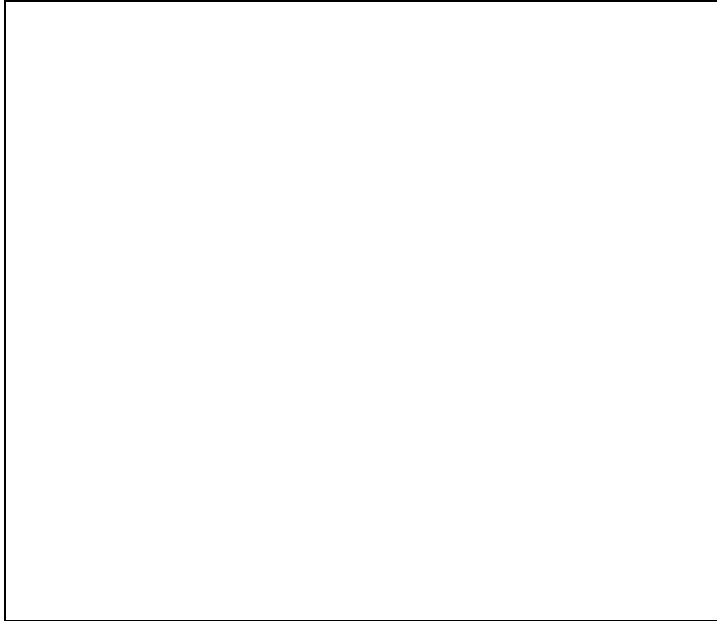


Fig. 1: The relationship between the percent MM in Hg_T and Hg_T concentrations in Pine Barrens samples collected in Aug. 00 (open circles) and in Apr. 01 (open triangles), and in Meadowlands samples collected in Aug. 00 (full squares) and Apr. 01 (full diamonds).

II. Initial analysis of the response of microbial communities to Hg suggests that in the highly contaminated water of Berry’s Creek (Meadowlands) the communities are adapted to Hg stress while Pine Barrens communities are not (Table 1). This conclusion is based on: (i) there was a higher tolerance to Hg(II) among heterotrophic bacteria from Meadowlands samples, (ii) the diversity of the resistant bacteria was higher in Meadowlands communities than in Pine Barrens communities, and (iii) *merA* genes specifying the reduction of Hg(II) to Hg(0) were detected in biomass from the Meadowlands but not in biomass from the Pine Barrens (Fig. 2). Physical-chemical measurements showed that the Pine Barrens waters were acidic (pH 4 to 5), had low conductivity ($< 50 \mu\text{S/cm}$), and no measurable salinity while Meadowlands waters had a neutral pH, conductivity of about $900 \mu\text{S/cm}$, and were slightly saline at 0.4 parts per thousand. Remaining parameters, TOC (0.5 – 1 mM) and dissolved O_2 (6.5 – 7 mg/L), were similar for Meadowlands and Pine Barrens samples.

Table 1: Microbiological parameters describing the response of the microbial communities in the Meadowlands and Pine Barrens Lakes to Hg (Aug. 00 sampling).

Parameter	Meadowlands sites:			Pine Barrens sites:	
	MLU	MLM	MLD	PBH	PBB
Total heterotrophs (CFU/ml)	NA ¹	4.8×10^4	2.2×10^4	NA	1.6×10^3
Hg ^R heterotrophs (CFU/ml)	2.8×10^3	4.2×10^3	1.8×10^3	NA	
Diversity – heterotrophic community (H') ²	NA	2.845	2.770	NA	2.659
Diversity – Hg ^R community (H')	2.714	2.067	2.311	NA	0.000

¹NA: Not available – Number of colonies observed was too low to allow determinations.

²Shannon-Weaver diversity index, calculated as:

$$H' = -\sum_{i=1}^{S^*} (P_i \ln P_i)$$

Where: $P_i = \frac{\text{No. of colonies in a specific morphology group}}{\text{Total No. of colonies analyzed}}$

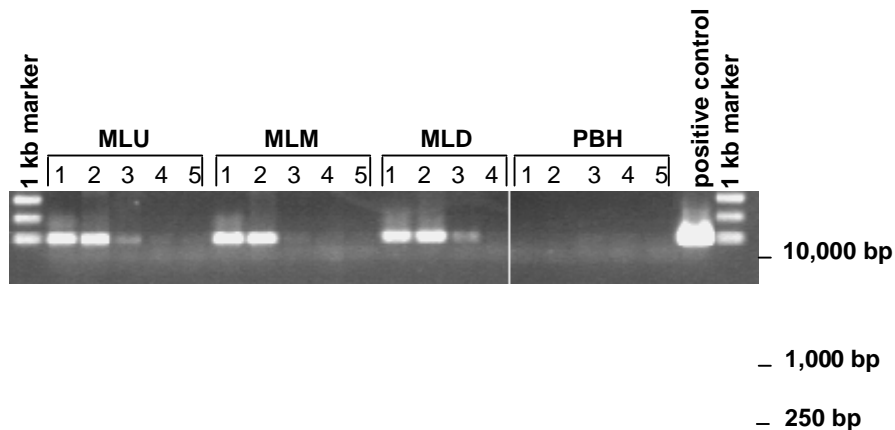


Fig. 2: Results of PCR amplifications using primers targeting highly conserved sequences in *merA*. Ten fold dilutions (dilution factors of 10^1 to 10^5 , lanes marked as 1 through 5, respectively) of DNA extracted from the microbial biomass in Meadowlands water (MLU, MLM, and MLD) and in Harrisville Lake (PBH) were amplified and amplification products were separated on 1% agarose gel. Positive control: amplification of DNA from a plasmid carrying a known *merA* gene.

