

Presentation Abstracts



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Likely impacts of the new or revised recreational water quality criteria

I propose to do the opposite of what is in the draft agenda; i.e., to talk about EPA's beach program without amendments to the BEACH Act. For several years, EPA's beach program has been anticipating substantial changes to the BEACH Act. But that is looking less likely as Congress is dealing with numerous difficult issues and preparing to adjourn before the November elections. Given the likelihood of no new legislation, the beach program took a fresh look to see what we could do within our existing authority. My presentation will discuss the results of our analysis of the current program's status; our program goals and directions over the next few years; and the activities we intend to undertake, including consideration of the likely impacts of the new or revised recreational water quality criteria.

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How Do the Great Lakes Beaches Look According to 303d and 305b Program Reporting through the ATTAINS System?

Every two years under the Clean Water Act, states submit to EPA an Integrated Report that describes the condition of a state's assessed waters (305b) and lists those waters that are deemed impaired or not meeting water quality standards (303d). For waters listed as impaired (303d), states must develop a Total Maximum Daily Load (TMDL) to determine the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. Water quality at all beaches, both coastal and inland, are included in this report. EPA joins the 305b, 303d, and TMDL reports into one data set and displays the information through the Assessment Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS). Using ATTAINS, this presentation will raise and answer questions on what the data shows about the conditions of state surface waters in the Great Lakes watershed and address four major questions: 1) What does this information tell EPA, States, and Water Program Managers about the health of the Great Lakes, areas of concern, and bacteria levels? 2) How well are the waters being reported and characterized? 3) What are the information gaps, who is responsible for reporting, and how can those gaps be filled? 4) How can this information be used in reporting and meeting goals through the Great Lakes Initiative?

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Can I Swim at the Beach? – Update on the Activities and Recommendations from the IJC Work Group on Beaches and Recreational Water Quality

As one of its 2007-2009 Great Lakes priorities, the International Joint Commission (IJC) identified recreational water quality issues related to “swimmability” as noted in the Great Lakes Water Quality Agreement (GLWQA) as a key concern. The Beaches and Recreational Water Quality Workgroup, comprised of members from each of the IJC’s binational advisory boards, undertook an assessment of the status of beach standards and practices across jurisdictions, as well as reasons for, and effects of, impaired recreational water quality on human health and economics. The current status of Great Lakes recreational water quality monitoring, surveillance, standards and prediction was reviewed and summarized in a series of contracted reports completed by experts on behalf of the Workgroup. Recommendations by the Workgroup in its 2009 final report to the Commission included a need for further research to determine sources of contamination, a need to develop new rapid monitoring methods and a requirement to provide head to head comparisons of now/forecasting models. Binational, standardized basin-wide surveillance and monitoring protocols, standardized criteria for beach postings, and a systematic, centralized and timely way to evaluate and report waterborne illness in the Great Lakes and track what is happening at the local, regional, state, provincial and federal levels were also recommended. Based on the 2007-09 results, the Commission again charged the Workgroup for the 2009-2011 priority cycle to examine existing information on (1) the relationships between the presence of FIB from birds and other wildlife at Great Lakes beaches and human health, and to make recommendations for priority research (2) beach management and improvement activities and their implementation within an adaptive management framework. To these ends, the Workgroup commissioned five discussion papers on these issues and also, a complementary Second Order Science (SOS) project focusing on the relationship between birds at beaches and human health. The Workgroup is also hosting an expert consultation immediately following the 2010 GLBA conference to address the question, “What is the state of the science and preferred risk management tools for protecting the health of beach visitors in the Great Lakes Basin?” Current findings and additional planned activities of the Workgroup will be summarized during this presentation.

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Beach projects funded under the Great Lakes Restoration Initiative

On November 23, 2009, EPA issued a Request for Proposals for Great Lakes Restoration Initiative (GLRI) projects to address the most significant Great Lakes ecosystem problems and efforts in five major focus areas. One of these focus areas, Nearshore Health and Nonpoint Source Pollution, targets high priority watersheds and reducing polluted runoff to address problems caused by nonpoint sources of pollution such as Cladophora, avian botulism, and beach closings. To strategically address these problems and make progress towards achieving the goals, objectives and targets identified in this focus area of the GLRI, EPA solicited proposals for nine program categories, four of which address beach health and beach management activities. The four beach program categories include Beach Sanitary Surveys to identify sources of contamination at Great Lakes beaches and implement actions to reduce contamination, Beach Forecasting Models to develop or improve water quality forecast models, Improving Beach Monitoring for Bacteria to improve methods for monitoring fecal indicator bacteria, and Communicating Beach Monitoring to the Public to improve methods of beach health

communication. Sixty-four projects were funded under these beach program categories at a total of \$13,501,729. The focus of the presentation will be on the beach projects funded under the GLRI this year. It will also provide an overview of the GLRI as well as information about the FY2011 GLRI Request for Proposal.

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Beach Health Interagency Coordination Team (BHICT)

Sonia Joseph Joshi, Michigan Sea Grant Outreach Coordinator, NOAA Center of Excellence for Great Lakes and Human Health (CEGLHH)

Sandra Morrison USGS Great Lakes Science Center,

David Schwab, NOAA GLERL

In 2009, the Beach Health Interagency Coordination Team (BHICT) was created to formalize a partnership between three federal agencies, NOAA, USGS, and USEPA, that have been focused on collaborative efforts related to beach health since co-hosting the Beach Health Research Needs Assessment Workshop in 2005, hosted at the Great Lakes Beach Association meeting in Green Bay, Wisconsin. BHICT aims to utilize the beach health research resources of USEPA, USGS, and NOAA more effectively and efficiently. This has been done by understanding each agency's programmatic goals, sharing tasks and capabilities whenever possible, and by identification of common geographical work areas and common research objectives. With the increase in funding and opportunities for monitoring and modeling provided by the Great Lakes Restoration Initiative in 2010, BHICT wants to establish a working relationship with GLRI grantees involved in beach modeling and beach sanitary surveys. The three federal agencies (NOAA, USGS and EPA) are interested in Great Lakes Beach Association efforts for beach monitoring and development of decision support tools needed for effective and safe beach management. We will present the means by which BHICT plans to accomplish this mission. Members of BHICT include: James Morris, Dr. Norman Grannemann, Sandra Morrison and Dr. Richard Whitman from US Geological Survey, Sonia Joseph Joshi (NOAA CEGLHH), David Schwab, and Richard Wagenmaker, representing NOAA, Dr. Richard Zepp, ORD, Holly Wirick and Richard Zdanowicz, from USEPA and David Rockwell, CEGLHH-NOAA/CILER-University of Michigan, as Chair of the Team.

David J. Schwab

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Activities at NOAA Center of Excellence for Great Lakes and Human Health

This talk will describe recent beach-related activities at the NOAA Center of Excellence for Great Lakes and Human Health, including the announcement of the new Ph.D. Traineeship Program in Oceans and Human Health at the Great Lakes WATER Institute and the UWM School of Freshwater Sciences. Much progress has been made in the last year on operational computer models for predicting river plume impacts on several beaches around the Great Lakes. There has also been considerable progress on using NOAA weather data in statistically-based nowcast and forecast models for beach water quality. In addition, an experimental product for forecasting the movement of algal blooms in Lake Erie will be described.

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Beach-related projects that GLC secured under the GLRI

The Great Lakes Commission has secured two beach-related grants through the Great Lakes Restoration Initiative. A \$30K grant will support enhancement of the GLBA website to make it “the source” for the latest news and information for and about the beach science and monitoring communities. The one-year project will focus on increasing access to near real-time data for beach managers, helping to coordinate and promote annual beach conferences, and creating a searchable database of beach management points of contact. A second two-year grant is supporting development of a smartphone application, myBeachCast, to enhance public access to beach closure notifications, weather forecasts, and other environmental and local information.

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Michigan’s Great Lakes Restoration Initiative Beach Projects

The Michigan Department of Natural Resources and Environment (DNRE), with expert partners and local health agencies, will expand the frequency, duration, and number of beaches regularly monitored with beach sanitary surveys; conduct wet weather monitoring; use microbial source tracking tools at beaches with historical contamination or are scheduled for a Total Maximum Daily Load; begin using rapid testing methods at five pilot-study beaches; develop forecasting models for five beaches; and implement remediation actions for four beaches in 2011 and 2012. The DNRE, along with Michigan State University, will also provide training and online resources to implement Quantitative Polymerase Chain Reaction techniques for rapid testing and potential source tracking applications. Local beach monitoring and source tracking data will be reported to the DNRE via progress reports and the BeachGuard system. Data will be incorporated into the DNRE’s programs to identify and eliminate sources of bacterial contamination in surface waters. The DNRE will review, summarize, and report data in annual beach reports, the Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Reports, and in progress reports and data submissions to the U.S. Environmental Protection Agency.

