RECREATIONAL WATER QUALITY CRITERIA RESEARCH UPDATE

December 5, 2006
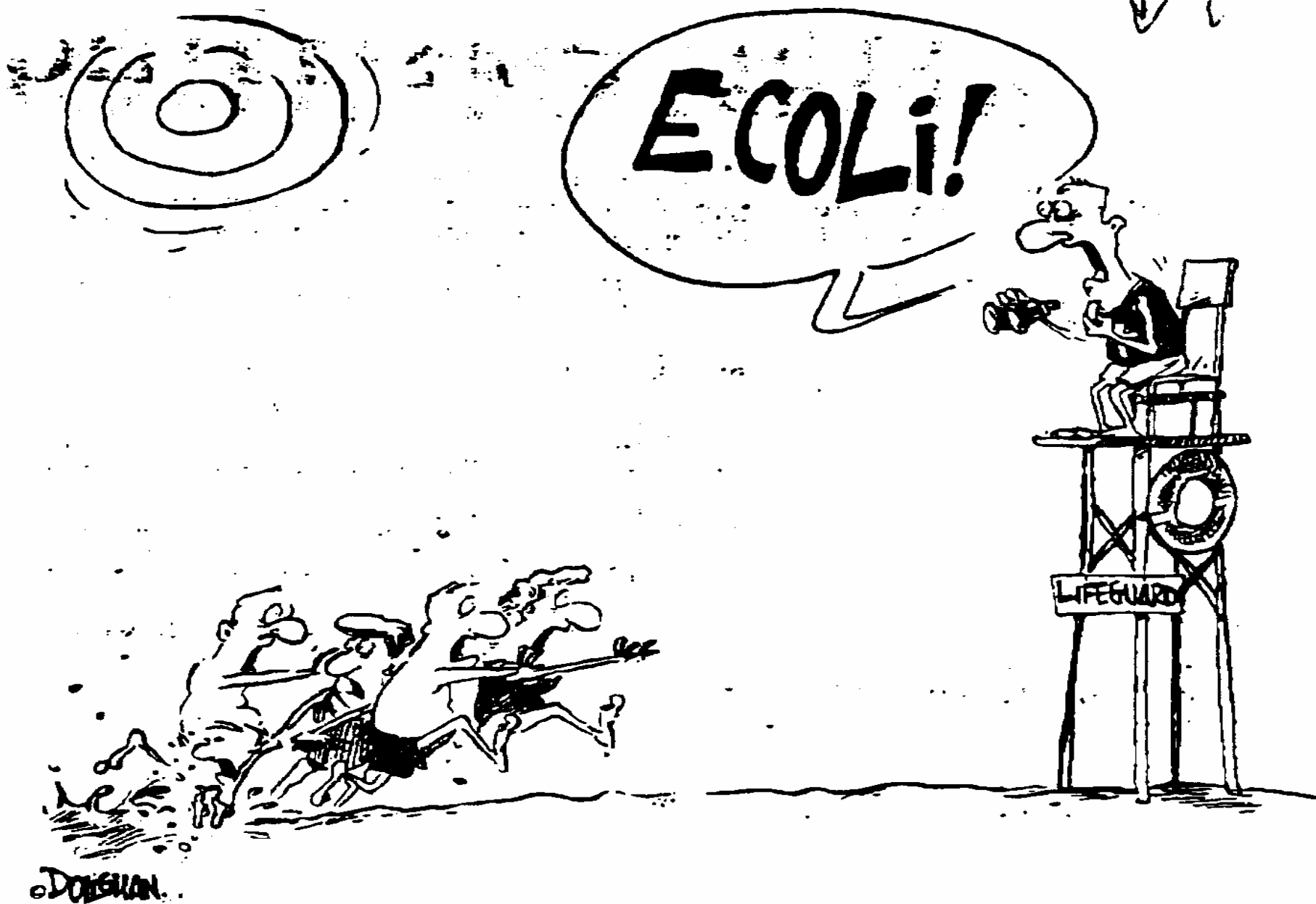
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USEPA

