Advancing the use of predictive models for estimating recreational water quality at beaches

April 30, 2014

Donna Francy and Amie Brady
USGS Ohio Water Science Center
Columbus, Ohio
Recreational water-quality advisories

Based on *E. coli* or enterococci state standards

1. Culture methods that take 18–24 hours

2. Real-time tools included in new recreational water quality criteria (EPA, 2012)
   - Quantitative polymerase chain reaction (qPCR)
   - Predictive models

EPA 820-F-12-058
Predictive models

- Use to supplement monitoring using culture-based methods (USEPA, 2012)
  - Rainfall-based notifications
  - Decision trees
  - Deterministic models
  - Statistical regression models
- Site specific
- Tools are available
- Relatively inexpensive
Nowcasts

• Systems that inform the public of beach closures or advisories based on predictive models.
• Use environmental and water quality variables
• Estimate conditions in real-time
  – Predicted concentration
  – Probability that standard will be exceeded
Results from a study of 49 Great Lakes beaches

Developing and Implementing Predictive Models for Estimating Recreational Water Quality at Great Lakes Beaches

Donna Francy, Amie Brady, Rebecca Carvin, Steve Corsi, Lori Fuller, John Harrison, Brett Hayhurst, Jeremiah Lant, Meredith Nevers, Paul Terrio, Tammy Zimmerman

http://pubs.usgs.gov/sir/2013/5166/
Study Objectives, 2010–12

• Expand operational nowcasts
• Improve existing nowcasts
• Install or maintain equipment for collecting data on model variables
• Provide tools for compiling data and developing predictive models

Weather station (Headlands State Park, Ohio) and buoy (Calumet Beach, Chicago)
Study sites

EXPLANATION
Beach sampling site
- Nowcast operational in 2010
- Nowcast in development

Base modified from U.S. Geological Survey
1:2,000,000 scale digital data.
Great Lakes Basin Albers Equal Area Projection
Methods

• Data collected by local agencies
  – Field measurements and observations
  – *E. coli* concentrations

• Site-specific data from nearshore buoys, weather stations, rain gages, staff gages, other sensors

• Data compiled from existing sources

• Operational nowcasts run 4–7 days/wk
Tools for compiling data

- EnDDat processes data from multiple sources
- PROCESSNOAA compiles rainfall, wind, and barometric pressure data from the nearest National Weather service airport location
- LAKE LEVEL compiles lake level data from NOAA

http://pubs.usgs.gov/sir/2013/5166
Virtual Beach

- Free software developed by USEPA
- Exploratory data analysis, model development, and model validation
Results for 49 Great Lakes beaches 2010–12 (some earlier years)
Model variables
43 Great Lakes beaches

- Field variables were used in 95% of models
  - Turbidity (79%), day (37%), and wave height (33%)
  - Water Temp, bird count, algae category, conductivity <10%

- Data compiled from other sources
  - NOAA and Great Lakes Forecasting System (60%)
  - National Weather Service airport weather data (44%)
  - USGS gage or buoy measurements (33%)
  - Local sources of rain, winds, temperature, etc. (33%)
Model results

• Developed 43 models with data collected during 2010–11
• Validated 42 models with data collected during 2012
• Evaluated abilities of models to predict exceedance of the bathing-water standard
  – Overall correct percent
  – Specificity
  – Sensitivity
Validation of 42 beach models, 2012

Overall percent correct: 80% goal

Illinois (n = 8)
Michigan (n = 2)
New York (n = 5)
Ohio (n = 10)
Pennsylvania (n = 6)
Wisconsin (n = 11)
Validation of 42 beach models, 2012

Specificity, correctly predict non-exceedances
85% goal
Validation of 42 beach models, 2012

Sensitivity, correctly predict exceedances 50% goal
Edgewater, Lakefront Reservation, Cleveland, Ohio

2 models

- **qPCR**
  qPCR for *E. coli*

- **Backup (no qPCR)**
  Turbidity, wave height, pH, day of the year, and rainfall

Sampling, model development, and daily operation of the Ohio Nowcast.
Maumee Bay State Park, Oregon, Ohio

2 models

- **Positive discharge**
  Turbidity, wind direction code

- **Negative discharge**
  Turbidity, discharge, solar radiation, lake level, wind

Sampling, model development, and operation of the Ohio Nowcast
2014

8 Lake Erie beaches

1 river site

1 inland lake beach
New York NowCast 2014

- Seven NY beaches
- Map interface reveals advisories
- Public Site access through QR Codes when visiting beach and seeing advisory sign
- NowCast predictions and historical data access
- Google map directions interface

Slide from Brett Hayhurst, USGS
Conclusions and future work

- Models can do better than the previous day’s *E. coli* at most beaches

- Models met goals
  - Many years of data
  - Moderately contaminated beaches
  - Understanding of the factors affecting *E. coli*

- Models must be continuously tested and refined
Conclusions and future work

With reduced budgets.....

• Tiered approach
  – Reduce sampling to 2–3 days/week
  – Collect data with a wide range of environmental conditions
  – Standard model with field-measured data
  – Automated model for non-sampled days
Conclusions and future work

• Operational nowcasts
  – Illinois, 8 beaches
  – Ohio, 10 sites
  – New York, 7 beaches
  – Pennsylvania, 6 beaches
  – Wisconsin, 10 beaches
  – Others?

• Expand beyond the Great Lakes and at inland beaches
Acknowledgements

Funding sources
• Great Lakes Restoration Initiative
• USGS Oceans Research Priorities Plan
• US EPA BEACH Act

Collaborations
• US EPA National Exposure Research Laboratory
• Many cooperating agencies and universities
THANK YOU!