Chris Bradley

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AbTech Industries Smart Sponge - Reduce beach closures due to bacteria contamination

About 15 years ago AbTech developed its Smart Sponge® technology, which is at the heart of its product innovation. Its unique molecular structure is based on innovative polymer technologies that are chemically selective to hydrocarbons. Once oil is absorbed into the Smart Sponge® it becomes chemically bonded and transforms into a stable solid, which prevents absorbed oil from leaching. Smart Sponge® was also designed not to deteriorate in water, allowing for a longer and more effective product life. Smart Sponge® technology provides cost-effective BMPs with low installation and maintenance labor costs. In comparison to other products, the Smart Sponge® technology also allows easier and less expensive handling and disposal or recycling

of the waste product, since its technology transforms liquid oil and other pollutants into a stable solid. Additional research and development allowed AbTech to incorporate an antimicrobial technology synergistic with the Smart Sponge® technology. This effort produced Smart Sponge® Plus, which features an antimicrobial agent chemically and permanently bound in a proprietary process to the Smart Sponge polymer surface. Due to this permanent bond, the antimicrobial agent is active but does not leach or leak, avoiding any downstream toxicity issues. Recently the EPA has registered Smart Sponge® Plus under FIFRA, approving it for the reduction of coliform bacteria found in stormwater, industrial wastewater, and municipal wastewater. This registration allows AbTech to use its laboratory and field testing data to engineer solutions specific to each site's flow rates and bacteria and pollutant levels. The presentation will cover the technology, how it works to reduce coliform bacteria, and the types of engineered solutions available to help keep beaches open.

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Landuse Trends Surrounding Michigan Great Lakes Beaches: Implications for Management

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As a continuation of previous collaborative work with the Michigan Department of Natural Resources and the Environment (MDNRE), the Center for Water Sciences (CWS) at Michigan State University has been further examining landuse and beach quality data for the state of Michigan by incorporating arial imagery with the objectives of: 1) comparing landuse surrounding Michigan's Great Lakes beaches at multiple spatial scales and 2) calculating landuse relationships to beach quality based on *Escherichia coli* (*E. coli*) sampling data. The State of Michigan's *Escherichia coli* database, compiled from recreational beach monitoring, was used to assign 61 Michigan Great Lakes beaches an Annapolis Protocol (AP) class (5 class levels ranging from A being 'good' to E being 'poor') based on previous statistical analysis conducted by our group using the Hazen method. ArcGIS software was used to analyze landuse patterns within the surrounding watersheds of these sampling sites at three scales: 1) entire watershed (HUC 8 and HUC12), 2) 5km contributing area upstream of site and 3) 1km contributing area upstream of site. Landuse was analyzed at each of these three scales for the entire watershed/contributing area as well as for 50 and 125 meter buffered sections of all rivers and streams within each area. We used Spearman Rank Order Correlations to analyze relationships between AP class and landuse. Contrary to our prediction, smaller spatial scales were not found to be more significantly related to beach quality as determined by AP class than larger spatial scales. Relationships between landuse type and AP class varied with spatial scale. Urban areas were found to be a factor in 'poor' quality sites at all landuse scales and wetland areas were a factor in 'good' quality sites but only at larger watershed scales. This suggests that beach management strategies should target multiple scales and landuse types. Further investigation regarding the relationship of wetlands to 'poor' quality sites and of barren land to 'good' quality sites at the smaller watershed scales managed by local county or park officials is needed.

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Designing a constructed wetland for water quality enhancement at Maumee Bay State Park on the southwestern coast in Lake Erie: Phase 1 - monitoring loadings of *Escherichia coli*, suspended solids and total phosphorus

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The public beach at Maumee Bay State Park (MBSP), located along the southwestern coast in Lake Erie, frequently has densities of *Escherichia coli* that exceed the water quality standard of 235 CFU/100 ml. Preliminary studies have identified Berger Ditch, which empties into the lake 70 m east of the beach, as a primary source of bacteria pollution. The overall goal of our research is to design a wetland system that reduces the loadings of *E. coli* that enter the beach. The purpose of this study was to monitor the water quality and hydrology of Berger Ditch for a one-year period to identify seasonal trends. Water samples were collected Monday through Thursday from July 27, 2007 to July 26, 2008 at a stream gage located one mile upstream from the lake that contained an acoustic Doppler velocity meter and a refrigerated automatic sampler. Individual samples and the average daily discharge were used to calculate the loadings of *E. coli*, suspended solids, and total phosphorus. The annual loadings for *E. coli*, suspended solids, and total phosphorus were 9.1863×10^{14} CFU, 4747.52 tons, and 20.23 tons, respectively. Whereas the loadings of *E. coli* were the highest during the summer (6.8963×10^{14} CFU), suspended solids and total phosphorus were the greatest in the winter (2702.57 tons and 10.38 tons, respectively). Densities of *E. coli* were strongly correlated with discharge ($r=0.8052$) and suspended solids ($r=0.8761$) in the summer, and total phosphorus was strongly correlated with discharge ($r=0.5712$) and suspended solids ($r=0.5763$) during the one-year study. Our results suggest that reducing the levels of suspended solids entering the lake may decrease the loadings of *E. coli* and total phosphorus, and thus enhance the quality of water at the beach and in the bay where algal blooms are frequently observed. Currently, the University of Toledo is collaborating with the Ohio Department of Natural Resources and local entities to design a wetland system in the Berger Ditch channel that will function to retain suspended solids and filter bacteria.

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Impact of Physical and Hydrogeological Conditions on Deteriorating Conditions at Beaches of the Great Lakes

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Many of the beaches throughout the Great Lakes have exhibited drastic changes for the worse during the past several years. Problems such as elevated levels of *E. coli*, invasive vegetation (*Phragmites*, rushes, sedges), loss of sand, and wet conditions has prompted a concerned public to demand research and action from all levels of government to identify the cause of the problems and offer solutions to save the beaches. This study was conducted to: (1) assess why some beaches are always wet (and exhibit a variety of problems) and why other beaches are always dry (and do not exhibit any problems); and (2) determine if changes to beaches by local residents have degraded the physical conditions and water quality of beaches. This study investigated the physical and groundwater conditions (grain size distributions, moisture contents, water table depths, hydraulic conductivity, ground surface elevations) present at beaches of southern Georgian Bay, Ontario, to understand the differences between natural beaches and deteriorating wet and dry beaches. Results of this study indicate that there are two principle factors affecting beaches: depth to the water table and grain-size distribution of the beach sand. Finer-grained sand has relatively higher volumetric water content, and larger capillary rise, and low hydraulic conductivity. Thus, beaches with finer sand retain more moisture close to the surface, and hence are wet beaches. Coarser-grained sand has low volumetric moisture content, smaller capillary rise, and higher hydraulic conductivity. Thus, beaches with coarse sand retain less water close to ground surface, and hence are typically dry beaches. Regardless of the grain size distribution, beaches with a shallow water table (< ~0.5 m) are typically wet beaches because the capillary rise is close to the ground surface. Alternatively, beaches with deep water tables have a capillary rise well below the ground surface. The presence of wet and dry conditions at beaches is the primary factor controlling the deterioration of beaches. *Phragmites*, sedges, rushes, etc. were observed only at wet beaches where sufficient moisture facilitates their growth. At dry beaches, only plants that can exist in the very low moisture conditions, such as American beach grass are observed. Furthermore, wet beaches provide conditions more conducive to the infiltration and transport of surface contaminants (e.g., *E. coli*) to the water table. Human activities that have changed the physical conditions of a beach, such as bulldozing sand dunes, have converted dry beaches to wet beaches. Natural factors have influenced the problems observed at the beaches. However, in many cases problems are caused by the activities of the beach-front residents and municipalities.

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Beach Health: *E. coli* levels and Effective Management Practices at St. Lawrence River Beaches

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In Ontario swim advisory postings at public beaches are common throughout the summer due to elevated levels of *Escherichia coli* bacteria. The time period from sample collection to beach posting may take up to 48 hr, during which repeated exposure to unacceptable levels may continue to occur. A more comprehensive risk assessment and risk management approach for beach safety is needed. The St. Lawrence River Institute of Environmental Sciences is working with the Eastern Ontario Health Unit, the Raison Region Conservation Authority and the St. Lawrence Parks Commission to determine the sources, management practices, and site characteristics that are related to *E. coli* levels at four candidate beaches along the St. Lawrence River. The summer of 2010 was the first year of a 2 year extensive sampling plan. The methods used to evaluate the

beaches include: sanitary surveys; water quality data analysis including E. coli levels, water temperature, turbidity, specific conductivity, pH, total suspended solids and optical brighteners; weather data including rain, temperature, relative humidity, wind direction, speed and gust. This information will be used to assess the current state of the candidate St. Lawrence River beaches, identify beach management options and to construct a preliminary predictive model for E. coli incidence.

