

SwimCast: Predicting E. coli Concentrations at Two Beaches in Lake County, IL



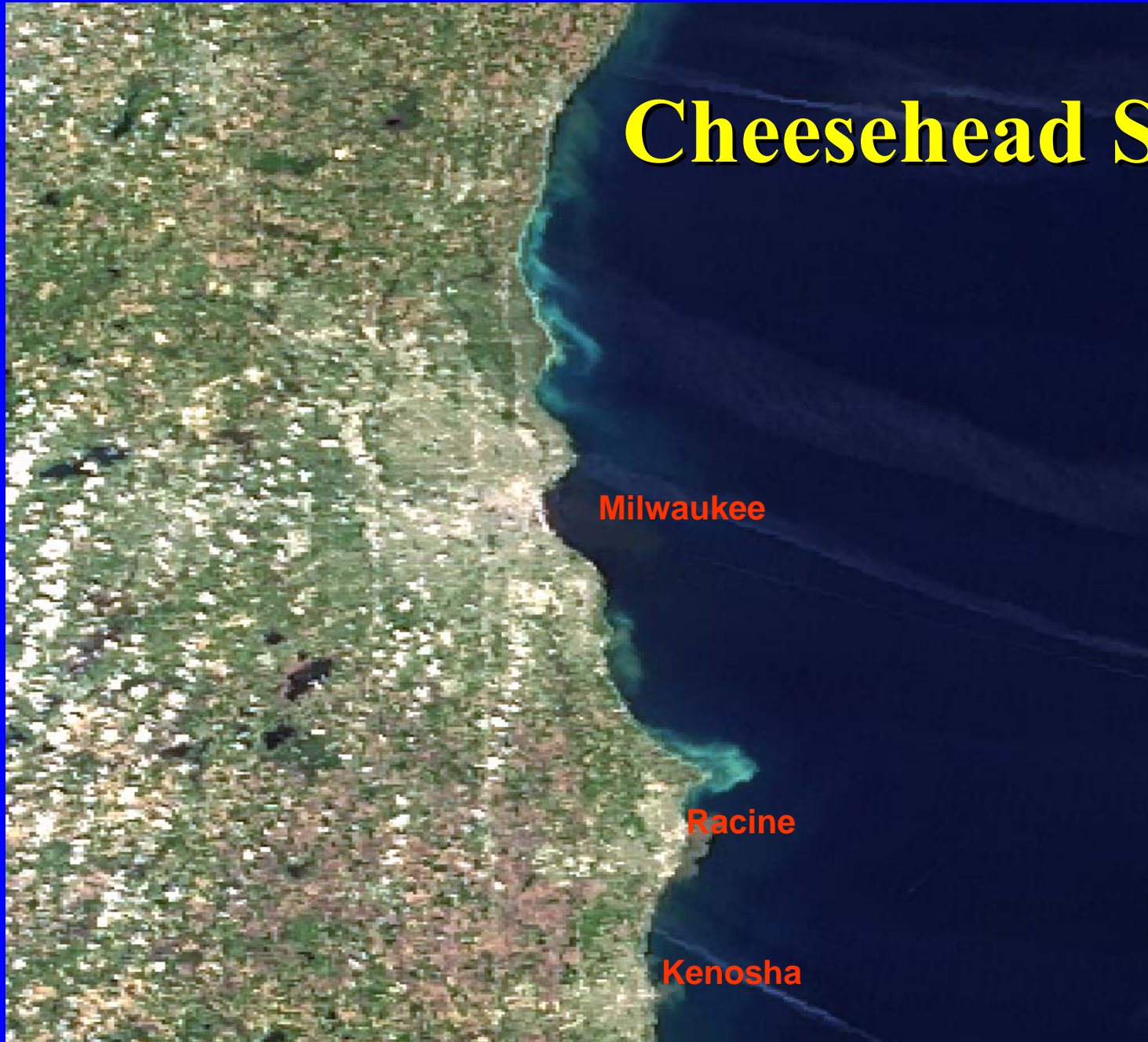
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Cheesehead Sewage?



