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Proceedings of the 2004 National Beaches Conference

March 2005

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Proceedings of the 2004 National Beaches Conference

October 13-15, 2004

Introduction

The goal of the U.S. Environmental Protection Agency's Beaches Environmental Assessment, Closure and Health (BEACH) Program is to work in partnership with states, tribes, territories, local governments, and the public to significantly reduce the risk of disease to users of the nation's recreational waters. This is accomplished through improvements in recreational water programs, communication, and scientific advances. BEACH Act grants are awarded to eligible coastal and Great Lakes states, territories, and tribes to develop and implement beach monitoring and notification programs.

On April 20, 2004, EPA announced the Administration's Clean Beaches strategy. The strategy includes the Clean Beaches Plan. By carrying out the Clean Beaches Plan, EPA is helping state, tribal, and local beach managers strengthen their programs. A strategy for reducing the risks of infection to people who use the nation's recreational waters, the plan recognizes that beach managers need tools that allow for local and regional differences in pollution sources and climate. The Clean Beaches Plan describes what EPA plans to do over the next couple of years to achieve two major goals: promote recreational water quality programs nationwide and create scientific improvements that support timely recreational water monitoring and reporting.

The national conference was organized as part of the Clean Beaches Plan. It provided a forum for learning about beach health initiatives across the country; presenting new methods, indicators, and modeling techniques; identifying beach health needs; discussing priorities for short-term and long-term actions; and recommending protocols and procedures to encourage greater consistency among jurisdictions. The conference was organized into the following sessions:

- Session One: Welcome and Plenary Speakers
- Session Two: State and Local Experiences in Implementing Beach Monitoring and Notification Programs
- Session Three: Design of Beach Monitoring Programs
- Session Four: The Public Notice Decision Process and Public Perception
- Session Five: Source Identification
- Session Six: Total Maximum Daily Loads
- Session Seven: Remediation Approaches
- Session Eight: Making Warning Systems More Rapid: Modeling and Rapid Methods
- Session Nine: New Health Risk Indicators
- Session Ten: Quantifying Swimmer Risk
- Session Eleven: Plenary Panel Discussion
- Session Twelve: Data Management and Communication
- Session Thirteen: Communicating Beach Condition to the Public
- Session Fourteen: Conference Wrap-Up

Each session consisted of individual presentations and a discussion period with questions and comments from the audience and responses by the speakers. This proceedings document contains each speaker's presentation slides, summaries of audience questions and responses, and a summary of the plenary panel discussion.

Acknowledgments

The Office of Science and Technology (OST) in the U.S. Environmental Protection Agency's Office of Water funded the 2004 National Beach Conference. The Standards and Health Protection Division in OST organized the conference and Tetra Tech, Inc. provided support for the conference and this proceedings document under EPA contract C-04-030.

The planning workgroup included the following representatives:

- EPA Headquarters: Beth LeaMond, Bryan "Ibrahim" Goodwin, Charles Kovatch, Rick Hoffmann, Jim Pendergast, Wendy Miller, and Denise Keehner
- EPA Regional and Research Offices: Matt Liebman, Joel Hansel, Al Dufour, Holly Wirick, Mike Schaub, Terry Fleming, and Janet Hashimoto
- State and local Beach Program or public health officials: Shannon Briggs, Blake Traudt, Don Killinger, Sara Sumner, Bob Vincent, Lynn Schneider, Toni Glymph, Esperanza Stancioff, Eric Sacon, Jody Connor, Paul Whelan, and Dave Burnett
- The California State Water Resources Control Board: Robin McCraw
- Tetra Tech: Shannon Prendergast and Melissa Canfield
- The Southern California Coastal Water Research Project: Steve Weisberg

Contributions of those who helped in the planning and organizing of this successful conference is greatly appreciated. Special thanks is extended to EPA Region 9 for helping to plan the conference and to the State Water Resources Control Board of the State of California for their contributions to the program and for welcoming us to their home territory. Steve Weisberg from the Southern California Coastal Water Research Project contributed much time and energy in developing the program, contacting people, and in helping with logistics. The contributions of the invited speakers and attendees are gratefully acknowledged. Their efforts were critical to the success of the conference.

The material in this document has been subjected to Agency technical and policy review and approved for publication as an EPA report. The views expressed by individual authors, however, are their own and do not necessarily reflect those of EPA. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

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National Beaches Conference

National Beaches Conference Agenda

October 13-15, 2004
San Diego, California

Tuesday, October 12, 2004

5:00–7:00 **Early Bird Registration**
Hotel Lobby

Wednesday, October 13, 2004

7:30–5:00 **Registration**
Grand Ballroom Lobby

8:00 **Registration**
Grand Ballroom Lobby

8:30–9:50 **Session I: Welcome & Plenary Speakers**
Moderator—Beth LeaMond,
U.S. Environmental Protection Agency
Salon D&E

8:30–8:45 **San Diego Welcome**
Donna Frye, City Councilmember,
City of San Diego

8:45–9:00 **EPA Welcome**
Wayne Nastri,
U.S. Environmental Protection Agency

9:00–9:25 **Plenary Speaker—Beach Act Actions: 2000–2004 and Beyond**
Denise Keehner,
U.S. Environmental Protection Agency,
Office of Science and Technology

9:25–9:50 **Plenary Speaker—Waterborne Pathogens and Indicators: A Pathway Forward**
Joan Rose, Michigan State University

9:50–10:20 **Break**

10:20–12:00 **Session II: State and Local Experiences In Implementing Beach Monitoring & Notification Programs**
Moderator - Janet Hashimoto,
U.S. Environmental Protection Agency
Salon D&E

10:20–10:40 **Hawaii Watershed Initiative and Clean Beaches**
Carl Berg, Hanalei Watershed Hui

10:40–11:00 **Florida's Healthy Beaches Monitoring Program**
Bart Bibler,
Florida Department of Health

11:00–11:20 **Surf and Turf: Developing Partnerships for Maine's Beaches**
Esperanza Stancioff,
University of Maine Cooperative Extension/ Sea Grant

11:20–11:40 **Incorporating the Bacterial Indicator Enterococci in Marine Beach Water Quality Monitoring Programs**
Clay Clifton, County of San Diego

11:40–12:00 **Washington State's Beach Environmental Assessment, Communication, and Health {BEACH} Program**
Lynn Schneider,
Washington State Department of Ecology

12:00–1:20 **Lunch**

1:20–2:50 **Session III: Design of Beach Monitoring Programs**
Moderator—Matthew Liebman, U.S. Environmental Protection Agency
Salon D&E

1:20–1:30 **EPA Overview: Current National Requirements, Guidance And Hot Issues**
Matthew Liebman, U.S. Environmental Protection Agency

1:30–1:50	**Public Health Protection at Marine Beaches: A Model Program for Water Quality Monitoring and Public Notification** Mitzy Taggart, Heal the Bay
1:50–2:10	**Comparison And Verification Of Bacterial Water Quality Indicator Measurement Methods Using Ambient Coastal Water Samples** John Griffith, Southern California Coastal Water Research Project
2:10–2:30	**Composite Sampling as an Alternative Technique for the Determination of Bacterial Indicators in Recreational Waters** Julie Kinzelman, City of Racine
2:30–2:50	**How Often and Where To Monitor: Outcome Of The EMPACT Study** Larry Wymer, U.S. Environmental Protection Agency
2:50–3:20	**Break**
3:20–5:00	**Session IV: The Public Notice Decision Process and Public Perception** Moderator—Robin McCraw, California State Water Resources Control Board Salon D&E
3:20–3:40	**Source Unknown: Questionable Geometric Mean Exceedances at Two Pristine North Carolina Beaches** J.D. Potts, North Carolina Department of Environment and Natural Resources
3:40–4:00	**Misinformation in Beach Warning Systems** Stanley Grant, University of California at Irvine
4:00–4:20	**The Cost of Beach Water Monitoring Errors in Southern California** Linwood Pendleton, University of California at Los Angeles
4:20–4:40	**Communication: Increasing Public Awareness about Beaches** Harry Simmons, American Shore and Beach Preservation Association
4:40 - 5:00	**City of Encinitas Perspective on Beach Postings** Katherine Weldon, City of Encinitas
6:00–8:00	**Poster Session** Sponsored by American Shore & Beach Preservation Association Ballroom Foyer & Sierra 5/6 Conference participants are invited to convene for light refreshments and discussion. Over thirty displays prepared by scientists and industry experts will be presented. Light refreshments and a cash bar will be available.

Thursday, October 14, 2004

Concurrent Track I: Identifying and Solving Beach Water Quality Problems

7:30–5:00 **Registration**
Grand Ballroom Lobby

8:00 **Registration**
Grand Ballroom Lobby

8:00–9:40 **Session V: Source Identification**
Moderator—Don Killenger, Cuyahoga County Board of Health
Salon A/B/C

8:00–8:20 **EPA Guidance Manual on Source Identification**
Gerard Stelma, U.S. Environmental Protection Agency

8:20–8:40 **Tiered Approach for Identification of a Human Fecal Pollution Source at a Recreational Beach: Case Study at Avalon Bay, Catalina Island, California**
Alexandria Boehm, Stanford University

8:40–9:00 **Fecal Source Identification with Bacteroidetes Molecular Markers**
Katharine Field, Oregon State University

9:00–9:20 **Using Microbial Source Tracking in New Hampshire: Applications, Results and Challenges**
Stephen Jones, University of New Hampshire

9:20–9:40 **Replication of *E. coli* in Sand at a Temperate Freshwater Beach**
Elizabeth Alm, Central Michigan University

9:40–10:20 **Break**

10:20–12:00 **Session VI: TMDLs**
Moderator—Joel Hansel, U.S. Environmental Protection Agency
Salon A/B/C

10:20–10:40 **A Watershed Scale Approach for Developing a Bacterial TMDL in an Urbanizing Puget Sound Embayment**
Christopher May, Battelle Marine Science Laboratory

10:40–11:00 **Improving Beach Water Quality through TMDLs: A Case Study of Santa Monica Bay Beaches**
Renee DeShazo, Los Angeles Regional Water Quality Control Board

11:00–11:20 **Delisting of Recreational Beaches on the 303(d) List for Exceedances of Bacterial Water Quality Standards**
Lisa Kay, MEC-Weston Solutions, Inc.

11:20–11:40 **"The Hunt for Red *E. coli*"–Bacteria Source Tracking in Lake Darling Watershed**
Eric O'Brien, Iowa Department of Natural Resources

11:40–12:00 **San Diego Creek Watershed Natural Treatment System**
Norris Brandt, Irvine Ranch Water District

12:00–1:20 **Lunch**
Pavillion

Linking the Oceans and Human Health: Perspectives from the U.S. Commission on Ocean Policy and the new NOAA OHH Initiative
Paul Sandifer, National Oceanic and Atmospheric Administration
Sponsored by Idexx Laboratories

1:20–3:00 **Session VII: Remediation Approaches**
Moderator—Holly Wirick, U.S. Environmental Protection Agency
Salon A/B/C

1:20–1:40 **California's Clean Beach Initiative**
Mark Gold, Heal the Bay

1:40–2:00 **EPA's Clean New England Beaches Initiative and Flagship Beaches**
Matthew Liebman, U.S. Environmental Protection Agency

2:00–2:20 **The Effectiveness of Spatial Distribution Studies in the Development of Successful, Cost-Effective, Targeted Remediation Efforts**
Julie Kinzelman, City of Racine

2:20–2:40 **Utilizing Storm Water Monitoring To Assess Beach Water Quality**
Jill Lis, Cuyahoga County Board of Health

2:40–3:00 **Diversion is the Solution to Pollution, So Far**
Cathy Chang, Santa Monica Bay Restoration Commission

3:00–3:20 **Break**

3:20–5:00 **Session XI: Plenary Panel Discussion**
Moderator—Steve Weisberg, Southern California Coastal Water Research Project
Salon D/E

Panel
- Denise Keehner, U.S. Environmental Protection Agency
- Shannon Briggs, Michigan Department of Environmental Quality
- Rachel Noble, University of North Carolina at Chapel Hill
- Mark Gold, Heal the Bay
- Monica Mazur, Orange County Environmental Health

Thursday, October 14, 2004

Concurrent Track II: Changes on the Horizon

7:30–5:00 **Registration**
Grand Ballroom Lobby

8:00 **Registration**
Grand Ballroom Lobby

8:00–9:40 **Session VIII: Making Warning Systems More Rapid: Modeling and Rapid Methods**
Moderator—Steve Weisberg, Southern California Coastal Water Research Project
Salon D/E

8:00–8:20 **A Regional Nowcast Model for Southern Lake Michigan Using Data Readily Available to Beach Managers**
Richard Whitman, U.S. Geological Survey

8:20–8:40 **Predicting the Need for Beach Closures in Real Time: Statistical Approaches and their Applicability to the Lake Michigan Shoreline**
Greg Olyphant, Indiana University

8:40–9:00 **High Frequency Radar Provides Real Time Data for Enhancing Beach Monitoring Programs**
Eric Terrill, Scripps Institution of Oceanography

9:00–9:20 **Rapid Measurement of Bacterial Fecal Pollution Indicators at Recreational Beaches by Quantitative Polymerase Chain Reaction**
Richard Haugland, U.S. Environmental Protection Agency

9:20–9:40 **Recreational Water Testing by Rapid, High-Throughput Real Time Quantitative PCR (QPCR) for Fecal Indicators**
Jack Paar and Mark Doolittle, U.S. Environmental Protection Agency

9:40–10:20 **Break**

10:20–12:00 **Session IX: New Health Risk Indicators**
Moderator—Rebecca Calderon, U.S. Environmental Protection Agency
Salon D/E

10:20–10:40 **Comparative Testing of Rapid Microbiological Indicator Methods for Marine Recreational Water Monitoring**
Stephen Weisberg, Southern California Coastal Water Research Project

10:40–11:00 **Assay and Remote Sensor Development for Molecular Biological Water Quality Monitoring**
Kelly Goodwin, National Oceanic and Atmospheric Administration (NOAA)

11:00–11:20 **Quantification of Enterovirus in Seawater at Imperial Beach, CA using real-time RT-PCR**
Rick Gersberg, San Diego State University, School of Public Health

11:20–11:40 **Rapid Detection of Enteroviruses in Environmental Samples using Real-time Quantitative Reverse Transcriptase PCR**
Rachel Noble, University of North Carolina at Chapel Hill

11:40–12:00 **Male-Specific Coliphages as Indicators of Fecal Pollution in Coastal Recreational Waters**
Greg Lovelace, University of North Carolina at Chapel Hill

12:00–1:20 **Lunch**
Pavillion

Linking the Oceans and Human Health: Perspectives from the U.S. Commission on Ocean Policy and the new NOAA OHH Initiative
Paul Sandifer, National Oceanic and Atmospheric Administration
Sponsored by Idexx Laboratories

1:20–3:00 **Session X: Quantifying Swimmer Risk**
Moderator—Al Dufour, U.S. Environmental Protection Agency
Salon D/E

1:20–1:40 **EPA national Epidemiology Study**
Timothy Wade, U.S. Environmental Protection Agency

1:40–2:00 **Mission Bay Epidemiology Study**
Jack Colford, University of California at Berkeley

2:00–2:20 **Risk Perception Bias and Self Reported Symptoms**
Jay Fleischer, NOVA Southern University

2:20–2:40 **Criteria Development: Beach Act Requirements and Schedule**
Stephen Schaub, U.S. Environmental Protection Agency

2:40–3:00 **Evaluation of Recreational Health Risk in Coastal Waters Based on Enterococcus Densities and Bathing Patterns**
David Turbow, Touro University International

3:00–3:20 **Break**

3:20–5:00 **Session XI: Plenary Panel Discussion**
Moderator—Steve Weisberg, Southern California Coastal Water Research Project
Salon D/E

Panel
- Denise Keehner, U.S. Environmental Protection Agency
- Shannon Briggs, Michigan Department of Environmental Quality
- Rachel Noble, University of North Carolina at Chapel Hill
- Mark Gold, Heal the Bay
- Monica Mazur, Orange County Environmental Health

Friday, October 15, 2004

7:30–12:00 **Registration**
Grand Ballroom Lobby

8:00 **Registration**
Grand Ballroom Lobby

8:10–9:50 **Session XII: Data Management and Communication**
Moderator–Charles Kovatch, U.S. Environmental Protection Agency
Salon D/E

8:10–8:30 **eBeaches**
Charles Kovatch, U.S. Environmental Protection Agency

8:30–8:50 **Managing, Storing and Sharing Beach Monitoring Data**
Bill Geake, Windsor Solutions

8:50–9:10 **Leveraging Technology for Effective Beach Management**
Eric Sacon, Rhode Island Department of Health

9:10–9:30 **Experience of Delaware**
Dennis Murphy, Delaware Department of Natural Resources & Environmental Control

9:30–9:50 **Experience of Massachusetts**
Tom Hinchliffe, Massachusetts Department of Public Health

9:50–10:20 **Break**

10:20–11:40 **Session XIII: Communicating Beach Condition to the Public**
Moderator: Toni Glymph, Wisconsin Department of Natural Resources
Salon D/E

10:20–10:40 **Heal the Bay's Beach Report Card®: Communicating Complex Water Quality Issues and Improving Public Health**
James Alamillo, Heal the Bay

10:40–11:00 **Methods for Assessing Beach Management Policy Effectiveness**
Sharyl Rabinovici, U.S. Geological Survey

11:00–11:20 **Beachwater Contamination and Source Control: the Public Right-to-Know**
Mark Dorfman, Environmental Research and Education

11:20–11:40 **So Many Report Cards, So Little Information**
Steve Aceti, California Coastal Coalition

11:40–12:00 **Session XIV: Conference Wrap Up**
Salon D/E
Workshop Summary and Future directions of the EPA BEACH Program
Denise Keehner, U.S. Environmental Protection Agency, Office of Science and Technology

Wednesday, October 13

8:30 a.m. – 9:50 a.m.

Session One: Welcome and Plenary Speakers

San Diego Welcome

Donna Frye
City of San Diego

Biosketch

Donna Frye was elected Councilmember for the City of San Diego's Sixth District in a special election on June 5, 2001. She was re-elected to a full, four-year term in March 2002 with a resounding 65 percent of the vote. Councilmember Frye currently serves as the Vice Chair of the Public Safety and Neighborhood Services Committee. She also serves on the Natural Resources and Culture Committee, Land Use and Housing Committee, Mayor Murphy's Clean Water Task Force, San Diego River Conservancy, Abandoned Vehicle Abatement Service Authority, Local Agency Formation Commission, SANDAG Walkable Communities Committee, San Diego Trolley Advisory Board and the Service Authority for Freeway Emergencies.

Councilmember Frye is an environmental activist who has advocated for more open decision-making by elected officials. She is the founder of Surfers Tired of Pollution (STOP), an advocacy group created in 1995 to protect natural resources, and is a past consultant for the Center for Marine Conservation, a national nonprofit group based in Washington D.C. Donna also co-owns a surf shop in Bay Park with her husband, legendary surfer, Harry "Skip" Frye.

As a Councilmember, Donna has worked tirelessly to increase public participation in local government, ensure that city resources are allocated to the communities of District Six, repair and replace aging infrastructure, ensure that development in District Six complies with Community Plans, expand Branch Library services, expedite undergrounding of utilities, protect and preserve our canyons, open space and public parkland, reduce sewage spills and prevent polluted runoff, and slow down traffic in our neighborhoods.

Before being elected, Councilmember Frye was active in community and environmental issues in San Diego since the early 1980s. Donna advocated for clean water issues and openness and ethics in government. She worked to strengthen San Diego City policies related to polluted runoff, including the initiation of the posting of warning signs in front of storm drains, the monitoring of discharges at storm drain outfalls, the diversion of dry weather low-flow runoff into the sewer system and she played a central role in obtaining millions of dollars for the clean up of Mission Bay.

Councilmember Frye is a member of the Clairemont Town Council, Linda Vista Civic Association, and Women In Business, and was a long-time member and former Vice Chair of the Pacific Beach Community Planning Committee. To ensure that small business owners had the right to vote when their taxes were increased for Business Improvement Districts, Donna worked jointly with the San Diego Taxpayers' Association and the Howard Jarvis Taxpayers' Association.

In recognition of her hard work on behalf of our communities, Donna has received commendations from the San Diego County Board of Supervisors and Assembly Member Howard Wayne. She also received the Bank of America Small Business Award for Commitment to Community and was named Environmentalist of the Year by the Surf Industry Manufacturers Association (SIMA). Washington D.C. based, Clean Water Network named Donna one of thirty national Clean Water Act heroes for her contribution to the protection and restoration the nation's rivers, lakes, wetlands and coastal waters.

EPA Welcome

Wayne Nastri
U.S. Environmental Protection Agency, Region 9

Biosketch

Wayne Nastri, a lifelong westerner, was appointed Regional Administrator for Region 9 in October 2001. Mr. Nastri has led the Region to real progress in meeting the west's environmental challenges, especially in improving air quality in the Central Valley and Southern California and in protecting of scarce water resources throughout the arid west. Clear communication, strong enforcement and accountability to the public for a measurable "bottom line" have been the hallmarks of his tenure. A strong proponent of partnership as the best route to environmental protection, Mr. Nastri has launched many creative collaborations to protect the health and environment of all those who live in the Pacific Southwest.

Most recently, Mr. Nastri partnered with EPA's Seattle region to launch the West Coast Diesel Emission Reduction Collaborative, which will speed voluntary reductions of diesel emissions from ports, trucks and other federally regulated sources in a significant assault on one of the west's gravest air quality problems. Mr. Nastri also created EPA's Southern California Field Office in Los Angeles -- a major improvement in EPA's local presence for the region's largest metropolitan area.

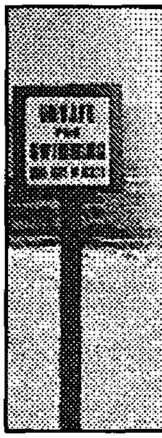
Prior to his appointment, Mr. Nastri held various environmental leadership positions, including Board membership for California's South Coast Air Quality Management District (covering Southern California), as well as participation in advisory boards for California's state air quality and waste management agencies. His fifteen years of environmental consulting experience culminated in his presidency of Environmental Mediation Inc. before accepting his position at EPA.

Beach Act Actions: 2000-2004 and Beyond

Denise Keehner
U.S. Environmental Protection Agency, Office of Science and Technology

Biosketch

Denise Keehner is the Director of the Standards and Health Protection Division in the Office of Science and Technology in the Office of Water. Her Division is the Headquarters Office responsible for the Water Quality Standards Program, the Beach Program, and, the Fish Advisory Program. Denise has been in this position since May 2003. Prior to her joining the Office of Water, Denise was the Director of the Biological and Economic Analysis Division (BEAD) in the Office of Pesticide Programs (OPP) and the acting Director of the Environmental Fate and Effects Division in OPP. She has been with USEPA at Headquarters for 26 years and has served in management positions since 1985.



Partnering for Clean Beaches
Taking Stock and Turning to the Future

Denise Keehner
U.S. Environmental Protection Agency

National Beach Conference
10/13/04

We have a dream . . .

- Imagine a time in the future when people don't have to wonder about whether swimming is safe at any beach in the country because:
  - pollution sources are controlled such that they do not impact beaches
  - you know that the water is sufficiently tested
  - the public is promptly notified in real time when there is a real problem

Overview of Conference Goals

- **Conference is a good chance to:**
  - Look at what we have accomplished
  - Develop a shared vision of where we want to go in the future
  - Identify key sets of priorities for federal, state, and local actions.

Environmental Concerns

- **BEACH Act passed in response to key concerns:**
  - Persistent beach advisories and closings
  - Substantial inconsistency in beach monitoring
  - Inconsistent public notification programs
  - Divergent water quality standards
  - Increased development pressure

Beach Act Progress

- Where are we?
  - Making good progress with substantial effort in following areas:
    - Water quality criteria and standards
    - Grants to support and strengthen state, territorial, and local programs
    - Monitoring
    - Public notification
    - Data systems development
    - Research

Water Quality Criteria & Standards

- Existing Criteria & Standards
  - **BA Provision:** State must adopt EPA's recommended water quality criteria (or criteria as protective) within 3 ½ years (4/04). If state fails to adopt, EPA shall propose regulations for revised standard
  - EPA's rule has consumed much of my office's time in recent months
  - *"Heads Up"*
    - Rule to be finalized soon putting 304(a) criteria in place wherever they aren't (coastal and Great Lakes); maybe as soon as this week

Water Quality Criteria & Standards

- New/Revised Criteria
  - **BA Provision:** EPA shall conduct research for new indicators & propose new criteria within five years [10/05]
  - **Status:** This topic will be discussed later in the program.
    - Multi-criteria status effort by EPA's Office of Research and Development. Collaborative effort between two labs (NERL and NHEERL)
      - Monitoring and epi studies: criteria dev.
  - *"Heads Up"*
    - Intensive Technical Review and significant decisions – Many upcoming reviews during next year that will affect states in the future.

BEACH Grants

- Grants
  - ***B A Provision:*** Act adds new Section 406 to Clean Water Act which authorizes federal grants to conduct monitoring and notification programs.
  - **Status:** $32 million since FY 2001
    - States have used grants to strengthen equipment, staff, and beach programs
  - *"Heads Up"*:
    - [illegible]
      - grant applications & approvals are timely & expenditure are prompt and meet requirements
      - programs are well established and performing well

Beaches & Monitoring

- National "List of Beaches" and Locations
  - **States** submitted their *List of Beaches* to EPA during fall 2003 and spring 2004.
  - EPA published the List of Beaches in the Federal Register on May 4, 2004. We have on the order of 6,000 beaches now listed with 57% reportedly monitored.
  - List will be updated periodically

Beaches & Monitoring

- **Monitoring accomplishments**
  - EPA guidance recommended risk-based, tiered monitoring
  - ORD intensive monitoring study undertaken
  - State revisions to improve, clarify, and/or expand monitoring. Better information on beach locations, monitoring stations and monitoring programs. Some increased monitoring apparent
  - *"Heads Up"*:
    - ORD and other recent monitoring studies raise issues about needed frequency and location of monitoring. Monitoring programs will face difficult choices about how to balance the need for more robust data with funding limitations.

Public Notification & Communication

- Public Notification
  - ***Status:*** Goal is to inform public so they can make informed decisions before going to the beach, reducing illness risk.
  - Public notification efforts improving
  - Emergence of reports from groups like *Heal the Bay, Surfrider, Earth 911*
  - *"Heads Up"*:
    - Be sensitive to information the public wants and how they interpret it. Some needs are "real time" whereas other information needs to be synthesized over multiple years for, say, vacation planning purposes.

Beach Data

- National Beach and EPA data
  - ***BA Provision:*** EPA provide national database monitoring and notification submitted by states & locals.
  - ***Status:*** Major effort by EPA and states.
    - "eBeaches": multiple databases to collect, store, display beach water quality data, beach advisory data, and beach location data.
  - *"Heads Up"*:
    - Need for prompt, complete and accurate beach-related information by the public, government managers, strategic planners, and others.
    - Change is constant in the Information Technology realm.

To Sum Up…

- 1986 pathogen criteria should be in place soon wherever still needed
- New criteria for at least the Great Lakes to emerge end of this FY
- New marine criteria to follow (epi studies still needed)
- Use Grant $ wisely part. in light of 2006
- Monitoring happening but research results on horizon will put pressure on $
- Public is more and more hungry for information—real time and synthesized and EPA is doing its part to help make this happen

What Else Should We Focus On?

- I need your help to fill in the blanks…
  - More linking of monitoring results to CDC outbreak data?
  - More predictive tools?
  - Additional pathogen criteria?
  - More collaborative work with groups like Surfrider, Heal the Bay, NRDC, Earth 911 to standardize criteria for comparing beaches?
  - More focus on pollution prevention?
  - ?
  - ?

Waterborne Pathogens and Indicators: A Pathway Forward

Joan Rose
Michigan State University

Biosketch

Dr. Joan B. Rose currently holds the Homer Nowlin Chair in Water Research at Michigan State University after receiving her PhD from the University of Arizona and spending 14 years at the University of South Florida. Dr. Rose is an international expert in water microbiology, water quality and public health safety publishing more than 200 manuscripts. Her work has examined new molecular methods for waterborne pathogens and zoonotic agents such as *Cryptosporidium* and enteric viruses and source tracking techniques. She has been involved in the study of water supplies, water used for food production, and coastal environments as well as water treatment wastewater treatment, reclaimed water and water reuse and quantitative microbial risk assessment. She specifically interested in microbial pathogen transport in coastal systems and has studied the impact of wastewater discharges and climate on water quality. She has recently been appointed to the Science Advisory Board for the International Joint Commission of the Great Lakes and the Drinking Water Committee for the Environmental Protection Agency. She was awarded the 2001 Clarke Water Prize. She is serving as the Chair of the International Water Association's Health-Related Water Microbiology Specialty Group.

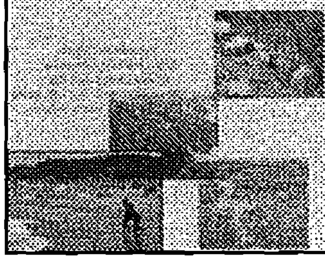
Waterborne Pathogens and Indicators: A Pathway Forward

Joan B. Rose

MICHIGAN STATE UNIVERSITY

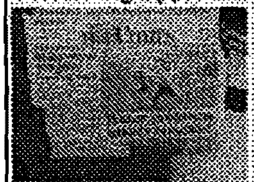
Indicators for Waterborne Pathogens

NRC report 2004



- Evaluate strengths and weaknesses of Indicators.
- Identify which can address sources.
- Define current waterborne pathogens and emerging pathogens.
- Report on Future indicators and methods.
- Address practicality of technology.
- Examine research and data needs for validation of methods.

Three-level Phased Monitoring Approach



Level A Screening/ Routine monitoring

Level B Investigations to confirm health risk

Level C Detailed Investigations Source Transport Mitigation

Indicators Screening Level A

	numbers of Jurisdictions 2002
Fecal coliforms	36 for Fresh; 14 for Marine waters
E.coli	11 for Fresh; 0 for Marine waters
Enterococci	2 for Fresh; 7 for Marine waters

Current and Alternative Indicators

Indicator Standards for Recreational and Marine Water

Fecal coliforms	200 cfu/100mL Ave density
E.coli	126 cfu/100mL Ave density
Enterococci	33 to 35 cfu/100ml Ave density
Clostridium perfringens	50 or 5 cfu/100ml (Fujioka et al 1985)
Coliphage	No current suggested standards. 100 pfu relates to enteric virus presence

---

Recreational Outbreaks in Ambient Waters

Indicators relationship:

- to health effects
- to pathogen occurrence
- To sources

Correlations of Indicators in a Marine coastal system

Indicators against each other	r value
E. coli/FC	0.868
Coliphage/Enterococci	0.781
Enterococci/FC	0.659
E. coli/Enterococci	0.623
FC/Coliphage	0.557
E. coli/Coliphage	0.516
Enterococci/*C. perfringens*	0.432
Coliphage/*C. perfringens*	0.374
FC/*C. perfringens*	0.368

Correlations with Enterovirus in a Marine coastal system

Indicators against Enterovirus results	r value
Enterovirus/Enterococci	0.553
Enterovirus/Coliphage	0.457
Enterovirus/Fecal Coliforms	0.442
Enterovirus/*E. coli*	0.370
Enterovirus/*Clostridium perfringens*	0.199

In studies children were 3X more likely to develop diarrhea and respiratory infections

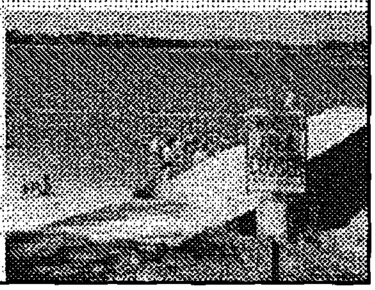
Risk of infections significantly higher when swimming in contaminated water

Respiratory infections

Skin infections

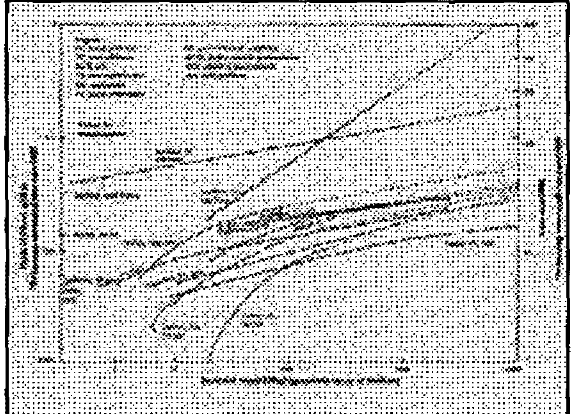
Eye/ear and nose infections

Gastrointestinal infections



Health Data Associated with Swimming in Polluted Waters

- Disease endpoints: Respiratory, gastrointestinal, ear, eye, nose and skin infections.
- England: respiratory most common, 24% had one symptom.
- Santa Monica Bay, CA: gastrointestinal, 3.7%, associated with storm drains.
- Key West, FL: gastrointestinal most common, 33% associated with leaky sewer, liveaboards.

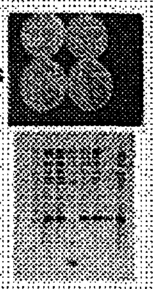


Meta Analysis
Jack Colford

- Recreational Epidemiological Studies
- Enterococci demonstrated the best statistical association in Marine Waters and was a good statistical fit in Fresh Waters
- E coli was the best indicator of risk in Fresh Waters
- Coliphage and Enteric virus showed some relationship, however only a few studies

Bacterial Source Tracking
Library-based methods "Fingerprinting" Indicator Bacteria

- **Antibiotic Resistance Analysis**
  - ⇨ **phenotype**
- **Ribotyping**
  - ⇨ **genotype**



Source Tracking Round Robin Study

J. Water and Health Vol 1, No. 4 Dec. 2003

- 22 researchers 12 methods.
- 12 prepared samples
- 4 contained untreated sewage
- 4 contained human feces
- 5 contained cow feces
- 4 contained dog feces
- 4 contained gull feces

Results

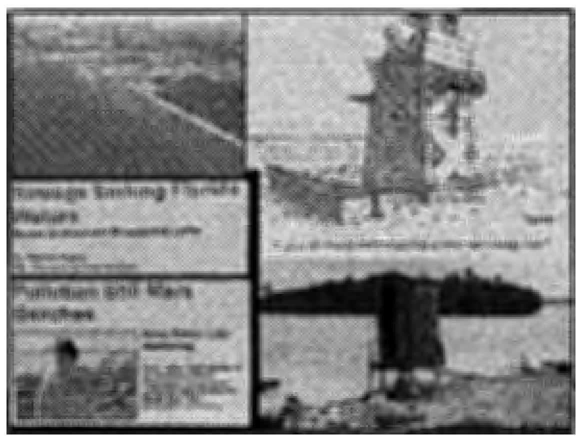
- F+ Specific Coliphage were isolated at high concentrations from all samples that had sewage.
- Typing did not address source
- Human feces were negative
- Antibiotic Resistance gave 39-65% False positives
- Ribotyping , Rep PCR and PFGE gave 14-33% False positives
- Small library
- Fecal Streptococci performed better

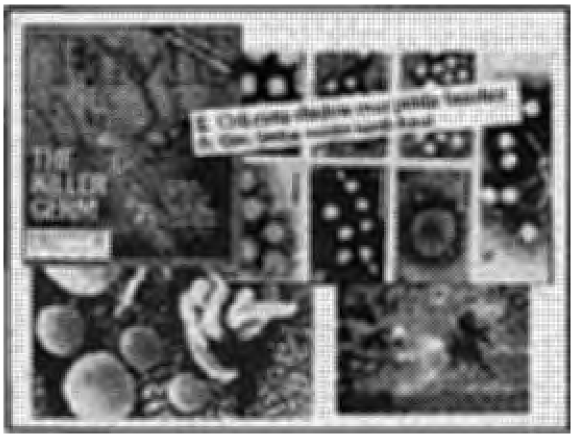
Host Specific Markers

- Bacteroides (PCR)
- 4/4 sewage, 4/4 human, 4/5 cow (lowest concentration missed) 4/4 dogs however no marker for Birds . Missed 2 samples with dog and 2 with cow that were mixed.
- E.coli Toxin genes able to detect sewage (4/4).
- Enteroviruses and Adenoviruses found in 3 of 4 sewage samples.

Source Tracking at MSU

- Recently developed method to track a Human marker in Enterococci.
- 107/109 samples from human sewage and septic tanks were positive.
- 0/80 samples from cattle, swine, bird, fecal samples and lagoons were positive.
- Enterococci proposed as a better indicator of recreational risk and groundwater risk, thus this marker can give the source of that risk.
- Can be used with Enterolert or membrane filtration methods.





EnteroVirus Detection in Coastal Waters

• Greece	• 21%
• Italy	• 32%
• Spain	• 44%
• Florida	• 79% PCR;20% cult.
• Hawaii	• 8% cult.
• Texas	• 40 to 72%

AdenoVirus Detection in Coastal Waters

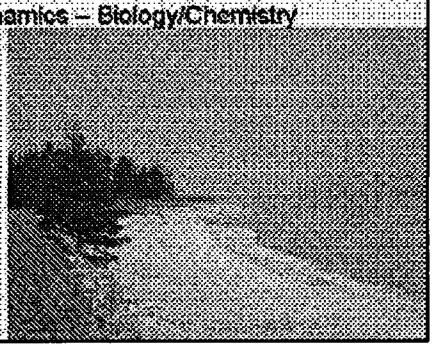
• Greece	• 34%
• Spain	• 78%
• California	• 33%

Other viruses detected include Norwalk virus (11%); HAV (35-63%); Reoviruses (3-30%)

TECHNOLOGIES FOR PROTECTION OF RECREATIONAL WATER QUALITY AND HEALTH

- Quantitative Risk Assessment to frame the assessment of human health implications
- Methods to Characterize human health hazards and the sources via monitoring for Enteric bacteria, viruses, *Cryptosporidium* and *Giardia*
- Watershed approach: environmental factors impacting water quality impairment
- Apply new technology and tools for source tracking and evaluate transport and fate

MODELING: LAND-WATER
Climate –Meterology –Hydrology –
Hydrodynamics – Biology/Chemistry



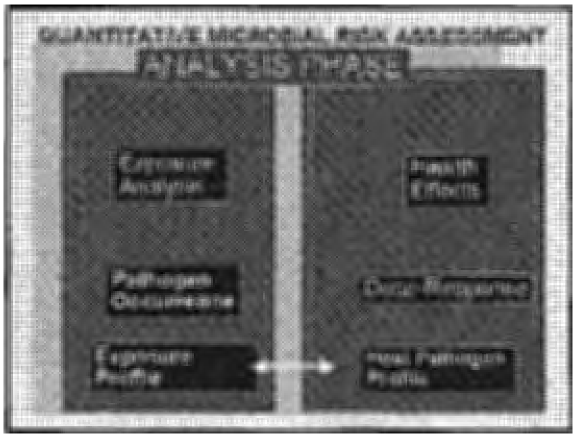
NATIONAL ACADEMY OF SCIENCES RISK PARADIGM

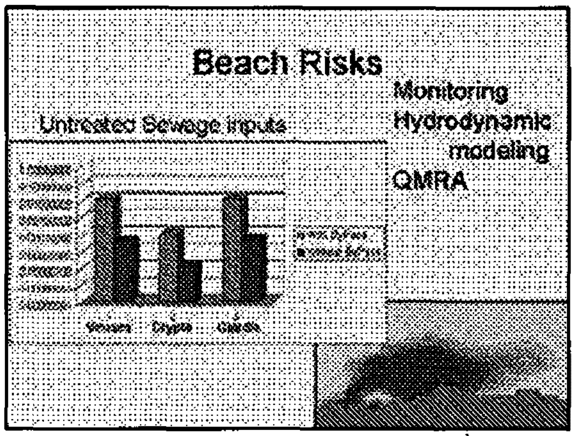
HAZARD IDENTIFICATION
Types of microorganisms and disease end-points

DOSE-RESPONSE
Human feeding studies, clinical studies, less virulent microbes and health adults

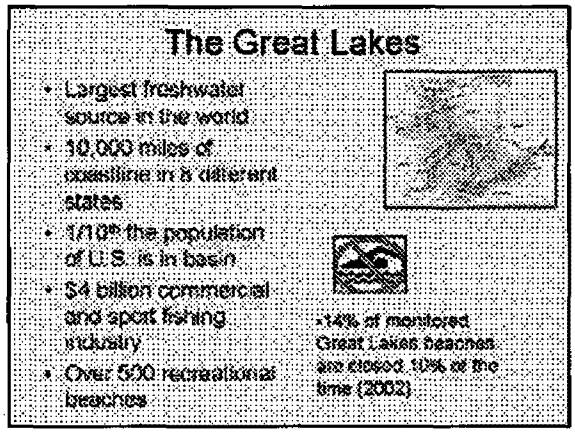
EXPOSURE
Monitoring data, indicators and modeling used to address exposure

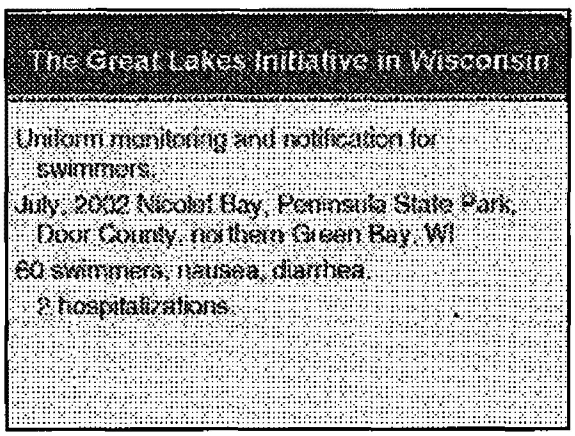
RISK CHARACTERIZATION
Magnitude risk, uncertainty and variability

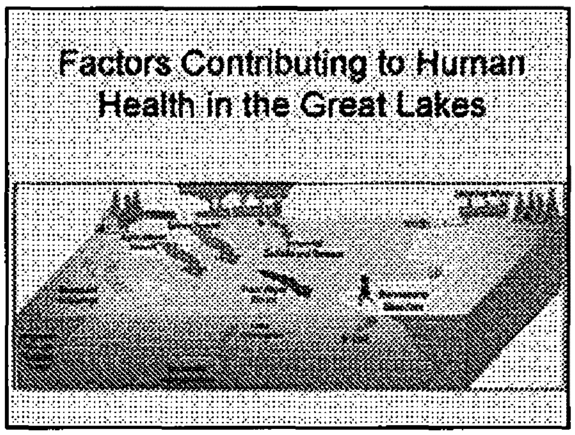

QUANTITATIVE MICROBIAL RISK ASSESSMENT
ANALYSIS PHASE
Exposure Analysis
Health Effects
Pathogen Occurrence
Dose Response
Exposure Profile
Host Pathogen Profile

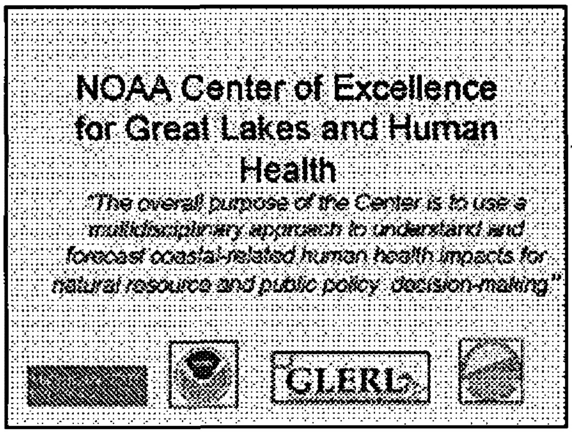

Beach Risks
Untreated Sewage inputs
Monitoring
Hydrodynamic modeling
QMRA

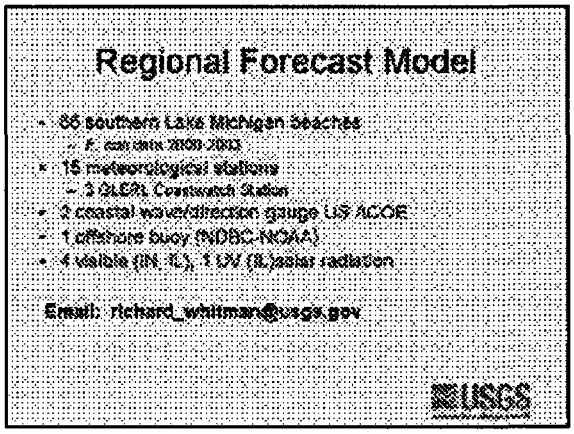

Recommendations for Florida Beaches
Evaluation of Indicators: Phase A
• The use of two indicators is warranted, Fecal Coliforms still have merit and Enterococci should be added.
• Coliphage should be added as a third indicator in areas with fresh water inputs and study of storm events.
Application of technology: Phase C
• Source tracking was used and correlated human sources with virus pathogens presence. Septic tanks and storm water.
• Environmental impacts & Risk: Phase B
• Rainfall linked to water quality, cumulative over 3 to 10 days, but other environmental factors are contributing.
• Enteroviruses are impacting coastal waters.

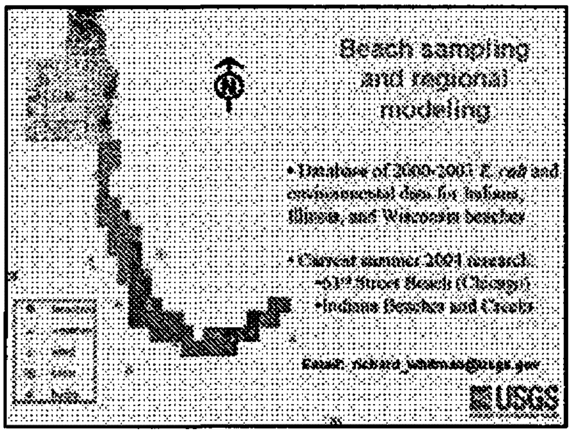

The Great Lakes
• Largest freshwater source in the world
• 10,000 miles of coastline in 8 different states
• 1/10th the population of U.S. is in basin
• $4 billion commercial and sport fishing industry
• Over 500 recreational beaches
•14% of monitored Great Lakes beaches are closed 10% of the time (2002)

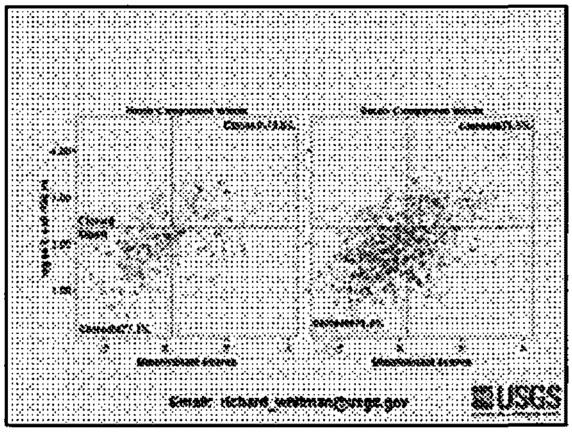

The Great Lakes Initiative in Wisconsin
Uniform monitoring and notification for swimmers.
July, 2002 Nicolet Bay, Peninsula State Park, Door County, northern Green Bay, WI
60 swimmers, nausea, diarrhea.
2 hospitalizations.

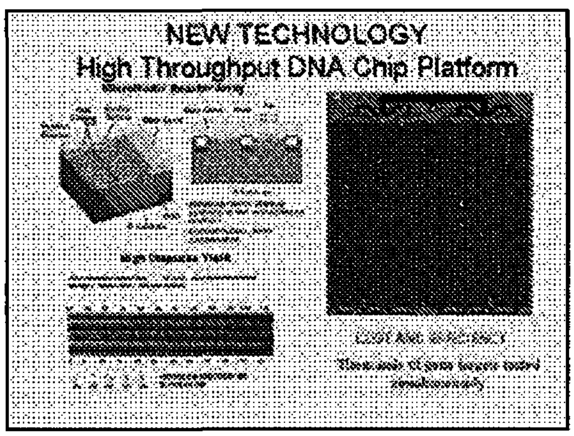

Factors Contributing to Human Health in the Great Lakes

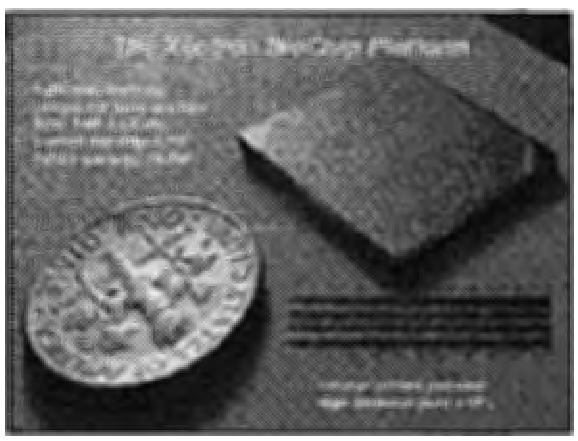

NOAA Center of Excellence for Great Lakes and Human Health
"The overall purpose of the Center is to use a multidisciplinary approach to understand and forecast coastal-related human health impacts for natural resource and public policy decision-making"
GLERL

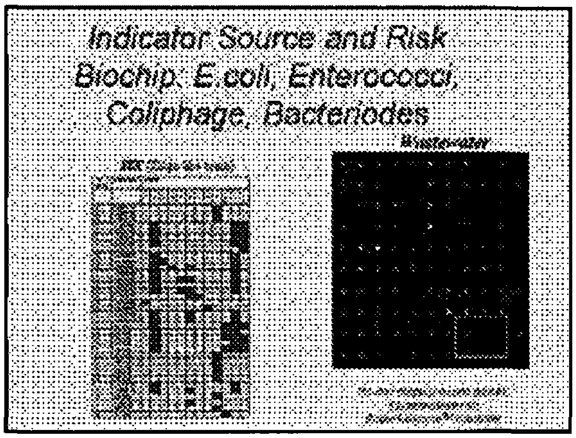

Regional Forecast Model
66 southern Lake Michigan beaches
15 meteorological stations
2 coastal wave/direction gauge US ACOE
1 offshore buoy (NDBC-NOAA)
4 visible (IN, IL), 1 UV (IL)solar radiation
Email: richard_whitman@usgs.gov
USGS


Beach sampling and regional modeling
USGS


Email: richard_whitman@usgs.gov
USGS

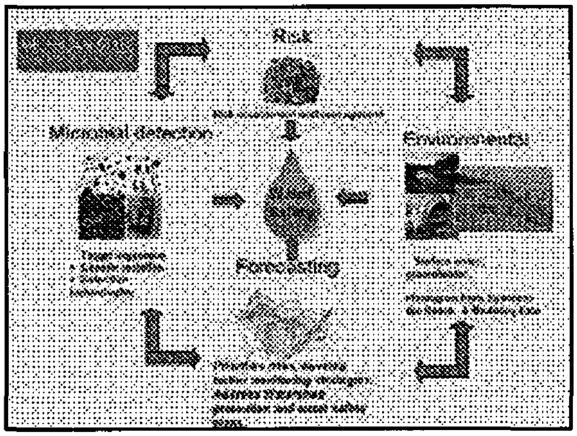

NEW TECHNOLOGY
High Throughput DNA Chip Platform

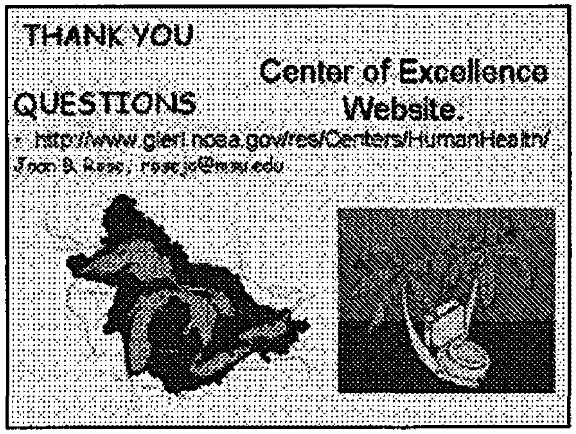




The FUTURE

- More studies are needed
- Political Will
- Longer term strategy for studying microorganisms and water quality
- Funding for surveys
- Application of new technology; better and more specific information.
- BETTER PROTECTION OF WATERS
- ABILITY TO PRIORITIZE
- LONG TERM SUSTAINABILITY





Wednesday, October 13

10:20 a.m. – 12:00 p.m.

Session Two: State and Local Experiences in Implementing Beach Monitoring & Notification Programs

Hawaii Watershed Initiative and Clean Beaches

Carl Berg
Hanalei Watershed Hui

Biosketch

Dr. Berg is Chief Scientist of the Hanalei Watershed Hui; a community based non-profit organization on Kauai. Dr. Berg received his B.A .in Zoology from the University of Connecticut, his M.S. in Marine Science from the University of the Pacific, and his Ph.D. in Zoology from the University of Hawaii. He was a professor at City College of New York, a research associate at Harvard and Columbia universities, a staff scientist at the Marine Biological Laboratory in Woods Hole, and a Biological Scientist at the Florida Marine Research Institute. His research focused on population ecology of marine invertebrates on islands in the Caribbean and in the deep sea at hydrothermal vents. He retired to Kauai in 1990, but briefly worked for the Hawaii Department of Health monitoring water quality in the ocean and streams. He later volunteered as water quality monitoring coordinator for the Hanalei Heritage River Program, assuming the role as Chief Scientist as it morphed into the Hanalei Watershed Hui.

Abstract

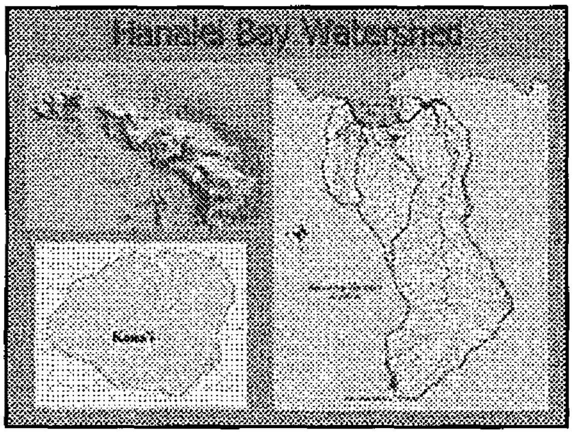
Hanalei Watershed Hui began monitoring waters of Hanalei Bay in 2000 because of community based concerns over pollution by people living aboard boats anchored in the Bay during the summer. Samples were collected by volunteers and analyzed for bacteria by the Hawaii Department of Health laboratory. No evidence of discharge was obtained, but the monitoring program has continued. We have found no correlation between the number of boats in the Bay and the bacteria counts.

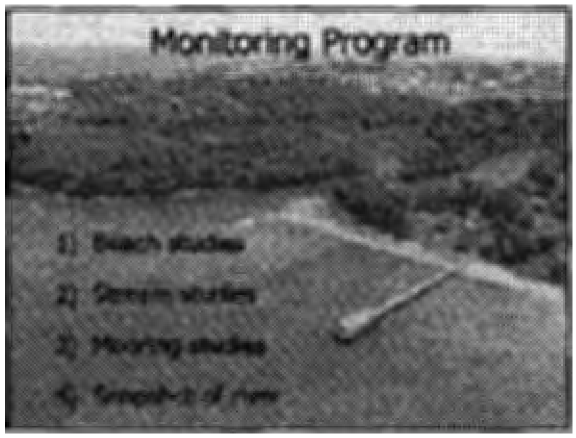
Starting in 2001, the Hui began its own monitoring program for Enterococcus bacteria using IDEXX Enterolert and Quanti-Tray technologies to supplement DOH sampling, spatially and temporally. Samples were taken at three beach parks on Hanalei Bay during periods of peak use, weekends and holidays, and in four recreational streams entering the Bay. Snapshot sampling was done in the Hanalei River and its tributaries to identify sources of contamination. This information was provided to the Hawaii DOH to aid its efforts in monitoring water quality and in identifying sources of contamination. It was also considered in listing Hanalei River in the Hawaii 303d list of impaired waters.

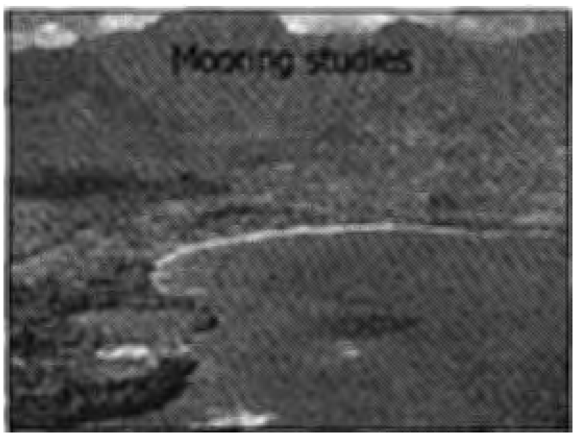
Results of the weekend testing for Enterococcus bacteria are provided to the community via popular surf reports on local public radio (KKCR). Reports of the overall testing program are provided via community meetings, newsletters, our website (www.Hanaleiriver.org), radio talk shows, and in a regular public television forum series. Our staff and volunteers are frequently asked "How is the water?" as they are out on the beach or in the community.

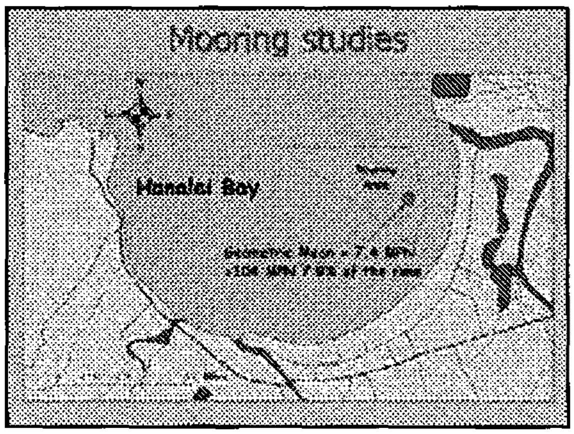

Hanalei Watershed Hui

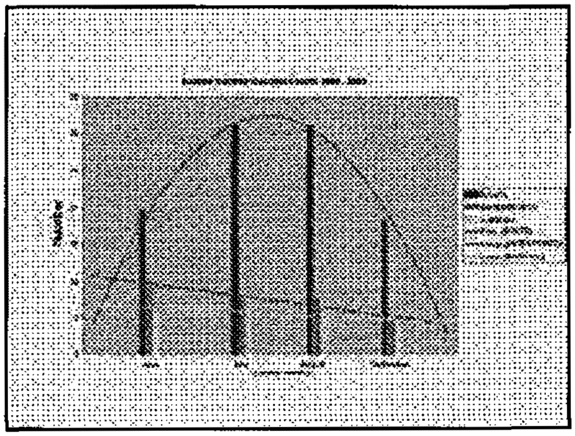

Hanalei Watershed Initiative

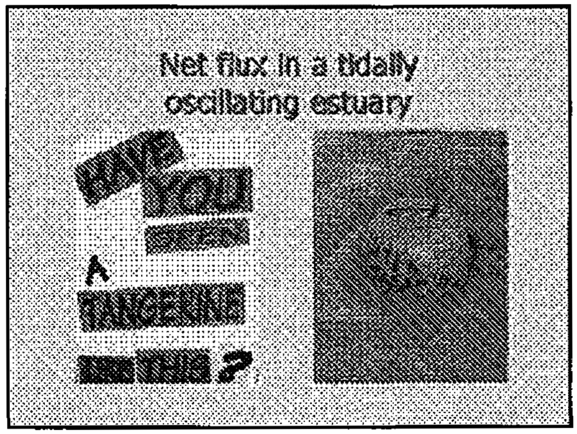

Hanalei Bay Watershed
Kaua'i

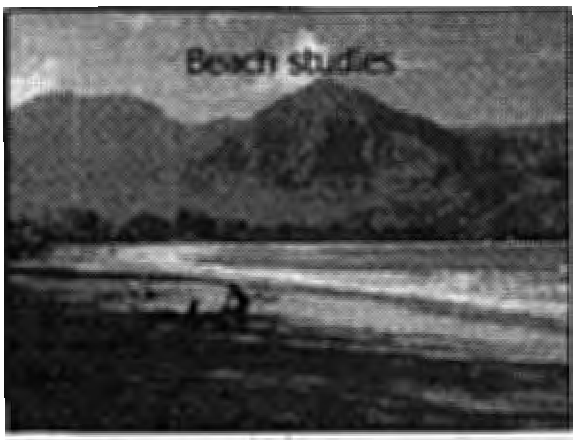

Monitoring Program
1) Beach studies
2) Stream studies
3) Mooring studies

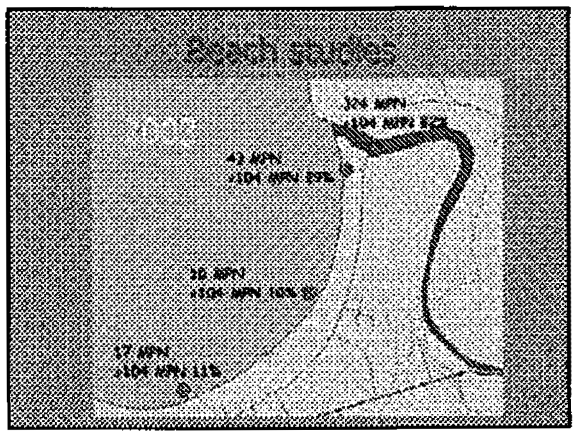

Mooring studies

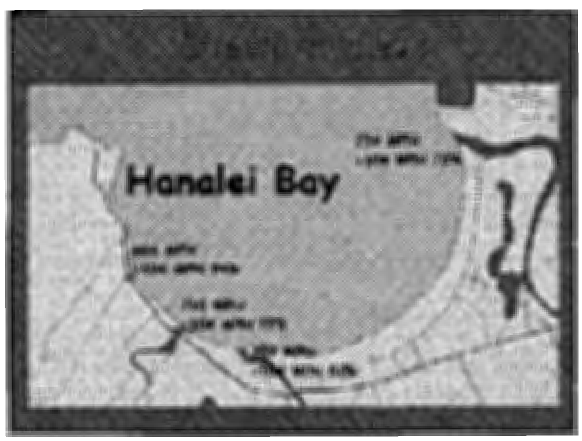

Mooring studies
Hanalei Bay

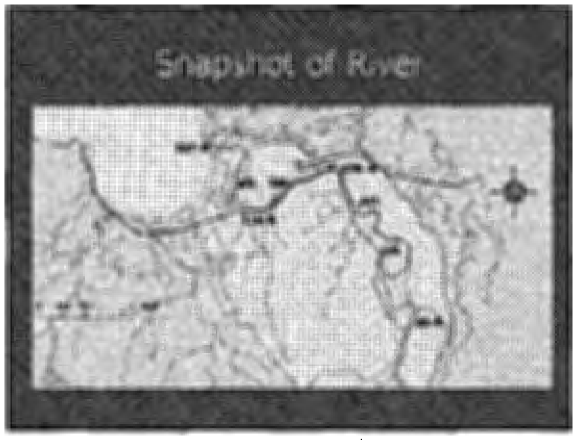



Net flux in a tidally
oscillating estuary
HAVE
YOU
A
TANGERINE
THIS ?


Beach studies

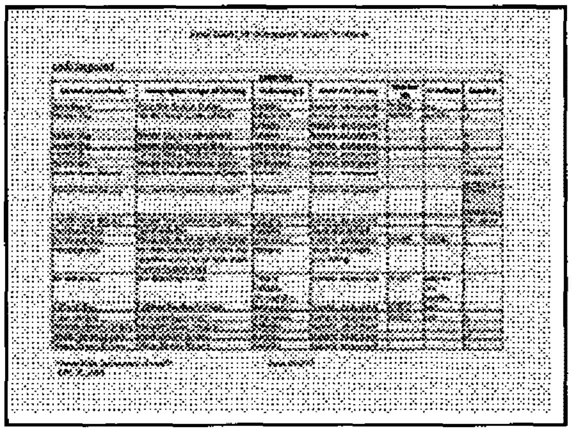

Beach studies


Hanalei Bay



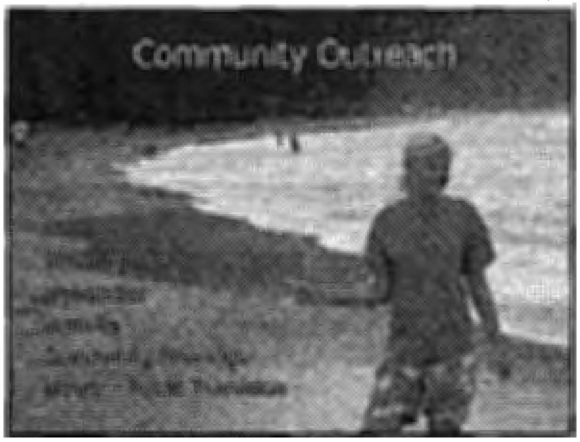
Working with Hawaii Department of Health

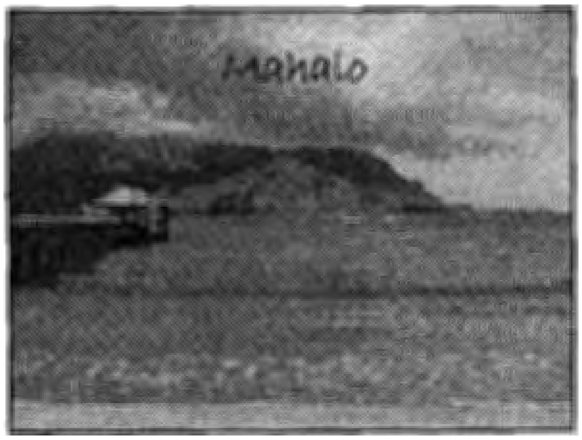
Supplemental Monitoring
Source Identification
303 (d) Listing
TMDL



NRDC report "suspicious" of isle beaches' spotless health record

- No beach closing in 2003
- HAR – "Warning signs shall be posted at locations where human sewage has been identified as temporarily contributing to the enterococcus count."


Community Outreach


Mahalo

Questions and Answers

Q: It was noticed that river bacteria readings were lower in the upper watershed and higher in lower watershed. The lower watershed levels compared to levels in southern California. Sometimes the levels in Southern California are higher (in the thousands) and reduced closer to the mouth, but in Southern California we see bacterial blooms, shore birds, ponding, and regrowth, near the river mouth. Why do the levels in Hawaii drop off as the river gets closer to the ocean?

Carl Berg

The drop of bacteria levels at the mouth is due to estuary mixing, as evidenced by the salinity values. A dilution occurs.

Q: Have you taken groundwater samples? The presence of a cesspool may not be the cause of groundwater contamination. Are there studies that show that bacteria can travel a long distance through the earth?

Carl Berg

No groundwater study was done, but there are studies that show that viruses can go 100 yards or more in a short period of time through soils. The area is sandy soils and our studies have looked at other tracers (such as estrogen levels) that show that the groundwater can get into the rivers. The Hanalei area gets enough rain to put the beach areas under water at certain times during the year.. To visitors in these areas, the cesspool contamination is obvious. Cesspool contamination occurs. Restroom facilities overflow and cause groundwater contamination.

Q: Leptospirosis is a problem in those streams and is spread primarily through urine, rather than feces. Could you predict which streams were likely to cause leptospirosis disease in humans?

Carl Berg

Leptospirosis is extremely important to study in the lake areas. The only evidence that I have for the presence of *Leptospira* is of people getting sick from the streams. There is no effective, fast way to measure *Leptospira* in the waters. Some people have been sick and/or died from contact with streams in Kauai, and larger rivers in Hawaii. Leptospirosis is prevalent in the state of Hawaii and the major streams are posted with warnings. They are not posted for *Cryptosporidium* and *Giardia*, even though they are contaminated with them. We are trying to develop an effective, quick means for measuring *Leptospira* in waters for better warnings.

Comment: There was an outbreak of aseptic meningitis in a hospital day care center. It was fecally spread by a virus. I'm concerned that there may be another outbreak of aseptic meningitis because it may be linked to one of the enteroviruses.

Carl Berg

Thank you for your comment and I would like to talk to you more about that.

Florida's Healthy Beaches Monitoring Program

Bart Bibler
Florida Department of Health, Bureau of Water Programs

Biosketch

Mr. Bart Bibler is Chief of the Florida Department of Health's Bureau of Water Programs. Mr. Bibler is an Environmental Engineer with primary focus on water quality and water management. He served as Director of Environmental Health and Engineering in Collier County, Florida. He was the Water Management Administrator for the Florida Department of Environmental Protection. And, he previously worked in the private sector, including the Orlando, Florida office of Camp, Dresser & McKee, Inc.

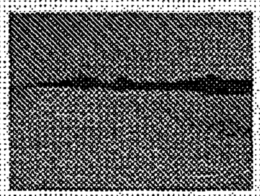
Abstract

Florida has a statewide coastal beach water quality-monitoring program to help ensure healthy beaches. The 2000 Florida Legislature enacted Senate Bill 1412 and House Bill 2145 (the Appropriations Act) authorizing and funding the Department of Health to conduct water quality monitoring of saltwater and brackish beaches. The federal BEACH Act, administered by the United States Environmental Protection Agency, supplemented the state funding with roughly an equal amount of federal funds. The Healthy Beaches Monitoring Program includes 34 of Florida's coastal counties sampling 305 sites once every week. These samples are analyzed for two types of enteric bacteria, fecal coliform and enterococci. The primary purpose of the Healthy Beaches Monitoring Program is to determine whether Florida has significant beach water quality problems, to provide this information to the public, and to gauge where or whether future beach monitoring efforts are necessary.

Fecal coliform and enterococci are both enteric bacteria, normally inhabiting the intestinal tract of humans and animals. The presence of enteric bacteria is an indication of fecal pollution, which may come from stormwater runoff, pets and wildlife, and human sewage. If they are present in high concentrations in recreational waters and are ingested while swimming or enter the skin through a cut or sore, they may cause human disease, infections or rashes.

The sampling results obtained through the program are automatically uploaded by the coastal county health departments onto the Department of Health's Internet Beach Water Quality website (www.doh.state.fl.us, click on the drop down arrow next to "-Choose Subject-" and then select "Beach Water Quality"). In addition, any advisories or warnings are promptly forwarded to the appropriate media.