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Adopt-a-Beach™ Volunteers Playing a Valuable Role in Beach Health Data Collection

Presentation overview: This presentation will explain the Alliance for the Great Lakes Adopt-a-Beach™ program through three case studies of how volunteers in the program partnered with beach health officials to help identify potential pollution sources at beaches in Cleveland, Ohio; Racine and Milwaukee, Wisconsin; and Ottawa County, Michigan. The presentation will also introduce the Alliance's GLRI project to expand coverage of the Adopt-a-Beach™ program and increase partnerships with beach health officials in targeted Great Lakes communities. In 2009 through the Adopt-a-Beach™ program, more than 9,000 volunteers participated at 245 beach locations in 5 states: Illinois, Indiana, Michigan, Ohio and Wisconsin. Volunteers that participate in the program not only remove litter but catalog their results. In addition to the litter information they collect adopters complete a beach health assessment form that aligns with EPA's Sanitary Survey Form. The goal of the program is to improve conditions at beaches by: 1) Involving volunteers in removing litter from beaches; 2) Collecting beach health data and assisting in identifying potential pollution sources; and 3) Sharing data collected with beach health officials and others so improvements can be made. In 2009, volunteers submitted 510 beach health assessment forms and 576 litter monitoring forms through the Alliance's online data entry system. This program is unique as it utilizes volunteers trained by the Alliance's Adopt-a-Beach™ team to collect data. Beach health officials and researchers are finding the data collected to be useful as not only supplemental data but also as it provides on-the-ground volunteers that are effective at identifying and tracking potential pollution sources. Of particular interest to officials is the detailed litter data collected by volunteers that can aid in identifying a source of pollution from stormwater outfalls, avian bird populations and in some cases sewage overflows. Litter information is currently not being collected at this level of detail through the Sanitary Survey Form. Over the last two years the Alliance has been working closely with a select group of beach health officials to provide officials with supplemental beach data. In addition the Adopt-a-Beach™ program has been of assistance to these officials by: identifying potential point and nonpoint pollution sources; providing data for a USGS modeling project; taking additional water samples to be analyzed in a lab setting; providing information on source tracking; and providing detailed litter data. This work has set the stage for the next phase of the Adopt-a-Beach™ to expand the program and increase partnerships with beach health officials in targeted geographic areas where beach closures have been a problem. In conclusion, the Adopt-a-Beach™ program has been effective at producing reliable beach health data and identifying potential pollution sources. The program is an effective method of identifying volunteers to partner with local beach authorities. Headquartered in Chicago, the Alliance for the Great Lakes is the oldest citizens' Great Lakes protection organization in North America. Its mission is to conserve and restore the world's largest freshwater resource using policy, education and local efforts, ensuring a healthy Great Lakes and clean water for generations of people and wildlife

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Developing a User Friendly Risk Tool for Nearshore and Beach Microbial Risk Forecasting

Quantitative microbial risk assessment (QMRA) has developed over 30 years into an adept tool for decision making and policy recommendations. QMRA, combined with predictive exposure models, allows for a means of forecasting potential risk. Statistical approximation of Great Lakes transport models allow for a means of predicting flows onto beaches and in the nearshore environment. However, current monitoring methods for recreational water quality do not give an indication of risk of illness for beachgoers beyond what can be inferred from a bacterial indicator threshold value. To establish what can be considered safe in terms of public health and environmental quality, we are developing a risk tool that will give beach managers more information on the risks posed to people swimming at Great Lakes beaches. Beginning fall 2010, we will initially focus our efforts on one or two recreational areas to pilot the risk tool. To incorporate the necessary parameters for establishing a risk threshold for primary recreational contact, we will use data describing wave and current movements, behavior statistics for swimmers of different ages (e.g. time spent swimming, volume of water ingested), and QMRA data for a spread of enteric pathogens which can impact beaches (i.e. *Escherichia coli*,). Using data already generated by our researchers at the Center for Advancing Microbial Risk Assessment at Michigan State University, and adapting the predictive transport models for the nearshore environment of the Great Lakes, we will develop a risk tool to give a statistical indication of risk to beach goers, based on current water quality information. The statistical approximations of the pathogen transport models will allow for a depiction of pathogen levels in the Great Lakes nearshore and beach environments, encapsulated in a simpler functional form. This simpler form allows for a more straightforward entry into a spreadsheet program such as Excel™, which requires near zero training for users. Combining these models with a current bank of mechanistic risk models for microbes of interest, will allow for a forecasting model for risk of illness for beach users. These forecasting models have the possibility of informing beach managers or users of the potential risks which may be experienced for specific beaches. It is proposed that this risk model is adapted to an easy to use, rapid response forecasting model for beaches and the nearshore environment. Our timeline for this research is one year, and in that period we will pilot the risk tool at one or two beaches. However we are looking beyond this initial phase and if the Great Lakes community is able to gain benefit from better understanding the risks to beach users, we aim to develop an enhanced tool that can be applied to the basin as a whole. This tool can then be improved upon as a standalone user friendly program which can shed more light on the varying risk levels throughout the beach and nearshore environment.

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Numerical Simulation of bacteria transport and deposition processes at a Chicago beach

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Embayment is a common setting of many Great Lakes beaches in the purpose of protecting the beach from sand erosion. A recent study of summer *E. coli* concentration variations at 23 Lake Michigan beaches in Chicago implied that embayments, especially with long breakwaters or jetties, also tend to considerably reduce the mass exchange between the beach and the lake waters and hence result in persistently high *E. coli* numbers at the beach. A numerical simulation using Princeton Ocean Model coupled with a mass transport component was conducted at Chicago 63rd Street Beach. Two ideal scenarios were considered to assess the bacteria loading process from the upcoast and the bacteria release process out of the embayment, respectively. Our results show that, due to the nearly stagnant current flows in the embayment, bacteria transport and settling occur on comparable time scales. In the case of loading from the beach front, only 5% of the bacteria initially suspended in the nearshore beach water can be discharged alive out of the embayment. About 20% of the initial bacteria will die as a result of natural decay and 77% will settle back into the bottom sediment. This settled portion is potentially a source for future resuspension during, e.g., large wave events. Our results indicate that more attention should be paid to the balance of sand retention and water quality when a recreational beach is designed.

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Does modeling *E. coli* improve risk protection and access for swimmers at Chicago beaches?

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Efforts to improve public health protection in recreational swimming waters have focused on obtaining real-time estimates of water quality to minimize swimming-related illnesses. Current monitoring techniques in the Great Lakes rely on the time-intensive culturing method for *E. coli* in water. The prolonged delay with results availability combined with rapidly changing concentrations of *E. coli* can lead to significant numbers of management errors, resulting in either increased exposure to microbial contaminants and associated greater public health risks or unnecessarily closed beaches. Empirical predictive models may provide a rapid test solution to address these issues; their accuracy or success is alternately assessed by the amount of variation in *E. coli* explained or the specificity of the prediction (% of false negatives). Given the specific goal of beach monitoring programs—to protect the public from exposure to swimming-related illnesses—it is reasonable to assess model success by the decrease in number of individuals exposed to water presumed to contain human pathogens. In this study, we examined four potential monitoring approaches with increasing refinement at 14 Chicago beaches: inactive, current protocol, use of a single predictive model for all beaches (regional model), and use of individual models for each beach. Using historical monitoring and hydrometeorological data, *E. coli* concentration was predicted for individual beaches using linear regression modeling. We also explored the effect of modifying the single-sample standard application for Chicago. Our results showed that predictability of FIB concentration based on the coefficient of determination improved with model refinement at all beaches but one, and there was an inverse but identical pattern in the root mean square error: a decrease with model refinement. Predictive models were not as clearly successful at reducing the number of management errors and therefore the overall illness burden; the instances of very high concentrations of FIB (could you provide some numbers or range here?) were not necessarily detected by the models. Use of a Chicago-specific monitoring standard combined with a predictive model resulted in the greatest number of open beach days

without an increase in presumed public health risk. These results emphasize that emerging monitoring approaches such as empirical models are not equally applicable at all beaches, and the most effective means of maximizing both health protection and open beaches may differ among beaches. In deciphering the best management plans for different beaches, efforts should focus on improving public health protection, perhaps considering a wide variety of available monitoring options, including predictive models and microbial source tracking methods.

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Comparison of rapid methods and culture-based methods for bacterial indicators at 12 Great Lakes beach sites

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Currently, swim advisories or closings are issued by beach managers based on standards for concentrations of *Escherichia coli* (*E. coli*) or enterococci; these standards are based on criteria established in 1986 and include analytical methods that take too long to provide timely and accurate assessments. USEPA is required to develop new criteria that include rapid assessments by 2012. As a result, research is being done by USEPA to test and standardize a rapid analytical method, quantitative polymerase chain reaction (QPCR). Another rapid method being tested by the USGS and others is immunomagnetic separation/adenosine triphosphate (IMS/ATP). Because of its relatively low start-up cost, local agencies have expressed interest in learning and testing the IMS/ATP method. As a result, the USGS continues to test and transfer techniques for IMS/ATP to local agencies and at the same time, collect data to determine the relations between results obtained by IMS/ATP, QPCR, and culture-based methods at a variety of different beaches. During 2010, working with the USGS, samples were collected by the Northeast Ohio Regional Sewer District, University of Toledo, Erie County Health Department (Ohio), and Macomb County Health Department (Michigan) at 12 Great Lakes beach sites. As an addition to existing monitoring programs, local agencies collected samples from 2-4 times/week for 8-12 weeks, analyzed samples for *E. coli* (using the culture-based method and IMS/ATP) and turbidity, measured wave heights using a graduated rod, noted field observations, and froze filters for QPCR analyses. Filters were subsequently analyzed for *E. coli* and enterococci using QPCR by the USGS Ohio Water Microbiology Laboratory. This presentation will include a discussion of rapid methods, thoughts on technology transfer, and preliminary data comparing rapid method and culture-based method results.

Susan Phillips

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Data support for beach managers, researchers, and modelers

Finding Information using the USGS Publications Warehouse website

USGS scientists have a long history of publishing scientific research. USGS Publications Warehouse contains information on and access to USGS reports. A new version of the USGS Publications Warehouse has just been released with expanded features and services. The citation database has been expanded to include citation data for USGS authored journal articles, proceedings, and other government and non-government reports. The

presentation will show new features of Publications Warehouse such as advanced search capabilities, saving searches, signing up for RSS feeds for your favorite topics and browsing science centers publications and collections.