Summary and future directions

Our results show that (i) proportionally more MM accumulates in Pine Barrens Lakes where Hg_T , mostly from atmospheric deposition is at the ng/L concentrations than in Meadowlands waters, and (ii) low population densities of bacteria with the potential to degrade MM were detected in Pine Barrens Lakes water. While these findings provide a tentative support to the hypothesis that in the Pine Barrens active microbial MM degradation is not induced due to low concentrations of inorganic Hg, further and more rigorous support is needed. This support will be obtained by, (i) measuring the rate of ^{14}C -MM degradation, (ii) quantitating *mer* genes and their expression in samples collected at Pine Barrens Lakes and the Meadowlands. The complete sets of data for all microbiological, molecular and physical-chemical parameters will be statistically analyzed to determine which of the measured parameters most significantly affect MM production.

Literature cited

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- Bloom, N. S., and W. F. Fitzgerald.** 1988. Determination of volatile mercury species at the picogram level by low-temperature gas chromatography with cold vapour atomic fluorescence detection. *Analytica Chimica Acta* **208**:151-161.
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Pak, K. R., and R. Bartha. 1998. Mercury methylation and demethylation in anoxic lake sediments and by strictly anaerobic bacteria. *Applied and Environmental Microbiology* **64**:1013-1017.

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The effects of water quality and habitat modification on benthic macroinvertebrates in urban forested wetlands in northeastern New Jersey

Basic Information

Title:	The effects of water quality and habitat modification on benthic macroinvertebrates in urban forested wetlands in northeastern New Jersey
Project Number:	2001NJ1102B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	6
Research Category:	Not Applicable
Focus Category:	Wetlands, Ecology, Water Quality
Descriptors:	channel morphology, substrate morphology, ecological integrity, benthic macroinvertebrates, anthropogenic disturbance, anthropogenic effects, urban watersheds, New Jersey, wetlands, urban wetlands, macroinvertebrates, water quality
Principal Investigators:	Robert Hamilton, Joan G. Ehrenfeld

Publication

1. Hamilton, R. IV, P. S. Kourtev, and J. G. Ehrenfeld. 2001. Effects of water quality and habitat modification on benthic macroinvertebrates in urban forested wetlands in northeastern New Jersey. [Abstract] Association of Southeastern Biologists, Annual Meeting, New Orleans, Louisiana.

Robert Hamilton IV

Part II

Project Information:

The primary objective of this study was to analyze benthic macroinvertebrate community structure and selected water quality and geomorphology parameters within wetland streams in highly urbanized watersheds to define a reference condition. It is already known that urbanized habitats are more impacted by anthropogenic stressors than nonurban ones. They have less abundance and diversity of benthic organisms, altered geomorphology, hydrology, and disturbance regimes, and a predominance of a few land use/land cover classes (e.g. industrial, residential, commercial). Since biodiversity is a commonly used surrogate for habitat quality these depauperate systems are classified as such and no further analysis is conducted. However, there appears to be high variability in the previously mentioned watershed characteristics that needs to be quantified. Once this information is quantified, and a “least impacted” reference condition is defined, it could be useful in management and conservation uses. Some uses include restoration of degraded areas, making decisions on preserved area sizes, and locations, limiting deleterious land use actions, and predicting which unimpacted areas may become at risk.

Methodology

Two preliminary studies were conducted during the fall of 2000 and 2001. The Y2000 study focused primarily on higher order streams reaches located in three different counties, where the Y2001 study focused on headwater regions all within two miles of Morristown, NJ. In the Y2000 study, seven wetlands streams along an urban to suburban gradient in urbanized northern New Jersey. The first study was used primarily to verify collection techniques of both benthic macroinvertebrates and water quality data. Benthic macroinvertebrates were collected using modified EPA multihabitat rapid bioassessment techniques. Benthic macroinvertebrates were subsampled and identified to family taxonomic level. They were also classified into functional feeding groups and water tolerance values. Water quality parameters, such as pH, dissolved oxygen, redox potential, and others, were measured using commercially available YSI and Orion probes. These respective data groups were analyzed using univariate and multivariate statistical methods. The Y2001 study used similar methods, but focused on four sites within one watershed (Whippany River).

Principal Findings and Significance

In the Y2000 study, the seven sites showed a clear separation along a gradient of physical and chemical parameters, including pH, redox potential, dissolved oxygen, and substrate composition. The benthic communities were dominated by detritivorous crustaceans (amphipods and isopods) and slightly to moderately pollution tolerant taxa. While the physical and chemical parameters showed a clear separation, the benthic communities did not, but generally showed more diversity in less urbanized, less densely populated, and less degraded areas. The Y2001 study showed that sites in close physical proximity to each other within the same watershed could have widely differing physical and chemical conditions and benthic macroinvertebrate communities. The results from both studies suggest that in order to characterize sites in urbanized areas and establish a reference system, studies should be conducted that use multiple and quantitative techniques (as opposed to unreplicated, rapid techniques) that sample physical, chemical, and biological parameters. In addition, due to past and present land use practices in adjacent municipalities, there could be high heterogeneity with respect to the aforementioned parameters within the same site class groupings.

References:

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Human Components of Exotic Species Invasion in Urban Forested Wetlands

Basic Information

Title:	Human Components of Exotic Species Invasion in Urban Forested Wetlands
Project Number:	2001NJ1161B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	6
Research Category:	Not Applicable
Focus Category:	Wetlands, Ecology, Methods
Descriptors:	exotic species, invasion, biodiversity, native species, urban land use, disturbance, anthropogenic disturbances, human activities, urban ecosystems, invasibility, Arthur Kill
Principal Investigators:	Heather Bowman Cutway, Joan G. Ehrenfeld

Publication

Problem and Research Objectives:

There have been many studies looking at the general effects of urbanization and edge effects (Saunders *et al.* 1991, Sukopp *et al.* 1998, Pouyat *et al.* 1995, Zhu & Ehrenfeld 1999), but very few have considered how different types of land use and specific human activities could affect the floral and faunal community composition in urban ecosystems. While it has become dogma that urbanization promotes exotic invasion, my preliminary studies reveal that there is a significant difference in the number of exotics and the extent of invasion among wetland patches in the urban environment. These differences appear to be associated with the type of land use around the wetland and the activities that take place within the wetland. Specifically, wetlands in industrial areas are less invaded (defined by exotic species abundance and richness) than wetlands in residential neighborhoods. There is also a higher presence of exotics in the interior of sites that have either ditches or trails (Bowman Cutway, unpublished data).