Florida Healthy Beaches Program



Bart Bibler, P.E., Chief
Bureau of Water Programs

Florida Healthy Beaches Monitoring Program

Introduction

Until 2000 Florida did not have funding allocated to regularly monitor coastal beaches, resulting in a "Bum" classification from the press and environmental groups.

In 2000 the state legislature established the Florida Healthy Beaches Program and provided a recurring appropriation of $525,000 per year for the water quality monitoring of saltwater and brackish beaches.

Chapter 514.023, F.S. gives the department the authority to monitor coastal beach waters and issue advisories when conditions exceed the standards.

Florida Healthy Beaches Monitoring Program

Introduction (cont)

- From August 2000 to August 2002, Florida's 34 coastal counties conducted beach water sampling every two weeks.
- The coastal counties implemented statewide guidance to ensure that testing frequency, laboratory methods, result interpretations, and actions were consistent.

Federal BEACH Act

Beaches Environmental Assessment and Coastal Health (BEACH) Act:

Allows EPA to award grants to eligible States and Territories to develop and implement work products consistent with BEACH Act requirements.

- Florida was allocated approximately $530,000 in 2002, $544,030 in 2003, and $540,220 in 2004.
- This allocation has allowed Florida to meet EPA guidelines through weekly sampling, beginning August 2002.

Florida Healthy Beaches Monitoring Program

Water Quality Data

- The initial focus of the Florida Healthy Beaches Program was to gather and evaluate the coastal beach water quality data, and determine whether there were any beach sites with chronic water quality problems.
- Currently, evaluations are being conducted to see if there are relationships between poor water quality and environmental factors such as rainfall or water temperature.
- Determine which sites have had 21 or more advisory days/year and correlate rainfall levels to indicator values.

Florida Healthy Beaches Monitoring Program

Water Quality Data

- A DOH/DEP TAC will consider rule revisions and predictive models for issuing advisories.
- Beach monitoring data is loaded into EPA's national STORET database every 3 months.
- Advisory days by sample site are supplied to DEP for the Impaired Waters Rule upon request – usually every 3 months.

Florida Healthy Beaches Monitoring Program

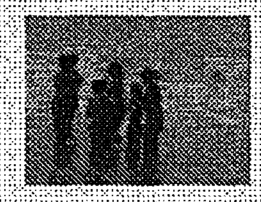
Testing has helped counties identify problems and take steps to correct.

There are over 300 beach sampling sites.

Approximately 42,000 samples have been collected since August 2000.

Florida Healthy Beaches Monitoring Program

The coastal beach water samples collected by the county health departments are analyzed for enterococci and fecal coliform bacteria, which indicate the probable presence of animal (including human) waste and pathogens.

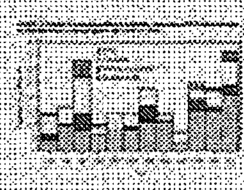


These indicators are found in the intestines of warm-blooded animals and are excreted in their waste.

Indicators are useful because it would be difficult and costly to attempt to directly detect the many different pathogens or parasites that can be found in surface waters.

Florida Healthy Beaches Monitoring Program

If waste pathogens are present in high concentrations in recreational waters and are ingested while swimming or enter the skin through a cut or sore, they may cause gastrointestinal illnesses, infections or rashes.



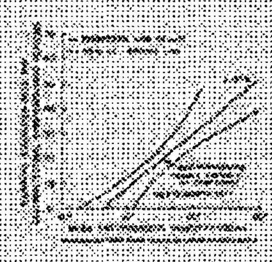
CDC. "Surveillance for Waterborne Disease Outbreaks — United States, 1999-2000" MMWR 2002;51(SS-8).

[illegible]

Florida Healthy Beaches Monitoring Program

EPA's "Ambient Water Quality Criteria for Bacteria – 1986" is based on epidemiological studies to evaluate the relationship between swimming in contaminated waters and illness rates.

Enterococci had the strongest correlation to swimmer illness rates.



EPA. "Health Effects Criteria for Marine Recreational Waters," August 1983, EPA-600/1-80-031.

Florida Healthy Beaches Monitoring Program

Bacterial Indicator Standards

Florida's adopted indicator organism for bacterial contamination is fecal coliform, as promulgated by the Florida Department of Environmental Protection.

In 1986, the federal Environmental Protection Agency revised their criteria to recommend the bacterial indicator enterococci, which provides equivalent protection but is considered a better indicator of the presence of human waste.

The Department of Health is utilizing the 1986 guidance to implement enterococci monitoring while also monitoring for fecal coliform to fulfill both Federal and State requirements.

Florida Healthy Beaches Monitoring Program

What this means

County Health Departments collect samples every week and compare results to the standard for the Single Sample Maximum (SSM).

Measures instantaneous water quality conditions.

If an enterococci result exceeds a SSM of 104 colony forming units (CFU) per 100 milliliters of beach water sampled and a resampling result also exceeds this value, then an "**Advisory**" will be issued.

If a fecal coliform result exceeds a SSM of 400, and this is confirmed, a "**Warning**" will be issued.

Florida Healthy Beaches Monitoring Program

Geometric Mean

- With the collection of weekly samples, DOH is calculating a Geometric Mean (GM) for enterococci.
  - A reflection of average conditions.
  - Calculated with the five most current sample periods, including any resampling data.
- The GM action limit for enterococci is 35 CFU/100 mL.

Public Notification

Advisories and Warnings

County health departments issue health advisories or warnings when these conditions are confirmed. If a resample cannot be collected and posted on the web page before the end of the sample period, the advisory or warning will be issued with the first poor result.

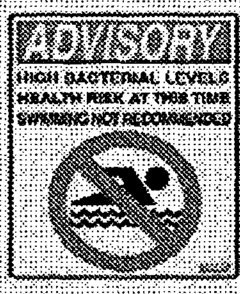
Any advisories or warnings are promptly sent to the appropriate media outlets, local officials, and the State Health Office.

Additional resampling of monitoring sites after advisories or warnings have been issued is conducted at the discretion of the county health departments.

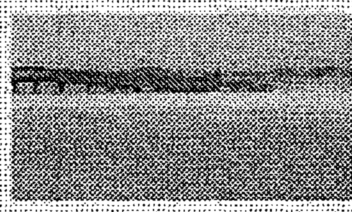
Public Notification

Measures to inform the public about advisories or warnings:

- Results are posted on the website.
- A sign is posted parallel to the sample location for the beach and at points of access.
- The media are notified.



Florida Healthy Beaches Monitoring Program



Florida Healthy Beaches Monitoring Program

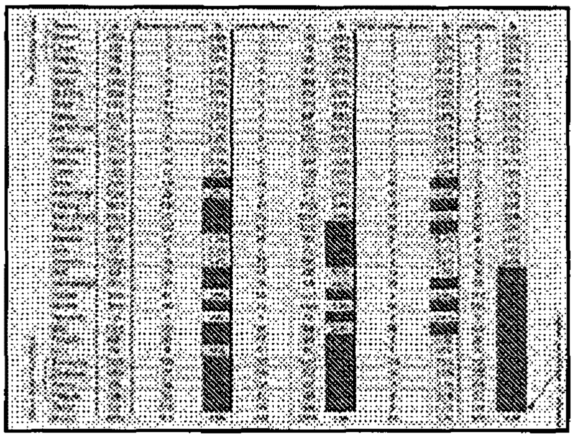
Results to Date

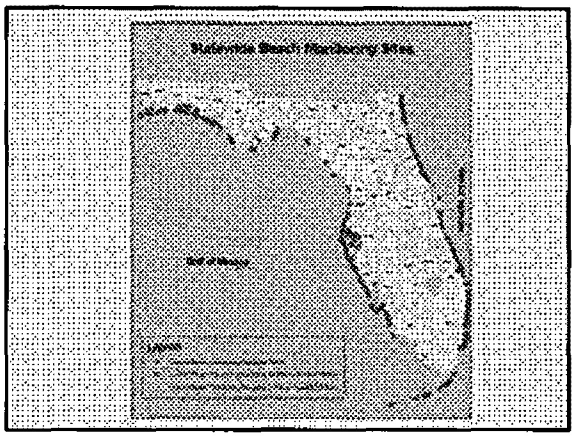
- Florida's coastal counties have reported a total of 1864 poor enterococci single sample levels, 1185 enterococci geometric mean exceedances, 746 poor fecal coliform results, and 1706 advisories/warnings from August 2000 to March 2004 (n=43,451).
- To put this in perspective, these numbers mean that 3.9% of the enterococci samples were poor, 4.7% of the geometric mean results exceeded the standard, and 1.7% of the fecal coliform samples were poor.

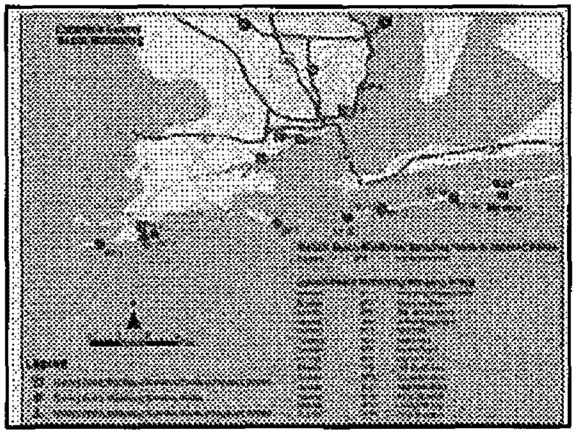
Florida Healthy Beaches Monitoring Program

Results to Date

- 3 counties (Brevard, Citrus, Flagler) have had no poor results and 1 other county (St. Lucie) has never had to issue an advisory/warning (the six exceedances have had resamples within acceptable limits).
- 4 counties (Escambia, Okaloosa, Wakulla, and Pasco) exceed state percentages for all four variables (enterococci, entero geomean, fecal coliform, and advisories).
- Taylor County has the highest percentage of advisories.

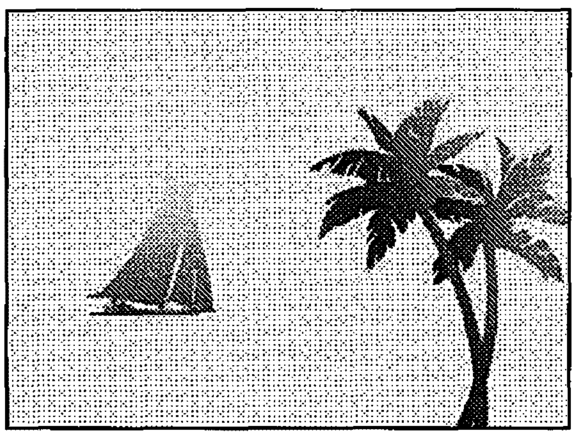






Web Pages of Interest

- CDC. "Surveillance for Waterborne-Disease Outbreaks — United States, 1999-2000." MMWR 2002;51(SS-8).
- EPA's BEACH Program
- Florida Healthy Beaches Program



Questions and Answers

Q (Toni Glymph, Wisconsin Department of Natural Resources): When does a water get listed as impaired? Once you determine it has exceeded standards in one year, what happens if it doesn't the next year? Are waters listed because they have problems for more than one year?

Bart Bibler

Waters with problems tend to have chronic problems. A beach with a monitoring, clean-up project is often higher priority for TMDLs than a beach being on the list. Monitoring, advisories, and warnings have higher priority.

Q: It is interesting that the 21 exceedances criteria are based on EPA standards and the Department of Health is complying with that. I think we are all trying to understand why they chose 21 days. Is that the way we need to go?

Bart Bibler

They are relying on our issuance of advisories and warnings even ahead of having enterococci as the state water quality standard. I think that has been a leap on their part and has never been challenged. Even exceedances of enterococci, whether or not it is part of the state water quality standards, they count in consideration of characterizing a beach as having impaired water. We are appreciative that EPA is taking it seriously. We are also appreciative that county governments will move it even faster than waiting for TMDLs that might take 15 years to solve.

Surf and Turf: Developing Partnerships for Maine's Beaches

Esperanza Stancioff
University of Maine, Cooperative Extension/Sea Grant

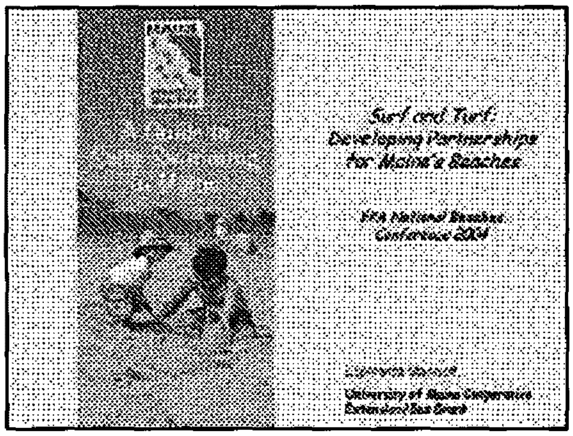
Biosketch

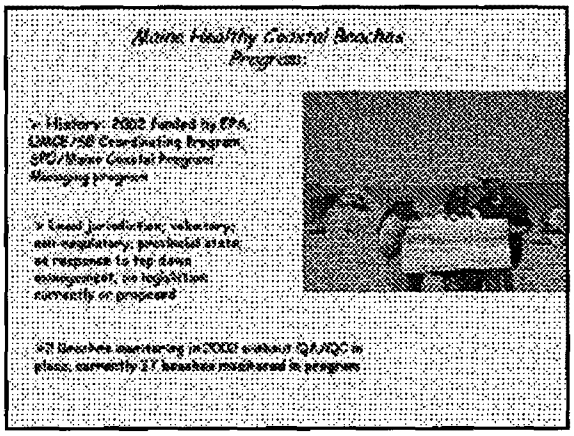
Ms. Stancioff received her BS in Marine Biology from Evergreen State College in Washington and her M Ed in Environmental Science from the University of Maine. Her work as Statewide Marine Extension Faculty with the University of Maine Cooperative Extension and Sea Grant focuses on Ecosystem Health including environmental monitoring, marine education, and community development. She developed one of the first coastal volunteer citizen water quality and phytoplankton monitoring efforts in the country. She works with state and federal agencies to direct and implement science and stewardship programs in assessment and remediation, planning and education.

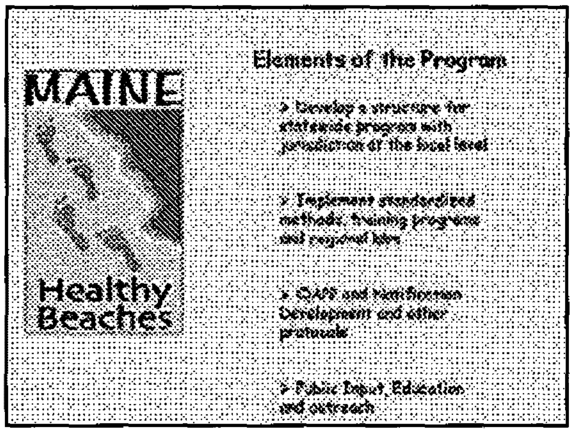
Abstract

Maine's challenge has been to develop a community-based volunteer water quality-monitoring program because the monitoring of water quality for swimming and other water contact usage is the responsibility of the local jurisdiction. It is not a mandated requirement from the State, nor does the State of Maine monitor public beaches other than State beaches. Maine rose to the test of unifying the protocols for monitoring, notification and education for coastal beaches through a stakeholder based process with representatives from the State, University, Nonprofit, NGOs and local municipalities which guided the development of the Maine Healthy Beaches Program.

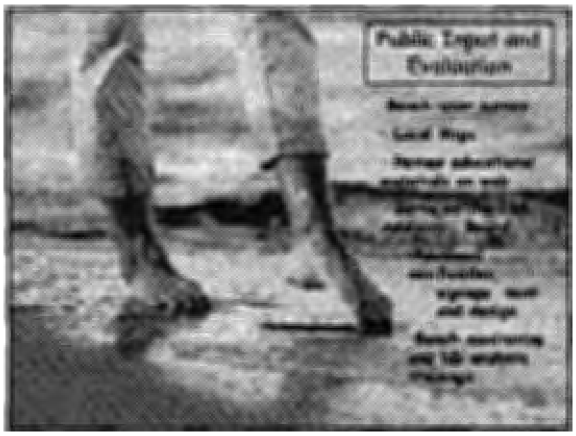
Maine has been faced with coordinating local municipalities and agencies that were implementing various approaches to monitor coastal water quality from drinking water standards to shellfish water quality standards to the US EPA's bacterial standard. The Maine Healthy Coastal Beaches Program required innovative and extensive coordinated public outreach and education efforts to provide the communities and agencies with the technical assistance and incentives to implement the program. Through the execution of a marketing campaign, involvement of local staff and volunteers and consistent one-on-one consultation from the University of Maine Cooperative Extension/Sea Grant, the program has gone from one (1) beach to thirty-six (36) in a two (2) year period of time.

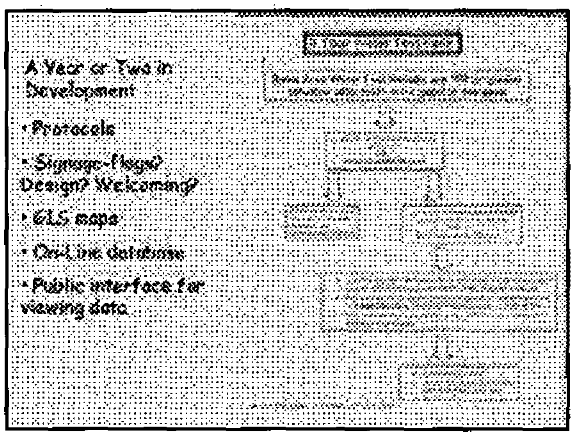

Surf and Turf:
Developing Partnerships for Maine's Beaches
EPA National Beaches Conference 2004
University of Maine Cooperative Extension/Sea Grant

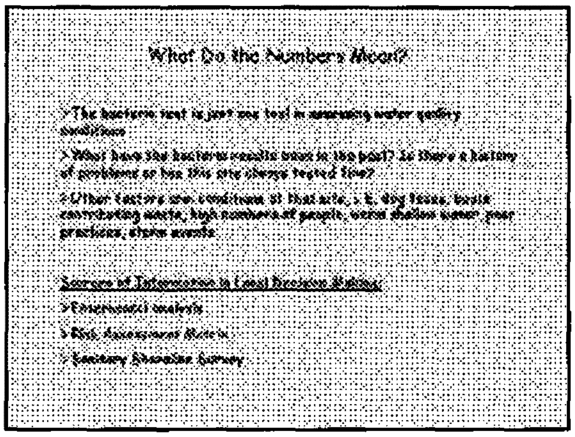

Maine Healthy Coastal Beaches Program:
History: 2002 funded by EPA, UMCE/SG Coordinating Program, SPO/Maine Coastal Program Managing program
Local jurisdiction; voluntary; non-regulatory; as response to top down management; no legislation currently or proposed
Beaches monitoring in 2002 without QA/QC in place, currently 27 beaches monitored in program


Elements of the Program
MAINE
Healthy Beaches
Develop a structure for statewide program with jurisdiction at the local level
Implement standardized methods, training programs and regional labs
QAPP and Notification Development and other protocols
Public Input, Education and outreach

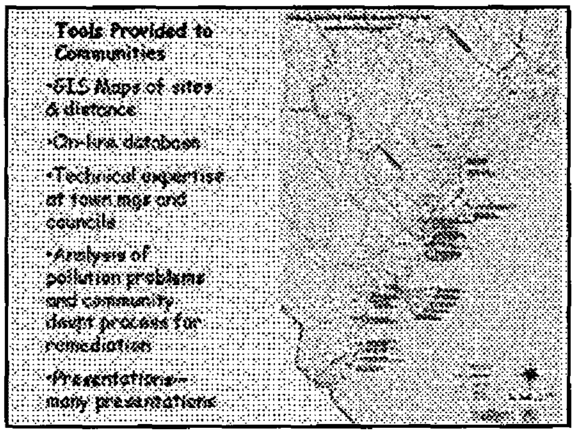

Partners-statewide and local:
State Park Personnel, Nonprofit Groups and Volunteers, EPA
Engaged In: Structure, Resources, Training, Implementation, Evaluation
Who's Involved
Pros and Cons to our Program
Community support into the future—only way possible in ME
Lengthy process to engage all
Stewardship activity and educational opportunities strong
Turnover in staff an issue-funding essential

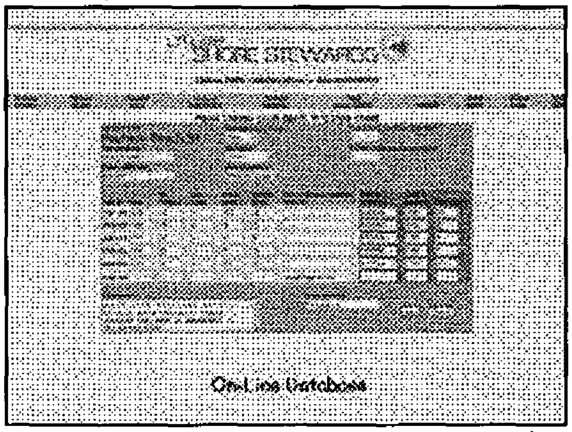

Public Input and Evaluation

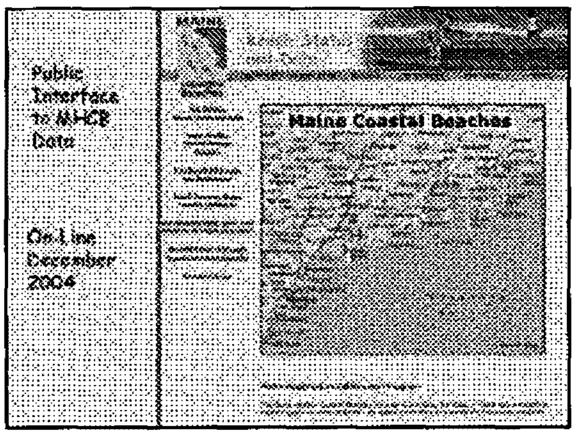

A Year or Two in Development
Protocols
Signage-flags? Design? Welcoming?
GIS maps
On-Line database
Public interface for viewing data

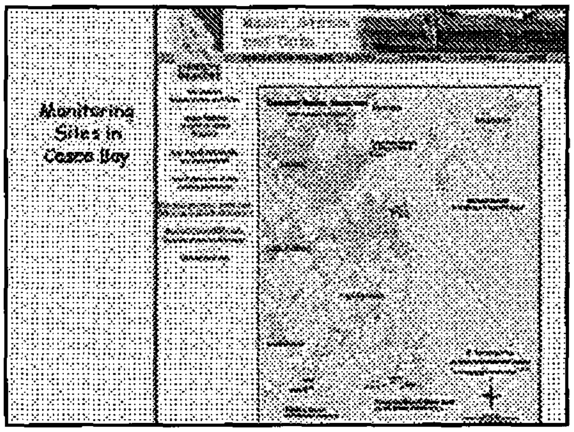

What Do the Numbers Mean?
>The bacteria test is just one tool in assessing water quality conditions
>What have the bacteria results been in the past? Is there a history of problems or has this site always tested fine?
>Other factors are: conditions at that site, e.g. dog feces, boats contributing waste, high numbers of people, warm shallow water, poor practices, storm events
Sources of Information in Local Decision Making:
>Sanitary Shoreline Survey

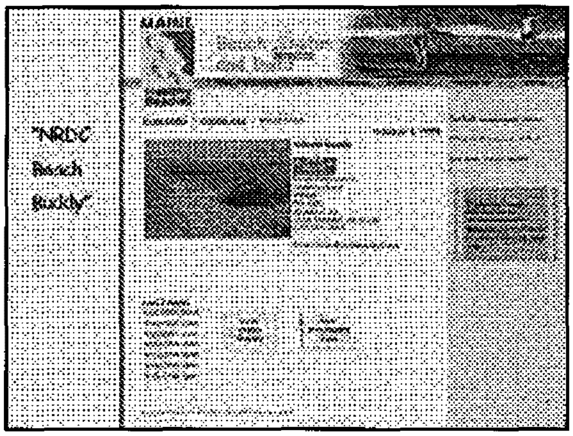

Story of the Signs
CLOSED
ATTENTION
Welcome!
For your safety and good health this beach is part of the Maine Healthy Beaches Program.
OPEN

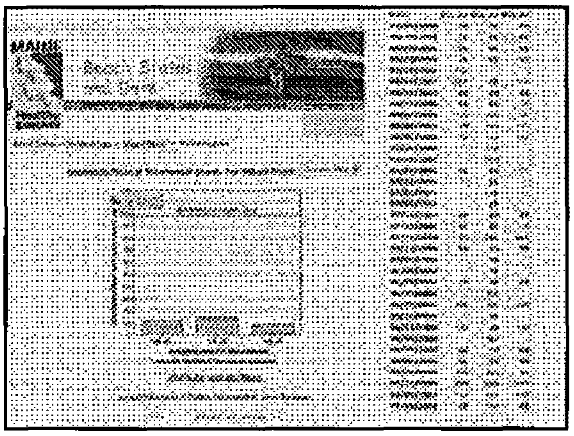

Tools Provided to Communities
•GIS Maps of sites & distance
•On-line database
•Technical expertise at town mtgs and councils
•Analysis of pollution problems and community dcsn process for remediation
•Presentations–many presentations

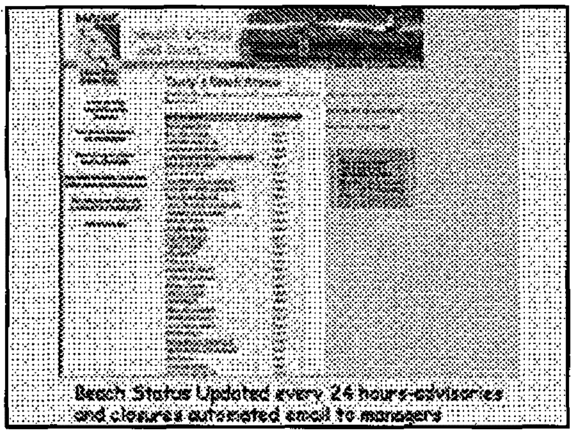

SHORE STEWARDS
On-Line Database


Public Interface to MHCB Data
On-Line December 2004
Maine Coastal Beaches


Monitoring Sites in Casco Bay

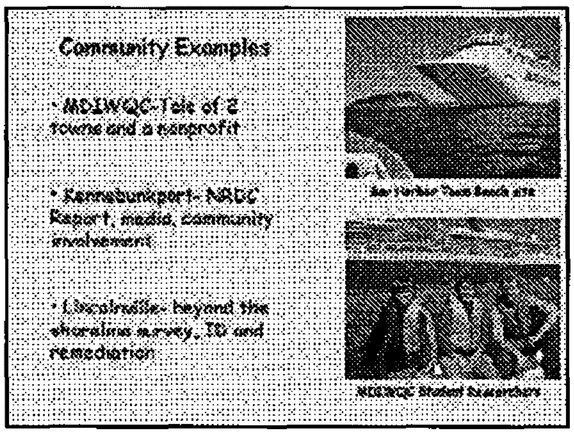


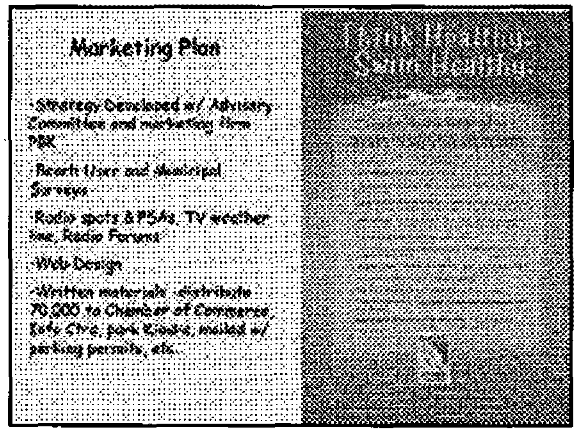


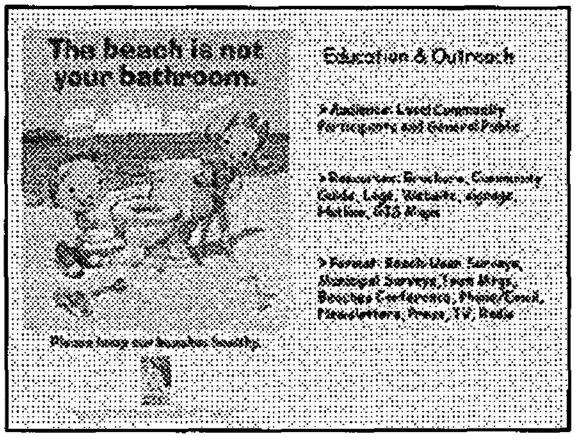


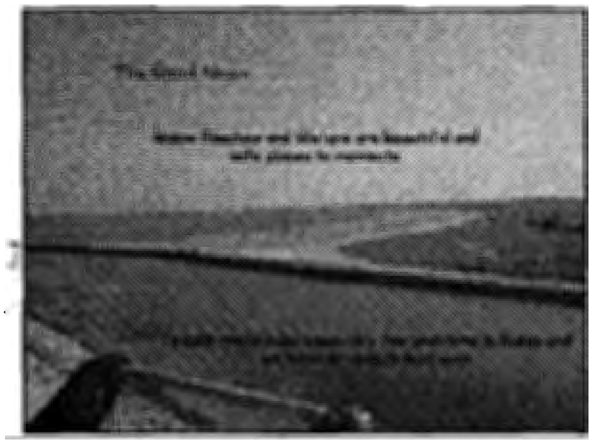
Program Mantra to Public

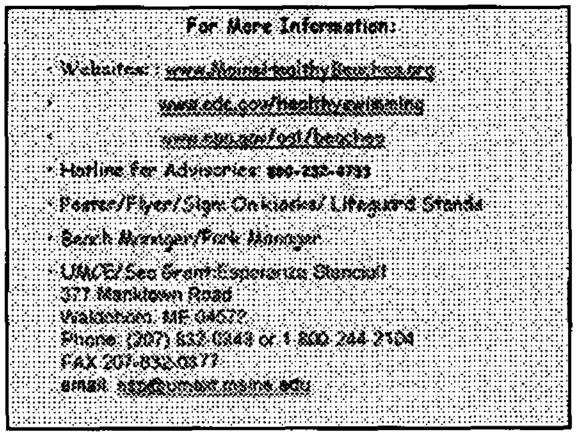
Beaches are not "closed" simply on the exceedance of the bacterial count, but on the Risk Assessment Matrix factors which includes bather numbers, time of last rainfall, and history of known problems. This is a coordinated decision between the Beach Manager, Program Coordinator, and State Epidemiologist.






The beach is not your bathroom.
Education & Outreach




For More Information:
Websites:
www.cdc.gov/healthyswimming
Hotline for Advisories:
Poster/Flyer/Sign: On kiosks/ Lifeguard Stands
377 Manktown Road
Waldoboro, ME 04572
Phone: (207) 832-0343 or 1-800-244-2104
FAX 207-832-0377

Questions and Answers

Q (Richard Haugland, U.S. EPA, Office of Research and Development): Who does the analyses for your voluntary monitoring program? How are the analyses funded?

Esperanza Stancioff

This whole program is funded through EPA Beach Program funds. The program is voluntary in the sense that it is not in some of the personnel's (i.e., lifeguards, state park personnel) job description. We also have some volunteer staff along the coast. However, it the program is not completely voluntary. Four regional labs are used; two are certified, two are not. Of those labs, two use Enterolert and two use Enterolert and membrane filtration.

Q: I had an opportunity to travel in Maine recently, and I was very impressed with the wonderful water resources the state has, especially the Rachel Carlson Reserve, which was wonderful. Have you done any background bacterial monitoring in some of those pristine areas (in Maine)? Also, have you done any water monitoring of urban runoff that might come from that big white house in Kennebunkport?

Esperanza Stancioff

We have been monitoring water quality, looking at bacteria in particular, for 16 years with volunteer support. The reserves in Rachel Carson (pristine) areas have good water quality. We have done a complete study of a large brook that is in one of the "pristine-looking" areas that has very high bacteria counts. So, we are doing a lot of investigative monitoring as well as looking at the beach area.

Incorporating the Bacterial Indicator Enterococci in Marine Beach Water Quality Monitoring Program

Clay Clifton
County of San Diego, Department of Environmental Health

Biosketch

Mr. Clifton is the Recreational Water Program Coordinator for the County of San Diego Department of Environmental Health (DEH). Mr. Clifton received his B.A. in Political Science from Furman University in Greenville, S.C. and M.A. in Marine Affairs and Policy from the Rosenstiel School of Marine & Atmospheric Science at the University of Miami. Mr. Clifton is taking the California Registered Environmental Health Specialist exam in November of this year. He started with DEH as an Environmental Health Technician in 1997 and worked as the sampler for the Recreational Water Program. Mr. Clifton represents DEH at the California Beach Water Quality Work Group, Monitoring and Reporting Subcommittee.

Abstract

In 1986 the EPA published Ambient Water Quality Criteria for Bacteria, which recommended replacing coliforms with enterococci as a better indicator of health risk from fecal contamination in marine waters. In 1999 California implemented AB 411, which added enterococci to coliforms as bacterial indicators for beach monitoring programs. The effect was dramatic for California, which experienced an exponential increase in advisories issued for bacterial exceedances. In San Diego County for example, there were 19 days posted under Advisory in 1998; and 2137 days posted in 2000. The addition of enterococci played a major role 60% of exceedances contained an enterococci exceedance. 91% of advisories caused by a single indicator were attributed to enterococci.

While the increases in advisories caught the attention of the media, state regulators, environmental and stormwater programs, the health departments implementing AB 411 tried to interpret the enterococci data. Officials examined the new indicator data in the context of the coliform data, which they were accustomed to analyzing, in an effort to characterize the relationship between the two.

Four years later health departments have a better understanding of advantages and limitations of enterococci as an indicator of fecal contamination. The enhanced understanding of enterococci and coliforms, much of it verified by research, and the resultant implications for beach monitoring programs can be presented in these categories:

- Characteristics of enterococci and interaction with coliforms
- Importance of auxiliary data in data interpretation
- Actual health risk vs. random noise in bacterial exceedances
- Implications for adaptive monitoring programs

Incorporating Enterococci in beach water monitoring

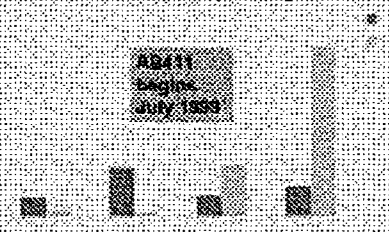
Clay Clifton

US EPA *Ambient Water Quality Criteria for Bacteria, 1986*

- Recommends replacing coliform bacteria with enterococcus as a better indicator of health risk from fecal contamination in marine waters
- In California AB411 implemented in July 1999
  - Single Sample Standards for TC, FC, Ent
  - Enterococci: 104 per 100ml MANDATORY

Results of implementing AB411...

Perception of deteriorating water quality



Exceedances of single sample standards Apr - Oct, 2000

- Of exceedances caused by one indicator only, 91% were Enterococci
- Of exceedances caused by more than one indicator, 60% had Enterococci
- 23% of exceedances attributed to Total and/ or Fecal Coliform *without* Enterococci

Confirmation of contamination (or lack thereof)

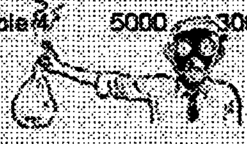
- In 136 (76%) of the 178 Advisories issued by DEH between April and October, the follow-up sample was within single sample standards for all indicators

Issues with implementing AB411

- Beaches are usually posted with:
1. Lack of indicator agreement
2. Lack of confirmation in follow-up samples

Is enterococci a good indicator of sewage contamination?

	TC	FC	Ent
● sample 1	>16000	>16000	>12000
● sample 2	900	500	300
● sample 3	9000	300	324
● sample 4	5000	3000	207



Unknown source exceedances

	TC	FC	Ent
●sample 1	1100	1100	20
ple 2	1300	1300	10
le 3	130	40	364
le 4	< 20	< 20	624

Aids in data interpretation

Knowledge of site/ beach

- Watershed land uses
- Sewer infrastructure condition
- Wildlife populations
- Coastal outlet flows (e.g., storm drains, river mouths)

Data interpretation, cont'd

Sample field observations

1. Time (UV radiation)
2. Tide
3. Current direction
4. Last rainfall
5. Numbers of wildlife or bathers
6. Coastal outlet flowing to ocean

So... interpret the data

Two beach types defined in southern California:

1. High risk: adjacent to coastal outlets and/ or enclosed bays with poor circulation
2. Low risk: open coast

- High risk beaches most likely to exceed the 30-day log mean standard for enterococcus – require adaptive sampling

Adaptive sampling

Routine

1. Sample high risk beaches at higher frequency

Follow-up

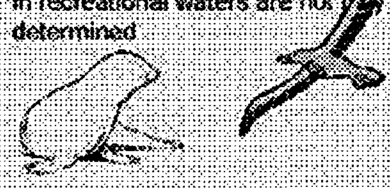
1. Time of day
2. Tide
3. Currents
4. Multiple (spatial / temporal) samples

Well, that was great! Let's go sample some beaches!

WAIT ! ... there are LIMITATIONS or shortcomings with the indicators!

The bacterial indicator monkey wrench

- Health risks from non-human sources in recreational waters are not fully determined



The bacterial indicator monkey wrench, cont'd

Environmental replication of enterococci and fecal coliform

- A NZ study found entero and fecal coliform levels in decaying seagrass up to 900x higher than adjacent seawater
- Indicator bacteria associated with biodegradation
- FC and Ent are able to replicate in a growth permissive environment

Local studies

- Mission Bay and San Diego River outlet
  1. Sediments, wrack line, and drains act as bacteria reservoirs
  2. Replication of bacteria on organic matter in storm drains
- Cal Trans study of pathogens in storm drain discharges
  1. Pathogens detected in 12 of 97 samples
  2. No correlation between indicator levels and pathogens

Conclusions, part 1

- 30-day log mean standard is better public health protection tool than the single sample standard
- Posting using a single sample standard should require confirmation:
  1. Multiple indicators, OR
  2. Follow-up sample

Conclusions, part 2

- Adaptive sampling is needed to obtain representative samples
- Non-anthropogenic sources can enable replication of coliforms and enterococci. What is health risk?

Endnotes

Endnotes 2

Endnotes 3

Questions and Answers

Q: Which pathogens did the CalTrans study find?

Clay Clifton

Adenovirus and *Salmonella* were found. I think the report is online.

Comment: I would be quite concerned with Shigella.

Clay Clifton

Yes, *Shigella* would be an indication of human presence.

Comment: You also mentioned that there was no correlation with pathogen and indictor levels. That would not necessarily be expected, but you would get worried when you have pathogens there but no indicators.

Clay Clifton

Yes, this case occurred in samples taken at the Tijuana River mouth. There was a presence of an enterovirus with no associated indicators. That is a problem. But, what is equally concerning to me is if there is no correlation between pathogens and indicators. We are working under the presumption that the indicators will tell us if there is a quantifiable health risk. But, if the pathogens do not correlate to the indicators, that is a limitation.

Q: You are using a fecal coliform/total coliform ratio. I am an epidemiologist, and to my knowledge that ratio has not been linked to any health effect in any of the literature, except for one study based on storm water. In addition, total coliform is known to multiply. Who made the decision to use that ratio or total coliforms as an indicator for health when there is little indication that it is a good indicator of health?

Clay Clifton

My understanding is that the total/fecal ratio was based upon the findings of the Santa Monica Bay epidemiological study. The California Department of Health Services wrote the bacterial standards in the California Code of Regulations. In developing those standards, they used the findings of the Santa Monica Bay study, which was the one that looked at surface runoff impact on beaches.

Q (Shannon Briggs, Michigan Department of Environmental Quality): In Michigan we have a 30-day and a daily standard. One of the frustrations we have is that you can exceed one standard and not the other. It's easier to get a better confirmation with the 30-day standard, if you have a lot of data over a 30-day period. However, what can be done if the 30-day average is high because there were high levels earlier in the month, but you have low counts today, it has not rained, and you think you have a really good beach situation? How do you deal with that situation, especially since we are trying to go to real-time results? Do you have a policy on that?

Clay Clifton

Yes, we are trying to get the protocol for the use of the 30-day log mean worked up right now. What I would do is track the 30-day log mean for Enterococcus, since that will most likely be the only one that will ever exceed the standard at any beach. Then, front end-load that 30-day log mean by taking multiple samples the week that you want to make the decision. For example we have beaches with chronic water quality problems that have high bacteria levels coming from multiple sources. In the course of 30 days, we could get two enterococcus sample results that are less than 10 cfu. But, I'm not going to lift the advisories in those cases because if I go out and get a third sample, it will probably be 400 cfu or even 3000 cfu. So, I look at the 30-day log mean. I see that my most distant time sample has 400 cfu, and I see a decreasing trend in the week I am in now, which has one clean (single) sample. So, I would want to take at least one more sample that week so that my 30-day log mean becomes front end-loaded and I'd be weighing it more towards the more recent data and then only counting one sample per other sample event going back to the 30-days.

Comment: So, you weigh your 30-day mean a little bit? You do not take it as an all-inclusive 30-day pile of data?

Clay Clifton

I have tried to come up with a procedure to address it. I would take the highest bacteria sample result per sample event per day and take all the data from the last 30 days. Then, when you are coming up to that decision point where it looks like you are coming out of the contamination event, collect more samples during that week so that you have more recent data points to use to front-end load your 30-day mean.

Q: (Rachel Noble): We're seeing similar trends with enterococcus. Do you have an idea of any kind of enterococcus speciation that was done on any of the samples? What species are found in the soil and plant samples—and are they available to be analyzed?

Clay Clifton

I saw a New Zealand study that found that *E. facium* and *E. faecalis* were the most common species of enterococci. That suggests there is a human source. But if there is replication in the environment, do we still have the associated health risk? If the indicator bacteria from a human source replicates, do the associated pathogens also replicate? I'm not aware that a virus particle can replicate outside of a host.

Q: Were E. facium *and* E. faecalis *in your wrack samples, as well as the plant and soil samples?*

Clay Clifton

It is uncertain. The City of San Diego told me during a conversation with their microbiologist that *E. facium* and *E. faecalis* were the most common, but it was not particular to the two studies I just mentioned. It was a more general observation.

Comment (Stephan Weurtz, University of California Davis): I was on the advisory committee for the CalTrans study. The study found pathogens when no indicators were found. Pathogens included adenoviruses and enteroviruses. They were detected using molecular techniques with no test for viability. They were totally unrelated with the presence of indicators.

Washington State's Beach Environmental Assessment, Communication and Health (BEACH) Program

Lynn Schneider
Washington State Department of Ecology

Biosketch

Lynn Schneider is the BEACH Program Coordinator for the State of Washington. The BEACH Program is a managed jointly by the State Departments of Ecology and Health. Because of the joint management, she splits her time between the two agencies.

Ms. Schneider received her B.S. in Environmental Chemistry from the Evergreen State College in Olympia, Washington in 1988. She worked as a chemist for Morton International for eight years prior to joining the Washington State Department of Ecology in 2001. Lynn became the BEACH Program Coordinator in 2001. Her main interest is the relationship between increases in indicator levels and increased illness rates associated with water contact and how increased risk is communicated to the public.

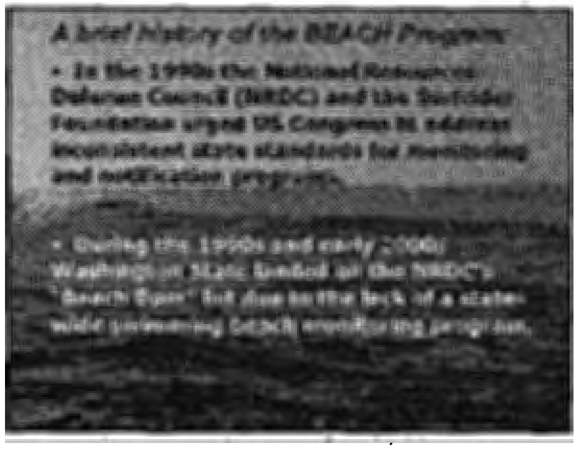
Abstract

Washington State's Beach Environmental Assessment, Communication, and Health {BEACH} Program began in 2002. An inter-agency BEACH Committee was established to develop program guidelines. The BEACH Program was implemented as a pilot project during 2003 in five counties. Full implementation to Washington's fourteen coastal counties with marine beaches began in 2004.

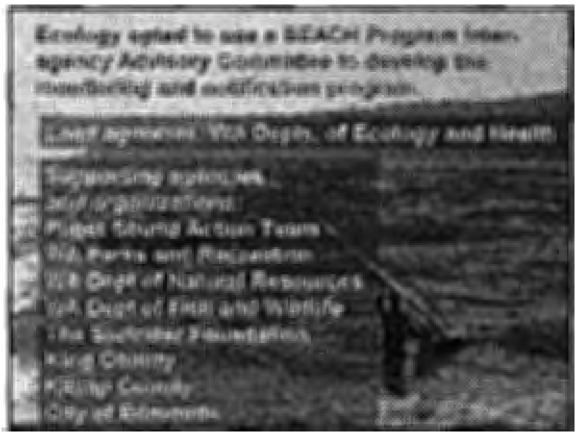
Washington's BEACH Program is completely funded through federal BEACH Act funds. The Program is a collaborative effort between state, county and local agencies, tribal nations, and volunteer organizations. Washington State has over 3000 miles of coastal waters with over 650 public recreational beaches. Using a matrix designed to prioritize beaches according to risk, 72 beaches were identified as Tier 1 beaches. Due to limited funding, Tier 2 beaches were not included in the 2004 sample plan.

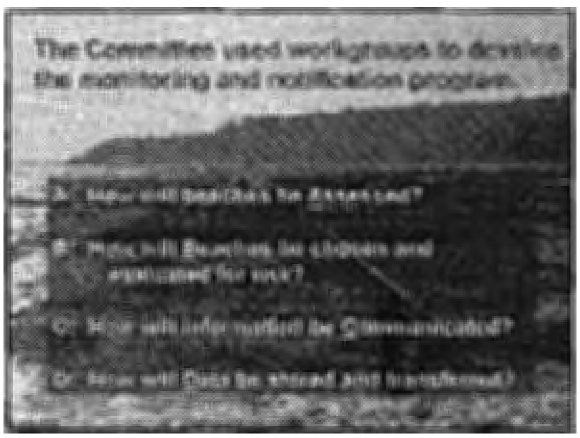
The Program is able to maximize the number of beaches being monitored by allowing counties to design sample collection plans best suited to their resources. Six counties use environmental health staff to collect the samples. Two use county staff supplemented by volunteers when available. Four are sampled completely by volunteers. One tribal nation is collecting samples. One county is sampled using state employees. One county did not have a Tier 1 beach.

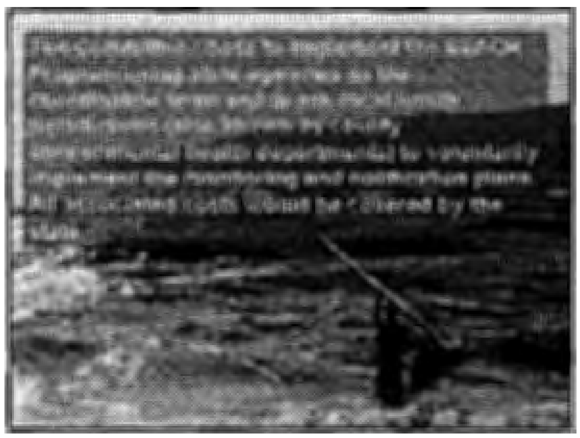
Three samples are collected across the beach and are analyzed by state accredited labs within six hours of sample collection. Results are e-mailed or faxed within 24 hours. The three samples are averaged and then compared to threshold limits. Geometric means are calculated using all the sample results from the five previous weeks. Advisories are posted on the BEACH Web within 24 hours, all sample results within 48 hours of arrival at the Department of Ecology.

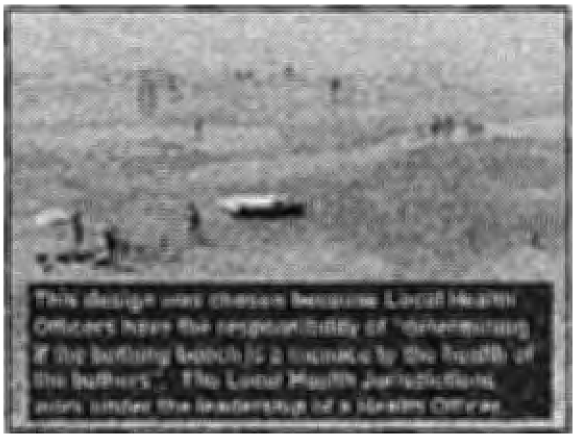

A brief history of the BEACH Program

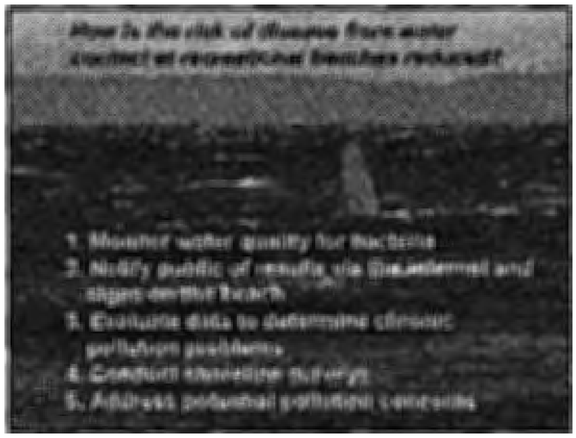

A brief history of the BEACH Program





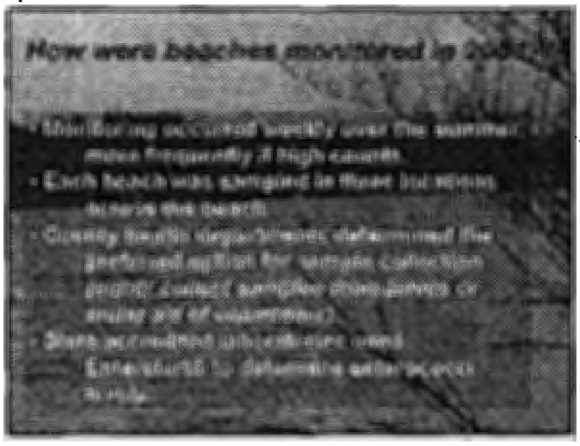


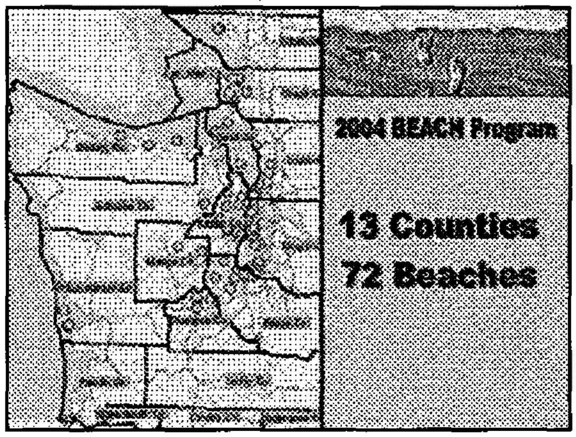


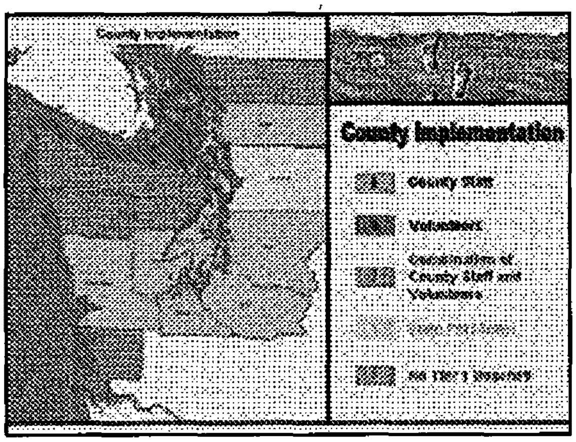


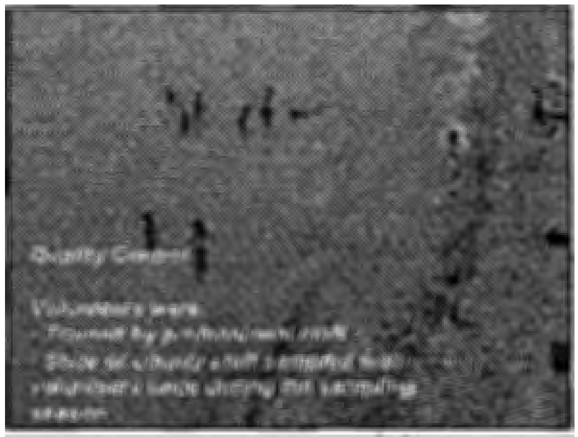
What do we monitor the beach water for?

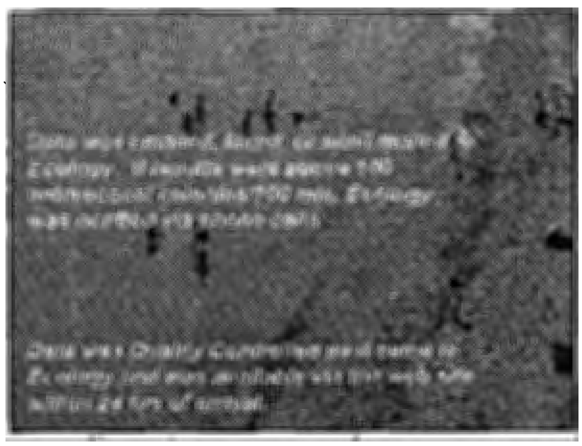
- Water samples are determined for bacteria using enterococci bacteria as the indicator.
- When results are above threshold levels, resamples are determined for enterococci and either *E-coli* or fecal coliform bacteria.

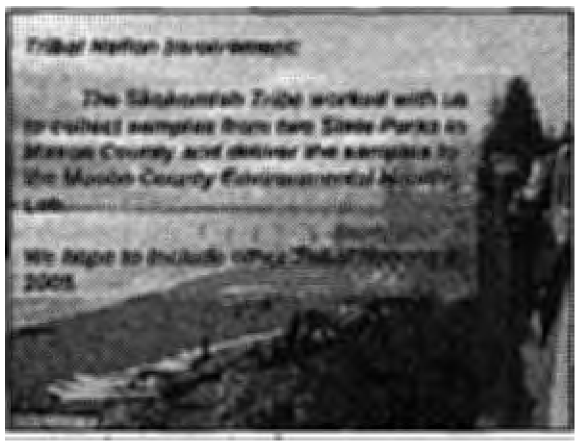


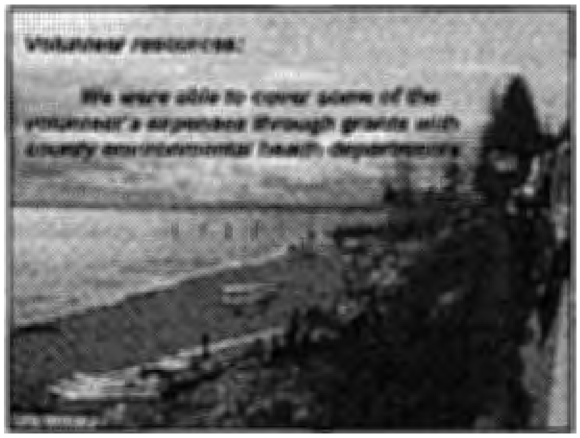

2004 BEACH Program
13 Counties
72 Beaches

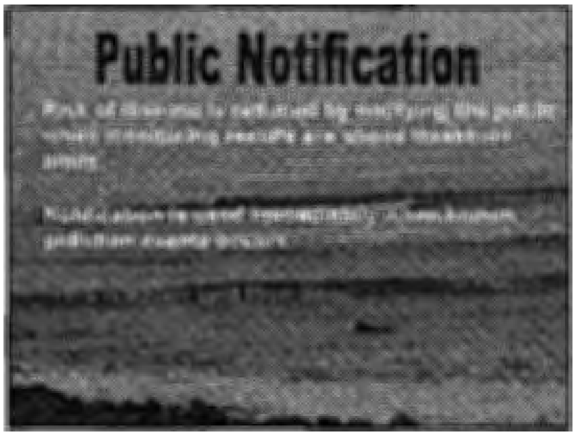

County Implementation
County Staff
Volunteers

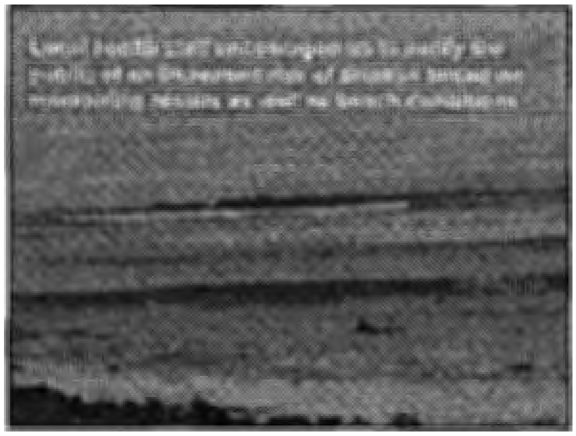


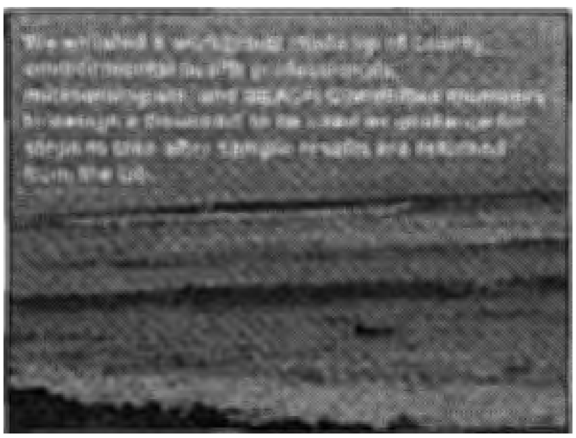


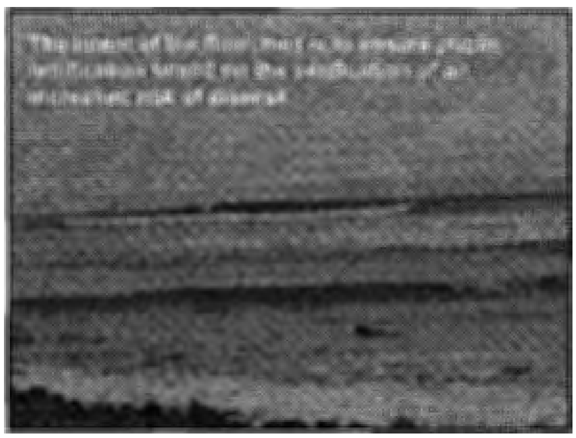


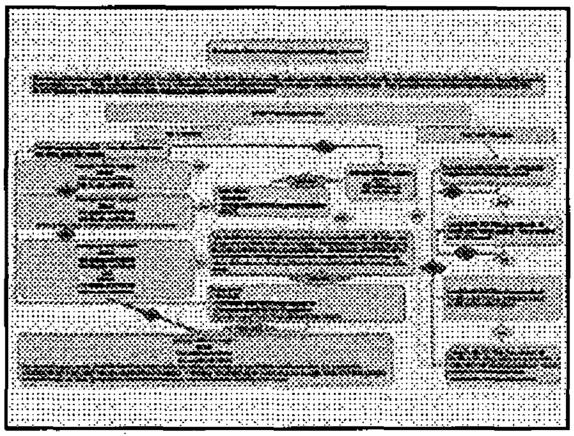


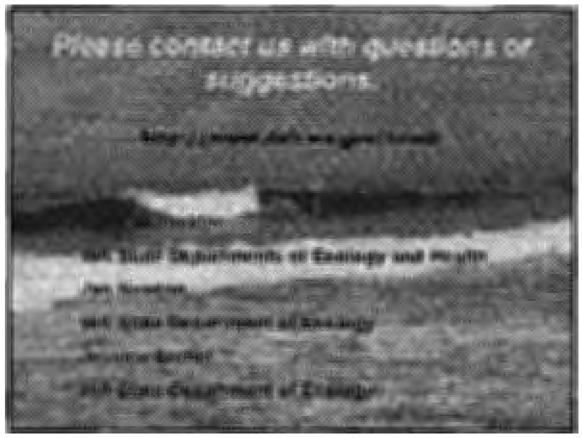

Public Notification










Please contact us with questions or suggestions.


Questions?

Questions and Answers

No questions.

Wednesday, October 13

1:20 p.m. – 2:50 p.m.

Session Three: Design of Beach Monitoring Programs

EPA Overview: Current National Requirements, Guidance and Hot Issues

Matthew Liebman
U.S. Environmental Protection Agency, Region I

Biosketch

Mr. Liebman is the Environmental Biologist at the U.S. Environmental Protection Agency New England regional office in Boston, MA. Mr. Liebman received his B.A in Biology in 1980 from Carleton College in Minnesota and a Ph.D. in Ecology and Evolution from the State University of New York at Stony Brook in 1991. Since 1990, he has worked at the EPA office in Boston as a project manager and scientist in the National Estuary Program, dredged material disposal and monitoring program, and as a water quality specialist. He is the regional coordinator for EPA's BEACH program, nutrient criteria initiative and national sediment inventory. At EPA, Mr. Liebman has conducted or been involved in research efforts in dredged material disposal site monitoring, and impacts of nutrients and bacteria on water quality in streams, coastal waters and beaches.

Abstract

This presentation will provide an overview of EPA's recommendations for monitoring beaches contained in the Beach Grant Performance Criteria document. EPA recommends that states develop a tiered monitoring plan so that beaches with higher use and more pollution sources (hence higher risks), be monitored more frequently. To classify beaches based on risk, state and local health officials should characterize water quality and pollution sources at each beach. EPA recommends that both the geometric mean (for long term exposure) and the single sample maximum (for daily observations) be used to notify the public that bacteria levels exceed acceptable health-based risk levels. EPA's recommendations for appropriate bacteria indicators and health-based thresholds for public notification stem from important epidemiological studies conducted in the 1970s and 1980s. These thresholds have been corroborated by more recent epidemiological studies. There is still, however, a central challenge in bacteria monitoring at beaches -- that elevated levels of bacteria are variable and intermittent, and that traditional analyses of bacteria take at least 24 hours, after the public has been exposed. As a result, questions such as how frequent to sample, and whether the geometric mean is a useful threshold are still being debated. Recent research conducted by EPA and others have demonstrated approaches to deal with these and other related issues, some of which will be reported on in this session.

EPA Overview: Current National Requirements, Guidance and Hot Issues

Matthew Liebman
US EPA New England

Recent History of Beach monitoring and management recommendations: the Rock'n 70s and 80s

- National Technical Advisory Committee to FWPC (1968) and EPA Quality Criteria for Water (1976) – recommends fecal coliform at 200 and 400 cfu/100 ml
- Health Effects Criteria for Freshwater and Marine Waters 1979 and 1983 – prospective epidemiological studies establishes relationship between enterococci and E. coli and illness rates
- Ambient Water Quality Criteria for Bacteria (1986) – sets criteria based on risk of illness

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Recent History of Beach monitoring recommendations: the bridge to the 21st century

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Key 1986 Bacteria criteria recommendations

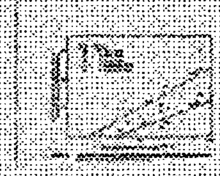
- Change indicator from fecal coliform to enterococci for marine, and enterococci or *E. coli* for freshwater
- Use the ***geometric mean*** over a 30 day period, based on (at least) five equally spaced (weekly) samples -- represents exposure related to the study design (long term exposure) (re-iterated recommendations from NTAC and EPA 1976)
- Statistically based ***single sample maximum*** used to close (or re-open) or post an advisory -- represents an increased risk of illness, ***that the exposed water is likely to exceed the geometric mean threshold with a certain level of confidence***
- Sample in three feet of water, one foot depth (i.e. two feet above bottom) (although EPA epi studies at waist to chest depth, about 3 to 4 feet for an adult)

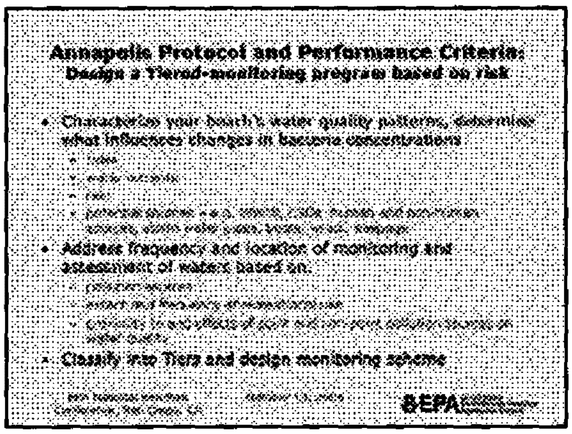
Appropriate threshold values used to post advisories for marine recreational waters

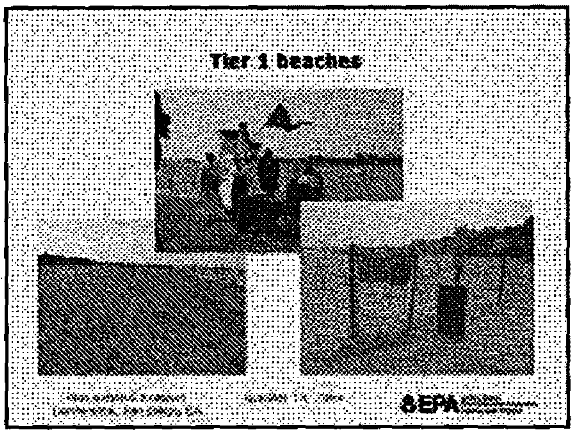
- Principle: *Enterococci* geometric mean standard equivalent to similar "acceptable" level assumed for 200 fecal coliform limit, which correlates to 19 GI illnesses per 1000 swimmers
- Geometric mean: 35 CFU or MPN/100 ml based on at least 5 samples for the previous 30 days
- Single sample: 104 CFU or MPN/100 ml, based on a standard deviation of 0.7, but could use a site-specific standard deviation
- *This represents an increased risk level, i.e. the levels of bacteria in the water are likely to be greater than the acceptable geometric mean value of 35 per 100 ml*

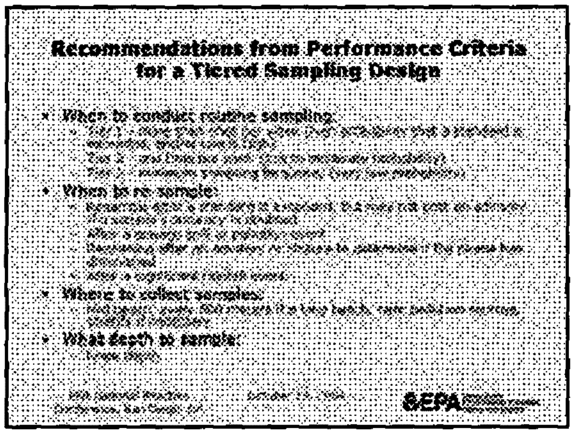
Important aspects of the design of EPA prospective epidemiological studies

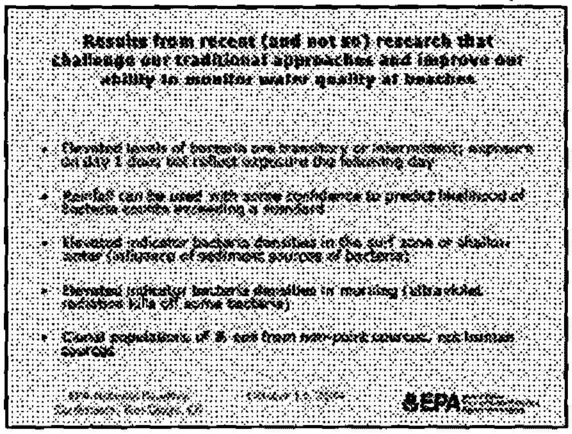
- Study design included clusters of days with similar water quality
- Each day was sampled 3 to 4 times, between 11 am and 4 pm in areas of high use
- Most sites were influenced by combination of point and non-point sources
- Swimmers exposed once (i.e. on one day) and followed for nine days

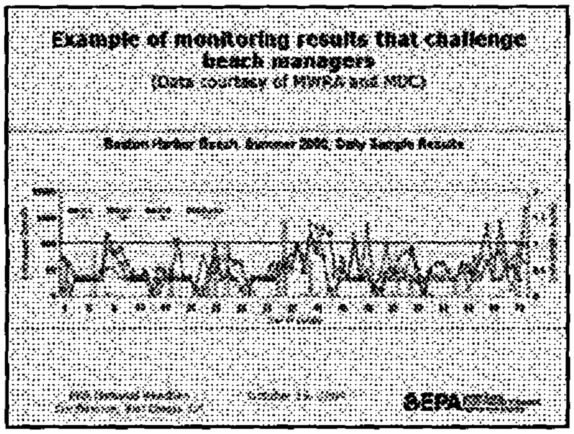


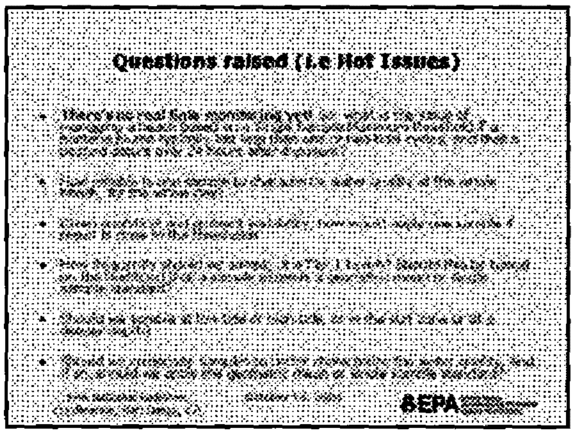

Annapolis Protocol and Performance Criteria:
Design a Tiered-monitoring program based on risk
Characterize your beach's water quality patterns, determine what influences changes in bacteria concentrations
Address frequency and location of monitoring and assessment of waters based on:
Classify into Tiers and design monitoring scheme
EPA


Tier 1 beaches
EPA

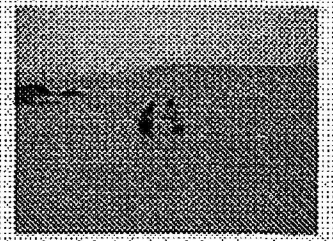

Recommendations from Performance Criteria for a Tiered Sampling Design
When to conduct routine sampling:
When to re-sample:
Where to collect samples:
What depth to sample:
EPA


Results from recent (and not so) research that challenge our traditional approaches and improve our ability to monitor water quality at beaches
Elevated levels of bacteria are transitory or intermittent; exposure on day 1 does not reflect exposure the following day
Rainfall can be used with some confidence to predict likelihood of bacteria counts exceeding a standard
Elevated indicator bacteria densities in the surf zone or shallow water (influence of sediment sources of bacteria)
Elevated indicator bacteria densities in morning (ultraviolet radiation kills off some bacteria)
EPA

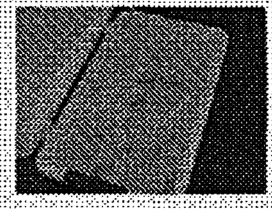

Example of monitoring results that challenge beach managers
(Data courtesy of MWRA and MDC)
Boston Harbor Beach, Summer 2000, Daily Sample Results
EPA

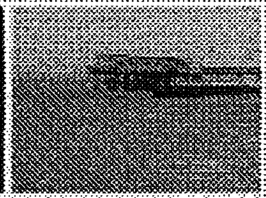

Questions raised (i.e Hot Issues)
EPA

Where should we sample? Waist depth?