USGS Beach Mobile Phone Applications for Accessing Advisory and Water Quality Data

The Center for Integrated Data Analytics is building a mobile phone application that will allow beach users to use their personal mobile devices to find information about Wisconsin beaches. The application will use the GPS coordinates of a mobile phone to show nearby beaches. Users can then select beaches of interest and bring up the latest advisory and water quality monitoring information. The presentation will demonstrate the application and discuss future steps in mobile application development for beach management and communication.

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Using routine PCR and qPCR as molecular mapping tools to determine bacterial inputs into the Red Cedar River in mid-Michigan

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The Red Cedar River is a tributary of the Grand River, the longest river in mid-Michigan that discharges into Lake Michigan at the popular tourist resort of Grand Haven. The watershed includes both rural and urban areas, and urban land use is approximately 33% of the watershed. Although the water quality of the Red Cedar has improved in recent years, it still suffers from bacterial impairment, particularly during wet weather events. Significant rainfall events have been shown to increase *Escherichia coli* and enterococci counts in excess of 1,000 colony forming units per 100 mL. During the summer of 2010, surface water samples were collected from five sites on the Red Cedar River in Ingham County. The sites were on the western edge of the Michigan State University, spanning approximately four miles of the river. One of the sites was at the discharge point of the East Lansing combined sewer overflow (CSO) facility, although only one CSO event occurred during the sampling period and it was not possible to capture this event in the sampling strategy. The objective of this research was to assess the influence of human and bovine into the river during low and high flow conditions, and quantify any variations in bacterial numbers and sources in the study area. Auxiliary data (preceding precipitation, discharge, pH, conductivity) were noted for each sampling event, and a maximum of five liters of water was collected at each site using a van Dorn sampler. Enterococci isolates were cultured to evaluate the water quality using US EPA Method 1600, and source tracking tools were used to determine the provenance of bacteria in the water. Routine polymerase chain reaction (PCR) techniques were applied to enterococci and *Bacteroides* spp. cells, targeting genetic markers for human and bovine sources. In addition, a quantitative PCR method was used as an additional tool for discriminating *Bacteroides* spp. from human sources. Analysis of the data is on-going, but the preliminary results show that enterococci CFU values do fluctuate dramatically with rainfall and consequently volumetric flow rate. By combining molecular tools targeting four genetic markers (three human, one bovine) for enterococci and *Bacteroides* spp., the current data show that bovine inputs are not evident, whereas bacteria from human inputs have been identified. The occurrence of human-associated bacteria was not related with any particular sampling site, and the qPCR analysis of *Bacteroides* spp. showed the highly variable concentrations (qPCR cell equivalents/100 mL) of the human genetic marker, and no correlation with the location of the CSO facility. However the majority of bacteria sampled from the river could not be identified as either human or bovine, suggesting that other sources are important contributors of indicator organisms to the river. Sampling of the river continues until the beginning of September 2010, thus final conclusions for this

research cannot be provided at this time, but the data so far suggest that although human bacterial inputs into the river are evident, their contribution may be low compared to other sources of environmental micro-organisms.

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COMPARISON OF BACTEROIDES HUMAN MARKERS FOR POLLUTION DIAGNOSTICS IN RECREATIONAL WATERS

Rapid quantitative polymerase chain reaction (qPCR) methods are ready for use to provide timely information to protect recreational-water users from waterborne pathogens. However, there is a need for bringing these high technology methodologies out of research laboratories into the field so that local laboratories could implement these new rapid tools. Beach managers face the challenge of assessing beach water quality and making management decisions using inadequate tools. The current methods and standards rely on cultivation of the bacterial indicators that have several disadvantages: they need rapid transport to a laboratory, incubation for generally 24 hours, and provide results that represent only a small percentage of the viable bacteria. These indicators also lack correlative or predictive value for many waterborne pathogens of concern. There are also published laboratory and field studies that show the regrowth of fecal indicator bacteria in sediments and water, which is one of the greatest reasons they are inadequate. There are numerous tools for microbial source tracking in the literature. The biggest issue with these tools is the specificity and therefore there is a need for a human specific marker that can detect the origin of the pollution. Members of *Bacteroides* genus are promising alternative indicators of sewage pollution. Unlike the traditional indicators, they are more abundant in the intestines and physiologically restricted outside their host. In this study, specificity of *Bacteroides* *thetaitaomicron* alpha mannanase gene that is a symbiotic bacterium in the human gastrointestinal system were compared to *Bacteroides fragilis* 16S rRNA gene in different pollution matrices using real time polymerase chain reaction (qPCR). Samples for specificity were collected from various farm animals including horses, swine, chickens, cows and sheep. Also geese samples were collected from wildlife. The results showed that all the samples were positive for *B. fragilis* 16S rRNA marker. Therefore, the 16SrRNA marker was not specific to human fecal pollution. On the other hand, *B. thetaitaomicron* marker was found to be much more specific to humans. Among the 96 animals tested for cross reactivity, only 6 swine samples came out to be positive with this marker. Searching and targeting particular genes for human specific targets that can be used for microbial source tracking is a promising. This study shows that rapid methods such as qPCR technology combine with gene specific targets such as the mannanase gene can be efficiently used for quantification of indicator of human fecal pollution. USEPA is expected to publish new bacteria criteria in October 2012. The new criteria will likely use emerging rapid molecular techniques, such as quantitative polymerase chain reaction (qPCR). The public health laboratories for beach monitoring will have to get through a training and technical assistance program with a strong emphasis on quality assurance/quality control and standardized data interpretation. The training will likely be based on Enterococci as EPA has already published the qPCR methodology. However, using qPCR tools after the training program, the health departments will easily be adapt any additional and up-to date parameter/indicator such as human specific *Bacteroides* into their list.

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Bacterial Pathogens and Microbial Source Tracking Markers at Great Lakes Beaches – U. S. Geological Survey Studies May-September 2010

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Health effects associated with both swimming and handling sand have been detected in epidemiological studies at Great Lakes beaches, but there have been few large-scale evaluations of the occurrence of bacterial pathogens and microbial source tracking (MST) markers at Great Lakes beaches. During the summer of 2010, the U. S. Geological Survey (USGS) conducted studies in four Great Lakes states to 1) identify physical and biological processes that influence pathogen and marker occurrence, 2) relate pathogen and marker occurrence to concentrations of *Escherichia coli* (*E. coli*) and enterococci fecal indicator bacteria concentrations, and 3) identify variables that might be useful for predictive modeling of pathogen occurrence. In cooperation with multiple local partners, USGS received approximately 30 samples from each of 12 beaches in Wisconsin, Michigan, Ohio, and New York, on Lakes Michigan, Huron, and Erie. Beaches were selected based on geographical coverage, potential sources of fecal contamination, and whether the beaches had existing or developing *Escherichia coli* (*E. coli*) predictive models. Samples were collected at fixed intervals and during or after rainfall events and conditions, known or assumed to influence fecal contamination at these beaches, such as high waves. Environmental conditions and field measurements for each sample collection date were recorded in an on-line database. The USGS analyzed samples for the occurrence of gene markers of selected bacterial pathogens --- *Shigella spp.*, pathogenic *Salmonella spp.*, pathogenic *E. coli*, *Campylobacter jejuni* and *coli*, *Staphylococcus aureus*, and methicillin-resistant *S. aureus* (MRSA). The USGS also analyzed samples analyzed for *Bacteroides* general and human markers and for the *Catellibococcus* gull marker by quantitative polymerase chain reaction (qPCR). This presentation will describe the sampling design, and present summary data on the occurrence of selected pathogens in the samples.

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Temporal and Spatial Variation in Genotypic Composition of *Cladophora*-borne *E. coli* Populations in Lake Michigan

Cladophora mats in the Great Lakes have been observed to contain high concentrations of attached *Escherichia coli*, which has raised concern about the use of this bacterium as an indicator of microbial water quality. However, determining the impact of these environmentally-abundant *E. coli* on water quality monitoring necessitates a better understanding of their ecology. In this study, the population structure of 4,285 *Cladophora*-borne *E. coli* isolates obtained from Lake Michigan was examined using DNA fingerprint analysis. Isolates were obtained from *Cladophora* mats at multiple Wisconsin beaches over numerous three day periods in 2007-2009.

In contrast to previous studies, the extensive sampling in this study produced a large dataset that allowed a unique examination of changes in population structure over a wide range of spatial and temporal scales. *Cladophora*-borne *E. coli* populations were found to be highly diverse and contain many unique isolates, but numerous clonal groups were also present and accounted for approximately 33% of all isolates examined. Patterns in population structure were also observed. At broad spatial and temporal scales, *E. coli* populations did not show extensive spatial distinction among sites, but showed temporal clustering when examined by year. However, even at much finer temporal scales, *E. coli* population structure also showed significant patterns. Populations were distinct for individual mats at a given site, and for individual days within a single mat. Taken together, results of these studies suggest that *Cladophora*-borne *E. coli* populations consist partly of stable, and possibly naturalized, strains that persist during the life of the mat, mixed with more unique, transient strains that can change over very rapid time scales. Further study of microbial processes at fine spatial and temporal scales is needed, and that caution must be taken when interpolating short-term microbial dynamics from results obtained from weekly or monthly samples.