Milwaukee

Racine

Kenosha

MODIS
Imagery

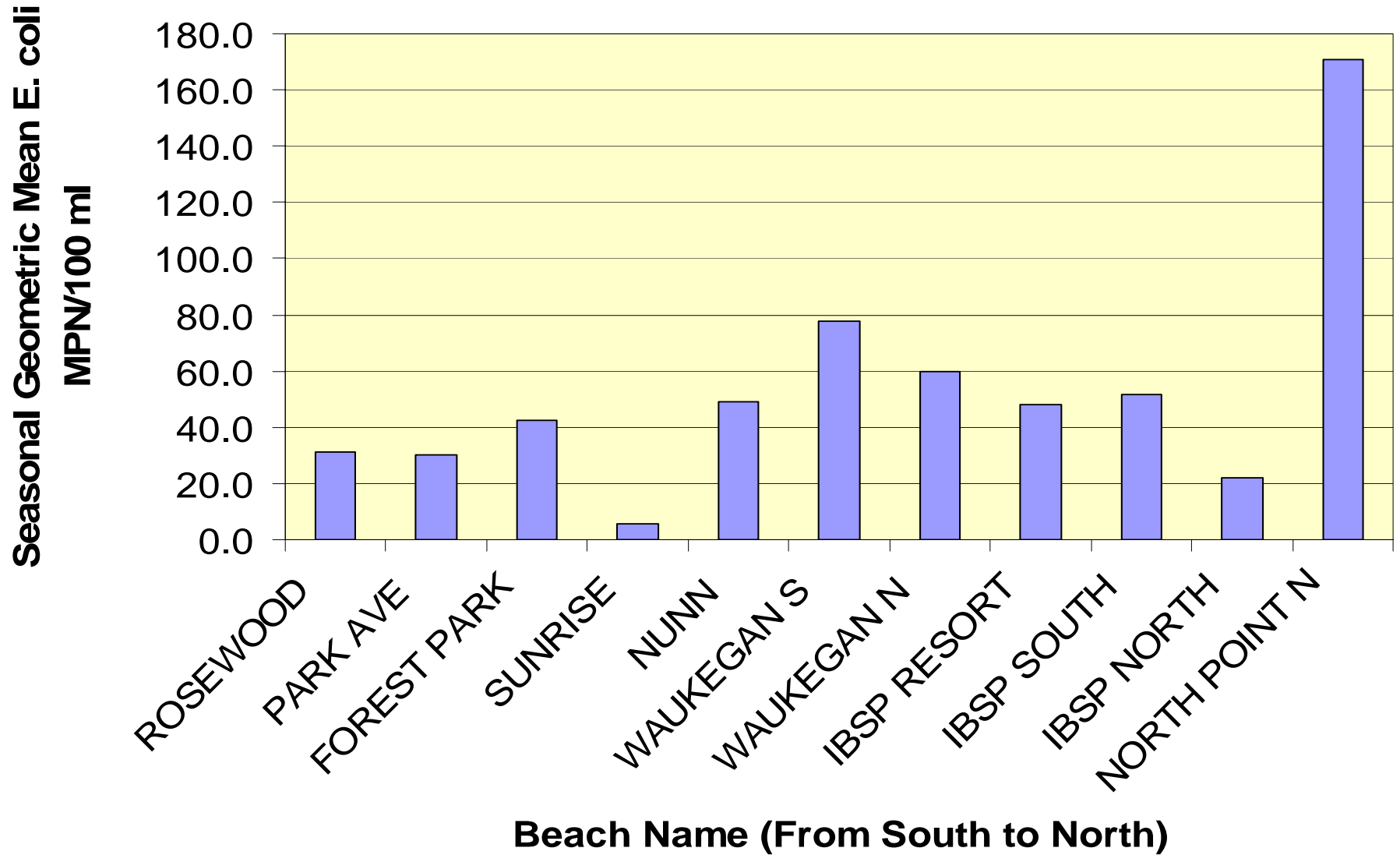
May 16, 2004

11:33 am CDT

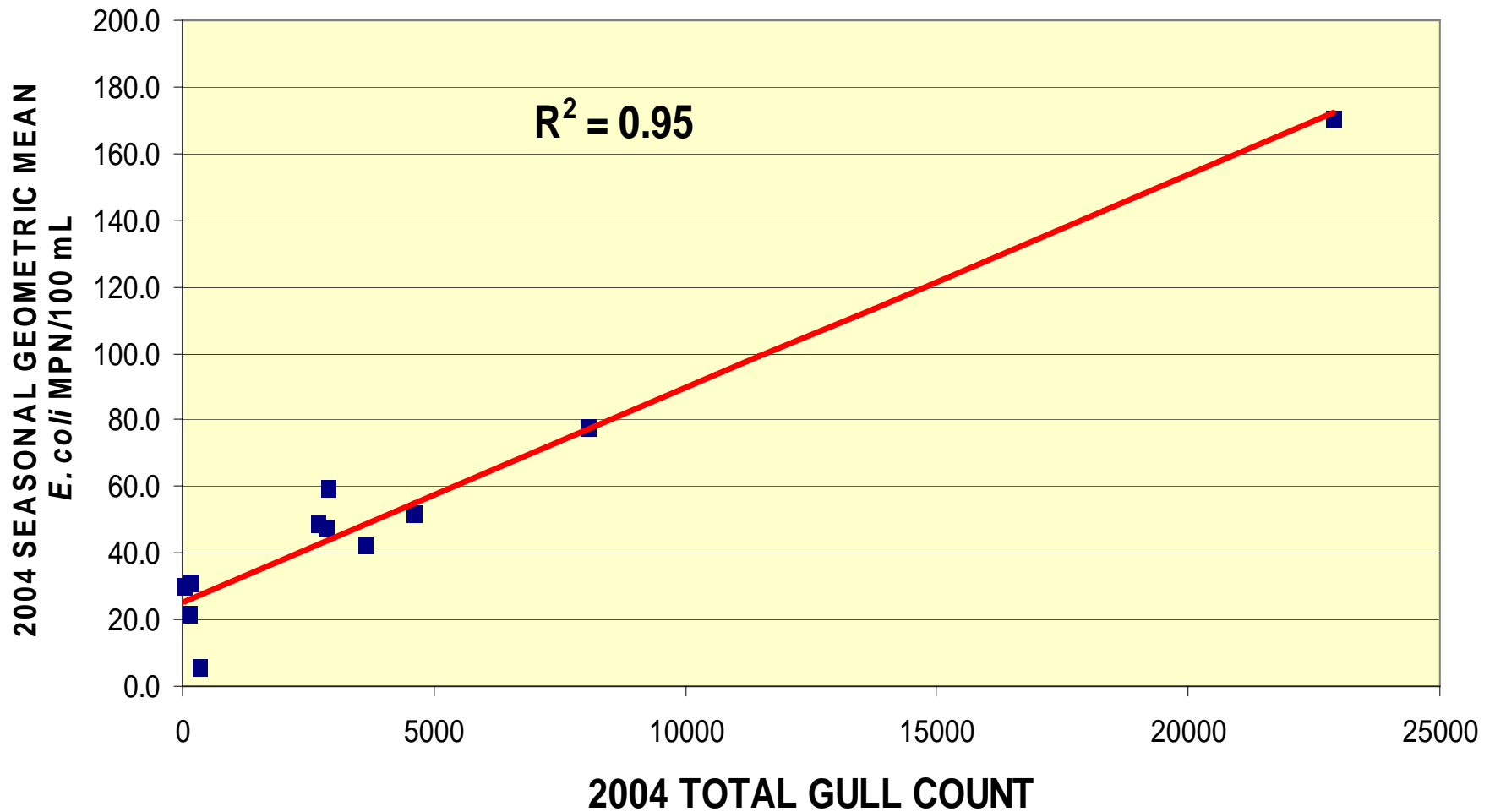
Image provided by the
University of Wisconsin at
Madison (www.lakesat.org)

2004 E. COLI SEASONAL GEOMETRIC MEAN

LAKE COUNTY, ILLINOIS LAKE MICHIGAN BEACHES



**2004 GULL COUNT TOTAL VS. *E. COLI*
SEASONAL GEOMETRIC MEAN
LAKE COUNTY, ILLINOIS LAKE MICHIGAN BEACHES**



Based On Previous Work for Chicago and Milwaukee

These are the guidelines employed in this project:

- Utilize **electronic instruments** that can be averaged/totalized over appropriate intervals for real-time forecasting.
- Deploy sensors in or near to the **surf zone** at each beach of concern.
- Place meteorological towers **close to the beaches** of concern.
- **Monitor beach water twice daily** in order to calibrate a model that can distinguish between morning and afternoon conditions.
- **Use statistical confidence intervals** when assigning health risk warnings or making swim ban decisions.