ORD RESEARCH

- **Beaches Action Plan – 1999**

  http://www.epa.gov/ord/htm/documents/600r98079.pdf

- **Water Quality Multi Year Plan – under development**

- **NEEAR Study – response to Beaches Act 2000**
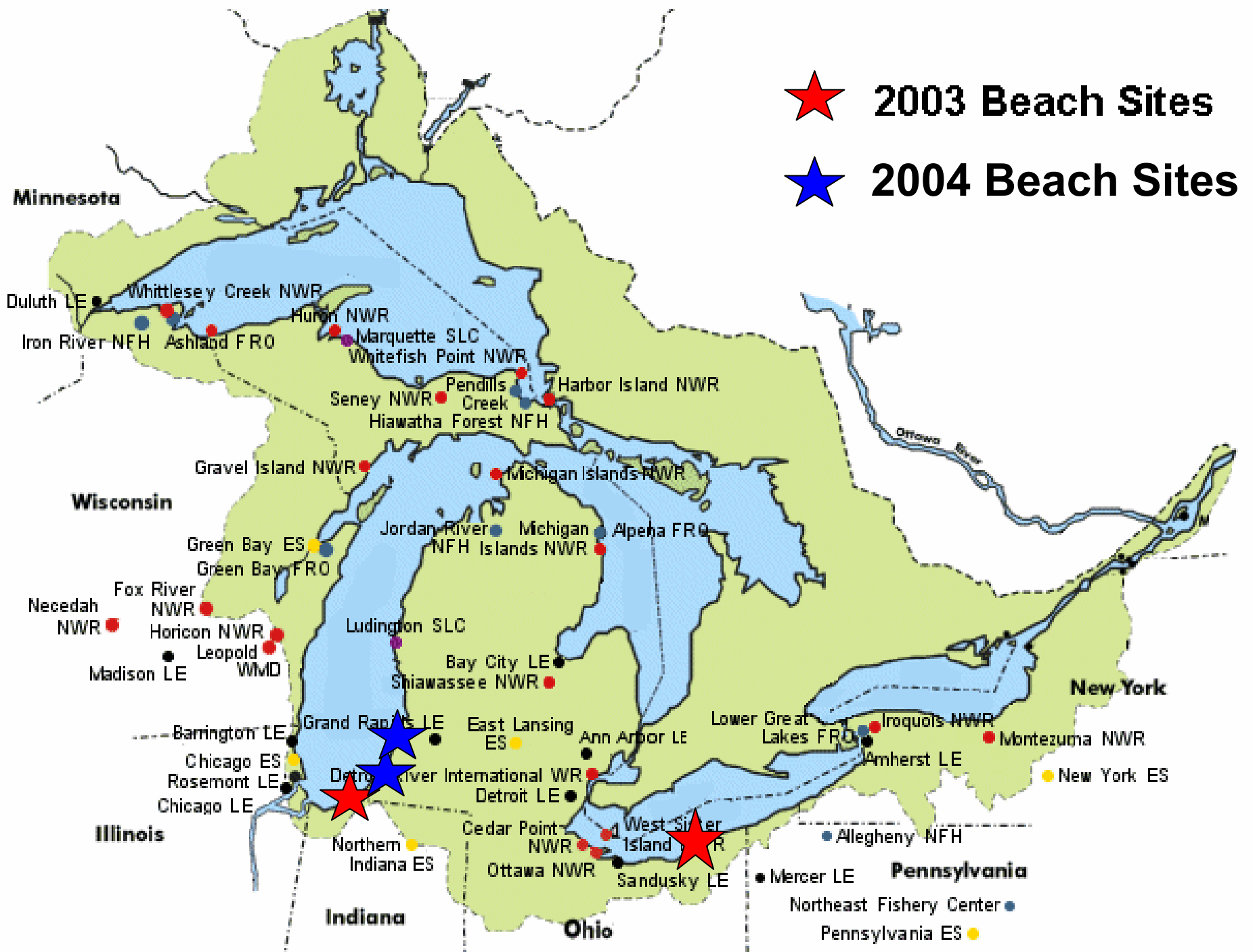
  http://www.epa.gov/nheerl/neear/

NEEAR STUDY OVERVIEW

- **BEACHES Act of 2000 from Congress**
    1. **104(v): Initiate studies to provide information for:**
        a. **Assessment of human health risks**
        b. **Developing indicators for improving detection in a timely manner**
        c. **Developing efficient and cost effective protocols for monitoring**
        d. **Implementation guidance for states for new or revised 304(a) criteria**
    2. **304(a)(9): EPA shall publish new or revised criteria**

    Final Goal: New risk-based water quality guidelines & rapid monitoring methods for recreational waters and new CWA 304(a) recreational criteria.