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Prevalence of enterophages and coliphages at selected sites across the Rio Grande de Arcibo

Discharge of treated or untreated domestic sewage into recreational waters is one of the main concerns in public health. Because of the impracticality of detecting pathogens, bacterial and viral indicators, such as the coliphage group, have been used to infer the presence of these pathogens, or simply the presence of sewage. However, these indicators fail to discriminate between the sources of contamination. We recently developed the methods for the detection of enterococci-specific phages (enterophages) and our data have shown that they may be alternate indicators not only of fecal contamination, but of the source of contamination. We propose the use of phages that specifically infects *Enterococcus faecalis* (enterophages) as new viral indicators of human fecal pollution in water sources and those that infect *Enterococcus casseliflavus*, *Enterococcus pseudoavium* and *Enterococcus faecium* as indicators of avian contamination. Results suggest that these are promising markers ! of fecal contamination; however, further characterization is still needed. Therefore, the prevalence of enterophages at ten different points across the Rio Grande de Arcibo watershed was studied. This watershed is one of the largest and most important sources of fresh water in Puerto Rico and discharges into the Atlantic Ocean. One liter samples were collected 2-4 times per month for a period of seven months and processed for the detection of enterococci, thermotolerant coliforms, coliphages and enterophages. For the detection of enterophages and coliphages, 100mL aliquots were separately processed using the single layer method. No significant difference was seen on the prevalence of enterococci and thermotolerant coliforms across the watershed. A significant difference was seen on the prevalence of coliphages ($f=10$, $df=45.06$, $p<0.001$), but not on that of enterophages. Even though no significant difference was seen on the prevalence of enterophages across the watershed, these results could be because they were not detected as frequently as coliphages. The period when enterophages were not detected corresponded to the times of drought in the watershed. No significant difference was seen on the survival of coliphages, but a significant difference was seen the survival of enterophages. *E. faecalis*-specific enterophages have been detected in human feces, but not in chicken or cattle feces using this host. However, phages that infect *E. casseliflavus*, *E. pseudoavium* and *E. faecium* were detected in chicken feces. These results indicate that the use of these bacteriophages to track the source of fecal contamination is promising, as they seem to be host-specific. Studies in other geographical areas need to be carried out to determine if these enterophages can in fact be an alternative tracer for microbial source tracking purposes.



Poster Abstracts

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Time scale changes in fecal contributions from humans and waterfowl and virulence gene profiling

The objective of this study was to determine short time scale changes in fecal contributions from humans and waterfowl and virulence gene profiles at Lake Superior beaches near Duluth, Minnesota. We examined the abundance of fecal coliforms, total and waterfowl-borne *Escherichia coli*, and human-associated *Bacteroides* populations, on a Lake Superior recreational beach (lake side) and two beaches within the Duluth-Superior harbor (harbor side). Water, foreshore sand, and sediment samples were taken two times per week, with the addition of daily sampling during one week in 2007, for a total of 60 individual sampling days over the course of two years. Total fecal coliforms and *E. coli* were quantified by culture-based methods, waterfowl-borne *E. coli*, Shiga toxin-like genes *stx1* and *stx2*, and the attaching and effacing (A/E) protein intimin (*eae*), were assayed using robot-assisted colony hybridization. Quantitative PCR (qPCR) was used to determine the abundance of human-specific *Bacteroides* and *Salmonella*. *E. coli* from waterfowl comprised 8 and 19% of *E. coli* isolates obtained from the lakeside and harbor sites, respectively. The number of waterfowl-borne *E. coli* was sufficient to account for exceedance of state standards in two instances. Human-specific *Bacteroides* were present in approximately 56% of water samples obtained from within the harbor, but absent from lakeside beach samples. Only 10 and 8% of the sand and sediment samples, respectively, from the harbor contained the human-specific *Bacteroides* marker gene. The numbers of *E. coli* or total fecal coliforms did not correlate with the presence of the human-specific *Bacteroides* marker gene. A total of 21,096 *E. coli* isolated from water samples were screened for the presence of virulence genes (*stx1*, *stx2*, and *eae*). While only three of 21,096 samples (0.0001%) were positive for the shiga toxin genes (found at harbor beach sites), 171 *E. coli* isolates (0.81%) contained the intimin virulence factor (*eae*). *Salmonella* was found in 3 of 241 samples (1.2%) analyzed. There was no correlation between sources of bacterial contamination and pathogen abundance. While fecal contamination from waterfowl and human sources was observed within the Duluth-Superior harbor, the contributions varied spatially. Lake Superior sanitation facilities likely contribute to fecal contamination of harbor beach sites. While the quantity of pathogenic bacteria on the tested Lake Superior beaches was low, the incidence of detection of intimin increased when *E. coli* counts were elevated. Consequently, the health risk associated with recreational water contact on beaches where human-specific *Bacteroides* marker has been identified is unclear. Further study is needed to characterize the pathogen load and the primary reservoirs of identified pathogens in order to adequately assess health risks associated with water contact.

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Analysis and Interpretation of Great Lakes Recreational Water Bacteriological Data Using Annual Sanitary Surveys

The problem of bacteriological contamination in the Great Lakes has garnered much attention from the Great Lakes beach communities, and has ultimately led to the creation of the Great Lakes Restoration Initiative (GLRI).

Funding from this project has enabled researchers to collect beach water samples at given depths in order to analyze whether or not a potential health risk is present at a given Great Lakes beach. These samples were collected at three different depths from the left, center, and right areas of the beach in order to obtain an accurate overview of the bacteriological organisms present in the water. The waters have been tested for the fecal indicator *Escherichia coli*. This data from these samples can then be used to improve the health of Great Lakes beaches by making physical improvements to the area. The data collected during the 2010 beach season has led to several temporary beach closures and advisories. Moreover, using data collected from nearby outfalls, several possible pollution sources have been identified.

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Routine sanitary surveys at 5 Lake Superior Beaches

E. coli concentrations have been monitored at Lake Superior public beaches in Ashland, Bayfield, Douglas, and Iron Counties in Wisconsin since the BEACH Act of 2000 was instituted. Due to an elevated closure rate in past summers, 5 of the 39 public beaches, Thompson's West End, Maslowski, Kreher, WI Point #2, and Barker's Inner Island were sampled more thoroughly in the summer of 2010, using the US-EPA sanitary survey protocols. This method looked at *E. coli* concentrations in spatial water and sand samples, as well as physical parameters such as wind speed and direction, current speed and direction, rainfall, outfalls, water temperature, turbidity, and presence of bathers, birds and other animals. These data were examined to see if a correlation existed between these variables and *E. coli* concentrations. Additional *E. coli* testing was completed on 2 tributaries draining into Lake Superior near Maslowski and an outfall draining into Thompson's, to determine if water input was a source of contamination. It appears that elevated concentrations of *E. coli* are observed after rain events and at beaches with higher avian populations. *E. coli* levels are seen to be higher in near shore waters. Data from routine monitoring at all beaches and sanitary survey data will be presented.

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Evaluation of Urban and Rural beach health in Manitowoc County

Evaluation of Urban and Rural beach health in Manitowoc County
Dean Sanders, Tyler Mickesh, Rebecca Abler, Richard Hein, Greg Kleinheinz, and Colleen McDermott
The presence of *Escherichia coli* has long been an indicator of water quality throughout the world. It is known that the bacterium is ubiquitous within mammalian, avian and reptilian gastrointestinal tracts. In an effort to understand beach health in Manitowoc County, WI, *E. coli* concentrations were measured four days/week at two beaches located within the same general geographic area, one rural (Point Beach State Park) and one urban (Neshota Park). The overall goal of this project was to determine if there was a significant difference in *E. coli* concentrations between urban and rural beaches during similar beach conditions (e.g. wind, waves, water temperature). One crucial environmental factor at these beaches was the presence of the nuisance alga, *Cladophora*. This green alga significantly affects the near shore ecosystem by providing a favorable environment for survival of enteric bacteria. This study, therefore, compares *Cladophora* accumulations at both an urban and a rural beach. In addition, enterococci concentrations were compared with *E. coli* concentrations at these locations.

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Analysis of the impact of a coal burning power plant on *E. coli* concentrations and physical conditions on an urban beach in Manitowoc, WI

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The city of Manitowoc is located on the northwestern shores of Lake Michigan 40 miles south of Green Bay, Wisconsin. This city has a population of 35,000 and is powered by Manitowoc Public Utilities (MPU), a coal burning power plant. MPU uses lake water to cool the reactors in the power plant and then discharges the warmed lake water back into the lake via a stream exiting the eastern wall of the facility. Lake Michigan serves as an important recreational and economic resource in Manitowoc County. The county currently monitors 10 beaches for *E. coli* contamination. Of these 10 beaches, three are within the city limits of Manitowoc, two are in the city limits of Two Rivers, and the remaining 5 are rural. In addition, Warm Waters Beach, is located adjacent to the MPU facility; however, this is not considered an official beach by Manitowoc County. Despite the lack of official beach status, Warm Waters Beach has historically been popular with locals and tourists. Past research indicates that physical conditions at the beaches influences *E. coli* concentrations in beach water sample. Warm Waters Beach has a unique set of physical conditions resulting from the warm water outflow from MPU. This study will present data comparing the physical and bacterial conditions at Warm Waters Beach to other urban beaches in Manitowoc. Additionally, data related to the source outflow from MPU, and its relationship to conditions at Warm Waters beach, will be presented. These relationships will be useful in determining whether the use of lake water as a power plant coolant by MPU significantly influences beach conditions.