I have focused on the effects that humans have on exotic species invasion in urban-forested wetlands at two levels of human interaction. My research set out to test two hypotheses. First, the different types of land use on the edge of an urban wetland will have different effects on the abundance and richness of exotic plant species. It is my hypothesis that edges along residential land use have a higher richness and abundance of exotics. Second, the presence of direct human activity within the site is correlated with a higher richness and abundance of exotic species in the interior of the wetland.

Methodology:

I am testing my hypotheses by examining the invasibility of forested wetlands (Cowardin Class PF01) in the Arthur Kill drainage basin in the central and northeastern New Jersey piedmont. Within the Arthur Kill watershed, I have a total of 17 study sites broken into several categories based on size and landscape position. Sites were selected by using NJDEP wetland inventory maps and aerial photographs, followed by a field visit for ground verification of site condition. I separated study sites into large (>50ha.) and small (<20 ha.) wetlands. Within the small category, wetlands have been separated by land use categories (residential vs. industrial) and shape/position categories (narrow riverine corridor vs. round, disconnected from a major waterway). All possible large study sites are within residential areas. Land use categories are determined by using aerial photographs and zoning designation. Very large box-like buildings, extensive parking lots, railroad tracks and roads characterize industrial sites. Vegetation is found in waste areas and small lawns surrounding the buildings, which are mown but not landscaped. The residential matrix usually consists of single-family homes on a range of lot sizes with mown and landscaped yards adjacent to the wetland. Small neighborhood parks with playground equipment are also commonly adjacent to the wetlands. Through this approach of considering two urbanized land use types, comparisons between categories can be made in addition to characterizing overall patterns.

Vegetation sampling was conducted in 2 x 2 meter plots set on transects with groups of 9 plots on 3 lines. Transects were located on two different edges, and within the interior along disturbances (trails and ditches), and in areas undisturbed by trails and ditches. Sample plots were perpendicular to the point of interest in intervals of 25 meters

(figure 2). The number of plots per site depended on site size and varied from 18 to 36. Within each plot, cover of herbaceous plants, number of shrub stems and tree seedlings were recorded. Diameter at breast height (DBH) of the tree closest to the plot was measured and an estimate of basal area of each tree species was made using a cruise angle. Canopy density was measured using a GRS densitometer. Bareground and trash cover estimates were made as indicators of disturbance (Crawley 1987).

Additionally, I conducted a perimeter study to determine which wetlands are in close proximity of an exotic seed source and if some species are more common on one type of edge. For the perimeter study, I walked the entire perimeter of each wetland and noted the number of exotic species within 5 meters of the wetland edge, the presence of ditch and trail entrances, density of trash, and physical disturbance of the land (deranged topography). I also made a detailed record of the land use adjacent to the wetland.

Principal Findings and Significance:

According to my vegetation sampling in 2000 and 2001, the number of exotics on the perimeter of each site only varied from 11 to 23 and there is no significant difference between land use, size or shape types. This indicates that there is a seed source available to each of these wetlands. However, the frequency of invaded plots differed in terms of size and land use categories. Riverine sites are the most invaded with a high percent of quadrats with at least one exotic species present (78-100%). Large residential sites had a surprisingly high number of invaded plots (31-52%), but the largest and least disturbed by trails had the lowest of that group (31%). Of the small class size, all industrial sites had a relatively low percentage of invaded plots (9-19%). Small residential sites were higher (39-78%) than small industrial and lower than small residential corridor sites, but there is no significant difference in percent of invaded plots between small and large residential (figure 5). In terms of herbaceous cover, there is a significant difference between small industrial, small residential and small residential corridor. There is not a significant difference between small industrial and large residential or small residential and large residential (figure 6).

Of the transect types, exotics were much more likely to be found on the edge and along trails and ditches (table 2). 50% of edge plots (n=301), 22% of the ditch plots (n=50), and 30% of trail plots were invaded while only 16% of interior plots (n=121) were invaded. The most common exotics in urban-forested wetlands were *Alliaria petiolata*, *Lonicera japonica*, *Microstegium vimineum*, *Polygonum cuspidatum*, and *Rosa multiflora*. These common exotics are characterized by a variety of dispersal mechanisms (table 2). Interestingly, the species that were found in sampling plots are not always just a subset of those on the perimeter.

During the summer of 2002, my research will further investigate the role of land use and human disturbance on invasibility by first, collecting seeds from seed traps to determine if seeds are entering the site at different sampling areas, how many seeds, which species, and propagule type (native and exotic). Second, a seed bank study will track both past and present dispersal events. Third, I will survey soil and hydrological conditions to determine if particular conditions encourage the establishment of exotic species.

