NOAA Beach Water Quality Experimental Forecasts

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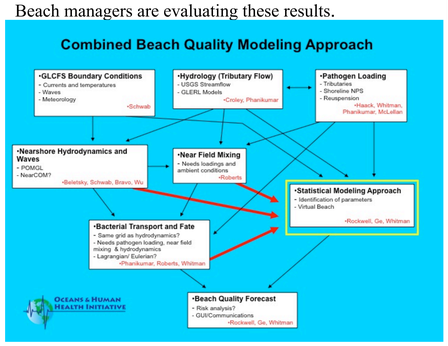
Abstract

Timely accurate forecasts of beach water quality is critical to protect human health against adverse exposure situations. The Center of Excellence for Great Lakes and Human Health, Great Lakes Environmental Research Laboratory, the National Weather Service, Detroit Pontiac Office, and the Cooperative Institute for Limnology and Ecosystems Research, University of Michigan are developing and testing beach management forecast decision support systems (FDSS) at five beaches in Michigan. The NOAA Beach Water Quality Experimental Forecasts are possible because Bay, Macomb, and Ottawa County Health Departments have provided their *E. coli* monitoring data. Recent developments in operational Ocean Observing Systems in the Great Lakes allow the National Weather Service to use model generated parameters as independent explanatory variables of *E. coli*. These variables include rainfall, wind direction, velocity and gusts, lake currents, air temperature, surface water temperature, cloud cover, and time of sampling. *E. coli* has been modeled at Bay City State Rec. Area, Bay Co. MI, Metro and Memorial Beaches, Macomb Co. MI, and North Beach Park and Grand Haven State Park, Ottawa Co. MI. These beach FDSS were tested during the 2012 swimming season between Memorial and Labor Day. The strength of the beach water quality forecasts was the ability to accurately forecast keeping swimming available when bacterial counts were low. The accuracy ranged from 83 to 100 percent (average = 93.4 +/- 6.6%) when compared with the County Health Departments *E. coli* monitoring. The FDSS was 98% accurate for Memorial Beach in keeping swimming available when bacterial concentrations were lower than 300 counts/100 ml. FDSS weakness was its inability to forecast the 2012 swimming season monitored high beach bacterial episodes. Although FDSS had fewer errors than present beach management model, this minimal skill level in forecasting high bacterial concentrations requires improvement before NWS can make FDSS available for widespread use. Beach managers are evaluating these results.



Objectives:

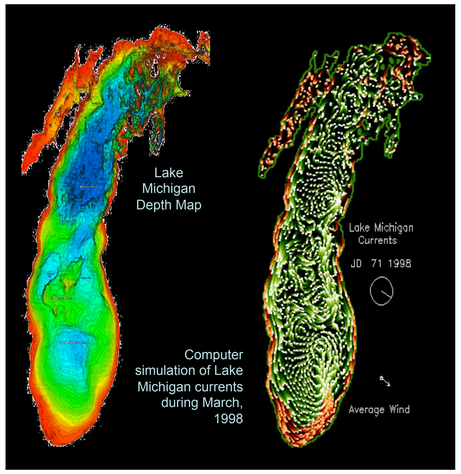
1. *Develop a modeling system based upon a fully 3D hydrodynamic model (GLCFS) for forecasting currents, wave heights, water temperature, and winds, and NWS (NDFD) for forecasting cloud cover, rainfall, and air temperature to explain the variation of* E. coli *measured at a beach impacted by a river plume (ultimately pathogens).*

2. *Link Great Lake Basin wide river discharge and bacterial concentration forecast model to nearshore hydrodynamics and waves.*

3. *Couple with NWS forecast offices and provide beach forecast information to beach managers allowing precautionary responses during weather episodes of elevated* E. coli *level predictions.*