How many samples do you need to take to characterize variability at a beach?





More hard questions

- Does the geometric mean have any value if we sample once per week? -- although the geometric mean doesn't tell you what the conditions are for a single day, is it a good predictor of the probability of exceeding the single sample standard?
- If we know the likelihood that a standard is exceeded, how frequently should we sample to detect, with some level of confidence, these exceedances?
- If a beach manager has funds to analyze four samples per beach per week, should he or she sample on four separate days, or on one day four times, or in four places?

Conclusions

with apologies to Michael Feldman

These questions have been extensively researched; the answers, however, have not. Until Now.

Enjoy the talks!

Questions and Answers

No Questions.

Public Health Protection at Marine Beaches: A Model Program for Water Quality Monitoring and Public Notification

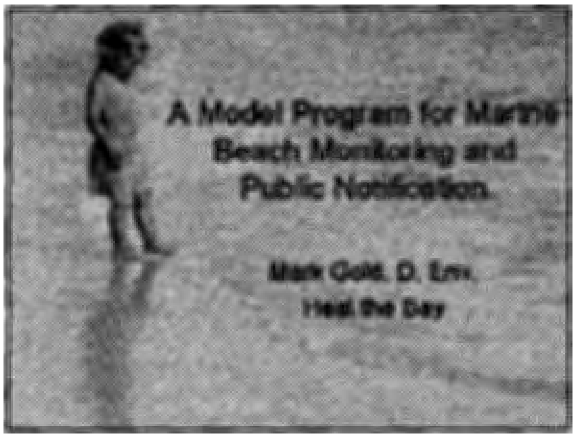
Mark Gold, D.Env.
Heal the Bay

Biosketch

Mark Gold, D.Env., is Heal the Bay's Executive Director. Heal the Bay is an environmental group dedicated to making Santa Monica Bay and Southern California coastal waters safe and healthy for people and marine life. Dr. Gold's extensive work with water quality and coastal natural resource topics ranges from sewage treatment, contaminated sediments, legislative and environmental education issues to urban runoff, contaminated fish and wetland restorations. In 1996, working in conjunction with the Santa Monica Bay Restoration Project and the USC Medical Center, he was a co-author of the first epidemiological study of swimmers in runoff-polluted water. He also has co-authored several stormwater, contaminated fish and beach water quality bills and ordinances, and he created Heal the Bay's Beach Report Card®. He is a vice-chair of the Santa Monica Bay Restoration Commission, sits on the State Water Board's Clean Beach Advisory Group and served on the EPA's Urban Wet Weather Federal Advisory Committee. Dr. Gold also was appointed to the California Ocean Trust. Dr. Gold has bachelor's and master's degrees in biology from UCLA, and he received his doctorate from UCLA in environmental science and engineering in 1994.

Abstract

Heal the Bay authored a guidance document, designed as a national model for routine water quality monitoring and public notification programs for marine beaches. Public awareness regarding beach water pollution and concern about swimming-related illnesses has increased, and attention to beach water quality has led to new legislation (the federal BEACH bill for example) and research on beach water quality issues. In turn, new regulations and an improved understanding of beach pollution have provided impetus for beach managers and local health agencies around the country to modify and expand their existing beach water quality programs. The model program is a tool for local and state health agencies and beach managers to develop and improve marine beach water quality monitoring and public notification programs. Currently, in most of the country, programs vary from state to state and even from county to county within states. The end result is that public health is not always adequately protected, and monitoring results are not comparable from state to state. The intent of the model program is to improve the efficiency and protectiveness of beach monitoring programs outlined in the U.S. EPA's existing guidance. This model program explicitly provides a risk-based rationale and scientific basis for many of the recommended protocols. We hope the model program will help promote consistency in monitoring and public notification programs implemented across the country.



Why develop a Model Program?

Improve public health protection:

- Provide a tool for beach managers to improve existing programs or develop new ones
- Promote consistency across programs
- Enhance guidance provided by U.S. EPA

Model Program Development

5 Guiding Design Principles
- Main goal: Protect public health
- Primary measure of water quality: FIBs
- M&PN protocols based on risk
- Monitoring protocols are conservative
- Public notification protocols are tiered based on risk, instead of binary system of open/closed

Model Program Development

Factors complicating Recreational Beach Risk Management:

- Uncertainty associated with using a non-specific indicator
- Large variability in bacteria indicator densities
- Lag-time from sample collection to public notification

Model Program Structure

Six components:
1: Goal & objectives
2: Recommended FIB standards
3: Prioritization of Beaches by Risk
4: Monitoring
5: Public Notification
6: Public Education

Model Program Objectives

- Main Goal: Protection of Public Health
- Develop specific management and scientific objectives to support main goal
- **Explicit development critical to ensure connection between data collected and agency/stakeholder expectations
- Recommend use of Bernstein's hierarchical methodology, (Bernstein, 1993)

FIB Measurements

Recommend use of 3 indicators: enterococcus, fecal, total coliform

T/F ratio provided strongest associations with risk in SM Bay epi. study

Beach Classification by Risk

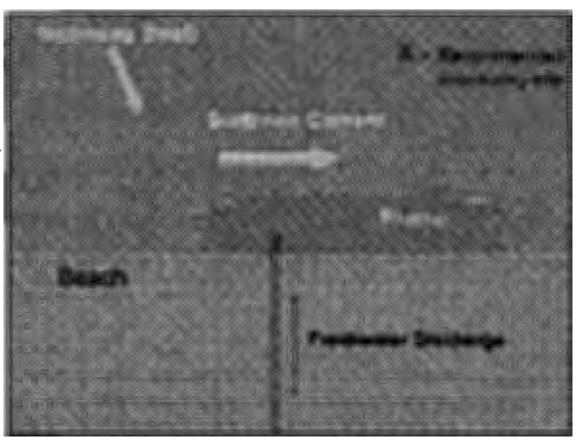
- 3 tiers
- Based on qualitative risk analysis
- Specific recommendations:
  - High risk: beaches w/freshwater discharges, enclosed beaches, beaches w/potential fecal sources
  - Risk category may be seasonal

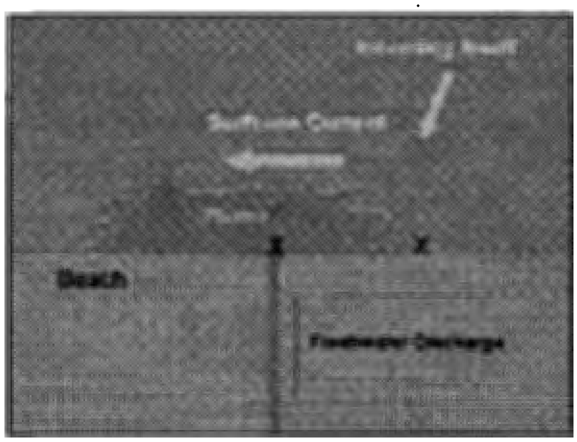
Monitoring

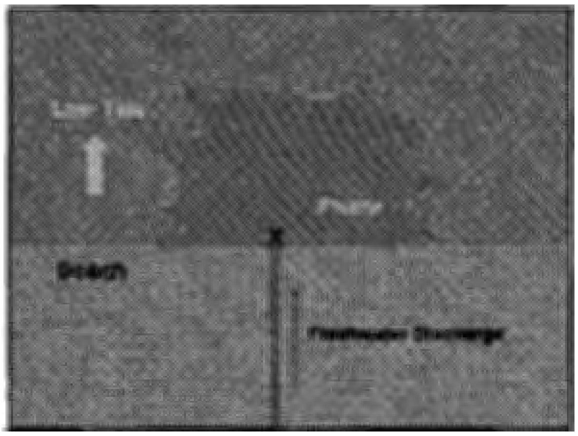
Conservative monitoring strategy: Sample at known or potential source locations in areas and times of highest expected FIB densities:

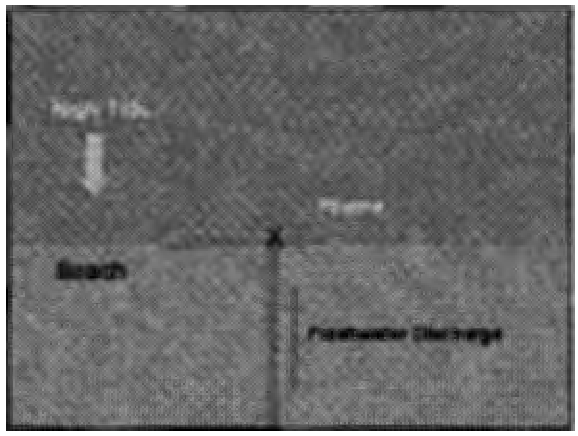
Ankle depth
Directly at known or potential sources
Freshwater discharges – point zero
Enclosed beaches – points of lowest circulation

Ankle Depth Monitoring









Monitoring

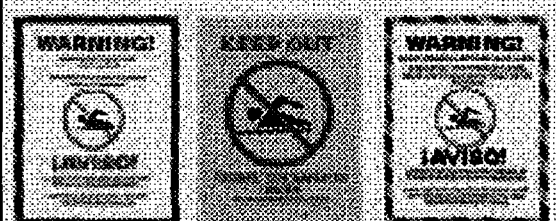
- Minimum required frequency: Weekly
- Beaches monitored less than weekly:
  - Notify public that beach is not monitored
  - Strive to get resources to monitor weekly
    - Use volunteer monitoring
    - Use less expensive chromogenic substrate tests
    - Engage local stakeholders to appeal for funding

Public Notification

Types and Triggers

- Advisory
  - Beach manager has information that increased health risk may exist (health-based standards exceeded)
  - Allows beach users to make personal risk decision based on notification information
  - General, Preemptive and Permanent
  - Trigger: geo.mean/single sample exceedances
- Closure
  - No swimming allowed
  - Trigger: Sewage release to beach

S. California's Signs



Public Notification

Minimum Notification Protocols

- Notify within 48 hrs from sample collection
- Signs at access points & *visible from entire length of beach with poor water quality*

Highly Recommended

- Post on web page within 48 hours
- Notify life guards within 48 hours

Public Notification

Confirmation Sampling

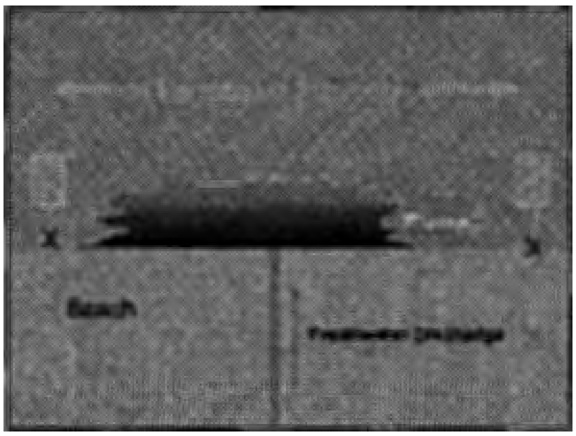
Only at low-risk beaches

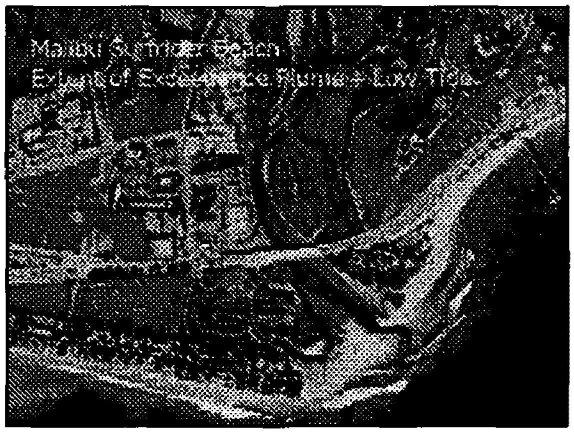
- Confirmation can occur by:
  - Confirmation in time (two consecutive samples exceed or geometric mean exceedance)
  - Exceedances of multiple indicator standard
  - Confirmation in space (two adjacent monitoring locations)
  - Confirmation by other data (e.g., odors, sanitary debris, etc.)

Public Notification

Permanent Advisory

- High risk beaches
- History of frequent, unpredictable exceedances of standards
- Protocol
  - Issue permanent warning for length of beach with poor water quality
  - Change routine monitoring goal and protocols
  - Conduct characterization survey if necessary
- Examples: storm drain impacted beaches, enclosed beaches





Public Education

- Separate component of program
- Three elements:
  - General beach pollution ed.
  - Beach
  - Outreach
- Outreach to all stakeholders including elected officials, sister agencies, lifeguards, etc.

Recommendations to Improve Public Health Protection

- Require comprehensive minimum protocols for BEACH Act grant funding
- Conduct priority Epi. study research:
  - Chronic exposures
  - Urban runoff and nonpoint source pollution
  - Alternative analytical methods/indicators
  - T/F ratio
  - FIB in tropics/subtropics

Recommendations to Improve M&PN Programs Nationwide

- Develop Rapid Indicators
- Develop source-tracking methods and guidance
- Identify pathogens of concern and develop easy analytical methods
- Assess sand and sediment as sources

www.healthebay.org

Questions and Answers

No questions.

Comparison and Verification of Bacterial Water Quality Indicator Measurement Methods and Using Ambient Coastal Water Samples

John Griffith
Southern California Coastal Water Research Project

Biosketch

Mr. Griffith is a microbiologist at the Southern California Coastal Research Project (SCCWRP). Mr. Griffith received dual B.S. degrees in Biology and Environmental Studies in 1995, and is currently a Ph.D., all at the University of Southern California. He has worked on numerous projects geared toward the development of methods and application of methods to detect and identify sources of fecal contamination and human pathogens in marine waters. Mr. Griffith joined SCCWRP in September 2001. His present research efforts focus on bacterial source tracking, and the development of rapid indicators for the detection of human fecal contamination and pathogens in urban runoff and marine receiving waters.

Abstract

More than 30 laboratories routinely monitor water along southern California's beaches for bacterial indicators of fecal contamination. Data from these efforts are frequently combined and compared even though three different methods (membrane filtration (MF), multiple tube fermentation (MTF) and chromogenic substrate (CS) methods) are used. To assess data comparability and quantify variability within method and across laboratories, 26 laboratories participated in an intercalibration exercise. Each laboratory processed three replicates from eight ambient water samples employing the method or methods they routinely use for water quality monitoring. Verification analyses were also conducted on a subset of wells from the CS analysis to confirm or exclude the presence of the target organism. Enterococci results were generally comparable across methods. There was a 9% false positive rate and a 4% false negative rate in the CS verifications for enterococci, though these errors were small in context of within and among laboratory variability. Fecal coliforms were also comparable across all methods, though CS underestimated the other methods by about 10% because it measures only *E. coli*, rather than the larger fecal coliform group measured by MF and MTF. CS overestimated total coliforms relative to the other methods by several fold and was found to have a 40% false positive rate in verification. Across laboratory variability was small relative to within and among method variability, but only after data entry errors were corrected. Nearly 20% of the labs had data entry errors, which were much larger than any method related errors.

COMPARISON AND VERIFICATION OF BACTERIAL WATER QUALITY INDICATOR MEASUREMENT METHODS USING AMBIENT COASTAL WATER SAMPLES

John F. Griffith
Southern California Coastal Water Research Project (SCCWRP)

Background

- > 30 laboratories routinely monitor microbiological water quality along southern California beaches
- Several different methods are used
  - Membrane filtration (MF)
  - Multiple tube fermentation (MTF)
  - Chromogenic substrate (CS)
- Despite differences between methods, results are often combined or compared
  - AB411 health warning decisions
  - CWA 303(d) listing

Background (II)

- Previous method comparison studies have used laboratory created water samples
- Natural samples are more complex
  - Contain interferences
    - Humic acids
    - Suspended solids
    - Native bacteria that can cause false positive results in CS methods

Purpose

- Assess comparability of results among three different bacterial measurement methods (MF, MTF, CS) using ambient water samples
- Examine variability among laboratories using the same method
- Evaluate reliability of CS methods by confirming presence or absence of the target organism
- Identify common sources of error in determining bacterial concentrations for water quality monitoring purposes

Methods (I)

- 26 laboratories participated in the study
- Ambient water samples were aseptically collected from 8 sites in southern California:
  - Open marine beaches
  - Estuaries
  - Creeks (dry weather urban runoff)
- Samples transported on ice to a central location
- 26 sets of 100 ml samples dispensed with constant stirring to ensure homogeneity

Methods

- Samples analyzed using method or methods routinely performed by each laboratory.
  - MF, MTF, CS (IDEXX media and Quantitray 2000)
  - Processing begun simultaneously
  - Multiple dilutions to ensure quantifiable range
  - Samples analyzed in triplicate

Methods (III)

- 5 laboratories performed confirmation testing
  - Secondary biochemical test or Vitek* system
    - 153 total coliform, 35 *E. coli* wells, and 71 enterococcus wells
    - 55 non-fluorescing and 21 weakly fluorescing Enterolert wells tested for false negative results

Results

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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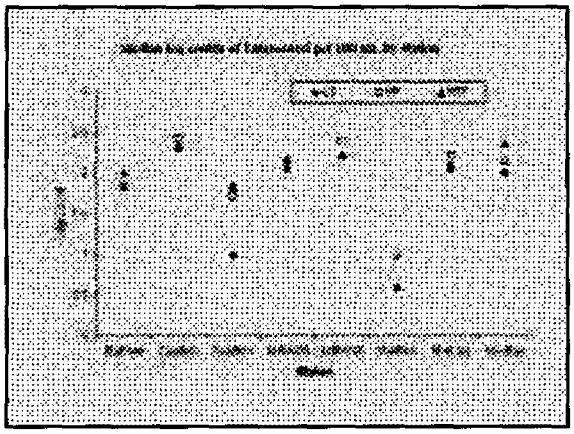

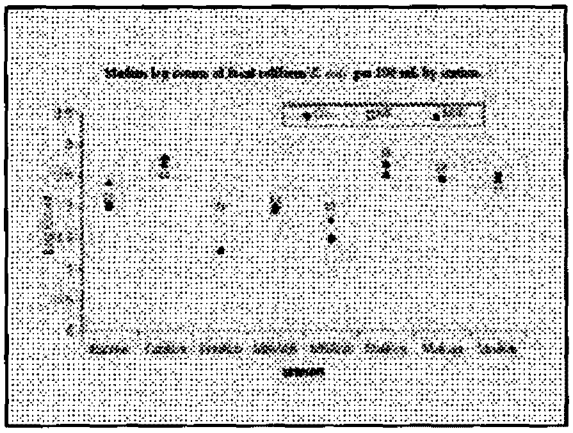

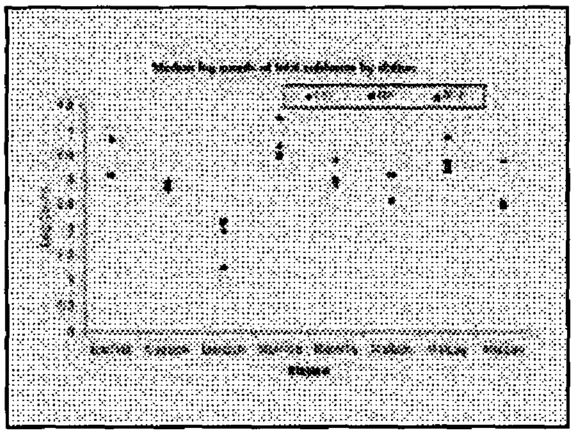

Method Comparability

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Verification Analyses

- 93 of 153 positive wells (61%) from IDEXX Quantitrays™ were confirmed to contain bacteria from the total coliform group.
- *E. coli* was isolated from all positive wells tested.
- 67 of 71 (94%) fluorescing and 5 of 55 (9%) non-fluorescing Enterolert® wells were confirmed to contain enterococci.
- 3 of 21 tested Enterolert® wells exhibiting weak fluorescence contained enterococci.

Within-lab Variability

- Enterococcus
  - Only 2 labs produced more than one result that differed from the group median by more than ½ log unit.
- Fecal coliforms/E. coli
  - 2 labs performing MF and one performing MTP produced values more than ½ log unit above the group median.
- Total coliforms
  - No lab differed by more than ½ log unit from the group median when compared within method.

Method Variability

[illegible]

Method	Enterococcus (CA Std.~104)				Fecal coliform/E. coli (CA Std.~400)				Total coliform (CA Std.~10,000)			
	Above		Below		Above		Below		Above		Below	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CS	160	287	68	30	634	2099	250	197	19977	20000	5307	6021
MF	180	176	7	18	767	1170	208	148	14800	26060	9145	3000
MTP	209	344	34	24	896	1424	186	122	21449	32360	2000	4678

Conclusions

- All 3 methods produced similar results for enterococci.
  - Some false positives and false negatives were confirmed for CS.
  - Both rates were small compared to within-lab and method variability.

Conclusions (II)

- The only large difference between methods was severe overestimation of total coliforms by the CS method.
  - Little practical effect on posting of beach warnings
  - TC standard is almost never exceeded without concurrent exceedence of FC or enterococcus standard.

Conclusions (III)

- Systematic error is of concern, but the largest source of error was attributable to data processing.
  - Pre-screening of results prior to data analysis identified four labs whose results differed by an order of magnitude from those of the other labs.
  - Review of original laboratory data sheets corrected data submission errors.
  - These labs then produced data similar to the other labs.

Acknowledgements

This study was undertaken as part of the Bight '98 Regional Monitoring program coordinated by the Southern California Coastal Water Research Project and was made possible through the cooperative efforts of the the following individuals and organizations:

Larissa Aumand, Jeannette Lee, Charles McGee, Linda Sikman, Kerry Ritter, Kathy Walker and Stephen Weisberg.

Orange County Sanitation District, Los Angeles County Sanitation Districts, County of San Diego, City of Long Beach, City of Los Angeles, City of Oceanside, City of Oxnard, City of Encinitas, City of San Diego, County of Ventura, Port of San Diego, Southern California Marine Institute, San Elijo Joint Powers Authority, South Orange County Water Authority, MEC Analytical Systems, Inc., ABC Laboratories, CRG Laboratories, IDEXX Inc., Heal the Bay, Orange County Coast Keeper, San Diego Baykeeper, Santa Monica Baykeeper, University of California at Irvine, Loyola Marymount University.

Questions and Answers

Q (Toni Glymph, Wisconsin Department of Natural Resources): We looked at ambient testing and saw similar results, but when comparing methods with wastewater discharge, we're getting a different picture. Depending on the type of disinfection, test methods, etc., data can be magnitudes different. Have you looked at the types of wastewater? The test methods do not compare when looking at wastewater effluent.

John Griffith

We did not look at any wastewater effluents. The hypothesis is that organisms are susceptible to the different chlorination methods at different levels, so when you grow bacteria on different media you will get differential results. That could be what we saw at Doheny Beach as well.

Comment: UV disinfection gives consistent results, but the chlorination method is completely different. So, it really depends on what test method you use and how you treat your wastewater.

Composite Sampling as an Alternative Technique for the Determination of Bacterial Indicators in Recreational Waters

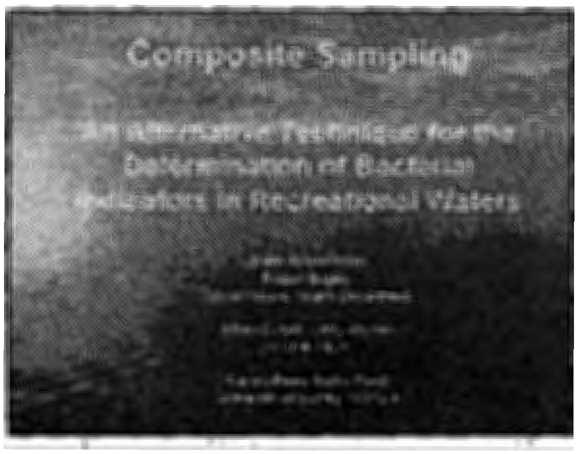
Julie Kinzelman
City of Racine

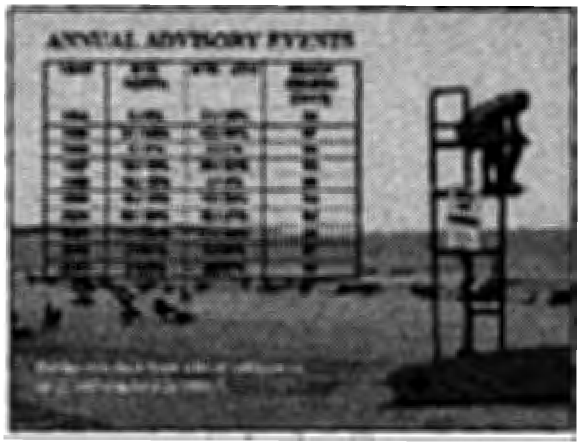
Biosketch

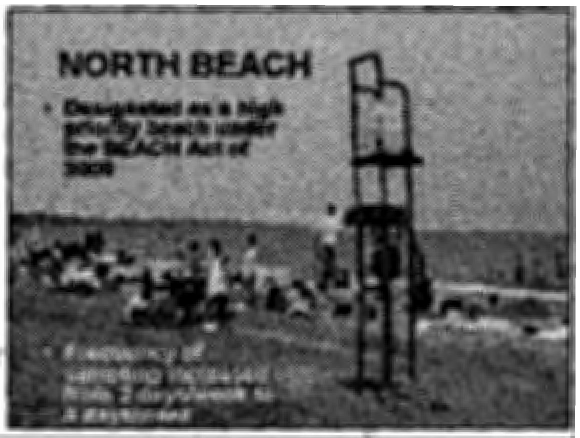
Julie Kinzelman is a microbiologist for the City of Racine Health Department where she has 14 years experience in recreational water quality monitoring and research. Dr. Kinzelman received a BS in Medical Technology from the University of Wisconsin - Parkside, a MS in Clinical Laboratory Sciences from the University of Wisconsin -Milwaukee, and is a Ph.D. Candidate (2005) in Public & Environmental Health at the University of Surrey (Guildford, UK). Dr. Kinzelman is the principal investigator or co-investigator on research initiatives funded by the National Institute of Health, S. C. Johnson Fund, Wisconsin DNR, and Wisconsin Department of Health & Human Services. Her current research activities focus on using public health based monitoring programs to assess the interaction of coastal processes contributing to recreational water quality advisories.

Abstract

The BEACH Act requires states to develop recreational water quality monitoring and notification programs using approved standards. Testing frequency is based on usage and beaches with extensive shorelines, which may require multiple-site sampling, could see significantly increased costs for monitoring recreational waters. This study explored composite sampling at two Racine, Wisconsin beaches over four months (n=68 days) in order to determine whether composite sampling could provide a valid, unbiased, and cost-effective measure of surface water quality. Multiple-point sampling occurred throughout the swimming season with samples being collected daily from three (Zoo Beach) or four (North Beach) fixed sampling points. From each individual sample, well-mixed aliquots were combined to form a single composite sample. Individual and composite samples were analyzed identically for *Escherichia coli* using Colilert-18/Quanti-Tray/2000®. Results indicated a reasonable expectation of a simple 1:1 ratio between the composite samples and the arithmetic mean of the 3 or 4 individual samples. Additionally, log variance of the composite sample results did not differ significantly from that of the single sample averages ($p > 0.2$). Empirical values for log standard deviations varied by no more than 7% between the composite sample and individually assayed samples. In this study, compositing appeared to introduce neither bias nor additional variability into the monitoring results and, therefore, stands as a reasonable alternative to data sets derived from single-sample methods. Regulatory programs requiring large numbers of samples to be analyzed could benefit from the adoption of this type of sampling scheme as a means of reducing the costs associated with the implementation.

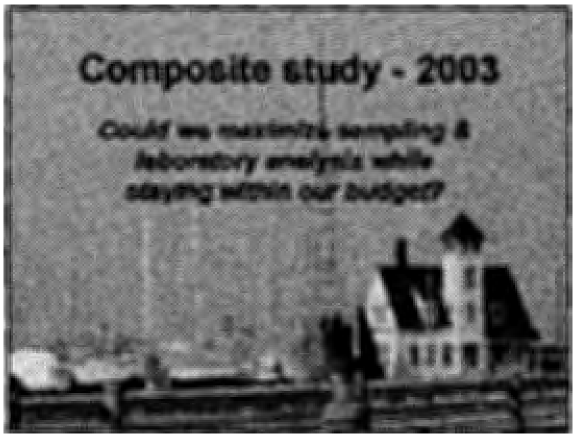


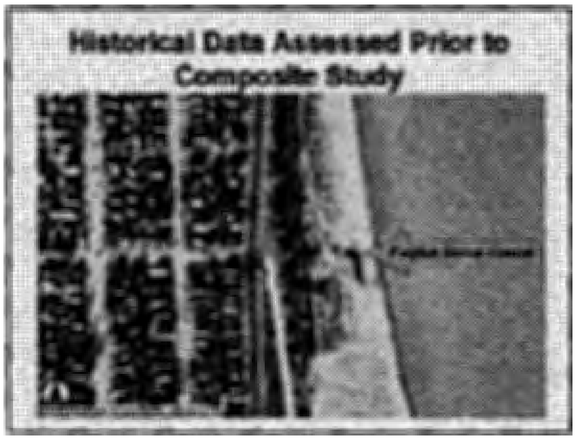




ADVANTAGES TO INCREASED MONITORING

- Increased frequency of monitoring is more protective of public health
- Increasing the number of sampling events will increase the probability of detecting changes in the bacteriological quality of surface water due to inputs of fecal contamination
- Increasing the number of monitoring stations provides a better characterization of water quality across the entire shoreline





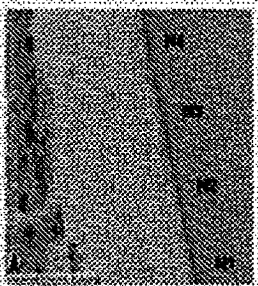
GPS SAMPLING LOCATIONS

SITE	LATITUDE	LONGITUDE	ERROR
N1	[illegible]	[illegible]	[illegible]
N2	[illegible]	[illegible]	[illegible]
N3	[illegible]	[illegible]	[illegible]
N4	[illegible]	[illegible]	[illegible]
Z1	[illegible]	[illegible]	[illegible]
Z2	[illegible]	[illegible]	[illegible]
Z3	[illegible]	[illegible]	[illegible]
Mouth of Root River	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

RESULTS OF HISTORIC MONITORING DATA

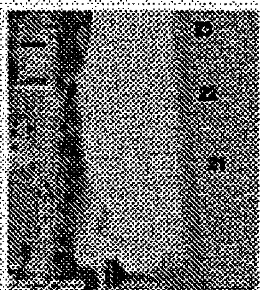
- Historic single point data for all beach sampling sites(N1 - N4 and Z1 - Z3) analyzed
- Newman-Keuls multiple comparisons & Tukey multiple comparisons demonstrated no significant difference in the mean *E. coli* concentrations across beach transects
- Population homogenous in nature
- Feasible to conduct composite study at this site

NORTH BEACH – SAMPLING SITES



- 4 fixed sampling sites
- Equidistant over length of beach
- Samples collected Monday –Friday
- Collected at depth of 1 meter (0.3 m below the surface)
- Sampling season is late May to early September

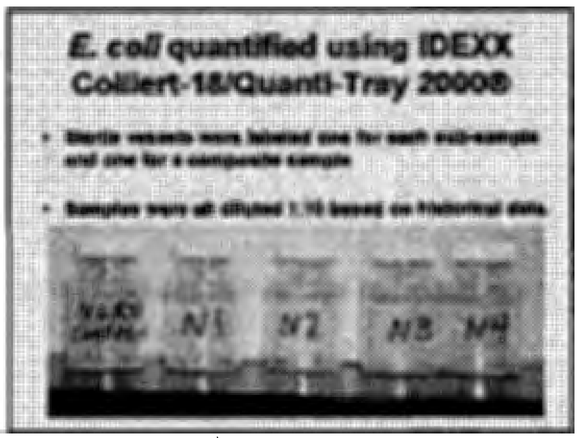
ZOO BEACH – SAMPLING SITES



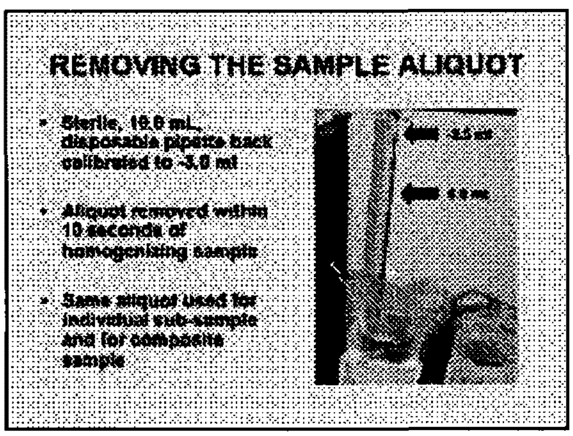
- 3 fixed sampling sites
- Equidistant over length of beach
- Samples collected Monday –Friday
- Collected at depth of 1 meter (0.3 m below the surface)
- Sampling season is late May to early September

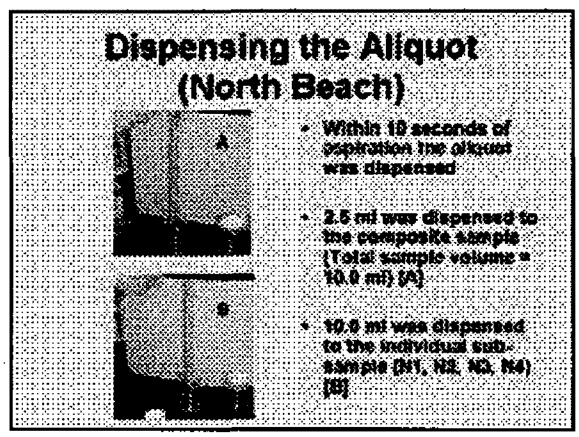

COLLECTION OF SURFACE
WATER SAMPLES


North Beach:
4 Sub-Samples


E. coli quantified using IDEXX
Colilert-18/Quanti-Tray 2000®
N1
N2
N3
N4


Each of the samples was
vigorously shaken by hand to
ensure homogeneity

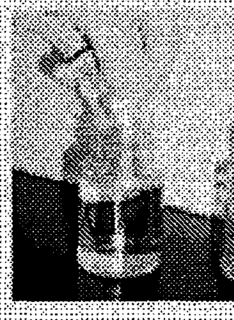

REMOVING THE SAMPLE ALIQUOT
• Sterile, 10.0 mL, disposable pipette back calibrated to ~3.0 ml
• Aliquot removed within 10 seconds of homogenizing sample
• Same aliquot used for individual sub-sample and for composite sample


Dispensing the Aliquot
(North Beach)
A
B
• Within 10 seconds of aspiration the aliquot was dispensed
• 2.5 ml was dispensed to the composite sample (Total sample volume = 10.0 ml) [A]
• 10.0 ml was dispensed to the individual sub-sample (N1, N2, N3, N4) [B]

Samples were divided using microbiologically sterile Type I wa

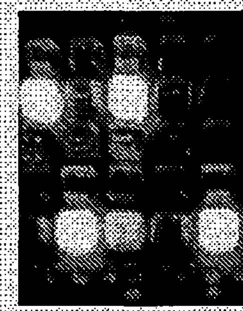
Addition of Reagent

- IDEXX Colilert-18 reagent was aseptically added to each sample
- Samples mixed & reagent allowed to go into solution
- Aseptically transferred to a Quanti-Tray 2000

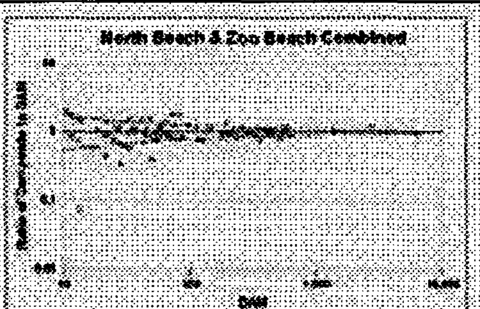


IDEXX Quanti-Tray/ 2000® & Quanti-Tray Sealer

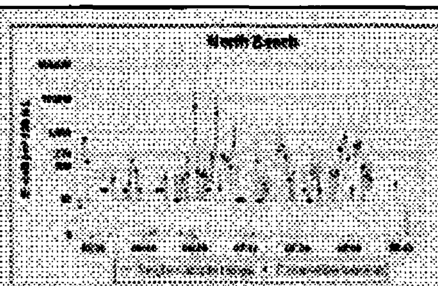
CONCENTRTATION OF *E. coli*



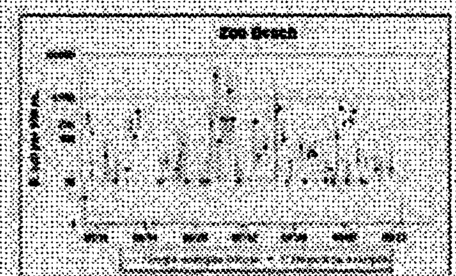
- Quanti-Trays were incubated for 18 hours at 35 ± 0.5 °C
- Wells producing blue fluorescence under UV light were counted
- Concentration of *E. coli* determined using the provided MPN table



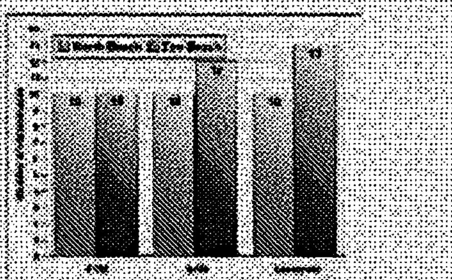
Observed ratios of composite sample to corresponding daily arithmetic mean (DAM). The dashed lines indicate the theoretical 90% occurrence envelope under ideal conditions. Because of sampling variation, the actual 90% limits will be somewhat wider than this. (The linear pattern that is evident at lower values of DAM is an artifact of the discrete nature of these data.)



Composite sample values and corresponding ranges of single sample densities of *E. coli* per 100 mL. Generally, composite sample results are seen to be within the range of single sample values, although, as would be expected, there are exceptions. On those occasions when the single sample results are unequivocal in regard to whether the single-sample limit has been exceeded (all 3 values above or below 235 per 100 mL), the composite sample result is in agreement.



Composite sample values and corresponding ranges of single sample densities of E. coli per 100 mL. Generally, composite sample results are seen to be within the range of single sample values, although, as would be expected, there are exceptions. On those occasions when the single sample results are unequivocal in regard to whether the single-sample limit has been exceeded (all 3 values above or below 235 per 100 mL), the composite sample result is in agreement.



Number of single-sample limit exceedances (E. coli per 100 mL > 235) for daily geometric mean (GMN), daily arithmetic mean (DAM), and composite samples. For North Beach, this is based on a total of [illegible] sampling days, and for Zoo Beach, a total of [illegible] sampling days. The relative number of exceedances by each of the three sampling/computational methods will depend on how far above or below the limit the true values are, but in general one expects a higher frequency of exceedance with DAM or composite samples.

RESULTS

- The log variance of composite sample did not differ significantly from that of the single sample arithmetic averages (p > 0.2)
- Results from this study indicate a reasonable expectation of a simple 1:1 ratio between the composite samples and the arithmetic mean of the 3 or 4 individual samples
- Empirical values for log standard deviations varied by no more than 7% between the composite sample and individually assayed samples
- Compositing appeared to introduce neither bias nor additional variability into the monitoring.

Days Exhibiting a Difference in Water Quality When Determining *Escherichia coli* Concentration (MPN/100 mL) by Composite Sampling Versus Single Point Samples - North Beach, Racine, WI (2003)

Date	N1	N2	N3	N4	Composite
6-26-03	63	256	<1	<1	63
6-29-03	10	31	323	41	74
7-3-03	30	256	269	327	189
7-6-03	148	187	316	246	187
7-8-03	20	249	175	218	98
7-15-03	10	143	97	650	150
7-23-03	109	345	51	228	185
7-30-03	<1	41	41	343	63
8-9-03	187	142	187	243	171

Days Exhibiting a Difference in Water Quality When Determining *Escherichia coli* Concentration (MPN/100 mL) by Composite sampling Versus Single Point Samples - Zoo Beach, Racine, WI (2003)

Date	Z1	Z2	Z3	Composite
6-10-03	158	295	379	185
7-3-03	31	547	110	231
8-9-03	250	187	201	231

DISCUSSION

- Small number of cases in this study (12 out of a total 136 observations) when there were discrepancies between composite and single point samples
- Could the composite sampling process mask a result which could pose a potential health risk to bathers?
- Basing pass/fail criteria on single samples taken days apart – the current process - is imprecise due to the extreme variability between samples.
- Likelihood of such a one-off result being truly representative is extremely small.
- Compositing samples is a step towards obtaining the best possible characterisation of mean indicator density

DISCUSSION (con.)

- Increase ability to detect true elevations above background levels
- Encourages more sampling
- More reliable estimate of mean indicator density
- Increases chance of detecting results that fall outside the expected range
- Significant financial benefit to agencies responsible for water monitoring programs

ACKNOWLEDGEMENTS

- City of Racine, Health Department Laboratory
- Gil Dichter & Scott King, IDEXX Laboratories
- S. C. Johnson, A Family Company
- Kevin Longmaid, Farnborough College Of Technology

UniS

Questions and Answers

Q: What method is used to monitor the Great Lakes?

Julie Kinzelman
IDEXX Colilert-18 for *E. coli.*

Q: You don't use Enterolort?

Julie Kinzelman
No, because we are looking at fresh water so we test for *E. coli*. Enterococci is also accepted by EPA, and we looked at enterococci in the past as an alternative to *E. coli*. But, we thought we would have more advisories in the absence of a defined public health risk. So, at this point-in-time we continue to use *E. coli.*

Q: Were samples collected away from the tide? You mentioned working in a sterile environment, and I am wondering if the sampler could be exposing himself to the sample bag?

Julie Kinzelman
There is no true tide in the Great Lakes. Samples were collected at arm's length (about 1 foot/0.3 m) below the surface of the water and pulled back up away from the body of the sampler.

Q: Have you ever had a false positive result?

Julie Kinzelman
Not that I'm aware of.

How Often and Where to Monitor: Outcome of the EMPACT Study

Larry Wymer
U.S. Environmental Protection Agency

Biosketch

Larry Wymer is a statistician for the US EPA Office of Research and Development. Mr. Wymer received his MBA in Quantitative Analysis from the University of Cincinnati. He has worked for the National Exposure Research Laboratory in Cincinnati, Ohio for the past 6 years. His main research interests are characterization of recreational water quality and indoor mold. He also serves as an Advisor to ASTM Committee D19 on water.

Abstract

Current EPA recommendations for monitoring the quality of recreational waters calls for the collection of five samples over a 30-day period and the calculation of a running geometric mean to determine if the water quality meets suggested standards. This approach does not provide timely, accurate information for risk managers or the public. A solution to this problem is to develop a statistically valid monitoring protocol which takes into account elements that contribute to the uncertainty associated with sampling bathing beach waters.

EMPACT partner cities, representative of various bathing beach environments, such as marine, freshwater, estuarine, and riverine sites, were recruited to participate in a study monitoring their respective beaches. The major objective of this research was to develop a monitoring protocol for measuring the quality of bathing beach waters describing when, where and how many samples should be taken, and how the data should be analyzed. The collected data were evaluated to develop an economically feasible monitoring protocol to effectively minimize uncertainty about the quality of bathing waters.

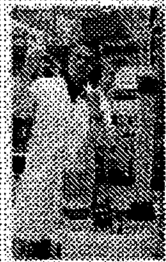
Major findings of this study were that distance from shoreline and time of day have significant effects on the results of water quality monitoring. In general, the further away from the shoreline samples were taken, the lower the bacterial densities observed. Indicator levels also tended to be lower in mid-afternoon compared to what they were in the morning. There is an indication that this decline is due to solar radiation, since it tended to be less pronounced, or even non-existent, with increasing cloud cover. Rain, wind direction and velocity, and tides (absolute water level) also significantly influenced bacterial indicator densities at the beaches, while bather density and water temperature did not appear to do so.

Spatial and temporal sources of variation were defined by the study. Replicate variance, sampling depth, distance from shoreline to knee or waist depth, as well as variance between transects from shoreline were all significant contributors to the spatial sources of variation observed at the beaches. Day-to-day variation would be the main source of variability over time. About one-half of the time the change in target indicator density was by a factor of two or more from one day to the next.

These data indicate that only three to six samples taken from water of roughly in the same depth (knee- to chest-deep) may be adequate to characterize water quality at a given point in time. This sample size recommendation is derived not only from variability of target densities observed in this study, but also from consideration of the relative uncertainty inherent in the estimated health effect.

Often and Where to Monitor: Outcomes of the EMPACT Study

Research and Development at EPA



- 1,950 employees
- $700 million budget
- $100 million extramural research grant program
- 13 labs or research facilities across the U.S.
- Credible, relevant and timely research results and technical support that inform EPA policy decisions

EMPACT Beaches Study "The Team"

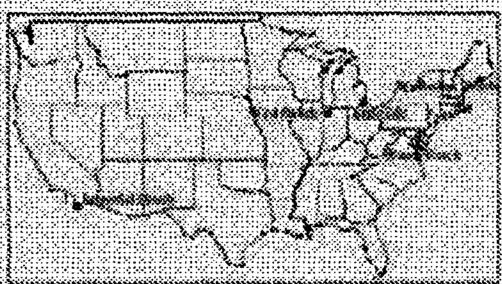
- Alfred P. Dufour[1]
- Stephan A. Schaub[2]
- Kristen P. Brenner[1]
- Larry J. Wymer[1]
- John W. Martinson[1]
- Walter R. Stutts[1]

[1]National Exposure Research Laboratory
[2]Office of Water

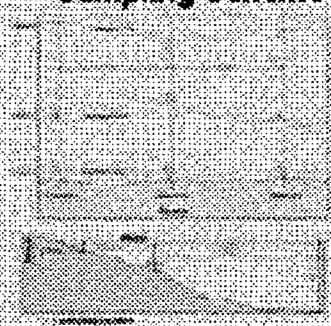
EMPACT Beaches Study

- July-August, 2000
- 5 beaches
- Twice daily sampling
  - Freshwater – *E. coli*
  - Marine/estuarine - enterococci
- 9 "fixed" locations in the water

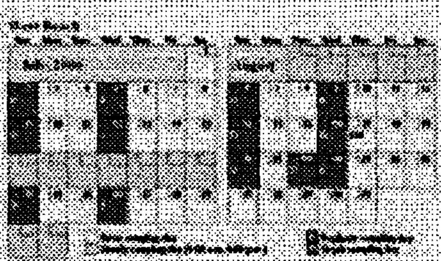
Study Beaches



Sampling Scheme



Sampling Schedule



Spatial Factors

- Transect (along shoreline)
- "Zone" (water depth)
- Sampling depth

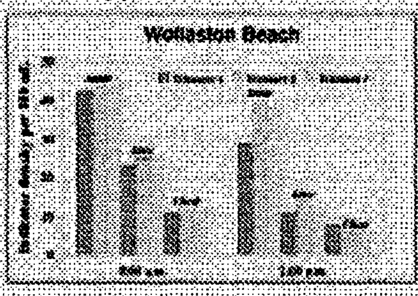
Temporal Factors

- Time of day (a.m. or p.m.)
- Day-to-day
- Day of week

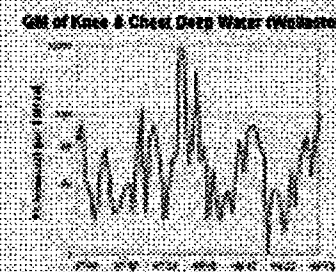
Environmental and Human Effects

- Weather
- Tides and currents
- Bathers

Typical Outcome



Another Typical Outcome



Study Results: Sources of Variation

Location	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Sample Size Requirements

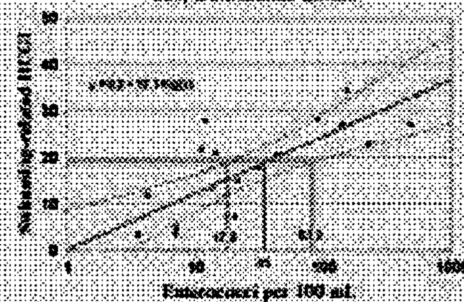
Location	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Is This Good Enough?

- In terms of the geometric mean:
  - +/- 0.3 logs is a factor of 2
    - If GM=35, 95% C.L. = 17.5 to 70
  - +/- 0.2 logs is a factor of 1.5
    - If GM=35, 95% C.L. = 23 to 53

Swimming-related Risk

95% Confidence Limits



+/- 0.3 Logs Appears to Be Adequate

- 95% C.L. for added risk of HCGI equal to 19 per 1000:
  - 17.8 – 83.2 enterococci/100 mL or
  - 1.25 – 1.92 logs (0.67 log range)
- +/- 0.3 logs

Lessons From the EMPACT Beaches

- ~3-5 samples in water of swimming depth
- Daily sampling (or as often as relevant)
  - Sample in a.m.
  - Rapid methods or accurate "nowcasting"

Questions and Answers

Q: From a bacteria study in San Juan Creek, samples collected near storm drain outlets had high concentrations of bacteria, including enterococcus. Also, the effects of sunlight may have reduced bacteria (Enterococcus). Can you demonstrate the die-off rate statistically? Is there a hypothesis on why bacteria would be persistent near the surface of water (closer to sunlight) in the ankle water? I assume when you say "ankle water" you mean that samples were taken in water that was ankle-deep. Is there a correlation with temperature? I t would seem that the bacteria counts would be inversely related to the temperature.

Larry Wymer

We did not see any change with temperature, which could be because the temperature did not vary much. However, there was definitely an effect of sunshine. The decline of bacteria was greater on sunny days compared to cloudy days, from morning to afternoon. Although, hourly samples did not show a consistent pattern in levels of bacteria.

Comment (Mark Gold, Heal the Bay): Heal the Bay, the City of Los Angeles, and the Los Angeles County Sanitation District did a very similar study about 15 years ago and got almost identical results, with high densities in morning. The project also showed a difference in bacteria levels among ankle, waist and chest depths. Although, temperature does not tend to vary enough to drive any results.

Q (Dustin Bambic, Larry-Walker Associates): You seem to be aware of the UV degradation that bacteria exhibit during the day. Are there any studies where the pathogens themselves showed a similar response to UV, since we are looking for the pathogens and not the bacteria themselves?

Larry Wymer

Yes. I hear that it's not just UV that causes degradation, but also visible light.

Mark Gold

I have not seen any pathogens studies, but I know that when Rachel Noble was at SCCWRP they did some extensive work on the indicators, but not on the pathogens themselves.

Comment (Dustin Bambic): I have done studies with sunlight and saw that it goes into the visible range [tape inaudible].

Wednesday, October 13
3:20 p.m. – 5:00 p.m.

Session Four: The Public Notice Decision Process and Public Perception

Source Unknown: Questionable Geometric Mean Exceedances at Two Pristine North Carolina Beaches

J.D. Potts
North Carolina Department of Environment and Natural Resources

Biosketch

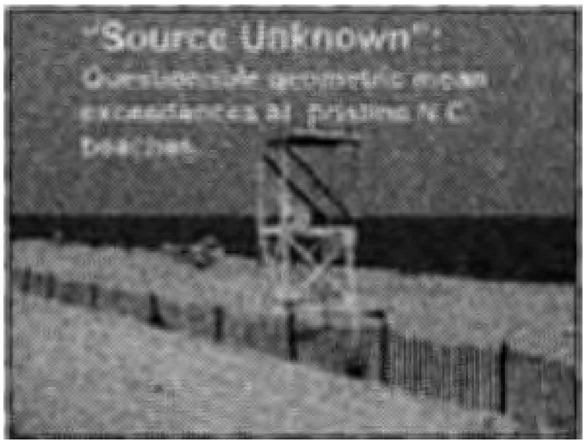
Mr. J.D. Potts is the manager of North Carolina's Recreational Water Quality Program. Mr. Potts received his B.S. in Fisheries and Wildlife Science from North Carolina State University. He has worked for the N.C. Division of Environmental Health in the Shellfish Sanitation and Recreational Water Quality Section for fifteen years. He worked as a shoreline surveyor for eight years before starting the state's recreational water quality program in 1997. He currently directs the program's statewide coastal recreational water quality activities.

Abstract

North Carolina's Recreational Water Quality Program tests 240 sites along the ocean beaches, sounds, and coastal rivers. During the 2004 swimming season, the program posted several swimming advisories at historically pristine beaches, including a public access ocean site in Carteret County and the Cape Hatteras Lighthouse in the Outer Banks in Dare County. These sites experienced high initial counts and the Carteret Co. site then experienced a high count on the re-sampling. The high sample results changed the basis of the swimming advisories from exceeding single-sample levels to exceeding the monthly geometric mean. Geometric mean exceedances require that the weekly sample results drop below the limit before the advisory is removed.

The high samples kept the geometric mean over the standard for over a month in the Carteret County case, with the sign staying up for four weeks while weekly tests showed minimal counts. No source of pollution was identified at the Carteret site. The single high sample for the Cape Hatteras Lighthouse resulted in the advisory remaining for a week, based on daily sampling results that were taken after a possible source was identified and removed. If the possible source, a National Park Service drainage culvert, had not been identified and closed, this advisory is likely to have remained up for several weeks as well, despite subsequent low bacterial counts.

These occurrences raise questions about whether the current geometric mean practices portray an accurate picture of coastal recreational water quality. The adverse public perceptions these advisories cause do not reflect actual water quality public health risks.



Shellfish Sanitation and Recreational Water Quality Section

N.C. Division of Environmental Health
Dept. of Environment and Natural Resources

Overview of N.C. RWQ Program

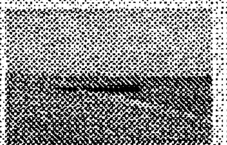
- 240 swimming sites monitored.
- 17 people directly involved in the RWQ program during the swimming season.
- 5 of the 17 people are funded by the BEACH grant.

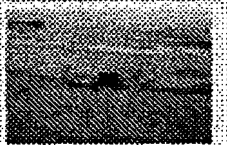
Overview of N.C. RWQ Program

- 3 regional labs.
- 12 boats for sampling interior waters.
- Annual budget approximately $545,000.
- $240,000 N.C. + $305,000 grant.

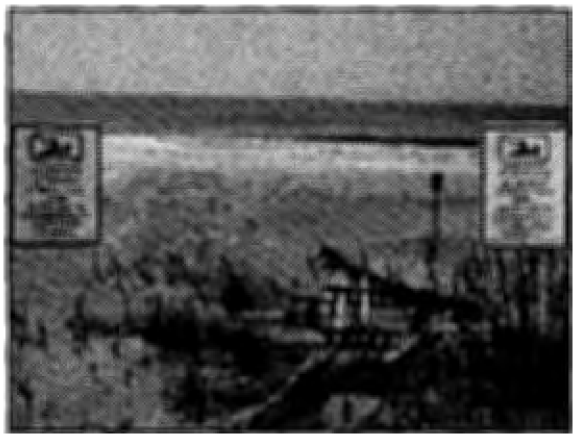
Storm Drains

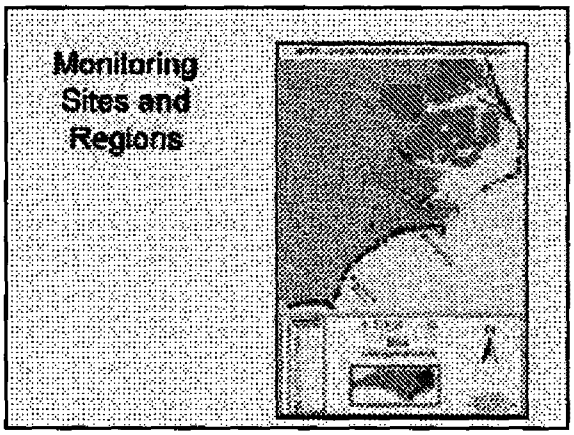
- New rules require all actively discharging pipes to be posted.
- 10 ocean storm drains have dry weather discharges.
- 10 additional ocean storm drains have wet weather discharges.

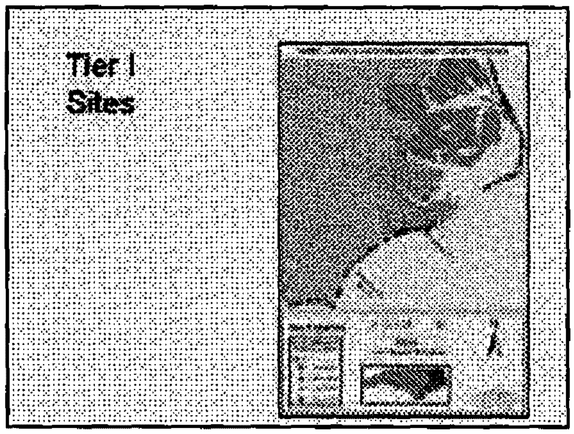


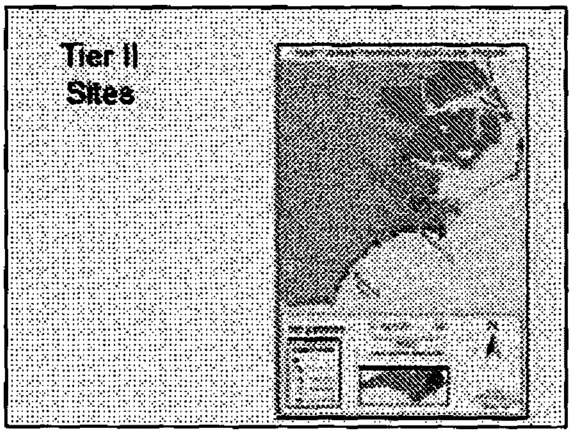


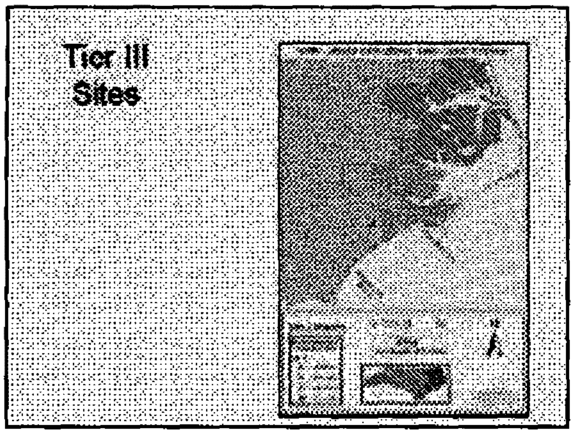
Non-Discharging Storm Drains

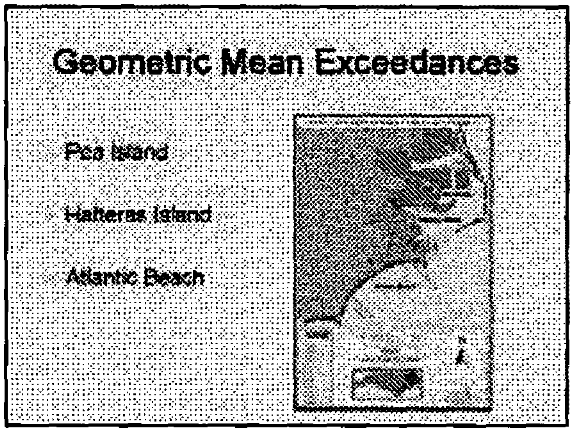


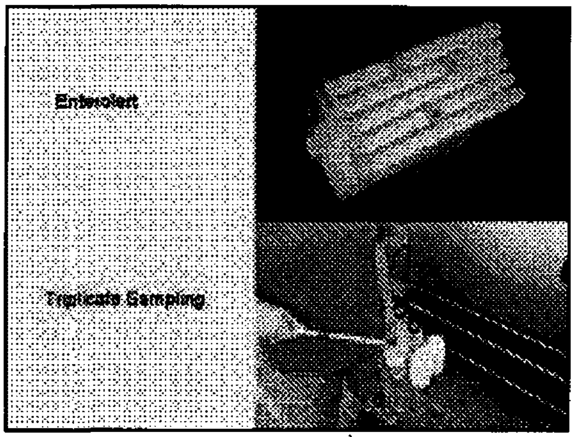

Monitoring
Sites and
Regions

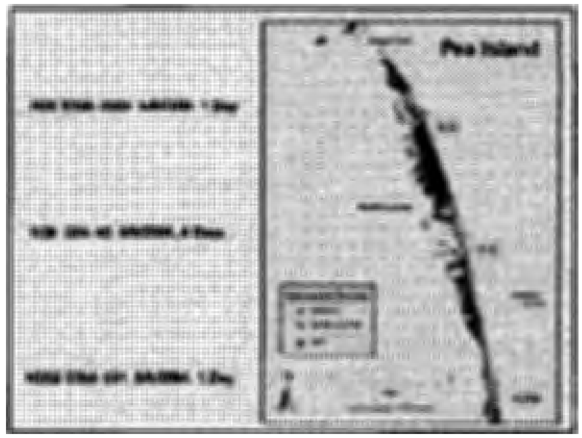

Tier I
Sites

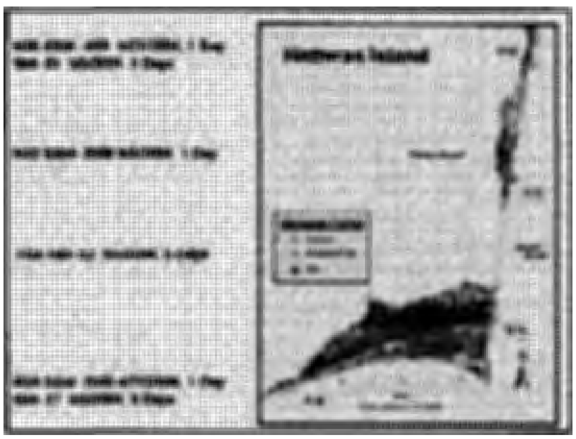

Tier II
Sites


Tier III
Sites

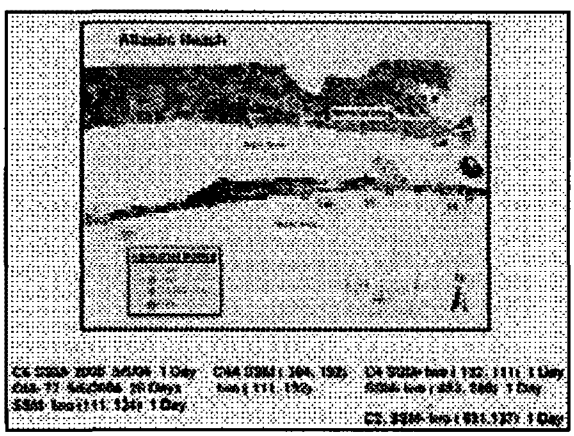

Geometric Mean Exceedances
Pea Island
Hatteras Island
Atlantic Beach

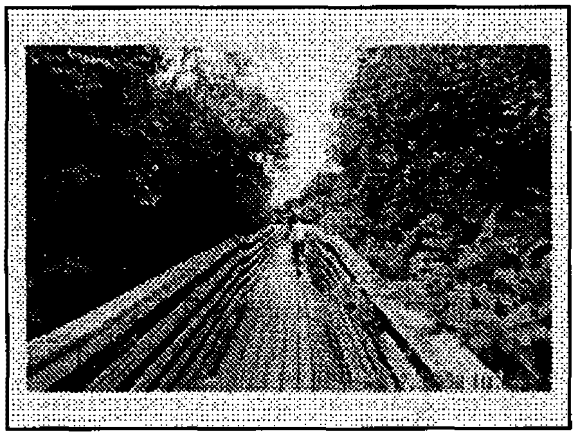

Enterolert
Triplicate Sampling

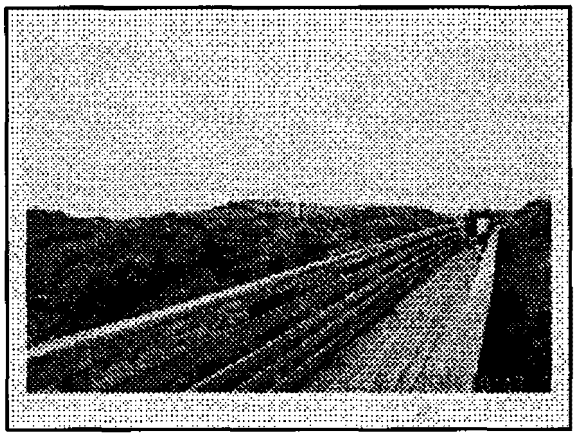

Pea Island

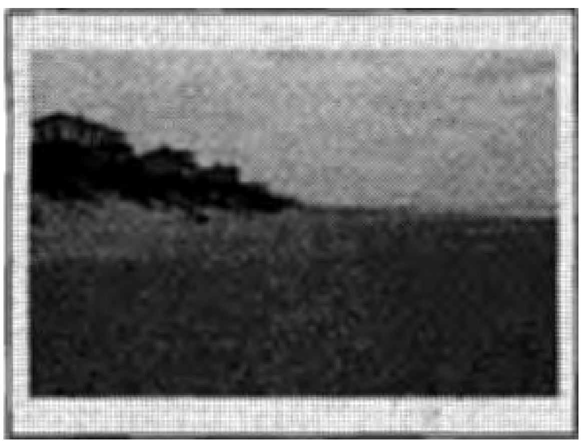


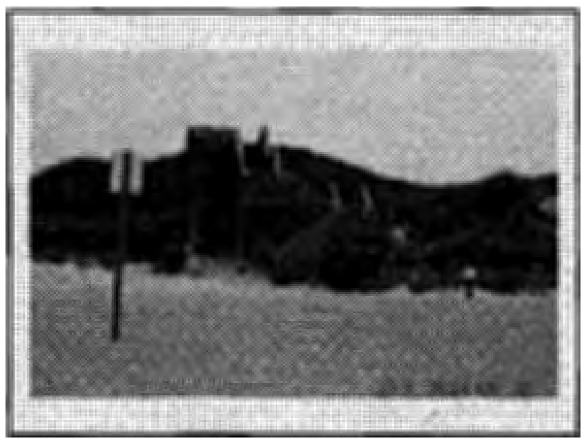

Wetland Drainage

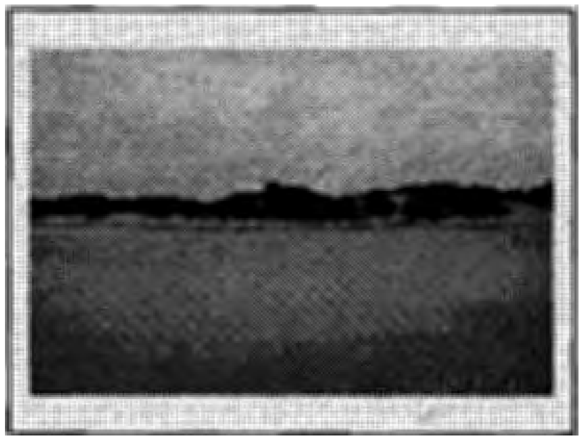




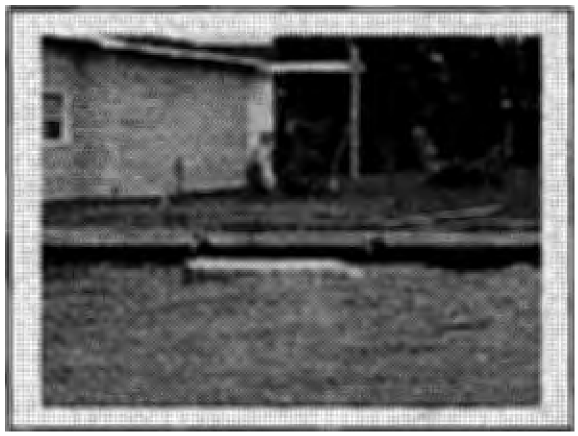








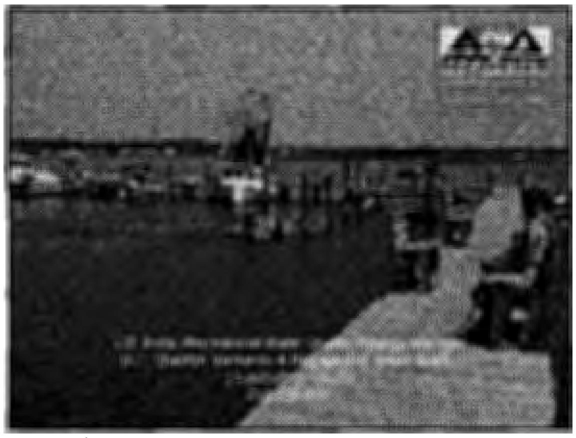

Precautionary Blanket Advisories



Conclusion

States should be able to use best profession judgment for rescinding geometric mean advisories at sites with no pollution sources when sampling indicates no further problems.

EPA guidance for blanket precautionary advisories associated with storms would be helpful.



Questions and Answers

No questions.