City of Lake Forest ~ Forest Park Beach Pile Installation



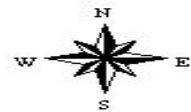
10 inch OD Steel Piling

Project Description:
E. coli Predictive Modeling Project
NWP 5: Scientific Measurement Devices

Location:
Lake County, Illinois



500 0 500 1000 Feet

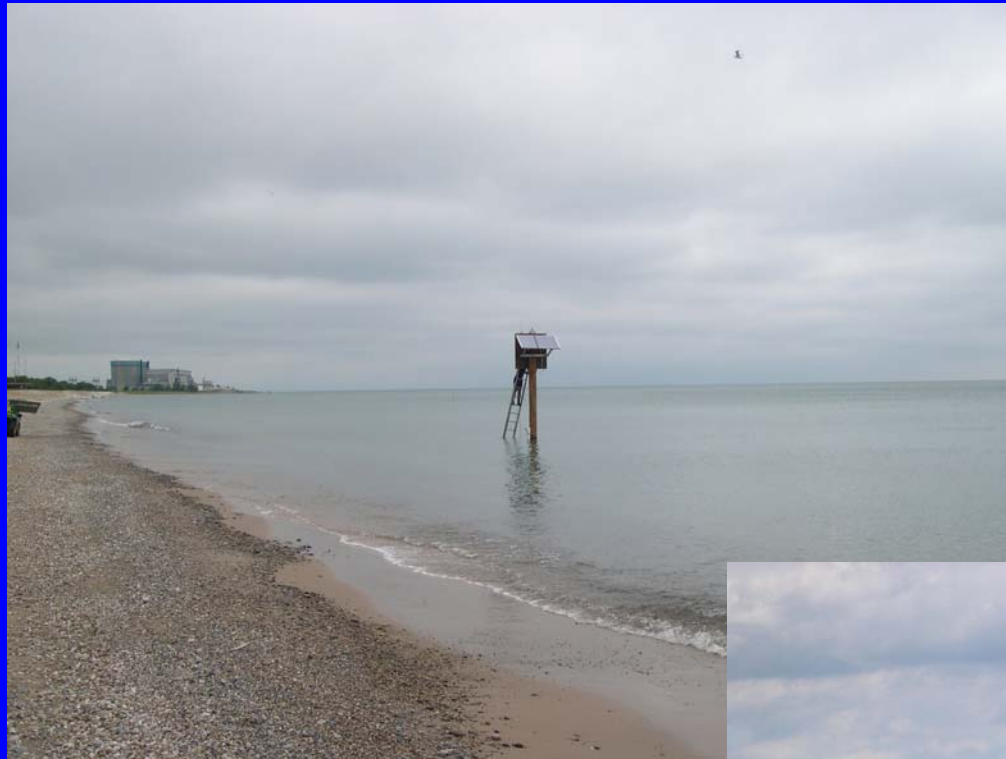


Illinois Beach State Park ~ South Beach Pile Installation









Illinois Beach State Park South Beach SwimCast System

Forest Park Beach SwimCast System

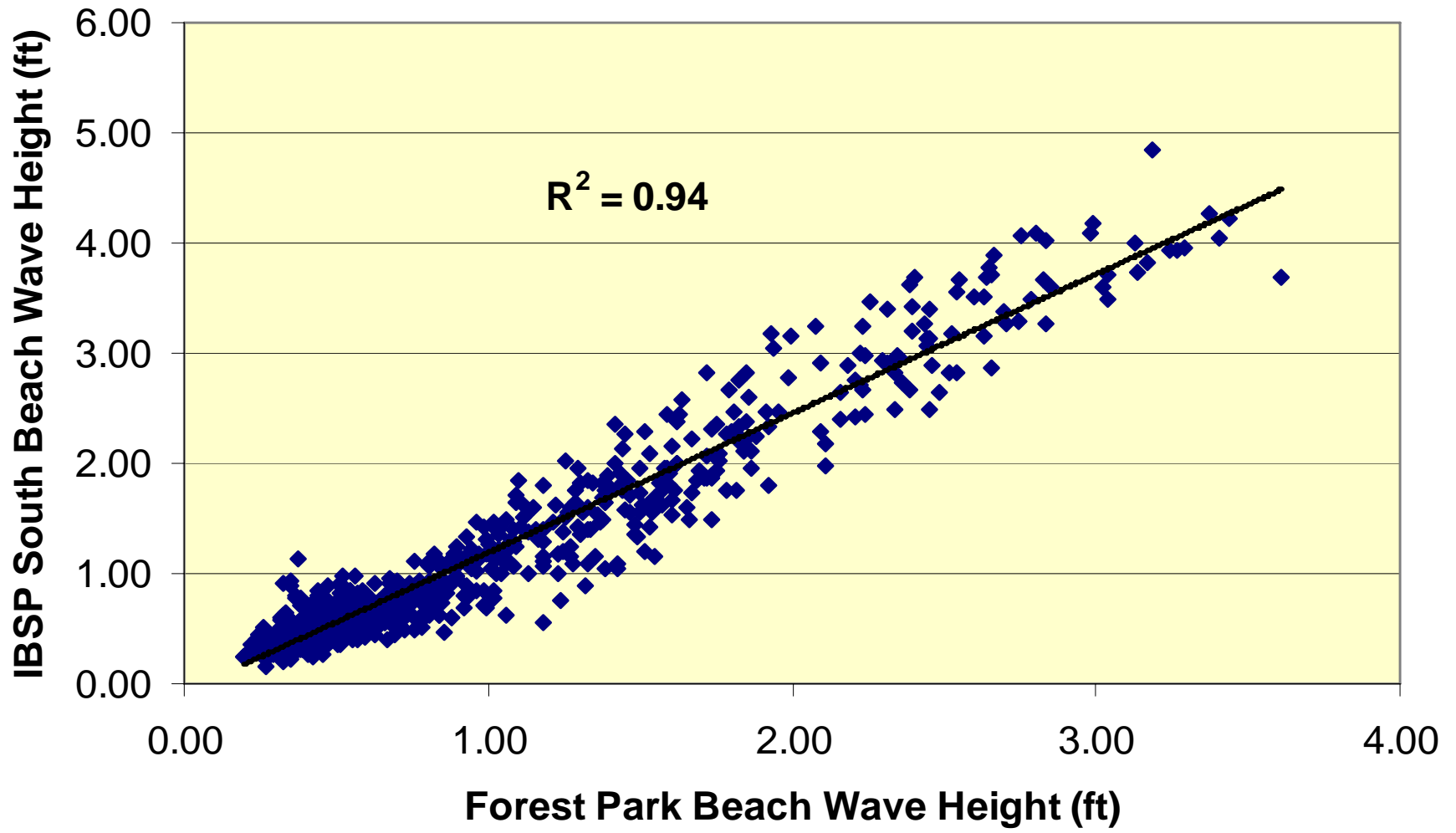


Variable Considered		IBSP	FP
Rainfall (1 hr, 4 hr, 12 hr, 24 hr totals)	<i>R</i> cm	√	√ *24 hr