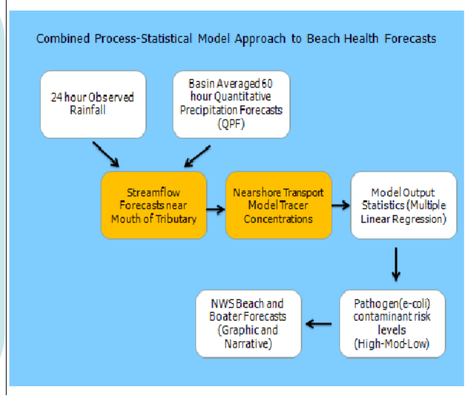
Lake Circulation

In contrast to the relatively stable circulation gyres of the oceans, lake currents lack persistence and depend more on short-term atmospheric forcing because of the relatively small size of lake basins. Wind-driven transport is the dominant feature of circulation in the lakes. In addition to the spatial and temporal variability of the wind forcing, the earth's rotation, basin topography, and vertical density structure are all important influences in the dynamical response of the lake. Storm-induced currents in the Great Lakes can be quite strong (up to several tens of cm/s), but the average currents are rather weak throughout most of the year (on the order of a few cm/s). Nevertheless, this average, or mean, circulation is important for many ecological and management issues because along with diffusion it strongly influences the transport pathways of nutrients and contaminants on large time scales.



Water Quality

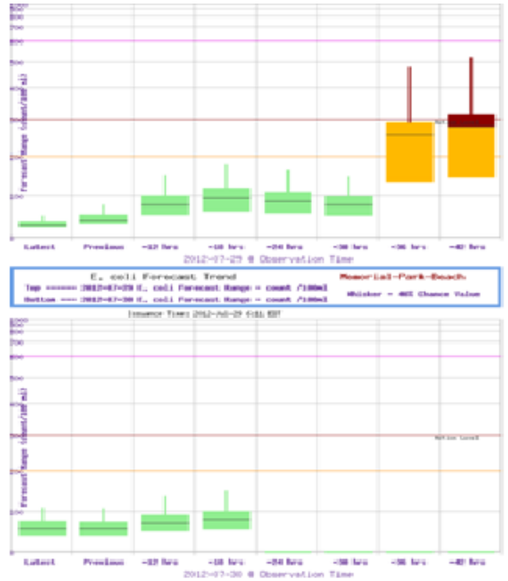
A variety of contaminants can adversely impact water (e.g. bacteria, viruses, and protozoa). Microbial contaminants, such as viruses and bacteria, may come from sewage treatment plants, septic systems, agricultural livestock operations, and widlife. The assurance of safe drinking water in the U.S. continues to be a challenge as a result of emerging and newly recognized contaminants, more sensitive and specific detection methods, better investigations, and more public awareness. The Center will predict transport of pathogens through water using ecosystem modeling, aiding in the location of hazard areas and non-point sources of contaminants.



Communication Plan for Distribution of Forecasts

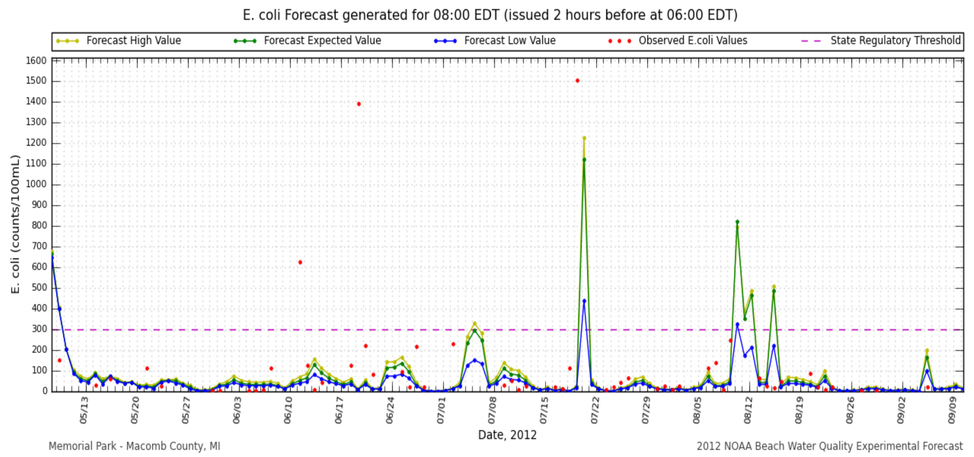
The National Weather Service Forecast Office in White Lake, Michigan (WFO DTX), will execute the beach forecast regression models for five Michigan Beaches in Bay, Macomb and Ottawa Counties 4 times per day through the beach and boating season (generally Memorial Day to Labor Day). Forecasts generated at midnight and 6 am EDT on a given day will be valid for morning observation times that day and the following day. Forecasts generated at noon and 6 pm EDT on a given day will be valid for morning observation times the following two days. Forecast output will include a most likely value, a range of expected values, and the likelihood that E. coli counts will exceed 300 parts per ml and 600 parts per ml respectively. These forecasts will be available to beach managers via the National Weather Service dissemination infrastructure, and specifically via specified URLs through the National Weather Service Information Dissemination System (NIDS).