Misinformation in Beach Warning Systems

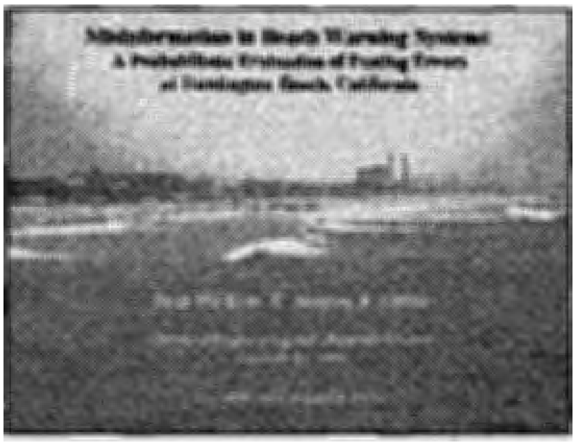
Stanley Grant
University of California at Irvine, Henry Samueli School of Engineering

Biosketch

Dr. Stanley B. Grant is Professor of Environmental Engineering, and Chair of the Department of Chemical Engineering & Materials Science at the University of California, Irvine (UCI). Dr. Grant received a B.S. (with distinction) in Geology from Stanford University (1985) and a M.S. and Ph.D. in Environmental Engineering Science from the California Institute of Technology (1990 and 1992, respectively). Dr. Grant studies the sources, fate, and transport of pathogens and indicator organisms in drinking water, urban runoff, and the coastal ocean. He is a member of the US Environmental Protection Agency's Science Advisory Board (Drinking Water Panel), and is the lead on several multidisciplinary research projects, including one on the influence of tidal wetlands on coastal pollution (joint with researchers from UCI, Scripps Institution of Oceanography, and UCLA, funded by the University of California Marine Council); another on the association of pathogens and particles in storm runoff (joint with researchers from UCI and UCSB, funded by the US Geological Survey and the National Water Research Institute); and a third on the contribution of marinas to fecal indicator bacteria impairment in tidal embayments (in support of the Newport Bay Fecal Coliform TMDL, funded by the California State Water Quality Control Board). Dr. Grant is recipient of the prestigious Career Award from the National Science Foundation (1985-2000), and a number of local awards including Conservator of the Year (2002) from the Bolsa Chica Wetlands Conservancy, and the Distinguished Assistant Professor Award for Teaching from the UCI Academic Senate (1999).

Abstract

Whenever measurements of fecal pollution in coastal bathing waters reach levels that might pose a significant health risk, warning signs are posted on public beaches in California. Analysis of historical shoreline monitoring data from Huntington Beach, southern California, reveals that protocols used to decide whether to post a sign are prone to error. Errors in public notification (referred to here as posting errors) originate from the variable character of pollutant concentrations in the ocean, the relatively infrequent sampling schedule adopted by most monitoring programs (daily to weekly), and the intrinsic error associated with binary advisories in which the public is either warned or not. In this paper, we derive a probabilistic framework for estimating beach posting error rates, which at Huntington Beach range from 0 to 41%, and show that relatively high sample-to-sample correlations (>0.4) are required to significantly reduce binary advisory posting errors. Public mis-notification of coastal water quality can be reduced by utilizing probabilistic approaches for predicting current coastal water quality, and adopting analog, instead of binary, warning systems.



Ocean Bathing Water Quality Standards for FIB in California

- Total Coliform
  - 10,000 MPN/100 mL (single sample)
  - 1,000 MPN/100 mL (30-day geo mean)
- Fecal Coliform
  - 400 MPN/100 mL (single sample)
  - 200 MPN/100 mL (30-day geo mean)
- Enterococci bacteria
  - 104 MPN/100 mL (single sample)
  - 35 MPN/100 mL (30-day geo mean)

Posting/Closure Protocol in California

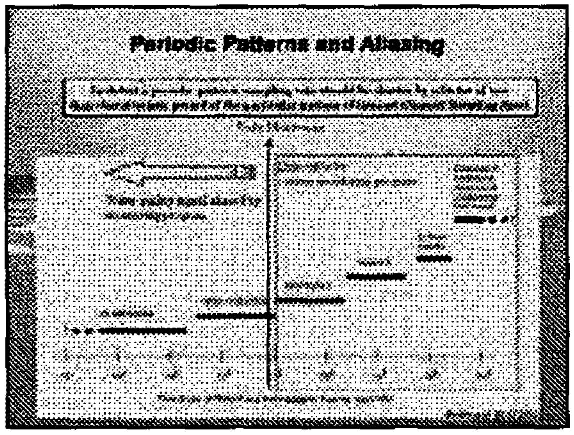
- If FIB concentrations in the surf exceed any of these standards, the local health officer is required to post a sign on the beach warning the public about potential health risks (*beach posting*)
- If the local health officer believes that the surf may be contaminated with sewage, he/she has the option of closing the beach to the public (*beach closure*)

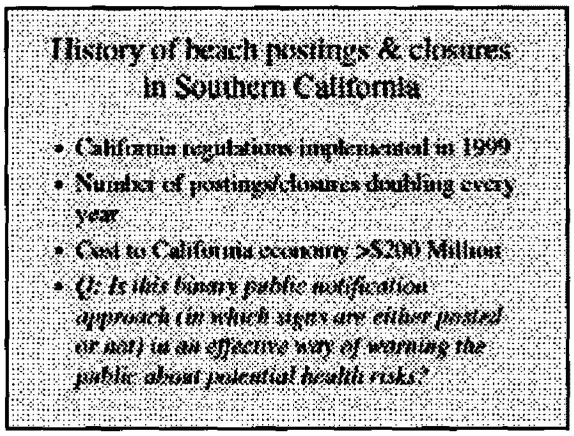
Primary Research Questions

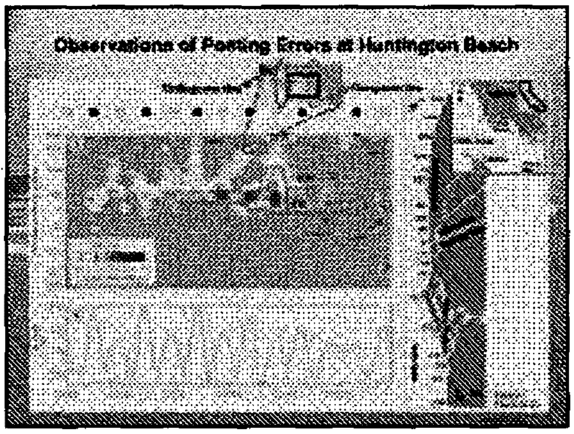
- Can the posting error rates observed at Huntington Beach be rationalized with a simple probability model for binary advisories?
- Can public advisories be improved by adopting probabilistic approaches for forecasting (or now-casting) water quality?

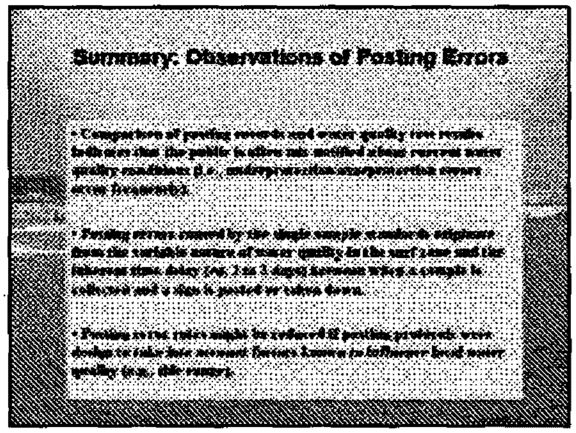
What factors influence water quality test results?

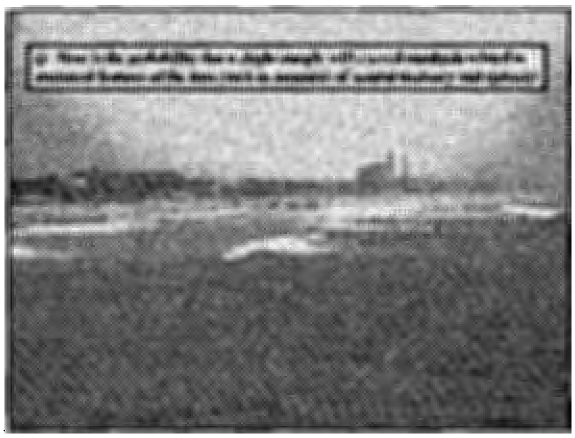
- A cascade of periodic cycling driven by both anthropogenic activities and physical processes (next slide)
- Errors associated with the test results themselves (ca., 20–30%)

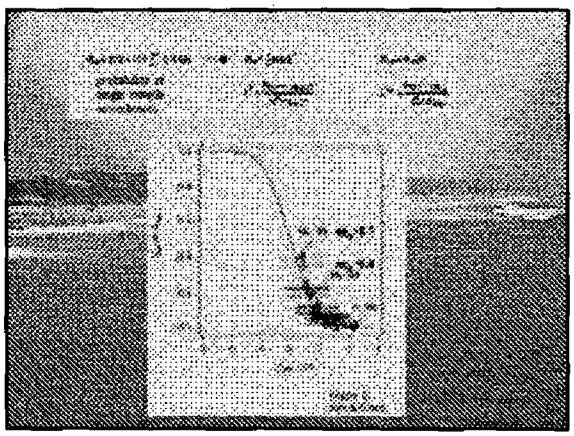

Periodic Patterns and Aliasing

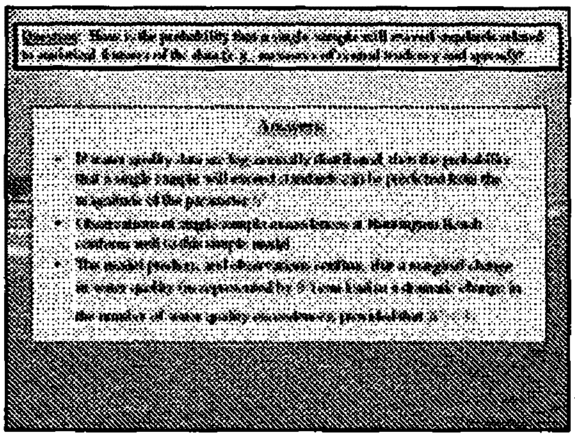

History of beach postings & closures in Southern California
• California regulations implemented in 1999
• Number of postings/closures doubling every year
• Cost to California economy >$200 Million
• Q: Is this binary public notification approach (in which signs are either posted or not) an effective way of warning the public about potential health risks?

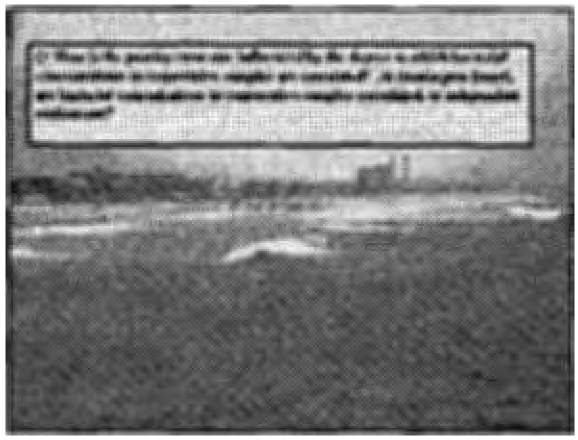

Observations of Posting Errors at Huntington Beach

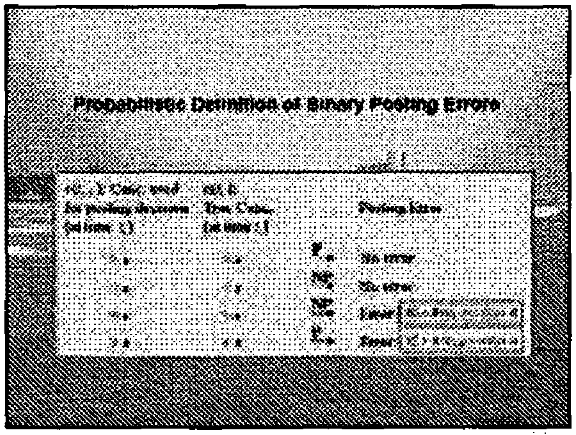

Summary: Observations of Posting Errors

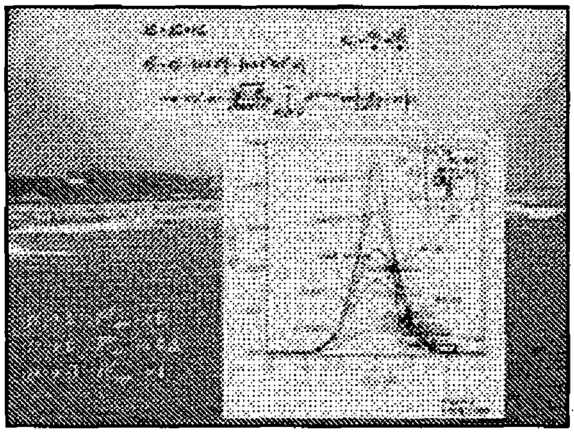


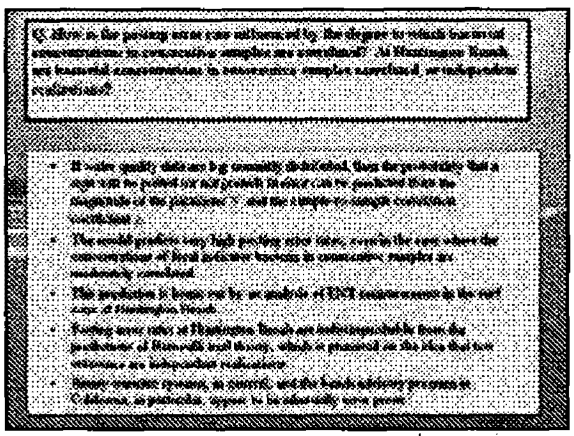


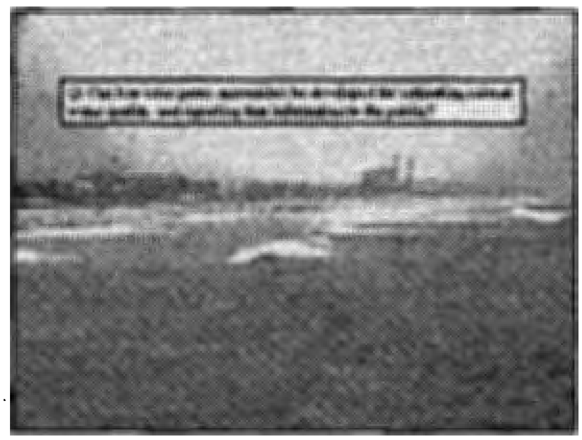


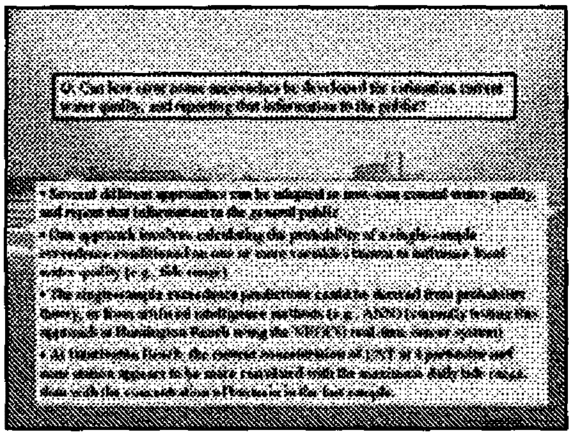


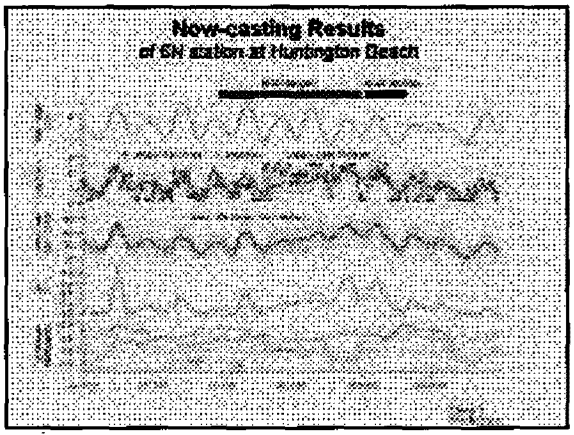

Probabilistic Definition of Binary Posting Errors











Acknowledgments

- Funding from the UCMC
- Beach slide from A. Boehm
- Many colleagues and reviewers for "feedback"

A paper describing this work was published in a recent issue of Environmental Science and Technology, along with two other papers focused on various aspects of the surf zone pollution at Huntington Beach
If you want copies, contact me at dbgrant@uci.edu

Questions?

Questions and Answers

Q (Bob Peeples, Earth 911): When fitting to log normal distribution, how do you allow for the fact that you can't go below the detection limit?

Stanley Grant

Throw out the non-detects. They contain no information.

Q: Do you think that your approach will be useful to help us understand if the samples that we do take will be meaningful to protect public health?

Stanley Grant

Focus on the indicators and pathogens relationship; know that one can be present without the other (and vice versa). We're working on trying to learn what are the physical transport processes that move the bacteria and pathogens, how is the transport process reflected in variability patterns, and how the patterns can be transferred to a probabilistic framework that can be useful for health risk.

We learn from cases where indicator bacteria and pathogens have a common source. We learn that what applies to one case often applies to the other. For example, during a storm event there is an infinite supply of indicator bacteria, but human viruses are diluted by the volume of water. Be careful of decoupling.

The Cost of Beach Water Monitoring Errors in Southern California

Linwood Pendleton
University of California at Los Angeles, School of Public Health

Biosketch

Dr. Linwood Pendleton received a B.S. in Biology (with a chemistry minor) from the College of William and Mary, an M.A. in Biology from Princeton University (for studies in tropical ecology), a Masters of Public Administration from Harvard's Kennedy School of Government, and a Doctor of Forestry and Environmental Studies in Natural and Environmental Resource Economics from the School of Forestry and Environmental Studies at Yale University. Dr. Pendleton works broadly in the area of coastal and ocean economics, with an emphasis on the economic impacts of coastal water quality pollution. Dr. Pendleton is the lead economist for the National Ocean Economics Project's Non-Market Values Information System.

Abstract

The current protocol and method of monitoring recreational water quality in the United States is known to be imperfect. On site sampling, off site laboratory analysis, and a reliance on fecal indicator bacteria instead of human pathogens result in two principle types of errors associated with water quality monitoring (Rabinovici et al 2004): 1) Type I errors in which beaches are closed even though water quality parameters are within a compliance range thought to be safe for swimming and 2) Type II errors in which water quality parameters exceed safe compliance levels yet beaches are not closed. The causes of these errors include a) precautionary beach closures when a source of contaminants are known, but the exact fate of contaminants in near shore waters is not known and b) lag times of two or more days between sampling and notification of water quality impairment. We estimate the economic cost of these errors using a retrospective analysis of beach closures and beach attendance in Los Angeles and Orange Counties. This study finds that a complete elimination of these types of errors in Los Angeles and Orange County could result in an annual economic savings of approximately $8 million annually.

Examining the Potential Economic Benefits of Improving Coastal Water Quality Monitoring in Southern California

Linwood Pendleton
Environmental Science and Engineering and Institute of the Environment, UCLA

Mission:

1) Maximize Recreation

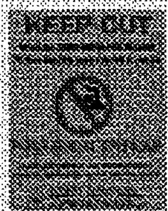
2) Protect Public Health

Protecting Public Health: Beach Monitoring

Is Water Quality Within Safe Limits?

Yes

No



Benefit: Public Health Savings

Cost: Lost Recreation

Beach Monitoring Errors

Within Water Quality Standards

Yes

No

Open

Closed

Open

Closed

Economic Perspective

Type I Error

Type II Error

√

Lost Recreation Values

People Get Sick!

√

Two Important Types of Error:

1) Type I:

Overly Prudent Closures (Closing all adjacent beaches)

2) Type II:

Time Delay b/w Monitoring and Closure (2 or 3 days)

Consequences

1) Overly Prudent Closures

Unnecessary loss of recreational value

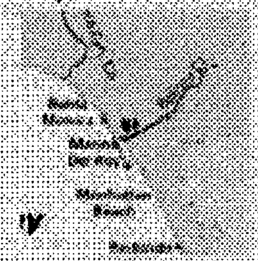
2) Time Delay

Unnecessary exposure → Public health burden

(i.e. sickness has a cost)

What's the Cost of Unnecessary Closures?

Average # Closure Days in LA and OC (1999-2002): 147



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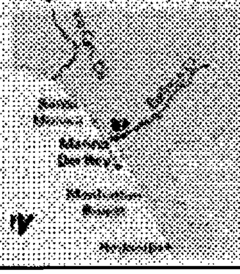


How can we reduce geographic extent of beach closures?

1. More monitoring stations
2. Nearshore current monitoring
3. Modified Coastal Ocean Observing System

What If We Reduced the Geographic Extent of Closures by ½?

Reduce loss of beach visits → saved expenditures
→ saved non-market values

What are non-market values?

1) Economic harm to beach goers
2) Represents value beyond what you pay
3) Increased costs of going to other beaches
4) Recognized in litigation

What's the economic impact of closures[1]?

Economic Cost of 147 beach closures/year

Annual Lost Expenditures ~ $[illegible]million - $[illegible]million

Lost Recreational Value ~ $[illegible]million - $[illegible]million

Economic Benefit of Reducing beach closures/year (1/2)

Annual Lost Expenditures ~ $[illegible]million - $[illegible]million

Lost Recreational Value ~ $[illegible]million - $[illegible]million

TOTAL ~ $[illegible]million/year

1. See Freeman 2001 for a summary of studies.

What's the Cost of Unnecessary Exposure?

Increased illness → Increased Cost of illness
1) Cost of medical care
2) Cost of lost time at work
3) WTP to avoid sickness

What kinds of illness?
1) HCGI – Gastroenteritis
2) Fever
3) Ear/Eye Ailments
4) Skin Rash

What is the Exposure?

1) Attendance data for two days prior to closures
2) Assume that only 28% of beach goers swim
   1) Pendleton et al. 2001 – 38%
   2) Hanemann, Pendleton, et al. – 28%
3) Assume that
   a) If closure lasts 2+ days, then exposure lasted 2 days including sample day
   b) If closure lasted 1 day, then exposure lasted 1 day (sample day)

What's the Increased Risk of Illness?

Illness	Excess Rate of Illnesses for Swimmers (x 100, sewage contamination background levels)
Gastroenteritis	8.4
Acute Febrile Respiratory	0.1
Ear ailments	4.6
Eye Ailments	2.5

*From Fleisher et al. (1998) ^From Haile et al. (1999)

What's the Cost per Illness?

Rabinovici et al. 2004:
Cost of Food Borne Illness ~ $283/case

Bloomquist et al. (2001):
Cost of Flu ~ $380

To be conservative, let's use $280

What's the Cost of Unnecessary Exposure?

$1.25 million/year

Annual Total Savings from Improved Monitoring

Unnecessary Closures:	$6 million
Unnecessary Exposures:	$1 million
Total Costs	$7 million

Does not include BEACH POSTINGS!
NRDC reports average of 2,456/year
LA and OC (1999-2002)

On-Going Research: What Else Do We Need to Know

1) What's the true cost/illness? (Dwight and Fernandez, forthcoming)
2) What's the increased public health burden from swimming in ocean waters (in SoCal)? (Pendleton and Boehm/Stanford labs)
3) Do beach postings and warnings reduce swimming exposures? (Pendleton and Boehm/Stanford labs)
   Can the public make informed decisions about water quality? (Pendleton and Turbow)

Footnote #1:

Method 1: Visits Increase By Daily Average Attendance

(Average visits/day) x (proportion of visitors that swim) x (additional beach days) x ($5/day) = change in recreational value

Method 2: Proportional Increase in Beach Visits

Current total value of water related activities x (additional beach days/ total beach days) = change in recreational value

Questions and Answers

Q: I think you are underestimating because you are not showing that although there were less acute gastrointestinal illnesses, people were more likely to stay home from work and more likely to go to a physician's office. So, I think you presented an estimate of what the true costs really are.

Linwood Pendleton

It is a lower bound. I try to do that with every step, and for the very same reason we chose that. But, you are right.

Comment: Yes, I think it is more than that. But I think you did a good study.

Q (Carl Berg, Hanalei Watershed Hui): A lot of the viruses and bacteria become aerosole-borne at the beaches. So, just by going to the beach you still have an exposure, even if you do not go into the water. I think you underestimate the effect of people going to the beach but not going swimming. Your 28 percent might not be a good factor because you have an exposure rate of perhaps 50 or 60 percent of the people.

Linwood Pendleton

I was looking at the beach closure. This would require that I know how the beach closures affected those who had gone to the beach. I could do that too. But, I can't do that with the data I have, but we could do that if we went to a beach and looked to see who was exposed. But when I'm using the attendance figures, it's everyone who came to the pier, even those who went bike riding and rollerblading. So, you are right. This is the lower bound if you add onto that the incidences of disease. I also looked only at gastroenteritis, so it is a lower-bound there. I did not look at eye or ear ailments or acute fever incidences. This is just a lower-bound. So, we may want to add to that a respiratory ailments from people sitting by the edge of the beach.

Q (Shawn Ultican, Kitsap County Health District): If you are looking at the costs of a closure, whether it is the cost of lost recreation or cost of going to a doctor, is that really a cost or is that money just being displaced? For example, if I want to go to Beach A, and Beach A is closed, maybe I just take my money and go to Beach B. It might be a half hour further away, but if I really want to go to the beach that day, I will still go if there is an opportunity available in another location. And, are the costs of going to the doctor just the costs of moving from me doing my job in producing whatever I produce in doing my job and transferring that to the healthcare system where I'm paying somebody else to do their job? Does that make sense?

Linwood Pendleton

The lost recreational values that are a cost to the economy is how much less happy you are or how much money you spend that you didn't need to spend to drive to the beach. So, those recreational values look at the value that people place on a beach recreation visit beyond whatever they paid. Expenditures, on the other hand, refer to when you take the money that you were going to spend on Doheny Beach, you go to San Clemente and spend you money there. In that case it's a transfer, unless you are in San Clemente. If you are in San Clemente and you are trying to figure out whether we want to go to this more expensive monitoring system, then it's a cost to San Clemente because you lose those expenditures. It is not a cost to the overall economy. Medical expenses are real costs. When you are using a doctor's time that could be spent on another patient, productivity is lost. For example, if you look at the gross state product of Florida, it will go up because you have all these building projects now. Everytime they build a new house that got knocked down by a hurricane that will look like an increase in the economy. Its not like that with medical costs. What we are talking about here are real costs to society because we are using resources to run medical tests and staffing the doctors' offices, and we are losing real productivity when you don't go to work. So, that is what is reflected in those medical costs. The willingness to pay is what in litigation they call psychological damages, which is when people are relatively unhappy because they got sick, and that represents an economic cost too. So, of those three, two are unambiguously costs to the economy, and the third one, expenditures, depends on the perspective from which you are viewing this.

Communication: Increasing Public Awareness about Beaches

Harry Simmons
American Shore and Beach Preservation Association

Biosketch

Harry Simmons is President of American Shore & Beach Preservation Association. Mr. Simmons also serves in his 5th year as Mayor of the Town of Caswell Beach, North Carolina and is executive director of North Carolina Shore & Beach Preservation Association. Mayor Simmons serves on the boards of directors of the North Carolina League of Municipalities, the North Carolina Coastal Communities Coalition and as a Coastal Cities member of North Carolina's Coastal Resources Advisory Council. He has recently formed Simmons Coastal, a broad-based coastal issues consulting firm currently seeking additional clients from among businesses, governments and individuals along America's coast. Find him on the web at SimmonsCoastal.com. A North Carolina native, Mayor Simmons earned his BS in Business Administration from the Kenan-Flagler Business School at the University of North Carolina in Chapel Hill.

Abstract

The American Shore and Beach Preservation Association has been successful linking healthy beaches and the economic benefits those beaches provide to both the local and national economies. This presentation will provide conferees with information on how to more successfully link healthy beaches and productive economies.

Over 53% of the nation's population lives in coastal counties. By 2015, the population of coastal counties is expected to reach 165 million residents, with an average of 3,600 people moving to coastal regions daily. Those that do not live in coastal regions often spend their vacations there. Beaches are American's top tourist destination. For instance, Miami Beach is visited by more people than all the National Parks combined.

Better beaches lead to increased travel and tourism. The benefits begin at the local level and expand outward. For example, tourists visiting healthy beaches spend money at local businesses, which in turn expand and invest in new employees and capital. Those employees, and the firms that benefit from capital improvements, then spend their money buying goods and services. According to a recent federal study, only 35 percent of a shore protection project's benefits accrue locally, while 65 percent accrue to people who reside elsewhere.

When a community's beaches must be closed for even a day, everyone loses tax revenue. We need to work together to publicize that message to the public and to elected officials so states and communities do more to assure the highest standards of beach water quality.

The Economic Engine that Drives Coastal America:

Healthy Beaches

Harry Simmons, President
American Shore and Beach Preservation Association

for US EPA National Beaches Conference

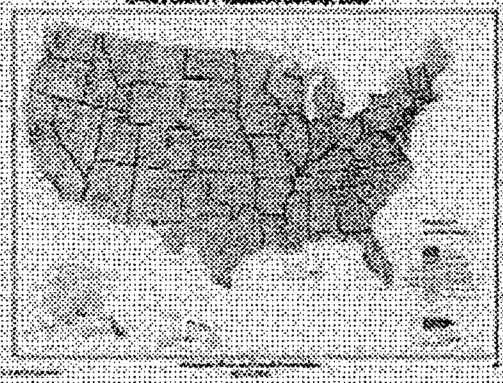
The Economic Facts

- 53% of Americans live in Coastal Counties
- 180 million Americans make 2 billion annual visits to ocean, gulf and inland beaches

Population Density

- The national population density is 79 people per square mile compared to the near shore area where density is 230 people per square mile.
- From 1970-2000 the national population density increased by 22 people per square mile while the near shore area increased by 43 people per square mile.

United States Population Density, 2000



The Coastal Economy

- Over 75% of all U.S. domestic economic activity takes place in the coastal states
- All of the economic tiers of the Coast, from the near shore area to the total coastal states, grew faster than the U.S. economy over the past decade
  - Establishments
  - Employment
  - Wages
  - Output (Share of State Gross Product)

Domestic Tourism

- Beaches are America's Number One tourist destination.
- Nearly 110 million U.S. Households traveled over 50 miles to go to a beach last year.
- 41% of U.S. households visiting the beach include children under the age of 18

Foreign Tourism

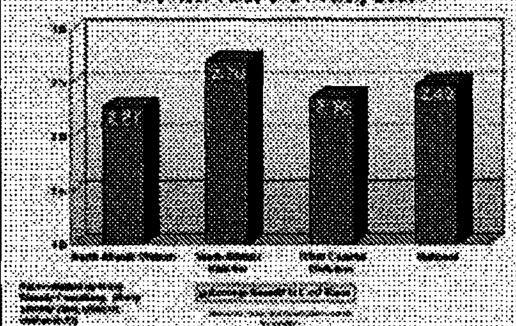
- More than **90 percent** of foreign visitors to the United States make a visit to our coast. [illegible]
  - The annual $2.4 billion revenue from foreign tourists at Miami Beach is about 50 times the total $52 million cost of the Miami Beach beach nourishment project that has lasted over 20 years (Houston, 1996). [illegible]
- In a recent year, 45.5 million international visitors came to the United States and spent $60 billion dollars [illegible]

Hierarchy of Coastal Benefits

- Benefits begin at the local level and expand outward:
  - Beach travelers are more likely to travel to their destination by plane and rent a car when they arrive.
  - Tourists visiting beaches spend money at local businesses.
  - These local businesses expand and invest in new employees and capital.
  - The employees and the firms that benefit from the coastal improvements then spend money buying goods and services.
- 85% of shore protection project benefits accrue to people who reside somewhere other than the beach area. (USACE economists) [illegible]

Benefits to Costs Ratio:

The Real Value of a Healthy Beach



But What About Water Quality and Beaches?

When a community's beach must be closed even for a day, everyone loses recreation, environment, and tax revenues.

We all need to work together to publicize the water quality connection clearly to the public and to elected officials, so communities will do more to assure the highest standards of beach water quality.

ASBPA stands committed to aid in that effort any way we can.

For More Information, Contact

ASBPA
c/o Marlowe & Company
1667 K Street, NW Suite 480
Washington, DC 20006
202-775-1796
beaches@asbpa.org
or contact me directly at
president@asbpa.org

Questions and Answers

No questions.

City of Encinitas Perspective on Beach Postings

Katherine Weldon
City of Encinitas, Clean Water Program

Biosketch

Katherine Weldon has over 12 years of experience in Water Quality Management Programs. Most of her experience has been in role of program manager for the Recreational Ocean Water Quality Coordinator for the County of San Diego and most recently as the Stormwater Program Manager for the City of Encinitas. Ms. Weldon has been active in the field of stormwater monitoring since 1993 when the County first began testing storm drains. Kathy developed a voluntary ocean-monitoring program with the POTWs, which became a routine monitoring program for the County of San Diego. She has been involved with the implementation of AB411, which mandated a routine coastal monitoring program for the State of California.

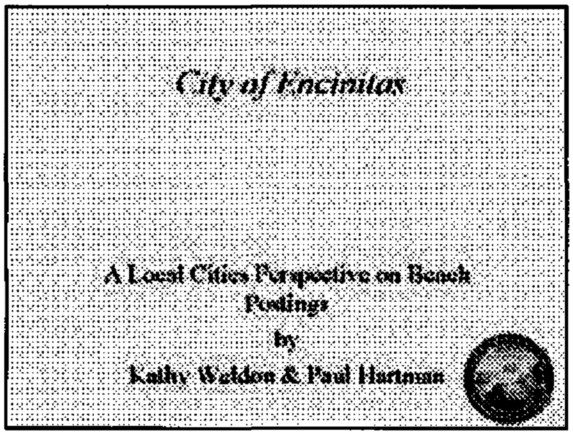
Throughout Ms. Weldon's career she has worked for the public sector. She has developed the City of Encinitas' Stormwater Program from the beginning, which is considered the model by the Baykeepers and the local Regional Water Board. Kathy has created numerous presentations for City Council as well as the local media. She works with each department from public works, engineering, construction and planning. Ms. Weldon's most recent accomplishment is the completion of the Moonlight Beach Urban Runoff Treatment Facility, which cleans the creek of bacteria and viruses prior to being discharged back into the creek.

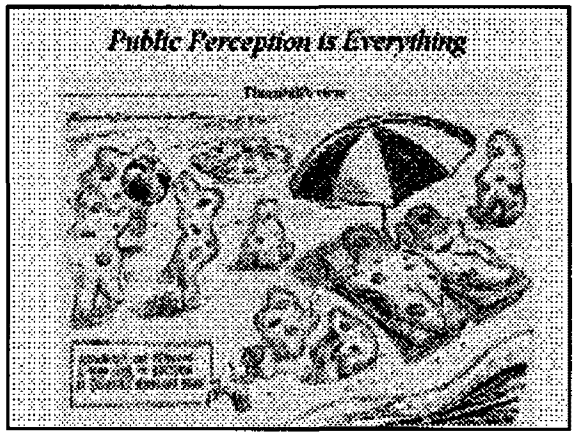
Abstract

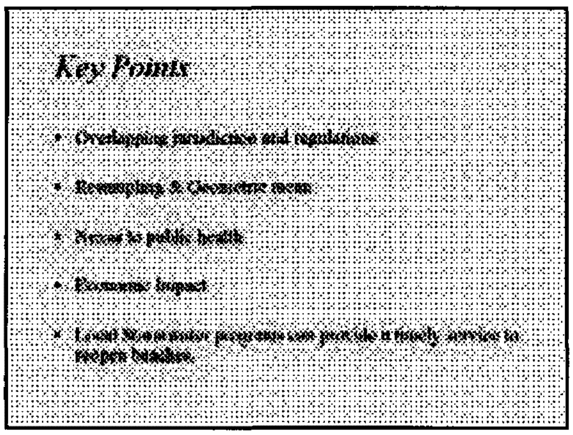
The City of Encinitas, a coastal town located 25 miles north of San Diego with 6.2 miles of beaches, generates an estimated $44,000,000 of revenue annually. Moonlight Beach, the crown jewel, supports 4000 beach users on a summer day, with facilities including volleyball courts, fire rings, snack/rental shops, and lifeguards. Water quality at Moonlight has been historically poor due to Cottonwood Creek, conveying bacteria in urban runoff directly to the beach. Understanding the value of the resource, the City installed an ultraviolet treatment facility on Cottonwood Creek to compliment persistent upstream investigations, killing 99.9% of the bacteria. Nearly $11,000 are spent annually monitoring water quality at Moonlight, above and beyond the required AB411 program. With these Best Management Practices, postings due to sewage and urban runoff have been nearly eliminated.

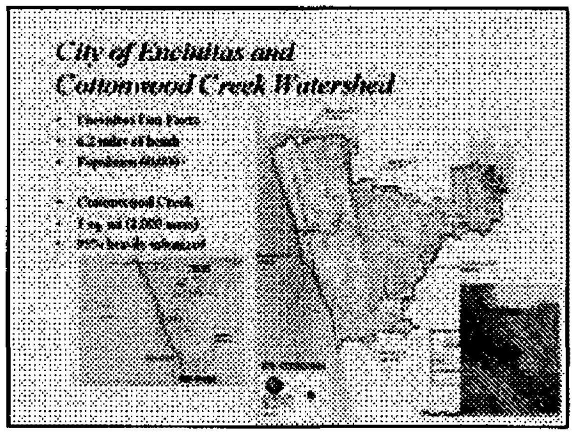
Yet, Moonlight continues to have postings, often a result of misguided policy not protective of public health. Guidelines such as sampling before 11 am or the inability of weekend staff to un-post beaches has kept Moonlight posted when bacteria samples indicate acceptable water quality. Three cases of postings not protective of public health and their fiscal impacts will be discussed.

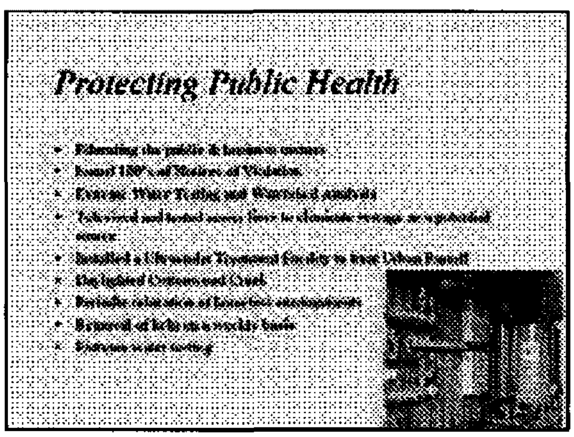
Samples of seagull feces have been analyzed for bacteria indicators, data will be presented. Understanding contributions from this source of bacteria leads the City to question how often beaches are posted due to natural sources. Is the enterococcus standard often exceeded because of natural sources, resulting in incorrect perceptions of water quality? A study supporting this hypothesis will be presented.

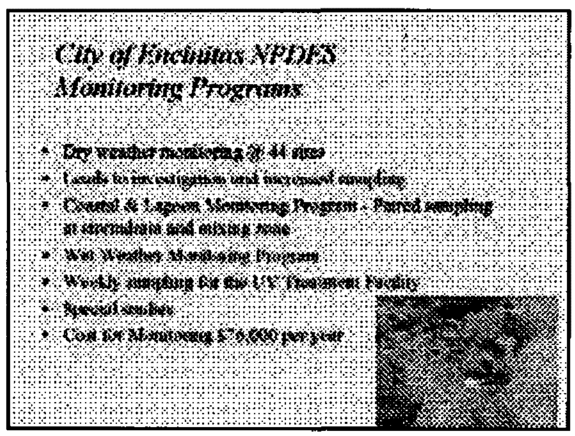

City of Encinitas
A Local Cities Perspective on Beach Postings
by
Kathy Weldon & Paul Hartman


Public Perception is Everything


Key Points
Overlapping jurisdiction and regulations
Resampling & Geometric mean
Economic Impact
Local Stormwater programs can provide a timely service to reopen beaches.

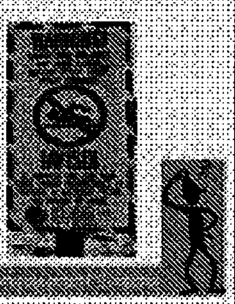

City of Encinitas and
Cottonwood Creek Watershed
Cottonwood Creek


Protecting Public Health
Installed a Ultraviolet Treatment Facility to treat Urban Runoff
Daylighted Cottonwood Creek


City of Encinitas NPDES
Monitoring Programs
Dry weather monitoring
Leads to investigation and increased sampling
Coastal & Lagoon Monitoring Program - Paired sampling at stormdrain and mixing zone
Wet Weather Monitoring Program
Weekly sampling for the UV Treatment Facility
Special studies
Cost for Monitoring

Numerous Coastal Regulations

- AB411, CA Health & Safety Code
- California Ocean Plan
- California Basin Plan
- Stormwater Coastal Monitoring Program
- TMDL for Bacteria
- EPA Beaches Act



Resampling & Geometric Mean

[illegible]

- Posted on 8/19/01
- Resample collected on 8/19/01 upon notification (<10 [illegible]); results clean
- Resample 8/20/01 (<9.10 [illegible]); results clean
- Posting remained due to geometric mean despite multiple days of clean data at multiple locations on beach ([illegible])

Issues we see...

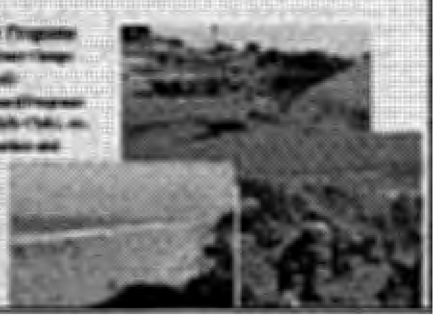
- Resample collection and acceptance of data, sample times: samples collected upon notification were NOT considered representative and excluded from data set
- Use of Geometric Means to post when analysis allows for detection limit of 10 mpn/100 ml (nearly 30% to a posting with the cleanest of the data!!)

Nexus to Public Health Protection

- Postings always occur 24 hours after an exceedance is collected; depending upon method, may be 72 hours after the initial sample was collected.
- Postings appear to be result of natural, transient sources most of the time.
- In house studies have shown elevated bacteria when creek water flows through heavy wrack line.
- 50% of the postings within the past three years have had a repeated AB411 Exceedance upon resampling; however, the beach is regularly posted for 3 or more days following a hit.
- There were no reports of illness at Moonlight Beach this past summer (per conversations with lifeguards and camp directors).

Moonlight Beach

- Summer Programs
- YMCA Water Camps
- Surf Schools
- Jr. Lifeguard Programs
- Boys & Girls Clubs, etc.
- Visitors, surfers and regulars



Moonlight Beach Attendance Data

3,300 people per day (June - Aug)

$88,000 daily revenue

2,387,400 - Total Annual Visitors

$41,305,200 - Annual Beach Generated Revenue for Local Businesses

Stormwater and Beach Postings

- Stormwater staff are trained, experienced and use only State certified laboratories (24 hr results)
- Investigate immediately and resample
- Laboratories send data electronically
- We believe we can reduce the beach postings days significantly and improve communication to the public

Questions and Answers

Q (Matt Liebman, US EPA, Region 1): Is there a perception about water quality that keeps people from coming back to the beach well after the beach has been posted or closed?

Kathy Weldon

In 1999 we had 93 days of beach postings. Yes, I believe there was a slow reduction in population, but we have seen it escalating since then and we have been reducing the beach closures every year since then. This doesn't stop families from going to the beach. Parents will still let their kids play in the water. I think it just adds a level of concern in their minds, and it makes them think about next time, asking them selves, "am I going to come back to this beach or go somewhere else?" It does the same thing to the lifeguards. They will ask themselves, "is our beach clean enough and should I let people go into the water?" It's a level of concern that is difficult to document.

Comment (Tim Wade, USEPA): I would suggest a more random sampling and/or a follow up survey prior to concluding that people are not getting sick. I think a lot of the cases we see are mild and may not be reported to the lifeguards.

Q (Carl Berg, Hanalei Watershed Hui): What kind of tests were you using? Was it enterococcus?

Paul Hartel

We used membrane filtration for enterococcus.

Comment (Carl Berg): We are using IDEXX technologies to do that, and with a dilution, you can only measure down to 10. However, if you take three simultaneous samples and they all show a zero , then your detection level is statistically down to one. That would help you with your geometric means quite a bit if you are able to do repeated sampling. This may statistically improve your numbers and bring them down much quicker.

Q (Charles Kovatch): How well does the laser counting estimate the population?

Kathy Weldon

It was close to the lifeguard counts from before.

Q (Charles Kovatch, US EPA): Are any other beaches in California using the lasers?

Kathy Weldon

Not that I know. Our lifeguards stopped collecting data (they were told not to) so we tried to find a way to collect the data without the lifeguards.

Q: How much did the people counters cost?

Kathy Weldon

They cost around $600 per site.

Thursday, October 14

8:00 a.m. – 9:40 a.m.

Concurrent Track I:

Identifying and Solving Beach Water Quality Problems

Session Five:

Source Indentification

EPA Guidance Manual on Source Identification

Gerald Stelma, Jr.
U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory

Biosketch

Dr. Gerard N. Stelma Jr. received a Bachelor's degree from the University of Michigan in 1965 and a PhD in microbiology from Michigan State University in 1974, specializing in bacterial physiology. He performed postdoctoral research at Purdue University from 1974 until 1976, where he studied spore coat synthesis in Bacillus cereus. He did additional postdoctoral work at the University of Wisconsin from 1976 until 1978, performing research on structure/activity relationships of Staphylococcus enterotoxins. He was a Research Microbiologist for the US Food and Drug Administration from 1978 until 1987. During his tenure there, he worked on the development of methods to detect pathogens and toxins in foods and on methods to distinguish between virulent and avirulent strains of bacterial pathogens. He joined the US Environmental Protection Agency's research staff in 1987 as a Research Microbiologist. From 1988 until 2002, he supervised a branch of EPA microbiologists and immunologists in the development of methods to detect hazardous microorganisms drinking water, recreational water and indoor air. He is currently a science advisor to the Director of the Microbiological and Chemical Exposure Assessment Research Division of EPA's National Exposure Research Laboratory.

Abstract

Beach closures or violations of total maximum daily loads of fecal organisms in watersheds frequently generate a need to identify the major sources of contamination or, at least, determine whether the source is human or animal. A few years ago *E. coli* ribotyping was the only method available for microbial source tracking (MST). Recently, however, a number of diverse methods are reported to be effective for MST; and it has become difficult for beach managers and other local officials to choose the method that is best for their specific needs. The USEPA is writing a guidance document to assist the users of MST methods in choosing the most appropriate method for their individual beaches or watersheds. The MST guide document contains descriptions of each published method, including references; the assumptions on which the methods are based; the limitations of each method; data collection and analyses and method performance. The final chapter provides decision criteria and includes a decision tree which guides the reader through the various scenarios in which MST may be useful. Each decision point in the tree contains a menu of the most appropriate methods for the user's needs. The document is comprehensive, including both library-dependent and library-independent molecular methods, as well as library-dependent phenotypic methods.

The EPA MST Guidance Document

Gerard N. Stelma Jr.
Jorge Santo Domingo

When are MST Methods Useful

- To supplement sanitary surveys
  - Identify sources of beach contaminants
  - Identify sources of TMDL violations
- [illegible]
  - Human vs animal
  - Domestic animal vs wildlife

Why Is a Guidance Document Needed?

- Recent proliferation of new methods
  - Genomic
  - Phenotypic
  - Cultural
  - Non-cultural
  - Different levels of discrimination
- Most useful method depends on circumstances

The Theory Behind MST

- Genomic Methods
  - Parallel evolution of mammalian host and intestinal flora
- Phenotypic Methods
  - Uses of different antibiotics for different animal species
  - Parallel evolution of mammalian host and intestinal flora

Levels of Discrimination Available

- Human vs animal
- Human vs domestic animal vs wildlife
- Human vs species of domestic animal
- Specific population of human or animal
  - Specific community of humans
  - Specific herd or flock of animal

Content of MST Guidance Document

I Introduction
- What is MST?
- Definitions of terms

II Decision Criteria
- When MST methods should be used
- Importance of sanitary surveys
- Decision tree

Decision Tree

- Questions
  - Is the problem adequately defined?
  - Has an adequate sanitary survey been conducted?
  - How many sources were identified?
  - Is the study area of manageable size?
  - What is the desired level of discrimination?

Content of MST Guidance Document

III. MST Approaches
- Summary descriptions of all current methods
  - Explanations of how they work
  - Summary tables with advantages and disadvantages
  - References

Content of MST Guidance Document

IV. Data Collection and Analysis
- Design sampling around study objectives
- General principles for sampling
- Library construction and validation
- Spatial and temporal variability
- Similarity measurement methods

Content of MST Guidance Document

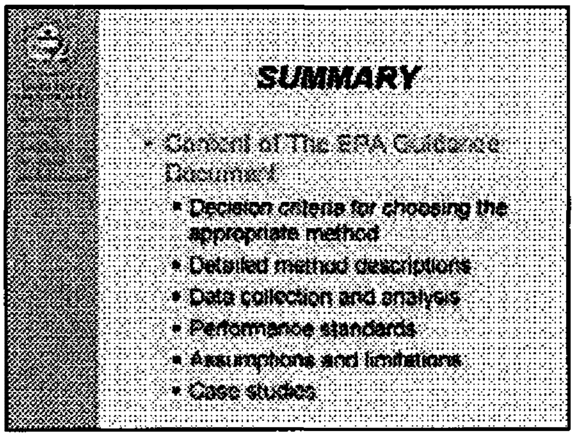
V. Performance Standards
- Universal quality measures
- Method-specific controls
- Method-specific performance criteria

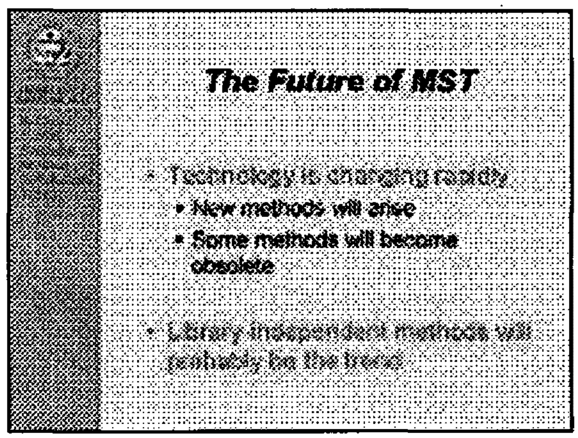
Content of MST Guidance Document

VI. Assumptions and Limitations
- Characteristics of source identifiers
  - Specificity
  - Distribution in host
  - Geographic range
  - Temporal stability
  - Survival in water

Content of MST Guidance Document

VII. Applications of MST Approaches
- Eight case studies are presented
- A glossary of MST terms is presented


SUMMARY
Content of The EPA Guidance Document
Decision criteria for choosing the appropriate method
Detailed method descriptions
Data collection and analysis
Performance standards
Assumptions and limitations
Case studies


The Future of MST
Technology is changing rapidly
New methods will arise
Some methods will become obsolete
Library independent methods will probably be the trend

Questions and Answers

Q: Is this on the Web site?

Gerard N. Stelma, Jr.

Not yet—it is still being reviewed. Everything has to be peer-reviewed before we can make it public. But I expect it to be available by the end of the calendar year.

Q: Will any of these methods become part of the regulations?

Gerard N. Stelma, Jr.

Because there are so many different needs and so many different levels of specificity and so on that are available, I don't see us ever becoming prescriptive. I don't think there will ever be a regulation. I think it will always be up to the user to choose the most appropriate method.

Q: Can you describe the methods that will be available in the future?

Gerard N. Stelma, Jr.

I can give you some examples. Some specific species of bacteroides are carried only by one particular type of animal. Betty Olsen, from the University of California, Irvine, has found some toxin genes that are carried only by *E. coli* of human origin and some other ones that are only carried by *E. coli* of porcine origin and some of bovine origin. So, you don't need a library—you just look for that specific gene.

Q: What do you mean by a library?

All of us carry a number of *E. coli* in our intestines, and if you look at a community or at sewage, there are even more out there. And so, there are so many types of *E. coli* that you can find in a contaminated environment, and if the theory is correct, there are some of these strains of *E. coli* that are common in the community and you've got to just go through and do ribotyping on a number of *E. coli* from, say, a particular sewage plant. The patterns that you get from ribotyping a large number of strains become your library. Then, when you go out to the contaminated water, you look at the ribotypes of the various organisms you isolated from the water and try to match those patterns to your human library, or whatever other species you are looking for. There are several PCR methods that are out there, too, that are library dependent, that you get different patterns on the gel from different strains of *E. coli*, and because there are so many possibilities, you have to isolate a large number of *E. coli* from each possible species that contaminated the water and you have to make a library of those various patterns.

Tiered Approach for Identification of a Human Fecal Pollution Source at a Recreational Beach: Case Study at Avalon Bay, Catalina Island, California

Alexandria Boehm
Stanford University, Department of Civil and Environmental Engineering

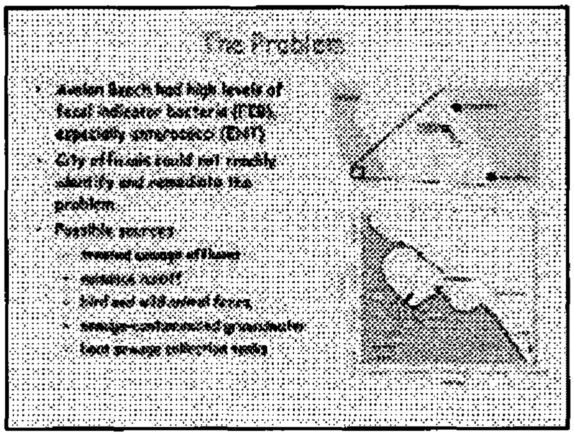
Biosketch

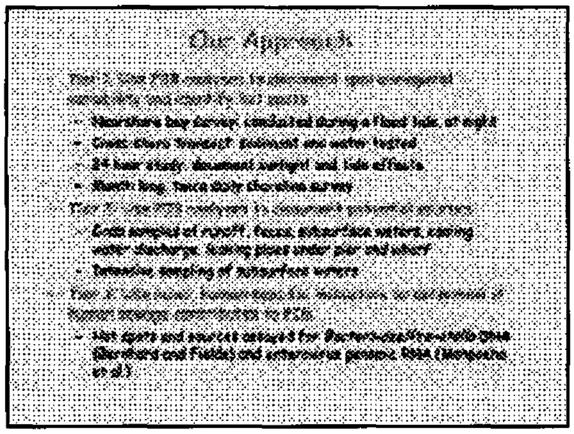
Dr. Boehm is the Clare Boothe Luce assistant professor of environmental engineering and science at Stanford University. Dr. Boehm received a B.S. with honors from California Institute of Technology in Pasadena, CA and her M.S. and Ph.D. in Environmental Engineering from the University of California Irvine. She has been at Stanford for two years and prior to that was a faculty fellow at University of California Irvine. Her research interests include coastal water quality, coastal transport processes and their influence on pollution, water borne pathogens, microbial pollution, water quality indicators, and particle fate in water.

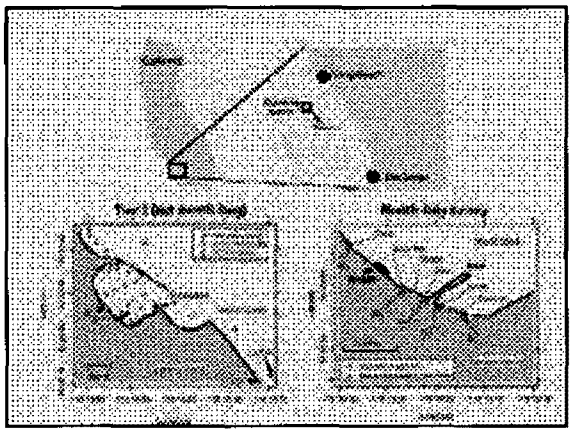
Abstract

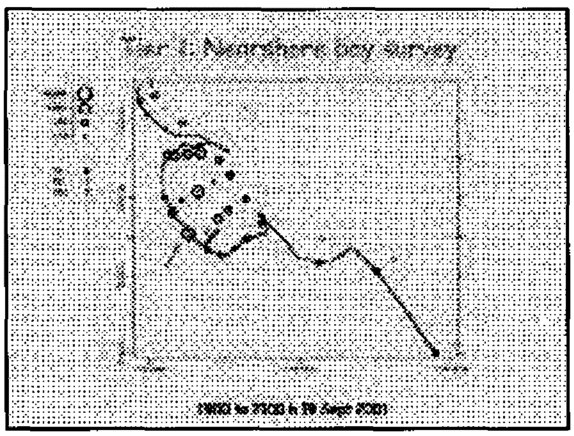
Recreational marine beaches in California are posted as unfit for swimming when the concentration of fecal indicator bacteria (FIB) exceeds any of seven concentration standards. Finding and mitigating sources of shoreline FIB is complicated by the many potential human and non-human sources of these organisms and the complex fate and transport processes that control their concentrations. In this study, a three-tiered approach is used to identify human and non-human sources of FIB in Avalon Bay, a popular resort community on Catalina Island in southern California. The first and second tiers utilize standard FIB tests to spatially isolate the FIB signal, to characterize the variability of FIB over a range of temporal scales, and to measure FIB concentrations in potential sources of these organisms. In the third tier, water samples from FIB hot spots and sources are tested for human-specific bacteria Bacteroides/ Prevotella and enterovirus to determine whether the FIB are from human sewage or from non-human sources such as bird feces. FIB in Avalon Bay appear to be from multiple, primarily land-based, sources including bird droppings, contaminated subsurface water, leaking drains, and runoff from street wash-down activities. Multiple shoreline samples and two subsurface water samples tested positive for human-specific bacteria and enterovirus, suggesting that at least a portion of the FIB contamination is from human sewage.

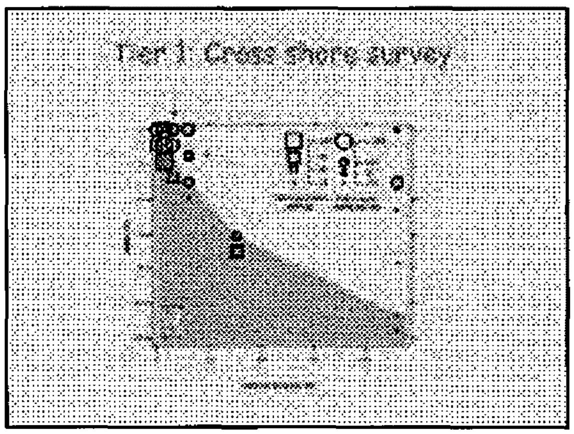

Alexandria Boehm, Jed Fuhrman,
Robert Mrše, and Stanley Grant

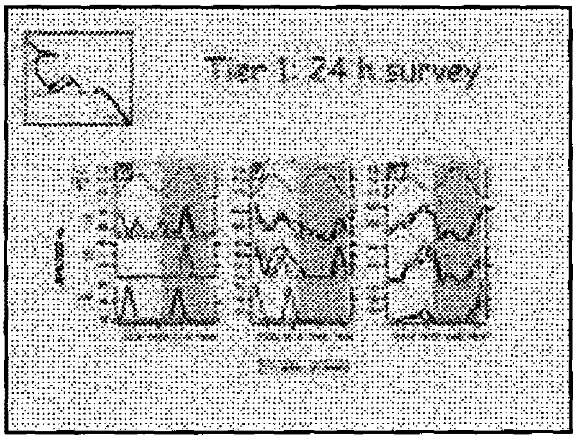

The Problem
Avalon Beach had high levels of fecal indicator bacteria (FIB), especially enterococci (ENT)
City officials could not readily identify and remediate the problem
Possible sources

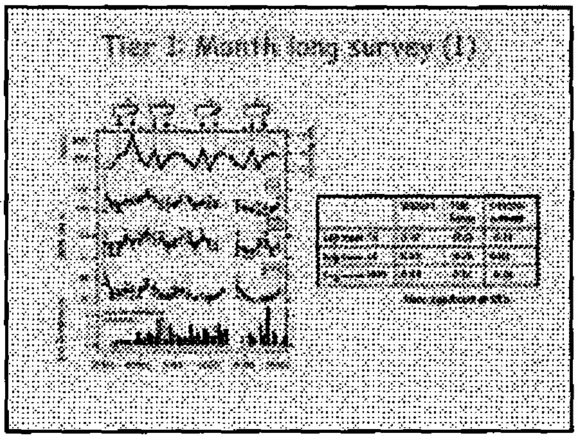

Our Approach
Nearshore bay survey: conducted during a flood tide, at night
Cross shore transect: sediment and water tested
24 hour study: document sunlight and tide effects

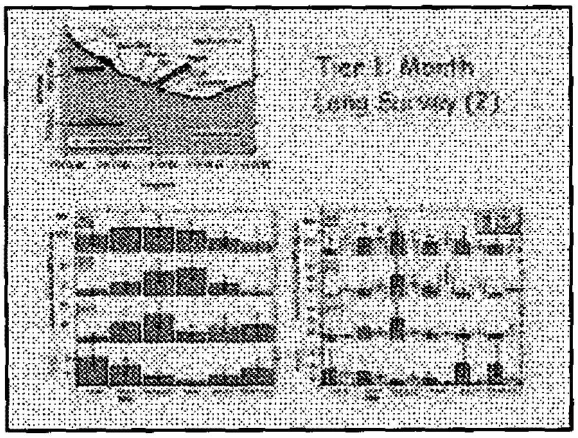


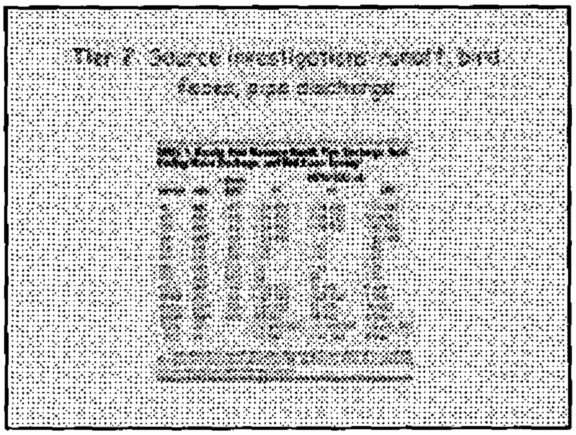

Tier 1: Nearshore bay survey
1900 to 2100 h 19 Sept 2001

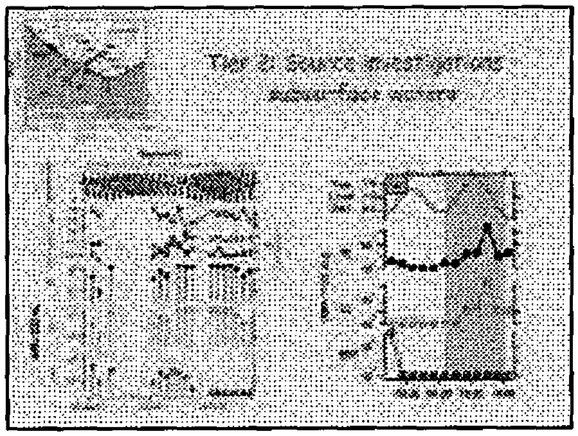

Tier 1: Cross shore survey

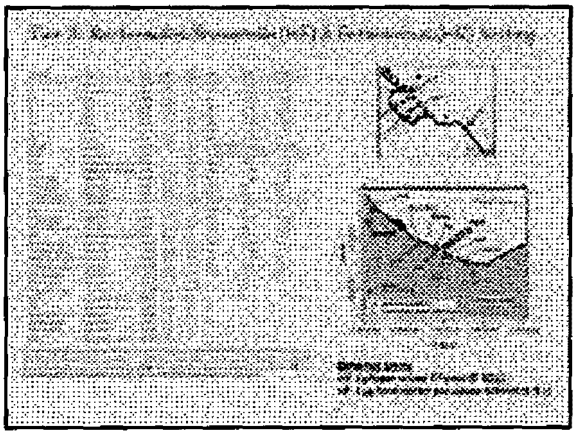

Tier 1: 24 h survey


Tier 1: Month long survey (1)


Tier 1: Month
Long Survey (2)


Tier 2: Source investigations-runoff, bird
feces, pipe discharge

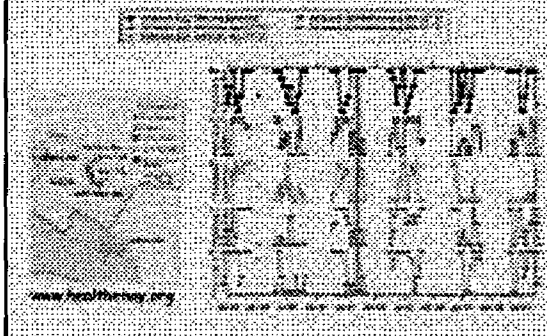

Tier 2: Source investigations
subsurface waters



Implications

- FIB at Avalon Beach are from sources inside the bay, from the land side of the beach
  - Nearshore bay survey, cross shore survey, ebb tide signal (24 hour study, month long survey)
- At least a portion of the pollution is from human sewage
  - Extraordinarily high levels of FIB in groundwater
  - HF and HV markers found at every shoreline site (except middle) and in a groundwater sample
- → City of Avalon slip-lined their sewer lines adjacent to the beach in the winter of 2001/2002

Has water quality improved?



Acknowledgements

- Funding from
  - The City of Avalon
  - Los Angeles Regional Water Quality Control Board
  - State of California Clean Beaches Initiative Prop 13
- Assistance
  - Ryan Reeves, Cynthia Jensen-McMullin, Mark Bachman, Lisa Gilbane, Burt Jones

Questions and Answers

Q (Donna Francy, USGS): I really like your tiered approach, and I think it's a really good way to go about it, instead of just going out there and ribotyping everything. So you found that it's partially human, at least, but then they took these remediation steps and that didn't help. So what do you think you should do next? Are there any other potential sources? Do you think it might be a nonhuman source also, like wildlife?

Alexandria Boehm

I haven't kept up with all the maintenance activities in the city of Avalon, but my first guess would be that the slip lining did not work. Also, the city is so densely populated and I'm not sure how the sewerage infrastructure is set up there and I think it might be possible that there are leaking sewer lines in other places where they did not slip line. If they wanted to do another study, then I would see if there is the same problem there, and if it is, then I would say the sewer lines are leaking somewhere and they need to do something about it.

Q: Can you define "nuisance runoff"? Is that from rain or dry weather flows? Also, how did you eliminate urban runoff? Did you do a loading estimate?

Alexandria Boehm

It may only occur in California, but "nuisance runoff" is the water that we see in the gutter when it hasn't been raining. In Avalon, they hose down the streets at night and the streets lie right next to the beach so that water from the hosing down we would call "nuisance runoff," or any water just trickling along when it hasn't been raining.

Q: How did you eliminate the urban runoff, the surface water, and the nuisance flows? Did you do a loading estimate?

Alexandria Boehm

No, we didn't say that it couldn't be nuisance runoff. We didn't eliminate that, but none of the nuisance runoff came back positive that we tested for the HF or the HV marker. Surely they are contributing a fraction of the pollution to the beach, so we did not eliminate it.

Q: Was it just one field event for the Bacteroides?

Alexandria Boehm

The design of our project was to first identify locations, and then sample those locations maybe a couple times, but we found the Bacteroides multiple times at multiple stations. So it was not just one sample.

Fecal Source Identification with Bacteroidetes Molecular Markers

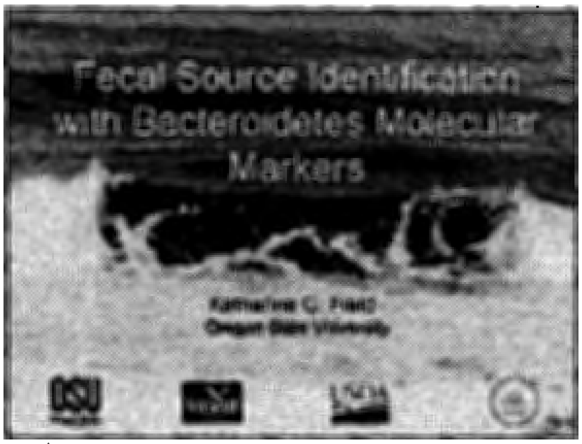
Katharine Field
Oregon State University, Department of Microbiology

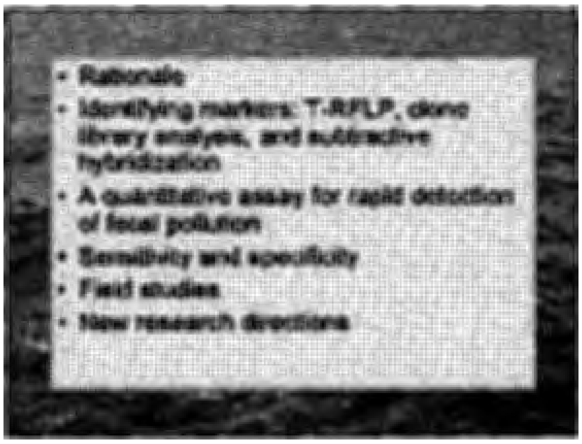
Biosketch

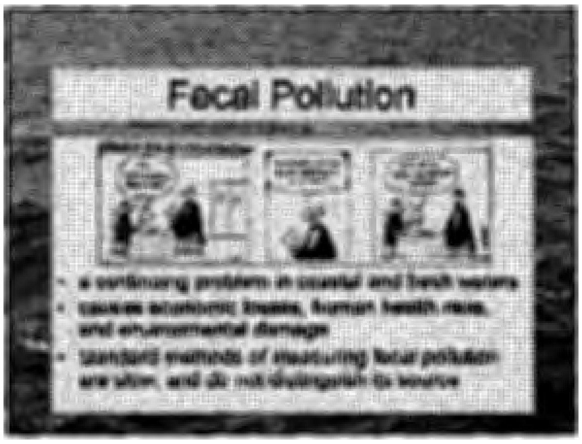
Dr. Kate Field is an Associate Professor in the Department of Microbiology at Oregon State University, where she also co-directs the Bioresource Research Interdisciplinary Program. Her research concerns new and rapid biotechnical methods of detecting and identifying bacterial pollution and pathogens in the environment, the study of microbes in natural populations, and the spread of antibiotic resistance in the environment. She has degrees from Yale University, Boston University, and University of Oregon. She is the author of two lab texts on molecular biology, and is on the editorial board of the journal Applied and Environmental Microbiology. Her research has been widely published and she has been an invited speaker for the World Health Organization, Food Safety Research Consortium, American Academy of Microbiology, American Society for Limnology and Oceanography, Environment Canada, British Department of the Environment and European Union, among others.