Onshore Component of Wind (1 hr, 4 hr averages)	<i>W_v</i> m/s	√ *1 hr	√
Alongshore Component of Wind (1 hr, 4 hr averages)	<i>W_{vp}</i> m/s	√	√ *1 hr
Wave Height (1 hr, 4 hr averages)	<i>H_w</i> cm	√ *1 hr	√ *1 hr
Lake Stage (1 hr, 4 hr averages)	<i>S</i> cm	√ *1 hr	√
Insolation (1 hr, 4 hr averages)	<i>I_f</i> -	√ *1 hr	√ *1 hr
Air Temperature (1 hr, 4 hr averages)	<i>T_a</i> C	√ *1 hr	√ *1 hr
Water Temperature (1 hr, 4 hr averages)	<i>T_w</i> C	√	√
Water Turbidity (1 hr, 4 hr averages)	τ NTU	√	√
Binary Indicator of when Sample was Collected	<i>MA</i> 1/0	√ *	√ *

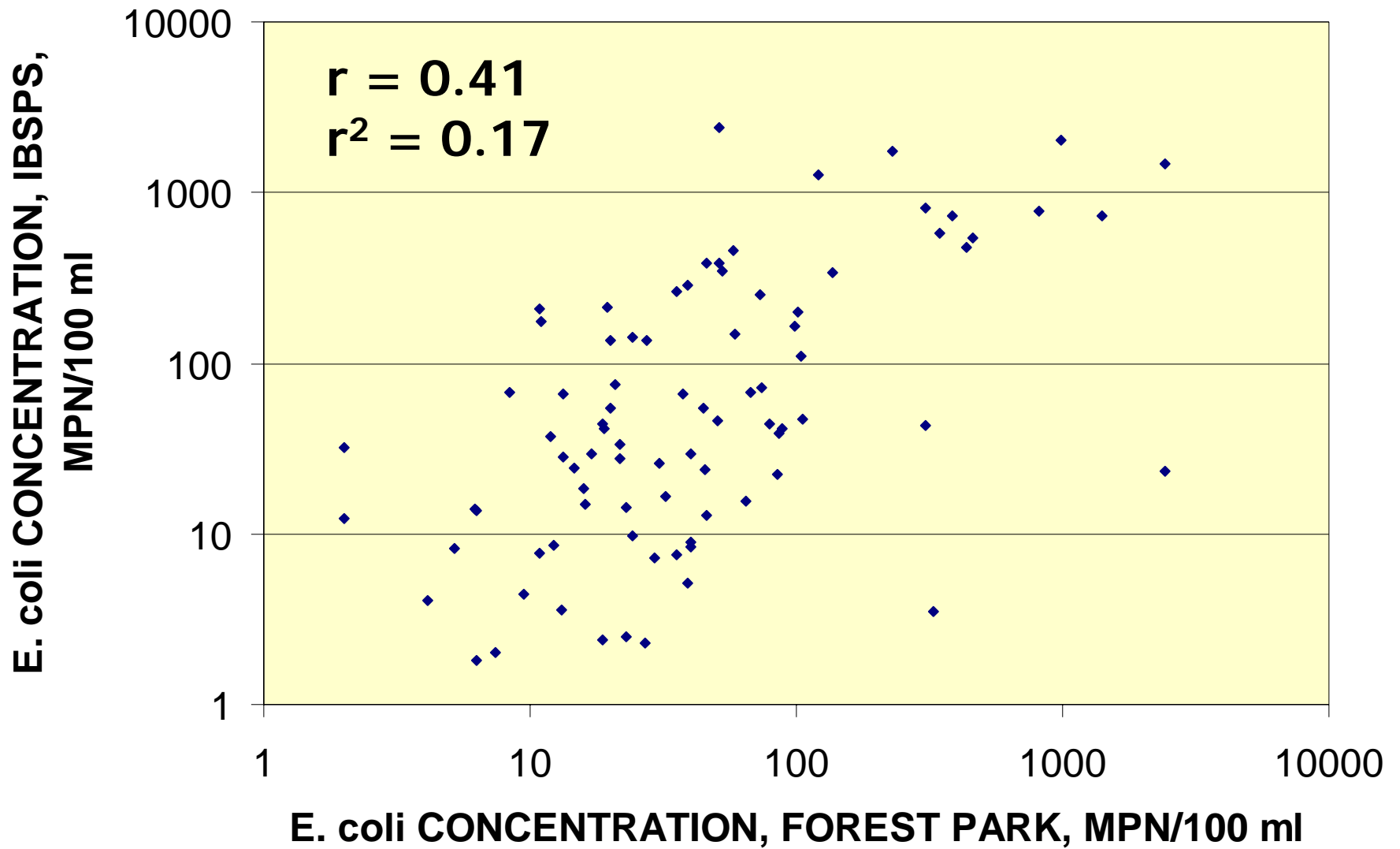
√ Variable was measured at the study beach.