Vapor phase UV Destruction of organic contaminants

Basic Information

Title:	Vapor phase UV Destruction of organic contaminants
Project Number:	2001NJ1181B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	6
Research Category:	
Focus Category:	Groundwater, Methods, Water Quality
Descriptors:	(PTO), photo-thermal oxidation, organic contaminants, (PCR), photo-chemical remediation, remediation, (PCE), tetrachloroethylene, subsurface contamination
Principal Investigators:	Jeff Jeong-yub Lee, Kenneth Lee

Publication

1. LEE, K. Y., J. KHINAST, J. J-Y. LEE, AND J. R. STENCEL, Design and construction of a field-scale photo-chemical remediation reactor, Thirty-Third Mid-Atlantic Industrial and Hazardous Waste Conference, edited by N. Assaf-Anid, 256-263, Riverdale, NY, 2001.
2. LEE, J. J-Y., Design and construction of a photo-chemical remediation reactor, (Third place student poster presentation), presented at New Jersey Water Environment Association annual conference, May 2001 (Advisor Dr. Kenneth Y. Lee).

PART II

Final Report:

Project Information:

Soil and groundwater contaminated with volatile organic compounds (VOCs) are often remediated using soil venting or pump-and-treat followed by air stripping, combined with carbon adsorption to treat off-gases (Hager et al., 2000). However, activated carbon simply changes the phase of the pollutant and generates contaminated carbon wastes. Another off-gas treatment method is thermal oxidation, but a fuel supply is needed to elevate the temperature up to 500°C to initiate the reaction (Chen et al., 1995). In recent years, photo-chemical oxidation has been studied as an alternative remediation technology because of the numerous advantages compared to conventional technologies (Prager and Hartman, 2001). The technology is based on a synergistic effect obtained when UV photo-initiation is combined with a reducing gas (e.g., hydrogen), oxidative atmosphere (ambient air), or combination of both. The advantages of photo-chemical oxidation are: (1) Photo-chemical process can be operated at ambient temperature and pressure, (2) complete and efficient destruction of a broad range of pollutants can be achieved, which produce innocuous final oxidation products such as CO₂, H₂O, and/or HCl, and (3) no chemical additives are required. In this study, a pilot-scale photo-chemical remediation reactor is designed and constructed.

Methodology:

The design of the pilot-scale photo-chemical remediation reactor is based on extensive bench-scale studies (EPA, 1994; EPA, 1999) performed at Energia, Inc. (Princeton, NJ). Figure 1 shows a schematic diagram of the reactor and the vapor phase flow path. Stainless steel (type 304) is selected for the construction of the tubular reactor vessel because of cost considerations, ability to resist corrosion, and ease in fabrication. The reactor is insulated to minimize heat loss. The reactor has an inner diameter of 32 cm and a length of 105 cm. The reactor volume is approximately 84.1 liters and this volume is reduced to approximately 73.7 liters with the insertion of sixteen Suprasil glass sleeves and three internal baffles. The Suprasil glass sleeves are geometrically positioned to provide uniform UV exposure inside the reactor (see Figure 1). Each Suprasil glass sleeve holds a low pressure mercury amalgam UV lamp (Heraeus Inc.), which protects the UV lamp from contaminant vapor while allowing transmission of UV light into the reactor. Each Suprasil glass sleeves has a 25 mm inner diameter and 28 mm outer diameter with a length of 110 cm. Three thermocouples are mounted on the reactor to observe reactor temperature progression. The reactor and all associated hardware are mounted on a mobile frame for possible technology demonstration at a field site. Figure 2 shows a picture of the reactor with UV lamps installed.

Gas-tight sealing between each Suprasil sleeve and the stainless steel end plate is accomplished using the “stuffing-box” configuration, which two 6.35 mm (1/4 inch) thick flexible graphite compression seals (Garlock Sealing Technologies, Palmyra NY) are compressed by a circular aluminum gland to form the seal. A reactor leak test is

conducted by pressurizing the reactor to 10 psig and the reactor pressure is observed over time. Results indicate that the leaks are insignificant especially if the system is operated at atmospheric pressure.