The NWS color codes for the forecast websites are presented in four levels depending on the likelihood of exceeding the *E. coli* threshold values of 300 counts/100ml and 600 counts/100ml (Minimal, Moderate, High, and Very High). These likelihood probabilities are calculated using the high *E. coli* value forecast for each time period. The expected value and low value complete the box plot.



Beach Closure Forecasting

The *E. coli* concentrations generated by the NWS using the FDSS for Memorial Beach are shown in the following figure for the 2012 swimming season. The red dots are the *E. coli* values measured by the Macomb County Health Department. *E. coli* values above the 300 counts/100ml dashed red line exceed Michigan's single sample maximum standard. Forecast values above the red line occur 7 times, but only once was a monitoring value available to compare with the forecast. This forecast was a false positive. The forecast did not correctly predict the three elevated bacterial concentrations measured. The forecast correctly predicted 98 percent of the samples below 300 counts/100ml and none of the samples above. Overall accuracy was 93%.



Results and Conclusions

A strategy has been developed for a generalized process for beach quality forecasting and product delivery was tested at five Great Lake Beaches in Michigan. The process has identified (1) appropriate currently-available parameters to use as independent variables, (2) how to obtain these parameters, (3) created equations usable by the National Weather Service to forecast *E. coli* concentrations and probabilities of exceeding Michigan's *E. coli* single sample maximum standard, and (4) NWS communication links to County Health Department Beach managers providing beach water quality forecasts.

The modeling approach depends on linking a high-resolution near shore hydrodynamic model with operational forecasts of whole-lake circulation (GLERL's-Great Lakes Coastal Forecasting System) and the NWS (National Digital Forecast Database) and a rain fall and bacterial concentration run off model for the entire Great Lakes basin.

NOAA-GLERL is testing the rainfall and bacterial concentration run off model for the Clinton River, Lake St. Clair and two Macomb County Beaches in 2012. Application of the FDSS have only just begun, but initial work is encouraging. The main conclusions and questions are:

1. We can develop FDSS for a wide variety of contaminate impacted beaches.
2. FDSS works best for beaches with greater than 5% of the samples exceeding the State single sample maximum standard.
3. Can we successfully forecast high *E. coli* risk levels at beaches with local point sources that are not affected by general hydrodynamic and meteorological conditions?

Federal Collaboration on Beach Health in the Great Lakes

Remediation, Decision Support, & Environmental Research

BEACH HEALTH INTERAGENCY COORDINATION TEAM

Beach Water Quality Forecasting Coordinator

Operational Forecasting & Research

USGS science for a changing world

Monitoring & Modeling Research

The Beach Health Interagency Coordination Team (BHICT) was created in January 2009 to develop coordinated responses to Great Lake Beach Health emerging issues. The resources provided by the Great Lakes Restoration Initiative are being utilized more effectively and efficiently because BHICT understands the research programmatic goals of USGS, USEPA, and NOAA. This allows sharing tasks and Agency research capabilities, identifying geographical work areas where combined research can be done.