* Variable contributed significantly to the predictive (regression) equation.

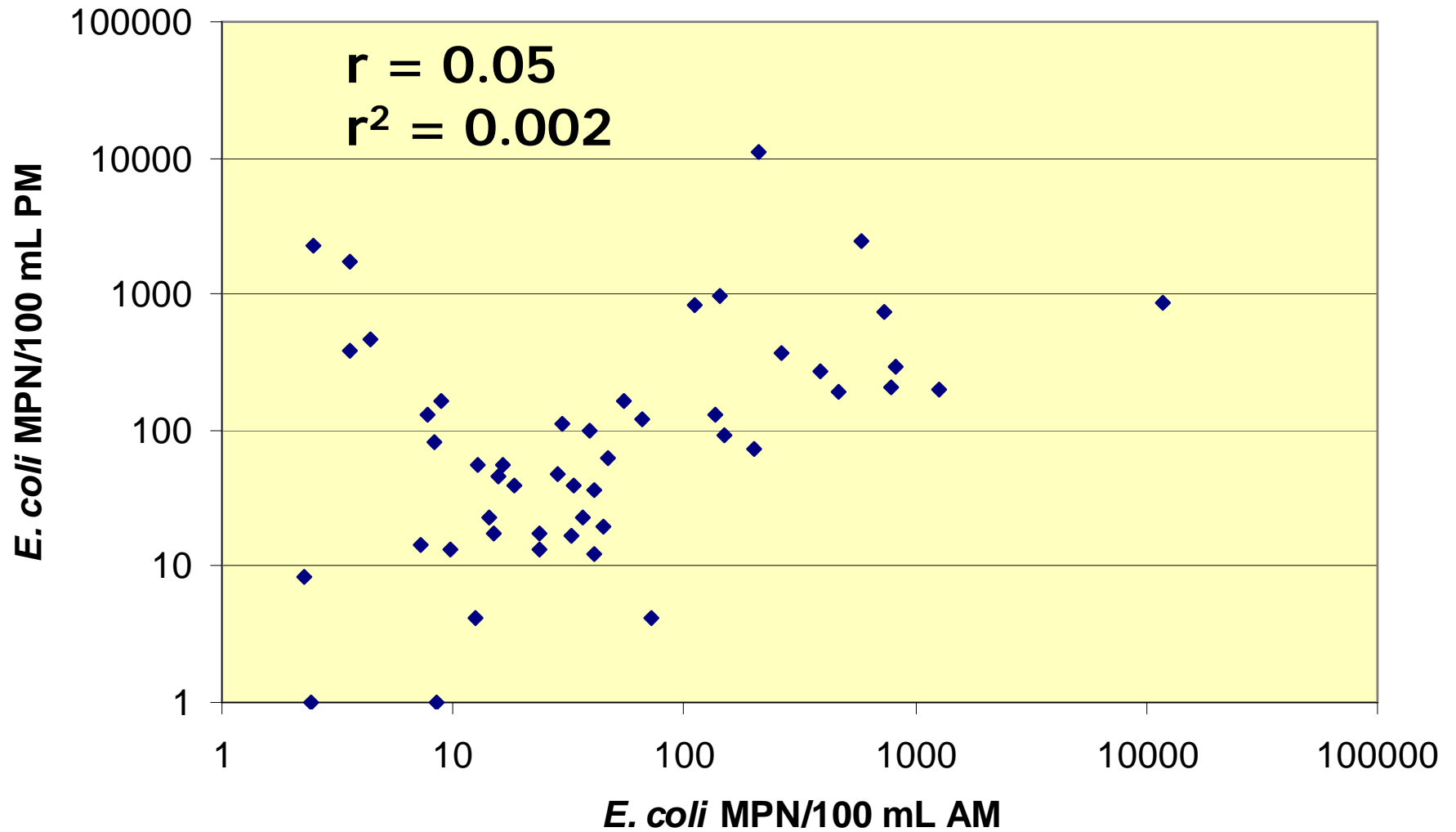
Forest Park vs. IBSP South Beach Wave Height From 00:00 8/1 to 24:00 8/31/2004



2004 FOREST PARK BEACH E. COLI VS. 2004 IL BEACH
STATE PARK SOUTH E. COLI (MORNING SAMPLES)



Illinois Beach State Park South Beach *E. coli* AM vs.PM



Best-Fit Model for Illinois Beach State Park Beach: 2004

$$\ln EC = b_0 + b_1 S + b_2 Hw + b_3 Wv + b_4 If + b_5 S \cdot Hw \cdot Wv + b_6 MA \cdot Ta \cdot If + e$$

