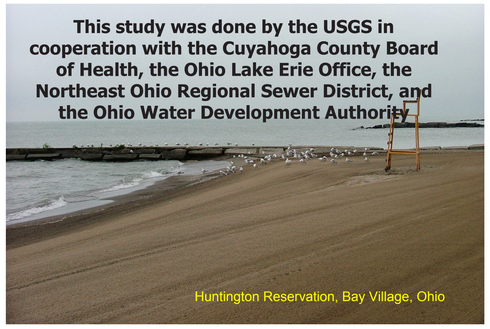
Nowcasting Bacteria Levels and Beach Advisories at Lake Erie Beaches

Donna S. Francy[1], Robert A. Darner[1], Erin E. Bertke[1], and Jill Lis[2]

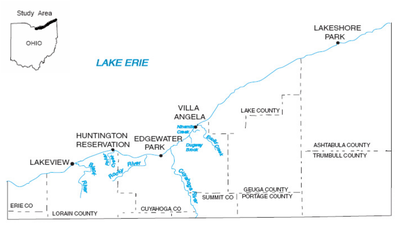
[1]U.S. Geological Survey (USGS) Ohio Water Science Center, Columbus, OH
[2]Cuyahoga County Board of Health, Parma, OH



Swim advisories issued by beach managers in Ohio are based on concentrations of the indicator bacterium *Escherichia coli* (*E. coli*). Because concentrations may change between the time of sampling and the reporting of results (18–24 hours), advisories issued on the previous day's *E. coli* may cause unwarranted loss of recreational access or may permit swimming when there is an unknown, unacceptable level of risk. Predictive models have been recognized as alternative tools to provide real-time assessments of recreational water quality.

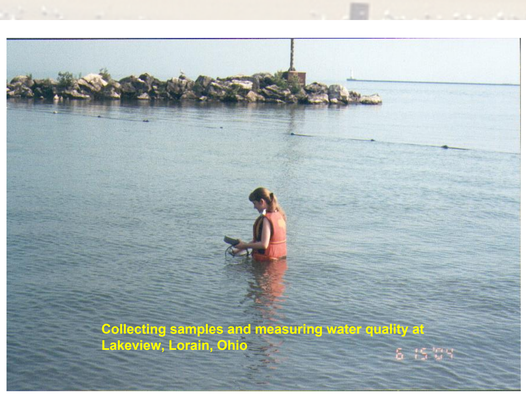
Work is being done to develop and test models to predict *E. coli* concentrations at five Ohio Lake Erie beaches. For Huntington, where investigations are further along than at the other beaches, predictions based on a model have been available to the public through an Internet-based "nowcasting" system since May 30, 2006. The other beach models are being validated for the first time in 2006 and will be added to the nowcasting web site in the future.

Models for predicting *E. coli* concentrations are being developed for five Lake Erie beaches.



Daily data on *E. coli* concentrations and environmental and water-quality variables were collected by local agencies to develop and test predictive models.

Samples were collected at 2- to 3-ft depths in the swimming area on weekdays between 8 a.m. and noon. Samples were collected at two or three locations at each beach, and resulting concentrations were averaged for analysis. Samples were analyzed for *E. coli* by means of the mTEC or modified mTEC membrane-filtration methods. Associated environmental and water-quality data (water temperature, rainfall, wave height, etc.) were collected by field crews or compiled from a variety of sources.



E. coli concentrations at Lake Erie beaches, 2004–2005
[CFU/100 mL, colony-forming units per 100 milliliters]

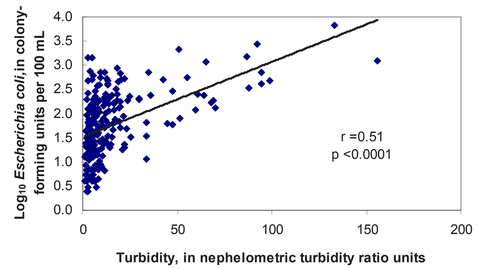
Beach	Number of samples	*E. coli* concentration (CFU/100 mL)			Number (%) of days exceeding 235
		Median[b]	Min	Max	
Edgewater	192	55	2	1,900	24 (12.5)
Villa Angela	188	70	1	6,900	51 (28.3)
Lakeshore	89	210	9	14,000	39 (43.8)
Lakeview	95	300	11	4,200	57 (60.0)
Huntington[a]	319	46	1	6,600	54 (16.9)

[a]Data were collected in 2000–2005.

The relations between *E. coli* concentrations and possible model variables were examined.

Models are based on the relations between explanatory variables and *E. coli*. Statistical tests were done and plots were constructed to determine the strength of associations between *E. coli* and explanatory variables.

Huntington 2000-2004: Relation between *E. coli* and turbidity.



The best model for each beach was based on a unique combination of explanatory variables.

Beach-specific models were developed using a statistical technique called multiple-linear regression. The output from the models is the probability of exceeding the single-sample maximum bathing-water standard of 235 CFU/100 mL. A threshold probability associated with too great a chance of exceeding the bathing-water standard was determined for each beach by maximizing the number of correct responses while minimizing the number of false negative responses. Water quality advisories are issued when the model predicts a probability equal to or greater than the threshold probability.

Lake Erie beach models

Beach	Time period for model development	R^2 of model[a]	Variables in model	Threshold probability
Edgewater	2004–2005	0.40	Turbidity Wave height Rainfall 72 hr, weighted Lake level	29
Villa Angela	2004–2005	0.38	Turbidity Wave height Rainfall 24 hr Water temperature	31
Lakeshore	2004–2005	0.35	Turbidity Water temperature Rainfall 72 hr, weighted	32
Lakeview	2004–2005	0.44	Turbidity Wind direction Day of the year	38
Huntington	2000–2005	0.42	Turbidity Wave height Day of the year Rainfall 48 hr, weighted	27

[a]R_a is the fraction of the variation in *Escherichia coli* concentration explained by the model.

The Huntington 2000-2005 model was validated in 2006 and compared to using the current method.

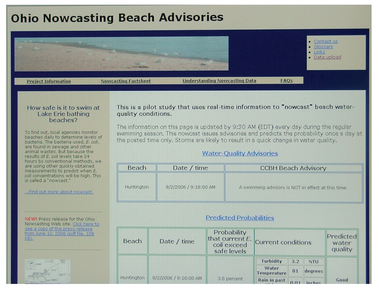
For 2006, the Huntington model yielded more correct responses and fewer false positive and false negative responses than did the current method for assessing recreational water quality (previous day's *E. coli* concentration).

Results in 2006

Predictive tool	Sample size	Percentage of responses		
		Correct	False positive (number)	False negative (number)
Hunt 2000-05 Model	85	80	10 (6/59)	42 (11/26)
Previous day's *E. coli* (all days)	84	57	30 (18/59)	72 (18/25)
Previous day's *E. coli* (M–R)	51	55	28 (9/32)	74 (14/19)

Predictions based on a model are available to the public through an Internet-based "nowcasting" system for Huntington.

www.ohionowcast.info



Conclusions and next steps

- Statistical techniques can be used to generate beach-specific models for Lake Erie beaches using a combination of three or more explanatory variables.
- A model for Huntington based on rainfall, wave height, day of the year, and turbidity performed better than using yesterday's *E. coli* during 2006.
- Models will be validated and refined in 2007.
- As the models are validated, steps may be taken to further refine and improve them. Possible improvements include obtaining more accurate measurements of wave heights, measuring continuous turbidity, obtaining data from local rain gages, and incorporating rapid analytical methods for *E. coli* into the models.