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Development of Predictive Models to Aid Beach Management at Toronto Public Beaches

The City of Toronto currently uses antecedent (24 - 48 hr) *E. coli* concentrations as a standard for beach postings at public beaches. Predictive models may provide a valuable tool to aid in beach management decisions. The objectives of this project were to assess the feasibility of developing predictive models that: (1) use readily available hydrologic and meteorological data as input, (2) would be operationally easy to implement for City beach managers, and (3) could be used as a framework for development and implementation of predictive models for other Ontario beaches. Data from the 2007-2009 beach seasons were evaluated for individual beaches to justify the use of a data driven modeling method like regression. In addition, correlation analysis showed at least moderate linear correlation between candidate explanatory variables and *E. coli*, suggesting that regression models are viable. Multiple linear regression models (MLR) and logistic regression (LR) models were developed for six beaches using 2007-2008 data, and tested with 2009 beach season data. Model performance was assessed using adjusted R² and root mean square error (RMSE), inspection of scatterplots and timeseries plots, and computation of true and false positives and negatives and overall correct classification relative to observed *E. coli* concentrations. The baseline for model performance was the prior day 1-day geometric mean *E. coli* concentrations, referred to as the empirical model. The beaches generally fall into two categories in terms of performance. At some, MLR models are able to produce higher overall percentages of correct classification, specificity, and sensitivity compared to the current empirical model. For other beaches, models have difficulty

predicting elevated concentrations. This latter group is characterized by relatively good water quality with a relatively small percentage of days exceeding the water quality standard. This means that fewer examples of conditions during days with elevated E.coli concentrations are available for model development. As shown by the high percentages of true negatives, models at these beaches do well at predicting concentrations similar to those that dominate the model development data set, i.e., lower concentrations of 1-day GM E.coli. The second difference for these beaches is that there is no major apparent driver for microbial water quality such as the mouth of a river or stream. Despite this, models are still able to provide some improvement over use of antecedent E.coli concentrations. The assessment of model performance and comparison with prior studies indicates that regression models using readily available meteorological, hydrologic and water quality data can provide overall greater percentages of correct classification and higher adjusted R² values than an empirical model based on prior day E.coli concentrations. Consistent with the findings of others developing predictive models for beaches, no single set of parameters emerged as universal explanatory variables so extension of similar models to other beaches will require site specific data analysis. However, site characteristics of the beach can be helpful in determining potential explanatory variables. For example, models for beaches near a river or stream will likely incorporate streamflow and wind direction.

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Towards a 120 Hour Beach Health Forecast Model for the Great Lakes

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Nowcast models predicting *E. coli*, an indicator of fecal contamination requiring at least 18 hours incubation, reduce the time when people unintentionally swim in contaminated water as well as lost revenues from unnecessary restrictions of swimming. Contamination by bacteria, viruses and protozoa in recreational waters is a health risk. Timely accurate forecasts of water quality are critical to protect human health against adverse exposure situations. The Center of Excellence Great Lakes and Human Health is developing and testing a new decision support tool incorporating 120-hour forecasts. This tool uses independent parameters from the National Digital Forecast Database (NWS NDFD) and the GLERL-Great Lakes Coastal Forecasting System hydrodynamic models to estimate recreational water quality at beaches. Recent developments in operational Ocean Observing Systems in the Great Lakes allow the National Weather Service to model deterministic generated parameters on a 24/7 operational basis to be used as explanatory variables of *E. coli*. Over 60 variables have been used in models e.g. rainfall, wind direction and velocity, lake currents surface and bottom, interpolated air temperature, surface water temperature, cloud cover, dew point, cumulative rainfall, and time of sampling. Using USEPA's Virtual Beach, *E. coli* will be modeled at five test-bed beaches in 2010. Initial results show model capability to predict *E. coli* at R² factors in the range of 29 to 30% and an adj. R² factor between 27 to 35%. These results are comparable to regional nowcast models (adj. R² between 14-43%) but at the low end of models used to manage swimming based on beach measured parameters (adj. R² between 38-42%). Forecast test beds at several NWS weather forecast offices were run this summer. The goal of a 120-hour forecast model is to provide the beach managers with the expected risk of swimming in waters where elevated bacterial levels may occur.. This service is relevant because the beach manager needs to advise the swimming public and can potentially provide information about risk several days in advance.

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Validity of Composite Sampling for Enumerating *E. coli* from Recreational Waters by Culture-based and Molecular Methods

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The United States Environmental Protection Agency (US EPA) is in the process of developing new or revised recreational water quality criteria which is likely to include guidelines based on a molecular standard. Due to the 2012 deadline for promulgation of these standards, the need for validation studies becomes greater, especially those related to the implementation of rapid analytical methods for the detection and enumeration of fecal indicator bacteria in aqueous environments. In Racine, WI, composite sample analysis is routinely utilized for monitoring recreational waters employing a culture-based method for *E. coli* (IDEXX Colilert-18®/Quanti-Tray 2000®). The objective of the current study was to determine if composite sample analysis was still a valid procedure when the bacterial target was quantified by molecular methods (quantitative real-time polymerase chain reaction, QPCR). During the 2009 (9 events) and 2010 (11 events) bathing seasons individual (North Beach = 4; Zoo Beach = 3) and composite samples were analyzed using both culture-based (IDEXX) and molecular methods (Noble et al. 2009). The purpose was twofold: 1) determine whether or not the composite sample value would fall within the range of the three or four individual values and 2) whether or not similar regulatory decisions would be made based on a molecular standard (using the current 1986 US EPA Ambient Water Quality guidelines for fresh water). Analysis of variance (ANOVA) demonstrated no significant difference in mean *E. coli* concentrations across beach transects (North = 4, Zoo = 3) and across methods (culture-based method and QPCR) for 2009, 2010, and 2009/2010 pooled data ($p = 0.29 - 1.00$) indicating that compositing of samples could be appropriately applied at the study sites. Composite values fell within the range of three or four individual sample values 95% of the time using IDEXX and 80% of the time using QPCR as the analytical method. In every instance but one, when *E. coli* levels exceeded US EPA guidelines the composite value fell within the range of the beaches' individual sites and was equivalent to their arithmetic and geometric mean values. This data shows that compositing of samples could continue at these two freshwater beaches using QPCR. Composite sampling maintains laboratory supply costs while providing better characterization of water quality. Being able to conduct these analyses in near real time will enhance protection of public health through rapid notification.

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Development of Standard Curves for the Assessment of Enterococci as part of qPCR-based Water Quality Monitoring Program

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In Response to Congressional legislation, the U.S. EPA is currently evaluating methods for rapidly determining the densities of fecal indicator bacteria (FIB) in recreational waters. A review of epidemiological studies by the US EPA found that density estimates of two different FIB groups, total Enterococci and total *E. coli*, as determined by quantitative polymerase chain reaction (qPCR) have been associated with swimming related illnesses. The analysis of Enterococci by qPCR is, therefore, being considered for approval as part of the development of new/revised health-related recreational water quality criteria. Potential widespread implementation of qPCR may be hindered by uncertainty in the ability to reproduce test results within and between laboratories. The primary objective of the study was to determine the precision of raw data (cycle threshold measurements) and quantitative estimates of analytes (estimation of target organism cells) obtained from the qPCR method via the evaluation of standard curve preparations. A variety of calibrator source materials were assessed including: lab prepared fresh cells, lab prepared archived frozen cells (2007), referee prepared cell impregnated filters (UNC-Chapel Hill), and commercially prepared cells (Bioballs™, BTF 12697-550) for the purpose of determining reproducibility of standard curve results from year to year, variation of standard curve results between different technicians in the same lab, and variation of standard curves between different labs. All of calibrator source materials were analyzed qPCR using US EPA Method A: Enterococci in Water by TaqMan® Quantitative Polymerase Chain Reaction (qPCR) Assay (formerly Method 1606). ANOVA conducted on the R² value derived from standard curves prepared by three analysts within the same lab using fresh cells demonstrated no significant difference ($p = 0.510$). Standard curves produced by different labs using the same cellular material demonstrated a high degree of similarity ($\sigma = 2.47E-3$). Commercially prepared cells yielded similar results but had less variance than referee prepared cell impregnated filters (0.106 vs. 0.328). Frozen cells prepared in 2007, stored at -80 °C, and re-analyzed in 2010 deviated little from their original value (standard curve R² value of 0.9933 vs. 0.9980). The difference between using fresh cells (any) over frozen archived cells was insignificant ($p = 0.794$).

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Assessment of Water Quality Before and After Renovations at three Door County Public Beaches

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Throughout Door County, WI, a reoccurring public health concern is the presence of *Escherichia coli* in the beach water surrounding the peninsula. By sampling over 34 beaches four times per week over the course of six years, a good historical data set has been established for the county. One of the possible sources of harmful bacteria in the water comes from the feces of warm-blooded animals. A major component of the fecal contamination derives from the waste of gulls and geese. The county has used this information to determine problem areas, and renovated three beaches including Ellison Bay, Egg Harbor, and Sunset Park. These renovations planted dune grass and re-sculpted the land above the bathing area to discourage the avian population from roosting. The purpose of this study was to correlate the *E. coli* concentrations in beach water with the presence of aves

before and after the renovations. The implications of the beach renovations in terms of efficacy and cost will be discussed.