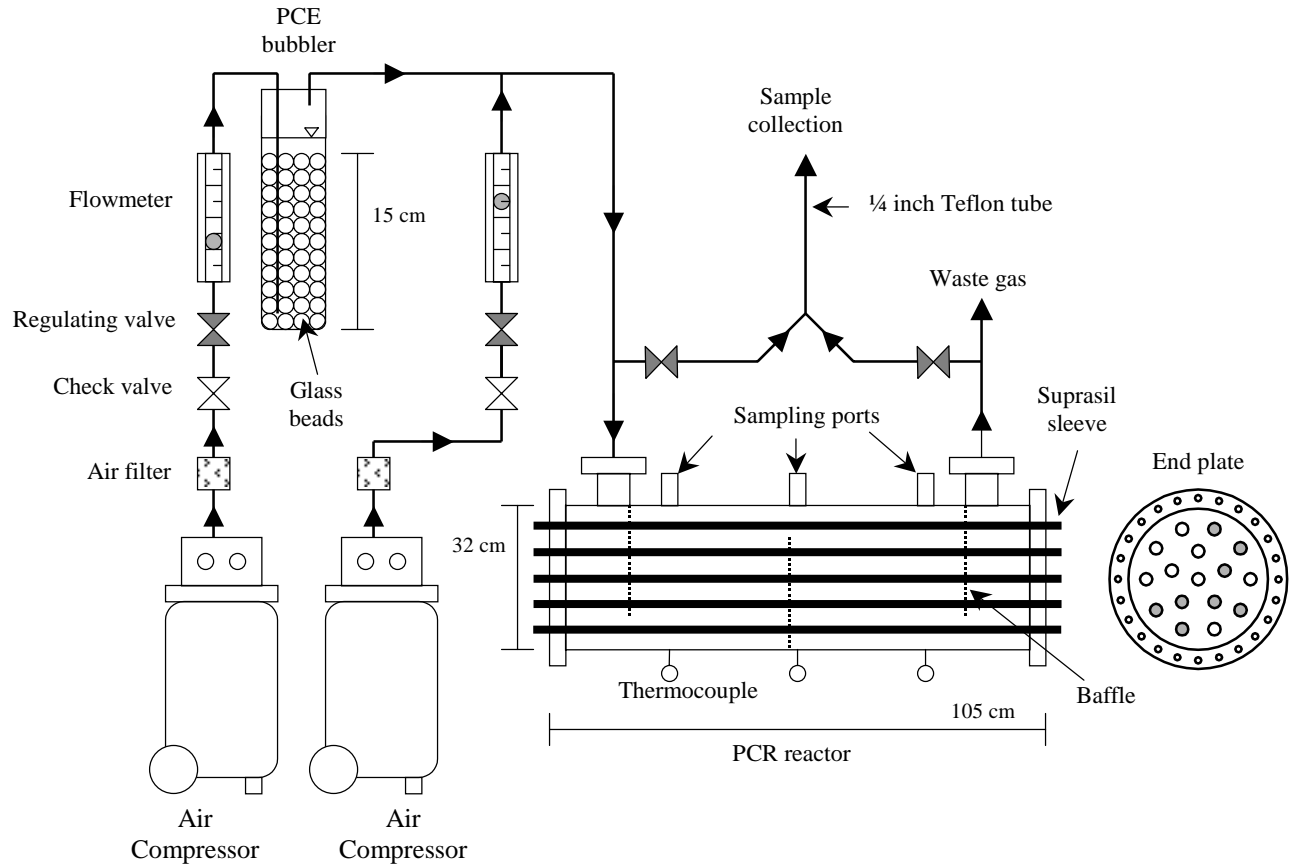


Figure 1: Design of reactor flow path.

Principal Findings and Significance:

A novel pilot-scale photo-chemical remediation reactor was designed and constructed. The reactor will be used to perform destruction experiments on volatile organic compounds such as PCE and TCE.



Figure 2: Photo of reactor.

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Pilot Study on the Use of Hydrogen Release Compounds for PCE Enhanced Biodegradation in Fractured Rock Aquifers

Basic Information

Title:	Pilot Study on the Use of Hydrogen Release Compounds for PCE Enhanced Biodegradation in Fractured Rock Aquifers
Project Number:	2001NJ1361B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	6
Research Category:	
Focus Category:	Groundwater, Methods, Toxic Substances
Descriptors:	TCE, dichloroethene, trichloroethene, tetrachloroethene, PCE, DCE, DNAPL, dehalogenating microorganisms, anerobic microbes, redevelopment, Brownfield, remediation, fractured rock aquifer, hydrogen release compound, HRC, carcinogen, drinking water, groundwater, chlorinated solvents
Principal Investigators:	Joseph R. Stencel, Kenneth Lee

Publication

1. Lee, K.Y., Transport of dissolved contaminants originating from a rectangular prism shaped multicomponent nonaqueous phase liquid source in saturated porous media, in press, Environmental Geology, 2002.
2. Stencel, J.R., and K. Y. Lee, Remediation options for PCE in a fractured rock aquifer, EOS, Transaction, American Geophysical Union, 91(48), 449, Fall 2000.

Project Information:

The main objective of the overall project is not only to show remediation in a fractured rock aquifer using hydrogen as the electron donor, but to show that a compound, such as HRC[®] is a very cost-effective method to remediate in a timely manner some of the most frequently found contaminants in many types of groundwater systems. The intent is to tie together other pilot studies of NJDEP, the clay aquitard system presently undertaken by Rutgers and this new media of a fractured-rock aquifer. This will have benefits for all of New Jersey because of the expected application of this process to inhomogeneous aquifer scenarios. The entire northern portion of New Jersey is underlain by a fractured bedrock formation commonly called the Brunswick formation, though it is alternatively called the Passaic formation. Given the industrialization of this portion of the state and the wide use of chlorinated solvents for degreasing application in the middle part of the 20th century, it is clear that once developed, this technology will have a very wide application. There is commercial relevance to Brownfield redevelopment as well as aquifer remediation in industrial and residential neighborhoods. In New Jersey alone, there are thousands of sites that would benefit from this new remediation approach.

New and innovative relevance include:

- Innovative use of an *in-situ* reductive dechlorination bioprocess for bedrock aquifers.
- Commercial development and field application of the bioprocess.
- Invention of biostimulation product.
- Innovative application for DNAPL chlorinated solvents.

One overall objective of this research and development program will be to show that a cost-effective commercially viable remediation process can be made available for some of the most prevalent contaminants found in fractured bedrock groundwater systems, particularly the Brunswick formation. If successful, the program will show that anaerobic hydrogen technology can not only be cost effective, but will produce cleanups in shorter time frames, will not cause disruptive activities on the property undergoing the remediation, and can be effective in the fractured-rock aquifers which are found in New Jersey.

The available funding through NJWRRRI is not sufficient for this entire project, however, it provides needed funding to help in providing a necessary tracer study as part of the overall pilot project leading to an understanding of the data being collected and in projecting the success of the remediation process over the expanse of the aquifer being studied.

Methodology:

The methodology to be employed included the drilling of a well for introduction of a tracer such as sodium bromide into a well, and the use of either a natural flow to recovery well in the same strike, and/or the use of pumping at the second well if the distance was too great. Follow up injection would include a hydrogen release type compound to see if it would flow into fractures and show up at the recovery well.

Principal Findings and Significance:

Funding for the project was received late and in the process the funding crisis in New Jersey affected a planned supported well for the project by Rutgers University. A subsequent well drilled on a limited budget proved to be in an inadequate fracture-rock zone to be of use for the project.

While delayed, the project will continue and is schedule to utilize some other established wells within a fractured-rock settings later this year. The results will be reported upon when the data is obtained.