Abstract

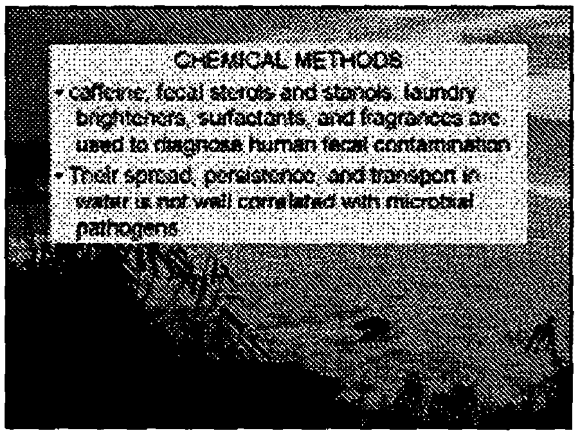
Fecal contamination of seawater is widespread in the coastal ocean of the United States, causing illness and beach closures, impacting shellfish harvest, and degrading habitat. Human and animal feces pose different threats to human health, but epidemiological data that link human health outcomes to exposure in water do not distinguish human from animal feces. Current methods of measuring fecal contamination with public health indicator bacteria do not identify its source. Often fecal pollution cannot be corrected, because the source is not known. We have developed a rapid and accurate method of identifying the source of certain kinds of feces in water, utilizing a PCR assay that targets host-specific groups of Bacteroidetes fecal bacteria. The method differs from existing methods of detecting fecal pollution in that it detects genetic marker sequences that identify bacterial groups specific to the host species that produced the feces, allowing discrimination among different potential sources. This method performed well in a comparative study of fecal source tracking methods. Field studies in Tillamook Bay, Oregon, and Mission Bay, California, demonstrate this approach. The method has been tested throughout the U.S., in Canada, Ireland, and New Zealand. Utilizing the same technology, we also developed a quantitative (Q-PCR) assay for Bacteroidetes bacteria that is being tested as a rapid method of detecting fecal pollution. Both of these methods use small water samples, do not require isolating and growing the bacteria, do not require a library, and are rapid and accurate.

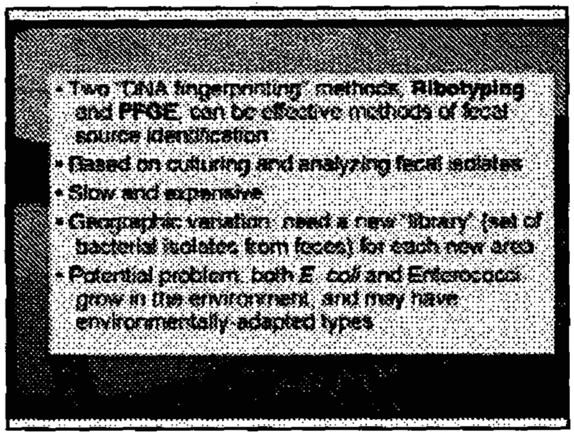

Fecal Source Identification
with Bacteroidetes Molecular
Markers
Katharine G. Field
Oregon State University

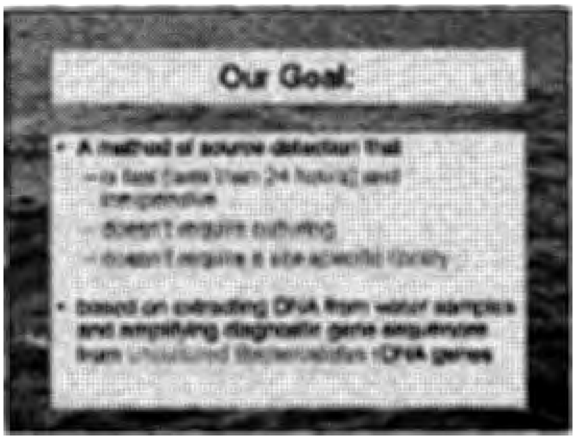

• Rationale
• Identifying markers: T-RFLP, clone library analyses, and subtractive hybridization
• A quantitative assay for rapid detection of fecal pollution
• Sensitivity and specificity
• Field studies
• New research directions

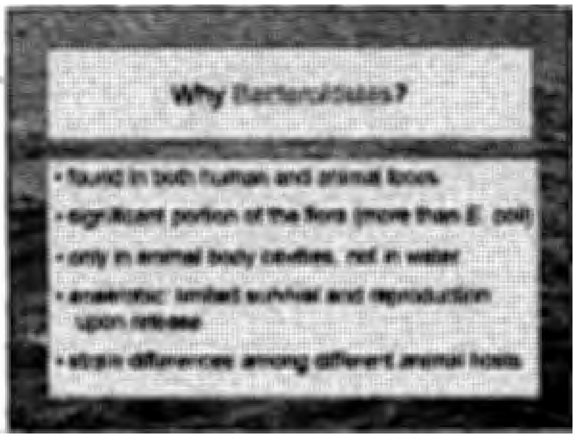

Focal Pollution
• a continuing problem in coastal and fresh waters
• causes economic losses, human health risks, and environmental damage
• Standard methods of measuring fecal pollution are slow, and do not distinguish its source

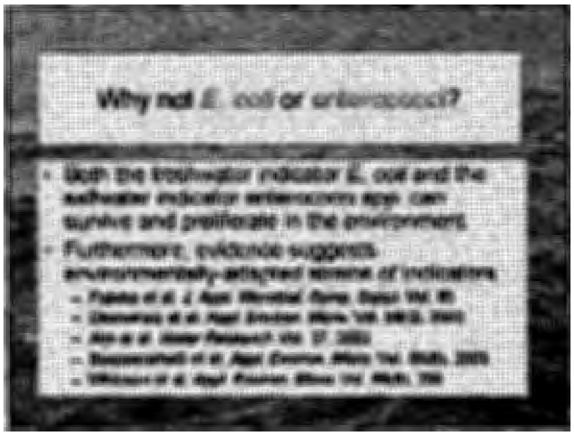

Potential Sources of Fecal Pollution:
Runoff from sewage, septic tanks, and agriculture
Wildlife

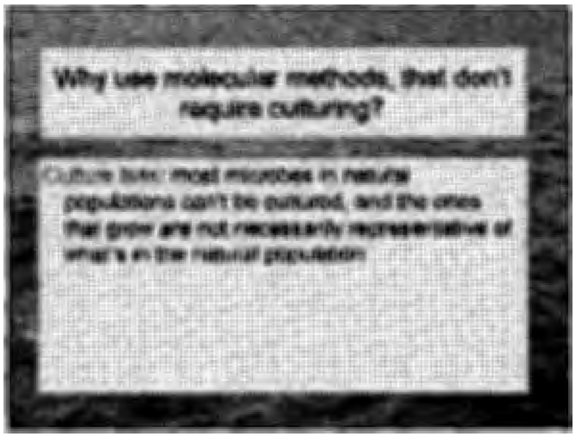

CHEMICAL METHODS
• caffeine, fecal sterols and stanols, laundry brighteners, surfactants, and fragrances are used to diagnose human fecal contamination
• Their spread, persistence, and transport in water is not well correlated with microbial pathogens

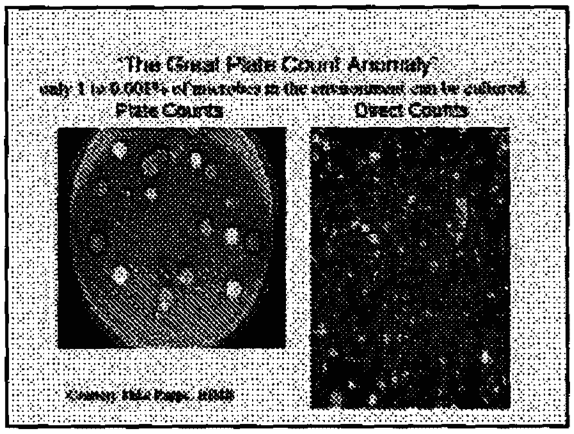

• Two "DNA fingerprinting" methods, Ribotyping and PFGE, can be effective methods of fecal source identification
• Based on culturing and analyzing fecal isolates
• Slow and expensive
• Geographic variation: need a new "library" (set of bacterial isolates from feces) for each new area
• Potential problem: both E. coli and Enterococci grow in the environment, and may have environmentally-adapted types

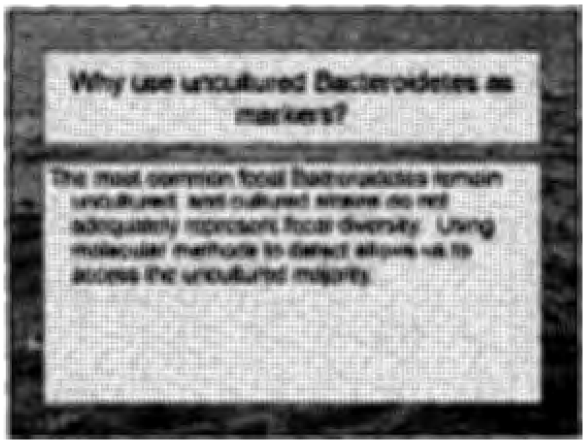

Our Goal:
• A method of source detection that
– is fast (less than 24 hours) and inexpensive
– doesn't require culturing
– doesn't require a site-specific library
• Based on extracting DNA from water samples and amplifying diagnostic gene sequences

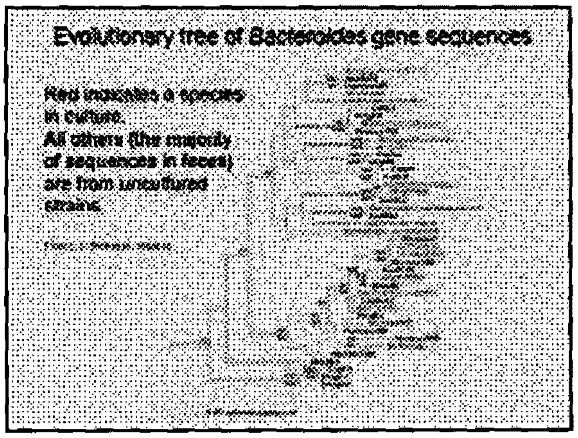

Why Bacteroidales?
• found in both human and animal feces
• significant portion of the flora (more than E. coli)
• only in animal body cavities, not in water
• anaerobic: limited survival and reproduction upon release
• strain differences among different animal hosts

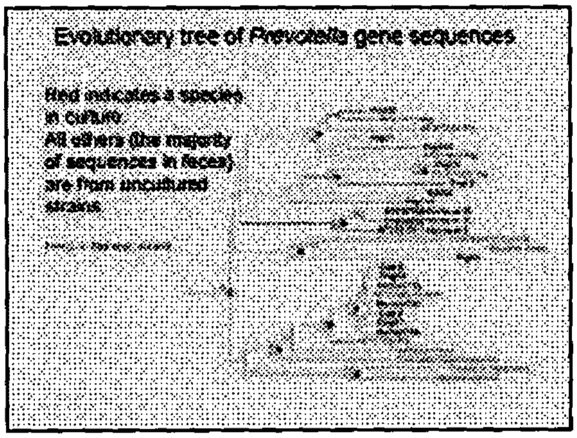

Why not E. coli or enterococci?
• Both the freshwater indicator E. coli and the saltwater indicator enterococcus spp. can survive and proliferate in the environment
• Furthermore, evidence suggests environmentally-adapted strains of indicators

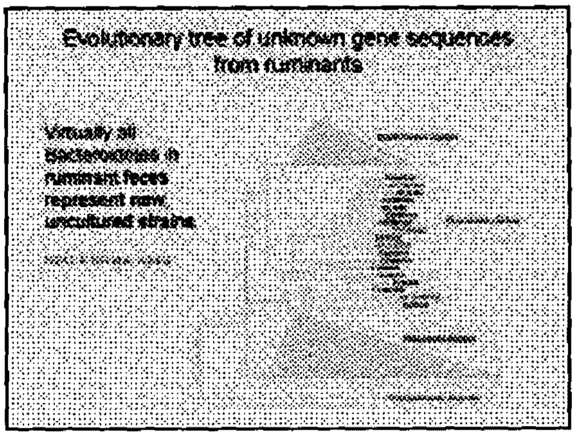

Why use molecular methods, that don't require culturing?
Culture bias: most microbes in natural populations can't be cultured, and the ones that grow are not necessarily representative of what's in the natural population


"The Great Plate Count Anomaly"
only 1 to 0.001% of microbes in the environment can be cultured.
Plate Counts
Direct Counts

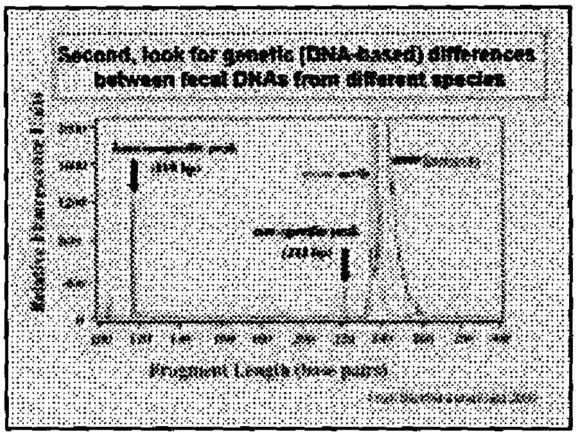

Why use uncultured Bacteroidetes as markers?

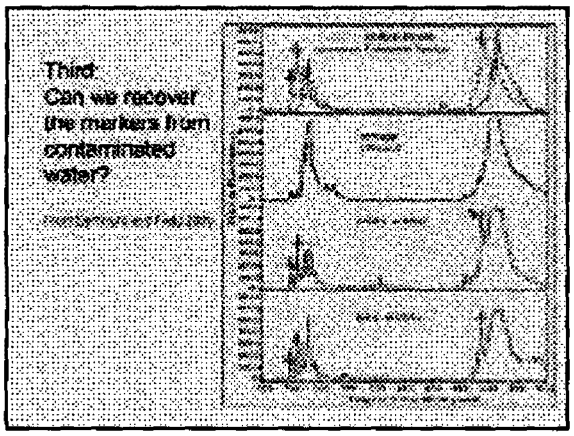

Evolutionary tree of Bacteroides gene sequences
Red indicates a species in culture.
All others (the majority of sequences in feces) are from uncultured strains.

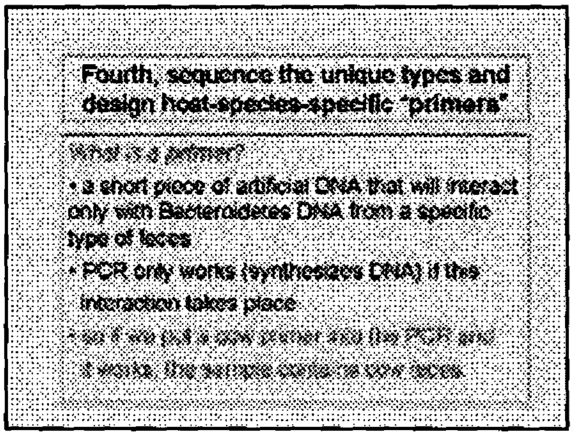

Evolutionary tree of Prevotella gene sequences
Red indicates a species in culture.
All others (the majority of sequences in feces) are from uncultured strains.

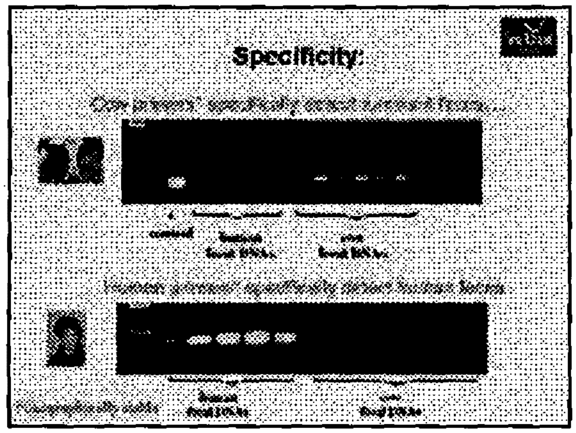

Evolutionary tree of unknown gene sequences from ruminants
Virtually all Bacteroidetes in ruminant feces represent new, uncultured strains.

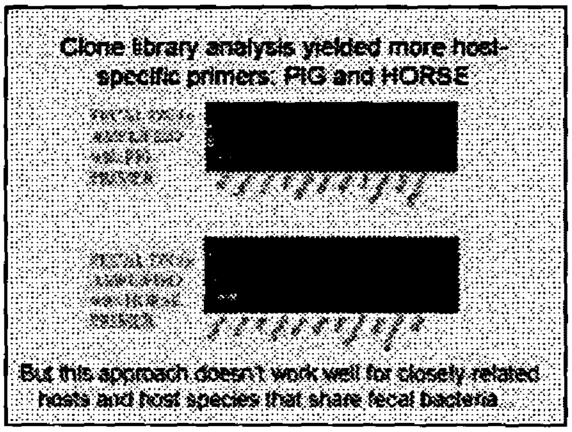

Method development: First, collect fecal samples and extract DNA

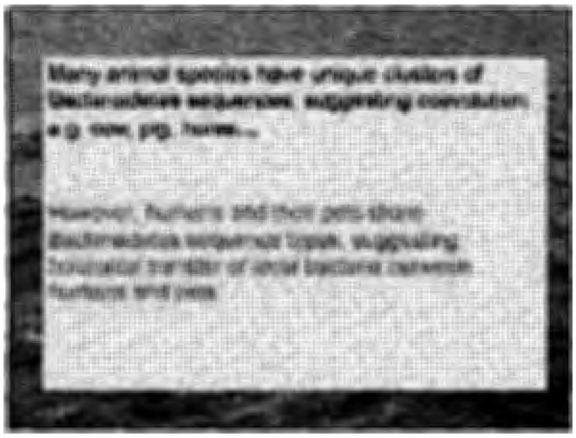

Second, look for genetic (DNA-based) differences between fecal DNAs from different species
Fragment Length (base pairs)

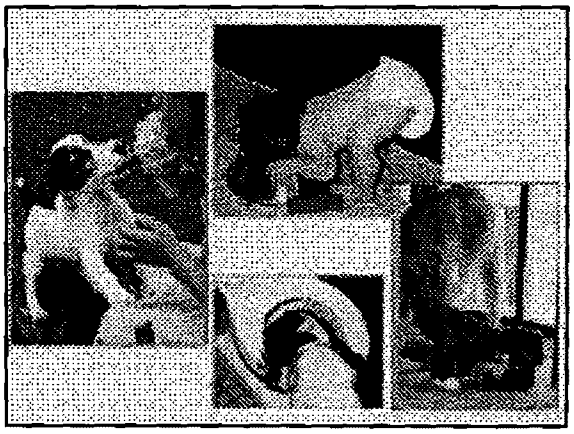

Third:
Can we recover the markers from contaminated water?

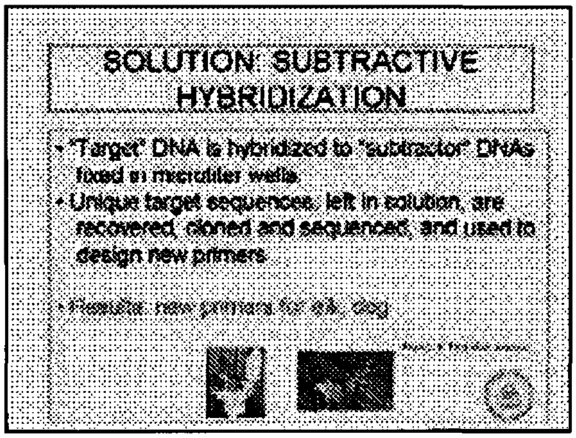

Fourth, sequence the unique types and design host-species-specific "primers"
• a short piece of artificial DNA that will interact only with Bacteroidetes DNA from a specific type of feces
• PCR only works (synthesizes DNA) if the interaction takes place

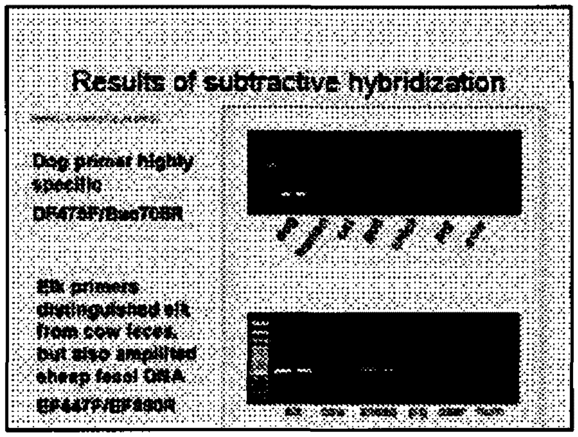

Specificity:

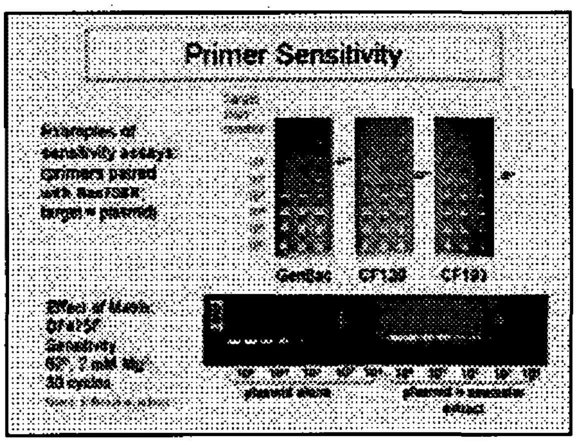

Clone library analysis yielded more host-specific primers: PIG and HORSE
But this approach doesn't work well for closely related hosts and host species that share fecal bacteria

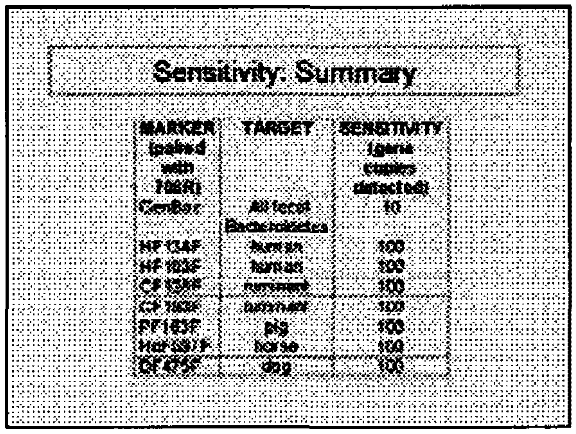

Many animal species have unique clusters of Bacteroidetes sequences, suggesting coevolution e.g. cow, pig, horse...

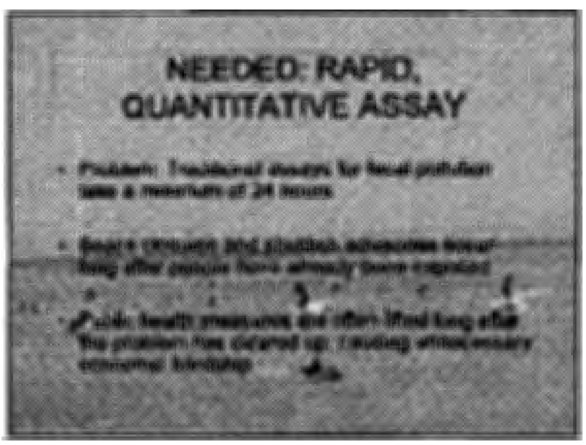


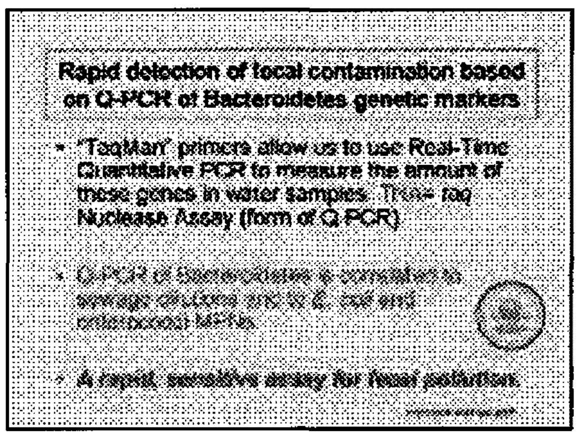

SOLUTION: SUBTRACTIVE HYBRIDIZATION
• "Target" DNA is hybridized to "subtractor" DNAs fixed in microtiter wells
• Unique target sequences, left in solution, are recovered, cloned and sequenced, and used to design new primers


Results of subtractive hybridization
Dog primer highly specific
Elk primers distinguished elk from cow feces, but also amplified sheep fecal DNA


Primer Sensitivity
CF128
CF193


Sensitivity: Summary
MARKER
TARGET
SENSITIVITY
All fecal Bacteroidetes
human
human
pig
horse
dog


NEEDED: RAPID, QUANTITATIVE ASSAY


Rapid detection of fecal contamination based on Q-PCR of Bacteroidetes genetic markers
• "TaqMan" primers allow us to use Real-Time Quantitative PCR to measure the amount of these genes in water samples. Thus Taq Nuclease Assay (form of Q-PCR)

Questions and Answers

Q: I don't think right now there are any truly quantitative methods that will allow us to say that Tellhook Bay is contaminated with 60 percent cow fecal matter and 40 percent human or anything like that, but do you think you can get at least an estimate of the prevalent sources? It looks to me like your method could be at least semiquantitative.

Katharine Field

It's easy to count the number of genes in a sample, so we can be quantitative in that sense, but the problem is that you don't know whether or not those markers have survived. If it's 2 weeks after the pollution event, is it the same proportion of survival as it was at the moment that it dropped into the water? So, what we are working on right now is looking at the survival profiles and correlating them with the survival of specific pathogens. We've got the 0157 strain of *E. coli* and we have some viral pathogens.

Q (Stephan Wuertz, CCD): My question goes in the same direction. Your last comment indicated that you may have evidence of bacteroidetes that have been released from different species that may have different survival properties. Do you have any indication that that is really the case? That would have implications for quantitative microbial source tracking.

Katharine Field

We don't have too much evidence except for some anecdotal evidence that we've seen with our field samples. I have a grad student right now that is growing the markers and labeling them with bromidioxuridine so that she can look at survival versus growth over time, and her experiments are working really well right now. We are hoping that within a year we'll have more specific information. But I would say that Ali Boehm's data were very nice. To me, it looked like her human fecal and human viral markers were not correlated.

Q (Kelly Goodwin, NOAA, Atlantic Oceanographic and Meteorological Lab): Do you have a gull-specific marker? And, have you or anyone looked at fish or marine mammals?

Katharine Field

All of those are things that we are working on. The gull is particularly refractory and we think we have figured out why that is, and that we are getting somewhere with it right now. I hope that we'll soon have some information. I also have some marine samples sitting in our freezer and I need more students and more money to do those.

Q: Are there ways for other labs to use your primers or do they have to start at point zero and develop their own primers as well? And, can you talk a little about cost for people who don't have their own lab?

Katharine Field

Some primers are not yet published but are in press. Many have been published already. The quantitative assay just came out last month. For research purposes, anyone can use them. For commercial purposes, my university is trying to get some sort of patent, but they have been trying to do this for 6 years and they are not having a lot of success. So, I'm not holding my breath on this, but that is the way my university is trying to play it, in terms of commercial application. We ourselves analyze samples for people all the time. People call us up and say they have certain questions or certain studies and ask if we can do it and we do, and the cost is about $50 a sample. We are also starting a collaboration with Mohsen Orodpour in Seattle because we see how our two different approaches of methods really get at different aspects of the same thing and can work very nicely together.

Using Microbial Source Tracking in New Hampshire: Applications, Results and Challenges

Stephen Jones
University of New Hampshire

Biosketch

Dr. Stephen Jones is a research associate professor of marine science and natural resources at the University of New Hampshire. Dr. Jones received his B.S. in Soil Science from the University of Maine in Orono, his M.S. in Soil Science at the University of Wisconsin in Madison and his Ph.D. in bacteriology from the University of Wisconsin in Madison. He conducted research on biodegradation of organic chemicals as a postdoctoral fellow in the Institute of Comparative and Environmental Toxicology at Cornell University from 1983-86, then became a research fellow and adjunct professor studying anaerobic digestion of municipal sludge in the Department of Civil Engineering at Syracuse University until 1987. Since 1987, he has been conducting research on a variety of environmental microbiological and toxicological issues at the University of New Hampshire's Jackson Estuarine Laboratory. He currently serves as the Director of the UNH Center for Marine Biology.

Abstract

Traditional investigatory methods are used by state agencies to track sources of fecal-borne microbial contamination that are causing pollution problems for recreational and shellfish growing waters. While methods such as bracketing streams using microbial indicator organisms and shoreline surveys have been successful in identifying various pollution sources in coastal New Hampshire, estuarine and coastal waters still have elevated bacteria levels in some areas. Since 1999, the New Hampshire Department of Environmental Services has worked with University of New Hampshire researchers to identify specific source species using a microbial source tracking technique called Ribotyping. NHDES and UNH have applied this MST technique while investigating sources of bacterial contamination at recreational beaches, shellfish growing waters, freshwater streams, and tidal rivers. The results, which show the relative contribution of specific source species, have been used in a Total Maximum Daily Load study and to guide remedial actions in both estuarine and fresh waters. In some cases the results were as expected, in others the results indicated unexpected sources, which were eventually verified. Research is continually refining the methodology including a move from manual to automated ribotyping using a RiboPrinter. The cost for ribotyping is an issue that has lead to several studies exploring the potential for using small source species databases that reflect local source species during the time of the study. Other ongoing research and experimental designs seek to expand possible applications of ribotyping for source tracking.

Using Microbial Source Tracking in New Hampshire: Applications, Results and Challenges

Stephen H. Jones, Ph.D.

Natalie Landry & Sara Sumner

NH-MST Partners & Organization

- Beach, Watershed Restoration & Shellfish programs at NHDES
- Lab analysis & field research at UNH-Jackson Estuarine Laboratory
- Cooperative strategy for MST

Water Quality Issues NH estuarine & coastal waters

- Water quality concerns at ocean beaches
- Shellfish harvesting is limited
- Pollution problems associated with storm events
- Remedial actions in some problem areas have not been successful in improving water quality
- TMDL process necessitates pollution source identification

Bacteria and Viruses

Water Quality Issues Pollution source investigations

- [illegible]
  - [illegible]
- Management needs: better methods for [illegible] source ID
- [illegible]
- [illegible]
  - [illegible]

Water Quality Issues Pollution source investigations-MST

- Mutual support and feedback
  - State conducts surveys to meet management needs
  - UNH conducts supporting research to refine survey approach & enhance results
  - Different State programs share limited resources

Today's Topics

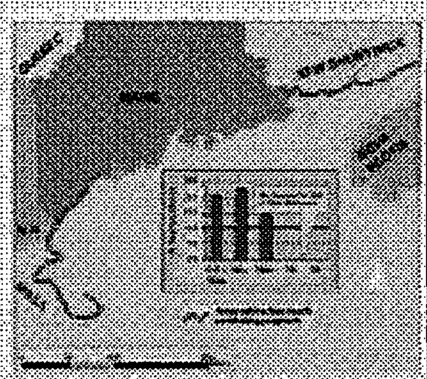
- Management applications
- Evolution of study design
- Gains in understanding limitations and uses

Escherichia coli Ribotyping

- Genotypic:
- Source identification:
- UNH Methodology:
  - Based on Parveen et al. (1999) & Hartel et al. (2002)

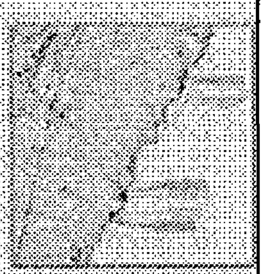
Using microbial source tracking: Bathing Beaches

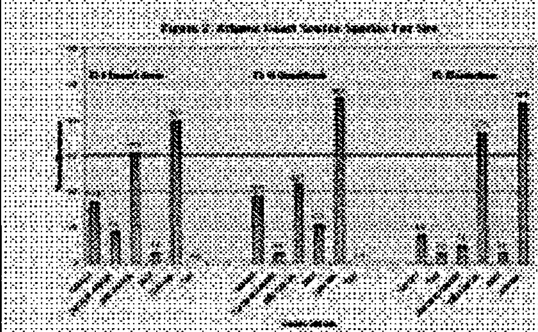
Monitored Beaches & Beach Closures in the Gulf of Maine (2002)

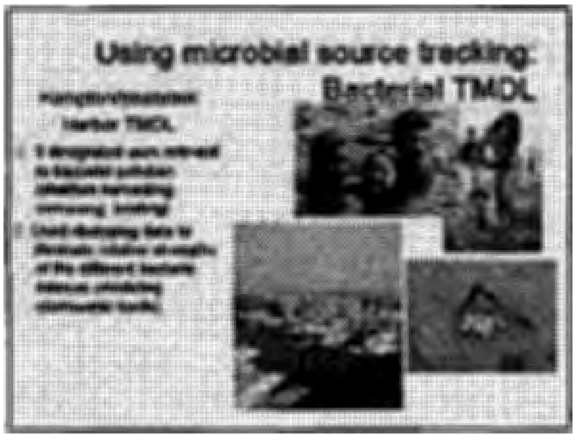


Using microbial source tracking: New Hampshire Coastal Beaches

- No advisories or closures through 2002
- 2003: 1 advisory
- 2004: 3 advisories

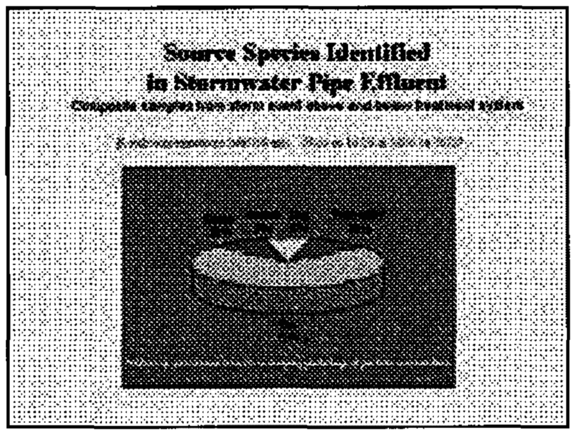


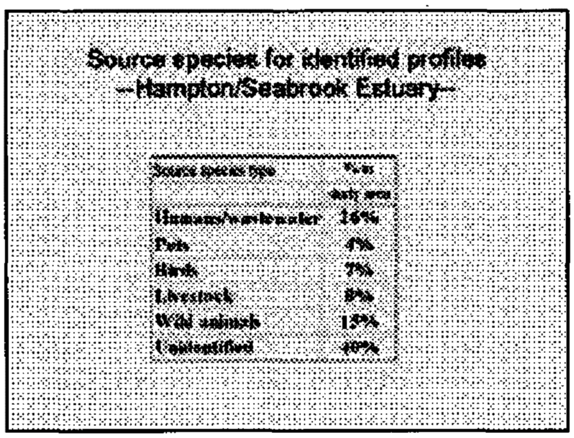


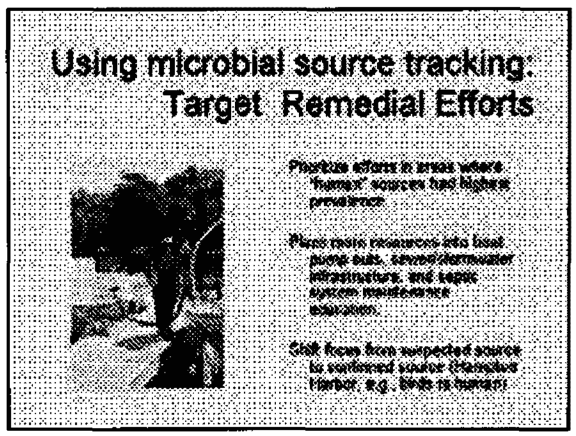

Using microbial source tracking:
Bacterial TMDL

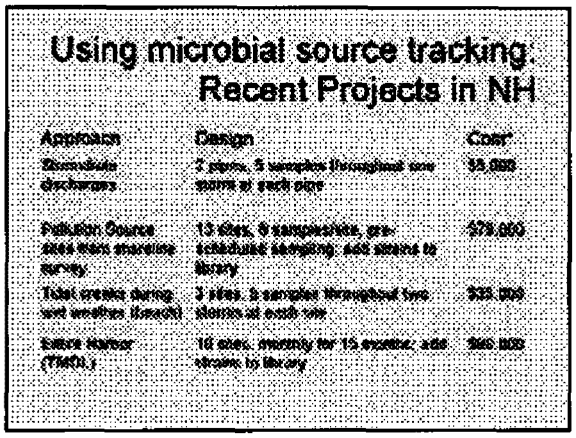

Using microbial source tracking:
Stormdrain Discharges

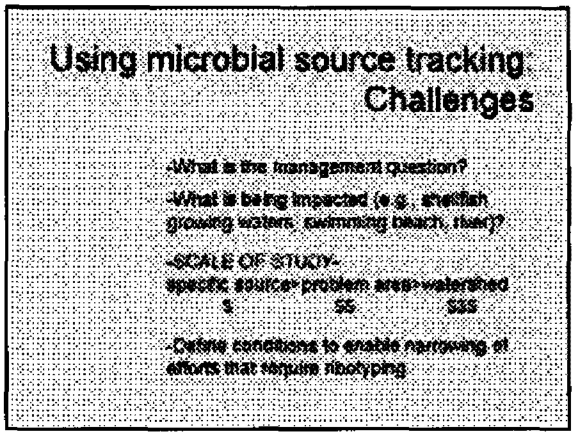

Source Species Identified
in Stormwater Pipe Effluent

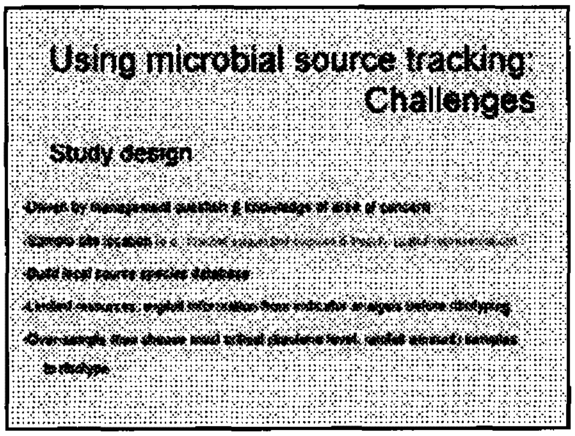

Source Species Identified
in Stormwater Pipe Effluent

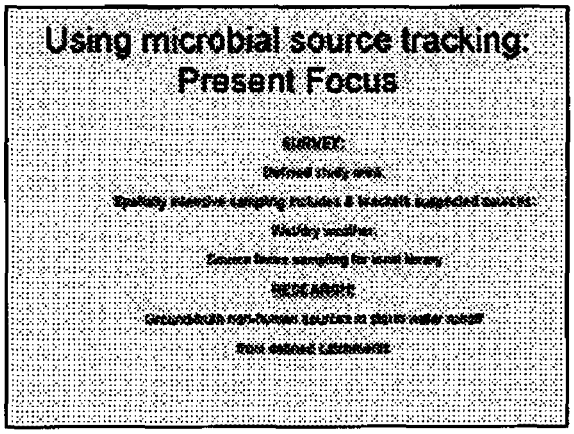

Source species for identified profiles
--Hampton/Seabrook Estuary--
Humans/wastewater 16%
Pets 4%
Birds 7%
Livestock 8%
Wild animals 15%
Unidentified 40%

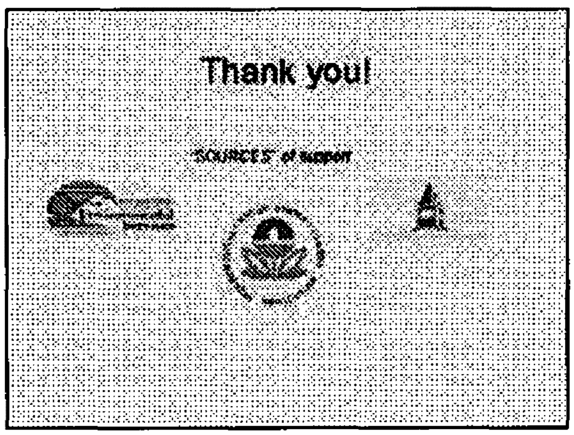

Using microbial source tracking:
Target Remedial Efforts

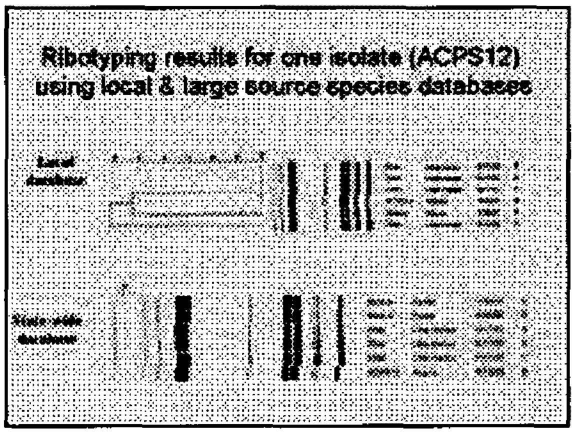

Using microbial source tracking:
Recent Projects in NH
Approach
Design
Cost


Using microbial source tracking:
Challenges
-What is the management question?
-What is being impacted (e.g., shellfish growing waters, swimming beach, river)?
-SCALE OF STUDY-
specific source> problem area> watershed
$
$$
$$$
-Define conditions to enable narrowing of efforts that require ribotyping


Using microbial source tracking:
Challenges
Study design


Using microbial source tracking:
Present Focus


Thank you!
SOURCES of support


Ribotyping results for one isolate (ACPS12) using local & large source species databases

Questions and Answers

No questions.

Replication of *E. coli* in Sand at a Temperate Freshwater Beach

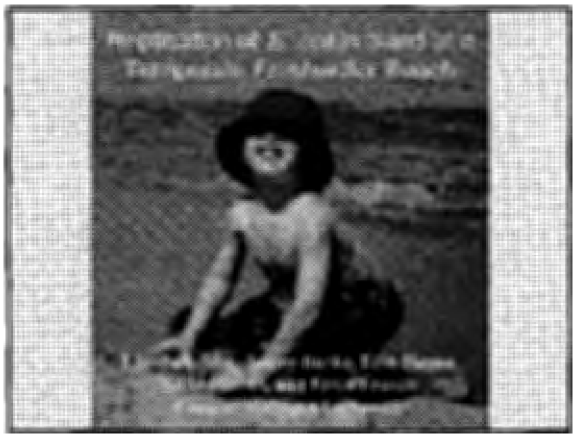
Elizabeth Alm
Central Michigan University

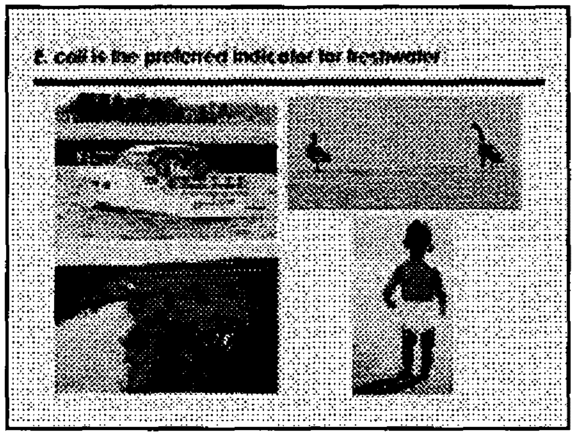
Biosketch

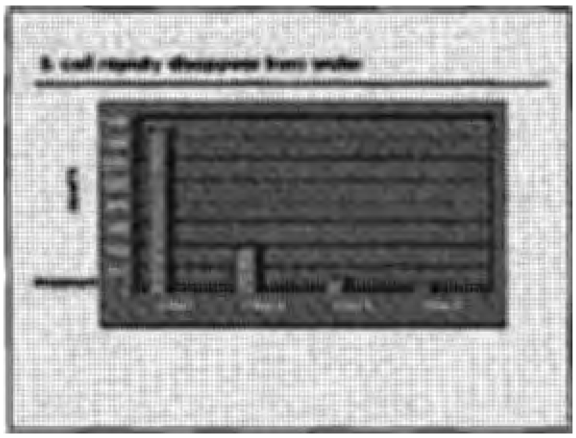
Dr. Elizabeth Alm is a professor of microbiology in the Biology Department at Central Michigan University. Dr. Alm received an A.B. in Biology from Randolph-Macon Woman's College in Virginia, a M.S. from Ball State University in Indiana, and a Ph.D. from the University of Illinois at Urbana-Champaign. She has been on the faculty at Central Michigan University since 1996. Dr. Alm has been studying microbial community structure in aquatic environments for over 12 years. For the past 4 years she has been focusing on the sources and fates of enteric bacteria at Great Lakes beaches. She is a participating faculty in the Michigan Water Research Center and in the Institute for Molecular Epidemiology.

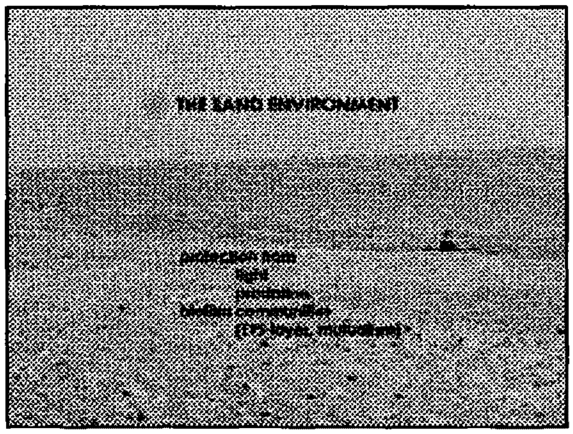
Abstract

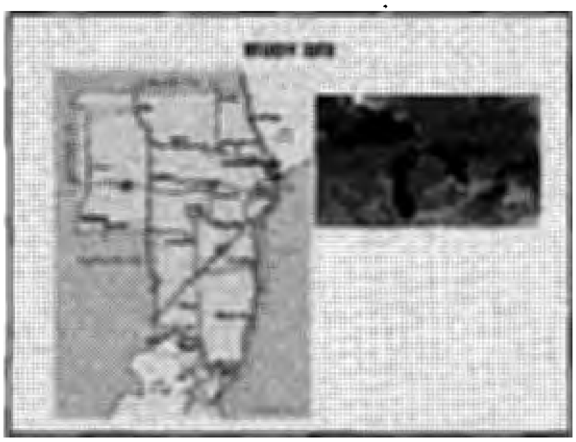
Escherichia coli have been used as indicators of recent fecal contaminftion in beach monitoring and source-tracking programs. Recent investigations have demonstrated high abundances of *E. coli* in sand at temperate freshwater beaches. This study was initiated to test the hypothesis that high abundances of *E. coli* can be explained, at least in part, by the ability of *E. coli* to live and replicate in beach sand. In laboratory microcosm studies, *E. coli* densities increased from 1.9 x 10^2 to more than 2 x 10^7 CFU/100 g sand after 2 days of incubation at 19°C, and remained above 2 x 10^7 for at least 35 days. In field replication studies, performed in diffusion chambers incubated in Lake Huron foreshore sand, *E. coli* were able to multiply rapidly at the beach, reach high densities in the sand (approximately 7.5 x 10^7 CFU/100g), and to persist in a cultivable state at high density for at least 48 days. In another field study, *E. coli* O157:H7 was observed in sand biofilm communities, suggesting in situ replication of this *E. coli* pathotype. Beach monitoring programs operate under the assumption that *E. coli* in water originates from a recent fecal contamination event. This study supports suggestions from recent monitoring studies: Some *E. coli* populations may be indigenous to beach sand and may be a source to swimming water. The potential for indigenous sand populations of *E. coli* to re-enter swimming water at some later time would frustrate *E. coli*-based monitoring and source tracking studies.

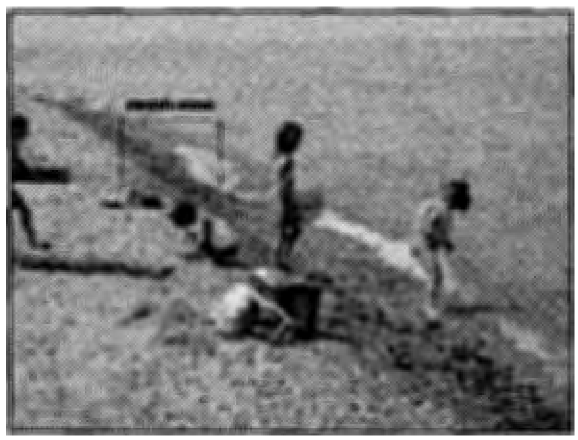



E. coli is the preferred indicator for freshwater



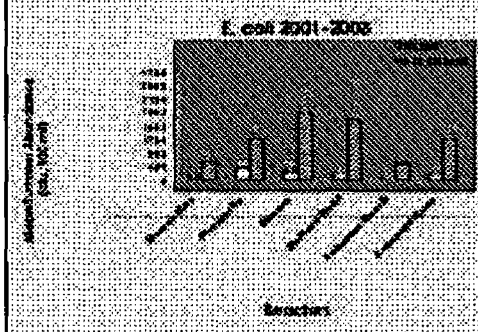

THE SAND ENVIRONMENT





Characteristics of the swash zone

•particle size - >0.5 mm in diameter
•temperature - 14 to 24.5°C (mean 19.6°C)
•moisture content - 12-25%
•nutrients - TP = 3ug/g;
TN = 1ug/g



What is responsible for abundance of *E. coli* in sand?

1. filtration and concentration of *E. coli* by the sand

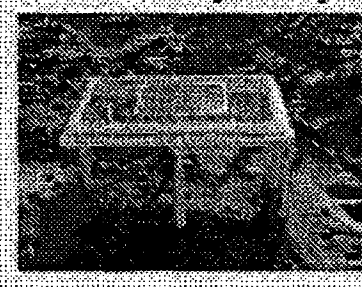
2. periodic direct fecal loading of *E. coli* to sand followed by persistence

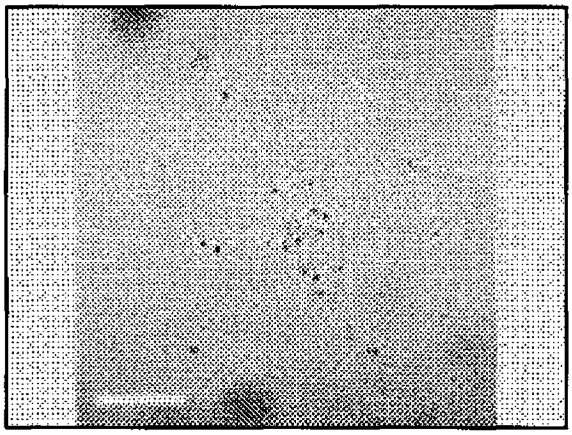
3. deposition followed by replication of *E. coli* in the sand environment

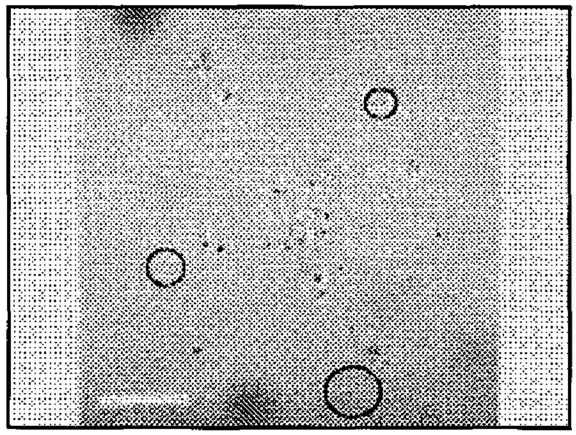
E. coli attached in the intestine

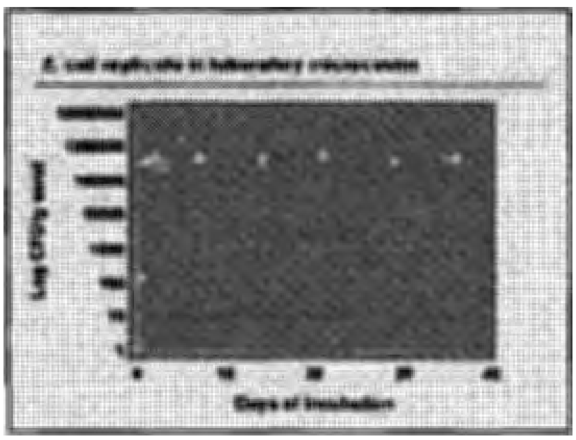
Sand grain habitat

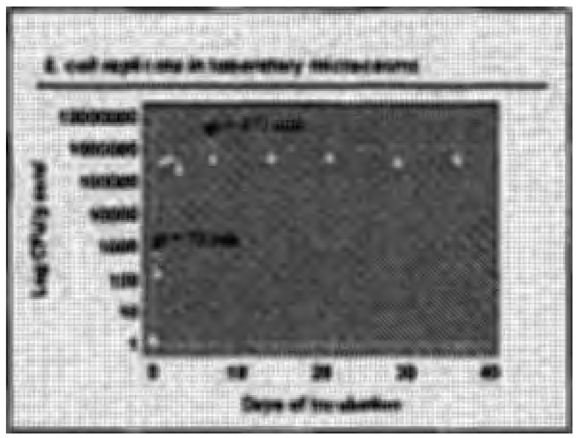
Glass slides used as surrogate for sand grains

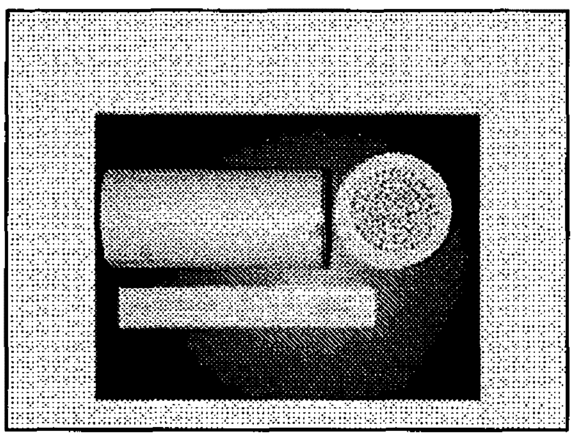


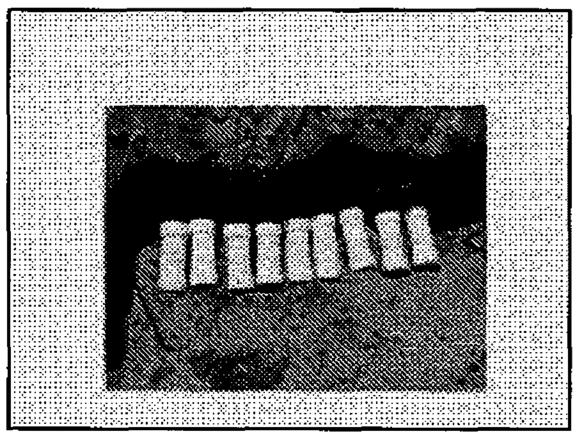


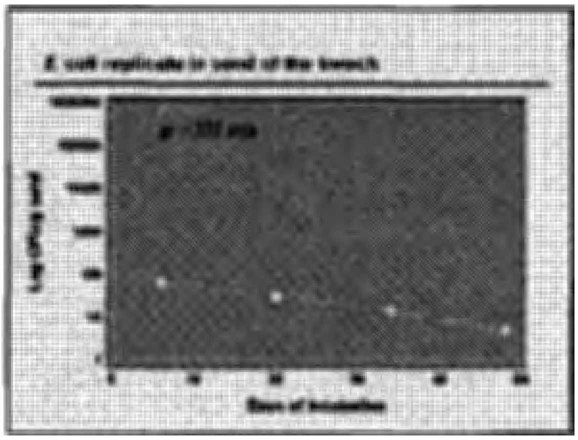






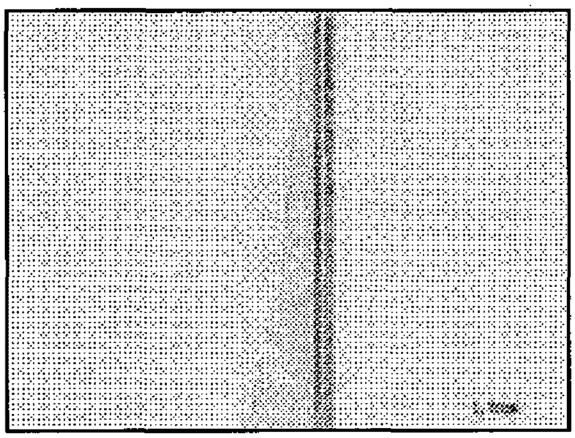






Might some *E. coli* be adapted to the beach?

with Seth Walk
and Dr. Tom Whittam
MSU



Summary

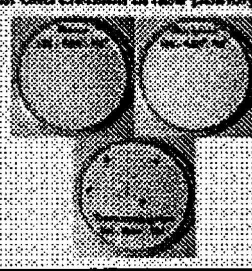
1. Dense populations of E. coli persist in sand
2. Some E. coli are indigenous to the beach

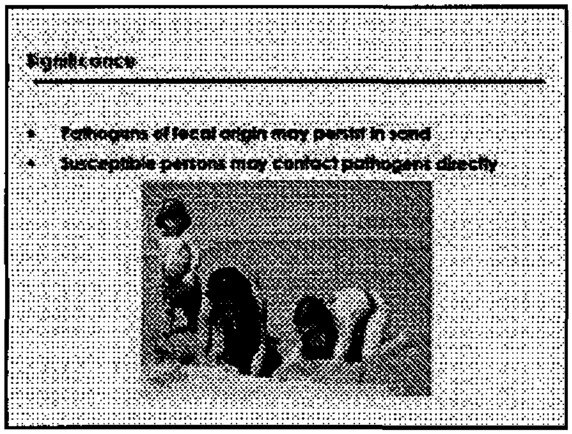
Significance

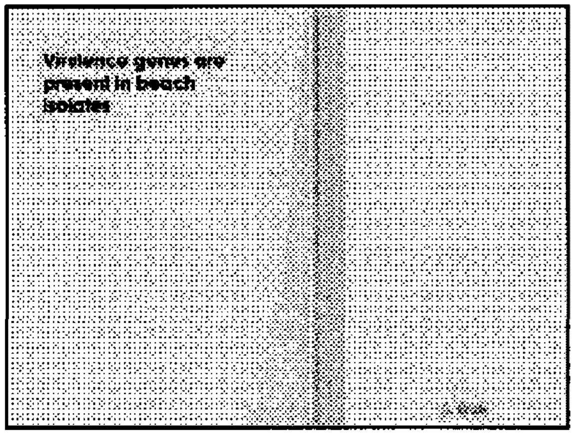
- Indigenous sand populations may be a source to water
  - ? Indicator of recent contamination?
  - ? Useful for source tracking?

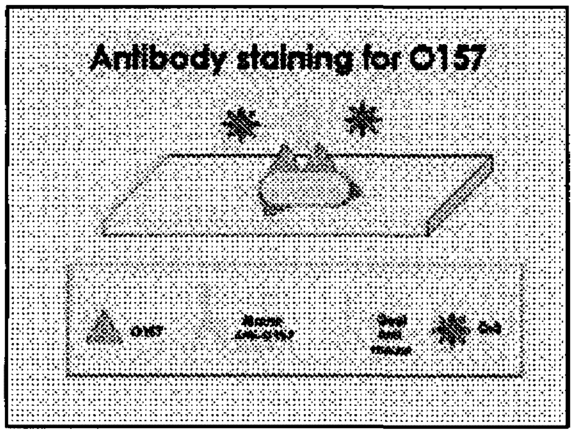
Significance

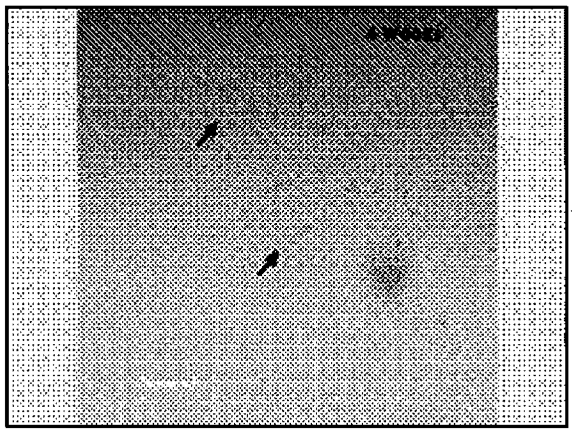
- Indigenous sand populations may participate in lateral gene transfer and creation of new pathotypes.

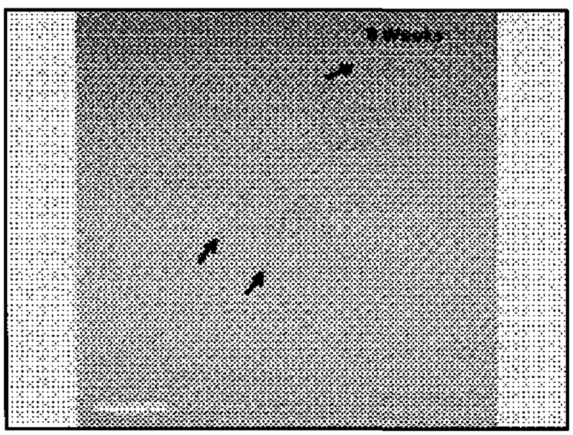


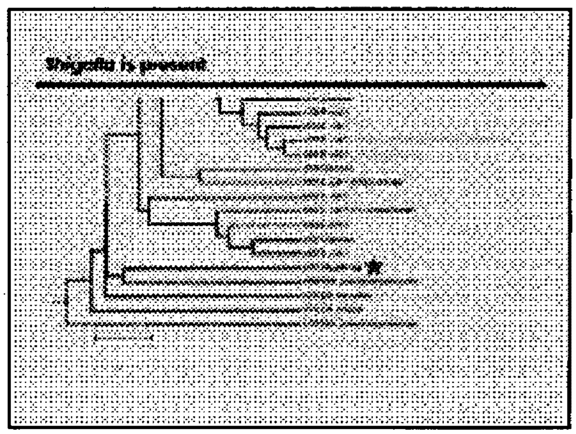

Significance
Pathogens of fecal origin may persist in sand
Susceptible persons may contact pathogens directly

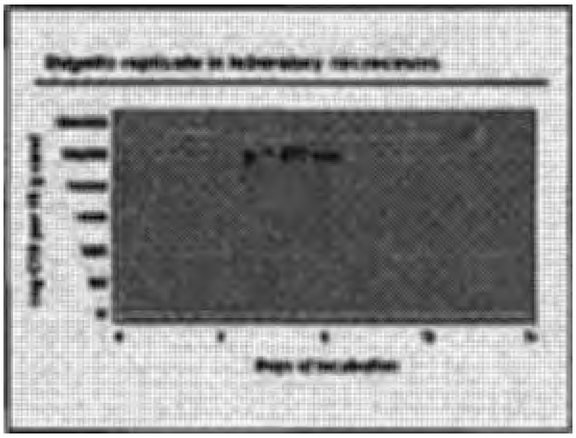

Virulence genes are present in beach isolates

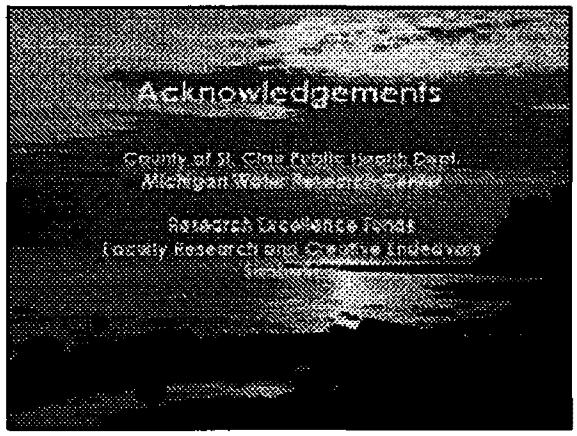

Antibody staining for O157
O157


4 Weeks


8 Weeks


Shigella is present




Acknowledgements
County of St. Clair Public Health Dept.
Michigan Water Research Center
Research Excellence Funds
Faculty Research and Creative Endeavors

Questions and Answers

Q: In your microcosm experiment where you spiked with the isolate that you've grown in the lab, you showed it could reproduce in your microcosm in the absence of competition. Have you done another experiment where there was competition to see whether that is still occurring?

Elizabeth Alm

In other experiments that we've tried to set up, for instance when we were trying to set up the assays to look at the exchange in antibiotic resistance, finding a pair of *E. coli* that we could maintain in our columns at the ratio that we wanted was challenging. Very often one strain would push the other one out and take over. So I think that we have a lot of evidence that competition is occurring and is probably a very important mechanism for regulating these populations.

Q: Can you justify your choice to compare directly E. coli *in cfu/100 grams of sand to* E. coli *in cfu/100 milliliters?*

Elizabeth Alm

Not very well because they are very different matrixes, and for the volume of sand there are a lot more attachment sites, so it is a bit like comparing apples and oranges. So, doing it on a per volume basis was the best that we could come up with, but I wouldn't say that a direct comparison like that is a fair comparison.

Q: That information you provided on Shigella *and 0157 growing in the sand is pretty frightening. You started your talk out with a picture of a kid wearing a swim diaper, and you are talking about control at the source. Do you think that kids in swim diapers may be something we need to control at beaches?*

Elizabeth Alm

Yes, definitely. I think that is a real problem and that a lot of studies have shown that bathers can carry—not just children but adults too—fecal organisms microorganisms on their skin that comes right off when they get into the water. So, I think that a lot more public awareness of the contributions they make is definitely important. I don't think the swim diapers do too much to keep the organisms out. It may remove the visible floaters, but not the bacteria and viruses.

Thursday, October 14

10:20 a.m. – 12:00 p.m.

Concurrent Track I:

Identifying and Solving Beach Water Quality Problems

Session Six:

TMDLs

A Watershed Scale Approach for Developing a Bacterial TMDL in an Urbanizing Puget Sound Embayment

Christopher May
Battelle Marine Science Laboratory

Biosketch

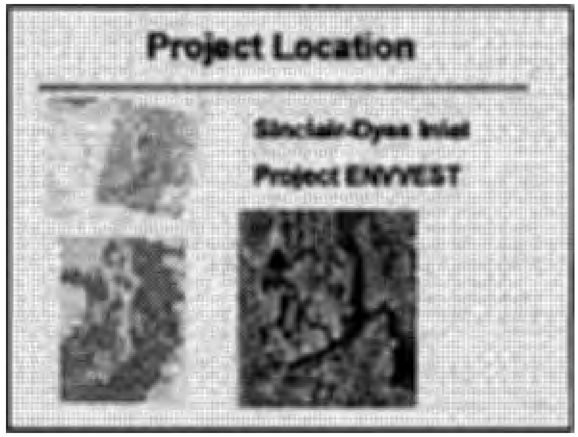
Dr. Christopher W. May, senior research scientist and engineer at the Battelle Marine Sciences Laboratory (MSL), is a freshwater ecologist and environmental engineer with expertise in urban watershed assessment and management. His areas of interest include stormwater management, watershed analysis using geographic information systems (GIS), salmonid habitat assessment, urban stream rehabilitation, water quality monitoring, stream biological assessment, and watershed restoration. His current research at Battelle focuses on the linkage between upland watersheds and nearshore-marine ecosystems, including natural processes and land-use impacts. Prior to joining the MSL team Dr. May was a research engineer at the University of Washington Applied Physics Laboratory (UW-APL). His research there centered on the cumulative impacts of urbanization on native salmonids in small streams in the Puget Sound lowland eco-region. Dr. May is an adjunct faculty member of Western Washington University, Huxley School of Environmental Studies, University of Washington, Tacoma Environmental Science Program, and the University of Washington, Professional Engineering Program.

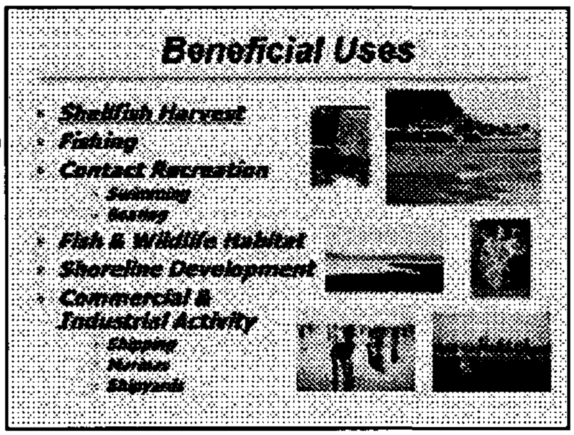
Abstract

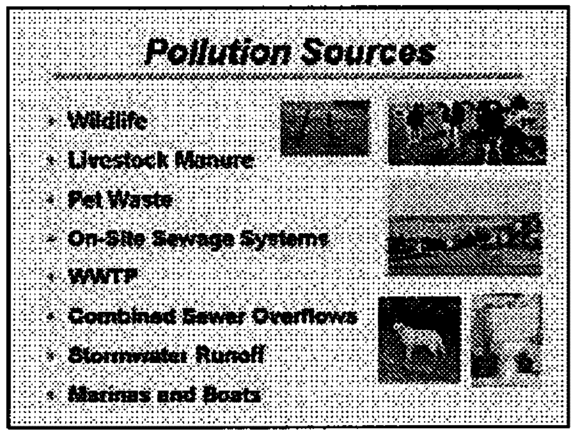
Shellfish are icons of the Pacific Northwest, associated with many recreational, cultural and economic values. Clean water is essential for shellfish harvesting. However, an increase in human population and development within nearshore environments and adjacent watersheds has degraded water quality by increasing the incidence of bacterial pollution, resulting in increased closures for shellfish harvesting, as well as restrictions on fishing and contact recreational activities such as boating and swimming. While research has long demonstrated that urbanization alters water quality in upland streams and rivers, primarily through the loss of native vegetative cover, increased impervious surfaces, altered hydrology and other impacts, the relationships between patterns of landscape alteration and the health of shellfish growing areas are generally not well understood.