Beach Selection Criteria for NEEAR

- **Fresh water & marine water**

- **Multiple sites**

- **Water quality within guidelines**

- **Evidence of point-source contamination**

- **Designated recreational area**

- **Possible recruit of 300-400 swimmers per day**

Map of the Great Lakes region showing 2003 Beach Sites (red stars) and 2004 Beach Sites (blue stars).

Legend:
- ★ 2003 Beach Sites
- ★ 2004 Beach Sites

Labels:
- Minnesota
- Duluth LE
- Iron River NFH
- Whittlesey Creek NWR
- Ashland FRO
- Huron NWR
- Marquette SLC
- Whitefish Point NWR
- Pendills Creek
- Seney NWR
- Hiawatha Forest NFH
- Harbor Island NWR
- Gravel Island NWR
- Michigan Islands NWR
- Wisconsin
- Jordan River NFH
- Michigan Islands NWR
- Alpena FRO
- Green Bay ES
- Green Bay FRO
- Fox River NWR
- Necedah NWR
- Horicon NWR
- Leopold WMD
- Ludington SLC
- Madison LE
- Bay City LE
- Shiawassee NWR
- New York
- Barrington LE
- Grand Rapids LE
- East Lansing ES
- Ann Arbor LE
- Lower Great Lakes FRO
- Iroquois NWR
- Montezuma NWR
- Chicago ES
- Rosemont LE
- Detroit River International WR
- Amherst LE
- Chicago LE
- Detroit LE
- New York ES
- Illinois
- Northern Indiana ES
- Cedar Point NWR
- West Sister Island NWR
- Allegheny NFH
- Ottawa NWR
- Sandusky LE
- Mercer LE
- Pennsylvania
- Indiana
- Ohio
- Northeast Fishery Center
- Pennsylvania ES

Study design

- **Summer weekends**
- **Prospective cohort**

  Target population: all beach goers

  Household sample

  Three interviews:
  - **Enrollment**
  - **Beach interview**
  - **Telephone interview 10-12 days later**