Effects of the Biopollutant, *Phragmites australis*, On the Nutritional Status (Biochemical Condition) of Juvenile Weakfish

Basic Information

Title:	Effects of the Biopollutant, <i>Phragmites australis</i> , On the Nutritional Status (Biochemical Condition) of Juvenile Weakfish
Project Number:	2001NJ1481B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	6
Research Category:	
Focus Category:	Nutrients, Ecology, Conservation
Descriptors:	fatty acid, sphigolipid, phospholipid, sterol, isotope. lipid, finfish, weakfish, Spartina, salt marsh, marsh, nutrient, macrophyte, trophodynamic, wetlands, biopollutants, <i>Phragmites australis</i> , <i>Phragmites</i>
Principal Investigators:	Steven Y. Litvin, Michael P. Weinstein

Publication

1. Litvin, Steven, Vincent Guida and Michael Weinstein. 2002. The use of thin layer chromatography with flame ionization detection (TLC/FID) to assess the biochemical condition of juvenile weakfish in Delaware Bay in American Association of Limnology and Oceanography Annual Meeting, Victoria, BC, 72.
2. Litvin, Steven, Michael Weinstein and Vincent Guida. 2001. Trophic linkages and relative importance of salt marsh habitats to resident and marine transient finfish in Delaware Bay: a stable isotope and "biochemical condition" approach in Estuarine Research Federation Bi-Annual Meeting, St. Pete Beach, FL, 63.

Problem and Research Objectives:

Phragmites australis ranks among the most aggressive plants in wetland landscapes. By altering the marsh through its influence on hydroperiod, and geomorphology, *P. australis* reduces nekton access to the marsh plain, and by affecting the exchange of materials including organisms (trophic relays; Kneib 1997), presumably negatively influencing the production of commercially and recreationally important species. Yet, *virtually nothing is known about the trophodynamic role of P. australis in salt marsh food webs in*

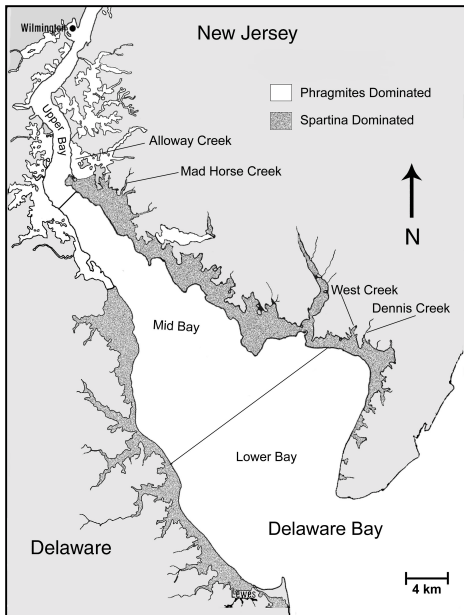


Figure 1.

North America. This gap in our knowledge begs the question as to whether the presumed fisheries impacts of *P. australis* genuinely warrant widespread efforts at control and prevention of proliferation of this species. In the past 50 years, *P. australis* has become the dominant macrophyte in many brackish marshes of the mid-Atlantic seaboard. For example, more than 16,000 ha of salt marsh are presently covered with a near monoculture of *Phragmites* on the Delaware side of the Delaware Bay, and the magnitude of coverage is similar on the New Jersey side (Weinstein and Balletto 1999, Figure 1).

Whether *Phragmites* affects the quality of habitat and contributes nutrients to the estuarine food web by export (POM and Fish) to the estuary and coastal waters is the key focus of the proposed study. Our goal is to compare the nutritional status (hereinafter, "biochemical condition") of juvenile weakfish that have resided in waters influenced by *Phragmites* as a nutrient source, versus those in waters most influenced by *Spartina* spp. By doing so, we will have the basis to not only integrate the quality of habitat in terms of nutrient flux, but also as it influences fish biochemical condition, secondary production, and survival potential.

The stable isotopes of carbon, sulfur, and nitrogen have been used to advance our understanding of food-web structure and energy flow in estuaries. The basic premise of the approach is that isotopic ratios are conservative and that physical mixing of end member sources determines the isotopic distributions of organic matter in natural systems (Cifuentes *et al.* 1988). This last point is particularly important because it allows for discrimination among mixtures of carbon and other nutrient sources, as opposed to single sources. Taken together, $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$ can distinguish phytoplankton signatures from among terrestrial, marsh and benthic algal signatures. Variability of $\delta^{34}\text{S}$ is observed to be lowest in macroalgae and phytoplankton ($\delta^{34}\text{S} \approx +18\text{‰}$) because they use seawater sulfate. $\delta^{34}\text{S}$ values for microphytobenthos are intermediate in range (4 to 14‰) depending upon the proportions of reduced sulfur and seawater sulfate at the sediment/water interface (Sullivan and Montcrieff 1990; Currin *et al.* 1995; Newell *et al.* 1995). Thus, stable sulfur and carbon isotopes can be used to differentiate between benthic versus pelagic nutrient sources, and rooted macrophyte versus algal nutrient sources. Our recent work has shown that fish in New Jersey salt marshes adjacent to Delaware Bay and in the open bay itself have stable isotope signatures that reflect the marsh macrophytes present in that region of Delaware bay (Weinstein *et al.* 2000).

Data on the intensity and direction of fat deposition and the level of body fat reserves are extensively used to assess the "degree of well being" or biological condition of finfishes (Schulman and Love 1999). The fattening cycle of many species is adapted in such a way that fat reserves are used as the energy source for overwintering, migration, gamete production, spawning, or a combination of these. For juveniles that accompany adults offshore in the fall, such as weakfish, it is the energy surpluses at the end of the first growing season that is the subject of this proposal. Are individuals from different regions, especially those from regions where the food web is influenced by *Phragmites*, equally fit for the rigors of coastal migration and overwintering? It has been generally observed in wild populations of fish that the rate of growth and size of depots of energy reserves can be correlated with the availability and nutritional content of the food. Although biochemical condition factors may sometimes be labile, the choice of relatively large samples,

specific life stages (juveniles), sexually immature individuals (thereby eliminating sex-related and gonad maturation differences), and sampling restricted populations (a single year class in a given system) can largely limit variability to *habitat* specific differences (Schulman 1974; Evans 1998). By reducing within sample variation to a manageable level, differences in the biochemical condition of juveniles from waters with *Phragmites* as a significant nutrient source (as determined by stable isotope analysis) can be compared waters with *Spartina* spp. as a nutrient.