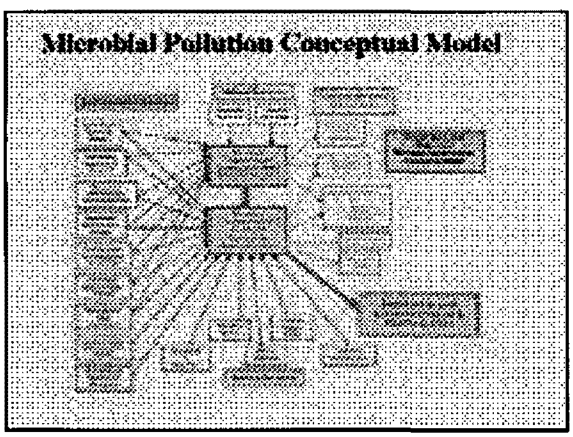
This research project explored the relationships between urbanization and nearshore water quality using a landscape scale analysis of the Sinclair-Dyes Inlet watershed. A landscape-scale empirical analysis of urbanizing sub-basins was conducted. Using bacterial contamination as the indicator of nearshore water quality conditions, we identified the landscape factors that best explained water quality conditions in nearshore shellfish growing areas. Across all sub-basins, we found that the loss of native forest cover, impervious surface area, and road density are the best predictors of nearshore water quality conditions. Within the more urbanized areas, the amount and connectivity of impervious surface areas explained most of the variance in bacterial pollution. In addition, the type and extent of the stormwater conveyance and treatment network significantly influenced bacterial contamination levels in the nearshore environment. The Sinclair-Dyes Inlet study was used to develop a TMDL implementation plan. A dynamic model was also developed as part of this project. The findings of this study also have broad implications for land-use and stormwater management policies in other coastal areas of the country.

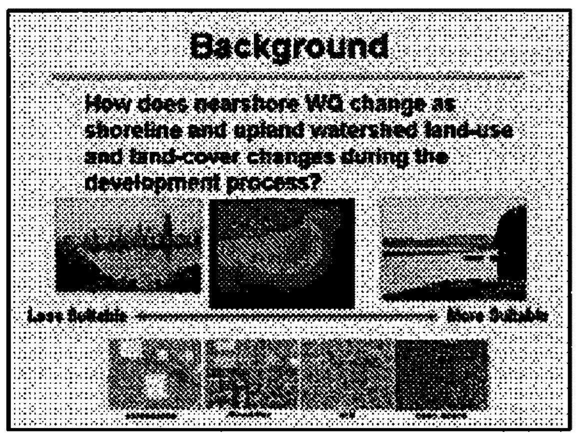

A Watershed Scale Approach for Developing a Bacterial TMDL in an Urbanizing Puget Sound Embayment
Chris May
Jerry Sharrell
Bob Johnston
PF Wang
Brian Skahill

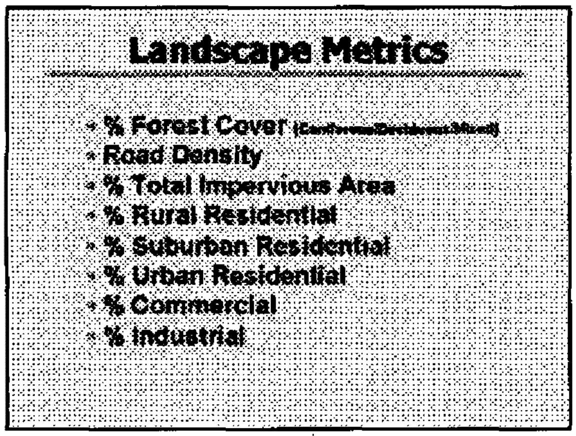

Project Location
Sinclair-Dyes Inlet
Project ENVVEST

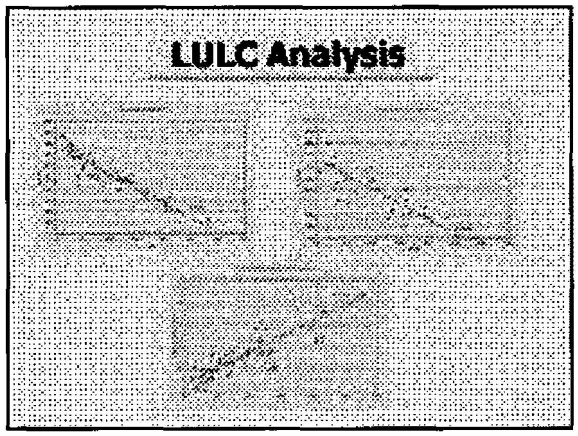

Beneficial Uses
Shellfish Harvest
Fishing
Contact Recreation
Swimming
Boating
Fish & Wildlife Habitat
Shoreline Development
Commercial & Industrial Activity
Shipping
Marinas
Shipyards

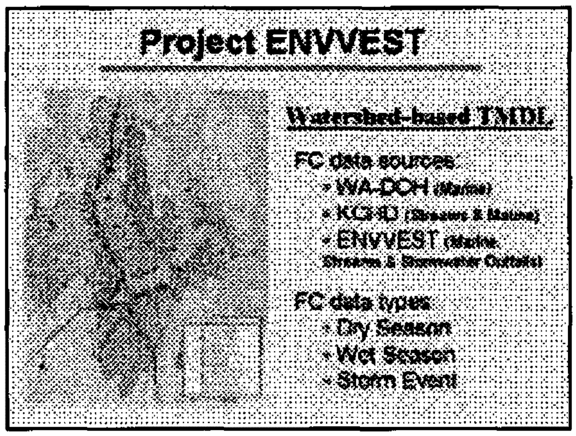

Pollution Sources
Wildlife
Livestock Manure
Pet Waste
On-Site Sewage Systems
WWTP
Combined Sewer Overflows
Stormwater Runoff
Marinas and Boats

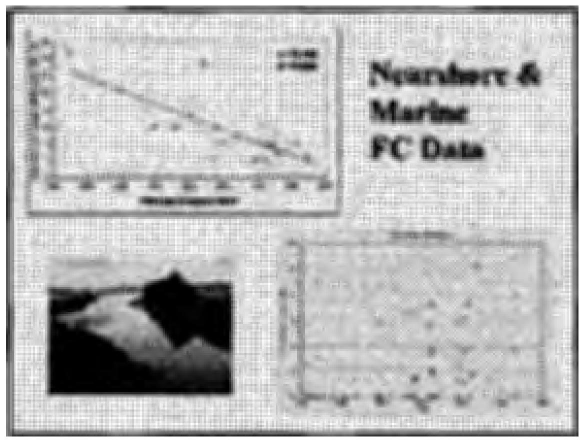

Microbial Pollution Conceptual Model

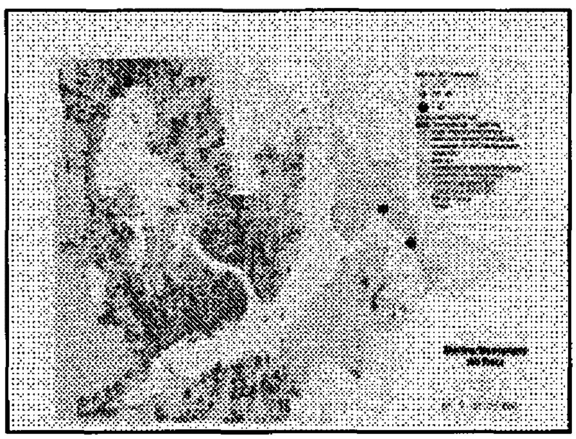

Background
How does nearshore WQ change as shoreline and upland watershed land-use and land-cover changes during the development process?
Less Suitable
More Suitable

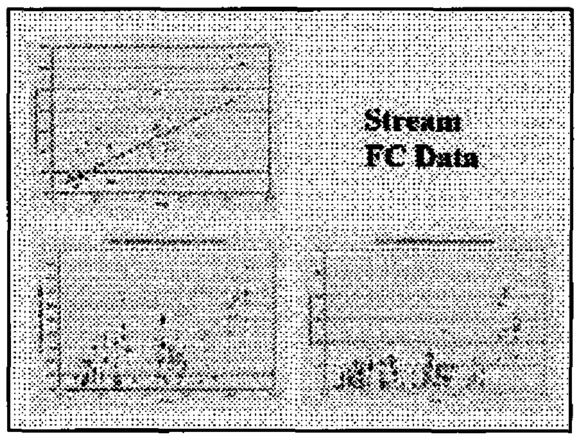

Landscape Metrics
% Forest Cover
Road Density
% Total Impervious Area
% Rural Residential
% Suburban Residential
% Urban Residential
% Commercial
% Industrial

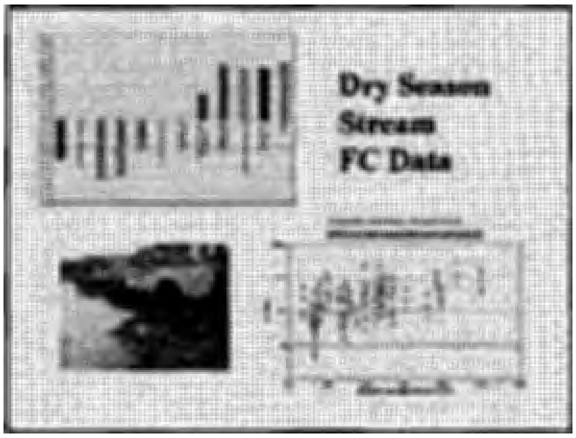

LULC Analysis

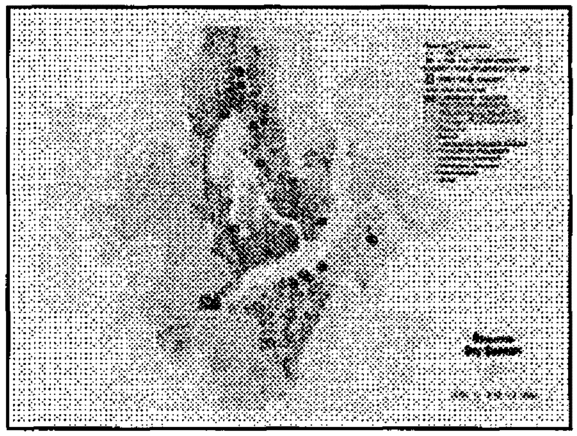

Project ENVVEST
Watershed-based TMDL
FC data sources:
WA-DOH (Marine)
KCHD (Streams & Marine)
ENVVEST (Marine, Streams & Stormwater Outfalls)
FC data types:
Dry Season
Wet Season
Storm Event

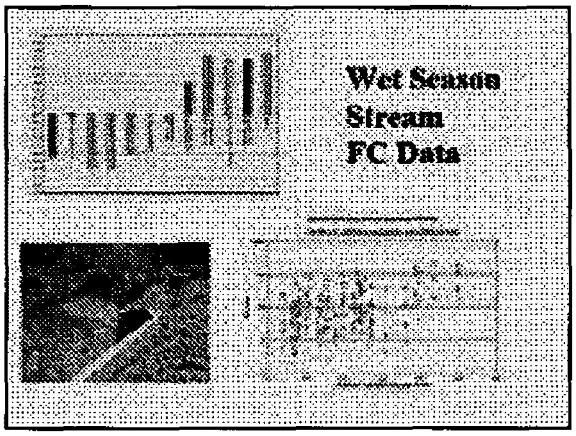

Nearshore &
Marine
FC Data

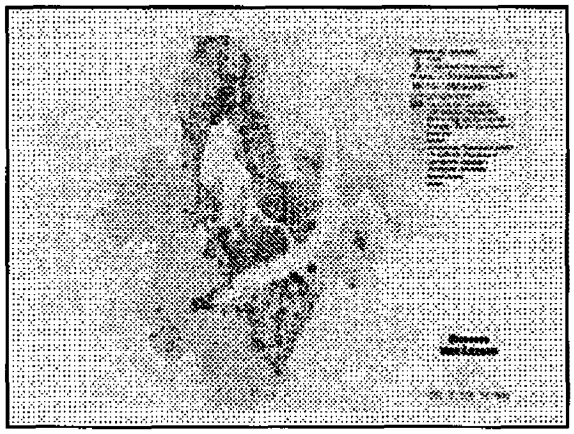


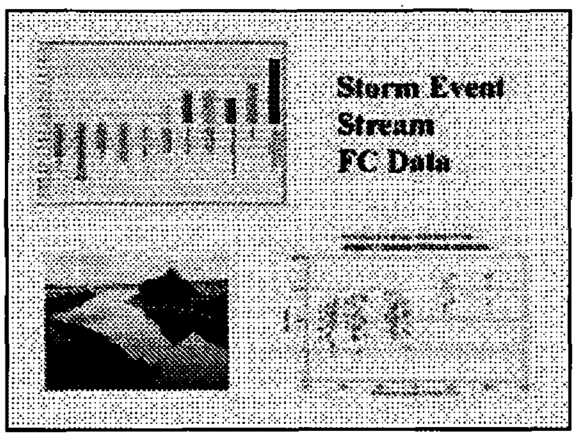

Stream
FC Data

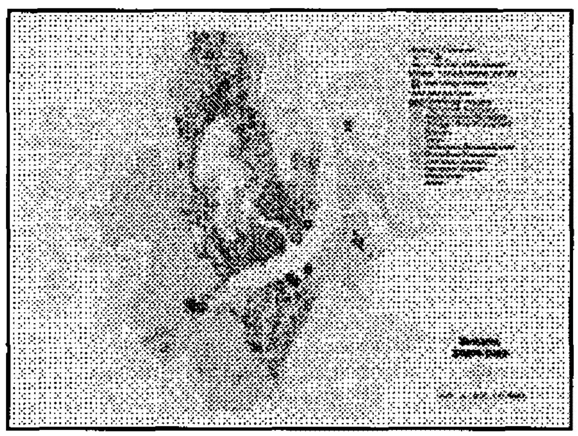

Dry Season
Stream
FC Data

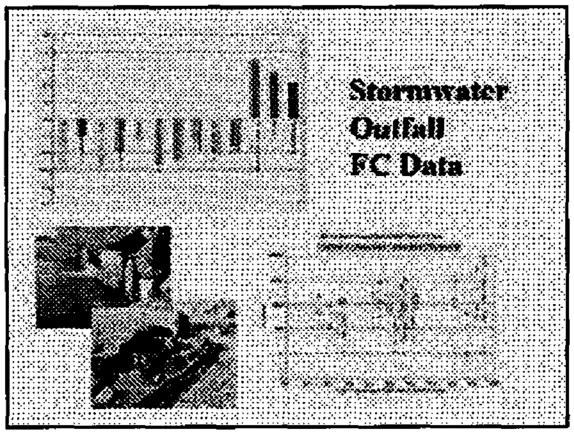


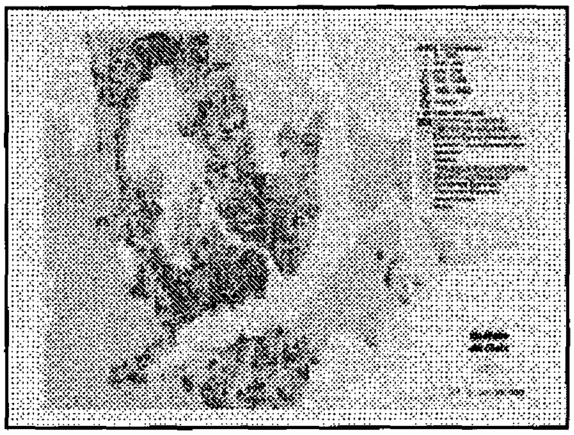

Wet Season
Stream
FC Data

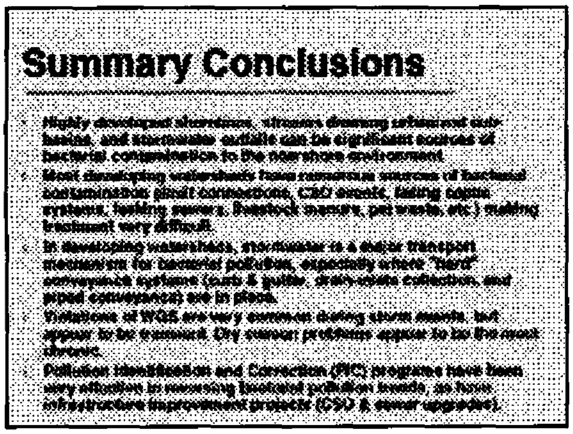


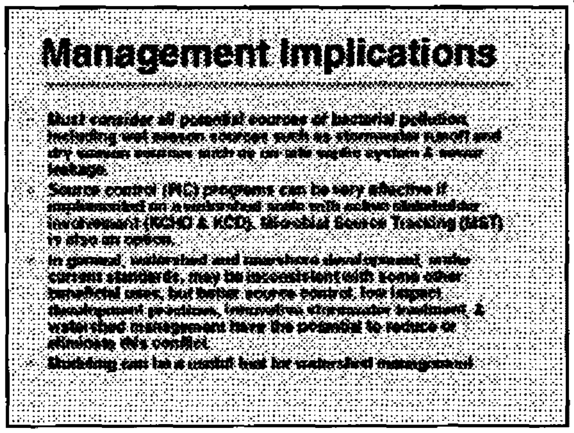

Storm Event
Stream
FC Data

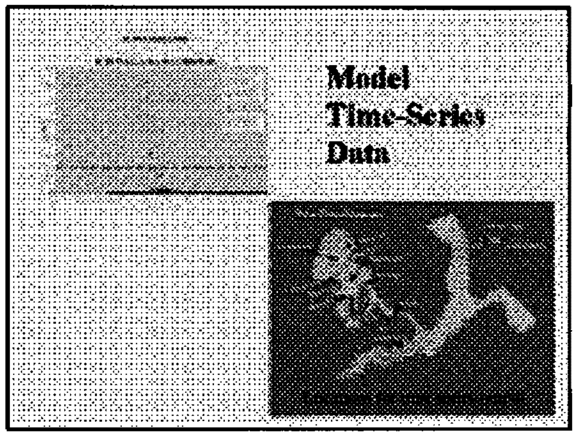



Stormwater
Outfall
FC Data

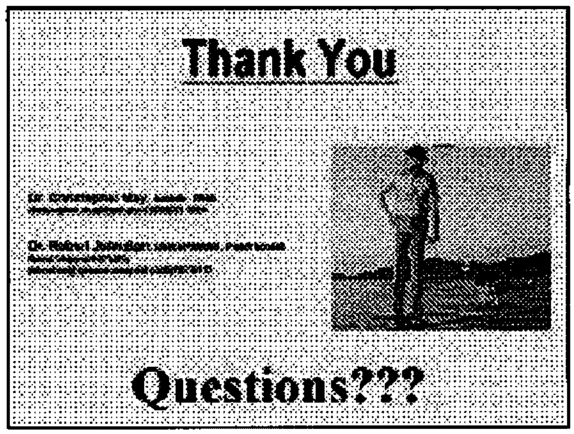



Summary Conclusions


Management Implications


Model
Time-Series
Data


WQS
Exceedance
Extent


Thank You
Questions???

Questions and Answers

Q: How much money did it take to create your model?

Christopher May

I can't really tell you, as we probably have to talk man-hours and things like that.

Q: Too many zeros?

Christopher May

Not really. We have the technique down. For the upland part, we use an HSPF-based model, which is fairly simple. Then, the CH3D model was the dynamic model used for the water column, and that takes a little doing, but I think we've worked the bugs out so it's not that difficult anymore. So, I can talk to you about how many man-hours it took.

Q: Did you verify the model?

Christopher May

Yes, we have done synoptic surveys, and all the sample points at the same time, plugged it into the model and its pretty close.

Improving Beach Water Quality through TMDLs: A Case Study of Santa Monica Bay Beaches

Renee DeShazo
Los Angeles Regional Water Quality Board

Biosketch

Renee DeShazo is the Basin Planning Coordinator for the Los Angeles Regional Water Quality Control Board. In this role, she oversees development of all regional basin plan amendments that incorporate or revise water quality objectives, beneficial uses and implementation policies for water quality standards. Ms. DeShazo also initiates early review of basin planning issues related to TMDL development, and works closely with the multidisciplinary TMDL Units on the basin planning components of TMDL development. She was the lead staff person in the development of the Santa Monica Bay Beaches Bacterial TMDLs and continues to work closely with stakeholders in the development of monitoring and implementation plans for those TMDLs. Prior to her position with the Regional Board, Ms. DeShazo worked for the Santa Monica Bay Restoration Project, and prior to that she was employed by the Massachusetts Department of Environmental Protection. Her educational background includes a Bachelor of Science degree from the College of William and Mary and a Master's degree from the University of North Carolina at Chapel Hill.

Abstract

Santa Monica Bay beaches are an icon and a major source of revenue to the Los Angeles Region, while Santa Monica Bay is the major receiving water for urban runoff and effluent from wastewater treatment plants for one of the largest population centers in the United States. As such, many of the beaches along Santa Monica Bay experience poor bacteriological water quality, particular during wet weather when storm water runoff is conveyed through numerous storm drain outfalls to the beaches. Yet, beach usage remains significant during winter months given the mild climate of Southern California and the year-round popularity of surfing and other water-related recreational activities. To address bacterial contamination at these beaches, the State adopted Total Maximum Daily Loads (TMDLs). These TMDLs are based on the principles that bacteriological water quality must be at least as good as at a reference site and there shall be no degradation of existing shoreline water quality if historical water quality is better than the reference site. The TMDLs have a multipart numeric target that includes four bacterial indicators. Using the principles above, a certain number of exceedances of the single sample limits for these indicators are allowed at the beaches. This approach is supported by a diverse group of stakeholders, including cities responsible for complying with the TMDLs as well as environmental organizations committed to ensuring the highest achievable level of public health protection for the local residents and visitors to the Bay's beaches.

Making the Most of a Difficult Situation:

The SMB Beaches Wet Weather Bacteria TMDL

National Beaches Conference
October 14, 2004

Background

- Dry-Weather TMDL
  - Easier problem to tackle
  - Much progress made already (i.e. LFDs)
  - 3 to 6 years for implementation
  - Approach same as Wet Weather

Wet Weather...Should we care?

- 1½ million beach visitors/month during winter months (Nov. to Mar.)
- Winter users are likely frequent users (e.g. surfers)
  - Longer and more frequent exposure than the average population
  - Likely to place a higher value on beach water quality

Health Risks of Swimming in Water with Elevated Bacteria Densities

- Epidemiological studies show links between bacteriological water quality and health risks
- Health effects observed include:
  - vomiting, fever, stomach pain, diarrhea
  - eye, ear and skin infections
  - respiratory ailments

Health Risks

Health Risks at Proposed Numeric Targets based on Santa Monica Bay Epidemiological Study

Bacterial Indicator	*Health Risk*	*Number per 10,000*
Enterococcus	Diarrhea with blood	27
	Gastroenteritis I	130
Total coliform	Skin rash	165
Fecal/total ratio	Nausea	239
	Diarrhea	781
	Gastroenteritis II	98
	Fever	117
Fecal coliform	Skin rash	74

Water Quality Objectives = TMDL Numeric Targets

Target	Single sample limit	Geometric mean limit
Total coliform	10,000	1,000
	1,000 when F:T>0.1	N/A
Fecal coliform	400	200
Enterococcus	104	35

Wet-Weather Problem Identification

- LA County DHS Data (1996-2000):
  - 60% of shoreline monitoring locations exceeded standards more than 10%
- Heal the Bay Annual Beach Report Card:
  - 80% of beach locations received a grade of C or lower
- SCB Shoreline Microbiology Survey (2000):
  - 58% of sites exceeded standards

Wet Weather Source Characterization

- Storm-water runoff is primary source of elevated bacteria densities
- Natural runoff contributes to some exceedances
- Supported by historical shoreline data & SCB survey, which show much higher levels of exceedance at freshwater outlets

Wet Weather...What can we do?

- Problem
  - Single sample "not-to-exceed" objectives
  - Bacteria is not solely a human-caused problem
  - Bacteria is ubiquitous in environment
  - Nature of So. Cal. storm events
    - short, intense
    - large peak flows & volume

Implementation Procedures for Bacteria Objectives

- Two implementation procedures proposed for single sample objectives
  - Reference System/Antidegradation Approach
    - Used in this TMDL
  - Natural Sources Exclusion Approach
    - Use if an appropriate reference system cannot be identified
- Does not apply to geometric mean objectives
- May only be applied in context of a TMDL

Why a Reference System/Antidegradation Approach?

- Not intent to require treatment or diversion of natural creeks that convey bacteria from natural sources
- Northern SMB sub-watersheds average 85% open space & associated beaches still exceed objectives occasionally

Objectives of Wet-Weather TMDL: The "Reference System/Anti-Degradation Approach"

- Water quality is at least as good as that of a natural system
- No degradation of existing shoreline water quality where it is better than natural system

Reference System Approach

- Three criteria for selecting local reference beach:
  - Watershed is predominately open space
    - Field observations indicate little human impact in watershed
  - Freshwater outlet onto beach
  - Adequate shoreline monitoring data

Waste Load Allocations

- Expressed as "allowable exceedance days" for single sample targets
  - Bacterial density and frequency of single sample exceedances are most relevant to public health
  - 'Appropriate measure' consistent with the definition in 40 CFR 130.2(i)

Waste Load Allocations

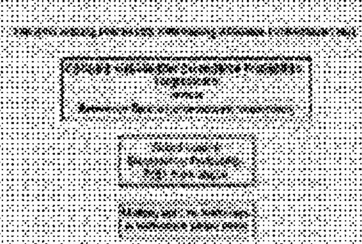
- Each of the 55 shoreline monitoring stations are assigned a final allowable number of exceedance days during wet weather
- All responsible jurisdictions and agencies within a sub-watershed are jointly responsible for complying with the WLA at the receiving shoreline monitoring location

Criteria for Determining Allowable Wet-Weather Exceedance Days

The Role of the Reference System and Anti-degradation

- Select smaller of two criteria based on historical data (1995-2000):
  - Wet-weather exceedance probability of the reference system
  - Wet-weather exceedance probability at a particular beach monitoring site

Method for Setting Allowable Wet-Weather Exceedance Days



Critical Condition

- Wet Weather
  - Historical shoreline monitoring data and SCB survey show a higher level of exceedance during wet weather
- Selected 90th percentile storm year based on wet days as critical/reference year
  - 1993 had 75 wet days

Wet-Weather Results for Leo Carrillo Beach Reference System

- Historical shoreline data for Leo Carrillo Beach
  - 22% wet weather samples exceeded standards
  - Also express as 0.22 probability of exceedance, given a wet day
  - Translates to 17 allowable exceedance days (0.22 x 75 wet days in "reference year" of 1993)*

Sample of Wet-Weather Waste Load Allocations by Beach

Beach	Wet Weather Exceedance Probability		Wet Days in Reference Year		Allowable Wet Weather Exceedance Days
Leo Carrillo Beach (reference site)	0.22	x	75	=	17
[illegible] Beach	[illegible]	x	75	=	[illegible]
Santa Monica Canyon	0.23	x	75	=	17
Santa Monica Pier	[illegible]	x	75	=	[illegible]
Manhattan Beach Pier	[illegible]	x	75	=	[illegible]
[illegible]	[illegible]	x	75	=	[illegible]

Schedule based on Implementation Approach

- Two broad approaches
  - Integrated Water Resources (IWR) Approach
  - Single-purpose Approach
- Schedules tailored to approach
  - As short as possible given public health risks
    - No more than 18 years for IWR Approach
    - No more than 10 years for Single-purpose Approach

What is an IWR Approach?

One that:

- Integrates planning for future wastewater, storm water, recycled water, and potable water needs
- Focuses on beneficially re-using or infiltrating storm water at multiple points throughout a watershed
- Addresses multiple pollutants
- Realizes water quality and other public goals
  - e.g. water supply, recreational opportunities, and open space

Why different schedules?

- To realize multiple benefits, IWR Approach requires more complicated planning & implementation, such as
  - identifying and designing viable integrated projects;
  - designing for multiple pollutants;
  - siting transmission infrastructure, storage and recharge areas at multiple points in a watershed;
  - identifying markets for reclaimed stormwater; etc.

Monitoring Program Objectives

- Re-evaluate possible reference system approaches, including the site(s) and years used
- Re-evaluate allowable exceedance days based on anti-degradation criterion and final compliance point (wave wash)
- Re-evaluate potential implementation scenarios based on refined source characterization
- Assess compliance with interim and final allowable exceedance days

Refinements to Wet-Weather Allowable Exceedance Days

- Revise TMDL 4 years after effective date to re-evaluate wet weather allowable exceedance days
  - Re-evaluate selection of reference system
  - Re-evaluate selection of reference year
  - Collect daily shoreline monitoring data from wave wash rather than 50 yards away

Summary

- Wet Weather Only
- Significant water quality & public health issue
- ~ 40% reduction in wet-weather exceedance days *Bay-wide*
- Increased protection for 7.3 million visitors to beaches during winter wet season
- Money well spent, considering magnitude of direct spending by visitors & importance of beaches to the local economy

Questions and Answers

No questions.

Delisting of Recreational Beaches on the 303(d) List for Exceedances of Bacterial Water Quality Standards

Lisa Kay
MEC-Weston Solutions, Inc.

Biosketch

Ms. Lisa Kay has over 19 years of experience in water quality assessments relating to the Clean Water Act, primarily involving project development, study design, project management, and quality assurance oversight. She assists her municipal clients in NPDES compliance; TMDL studies, watershed management planning, and the development of grant funded projects. She co-designed the NPDES storm water-monitoring program for the 22 municipal copermittees in San Diego County. She has been managing the implementation of this urban runoff program since the year 2000. Ms. Kay is the Water Resources Practice Leader for MEC-Weston Solutions, Inc.

Abstract

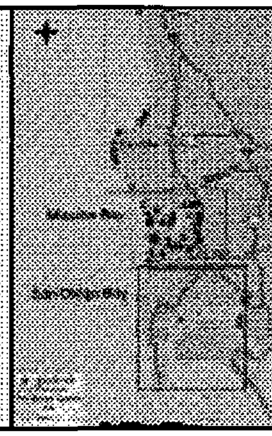
In southern California, there are numerous shoreline water quality monitoring sites located along coastal beaches, bays, and harbors that are monitored for bacterial indicators (total coliform, fecal coliform, and enterococcus). Due to exceedances of bacterial indicator standards, many of these sites are listed as impaired on the California State Water Resources Control Board (SWRCB) 303(d) List. In December 2003, the SWRCB developed draft guidance criteria for removing sites from the 303(d) List (a process known as delisting). The primary consideration for removal of a water segment from the 303(d) List is an exceedance frequency of water quality standards of less than 10% of the analyses conducted (with at least 90% confidence). In this assessment, five years of bacterial data from all of the beach sites within the City of San Diego that are listed on the 2002 303(d) List were reviewed and compared to the draft guidance criteria. A total of 62 sites are identified on the List, including 45 that are located in Mission Bay, which is listed in its entirety. Of the 17 sites listed outside of Mission Bay, 11 were recommended for delisting. Within Mission Bay, nearly half the sites monitored were recommended for delisting. The SWRCB delisting guidance provides a meaningful, statistically based process for removal of sites from the 303(d) List. The results of the assessment using the process suggest that many of the sites that are currently on the 303(d) List within the City of San Diego should be considered for delisting.

MEC

Delisting of Recreational Beaches on the 303(d) List for Exceedances of Bacterial Water Quality Standards

Lisa Marie Kay,
Stephen Gruber,
Susan D. Watts

City of San Diego Beaches



Project Objective

- Compile and summarize the available bacterial data of all the shoreline sites monitored in the City of San Diego,
- Assess the data at sites on the 2002 303(d) List, and
- Identify those sites to be considered for removal (delisting) from the 303(d) List

Draft 303(d) Delisting Criteria

CA State Water Resources Control Board

- *SWRCB's Draft Functional Equivalent Document (December 2003).*
- Removal criteria: exceedance of water quality standards of less than 10% of the analyses.
- The AB411 single sample limits were used in this document to determine the number of exceedances for a given sample size.

Applicable Water Quality Standards

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Information Assessed

- Five years of data were assessed: from January 1999 through October 2003.
- Data were compiled from raw data for all shoreline sites within the City of San Diego.
- Weekly monitoring by City of San Diego or the County Department of Environmental Health (DEH).
- Samples were analyzed for three bacterial indicators: total coliform, fecal coliform, and Enterococcus.

Draft Guidance

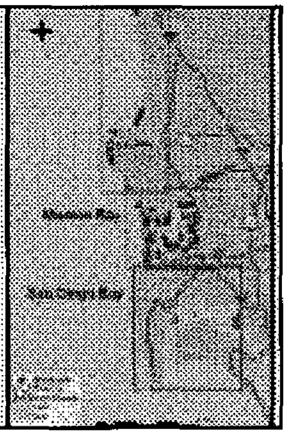
For numeric water quality objectives for bacteria in water, SWRCB (2003) states that the primary consideration for removal of a water segment from the 303(d) List shall be the following criteria:

"Numeric water quality objectives or standards for bacteria are exceeded in fewer than 10 percent of the samples with a confidence level of 90 percent using a binomial distribution."

September 2004 Final Guidance

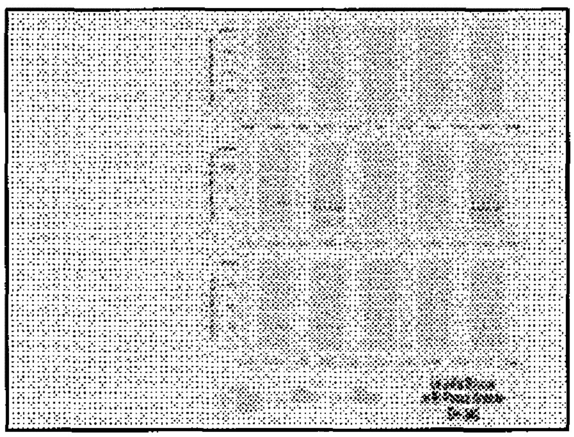
- Uses bionomial distribution with <10% exceedance (n=26)
- Also applies site specific exceedance frequency IF used to place beach on list
- Proposes use of reference beach approach for comparison

City of San Diego Beaches

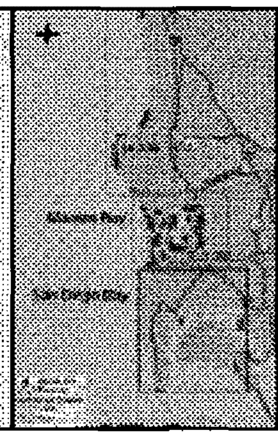


Data Representation

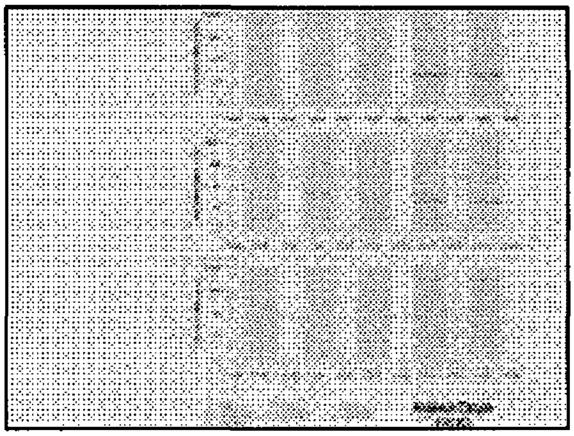
- Total number of analyses for all three indicators
- (No) = number that did not exceed criteria
- (Yes) = number that did exceed criteria
- (allowable) = The number allowed by SWRCB
- (percent) = percentage exceedances relative to the total number of analyses



City of San Diego Beaches



Anderson Canyon

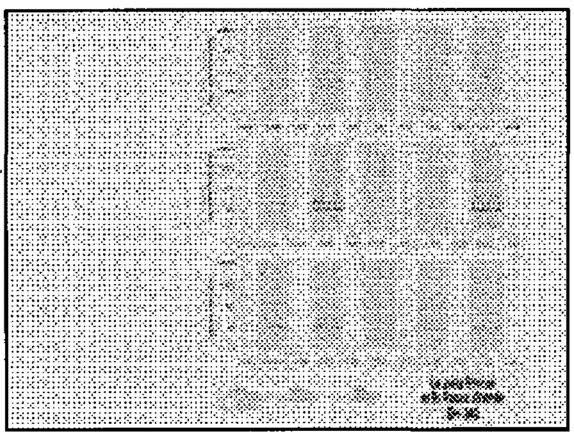


La Jolla Shores at Paseo Grande

he number of exceedances of water quality standards at this site are presented in Table 5. A total of 366 analyses were performed from 1999 through 2003. Of these, there were only six exceedances of the bacterial standards for all three indicators: one for total coliform, three for fecal coliform, and two for Enterococcus (Figure 9). Six exceedances out of 366 analyses is well below the number of exceedances allowed by the SWRCB guidance document (28). These data suggest that the El Paseo Grande site should be considered for de-listing from the 303(d) List.

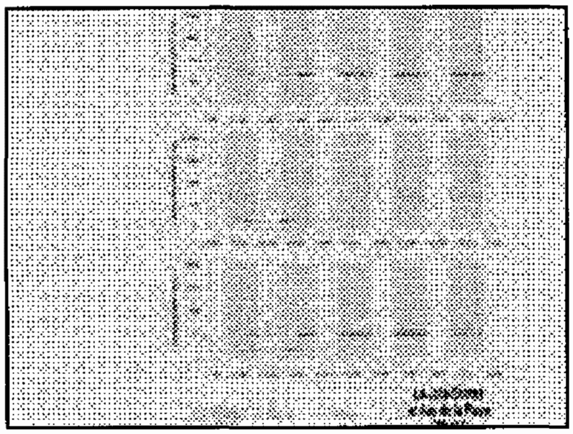
La Jolla Shores at Paseo Grande

Seven stations were monitored at the El Paseo Grande site during this time; the majority were taken at the sampling site and 75 ft to the left and right.



La Jolla Shores at Avenue De La Playa

Fourteen stations were monitored at La Jolla Shores at Avenue De La Playa during this time: one at the sampling site ([illegible]), six as far as 150 feet to the left, and seven as far as 150 feet to the right of the site.



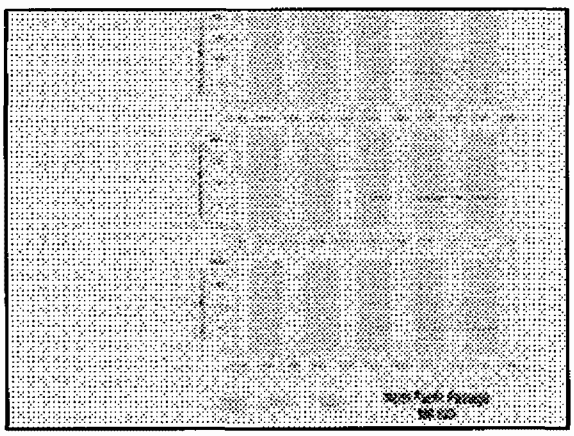
Mission Bay

- 4,235 acres
- 27 miles of shoreline
- 303(d) listed for bacteria
- 45 monitoring locations
- Intensely monitored

North Pacific Passage (MB-042)

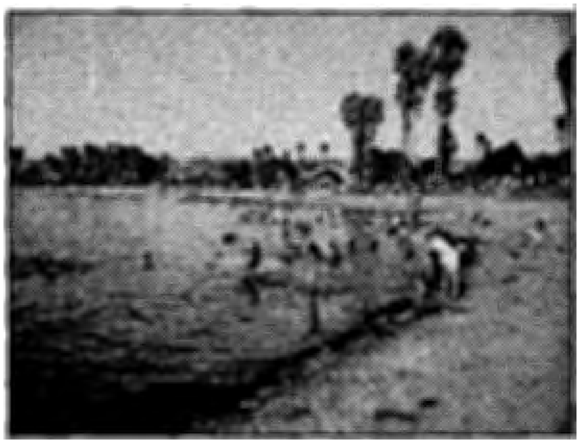
This site is located on the east side of Mission Bay, directly in front of the Hilton Hotel.

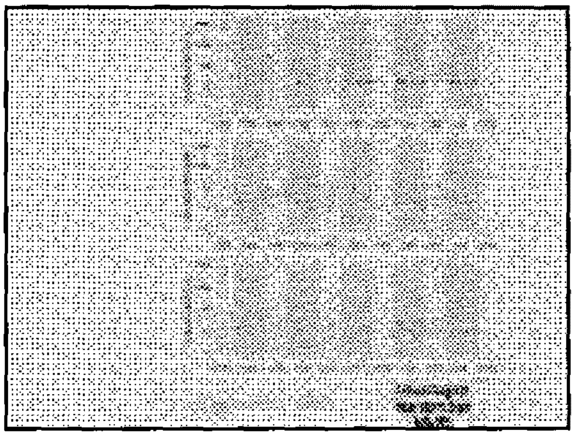
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

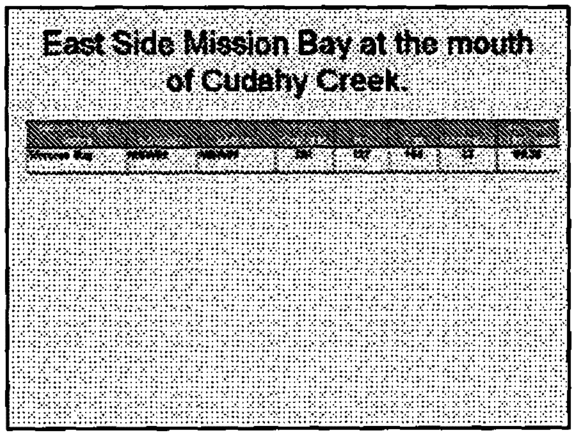


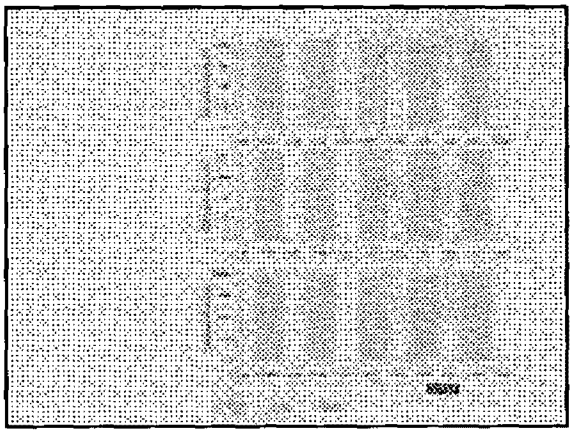
Leisure Lagoon Near Storm Drain

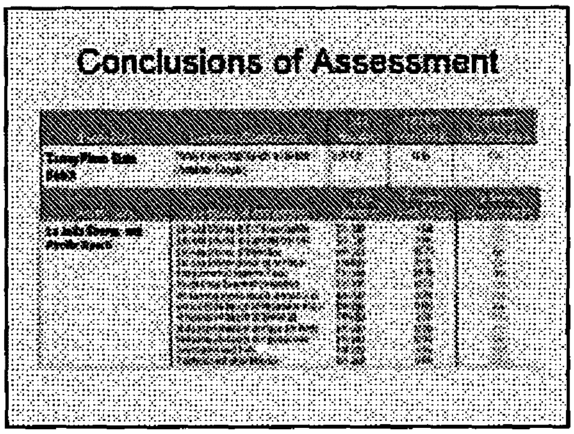
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

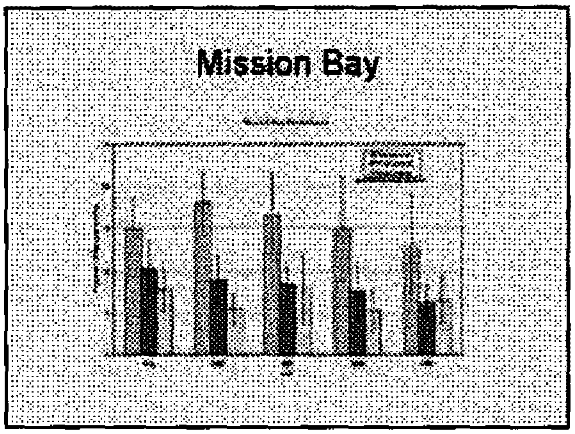


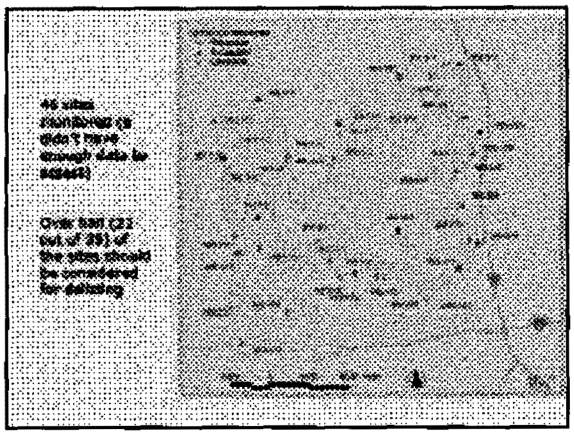


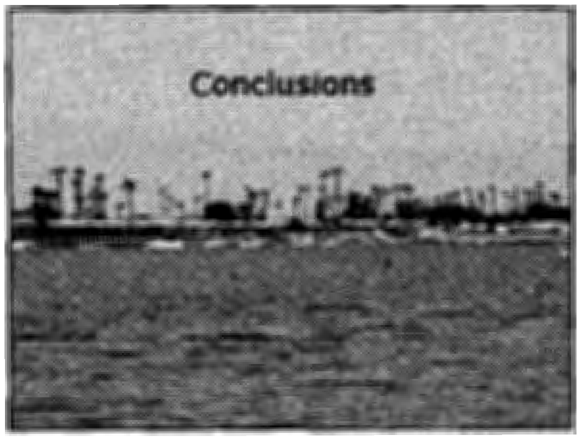

East Side Mission Bay at the mouth
of Cudahy Creek.




Conclusions of Assessment


Mission Bay


Over half (21 out of 39) of the sites should be considered for delisting


Conclusions

Questions and Answers

Q: For both Leisure Lagoon and one of the other sites, it looked like you showed a number of sampling locations within each site. For Leisure Lagoon, for instance, one of the sampling locations had a high number of exceedances of the standard. Have you gone into further analysis of what that means and how to deal with that? How do you justify taking it off the list if you've got ongoing exceedances for specific locations?

Lisa Kay

Basically, it depends on how far away from each other those locations are. That is a policy decision. At this point we are just presenting the information. But, I would like to add that there was a completely different study that looked at sources of bacteria and remediated those sources, and in many instances, sources of bacteria have been remediated or removed in a lot of Mission Bay, and there are ongoing projects to continue that effort.

Q: It does look to be pretty site-specific. When you still have a strong source coming in, and if that data are still accurate, then you probably wouldn't want to delist it.

Lisa Kay

Yes, then you probably would not want to remove it.

"The Hunt for Red *E. coli*" – Bacteria Source Tracking in Lake Darling Watershed

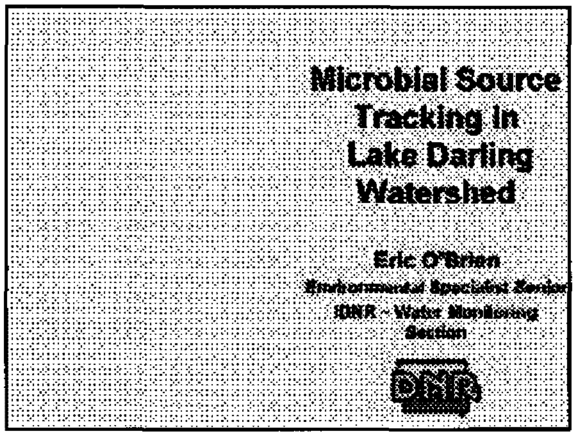
Eric O'Brien
Iowa Department of Natural Resources, Water Monitoring Section

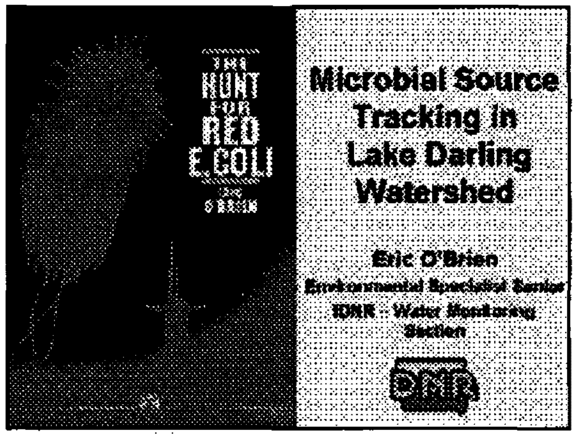
Biosketch

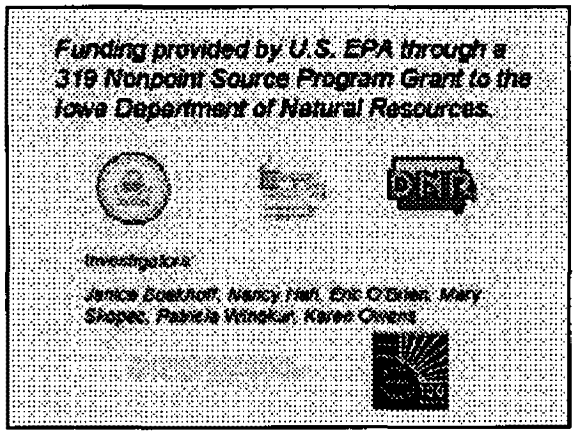
Mr. Eric O'Brien is an environmental microbiologist for the Iowa Department of Natural Resources and University of Iowa. Mr. O'Brien completed his master's research in Environmental Science at the University of Northern Iowa in May 2003. His primary interest of focus is environmental microbiology, specifically focusing on bacterial source tracking. Before joining the Iowa Department of Natural Resources Water Monitoring Section, Mr. O'Brien also helped coordinate undergraduate water research activities at the University of Northern Iowa. These interests led him to work for the Water Monitoring Section of the Iowa Department of Natural Resources in June 2003. Mr. O'Brien directs most of his efforts toward the ongoing bacterial monitoring of Iowa's State and County owned beaches as well as tracking of bacterial sources at these beaches.

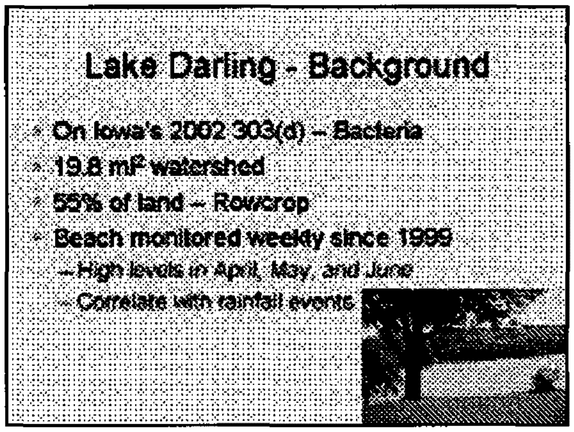
Abstract

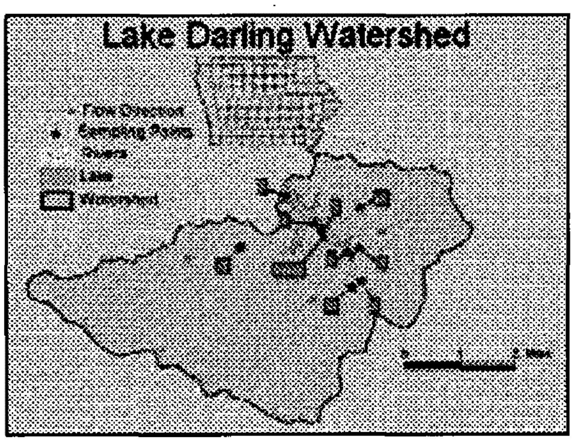
Contamination of Iowa's surface water by fecal microorganisms threatens human health and results in beach postings that have substantial economic impacts to local communities. The typically high nutrient levels and turbidity in most Iowa surface waters compounds this problem. Lake Darling, located in southeast Iowa, has been placed on Iowa's 2002 303(d) list, the list of impaired water bodies, for high levels of indicator bacteria. A Total Maximum Daily Load (TMDL) plan will need to be created for this watershed in the future. Therefore, the state has a vested interest in determining the source of bacteria at the beach and in the lake. The Lake Darling watershed consists of 19.8 square miles, much of which is agricultural (55%). To understand and control fecal contamination problems and to assess human health risks, it is necessary to identify contamination sources and transport pathways. This study used a combination of several source-tracking tools to determine the origin of fecal contamination in Lake Darling and the surrounding watershed. These source-tracking tools included DNA ribotyping, antibiotic resistance analysis (ARA), pathogens analysis and sterols/caffeine/cotinine analysis. By using the libraries created from ribotyping and ARA together, increased discriminatory power was observed compared to each library individually. Additionally, analysis noted pathogens to be present in all tributaries entering Lake Darling during various flow regimes, including low flow conditions, throughout the study. Data from this project have provided insight into areas to target implementation of best management practices to eliminate or control these sources.

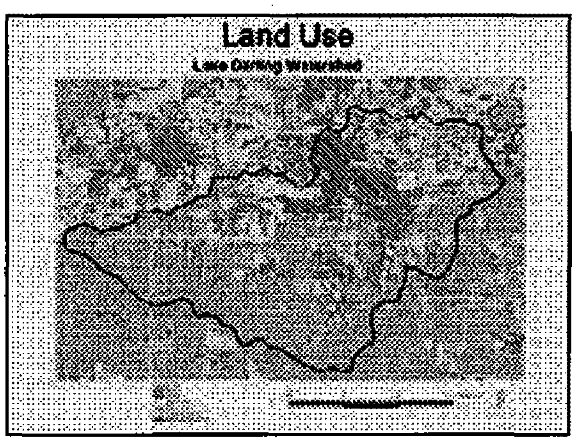

Microbial Source Tracking in Lake Darling Watershed
Eric O'Brien
Environmental Specialist Senior
IDNR - Water Monitoring Section
DNR


HUNT
RED
E.COLI
Microbial Source Tracking in Lake Darling Watershed
Eric O'Brien
Environmental Specialist Senior
IDNR - Water Monitoring Section
DNR


Funding provided by U.S. EPA through a 319 Nonpoint Source Program Grant to the Iowa Department of Natural Resources.
DNR
Investigators
Janice Boekhoff, Nancy Hall, Eric O'Brien, Mary Skopec, Patricia Winokur, Karen Owens


Lake Darling - Background
On Iowa's 2002 303(d) – Bacteria
19.8 mi² watershed
55% of land – Rowcrop
Beach monitored weekly since 1999
– High levels in April, May, and June
– Correlate with rainfall events


Lake Darling Watershed
Flow Direction
Sampling Points
Lake
Watershed


Land Use
Lake Darling Watershed

Source Tracking Methods

- DNA Ribotyping
- Antibiotic resistance analysis
- Fecal coliform & *E. coli* bacteria levels
- Pathogens analysis
- Caffeine and cotinine analysis

Source Tracking Sampling Events

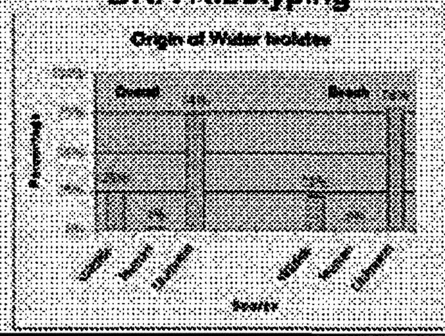
Sampling Date	Flow Regime	Rainfall previous 24 hrs (in.)	Season
[illegible]	Mid flow	[illegible]	Summer [illegible]
[illegible]	Mid flow	[illegible]	Summer [illegible]
[illegible]	Low flow	[illegible]	Fall [illegible]
[illegible]	Low flow	[illegible]	Fall [illegible]
[illegible]	Low flow	[illegible]	Fall [illegible]
[illegible]	Low flow	[illegible]	Fall [illegible]
[illegible]	High flow	[illegible]	Spring [illegible]
[illegible]	High flow	[illegible]	Spring [illegible]
[illegible]	High flow	[illegible]	Spring [illegible]

Fecal Samples

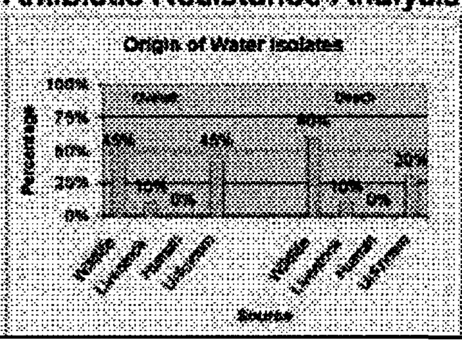
Fecal samples were collected from 5 host classes:

- Cattle
- Swine
- Human
- Goose
- Deer

Results
DNA Ribotyping



Results
Antibiotic Resistance Analysis

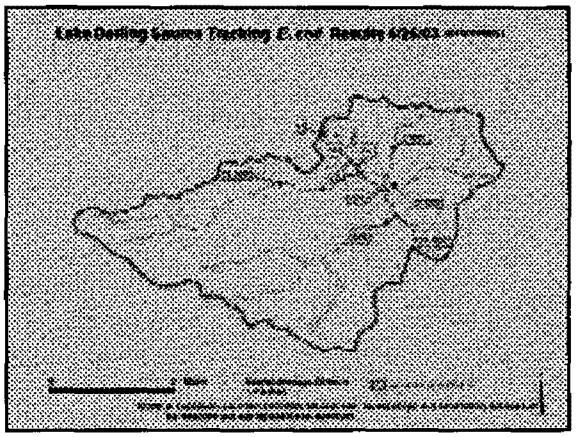


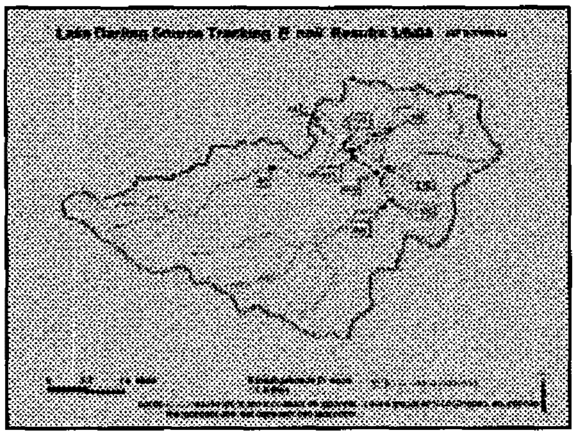
Results

- More unknown sources than known sources suggest the isolate library was either not large enough or not representative of the sources in the watershed
- Future studies are increasing the size of isolate database (especially cattle and swine groups)

Results
Patterns of High Bacteria Levels

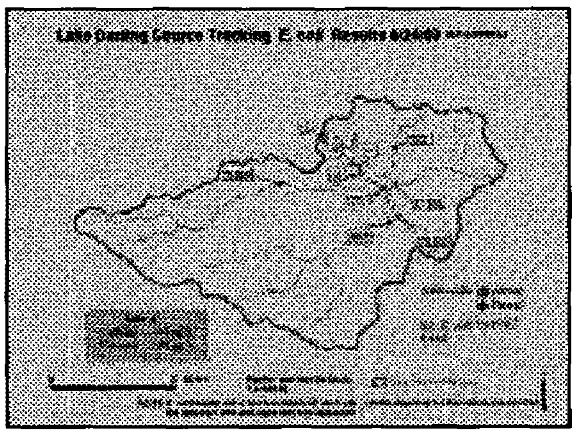
- Higher levels of bacteria were seen after rainfall events
- Sites 7,8, and 12 (tributaries on south/southeast side of lake) exceeded the bacterial standard 7 of the 9 sampling events
- Lake sites were shown to be high after spring rainfall event on 3/5/04

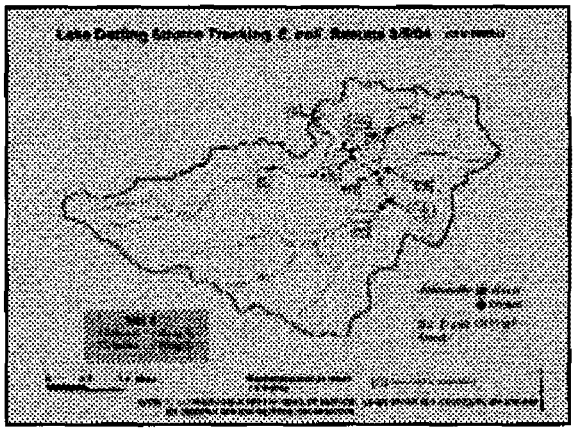




Results
Pathogens

- Found *Salmonella* in all tributary sites, at the beach and in all of the lake sites except site 5 (near dam)
- *Salmonella* species could not be identified to a particular animal/human group
- *Salmonella* species did not correlate with bacteria levels
- No *E. coli* O157:H7 was found anywhere





Results
Caffeine/Cotinine

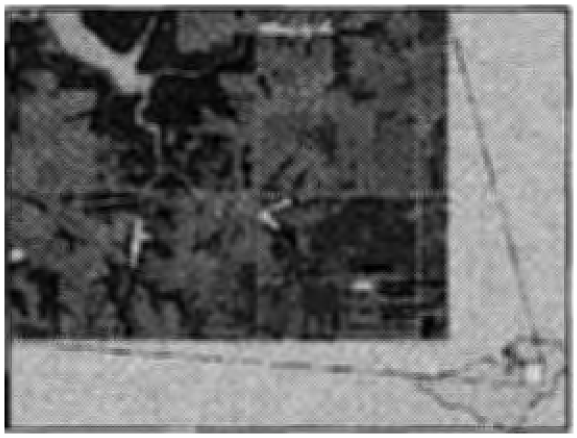
- Caffeine
  - Some caffeine found in site 5 (near dam), but it was just over the detection limit
- Cotinine
  - No cotinine was found in any site
- Caffeine/cotinine results from this project does not indicate human sources

Summary

- Ribotyping, antibiotic resistance and the patterns of high *E. coli* levels in the watershed suggest the sources of fecal contamination are primarily animals present throughout the watershed
- Large number of isolates classified as unknown suggest the library needs more isolates from groups that were not well represented (cattle and swine)
- Caffeine/cotinine results do not indicate the presence of significant amounts of human sources

Outcomes

- Major efforts to control sedimentation
  - Bacteria levels in sediment are very high
  - 9% of land in watershed had sediment control put in during 2004



Outcomes

- Beach exceedances at vulnerable beaches during 2003-2004
  - Statewide rose from 4.5 to 9.5
  - Lake Darling dropped from 5 to 4
    - One of 3 beaches in state to drop

Acknowledgements

- Tony Maxwell and Stan Simmons of the NRCS have collected water and fecal samples and organized the nonpoint source project in the area
- Don Kline and Vance Poulton for assistance in sample collection and use of their boat
- Jeff Hildebrand and Merrill Lucas for their interest, willingness to help and the use of their boat
- Jim Sievers and Paul Brandt for their help with inspecting the sewage lagoons in the area
- The University Hygienic Laboratory (UHL) performed all analyses and reported all results. Mike Schueller and John Miller coordinated the weekly beach sampling and Nancy Hall of UHL provided coordination and expertise in interpretation of the results.

Questions and Answers

No questions.