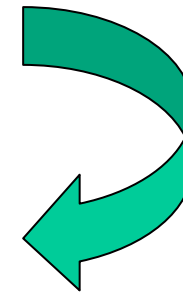- **Water sample collection**

STUDY APPROACH

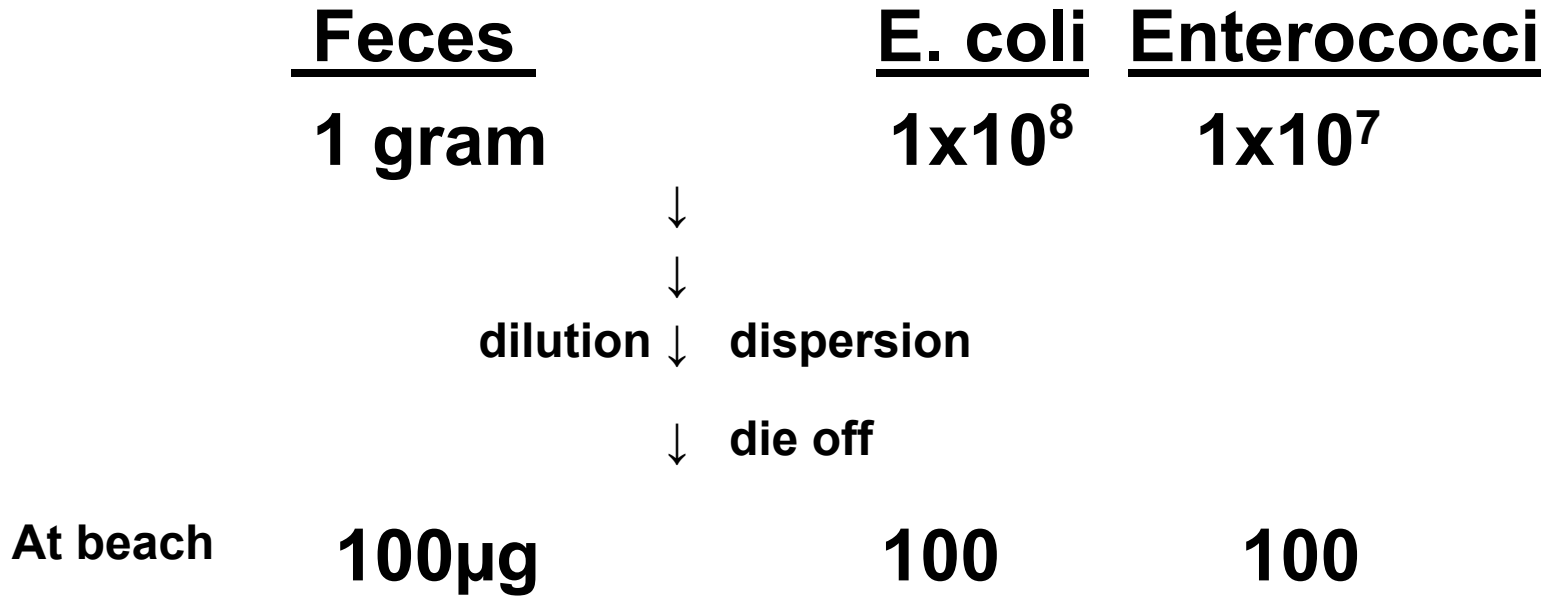**Water sampling methods**

New rapid detection methods
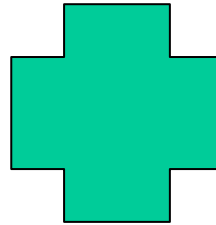
Health studies

New, rapid, validated water quality indicators (under 2 hours for results)

THE INDICATOR CONCEPT

	Feces	E. coli	Enterococci
	1 gram	$1x10^8$	$1x10^7$
	↓		
	↓		
	dilution ↓ dispersion		
	↓ die off		
At beach	100μg	100	100

Water Quality Measures

- **Traditional method:**

  Enterococci Method 1600

- **Rapid methods (2 hours analysis):**

  Enterococci QPCR

  Bacteroides QPCR

  Additional Method

  Additional Method

Water Sampling Strategy

- **Taken 3 times daily** → 8:00   AM

  11:00 AM

  3:00   PM

- **Two depths** → .3 meters

  1.0 meter

- **Modified sampling scheme according to beach area**

- **Utilized stationary landmarks as location guides**

Beach Interviewing
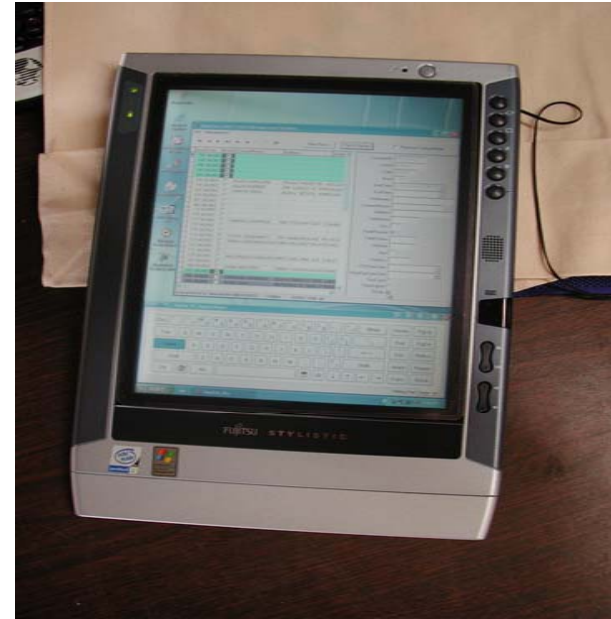
# *Computerized Assisted Telephone Interviewing (CATI)*