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Sanitary Survey Analysis at Sheboygan County Beaches

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Environmental factors have been used to determine, and predict fecal contamination in Lake Michigan. *Escherichia coli*, a gram-negative enteric bacterium, was used as an indicator for fecal contamination. Research has shown that a variety of beach and environmental factors, such as rainfall, current or algal accumulation can play a critical role in affecting fecal contamination along coastlines. Sanitary Surveys were conducted at Sheboygan County beaches to help establish sources of potential fecal contamination, and potentially to reconstruct beaches to decrease or eliminate those sources. In this study, baseline data was collected 3 days a week, alternating between determination of *E. coli* concentrations at various water depths and in sand. Water samples were collected at 12, 24, and 48 inches of water from the center, right, and left of each beach. Sand cores were taken from the up shore beach, swash zone, and submerged, at the same spatial distribution as depth samples. Correlations between *E. coli* concentrations and physical beach parameters will be discussed. Potential sources of fecal contamination will be identified, if possible, and suggestions made for remediation strategies.

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Application of glyphosate-based herbicide to *Phragmites australis* at a beach on southern Georgian Bay: impact on groundwater and near-shore lake water

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During the past decade, the invasive *Phragmites australis* (common reed) has established itself along beaches of the Great Lakes, causing detrimental impacts to both the natural ecological integrity of the shoreline and the recreational value of beaches. Public and environmental concern has prompted demands for action from municipalities and government agencies to eradicate *Phragmites* from beaches. The most effective method of eradicating *Phragmites* is through the application of the herbicide containing the active ingredient glyphosate. However, given the proximity of *Phragmites* to the shoreline, possible impacts on aquatic life, and public usage of beaches, application of a herbicide at a beach presents risks. The herbicide Roundup[®], containing the active ingredient glyphosate, was applied to *Phragmites* along a beach on the southern shore of Georgian Bay, Ontario, Canada, to eradicate *Phragmites*. Groundwater and lake water was tested to determine if glyphosate enters the groundwater and lake at the beach, if concentrations are above Canadian water quality guidelines for human

health (260000 ng/L) and protection of aquatic life (65000 ng/L), and how long glyphosate will persist. Glyphosate was detected in the groundwater below the Phragmites. Two days after application, the geometric mean concentration of glyphosate (5 analyses) was 600 ng/L with a maximum of 12500 ng/L. However, concentrations rapidly declined over the next two to three weeks to minimum detection limits (20 ng/L). Glyphosate was also detected in the nearshore lake water with concentrations peaking at a geometric mean 140 ng/L one week after application and declining to 39 ng/L 4 weeks after application. Concentrations of glyphosate never exceeded the Canadian water quality guidelines in either the groundwater and lake water. A linear trend of the log geometric concentrations of glyphosate vs. time declined linearly ($r^2=0.94$), producing a calculated half-life of 3.5! days for the dissipation rate (decline in glyphosate concentrations due to both degradation and by flushing as groundwater flows towards the lake) for glyphosate in the groundwater at the beach, yielding a half-life for the dissipation rate of glyphosate in the groundwater below this beach. The results of this study shows that: (1) when a glyphosate-based herbicide is applied to Phragmites at a beach, glyphosate will enter the groundwater below the beach; (2) because groundwater rapidly flows towards and discharges at the shoreline, glyphosate will enter the near-shore lake water, (3) concentrations of glyphosate in both the groundwater and near-shore lake water will be well below Canadian water quality guideline for both human drinking water and aquatic life; and (4) concentrations of glyphosate in the groundwater below the beach rapidly dissipates with a few weeks after the herbicide was applied.

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Web-Based Tools to Expand Access to Beach Water Quality Monitoring

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Presence of fecal indicator bacteria like *Escherichia coli* (*E. coli*) in beach water is a sign that the water may pose a health risk to bathers. Since measuring *E. coli* concentration takes a full day, using environmental surrogates (e.g. recent rainfall) to predict the *E. coli* concentration in beach water is one way to protect the public from water-borne pathogens. The predictions are generated by a statistical model that relates beach water quality to environmental surrogates. Creating and using such a model requires a record of historical data, a way to pass new observations to the model, and a way to report the model's output. Often, this has meant developing a standalone computer program to run at the command line, with the user entering the current value of each environmental surrogate. Typically the model's output must be compared to a decision threshold in order to decide whether the regulatory limit will be exceeded. Asking beach managers to collect, store, manage, and interpret data adds to the burden of using statistical models. Reducing this burden will likely accelerate the adoption of statistical modeling methods for assessing beach water quality. This project uses a centralized database to store observations from three Great Lakes beaches. Beach managers use a web form to interact with the database and the models it supports. Much of the surrogate information used to predict *E. coli* concentration at these beaches is publicly available meteorological data; software scripts are used to automatically collect that data each day. Manual observations are entered via the web form. Once the data is entered, the web form computes and presents the model's output. The web form can use several different models to make predictions (such as in the case that a new candidate model is being compared to an existing model) with no additional input from the user. The goal of beach water modeling is to decide whether the *E. coli* concentration is above or below the regulatory limit. The best threshold for interpreting the models output might be different from the regulatory limit - for instance if a false negative is considered worse than a false positive. Before it is reported, the output from the model is normalized to a scale where the decision threshold

is equal to the regulatory limit, and the probability of exceedance is computed. When the computed probability of exceedance is greater than 50%, the model result is considered an exceedance. Getting the benefits of statistical methods to predict *E. coli* concentration requires some work on the part of local beach managers. The extra burden is reduced by storing data on a centralized database with a web form for access and automated data collection. Normalizing the result greatly simplifies interpretation of the models output. These improvements should facilitate the wider and faster adoption of statistical methods to predict beach water quality.

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Removal of the indicator organism *Escherichia coli* from specific mixtures of sediment to evaluate their effectiveness

Escherichia coli, or *E. coli* has generally been found in recreational waters and its presence is used to indicate recent fecal contamination. *E. coli* presence may be caused from human waste, birds, mammals, fish, turtles etc and is harbored in sand and soil. Stormwater can lead to high amounts of runoff, which cause beach closures and potentially unsanitary conditions at popular swimming areas. Biofilters or infiltrations units are gaining popularity as a treatment option for stormwater around the Great Lakes basin to help keep recreational waters clean and safe. In this study, biofilters were created in the laboratory setting to observe four different sediment mixtures of Station 910, which was sediment from a specific location, a 40:40:20, 40:30:30 (compost: peat: sand) and a 50:50 (compost: peat) to analyze their efficiency of the removal of *E. coli*. Serial dilutions were performed to establish a known initial concentration of *E. coli*. The known concentration was then introduced to the sediment mixtures and the runoff was collected and analyzed for the removal of *E. coli*. Tap water was then introduced to the biofilter as stormwater and allowed to settle for a period of 4 weeks to simulate some areas that have stagnant water. The water was finally collected after four week at two dilutions and analyzed to distinguish the removal of the *E. coli* from the sediment over a period of time. We concluded that station 910 (specific to a certain location) was most effective in the removal of the initial concentration of *E. coli*. The overall objective of this study was to evaluate the performance of stormwater biofilters with specific sediment in removing the indicator organism *E. coli* in a laboratory system.

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Comparison of two methods for *E. coli* enumeration in recreational water

In recent years, the threat of potential fecal contaminated recreational water has become an increasing public health concern. With an increasing interest for public notification of current recreational water quality, public health departments are in need of more affordable methods for detecting fecal indicator organisms including *Escherichia coli* (*E. coli*). The current EPA approved method for detection of *E. coli* is the defined substrate method which requires expensive equipment for analysis. 3M™ Petrifilms™ is not currently approved for analysis of recreational water, but have been previously approved for microbial analysis in the food industry. These Petrifilms™ typically require expensive incubators for analysis that most local public health departments can't afford. The overall objectives of this project were to compare beach monitoring results for *E. coli* using a

traditional defined substrate test and the Petrifilm™ *E.coli* test system and to evaluate the effects of different incubation temperatures on the Petrifilm™ results. Beach monitoring was performed at 20 beaches located along Lake Michigan and Lake Superior. Results indicated that at 19 of our 20 beaches had log mean Petrifilm™ concentration for *E. coli* of 1-2 orders of magnitude higher than that of the EPA approved defined substrate method. This could be due to the lack of exclusivity of the Petrifilms™ or broad spectrum of inclusivity of microbes the test incorporates. In most cases this would make Petrifilms™ overprotective of public health by producing higher *E. coli* concentrations resulting in unnecessary advisories and closures at beaches when the approved methods would have *E. coli* counts below regulatory thresholds. The laboratory study regarding incubation temperatures resulted in requiring 3 days to become fully developed at 25°C and 30°C at both high and low concentrations. This could conclude that Petrifilms™ could be incubated at room temperature but for several days to obtain concurrent results with the Petrifilms™ incubated at 35°C for 24 hrs.

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Great Lakes Beach Visualization and Analysis Utilizing a Web-based Geographic Information System (GIS)

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Preference for poster session; will need internet connection and ability to set up a computer for the demonstration.