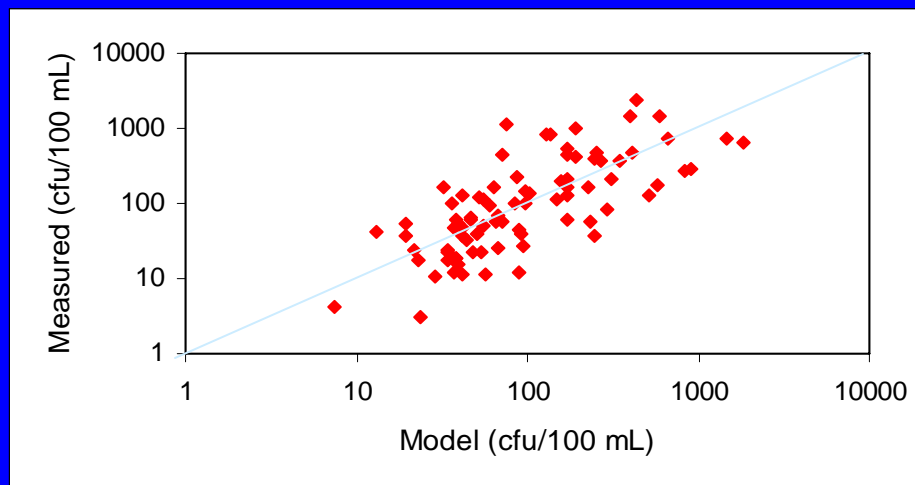
Parameter	b_0	b_1	b_2	b_3	b_4	b_5	b_6
Estimate	-0.698	0.048	0.038	0.504	-1.59	-6.5×10^{-5}	0.033
St. Error	2.488	0.024	0.007	0.110	0.428	1.8×10^{-5}	0.018
<i>t</i> -ratio	-0.28	2.01**	5.46***	4.57***	-3.71***	-3.65***	1.88*

Multiple correlation coefficient, R = 0.75. Total sample size, N=86.

*****Estimated regression parameter is statistically different from zero at the 99 percent confidence level.**

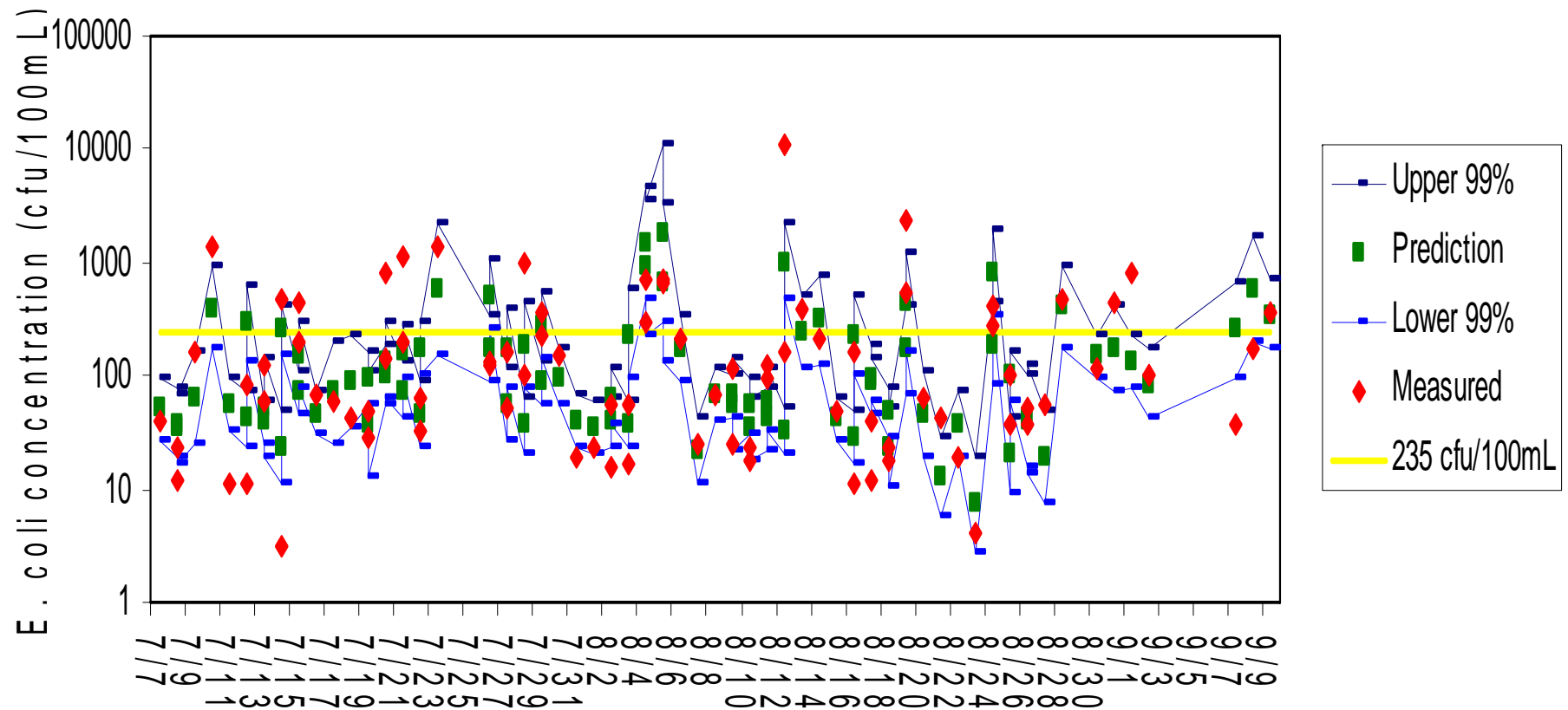
****Estimated regression parameter is statistically different from zero at the 95 percent confidence level.**

***Estimated regression parameter is statistically different from zero at the 90 percent confidence level.**



Predicted versus measured E. coli concentrations straddle the line of one-to-one correspondence over three orders of magnitude

Illinois Beach State Park Beach: Model Performance 2004



Bottom Line – using a “SwimCast” people would have been subjected to a health threat without warning on only 3 occasions and would have been kept out of the water when it was safe on only 1 occasion compared to 19 and 12 occasions respectively using daily morning monitoring data alone.