Exposure and Health Effects

- **Any contact with water ("any contact")**

- **Immersed body in water ("body contact")**

- **Head under water ("head under")**

- *Gastrointestinal illness (HCGI)*

- *Upper respiratory illness (URI)*

- *Skin rash*

- *Eye irritations (watery eye or eye infection)*

- *Earache*

Summary of Data

- **Four Beaches (2003 & 2004)**

  78 days of sampling and beach interviewing

- **21,015 people surveyed**

  21% children

  49% swimmers

- **1596 number of water samples tested for QPCR**

  2 depths, 8:00 am 11:00 am 3:00 pm

Swimming associated HCGI and Enterococcus exposure, all participants, censored water sample excluded
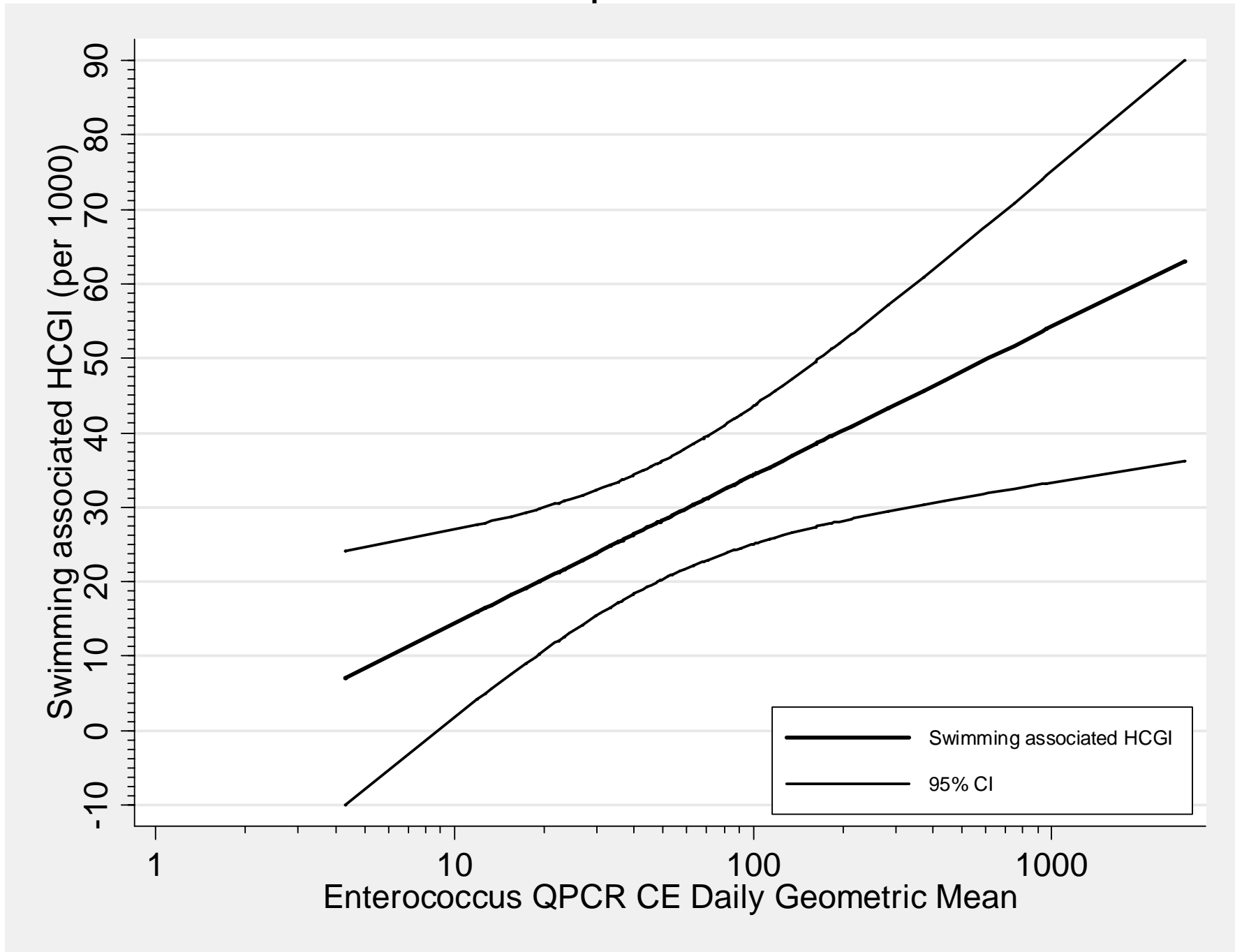
NEEAR Summary and Conclusions

- QPCR appears to be a promising predictor of gastrointestinal illness in fresh water
- First rapid indicator to be correlated with health effects
- Trends were not observed for respiratory illness
- Trends were not observed for rash, earache, and eye ailments, but more data may be necessary

EMPACT STUDY

To determine the effect of spatial and temporal factors on the variation of approved methods

To determine the best way to monitor recreational water to assist beach managers in developing site-specific monitoring protocols for their beaches

SAMPLING

1. *Basic -* Twice a day (9 am & 2 pm) at each location for 36 days.