Methodology:

Juvenile weakfish were collected in September (2001) in the lower, mid and upper Delaware Bay open waters. In the laboratory, individual fish were measured for body depth and standard length (SL) to the nearest mm. Fish from each region were weighed to the nearest 0.001g, freeze-dried, re-weighed, and ground dry. Samples of dry homogenate will be analyzed for lipids via thin layer chromatography-flame ionization detection or TLC/FID (Parrish 1987). This combination of analyses will provide a complete and detailed picture of both the magnitude and biochemical distribution of energy reserves.

TLC/FID lipid method was chosen because it provides a sensitive means of assessing lipid storage, since it allows the separate quantification of lipids by biochemical class, unlike total lipid methods by gravimetric or chemical means. For example, the degree of variation in lipid storage among individual juvenile weakfish captured in a preliminary study at a restored marsh (Dennis Township Salt Hay Farm) and a reference marsh (Dennis Creek) in 1999 is made much more evident by comparing neutral lipid fractions (especially TAG, which ranges from near zero to about 3 mg g⁻¹ dry wt between about 25 mm and 125 mm SL, followed by a dramatic increase to near 180 mg g⁻¹ dry wt at about 190 mm SL). Values of structural lipids including sterols, phospholipids, sphingolipids and other polar fatty acids form a fairly consistent proportion of total body weight over this same length interval. It appears that much of the incoming energy in the form of lipids is utilized for somatic growth between 25 and 125 mm SL (approximately June to mid-September) with energy reserves rapidly laid down as fish continued to grow and made preparations for their fall migration to overwintering grounds.

Aliquots of homogenate from each fish were also subjected to stable isotope analysis for $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$. The stable isotope and lipid data, taken in conjunction, will let us to determine if the biochemical condition of juvenile weakfish that have resided in waters influenced by *Phragmites* as a nutrient source differ from those that have resided in waters most influenced by *Spartina* spp.

Progress to Date:

138 juvenile weakfish from throughout the open waters of Delaware Bay in September of 2001. The weakfish are in the midst of preparation for stable isotope and TLC/FID analysis. The goal is to have both analyses for all fish completed by the end of 2002.

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Information Transfer Program

Information Transfer Program

Basic Information

Title:	Information Transfer Program
Project Number:	2000NJ11B
Start Date:	3/1/2000
End Date:	3/1/2001
Funding Source:	104B
Congressional District:	06
Research Category:	None
Focus Category:	None, None, None
Descriptors:	newsletter, New Jersey Flows, watershed management, website, Common Waters
Principal Investigators:	Joan G. Ehrenfeld

Publication

NJWRRI Information Transfer

Basic Information

Title:	NJWRRI Information Transfer
Project Number:	
Start Date:	3/1/2001
End Date:	3/1/2002
Funding Source:	104B
Congressional District:	6
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	New Jersey Flows, watershed, TMDL, South Jersey,
Principal Investigators:	Joan G. Ehrenfeld

Publication

Our information transfer efforts included the following activities:

1. Four issues of an 8-page newsletter, "New Jersey Flows", was published and distributed to a mailing list of approximately 1,800 people around the state (an increase of about 600 names since the previous year). The issues included two issues highlighting research projects carried out with WRRRI funding, by the NJ USGS, and by the NJ DEP, including a description of the LINJ NAWQA program; and an issue containing articles derived from presentations at the "Water for South Jersey conference", and an issue on TMDLs. The newsletter also carries announcements of water-related publications and conferences. The newsletter is also archived with the New Jersey Environmental Digital Library, a service of the Rutgers University Library system.

The newsletter carries regular columns in most issues that include 1) an update on water-related research activities at the NJ DEP Division of Science and Research, (2) an update on water-related research activities at the USGS - Trenton District Office, (3) an article by the State Climatologist on notable aspects of recent weather, as it affects water resources, (4) an article describing one of the 20 watershed management units of the state, written by a member of the planning staff for that unit (our goal is to acquaint readers with the diversity of watersheds present in the state).

2. Our website (<http://njwrrri.rutgers.edu/>) was updated by adding pages in which the results of research projects carried out by senior investigators, graduate students and undergraduates were presented.

3. We were represented at conferences, including the AWRA National Water Resources Policy Dialogue and the AWRA Annual Conference

4. As part of our "Seminars in Water Resources" series, we sponsored an extended visit by Dr. Ken Reckhow to speak about the TMDL program. In addition to his public lecture, Dr. Reckhow met with several stakeholder groups (private-sector consultants working on TMDL contracts, government agency personnel involved with water quality management and the TMDL program, and representatives of nonprofit watershed association concerned about the TMDL program.). Participants in these meetings were enthused about the value of conversations in clarifying the NJ program.

5. We co-sponsored a regional meeting on coastal marsh ecology (lead agency, NJ Marine Consortium), a state-sponsored meeting on water quality and agriculture, and a meeting organized by NJ DEP "The Watershed Symposium". As part of our co-sponsorship, we circulate meeting announcements via both email and regular mailings.

6. We circulated numerous announcements of meetings, water-related seminars, grant announcements and similar items to our list of about 200 water researchers around the state.