San Diego Creek Watershed Natural Treatment System

Norris Brandt
Irvine Ranch Water District

Biosketch

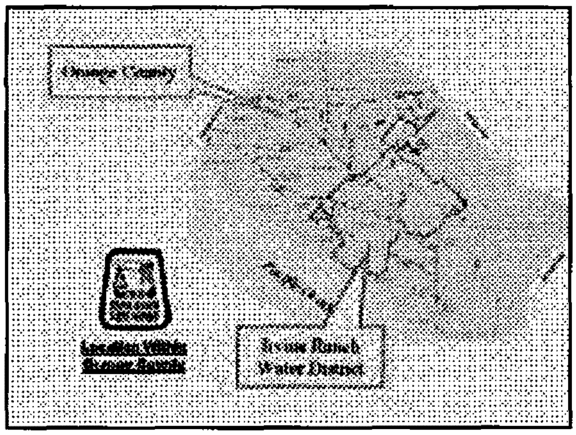
(Not submitted)

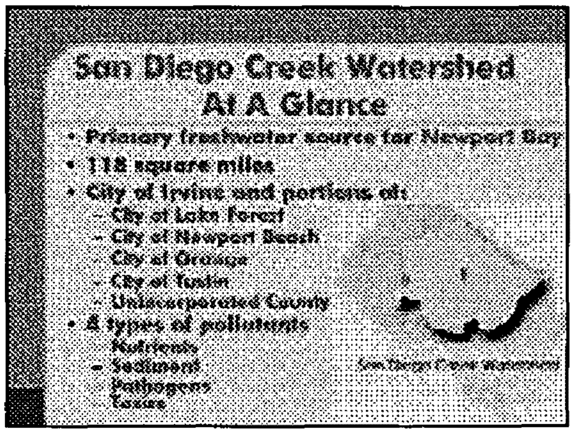
Abstract

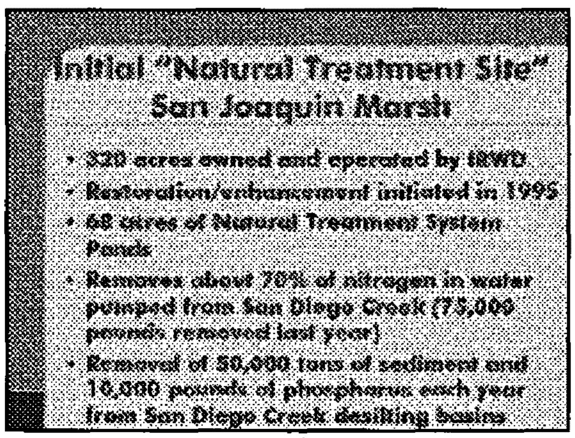
(Not submitted)

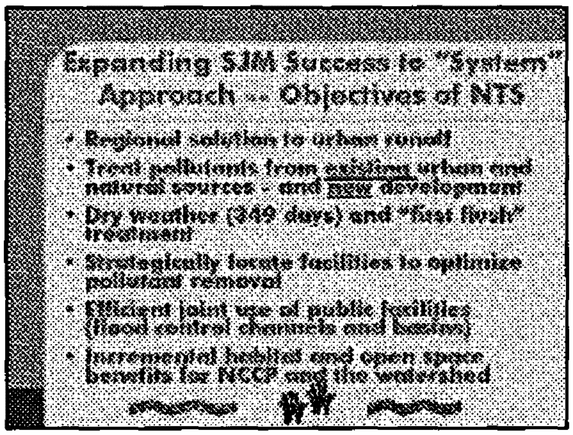

Irvine Ranch Water District
San Diego Creek Natural Treatment System

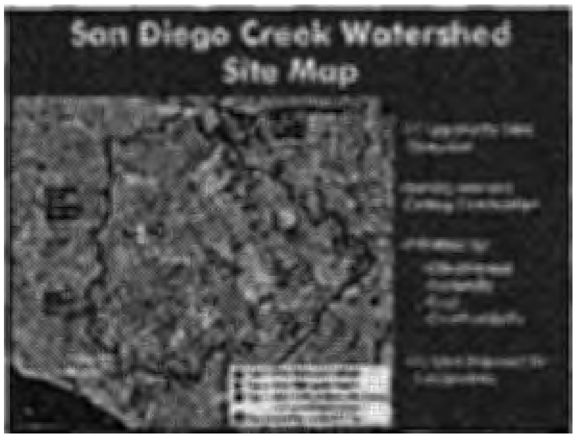

Irvine Ranch Water District
At A Glance
Sewage Collection and
Treatment

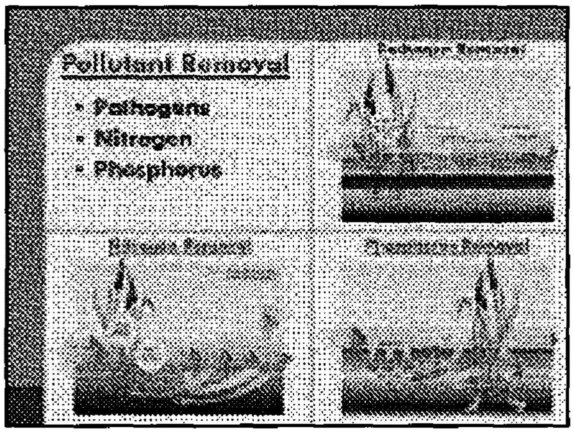

Orange County
Irvine Ranch
Water District

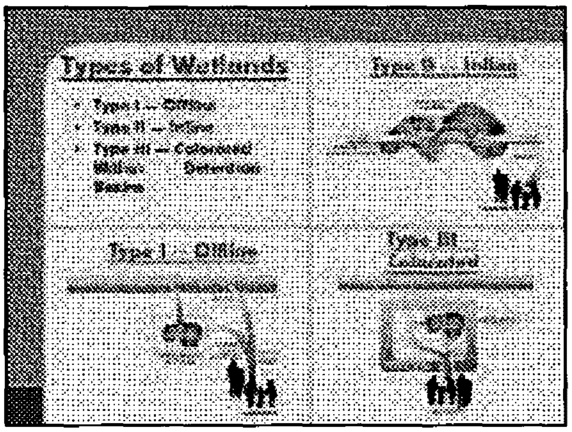

San Diego Creek Watershed
At A Glance
• Primary freshwater source for Newport Bay
• 118 square miles
• City of Irvine and portions of:
– City of Lake Forest
– City of Newport Beach
– City of Orange
– City of Tustin
– Unincorporated County
• 4 types of pollutants
Nutrients
– Sediment
Pathogens
Toxics

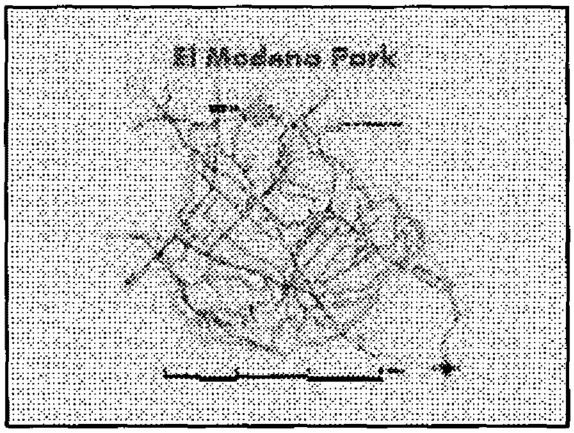

Initial "Natural Treatment Site"
San Joaquin Marsh
• 320 acres owned and operated by IRWD
• Restoration/enhancement initiated in 1995
• 68 acres of Natural Treatment System Ponds
• Removes about 70% of nitrogen in water pumped from San Diego Creek (75,000 pounds removed last year)
• Removal of 50,000 tons of sediment and 10,000 pounds of phosphorus each year from San Diego Creek desilting basins

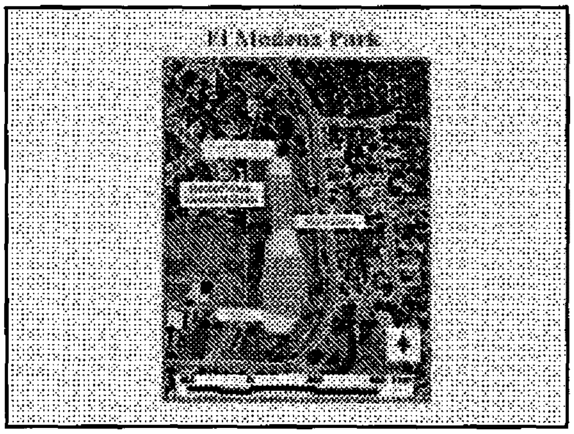

Expanding SJM Success to "System" Approach -- Objectives of NTS
• Regional solution to urban runoff
• Treat pollutants from existing urban and natural sources - and new development
• Dry weather (349 days) and "first flush" treatment
• Strategically locate facilities to optimize pollutant removal
• Efficient joint use of public facilities (flood control channels and basins)
• Incremental habitat and open space benefits for NCCP and the watershed


San Diego Creek Watershed
Site Map

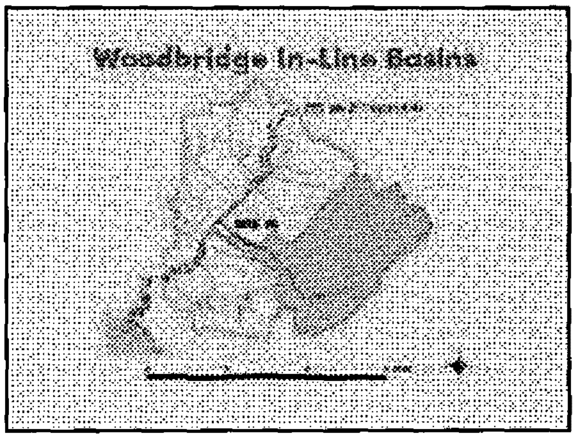

Pollutant Removal
• Pathogens
• Nitrogen
• Phosphorus

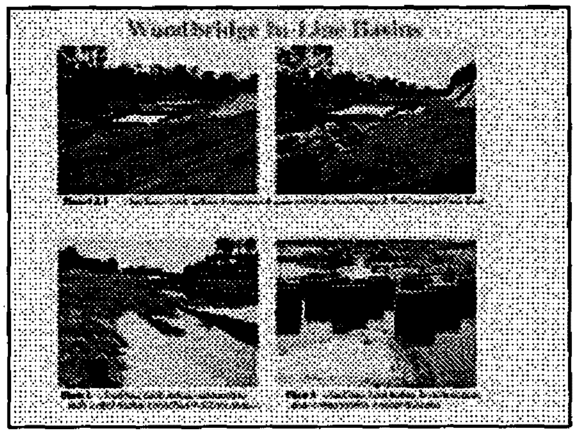

Types of Wetlands
Type I -- Offline

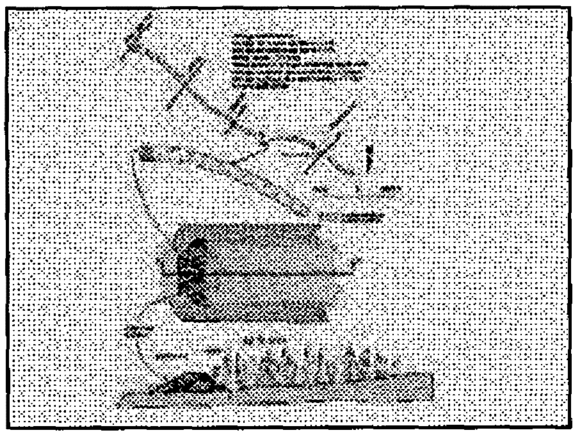

El Modena Park

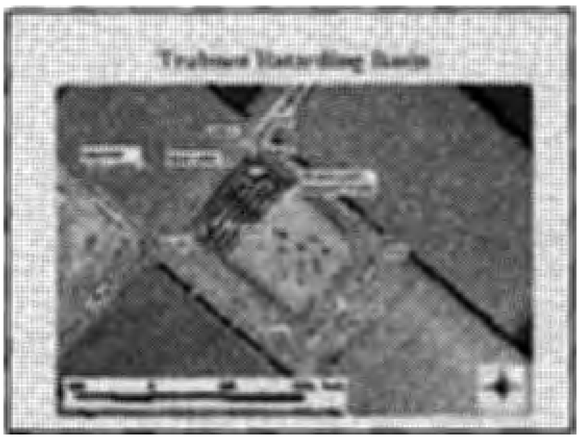

El Modena Park


El Modena Park

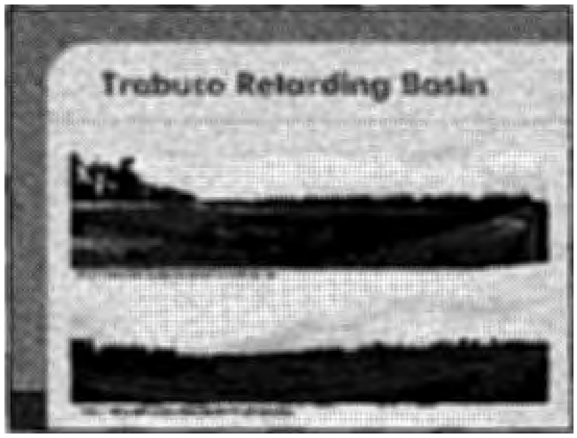

Woodbridge In-Line Basins

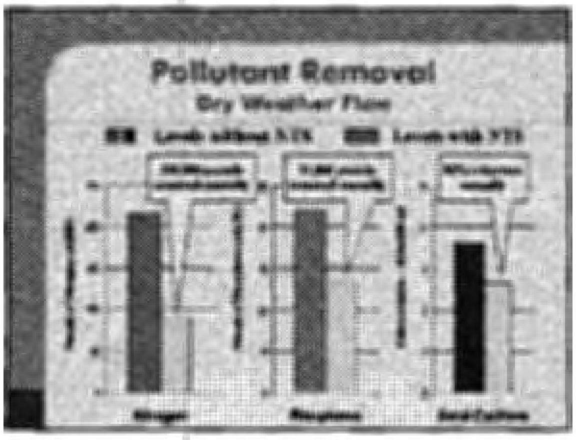

Woodbridge In-Line Basins

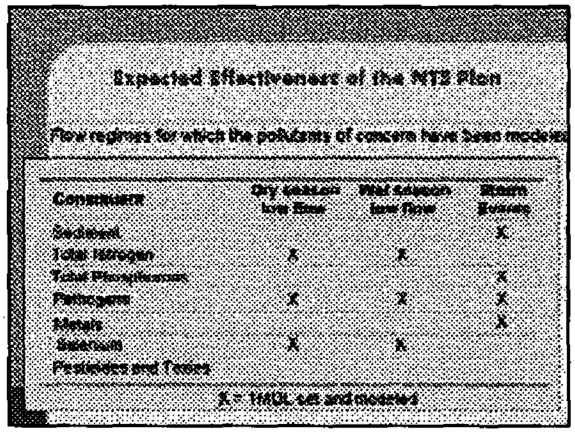


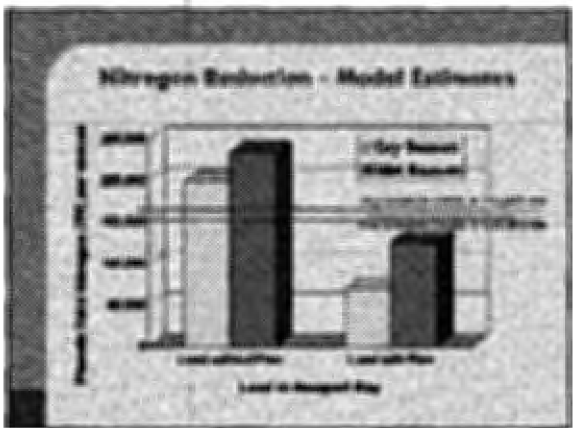


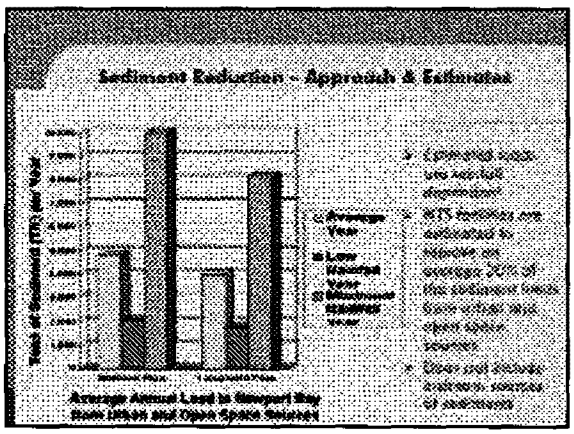

Trabuco Retarding Basin

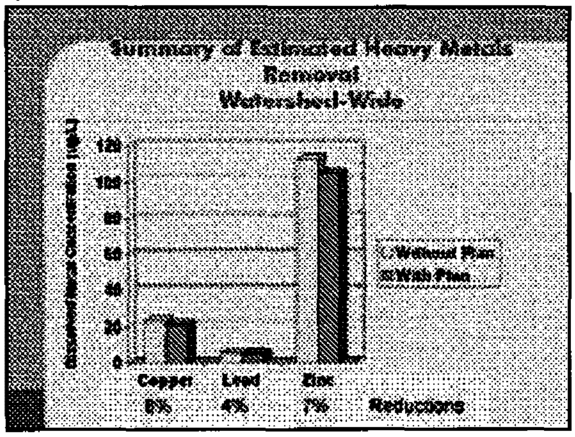

Trabuco Retarding Basin

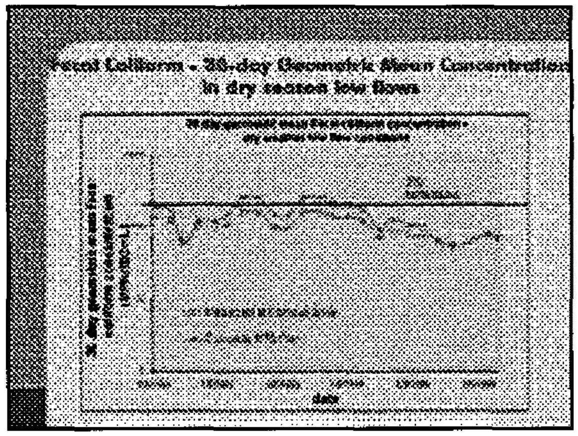

Pollutant Removal
Dry Weather Flow

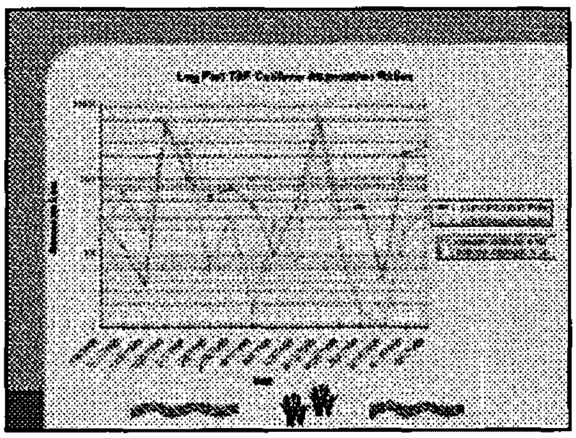

Expected Effectiveness of the NTS Plan
Flow regimes for which the pollutants of concern have been modeled
Constituents
Dry season low flow
Wet season low flow
Storm Events
Sediment
Total Nitrogen
Total Phosphorus
Pathogens
Metals
Selenium
Pesticides and Toxics
X = TMDL set and modeled

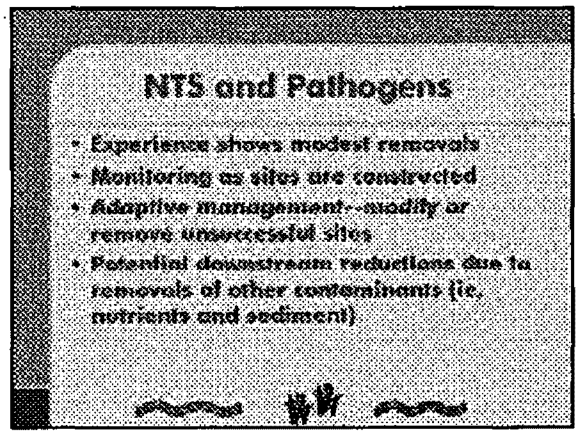

Nitrogen Reduction - Model Estimates

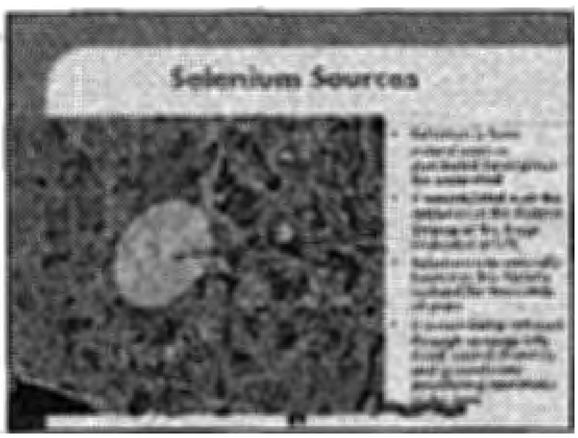

Sediment Reduction - Approach & Estimates

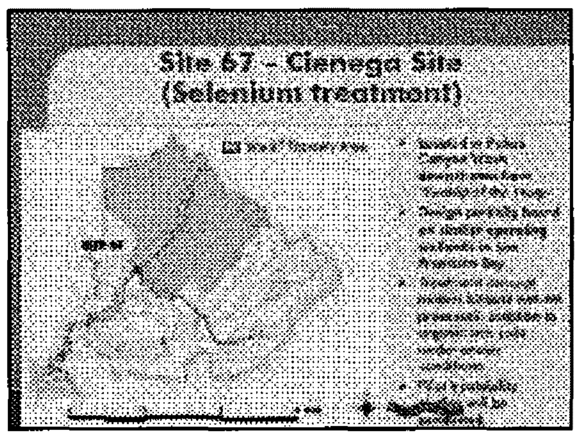

Summary of Estimated Heavy Metals
Removal
Watershed-Wide
120
100
80
60
40
20
0
Without Plan
With Plan
Copper
Lead
Zinc
6%
4%
7%
Reductions


Fecal Coliform - 30-day Geometric Mean Concentration
in dry season low flows

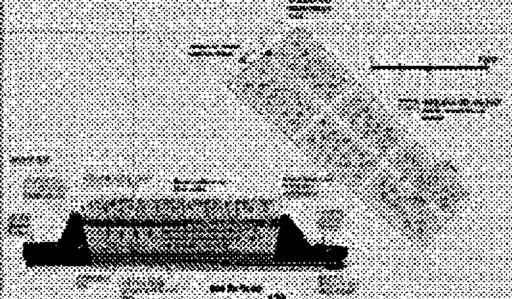



NTS and Pathogens
• Experience shows modest removals
• Monitoring as sites are constructed
• Adaptive management--modify or remove unsuccessful sites
• Potential downstream reductions due to removals of other contaminants (ie, nutrients and sediment)


Selenium Sources


Site 67 - Cienega Site
(Selenium treatment)

Selenium Treatment Concept



Ultimate NTS Buildout Costs

- Construction $41 million
- Annual Operation and Maintenance $2 to $3 million

*Costs will be incrementally incurred as facilities are constructed.

Buildout Cost Recovery Model

- Construction Costs
  - Developer-donated facilities 55%
  - State/federal grants 35%
  - IRWD bond financing 10%
- Operation and Maintenance Costs
  - IRWD water bills 100%

Schedule

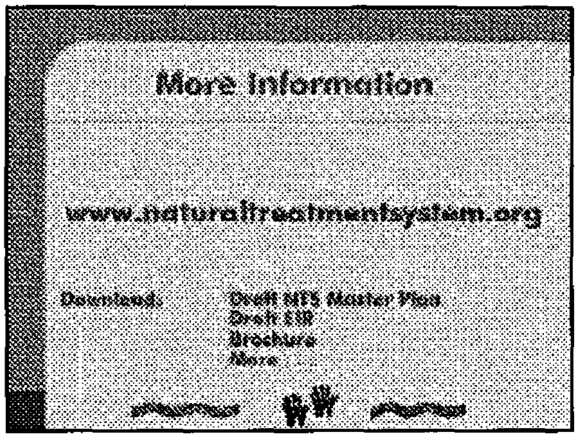
- Master Planning Spring 2001 - Spring 2004
- Environmental Review Fall 2003 - Spring 2004
- Phase I Design Fall 2004
- Phase I Construction February 2005 - July 2005

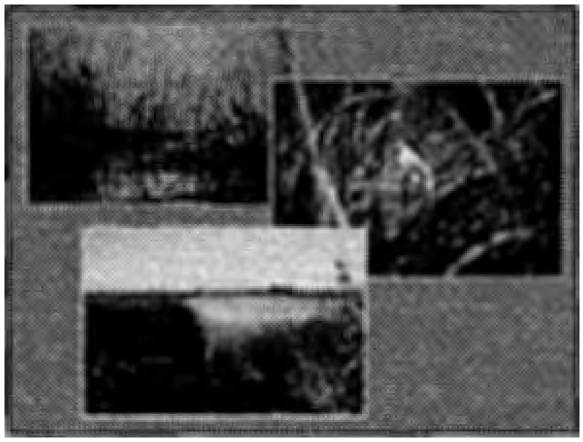
Hot Topics

- O&M Versus Habitat Preservation
- Waters of the US
- Bioaccumulation of Toxics
- Mosquito Control
- Regulatory Framework (TMDLs, MS4, NPDES, Waters of US, Endangered Species)

Cooperative Effort

- County of Orange
- Watershed Cities -- Irvine, Lake Forest, Newport Beach, Orange, Tustin
- IRWD
- Landowners
- State Water Resources Control Board
- Regional Water Quality Control Board
- CDFG, USFWS, Corps, EPA, USBR
- Coastal Conservancy
- Environmental Groups
- Residents


More Information
www.naturaltreatmentsystem.org
Download:
Draft NTS Master Plan
Draft EIR
Brochure
More



Questions and Answers

Q: Do the subterranean filters that you were talking about do a better job at removing bacteria?

Norris Brandt

No, it's actually really focused on nutrients (nitrogen, specifically) and selenium. I don't know how well it removes bacteria. We didn't really look at pathogens, because we were so focused on the other contaminants. But it would be interesting to check to see if that does occur.

Q: During storms, do those structures get destroyed? I understand that you're in a flood-control structure, so how do you deal with storms and the wet weather?

Norris Brandt

We expect the small rock weirs to be blown out. It's a small volume of coarse sediment that's going to be in the channel. But those are the only ones that are going to be destroyed during that period. Remember, we had the detention basins, and for those, the water rises but it does not flow at a high velocity. So, it rises but does not kill anything, and then it drops back down within about 72 hours at the most.

Q: So, there should be some build-up in the sediments. Do you remove those sediments prior?

Norris Brandt

Yes, there is a whole program that is part of our operation and maintenance (O&M) for that, testing the sediments and making sure we know where we can get rid of them. We are already using some of those sediments for construction materials because it is safe to do so.

Thursday, October 14

1:20 p.m. – 3:00 p.m.

Concurrent Track I:

Identifying and Solving Beach Water Quality Problems

Session Seven: Remediation Approaches

California's Clean Beach Initiative

Mark Gold, D.Env.
Heal the Bay

Biosketch

Mark Gold, D.Env., is Heal the Bay's Executive Director. Heal the Bay is an environmental group dedicated to making Santa Monica Bay and Southern California coastal waters safe and healthy for people and marine life. Dr. Gold's extensive work with water quality and coastal natural resource topics ranges from sewage treatment, contaminated sediments, legislative and environmental education issues to urban runoff, contaminated fish and wetland restorations. In 1996, working in conjunction with the Santa Monica Bay Restoration Project and the USC Medical Center, he was a co-author of the first epidemiological study of swimmers in runoff-polluted water. He also has co-authored several stormwater, contaminated fish and beach water quality bills and ordinances, and he created Heal the Bay's Beach Report Card®. He is a vice-chair of the Santa Monica Bay Restoration Commission, sits on the State Water Board's Clean Beach Advisory Group and served on the EPA's Urban Wet Weather Federal Advisory Committee. Dr. Gold also was appointed to the California Ocean Trust. Dr. Gold has bachelor's and master's degrees in biology from UCLA, and he received his doctorate from UCLA in environmental science and engineering in 1994.

Abstract

The Clean Beach Initiative was authored by Assemblywoman Fran Pavley, working together with Heal the Bay, in response to California Assembly Bill 411, the state's beach bathing water standards bill. AB 411 requires monitoring of California's most frequently visited beaches. The resulting monitoring demonstrated that there were numerous beaches with frequently high fecal indicator bacteria densities. Reducing bacteria densities, beach closures, and health warnings at California's most polluted beaches became a high priority for funding. This innovative initiative allocates $80 million to clean up the state's most polluted beaches and to fund rapid indicator research. The major successes have been with simpler projects, such as the nearly 20 dry weather diversions from storm drains into sewers that are now in place. Other funds have been allocated for dry weather runoff mini-treatment plants, such as the one at Moonlight Beach in Encinitas. However the challenges of source identification and abatement have proven too difficult a task at some beaches and water quality problems at many of these locations remain unsolved. Reducing fecal bacteria densities at enclosed beaches with poor water circulation has proved to be particularly difficult. Unconventional bacteria reduction technologies such as treatment wetlands and mechanical water circulation enhancement devices are being considered for funding, but few have been implemented to date. Other regions may learn from California's experiences trying to comply with legislature-mandated project design and construction deadlines, and using a Clean Beach Advisory Group made up of health and water quality experts, to provide project approval, enhancement and monitoring recommendations to California's funding decision making body, the State Water Resources Control Board.

California's Clean Beach Initiative

Mark Gold, D. Env.

Heal the Bay

Overview of CBI

- Total of $78M dedicated to State's most polluted beaches
- Capital projects to reduce beach fecal pollution
- $1.5M for Rapid Indicator Measurement research
- First large appropriation for beaches in CA

Genesis of CBI

- California's beach standards, monitoring & public notification law (AB-411 Assemblyman Howard Wayne)
- Statewide grading system – Heal the Bay's Beach Report Card
- Political Environment:
  - Governor Wilson's Administration
  - Bipartisan support
  - Support from CA Health Departments, SD's Councilperson D. Frye

Genesis of CBI

- AB-411 data collection started in 1999
- Huntington Beach closure in 1999
- Prop. 13, March 2000 - $2 billion
  - Phase I CBI – Budget bill 2001 $32 million
- Prop. 40, March 2002 - $2.6 billion
  - Phase II CBI – Budget bill 2003 – $46 million

Key Elements of CBI

Statewide priority list of projects

- Statewide monitoring and grading assisted in prioritization
- $$'s assigned to specific beach/project
- Project Criteria
  - Demonstrated problem beach
  - Capital project
  - Reduction in Postings/Closures
  - Durability, O&M for 20 years
  - CEQA Compliance
  - Monitoring Program

Key Elements of CBI

Significant funds

- Project funding ranges from 50k to $3 million
- Typical funding:
  - Diversions – $0.5 - $1.5 million
  - Dry-weather treatment - $0.8 - $1.5 million
  - Source ID/Feasibility Study – $0.2 – $1 million

Key Elements of CBI

Technical Review Panel (CBTF)

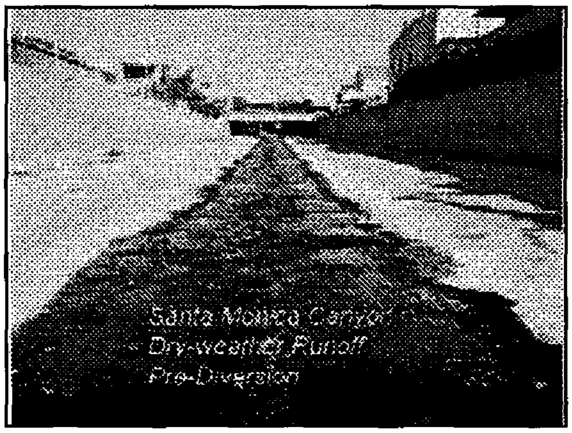
- Expert members representing the coastal beach public health community
  - Local health agencies
  - POTWs
  - Researchers
  - Environmental group water quality scientists
- All projects must be reviewed by CBTF

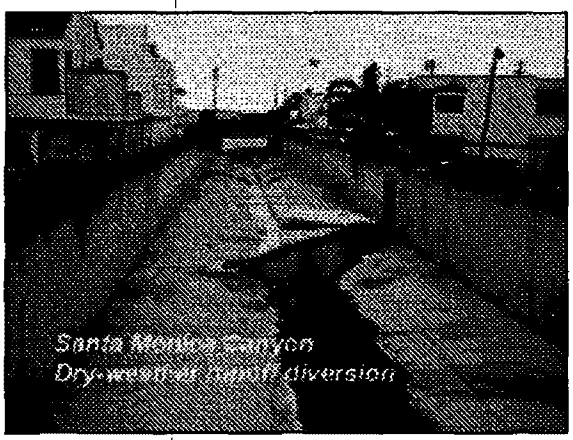
Drawbacks to CBI

- Capital projects only
  - Largely limited to beaches with known sources
  - Beaches where capital abatement projects are difficult
    - Enclosed beaches
    - Beaches receiving natural freshwater discharge
- Local sponsor must take lead role
  - Some Prop. 13 project funds were not awarded – Why?

Effective Projects

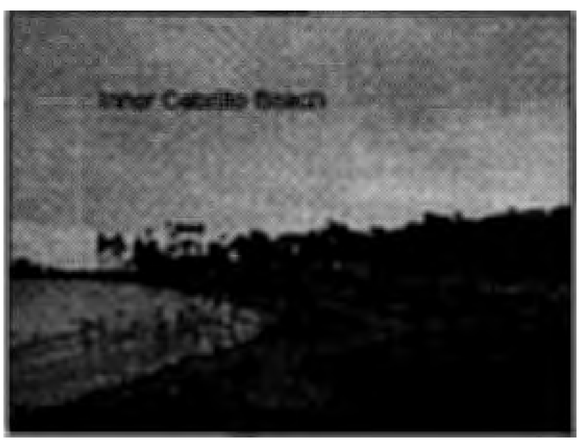
- Storm drain diversions
  - 38 dry weather diversions
- Storm drain treatment plants
  - 8 dry weather treatment plants
- Sewer upgrades
  - 10 sewer collection system projects





Problematic Projects

- Enclosed beaches
  - Unidentified sources
  - low circulation
- CEQA-related issues
- Indifferent local agencies



Conclusions

- CBI is an effective model for use nationally
  - Project criteria
  - Technical review: Project proposal to Completion
  - Monitoring: Pre and Post
- Is $78 million enough?

Questions and Answers

Q: I'm from the San Diego area, and we've had a lot of talk in the past and today about this watershed concept and how what's going on in the watershed is driving beach water quality. So, can you talk a little about some limitations of Clean Beach Initiative (CBI) projects to fund upstream inland restoration projects, as opposed to being focused on cleaning up after the fact?

Mark Gold

Yes, clean beaches projects have been focused more on end-of-pipe solutions. The reality is that if it's a small, concrete-lined channel, and there are a lot of those that are causing pollution problems at beaches, those are the ones that are more easily solved. Upstream pollution abatement projects and source identification projects cost a lot of money, and the incremental improvement for any one project doesn't quite meet the threshold that the legislature passed, which is that you have to have a measurable improvement in the reduction of beach postings and closures. So, because of that, it has been a problem. So, these other funds from these bond measures that are sitting up there at the State Water Resources Control Board are a much better source of potential funds (i.e., Proposition 40, Proposition 50) to reduce upstream sources.

Q: Baby Beach in Dana Point Harbor doesn't have a whole lot of people entering the water. There are a lot of people there, but they are walking between the Ocean Institute and the marina. What would you think about eliminating the beach and turning it into an intertidal rocky zone with field trips and that type of stuff with the creatures that could be using the intertidal rocky zone?

Mark Gold

I think local beneficial use determinations need to be made by the people who live there. For me (running a Santa Monica Bay group), giving an opinion on that would be out of place. That is something that the community in Orange County needs to work with their local regional board and see what happens if there is dedesignation of that direct Recreational 1 use. But, it's not appropriate for me to weigh in on that.

EPA's Clean New England Beaches Initiative and Flagship Beaches

Matthew Liebman, Ph.D.
U.S. Environmental Protection Agency, Region 1

Biosketch

Matthew L. Liebman, Ph.D is an Environmental Biologist at the U.S. Environmental Protection Agency New England regional office in Boston, MA. Dr. Liebman received his B.A in Biology in 1980 from Carleton College in Minnesota and a Ph.D. in Ecology and Evolution from the State University of New York at Stony Brook in 1991. Since 1990, he has worked at the EPA office in Boston as a project manager and scientist in the National Estuary Program, dredged material disposal and monitoring program, and as a water quality specialist. He is the regional coordinator for EPA's BEACH program, nutrient criteria initiative and national sediment inventory. At EPA, Dr. Liebman has conducted or been involved in research efforts in dredged material disposal site monitoring, and impacts of nutrients and bacteria on water quality in streams, coastal waters and beaches.

Abstract

Co-authors: David Turin, Larry Macmillan, Chris Ryan and Warren Howard, EPA Region 1

Taking advantage of the Federal Beach Act, EPA New England launched an initiative in 2002 to enhance our ability to protect public health by reducing beach closures or advisories, while establishing consistent statewide monitoring and assessment programs. In addition to providing grants for monitoring, assessment and public notification at coastal beaches, the goals of the initiative are to control sources of fecal contamination from storm water and non-point pollution sources; establish "Flagship Beaches" in each of the five coastal New England states; promote high quality monitoring and assessment methods and new technologies; promote information sharing among beach managers; and involve the public and communities in education, monitoring and advocacy. The Initiative raises the profile of coastal beaches as important recreational resources by enhancing existing EPA and state programs with increased financial and technical assistance. Since 2001, the number of closure days for coastal and inland beaches has declined from 2400 to 1900 in 2003. We attribute this decline to improvements in beach management and monitoring and actual improvements in water quality due to investments in remediation. Nevertheless, one in five beaches in New England experiences a closure at some point during the summer.

In New England, the major cause of closures are storm water discharges to beaches located in urban areas, especially at beaches in or near Boston Harbor, Massachusetts, Greenwich Bay, Rhode Island, and western Long Island Sound, Connecticut. Many storm water pipes discharge directly onto the beach, with little or no treatment; some storm water is contaminated with human sources of bacteria, from illicit and improper connections, or from leaks in the systems. This presentation will highlight examples of these problems, and discuss strategies to remediate these difficult problems at Flagship and other beaches in New England.

EPA's Clean New England Beaches Initiative and Flagship Beaches

- Matthew Liebman, EPA New England
- With David Turin, Larry Macmillan, Warren Howard, Chris Ryan, Alison Watanabe and Deborah Perez-Rivera

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IT'S A SHORE THING

Clean New England Beaches: It's a Shore Thing

- Goal: To protect public health by reducing beach closures in New England, with appropriate and consistent, high quality monitoring
- Why: Coastal and freshwater beaches were closed or posted more than 700 days in summer of 2003
- How: Federal Beach Act provided funding (nationally over $10 million in FY02) to Coastal States for monitoring, assessment and public notification activities

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IT'S A SHORE THING

Green Harbor, New London, CT

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IT'S A SHORE THING

The BEACH Act of 2000

Beaches Environmental Assessment and Coastal Health Act (Section 406 of the Clean Water Act)

- Consistent Criteria and Standards for Coastal Recreational Waters
  - States need to adopt EPA criteria (i.e. enterococci) for pathogen indicators within 42 months (2004)
- Performance Criteria for Beach Monitoring, Assessment and Notification (The Beach Guidance Document)
- Grants to develop and implement State Coastal Beach Monitoring Programs
  - State programs must be consistent with Performance Criteria
  - a funded mandate

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IT'S A SHORE THING

1. Provide Federal money to develop and implement state beach programs

- Ensure states and municipalities monitor water quality at beaches, assess sources of pathogens (perform sanitary surveys), and notify the public of water quality conditions consistent with EPA's new performance criteria -- all states have met performance criteria
- Press events in all five coastal states usually at Flagship Beaches, with Gov. Whitman, R. Varney and other officials to give away about $1.1 million granted annually to five coastal states

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Press events at Flagship beaches

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2. Control non-point and storm water pollution sources that contribute to beach closures

- Eliminate human fecal contamination of storm water
- Major component of NPDES storm water permit -- 6 minimum controls include elimination of illicit discharges -- will look closely at Phase 2 permits for communities with history of problems
- Targeted enforcement where appropriate
- Technical assistance
- Put the pressure on local officials to reduce sources of bacteria at beaches with letters

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Keeping the pressure on communities with chronic beach closures

- Sincerely, Robert Varney, Regional Administrator

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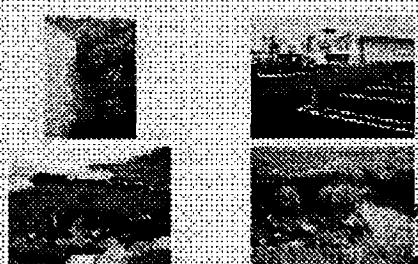
Stormwater, the major culprit



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3. Establish "Flagship Beaches" with States

- Relatively high use, diverse or low income population, history of beach closures, potential for improvement, selected with states
- Highlights good beach management, monitoring practices
- Commitment to target resources and track improvements

CT Rocky Neck SP, Ocean Beach Park (New London)
ME Ferry Beach SP, Wells
NH Hampton Beach SP
MA Salem, Wollaston (Quincy), Provincetown
RI Goddard SP, Warren, King Park Swim Area

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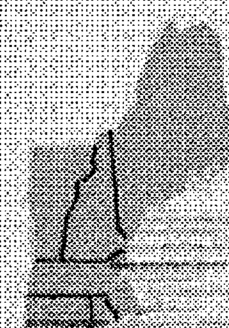

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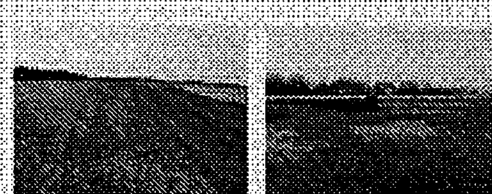
Wollaston Beach Quincy, MA



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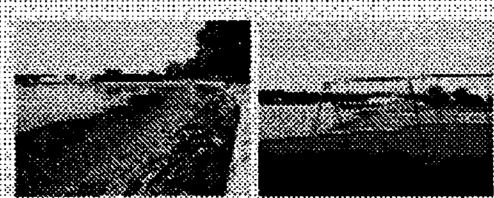
Warren Town Beach, RI



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4. Promote high quality monitoring and assessment technologies

- Ensure state laboratories have an established quality assurance management plan, and an approved quality assurance project plan (QAPP) – all states have approved QAPPs as part of performance criteria and several have established regional laboratory networks (e.g. MA and RI)
- Promote research on rapid indicator methods (RI, MA, CT) – funded a RARE project at University of Rhode Island
- Promote microbial source tracking (MST) to identify potential sources of fecal contamination, establish a network, build capacity at EPA New England – see talk by Mark Quilliam and Jack Paar of EPA (Q-PCR) and Steve Jones of UNH (Ribotyping)

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5. Promote information sharing among beach managers

- Hold "quarterly" meetings with state beach managers
- Topics have included:
  - Comparison of beach monitoring programs, including indicator [illegible]
  - [illegible]
  - [illegible]
  - [illegible]

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Beach closure days in New England

State	2001	2002	2003
CT	195	77	200
ME	16	5	0
MA	847	503	559
NH	0	0	3
RI	330	76	380
Totals	1388	661	1142

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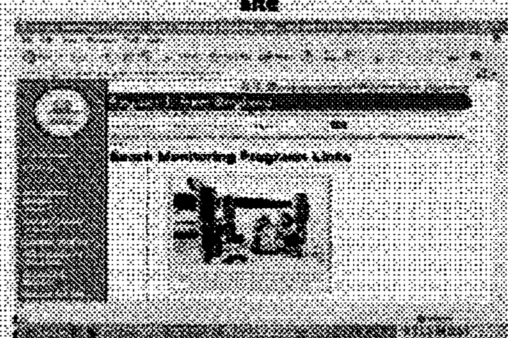
Clean New England Beaches web site



Sanitary Surveys

- Sanitary survey training conducted by all states including one with NSSP in RI
- Sanitary surveys conducted at flagship and other beaches by states
- EPA staff with interns, conducted preliminary sanitary surveys at flagship and other beaches to assist municipal health officials

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6. Involve and educate the public and municipalities

- Develop educational material to encourage citizens to bring storm water discharges to local governments attention – fact sheets and web page
- Develop material targeted at municipalities (NPDES permits) to control non-point source pollution affecting recreational waters

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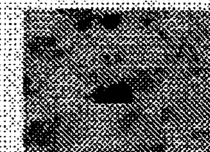
IT'S A SHORE THING

Do people really read the signs?

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Results of Sanitary Surveys

- Most surveys are at coastal beaches in urban or suburban eastern Massachusetts or Rhode Island
- ***Major problem is that natural streams have been integrated into the stormwater infrastructure, so point or nonpoint sources are not attenuated***

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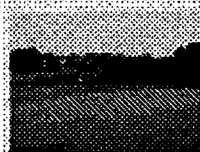
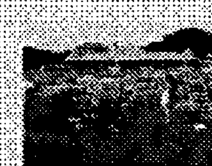
IT'S A SHORE THING

Source of bacteria — a golf course with discharge directly downstream with little attenuation

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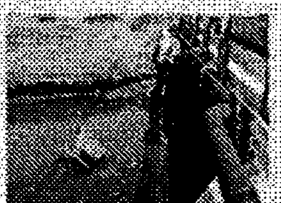
IT'S A SHORE THING

Ask town for information, they know about leaks in sewer pipe



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When conducting sanitary surveys, it's important to sample in streams where people swim

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Beach in Beverly, MA, north of Boston

- Small neighborhood beach with moderate use by families in summer
- About 1 closure per year, geomean about 20
- Three storm water outfalls, sampled by local watershed organization finds consistent counts > 1000 enterococci
- Most of town is sewered

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Topographic map of Beverly, MA

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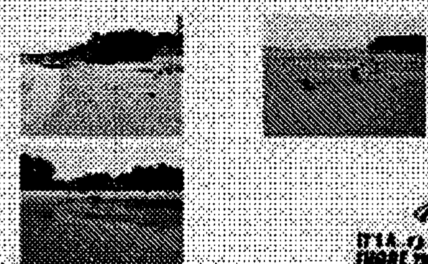
Beverly, MA Beach



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Aerial photo of Beach with sampling stations

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Culvertized stream and sampling large outfall at beach

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Another beautiful Beach in Beverly, MA

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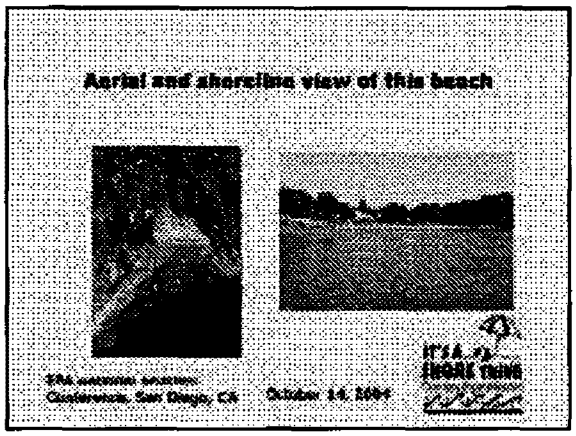
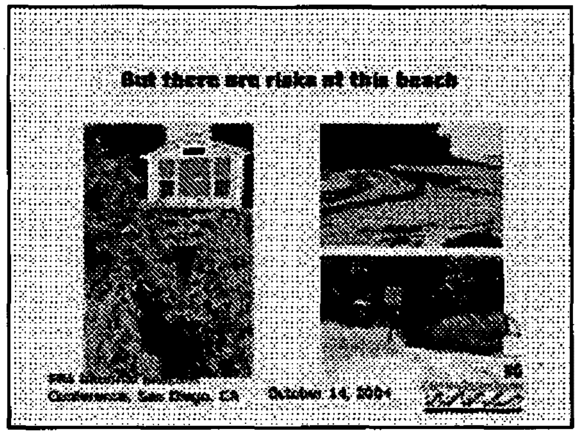
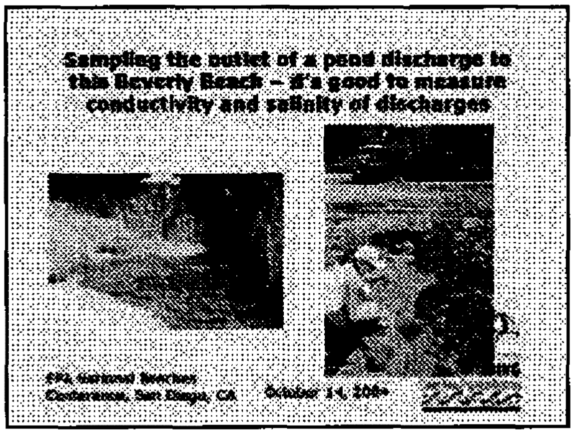
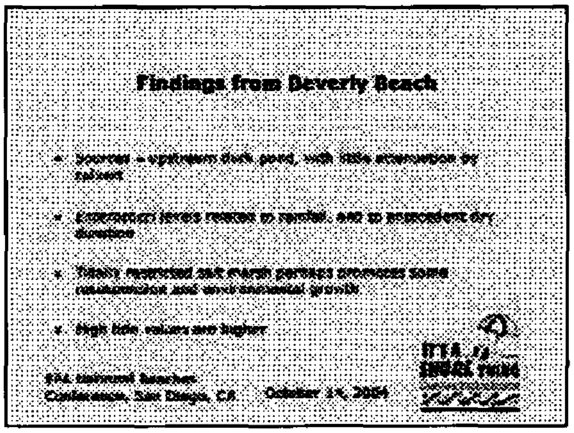

Aerial and shoreline view of this beach
Conference, San Diego, CA
October 14, 2004


But there are risks at this beach
Conference, San Diego, CA
October 14, 2004


Sampling the outlet of a pond discharge to this Beverly Beach – it's good to measure conductivity and salinity of discharges
EPA National Beaches
Conference, San Diego, CA
October 14, 2004


Findings from Beverly Beach
High tide values are higher
EPA National Beaches
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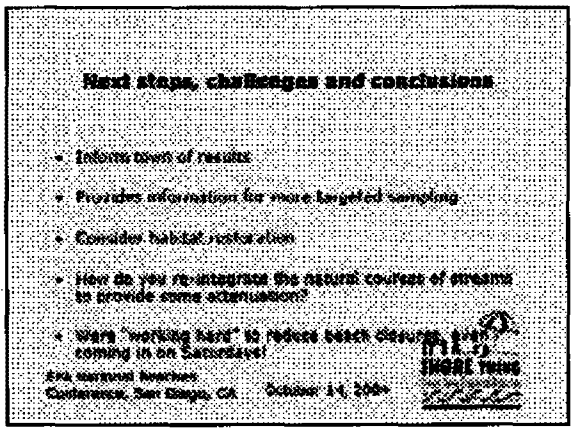
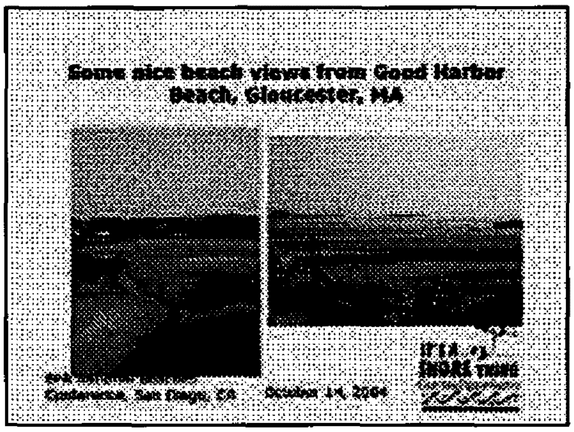

Next steps, challenges and conclusions
Inform town of results
Provides information for more targeted sampling
Consider habitat restoration
How do you re-integrate the natural courses of streams to provide some attenuation?
Were "working hard" to reduce beach closures
coming in on Saturdays!
EPA National Beaches
Conference, San Diego, CA
October 14, 2004
IT'S A SHORE THING


Some nice beach views from Good Harbor Beach, Gloucester, MA
Conference, San Diego, CA
October 14, 2004
IT'S A SHORE THING

Questions and Answers

Q (Stephen Jones, University of New Hampshire): One of your last statements was about opening salt marshes and improving tidal flushing, and maybe improving water quality. There is some evidence in New Hampshire where they have been doing a lot of salt marsh restoration, right next to the beaches. During my presentation this morning I showed how we were looking at our beaches and they all have these outlets from the salt marshes. In a couple of instances they have increased the size of the culverts and the flushing in and out of these salt marshes, and the water quality has decreased. So, it may not be as straightforward as it seems. It seems right what you are saying, but we are going to be taking another look at this because they are going to be doing another salt marsh restoration at one of the beaches this spring, and in the upcoming year we are going to be doing some source tracking and microbial work. But be aware that it may not be as straightforward as it seems.

Matthew Liebman

Every place is site-specific, but I'm wondering if in those cases in New Hampshire the levels of bacteria are probably much lower than what we're finding in the Boston area. So, when you say you see a decrease in water quality, it could be a matter of scale.

Q: Yes, but the mechanisms by which this happened—we are not sure what is going on. So, it would be interesting to find out.

Matthew Liebman

We deal with people who protect wetlands all the time, and there is a major issue because people are always complaining about the salt marsh and the wetlands contributing the sources of bacteria to their beach. And, our coastal wetlands people kind of resent that because it implies that we should not protect the wetlands as much. So, it's important to remember that healthy functioning wetlands appear to contribute only small amounts of bacteria to coastal waters.

The Effectiveness of Spatial Distribution Studies in the Development of Successful, Cost-Effective, Targeted Remediation Efforts

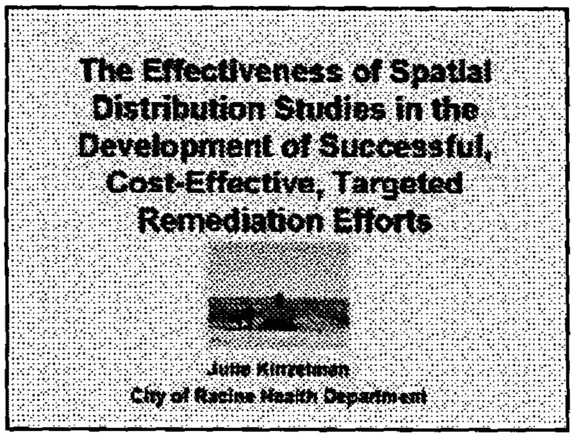
Julie Kinzelman
City of Racine

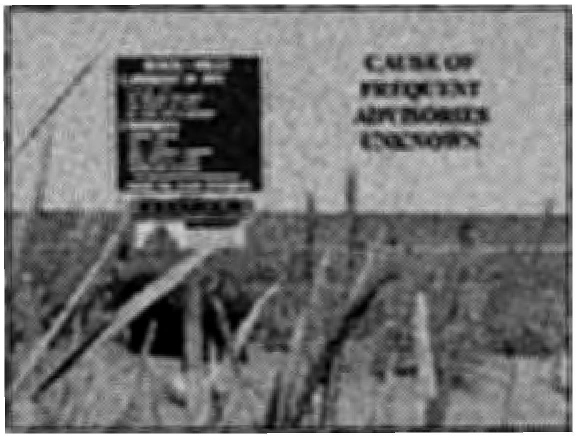
Biosketch

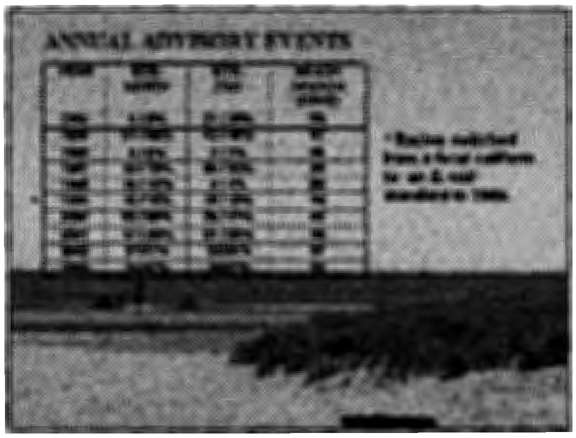
Julie Kinzelman is a microbiologist for the City of Racine Health Department where she has 14 years experience in recreational water quality monitoring and research. Dr. Kinzelman received a BS in Medical Technology from the University of Wisconsin - Parkside, a MS in Clinical Laboratory Sciences from the University of Wisconsin -Milwaukee, and is a Ph.D. Candidate (2005) in Public & Environmental Health at the University of Surrey (Guildford, UK). Dr. Kinzelman is the principal investigator or co-investigator on research initiatives funded by the National Institute of Health, S. C. Johnson Fund, Wisconsin DNR, and Wisconsin Department of Health & Human Services. Her current research activities focus on using public health based monitoring programs to assess the interaction of coastal processes contributing to recreational water quality advisories.

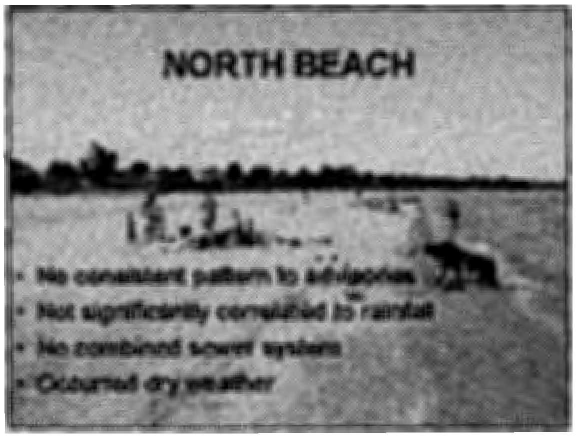
Abstract

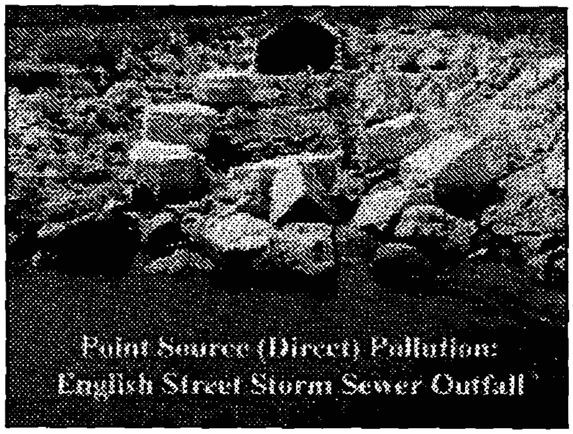
An interdependent relationship exists between localized sources of contamination and coastal processes. Both direct and indirect sources of contamination if provided with a suitable mechanism of transport, such as run-off due to rainfall or wave action, can negatively impact surface water quality. An unacceptable amount of swimming advisories over the course of several years prompted Racine, Wisconsin to conduct scientific studies to detect and remediate point and non-point sources of contamination impacting the adjacent Lake Michigan coastal waters. A storm sewer outfall, previously identified as a significant source of *Escherichia coli* and other bacterial indicators, now is pretreated and discharges first-flush storm water (during rainfall events) to a series of infiltration/evaporation beds and incorporates a constructed wetland to provide further filtration. Beach sands are now maintained by mechanical grooming equipment in such a way that the bacterial density is significantly decreased, effectively reducing the number of dry weather advisories previously encountered at this site by 30%. In Racine, beach management strategies are ongoing and continually re-evaluated in light of new research findings. Cost-effective remediation steps have been implemented to reduce the bacterial burden on adjacent surface waters and hence the risk of contracting disease through swimming-related activities. The development of site-specific targeted remediation efforts benefits both public and environmental health.


The Effectiveness of Spatial Distribution Studies in the Development of Successful, Cost-Effective, Targeted Remediation Efforts
Julie Kinzelman
City of Racine Health Department

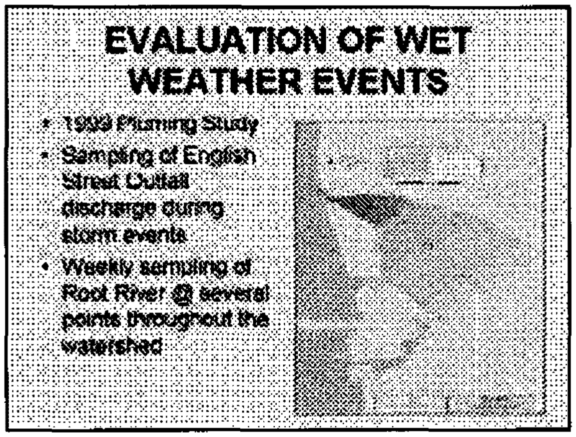

CAUSE OF FREQUENT ADVISORIES UNKNOWN

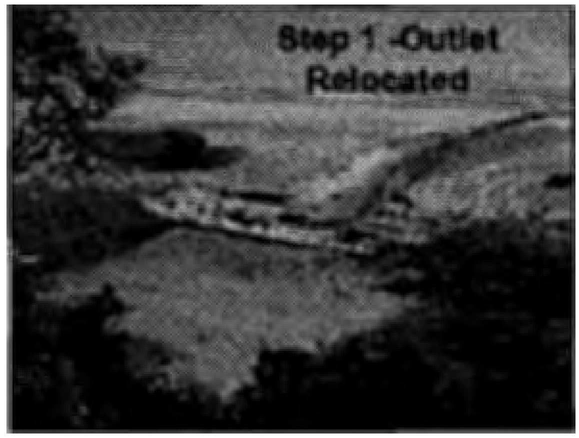

ANNUAL ADVISORY EVENTS

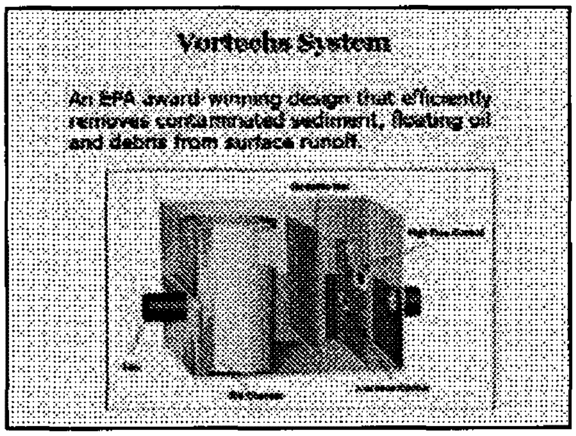

NORTH BEACH
• No consistent pattern to advisories
• Not significantly correlated to rainfall
• No combined sewer system
• Occurred dry weather

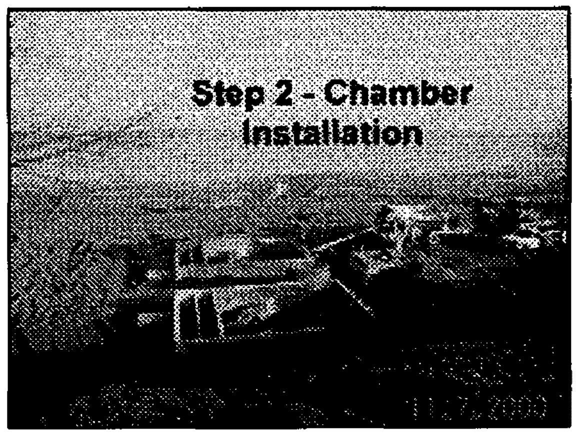

Point Source (Direct) Pollution:
English Street Storm Sewer Outfall

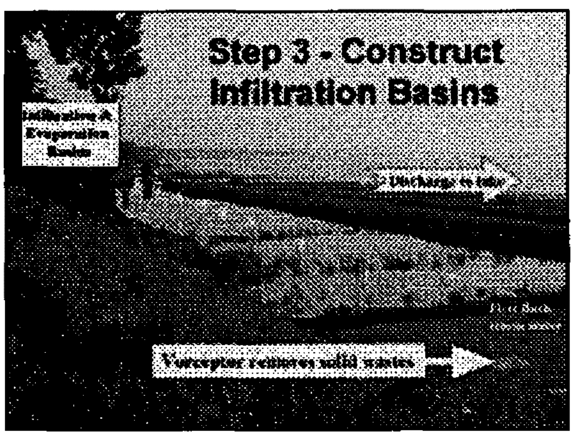

- COLLECTING AREA -
ENGLISH STREET STORM SEWER

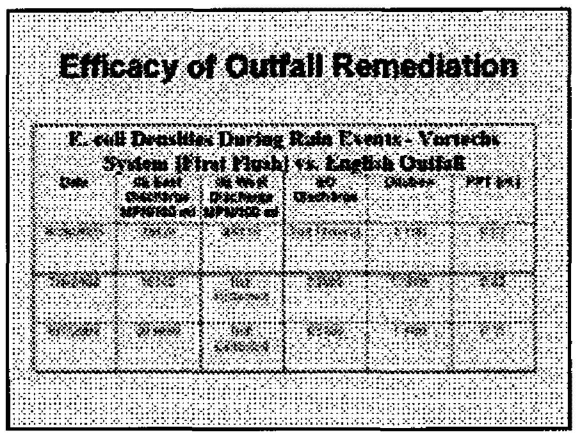

EVALUATION OF WET WEATHER EVENTS
• 1999 Pluming Study
• Sampling of English Street Outfall discharge during storm events
• Weekly sampling of Root River @ several points throughout the watershed


Step 1 -Outlet Relocated


Vortechs System
An EPA award-winning design that efficiently removes contaminated sediment, floating oil and debris from surface runoff.

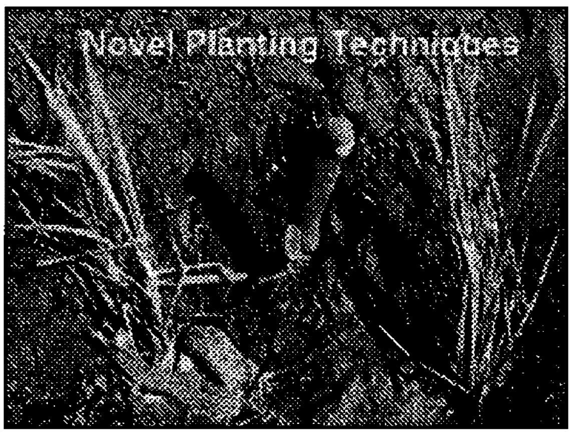

Step 2 - Chamber Installation


Step 3 - Construct Infiltration Basins
Infiltration & Evaporation Basins
Discharge to lake
Vorceptor removes solid wastes


Efficacy of Outfall Remediation
E. coli Densities During Rain Events - Vortechs System (First Flush) vs. English Outfall

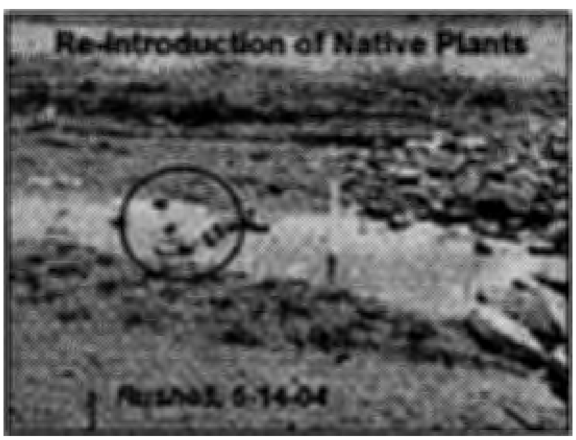
Comparison of *E. coli* Densities Retention Basin vs. Overflow Outlets

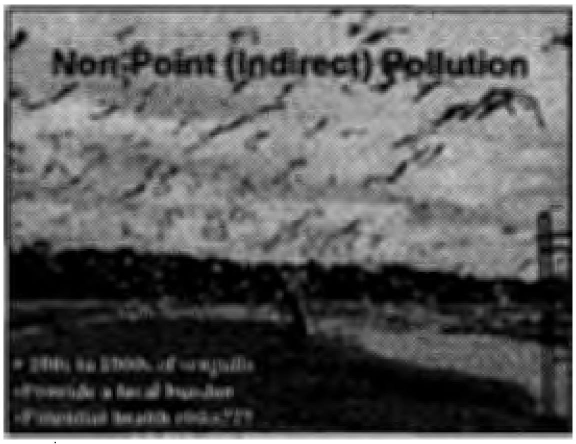
Date	[illegible]	[illegible]	Temp. [illegible]	[illegible]	Dilution
[illegible]	[illegible]	161	Not Taken	0	1:10
5/21/2003	210	74	63/59	0.25	1:10
6/6/2003	120	345	58/58	0	1:10
6/12/2003	145	96	60/60	0	1:10
6/19/2003	410	56	65/68	[illegible]	1:10
[illegible]	[illegible]	[illegible]	74/73	[illegible]	1:10
7/3/2003	[illegible]	[illegible]	82/70	0	1:10
7/10/2003	458	368	80/72	0.05	1:100
7/17/2003	[illegible]	259	[illegible]	0	1:10
7/24/2003	88	40	Not Taken	0	1:10
7/31/2003	52	1	71/81	0	1:10
8/7/2003	571	1	72/83	0	1:10
8/14/2003	498	15	63/61	0	1:10
8/21/2003	[illegible]	55	70/64	0	1:10
8/28/2003	[illegible]	43	Not Taken	0	1:10
9/3/2003	921	250	72/48	0	1:1
MEAN	438	154	without 6/26/03		

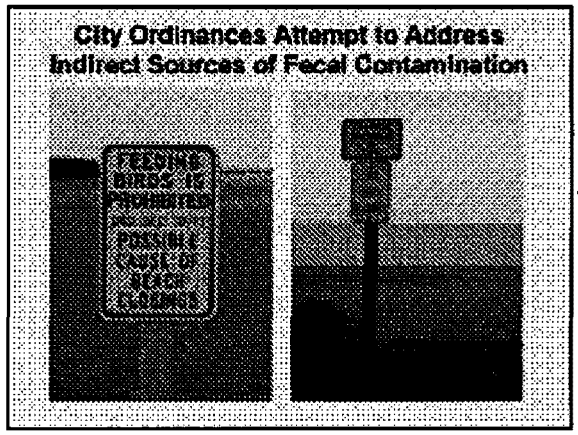


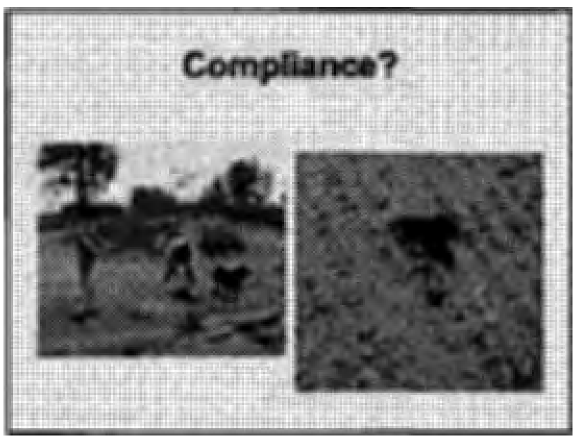
Water Sedge (*Carex aquatilis*)

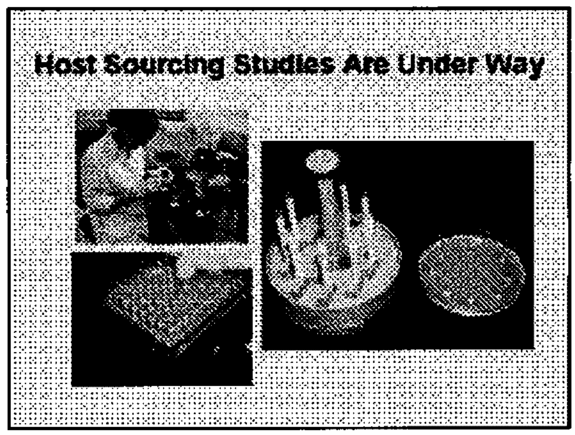
- 300% increase in height (10 cm to 31.2 cm)
- Increased in number (50 plants to 67 plants)
- Provided bank stabilization
- Phase II planting (8/14/04) added 100 additional plants





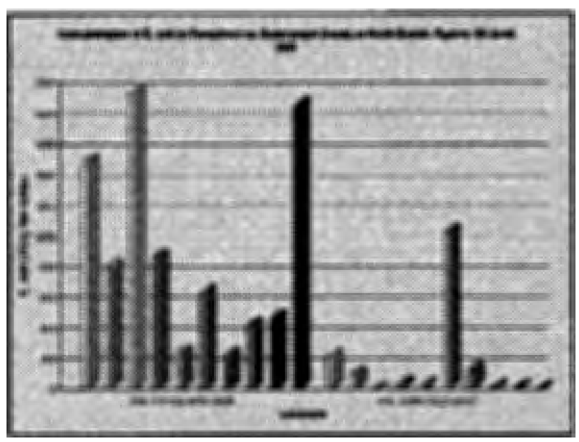


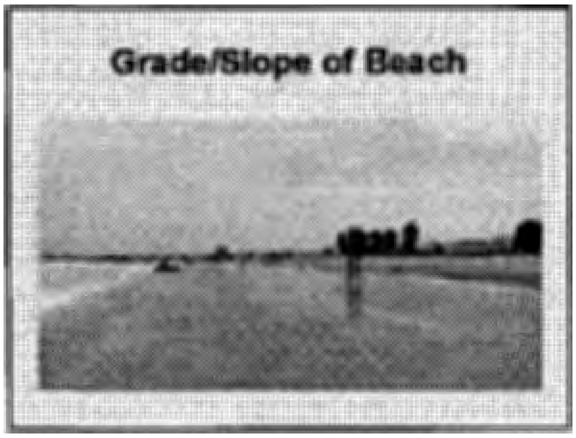


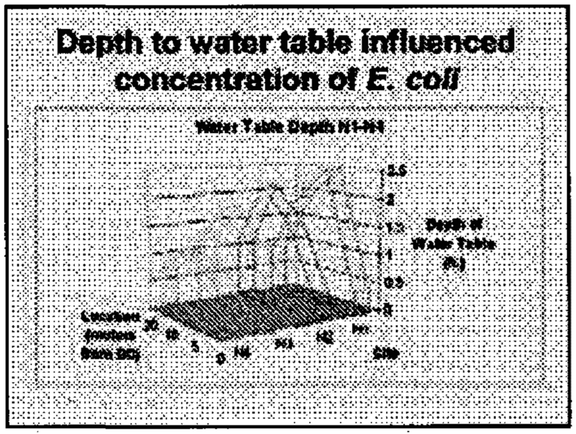


Distribution of *E. coli* in Beach Sands

- *E. coli* concentration highest in beach sands
- Backshore sands had little or no *E. coli* (per gram dry weight)
- Highest levels of *E. coli* were detected between the lifeguard stands & the berm crest
- Continually wetted sands had the highest concentration of *E. coli*. [Distance to groundwater]
- Partitioning of core sediments showed a decrease in *E. coli* concentration up to an order of magnitude for every 5-cm increment below the surface

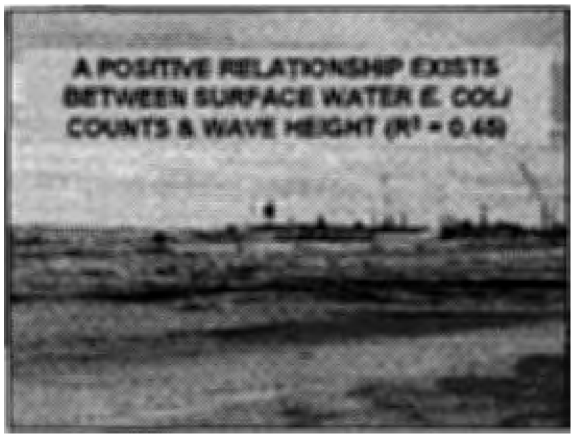


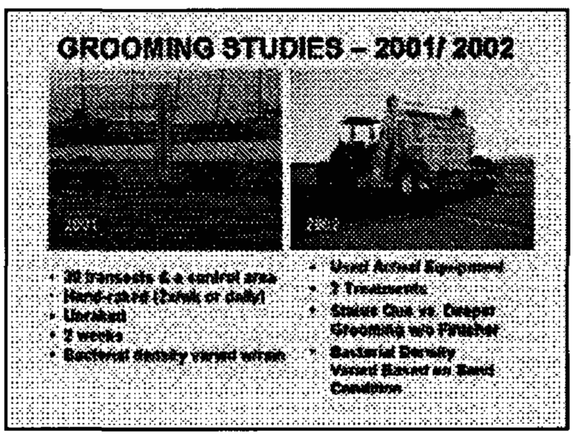


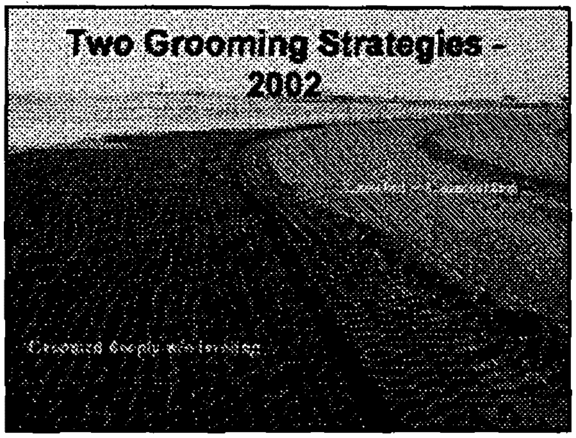


CORE PARTITIONING
N2 – Wet Strip Behind Lifeguard Stand

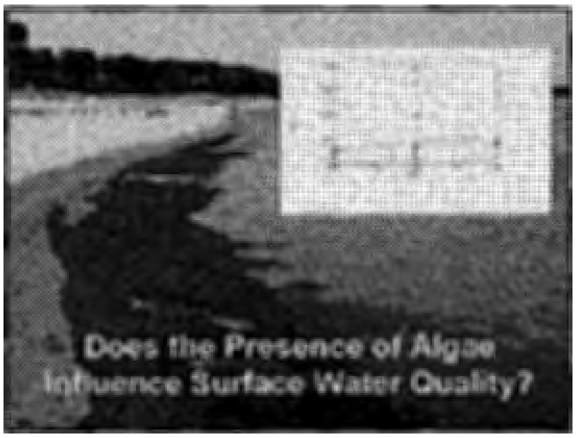
DEPTH	MASS	WET/DRY	DILUTION	EC MPN/100 mL	EC/G
0-5 cm	43.2	Wet	1:[illegible]	11370	263.2
6-10 cm	52.7	Wet	1:100	[illegible]	[illegible]
11-15 cm	41.3	Wet	1:100	1730	41.[illegible]
16-20 cm	[illegible]	Wet	1:100	100	2.4
21-25 cm	[illegible]	very wet	1:100	<100	0



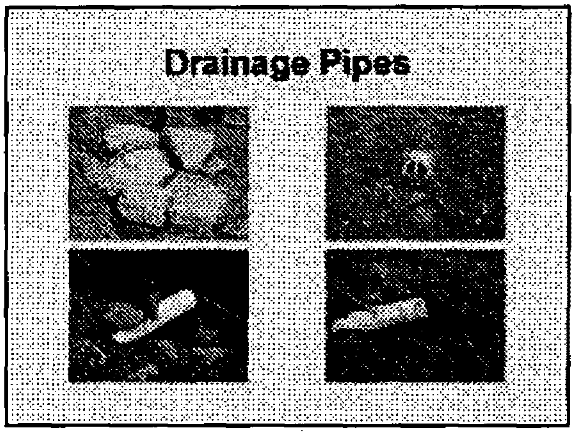


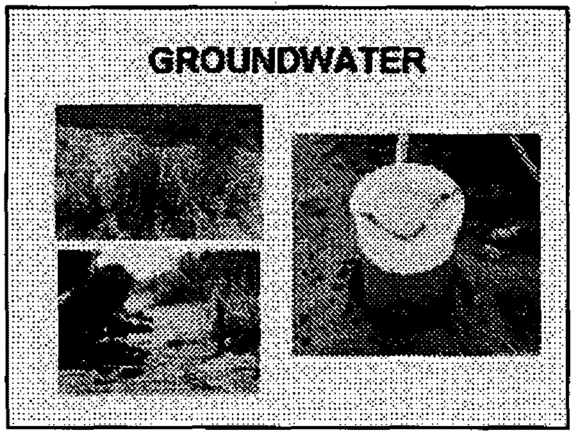

Two Grooming Strategies - 2002

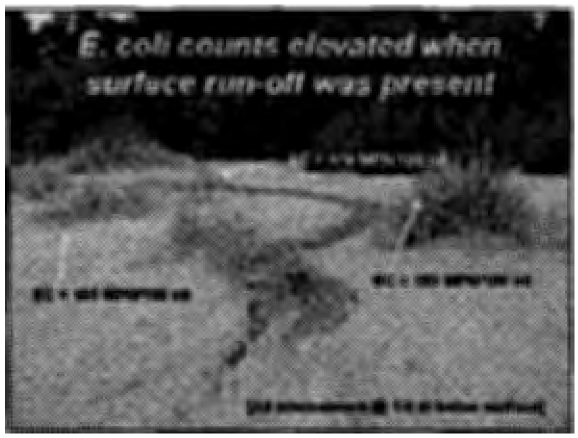

ALGAL BLOOMS

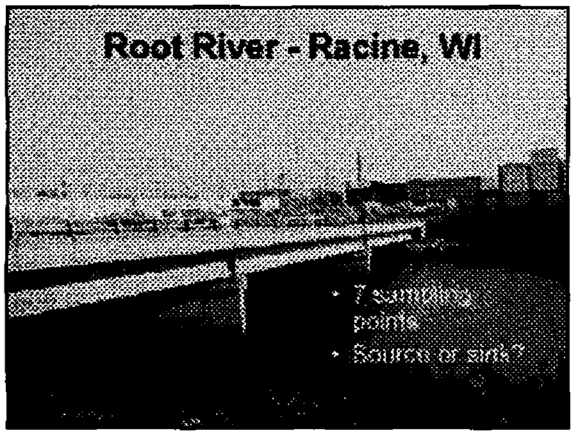

Does the Presence of Algae
Influence Surface Water Quality?