2. *Hourly* – Ten times a day at each location at hourly intervals (9amto 6pm) for 14 days

3. *Replicate* – Two per location or ten samples in the center location for 8 days

4. *Depth* – One to three depths per location for 4 days.

EMPACT STUDY

METHODS

1. *E. coli-* EPA method 1603 (mTEC agar)

2. *Enterococci* – EPA method 1600 (mEI agar)

3. Ancillary – pH, turbidity, TSS, rainfall, weather conditions, tides and/or currents, # of bathers and animals in the water, debris, boats near the beach and GPS

SUMMARY

Bacterial levels were highest:

In ankle-deep water and lowest in chest-deep water

In the morning vs the afternoon

On cloudy days vs sunny days

With onshore winds

MATRIX STUDY

To determine what the interferences on qPCR from a variety of water types (matrix) across the country

To look at the variations in the qPCR method using five different reagent/probe combinations

METHODS

QPCR   Culture

    Bacteroides   Method 1600

    Enterococci

MATRIX STUDY

Preliminary Summary

1. Minimal dilutions (i.e. 5-fold) of bead-milled DNA extracts (spiked samples) from diverse freshwater filtrates substantially **reduced** the frequency of samples causing full or potential QPCR **inhibition** while only slightly (*Enterococcus*) or not at all (*Bacteroides*) reducing the frequency of samples in which these fecal indicator organisms were not detected.

2. Mean QPCR measurements of spiked enterococci in diverse freshwater filtrates were **highly accurate**, however, the low **precision of single sample** measurements of these bacteria at ambient surface water densities remains a characteristic requiring further improvement.

3. Mean QPCR measurements of spiked and ambient enterococci in these matrices by four different QPCR instrument and reagent systems (including two newer systems that produce analytical results in ~30 min and one in ~45 min) were **not significantly different.**

4. Using a recently improved primer and probe assay, fecal indicator bacteria in the class *Bacteriodes* were shown to be highly abundant targets for QPCR analysis in diverse freshwater samples. Single sample measurements of these organisms **showed better precision** than corresponding *Enterococcus* QPCR measurements.

5. A **positive correlation** was observed in this national freshwater study between enterococci measurements by the QPCR and membrane filtration (EPA 1600) culture methods.

Many Thanks

ORD team - Alfred P. Dufour, Kristen Brenner - NERL
Timothy Wade, Elizabeth Sams - NHEERL

Field Team support

> Region 5 – Holly Wyrick

> Region 4 – Joel Hansel

> OW/OST – Beth Leamond, Charles Kovatch

> CDC – Michael Beach

> HSD field team – Ed Hudgens, Scott Rhoney, Danelle Lobdell, Mike Schmitt, Gina Terrill, Ann Williams

Local support – National Park Service, County Health Departments, Municipal governments

Predictive Tools to Evaluate Fecal Bacterial Exposure in Recreational Waters

## Walter Frick, Marirosa Molina and Richard Zepp- ORD/NERL

Overall Objective

- **Evaluate the sources, fate and transport of bacterial contaminants in recreational waters through the use of predictive modeling and DNA-based technology.**

General Approach:

- **Microbial Source Tracking Methodology (MST) in combination with QPCR is used to identify and quantify specific source of fecal contamination. Results will be used to develop and validate forecasting models.**
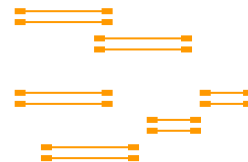

Collection and membrane filtration of water sample
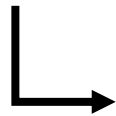
Genomic DNA

PCR amplification with fecal markers

Amplified fragments

Gel analysis

Significance

🌐 **Predictive modeling will provide beach managers and the public with the ability to plan their use of recreational waters up to 48 hrs in advance.**

Sandy Creek, Athens, GA

FUTURE PROJECTS

- **MARINE BEACHES IN 2007**

  ORD's thoughts on marine beach selection criteria:

  Meets current state water quality standards

  300-400 visitors a weekend day

  potentially impacted by point sources

  designated recreational site

- **Fate and Transport for indicators**
- **Modeling**
- **Indicator development**

Contact Information

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