Improving Beach Water Monitoring to Protect Human Health

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NEEDS

- Beach managers need timely, accurate assessments of water quality to protect human health
- Sources of *E. coli* need to be identified to focus remediation efforts
- Health risk of exposure to recreational water needs to be assessed so that monitoring and management can be directed toward minimizing human illnesses and maximizing beach access

BACKGROUND

- Beach monitoring is based on concentrations of fecal indicator bacteria, which signals recent sewage contamination *(E. coli* in fresh water)
- *E. coli* analysis takes 24 hours, during which time concentrations can change significantly, leading to erroneous beach management decisions
- Natural sources of *E. coli* in sand, soil, and algae have been identified and may contribute to presumed water quality contamination

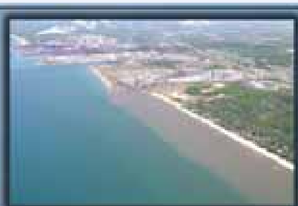
PREDICTIVE MODELS & RAPID TESTS FOR WATER QUALITY

- Using measurements of water quality and weather conditions, we develop empirical predictive models for *E. coli* concentrations at a given beach. This provides beach managers with a real-time, reliable estimate of water quality

- Predictive models have been developed, refined, and implemented at beaches throughout the Great Lakes, and recent activities include the incorporation of mechanistic models, expanding the range of predictions, and directly predicting health risk

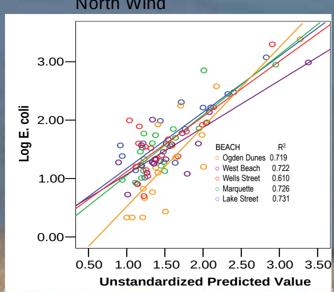
WEST BEACH & BURNS DITCH MODEL

- A real-time model to determine *E. coli* counts simultaneously at five beaches west of Burns Ditch
- Varying results using the models for individual beaches

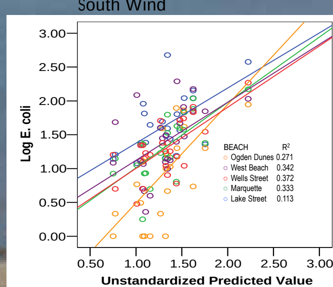


- A dynamic model developed by NOAA GLERL confirms the significant effect Burns Ditch has on the five beaches to the west.

North Wind



South Wind

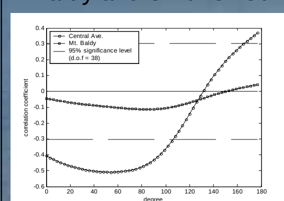


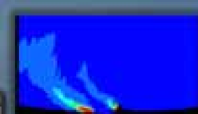
North wind
Log *E. coli* = 0.441+0.652(waveheight)+0.003(BDturbidity)+0.010(lake_chlorophyll)+ 0.011(lake_turbidity)+e
South wind
Log *E. coli* = 1.575+ 0.765(waveheight)+0.131(waveperiod)+ 2.944(precip_4hour)+e
All Winds
Log *E. coli* = 1.124+0.789(waveheight)+0.003(BDturbidity)+ 0.004(lake_chlorophyll)+0.013(lake_turbidity)+0.114(waveperiod)+ 3.220(precip_4hr)+e

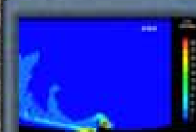
Nevers, M. B., and R. L. Whitman. 2005. Nowcast modeling of *Escherichia coli* concentrations at multiple urban beaches of southern Lake Michigan. Water Research 39:5250-5260.

MT. BALDY & CENTRAL AVE MODEL

- Nowcasting at two Indiana beaches impacted by Trail Creek and Kintzele Ditch
- Model used wave height, wind direction, and Kintzele Ditch conditions to predict *E. coli* concentrations at the beaches
- Models could explain variation in *E. coli* : 72% for Mount Baldy and 51% for Central Avenue







- High correlation between current speed and *E. coli* at Central Avenue implicates Kintzele Ditch as a significant source of *E. coli* to the beach, especially during sudden current shifts

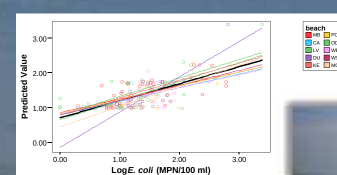
Nevers, M. B., R. L. Whitman, W. A. Frick, and Z. Ge. 2007. Interaction and influence of two creeks on *E. coli* concentrations of nearby beaches: Exploration of predictability and mechanisms. Journal of Environmental Quality 36:1338-1345.

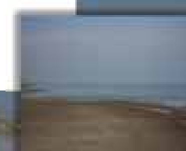
INDIANA REGIONAL MODEL

- Model explains 48% of the variation in *E. coli* using two variables: wave height and creek turbidity*wind direction

	R_o	Adj. R^2_i	**Avgturb*wdir**	**Wave height**	Rain	KDgauge	BDgauge	Turb	KDturb	BDturb	Lec_mn1
MB	0.575	0.475		**0.397**		0.430	0.207				
CA	0.660	0.565	**0.289**	**0.326**	0.291					-0.199	
LV	0.662	0.411	**0.360**	**0.275**							
DU	0.688	0.482	**0.647**		0.220						
KE	0.630	0.455	**0.342**	**0.223**	0.310						
PO	0.715	0.579	**0.553**		0.221	0.149	0.220				
OD	0.633	0.388	**0.411**	**0.203**							
WB	0.596	0.366		**0.316**				0.195	0.263		
WS	0.669	0.546	**0.264**	**0.317**				0.265			-0.175
MQ	0.576	0.516	**0.182**			0.314	0.220	0.206			

- *E. coli* fluctuate simultaneously along the entire coast, indicating a persistent, background source independent of localized sources
- Creek outfalls have strong influence on nearby beaches





Nevers, M.B. and R.L. Whitman. 2008. Coastal strategies to predict *Escherichia coli* concentrations for beaches along a 35 km stretch of southern Lake Michigan. Environmental Science & Technology 42:4454-4460.

ASSESSING AND MINIMIZING HUMAN HEALTH RISK

- Use of predictive models immediately improves management for human health by providing estimates of water quality in real time.
- Current efforts are focusing on improving assessments of human health risk by considering estimates of human exposure, pathogen concentration, and source of bacteria contamination.

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