Best-Fit Model for Forest Park Beach: 2004

$$\ln EC = b_0 + b_1 R_{24} + b_2 If + b_3 Hw + b_4 MA \cdot Hw \cdot Wvp + b_5 MA \cdot If \cdot Ta + e$$

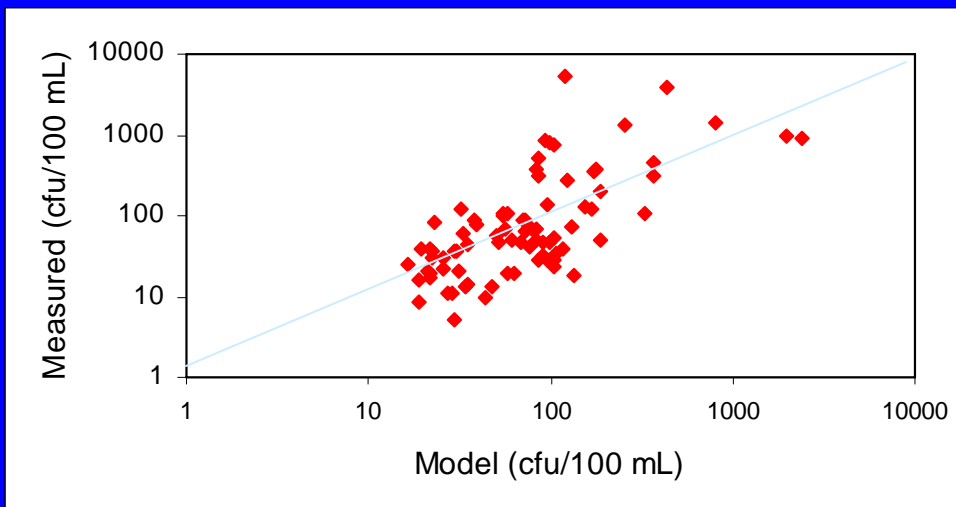
Parameter	b_0	b_1	b_2	b_3	b_4	b_5
Estimate	3.53	0.566	-0.947	0.042	-2.88×10^{-3}	0.065
St. Error	0.39	0.296	0.433	0.007	1.19×10^{-3}	0.019
<i>t</i> -ratio	9.17***	1.91*	-2.19**	6.16***	-2.43***	3.48***

Multiple correlation coefficient, $R = 0.69$. Total sample size, $N=80$.

***Estimated parameter is statistically significant at the 99 percent confidence level.

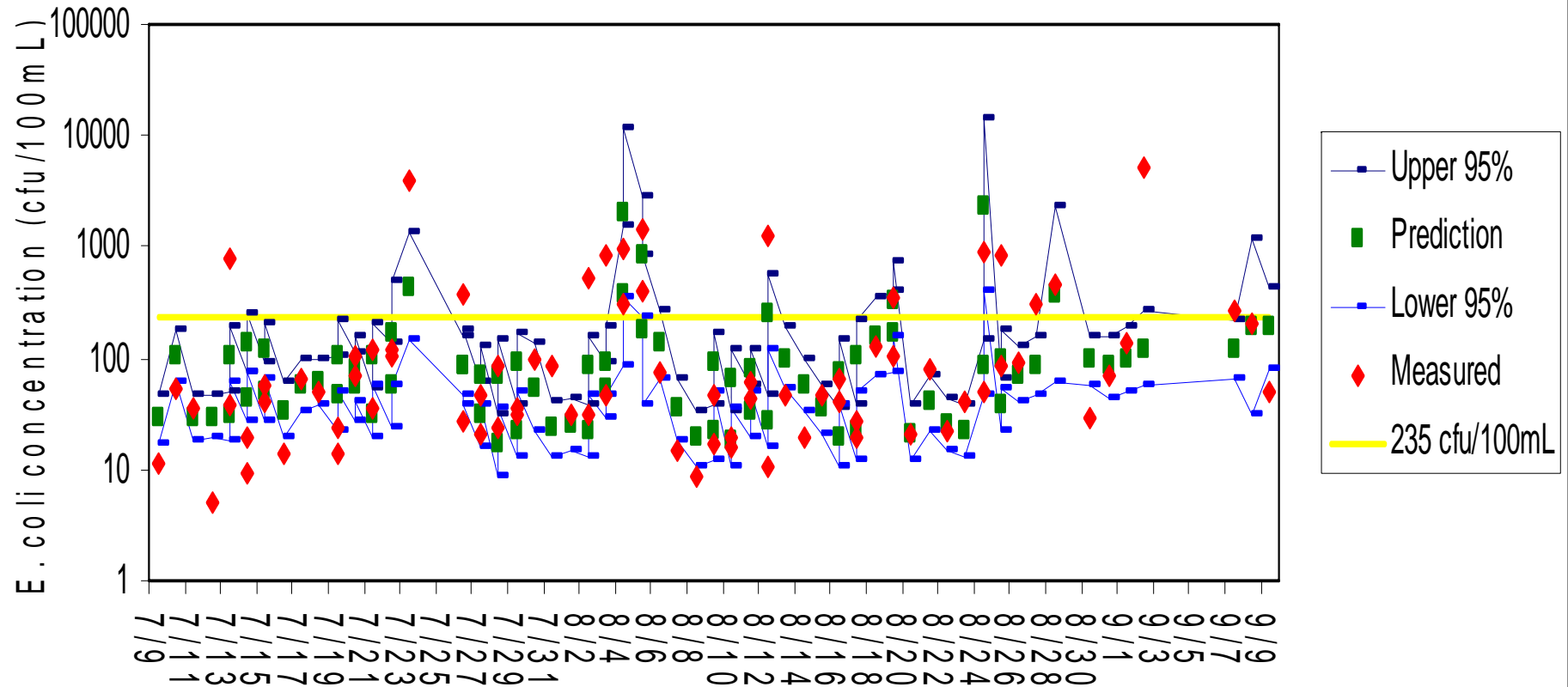
**Estimated regression parameter is statistically different from zero at the 95 percent confidence level.

*Estimated parameter is statistically significant at the 90 percent confidence level.



Predicted versus measured *E. coli* concentrations straddle the line of one-to-one correspondence over three orders of magnitude (with one significant outlier).