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	7	0	0	0	0
Masters	0	0	0	0	0
Ph.D.	5	0	0	0	0
Post-Doc.	3	0	0	0	0
Total	0	0	0	0	0

Notable Awards and Achievements

"Water for South Jersey Will the Supply Meet the Demand?" conference funded by NJWRRI and Southern New Jersey Development Council represented a multi-agency collaboration among federal, state, and local groups to present timely information on aspects of the growing demand for water in South Jersey and its emergence as a limiting factor for development. Trends, alternatives, perspectives and solutions were presented to a group representing a cross-section of those most concerned with water use including industry, developers, builders, environmental advocates, academics, government officials, politicians, attorneys, and environmental advocates. News coverage in several local and state newspapers was extremely favorable.

"Assessing the Total Maximum Daily Load (TMDL) Approach to Water Quality Management," a public seminar, featured Dr. Kenneth Reckhow, Chairman of the national Congressional committee on TMDLs. With TMDL requirements looming on New Jersey's horizon, this timely topic was well attended by a diverse community of 200+ water professionals, acamedicians, government officials and environmentalists. Additionally, a smaller seminar was presented in Trenton for the benefit of over 50 state environmental employees. Dr. Reckhow provided NJWRRI with two powerpoint presentations on the subject, which several entities have utilized to further disseminate and inform on TMDLs. Dr. Reckhow also presented a smaller seminar to state employees in Trenton and met with small groups such as environmental consultants, nonprofits, students, etc.

(1) CHAO, N. AND K. Y. LEE, Measuring the viscosity of two-phase NAPL-water systems in the presence of a cosolvent, New Jersey Water Environment Association annual conference, May 2002. (First place undergraduate presentation)

(2) LEE, J. J-Y. AND K. Y. LEE, Experimental results on the destruction of tetrachloroethylene (PCE) using a novel photo-chemical remediation reactor, New Jersey Water Environment Association annual conference, May 2002. (First place Ph.D.-level presentation)

(3) Mary Anne Carletta, who was supported in a previous year., received the Best Student Award at the Atlantic Estuarine Research Society meeting Spring 2002.

Heather Bowman Cutway presented research on "Exotic Species Invasion: Land Use and Human Disturbance Components" and was an invited member of an expert panel for New Jersey's Annual Land Conservation Rally in Basking Ridge, NJ on March 16, 2002.

Undergraduate student researcher Shira Perlis was awarded the NJWEA drinking water scholarship in 2002 and is pursuing graduate studies at Cornell University.

(Third place student poster presentation) LEE, J. J.-Y., Design and construction of a photo-chemical remediation reactor, presented at New Jersey Water Environment Association annual conference, May 2001 (Advisor Dr. Kenneth Y. Lee).

The undergraduate project that supported Michael Cohen in the analysis of stream corridor conservation easements was involved with an important drought-related effort to reduce the speed of runoff and increase groundwater recharge in New Jersey. Protection of the stream corridors may have one of the most important results in buffering flooding and maintaining lower, longer-term stream flow as well as replenishing drinking water supplies

"Phragmites Forum and Workshop" was co-sponsored with Institute of Marine and Coastal Sciences. 24 invited, peer-reviewed papers will appear in a special issue of Estuaries in April or June issue. Also, a Sea Grant proceedings of edited tape of workshop discussion, a "white paper," Phragmites diagnostic service (Cornell), Phragmites genetics paper, and several other chapters will be published in the spring

Publications from Prior Projects

1. Mary Anne Carletta, Peddrick Weis, and Judith S. Weis. 2002. Development of thyroid abnormalities in mummichogs, *Fundulus heteroclitus*, from a polluted site. *Marine Environmental Research* 54: 601-604.
2. Claude M. Epstein, 1999, Rosgen Analysis of a New Jersey Pineland Stream, *Wetland Journal*, vol.11 No.3, pp.4-9.
3. Weis, J.S., L. Windham, C. Santiago-Bass and P. Weis 2002. Growth, survival and metal content of marsh invertebrates fed diets of detritus from *Spartina alterniflora* Loisel and *Phragmites australis* Cav. Trin. ex Steud. from metal-contaminated and clean sites. *Wetlands Ecology and Management* 10: 71-84.
4. Barkay, T., and J. Schaefer. 2001. Metal and radionuclide bioremediation: Issues, considerations, and potentials. *Curr. Opin. Microbiol.* 4:318-323.
5. Schaefer, J.K., R. Dorn, and T. Barkay. 2001. Microbial factors controlling methylmercury accumulation in freshwater ecosystems in New Jersey, USA. *Materials Geoenviron.* 48:219-225.
6. Schaefer, J.K., J. Letowski, and T. Barkay. 2002. mer-mediated resistance and volatilization of Hg(II) under anaerobic conditions. *Geomicrobiol. J.* 19:87-102.
7. J.K. Schaefer, J. Reinfelder, J. Yagi, and T. Barkay The Potential Role of mer-mediated Resistance in Controlling Methylmercury Accumulation in Freshwater Ecosystems in New Jersey. 102th Annu. Meet. Am. Soc. Microbiol. Salt Lake City, May 19 - 23, 2002.
8. Barkay, T., and J. Schaefer. Microbe-mercury interactions: old paradigms, new frontiers.

Bioremediation and Biodegradation: Current Advances in Reducing Toxicity, Exposure and Environmental Consequences. Asilomar Conference Center, Pacific Grove, CA, June 9 - 12, 2002.

9. J.K. Schaefer, J. Reinfelder, J. Yagi, S. Tel-Or, and T. Barkay. The Potential role of mer-mediated resistance in controlling methylmercury accumulation in freshwater ecosystems in New Jersey. The 34th Mid-Atlantic Industrial & Hazardous Waste Conference, Rutgers University, New Brunswick, NJ, Sept. 20-21, 2002.