To enhance stewardship of Great Lakes beaches, new and innovative means of communicating and assessing complex beach water-quality data and trends are required. Geographic Information Systems (GIS) offer great potential for displaying data and trends across the entire Great Lakes Basin. Funded in part by the Ocean Research Priorities Plan (ORPP) and in part by the Great Lakes Restoration Initiative (GLRI), the U.S. Geological Survey has developed a Web-based tool for Great Lakes beach visualization and analysis. The tool was developed with the intent of 1) improving communication and sharing of available monitoring and scientific information; 2) developing analysis tools that can relate beach conditions to Great Lakes physical settings and conditions; and 3) identifying physical and biological processes that influence beach health. This tool enables users to assemble various types of geographic data, including land cover and aerial photography, for Great Lakes beach managers to evaluate potential relations between the geographic setting of the beach and beach conditions. The user can search for a specific beach or beaches using various search criteria, and can view, print and download beach-specific water-quality data from 2007-2009. Example layers presenting Great-Lakes-wide statistics also have been developed. Links to sources of information about individual beaches and to other sites of interest to beach managers and the public have been included in the tool. This live presentation will demonstrate some aspects of the Web-based GIS Great Lakes Beach Visualization and Analysis Tool, and will be a platform to solicit feedback from the Great Lakes Beach Association membership on desired additional data and functionality.

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Testing for staphylococci including Methicillin Resistant *Staphylococcus aureus* (MRSA) at Great Lakes beaches, June-August 2010

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Bacteria in the genus *Staphylococcus* are ubiquitous on the skin and in the nostrils of many animals, including humans, and select species may cause skin or blood infections. Most staphylococci infections are caused by *Staphylococcus aureus*. In recent years, methicillin-resistant *Staphylococcus aureus* (MRSA) have become of increasing concern due to the difficulty in treating infections caused by these antibiotic-resistant bacteria, and the increased frequency of their detection in both hospital and environmental settings. MRSA have been reported from marine beaches, but little is known about their occurrence in water from Great Lakes beaches. The current protocol for collecting staphylococci from beach waters are no different from those protocols used in collecting indicator bacteria. Standard procedures for beach water collection that involve physical contact with the water, such as the sampling procedure for fecal indicator bacteria at beaches, could compromise samples collected for *Staphylococcus* testing. To evaluate factors effecting the detection of *Staphylococcus* and MRSA at Great Lakes beaches, we tested approximately 350 samples, collected under varying environmental conditions, from 12 Great Lakes beaches for the presence of *Staphylococcus* bacteria, and for the *femA* gene (indicating *S. aureus*) and also presence of the gene responsible for methicillin resistance in staphylococci species (*mecA* gene). As part of the study, sampling protocols were tested and quality assurance samples were evaluated at a single beach to test the influence of samplers and swimmers on staphylococci numbers. We also conducted a detailed temporal survey at the same beach, evaluating changing environmental conditions and potential sources. This poster reports the outcome of the effectiveness of different sampling methods, the influence of swimmers, and the influence of other select environmental variables on staphylococci concentrations, and the presence of MRSA in Great Lakes beach water.

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Rapid Enumeration and Identification of *Clostridium perfringens* in the Beach Waters of Huron Erie Corridor

The anaerobic spore forming bacteria *Clostridium perfringens* was evaluated as a candidate marker for screening fecal contamination. This fecal bacterium has a fast doubling time of less than 10 minutes and does not multiply under aerobic conditions. We developed a new assay procedure, the Rapid Fung Double Tube method (RFDT) for enumerating *C. perfringens* in surface waters within 5-6 hours. Conventional membrane filtration (MF) methods used for enumerating *C. perfringens* in water samples are costly, and time-consuming. Moreover, the standard methods of using an anaerobic chamber/jar in combination with selective and enriched *C. perfringens* culture media is not practical for many laboratories and it takes at least 24 hours to obtain results. In contrast, the RFDT system allows the enumeration of *C. perfringens* colonies without the need for cumbersome and tedious filtration process, costly external anaerobic chambers, and takes only 5-6 hours to obtain easily enumerated data. In this study, we present, evaluate and apply this new methodology in the beach

waters of Huron Erie Corridor (HEC). We demonstrated that the RFDT system is a rapid, reliable, accurate, simple, and cost effective method to precisely enumerate *C. perfringens* in surface waters. The RFDT method had consistently greater recovery efficiency than the MF method. Concentrations of *C. perfringens* were enumerated from recreational beaches along the HEC using the newly developed RFDT technology and the traditional MF method. The results provided biological evidence of fecal contamination in the recreational waters along the HEC, and demonstrate the potential usefulness of *C. perfringens* as tracer for fecal contamination. From this study, it can be concluded that the RFDT method is a rapid and robust method to enumerate *C. perfringens* in beach waters when compared to the traditional MF method, therefore beach closure and opening decisions can be made on the same day of sample collection and assessment.

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Thermotolerant *Campylobacter* species at Two Lake Ontario Beaches

In 2006, a preliminary investigation was initiated on the prevalence of thermotolerant *Campylobacter* species at two freshwater Lake Ontario beaches Pier4 and Bayfront located in Hamilton Harbour. The preliminary results showed that three important species of *Campylobacter* species associated with human gastrointestinal infection including *C. jejuni*, *C. coli* and *C. lari* were frequently found. Based on those results, a three-year comprehensive study was carried out, and this presentation will provide results on the prevalence of thermotolerant *Campylobacter* species at those two beaches. Bi-weekly water sampling was carried out along a single transect from three different depth zones (sand pore water, ankle depth water and chest depth water) at Pier4 and Bayfront beaches as well as offshore from the middle of the harbour. In order to investigate and understand the sources of contamination, samples were also collected from potential point and non-point fecal pollution sources nearby including a combined sewer overflow (CSO) tank at Bayfront Park, final effluents from four different municipal wastewater treatment plants surrounding the Hamilton Harbour, offshore surface water at a wastewater treatment plant outfall in the harbour as well as fresh fecal droppings of ring-billed gulls, Canada geese and other bird species. All water samples were processed for *Campylobacter* isolation and detection using a minimum probable number (MPN) culture enrichment protocol. The putative culture isolates were further confirmed by DNA-based genus- and species-specific multiplex PCR assays. A total of 288 sand pore and water samples were collected from both beaches, and thermotolerant *Campylobacter* species were detected at the rate of 56% (n= 144) and 42% (n= 144) of water samples from Bayfront and Pier4 beaches, respectively. Whereas, of total 479 samples collected from potential point and non-point fecal pollution sources, thermotolerant *Campylobacter* species were also detected more commonly in bird fecal droppings 39% (n= 165) than CSO 33% (n= 45), final inshore and offshore outfall effluent 15% (n= 224), and mid harbour 15% (n= 45) samples. The present study is contributing towards identifying possible sources of contamination at these beaches and understanding the potential health risks to humans.

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New approach for understanding integrative health risks from recreation water using multiple genetic markers targeting fecal bacteria and virus

Current beach monitoring criteria do not protect the public efficiently from exposure to waterborne disease-causing microbes. Present culture methods for detecting fecal indicators take at least 24 hours. During this period, the water quality may worsen significantly placing recreational water users at risk or may improve, thus closing the beach unnecessarily. The current fecal indicators do not represent comprehensive recreation illnesses since they were developed based on epidemiological evidence that considered only gastroenteritis. As molecular techniques have advanced and significant findings about health effects and fecal indicators accumulate, an urgent research need has emerged for direct pathogen measurements, identification of more specific fecal indicators for diseases, and reliable rapid method. The objectives of this study were to investigate the significance of *Bacteroides* as a new fecal indicator, norovirus as a water pathogen, and to explore an innovative approach to understand the integrative health risks associated with contact recreation using a risk-based analysis. The prevalence of antibiotic resistance among beach water samples was also investigated as an additional risk factor. Another objective was to understand the association between the density of *Bacteroides*, *E. coli*, enterococci, and norovirus with physical and chemical water quality, water quality determinant and human health survey data. Water samples were collected twice per week from three inland Ohio beaches during the summer of 2009 (East Fork Lake, Delaware Lake, Madison Lake). Water quality parameters and *E. coli* were measured on the sampling day and the samples were archived for genetic analyses. We developed a rapid real-time PCR method for detecting human-specific *Bacteroides* and optimized a procedure for detecting norovirus in beach water. The newly developed *B. fragilis*-specific method showed outstanding specificity for human-origin contamination in water and lack of cross-reactivity with animal fecal sources (e.g. cow, pig, dog) compared to previous 16S rRNA-based methods (qHS601F/qBac725R, g-Bfra-F/g-Bfra-R). Six genetic markers that are related to fecal contamination were used for the detection of *Bacteroides* (*gyrB*, two 16S rRNA), enterococci (16S rRNA, *esp*) and antibiotic resistance (*tetQ*) with real-time PCR. *Bacteroides* levels measured by qHS601F/qBac725R, g-Bfra-F/g-Bfra-R, and *gyrB*-based primers were 10-414, 0-1050, 0-230 CFU/100ml, respectively. Enterococci levels measured by 16S rRNA based primers were 13-453 CFU/100ml, but the *esp* gene method did not generate any positive results. *E. coli* levels measured by EPA Method 1603 were 0-1538 (East Fork Lake), 1-1045 (Delaware lake) and 5-460 CFU/100ml (Madison Lake). Antibiotic resistance markers were detected in 58.3 (East Fork), 50 (Delaware Lake), and 47.6 % (Madison Lake) of the beach samples. The novovirus levels are being determined using RT real-time PCR. The integrative risk factors based upon the multiple fecal indicators, norovirus, antibiotic resistance, and health survey data are being analyzed and a risk model is being developed. The outcome of this study would be beneficial for the upcoming change in US EPA's recreational water quality criteria scheduled in 2012.