Forest Park Beach: Model Performance 2004



Bottom Line – using a “SwimCast” people would have been subjected to a health threat without warning on 7 occasions and would have never been kept out of the water when it was safe for full body contact. Compared to 15 and 7 occasions respectively using daily morning monitoring data alone.

CONCLUSIONS

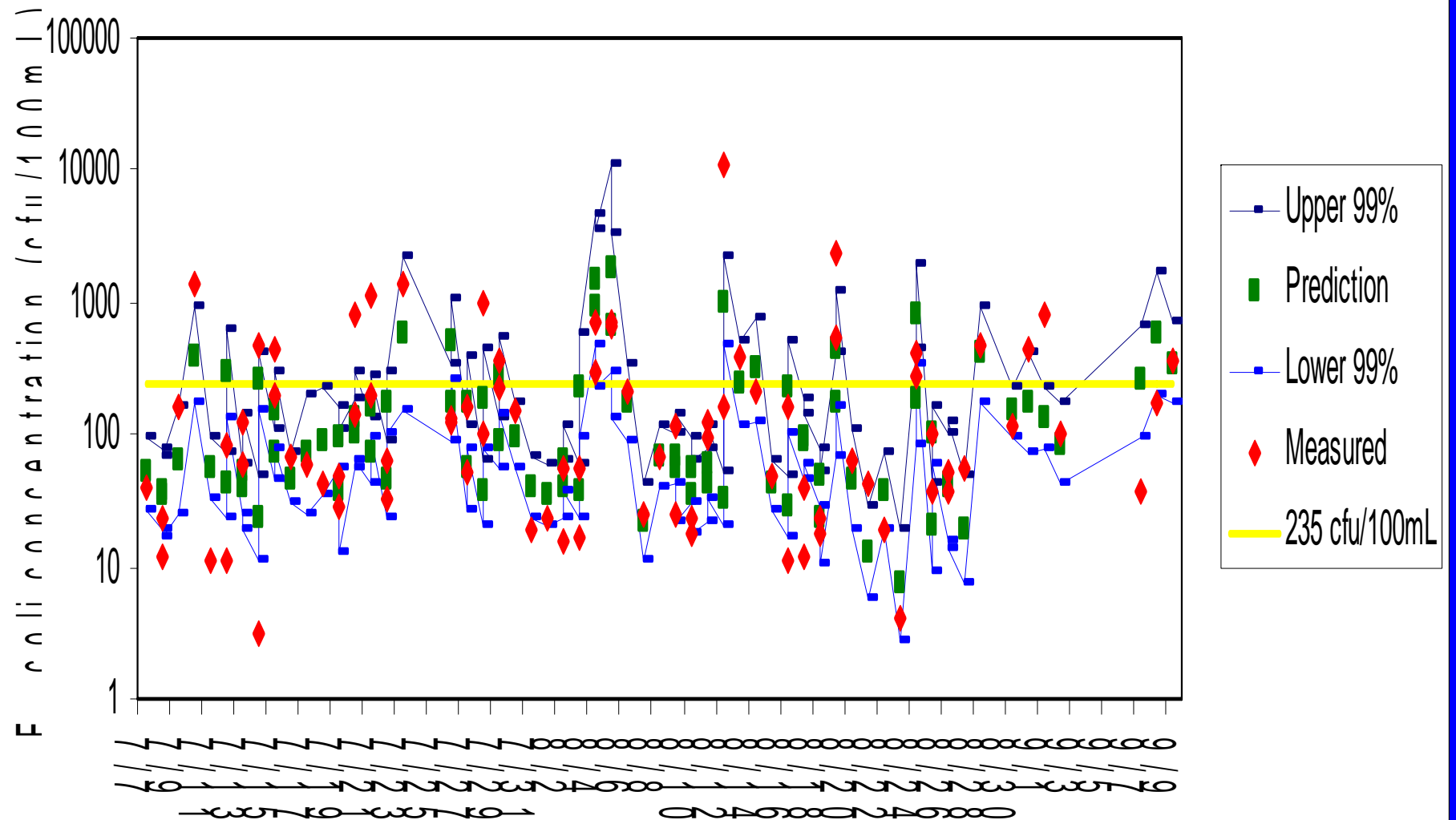
- Predictive Models based on continuously measured hydrometeorological variables -“SwimCasts”- provide a better alternative because they are more accurate and can be revised on an as-needed basis. All such predictive SwimCasts have uncertainty associated with them and should be based on probabilities (see table, next slide).
- Predicting the need for swim bans cannot be reliably achieved from samples taken a day or even several hours earlier.
- Since many beaches are not directly impacted by a river or major stormwater outfall the bacterial water quality in the swimming zone is strongly conditioned by any or all of the following: rainfall, sunshine, air and water temperature, lake stage, tides, wind and waves.
- *E. coli* concentrations at monitored beaches have a very short “memory” ; (i.e., very little temporal autocorrelation). So postings/warnings should be updated every few hours – or at least on a morning/afternoon basis. Our current research is to determine how well the 2004 model predicts in 2005.

Recommended Basis for Assigning Health Risk on the Basis of Predictive Model Output (Success Evaluation is for Both Beaches Combined)

Predicted Threat	Number of Cases	Geometric Mean E. Coli Concentration	Number of Successes	Success Rate (%)
Extreme	11	785 cfu/100 mL	9 over 235 threshold	82
High	27	537 cfu/100 mL	21 over 235 threshold	78
Moderate	50	329 cfu/100 mL	28 over 235 threshold	56
Low	116	47 cfu/100 mL	106 below 235 threshold	91

Key: Extreme = lower bound of 99% confidence limit > 235 cfu/100 mL
High = average model prediction > 235 (but not lower bound)
Moderate = only upper bound > 235 (not average or lower bound)
Low = entire confidence interval < 235 cfu/100mL

Illinois Beach State Park Beach: Model Performance 2004



Acknowledgements

- Lake County Health Department Lakes Management Unit and Laboratory Staff
- USEPA BEACH Act Funding (Holly Wirick)
- Illinois Department of Public Health (Lane Drager and John Reilly)
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- RemoteData, Inc.