A Best Management Practice
Remove the Algae


Drainage Pipes

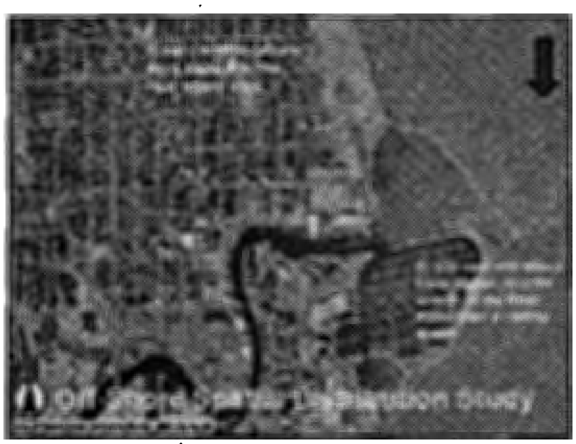






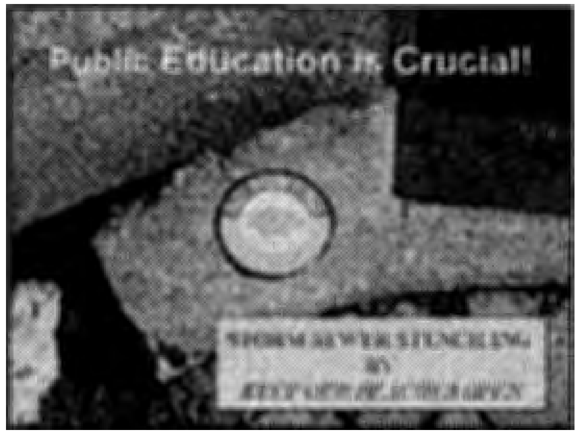
Root River *E. coli* Densities - 2004

SITE	MEAN EC MPN/100 ml	RANGE
Johnson Park (R1)	1318	18 – 14,136
Horlick Dam (R2)	1471	18 - 12,987
Cedar Bend (R3)	3765	0 - 12,997
Washington Park OF (R4)	33,888	0 - 198,628
Water Street OF (R5)	13,878	190 – 173,287
State Street Bridge (R6)	1372	61 – 11,159
Chartroom (R7)	1098	78 - 6884



Could Boaters be a Source of Contamination?

- 2003 survey
- 6 marinas
- 1305 boat slips
- 63% occupied (823 slips)
- 2 pumping stations
- $7.00 to pump regardless of amount
- Pumping stations connected directly to city sewer system
- 8000+ gallons of sewage pumped in 2003
- New head design makes illegal dumping next to impossible
- Illegal dumping occasionally observed by Sheriff's patrol boats



ACKNOWLEDGEMENTS

- City of Racine Departments of Health (Laboratory), Parks & Recreation, and Public Works.
- University Of Surrey, Guildford, Uk
- Keep Our Beaches Open (KOBO)

Research funded by:

- WI Department of Health & Family Services
- Sustainable Racine

Questions and Answers

Q: Can you talk about the cost of your Vortechs system?

Julie Kinzelman

For the Vortechs system, including the whole engineering process, the relocation of the outlet, and the installation of the two Vortechs, it was about $750,000 dollars. We had about $150,000 through a grant from the Department of Natural Resources, and the city put in about $600,000 of its own money.

Utilizing Storm Water Monitoring to Assess Beach Water Quality

Jill Lis, R.S.
Cuyahoga County Board of Health

Biosketch

Jill Lis is a Program Manager in the Environmental Health Service Area of the Cuyahoga County Board of Health. Ms. Lis received her B.S. in Environmental Health from Bowling Green State University in Bowling Green, Ohio in 1992. Since then, she has been working as a Registered Sanitarian in the Environmental Health Service Area of the Cuyahoga County Board of Health in Cleveland, Ohio. She has been managing the Bathing Beach Program since 1997, in addition to several other recreational and water quality programs. She is also an active member of the Ohio Environmental Health Association.

Abstract

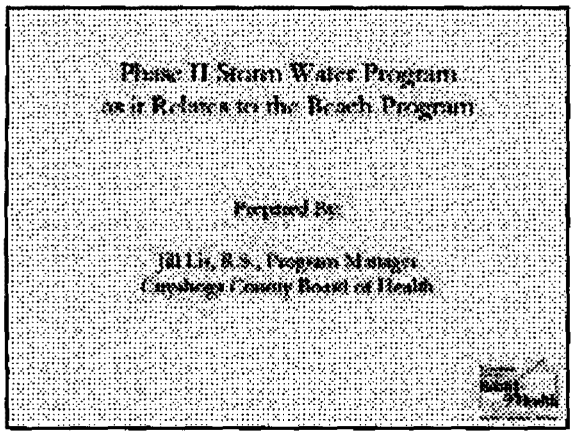
The Cuyahoga County Board of Health (CCBH) received Beach Act funds in 2003 to re-evaluate its existing program to meet the objectives of the Beach Act. The overall goal was the development of a comprehensive risk-based beach monitoring and public notification program. To aid in the beach classification process, the Lake Erie shoreline was evaluated for the location of storm sewer outfalls and streams in the vicinity of the beaches. A total of 20 locations, 11 storm sewer outfalls and 9 streams, were identified that were accessible for sampling. These locations were sampled once a week during the recreation season for *E. coli* bacteria.

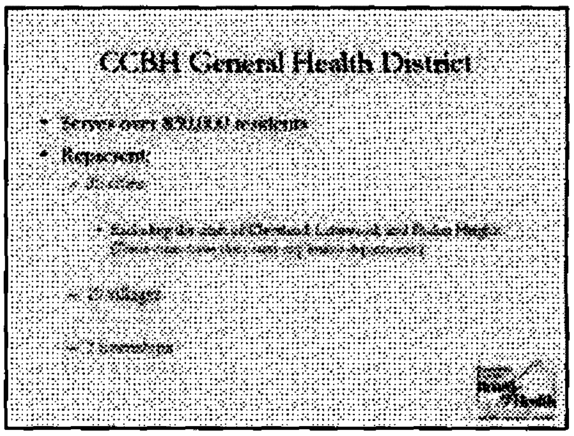
Sampling results revealed that 16 out of the 20 locations have potential to impact beach water quality. Several significant rain events occurred during the 2003 recreation season which may have contributed to elevated bacterial levels; however, elevated concentrations of *E. coli* were identified even during dry weather conditions. The data collected has been provided to the municipalities in which the sampling locations were located for collaboration in investigating potential sources of pollution. This work is being continued throughout the 2004 recreation season in order to validate the 2003 data.

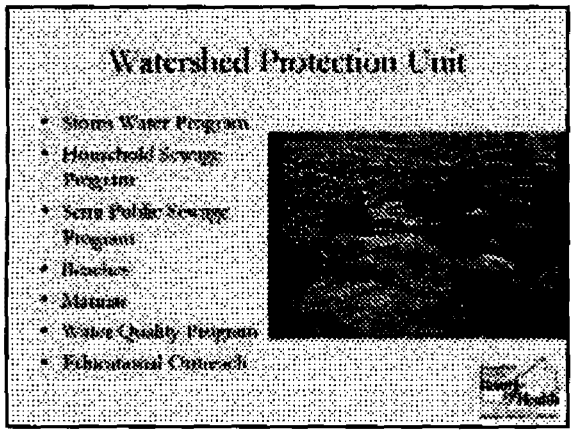
The CCBH conducts an extensive water quality program, including a Phase II Storm Water Program, in which illicit discharges are detected for their elimination. Fifty-five of the 56 communities within the CCBH jurisdiction are designated Phase II communities that must comply with Phase II Storm Water Management Plans and Programs. A regional storm water program has been developed by the CCBH to assist these communities in meeting their requirements. The program provides communities with educational outreach and participation, illicit discharge detection, MS4 inventories, dry weather flow surveys, water quality monitoring of MS4 outfalls, and investigative activities to identify illicit pollution sources to MS4 systems.

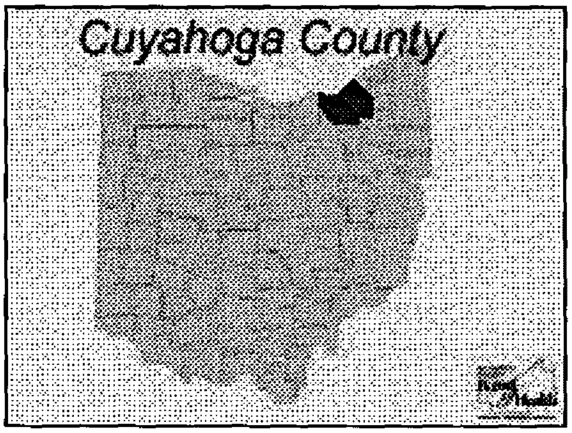
In addition to its Phase II Storm Water Program, the CCBH performs numerous water quality activities. These activities include: identifying and eliminating public health nuisances and hazards in the surface waters within the health district, surveying the watersheds within the health district, educating the public on non-point source pollution, participating in local watershed protection groups and meetings, and supporting the Household Sewage, Semi-Public Sewage, and Parks and Recreation Programs, including the Bathing Beach Program.

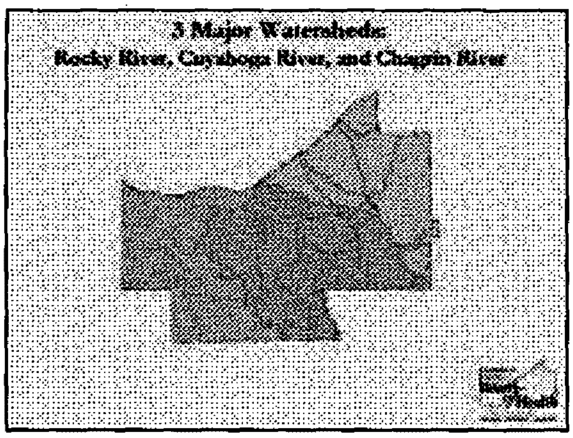
The CCBH utilizes a watershed approach in dealing with water quality issues. Cuyahoga County consists of 3 principal watersheds, all of which drain to Lake Erie: the Rocky River Watershed, the Cuyahoga River Watershed, and the Chagrin River Watershed. The overall water quality in Cuyahoga County ultimately affects the beach water quality. In efforts to enhance its role with these issues, the CCBH is actively working towards developing a Watershed Protection Unit, which will address all water quality issues within its health district.


Phase II Storm Water Program
as it Relates to the Beach Program
Prepared By:
Jill Lis, R.S., Program Manager
Cuyahoga County Board of Health


CCBH General Health District


Watershed Protection Unit
Storm Water Program
Household Sewage Program
Semi Public Sewage Programs
Beaches
Water Quality Program
Educational Outreach


Cuyahoga County


3 Major Watersheds:
Rocky River, Cuyahoga River, and Chagrin River

Phase II Storm Water Program

- U.S. EPA/Ohio EPA Phase II Storm Water Regulations
  - Effective March 10, 2003
- Requirement
  - Phase II designated communities must develop and implement storm water management plan
    - [illegible]

Phase II Cont…

- 6 minimum control measures
  - 1. Public education
  - 2. Public involvement
  - 3. Illicit discharge detection and elimination
  - 4. Construction site runoff control
  - 5. Post construction site runoff control, and
  - 6. Good housekeeping

CCBH Involvement

- Household Sewage Treatment Systems (HSTS)
- Water Quality Sampling
- No Guidance from Ohio EPA
- Communities looking for assistance
- Principal Member of Northeast Ohio Storm Water Task Force Committee

Illicit Discharge Detection and Elimination

- Identify any discharge into a community's MS4 system that is not storm water
  - MS4: Municipal Separate Storm Sewer System
  - Conveyance Systems can be storm sewer, swale, or ditch

Illicit Discharge Detection and Elimination

- By 2008:
  - Communities need to identify all outfall locations within their MS4 system
  - All outfalls must be mapped
  - Communities must have their illicit discharge detection and elimination plan in place

Illicit Discharge Detection and Elimination Plan

- Sources of discharge into an MS4 other than storm water or ground water must be detected and eliminated.
- Communities must develop this plan in order to meet the Phase II requirements.

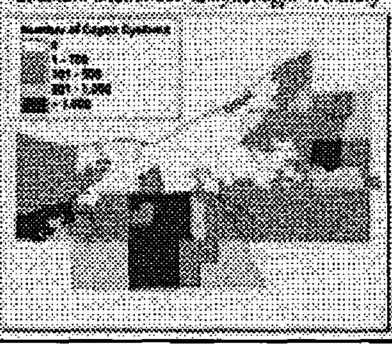
Illicit Discharge

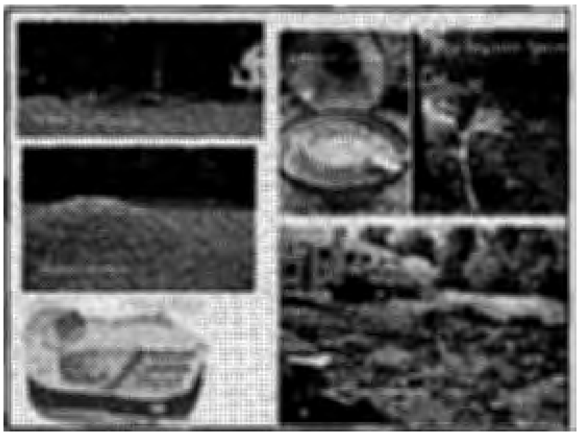
- Example:
  - Household Sewage Treatment Systems (HSTS) that discharge are sources of an illicit discharge
- Communities have until 2008 to assess these systems and develop a plan on eliminating these sources of illicit discharge.

Off-lot Discharging HSTS

- Approved in the State of Ohio
  - Outdated rules / no legislation
  - No general NPDES permit for household septic systems from the Ohio EPA
- One of only a handful of states that approves these systems
- Are now illicit sources of discharges under Phase II Storm Water

Household Sewage Treatment System Distribution In Cuyahoga County

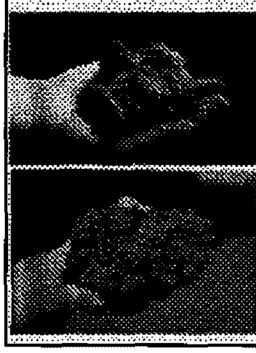




Illicit Discharge Cont…

- Three ways to eliminate HSTS as an illicit discharge
  - Sanitary Sewers
  - Install an On-Lot HSTS
  - Permit off lot HSTS with Ohio EPA NPDES Permit

Soil Conditions



Sandy soils
- Only in isolated areas

Heavy clay soils
- Widespread
- Not suitable for leaching systems

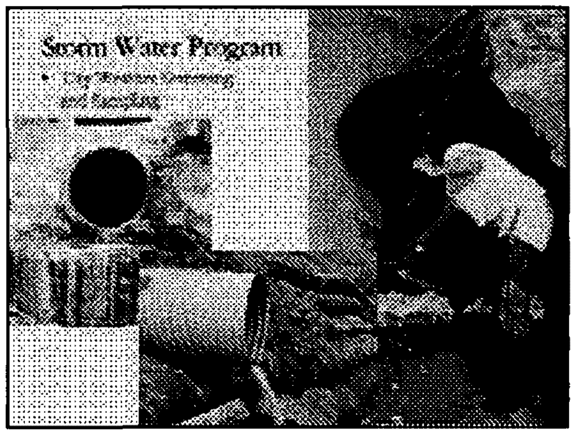
Simple activities impact the State's Water Quality

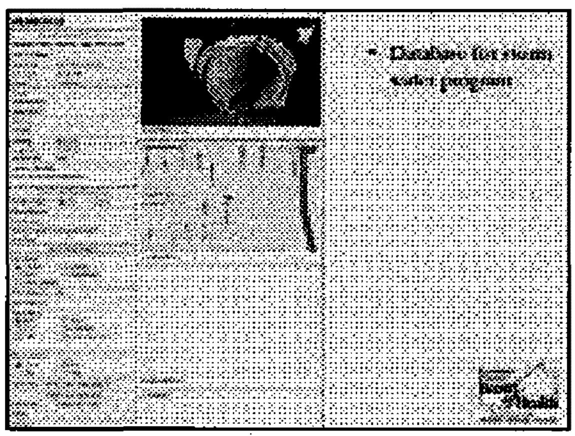
- Improperly disposing of motor oil
- Over using lawn and garden products
- Leaving pet waste on the ground

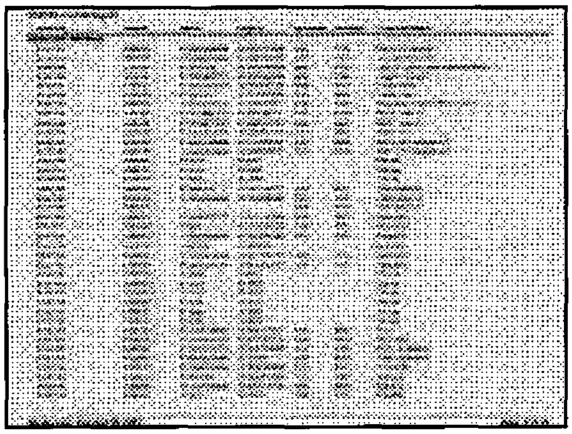
- Rain, snowmelt, and over-watering move these household generated pollutants to rivers, lakes, and streams. This polluted runoff has a major impact on water quality.

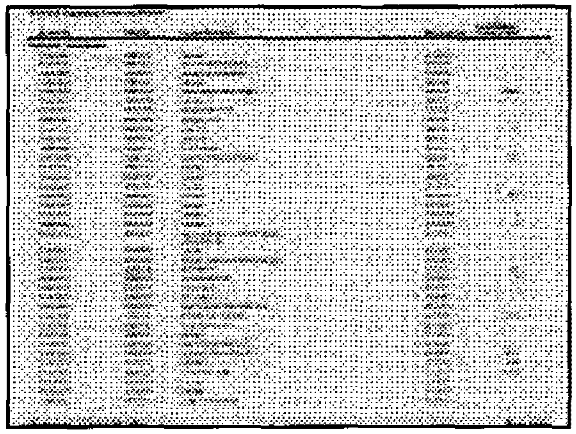
Storm Water Program

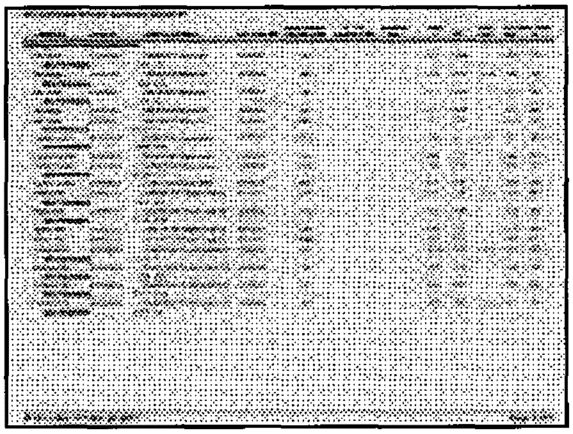
- CCBH provides the following services:
  - MS4 inventory
  - Dry Weather Screening
  - MS4 outfall sampling
  - Illicit Discharge detection
  - Public Education and Outreach
- Completed MS4 inventories for 20 communities
- Have contracts with 30 communities for dry weather and sampling projects.

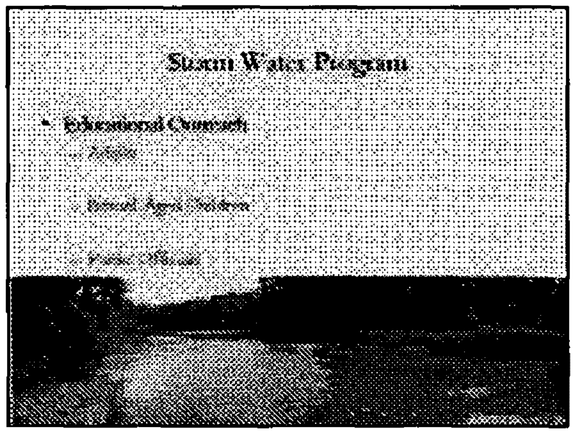


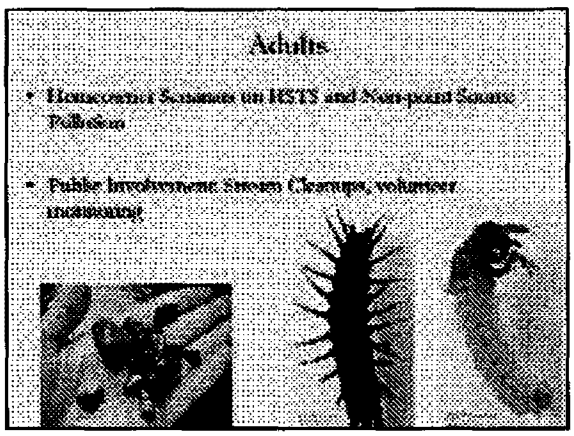


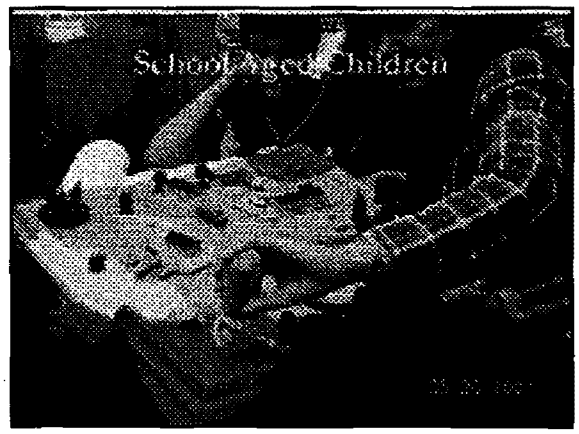







Storm Water Program
• Educational Outreach

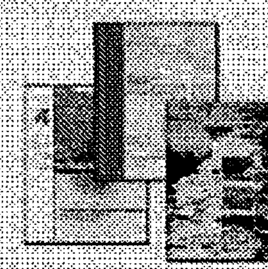

Adults
• Homeowner Seminars on HSTS and Non-point Source Pollution
• Public Involvement: Stream Cleanups, volunteer monitoring


School Aged Children

Public Officials

- Attend Council Meetings
- Educate on Phase II requirements
- Draft Ordinances from Storm Water Task Force Committee

Other Outreach Activities

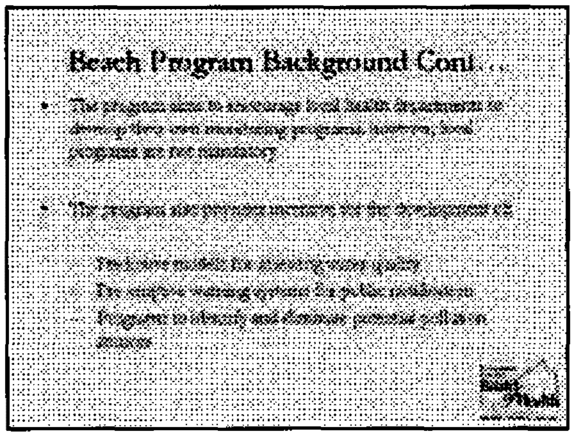


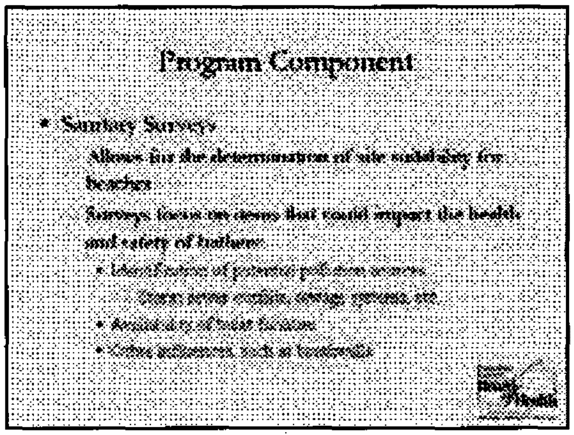
Storm Water Program

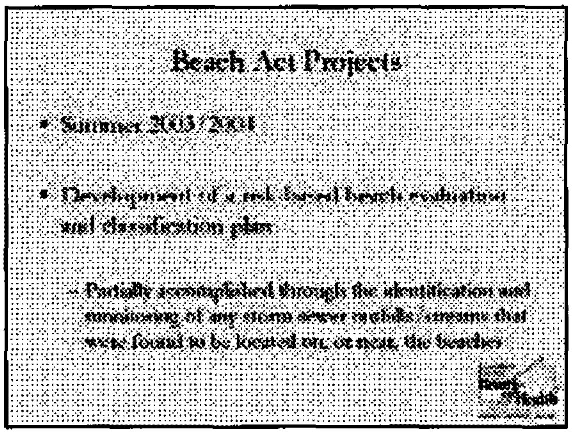
- Collaboration:
  - Watershed Organizations
  - County Planning Agency
  - Cleveland Metroparks
  - Regional Sewer
  - Ohio Department of Natural Resources
  - Ohio EPA
  - Communities
  - School Districts

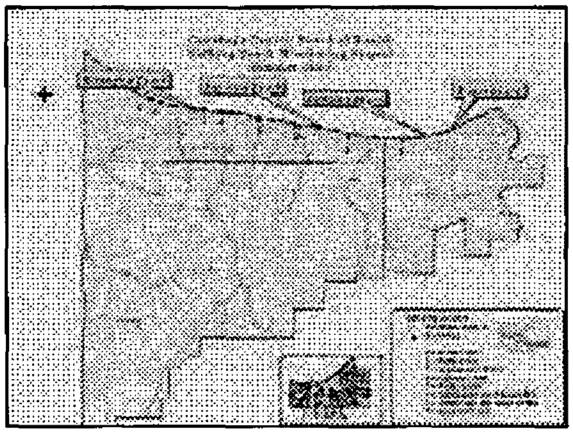
Beach Program Background

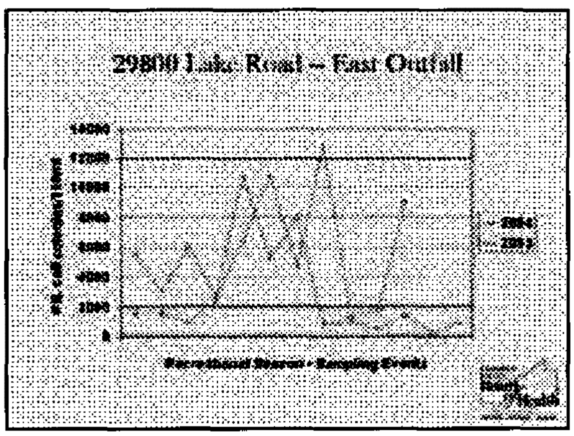
- The Ohio Department of Health (ODH) administers the Bathing Beach Monitoring Program for the State of Ohio
  - Program has been in place since the mid 1970's
  - Cooperative effort between the ODH, the Ohio Department of Natural Resources, public and private organizations along the Lake Erie shoreline, and local health departments with beaches in their jurisdictions

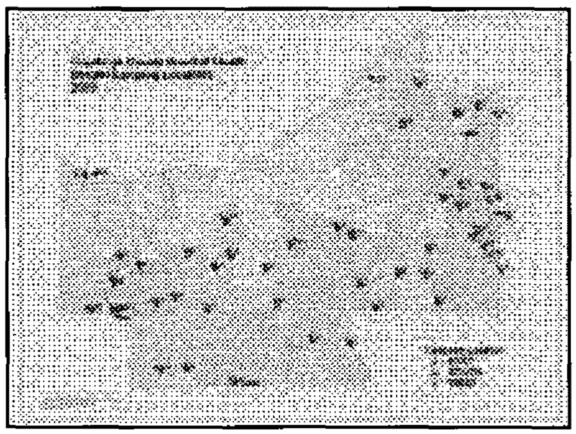

Beach Program Background Cont…

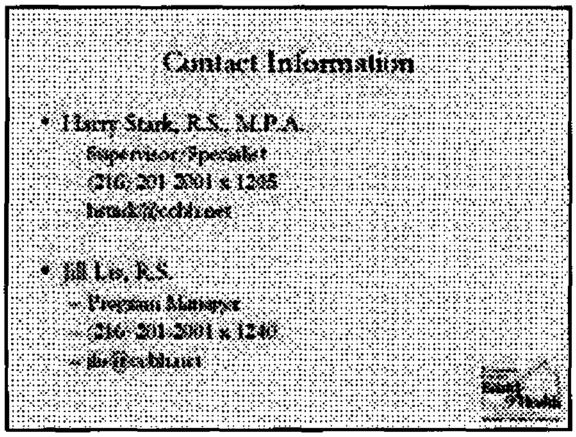

Program Component
Sanitary Surveys
Allows for the determination of site suitability for beaches
Surveys focus on items that could impact the health and safety of bathers


Beach Act Projects
Summer 2003/2004
Development of a risk-based beach evaluation and classification plan
Partially accomplished through the identification and monitoring of any storm sewer outfalls/streams that were found to be located on, or near, the beaches




29800 Lake Road – East Outfall
2004
2003




Contact Information
• Harry Stark, R.S., M.P.A.
Supervisor/Specialist
(216) 201-2001 x 1285
• Jill Lis, R.S.
– Program Manager
– (216) 201-2001 x 1240

Questions and Answers

No questions.

Diversion is the Solution to Pollution, So Far

Cathy Chang, D.Env.
Santa Monica Bay Restoration Commission

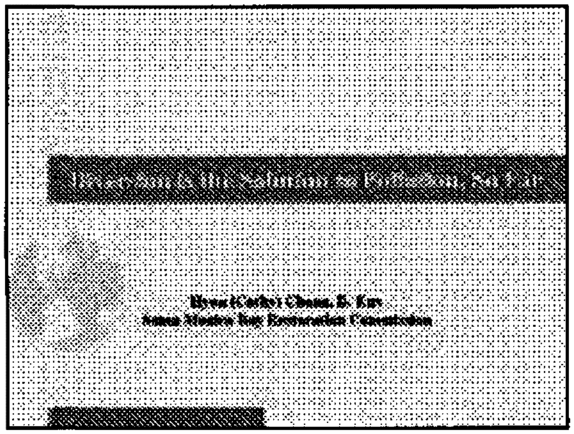
Biosketch

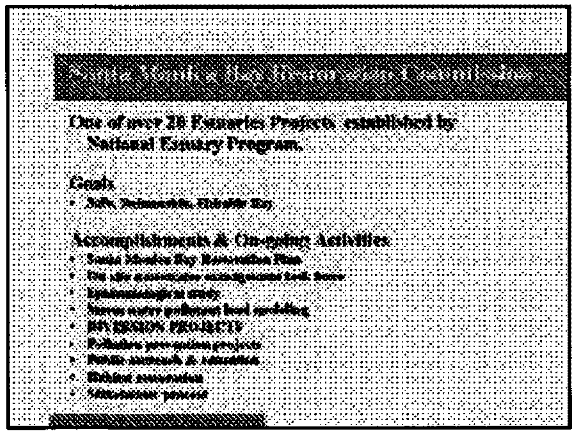
Dr. Cathy Chang is a water resource control engineer at the Santa Monica Bay Restoration Commission. Dr. Chang received her B.S. in Physics, her M.S. in Civil & Environmental Engineering, and her D.Env in Environmental Science and Engineering-- all three degrees from U.C.L.A, California. She worked on storm water and urban runoff pollution regulation and policy for several years at the Los Angeles Regional Water Quality Control Board. For the past four years, she has been a staff for the Santa Monica Bay Restoration Commission, where she has completed a comprehensive assessment of storm water programs in Los Angeles County and oversees projects that provide regional solution to storm water and TMDL issues in the Santa Monica Bay Watershed.

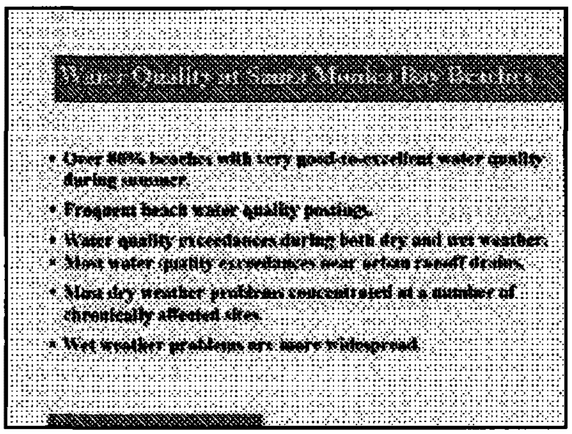
Abstract

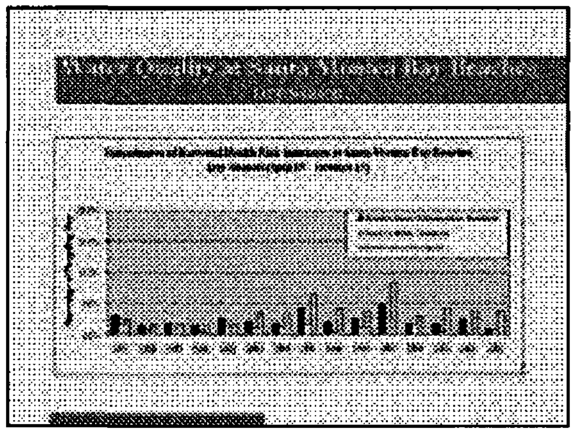
In the late 1980's, alarmed by the evidence that dry-weather urban runoff is the main cause of bacterial contamination at beaches along Santa Monica Bay, California, Los Angeles County public agencies began testing and implementing various pollution control measures. Many of these measures were fully or partially funded by the Santa Monica Bay Restoration Commission (SMBRC). Measures ranged from source control to end-of-pipe solutions, and included programs to conduct sanitary surveys, detect illicit connections, reduce street washing, extend storm drain outlets beyond surf zones, and divert runoff to sanitary sewers or on-site treatment facilities.

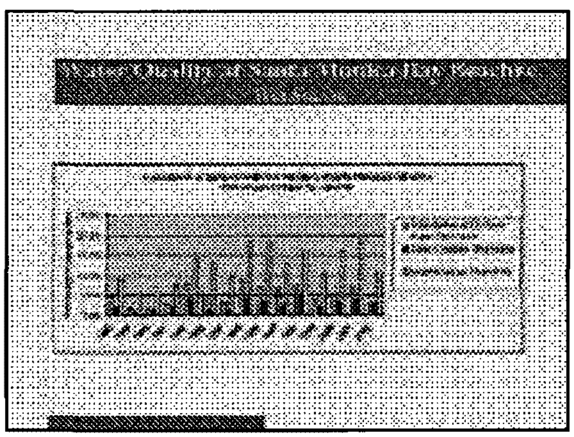
Meanwhile, valuable monitoring data, collected concurrently with project implementation, has allowed agencies to evaluate the feasibility and effectiveness of many of these measures. Currently, diversion of runoff to sanitary sewers appears to be the most effective measure. Pre- and post diversion monitoring data at several project locations indicates a rapid and significant improvement in water quality. Data have also shown that on-site treatment can be equally effective if properly sited and the treatment method is appropriate to the on-site conditions. Failures have also yielded valuable lessons. Even some of the diversions which were highly effective initially, have required modifications to correct deficiencies in their original engineering designs.

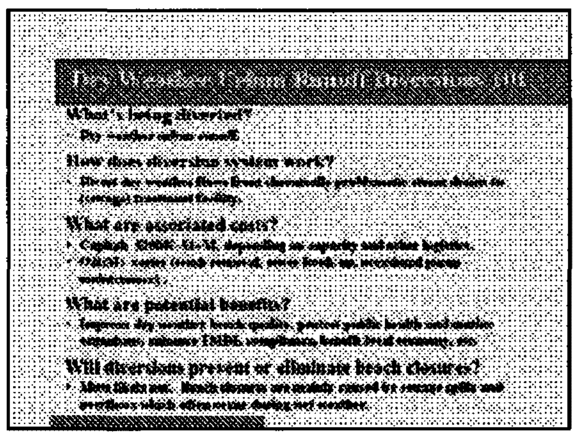


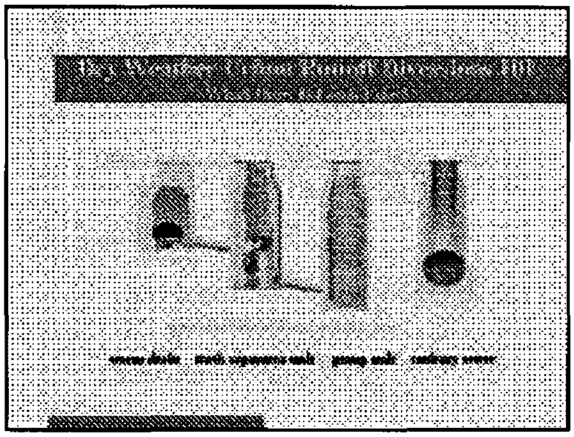

One of over 28 Estuaries Projects established by National Estuary Program.
Goals
Accomplishments & On-going Activities
Santa Monica Bay Restoration Plan
Pollution prevention projects
Public outreach & education
Habitat restoration

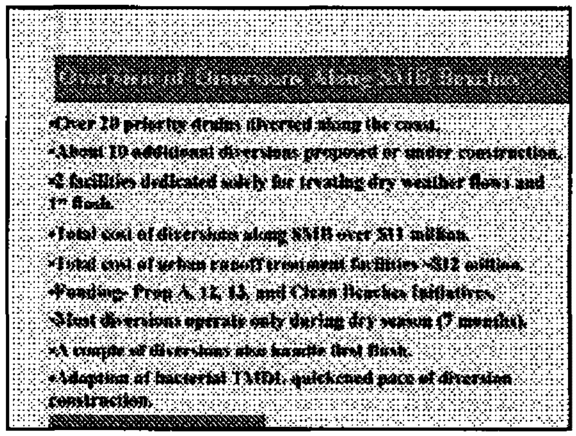

Water Quality at Santa Monica Bay Beaches
• Over 80% beaches with very good-to-excellent water quality during summer.
• Frequent beach water quality postings.
• Water quality exceedances during both dry and wet weather.
• Most water quality exceedances near urban runoff drains.
• Most dry weather problems concentrated at a number of chronically affected sites.
• Wet weather problems are more widespread.

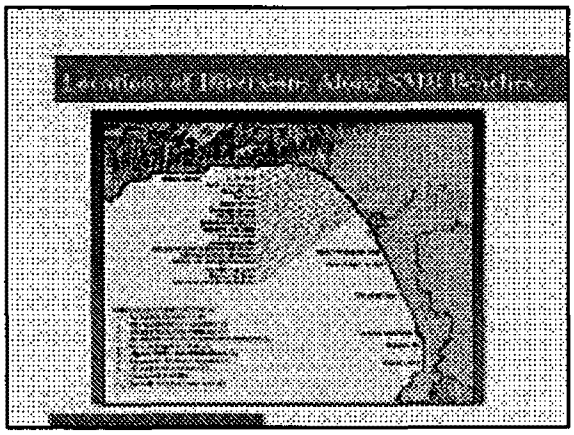


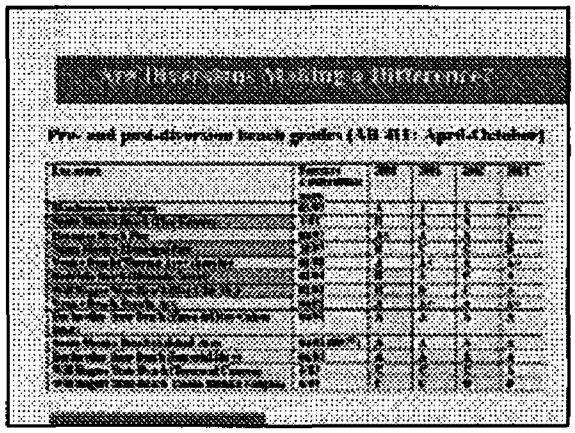


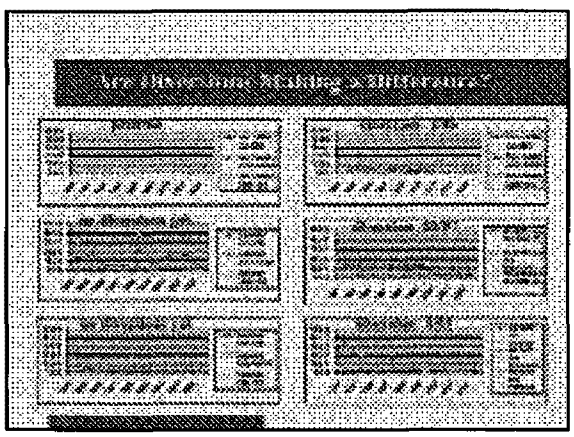

What's being diverted?
How does diversion system work?
What are associated costs?
What are potential benefits?
Will diversions prevent or eliminate beach closures?

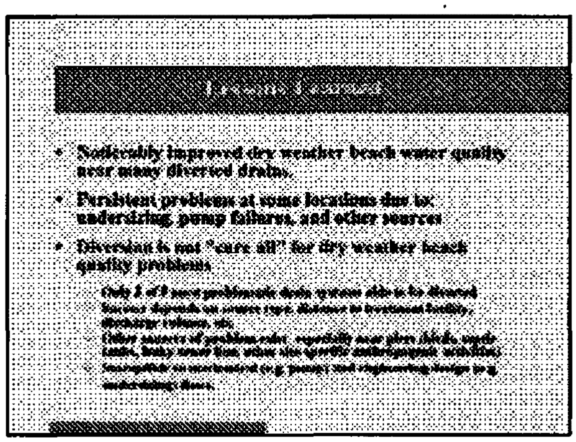

storm drain
trash separator unit
pump unit
sanitary sewer

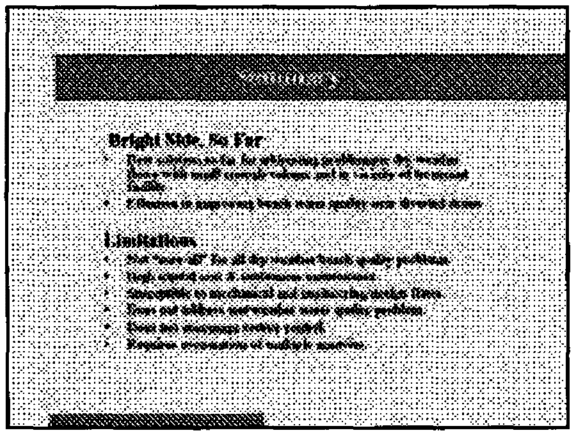

•Over 20 priority drains diverted along the coast.
•About 10 additional diversions proposed or under construction.
•2 facilities dedicated solely for treating dry weather flows and 1st flush.
•Total cost of diversions along SMB over $11 million.
•Total cost of urban runoff treatment facilities ~$12 million.
•Funding- Prop A, 12, 13, and Clean Beaches Initiatives.
•Most diversions operate only during dry season (7 months).
•A couple of diversions also handle first flush.
•Adoption of bacterial TMDL quickened pace of diversion construction.


Locations of Diversions Along SMB Beaches


Are Diversions Making a Difference?
Pre- and post-diversion beach grades (AB 411: April-October)


Are Diversions Making a Difference?


Noticeably improved dry weather beach water quality near many diverted drains.
Persistent problems at some locations due to: undersizing, pump failures, and other sources
Diversion is not "cure all" for dry weather beach quality problems


Bright Side, So Far
Limitations

Questions and Answers

Q: (Diana Munz). When you are able to see water quality improvements from this, do you just see it immediately downstream of the diversion, or are you able to show reduced postings at the receiving beach?

Cathy Chang

It is tricky in Los Angeles County to talk about postings because when the storm drains have continuous flows they have permanent postings. I assume the postings have disappeared for the permanent ones, where ifnprovements have been seen.

Mark Gold

That is true for some of them. They have reduced postings for the ones that are not permanent and flowing. It has been a pretty positive program.

Q (Steve Hartsel, San Mateo County): Have you done a follow-up epidemiological study that shows the actual health effects of the improvement of the water quality here?

Cathy Chang

No we have not.

Q (Steve Hartsel, San Mateo County): Are there any plans to do so? It seems like it would be the logical thing to do,.

Mark Gold

No. With the epidemiology design, it would not be logical. That is because the way the study was designed was comparing swimmers to swimmers. So, the controls were those swimming right in front of the storm drains compared with those swimming 400 yards away in cleaner conditions. So, one would expect that it would be a similar outcome to when you actually remove the pollution source. There is no reason to think that they would be a different population.

Q (Steve Hartsel, San Mateo County): That wouldn't be confirmation to go back and test in the same place and do the same surveys?

Mark Gold

Not for a million dollars, which was the cost of the study.

Thursday, October 14

8:00 a.m. – 9:40 a.m.

Concurrent Track II:

Changes on the Horizon

Session Eight: Making Warning Systems More Rapid: Modeling and Rapid Methods

A Regional Nowcast Model for Southern Lake Michigan Using Data Readily Available to Beach Managers

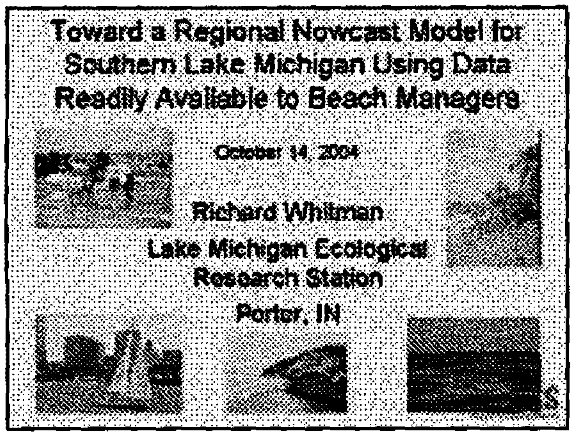
Richard Whitman
U.S. Geological Survey, Great Lakes Science Center

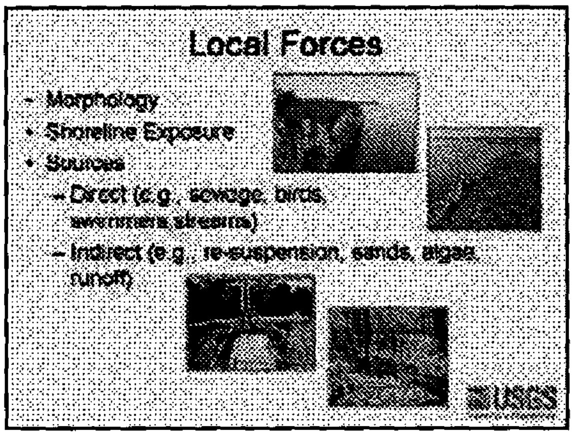
Biosketch

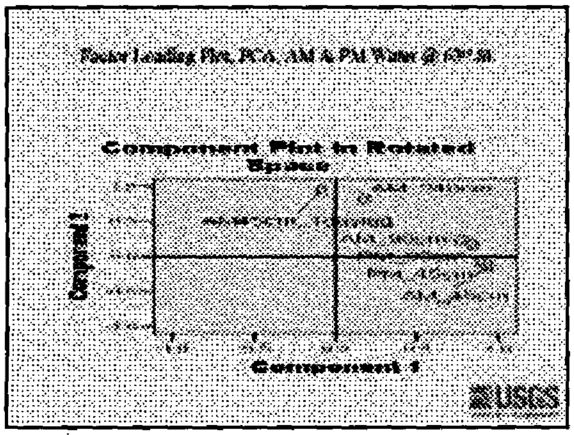
Dr. Whitman is the station chief and research ecologist at the U.S. Geological Survey Lake Michigan Ecological Research Station. Dr. Whitman received his Ph.D. from Texas A&M University in Wildlife and Fisheries Science. He went on to teach at Indiana University NW for 10 years as an associate professor of biology. He became a research biologist with the National Park Service and then the U.S. Geological Survey Great Lakes Science Center, where he has worked for the past 15 years. Dr. Whitman's research interests include sources and occurrence of bacteria contamination in sands and waters of Lake Michigan and the relationship of hydrometeorological and antecedent biological conditions to indicator bacteria contamination in freshwater streams and beaches.

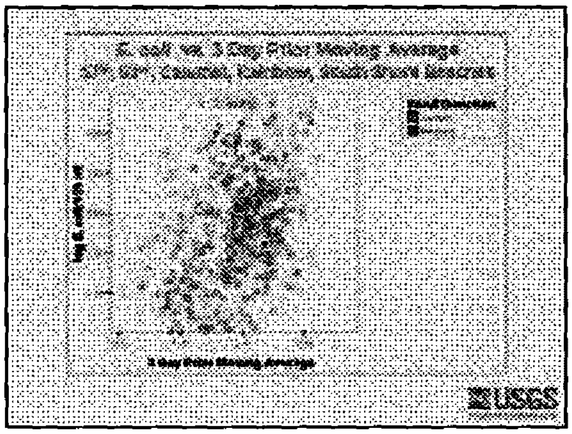
Abstract

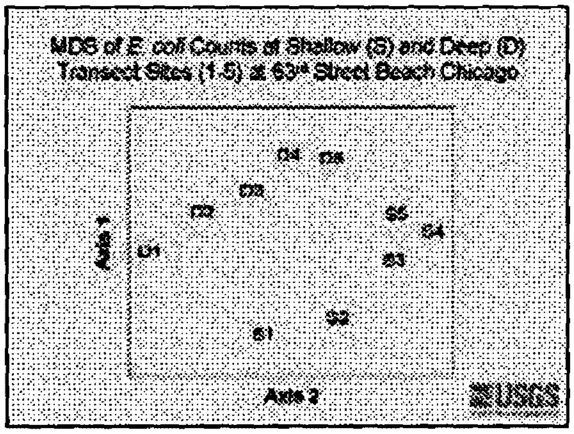
In recent years predictive modeling of beach water quality from retrospective empirical local hydrometerological measurements have become common. Factors influencing recreational water quality are both local (e.g., sewage, hydrodynamics, morphology) and regional (e.g., weather patterns, currents, antecedent conditions). We explore regional factors that help explain *E. coli* concentrations with hopes of later partitioning these from local effects. *E. coli* data from 55 beaches along 217 km shoreline from Milwaukee, Wisconsin to Michigan City, Indiana were assembled for 2000-2003 in addition to ambient and derived data from national, state and local weather stations, wave dynamic installations and lake buoys. Local *E. coli* spatial correlation was clearly evident. This fine-grain spatial pattern was layered within seven larger scaled geographic zones. Regression demonstrated that rainfall, wind speed, solar radiation, wave height, barometric pressure, and antecedent *E. coli* were important factors. While there were strong seasonal trends and multi-day momentum of *E. coli*, there was only weak daily autocorrelation. Resultant regression models yield coefficients that were several times higher than those predicted by currently used protocols (i.e., 24-hour lag between collection and closure). Discriminant functions correctly classified a beach closure or opening most of the time using these hydrometeorological conditions, whether or not the beaches were aggregated by wind direction, zone or day. These models demonstrate local differences among beaches and the explanatory factors, provide reasonably good real-time predictions, and help explain general hydrometeorological interactions with recreational water quality. All independent factors are readily available on the Internet and through cooperation among beach managers.

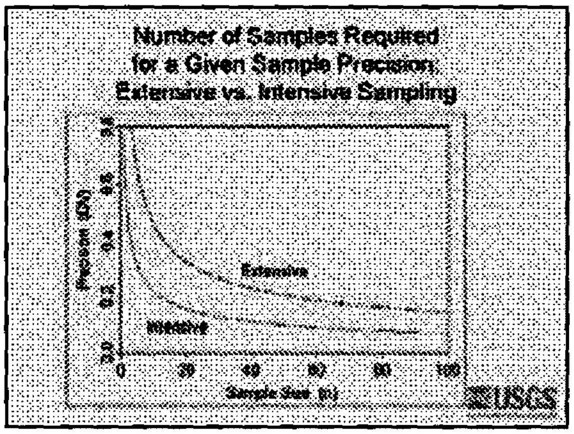

Toward a Regional Nowcast Model for Southern Lake Michigan Using Data Readily Available to Beach Managers
October 14, 2004
Richard Whitman
Lake Michigan Ecological Research Station
Porter, IN

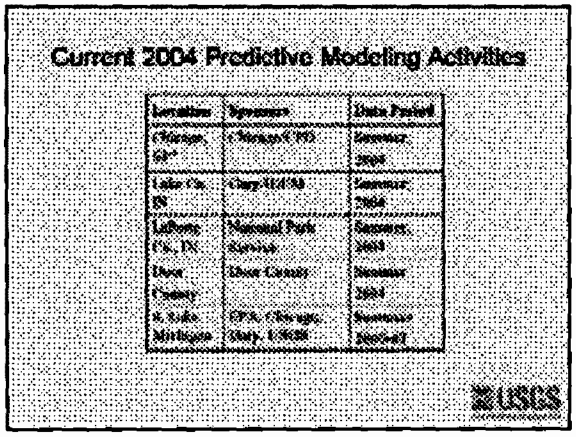

Local Forces
• Morphology
• Shoreline Exposure
• Sources
– Direct (e.g., sewage, birds, swimmers, streams)
– Indirect (e.g., re-suspension, sands, algae, runoff)
USGS


Component Plot in Rotated Space
Component 1
USGS

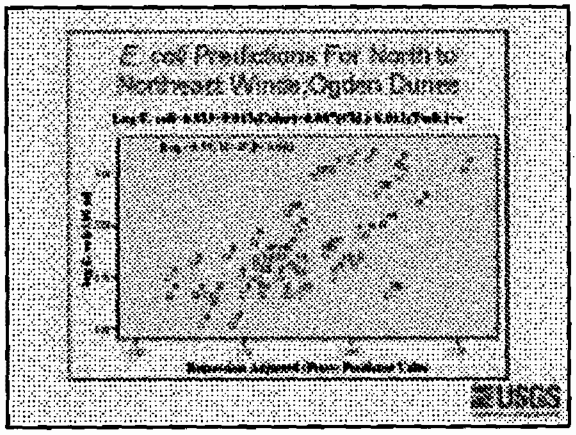

3 Day Prior Moving Average
USGS

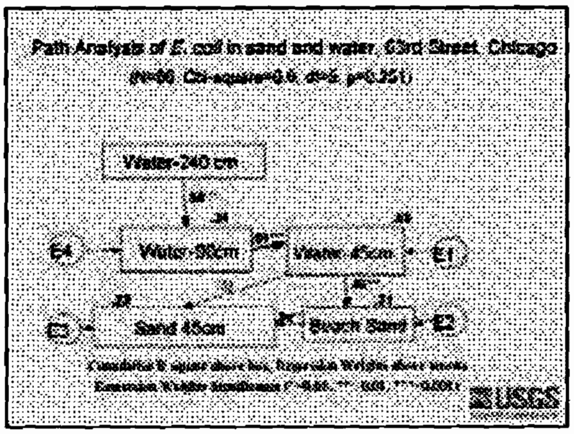

MDS of E. coli Counts at Shallow (S) and Deep (D) Transect Sites (1-5) at 63rd Street Beach Chicago
D4
D5
D3
D2
S5
S4
D1
S3
S2
S1
Axis 1
Axis 2
USGS

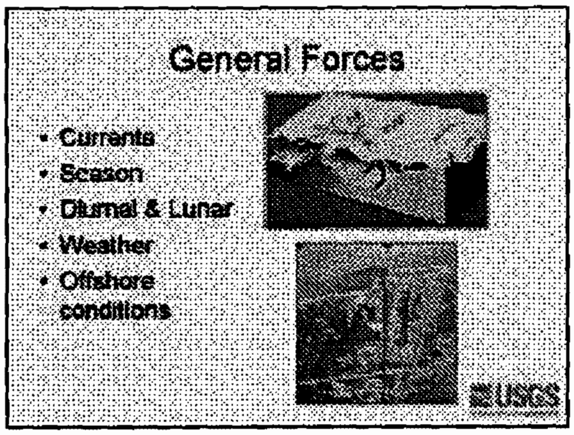

Number of Samples Required for a Given Sample Precision, Extensive vs. Intensive Sampling
Extensive
Intensive
0
20
40
60
80
100
Sample Size (n)
USGS

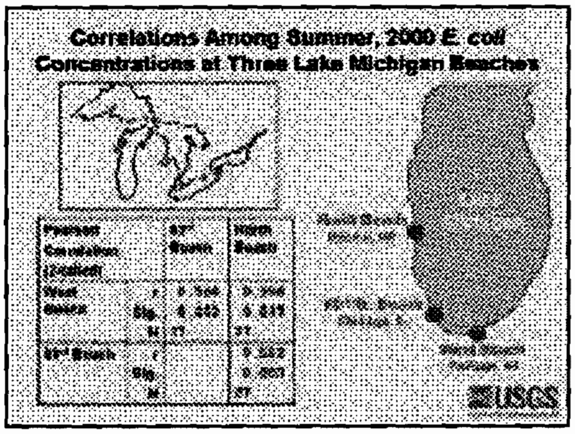

Current 2004 Predictive Modeling Activities
Location
Sponsors
Data Period
USGS

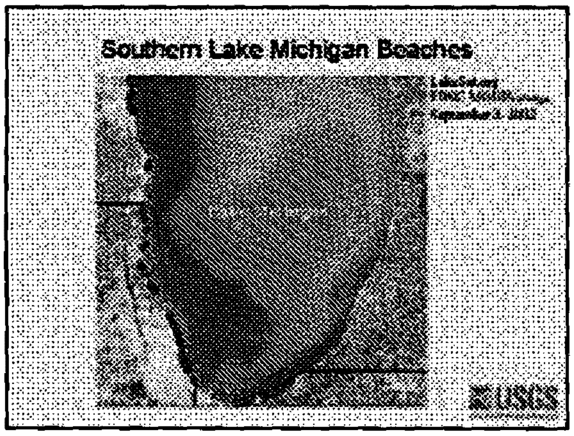

Burns Ditch: Westerly Wind
USGS

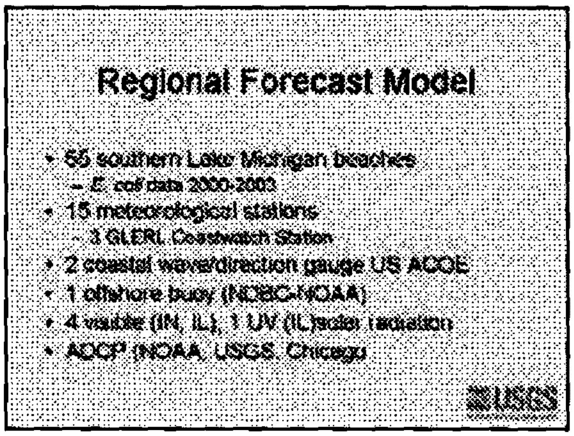

E. coli Predictions For North to Northeast Winds, Ogden Dunes
USGS

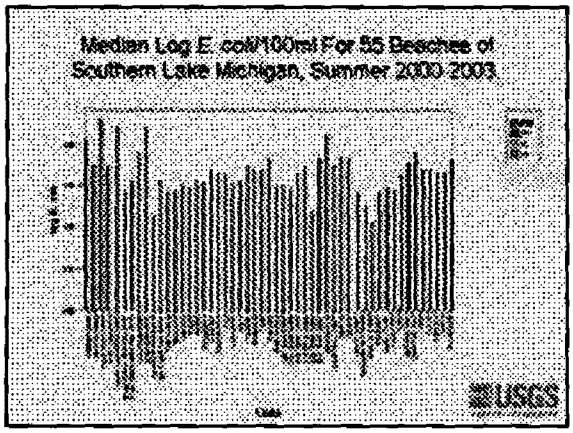

Path Analysis of E. coli in sand and water, 63rd Street, Chicago
Water-240 cm
Water-90cm
Water-45cm
Sand 45cm
Beach Sand
E1
E2
E3
E4
USGS

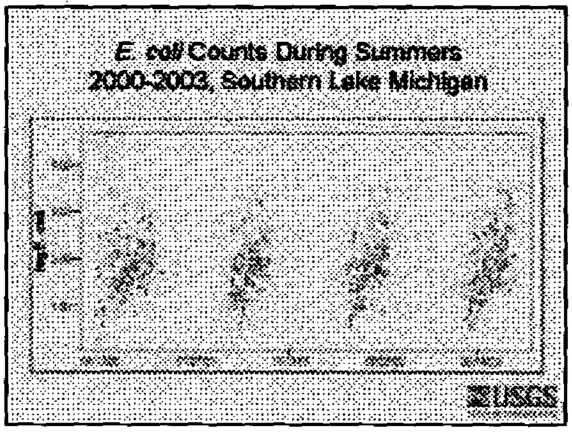

General Forces
• Currents
• Season
• Diurnal & Lunar
• Weather
• Offshore conditions
USGS

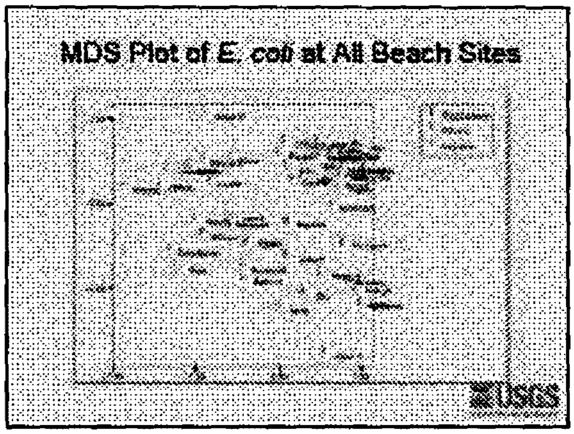

Correlations Among Summer, 2000 E. coli Concentrations at Three Lake Michigan Beaches
USGS

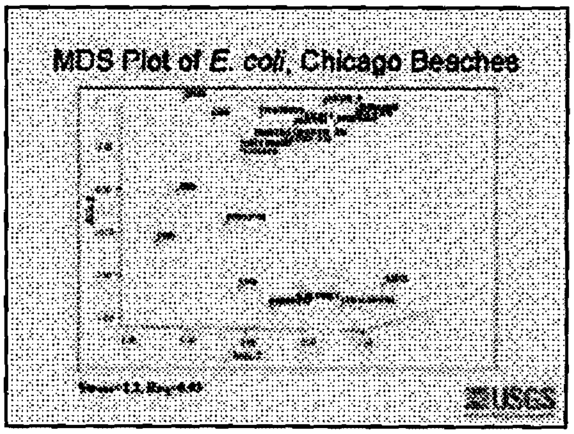

Southern Lake Michigan Beaches
USGS

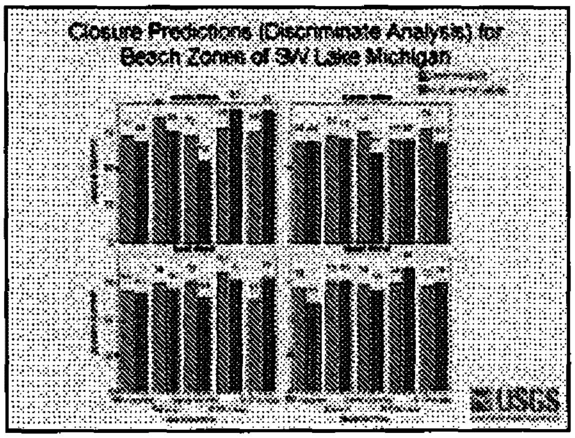

Regional Forecast Model
• 55 southern Lake Michigan beaches
– E. coli data 2000-2003
• 15 meteorological stations
– 3 GLERL Coastwatch Station
• 2 coastal wave/direction gauge US ACOE
• 1 offshore buoy (NDBC-NOAA)
• 4 visible (IN, IL), 1 UV (IL)solar radiation
• ADCP (NOAA, USGS, Chicago
USGS


Median Log E. coli/100ml For 55 Beaches of Southern Lake Michigan, Summer 2000-2003
USGS


E. coli Counts During Summers 2000-2003, Southern Lake Michigan
USGS


MDS Plot of E. coli at All Beach Sites
USGS


MDS Plot of E. coli, Chicago Beaches
USGS



Wind Direction		Function 1
Southerly	EC_3dayPMA	.735
	Rain	.441
	Temp_10PMA	.350
	Stage	.295
	Wave ht	.264
	Insolation*	-.137
	Windspeed*	.063
	Pressure*	.023

Correlations between Discriminating Variables and Canonical Discriminant Functions

a. Variable not used in the analysis (p<0.05)

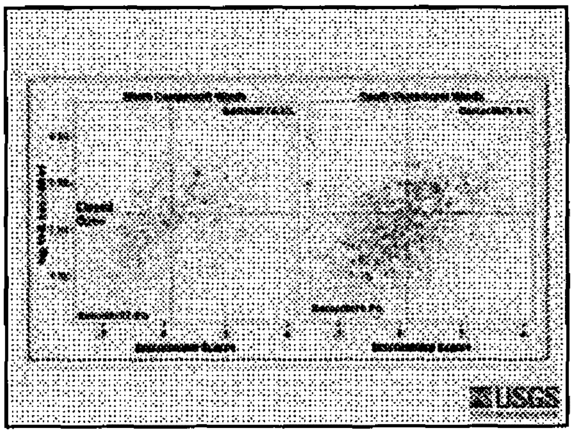
USGS

Wind Direction		Function 1
North Component	Wind Speed	.531
	Stage	.529
	Wave Ht.*	.443
	Rain	.436
	EC_PMA	.348
	Insolation*	-.134
	Pressure*	.080
	Temp_PMA*	.025

Correlations between Discriminating Variables and Canonical Discriminant Functions

a. Variable not used in the analysis (p<0.05)

USGS



Acknowledgments

Cities of Milwaukee, Racine, Chicago, Gary, National Park Service, Chicago PD, Indiana DNR, Lake County IL, USGS, EPA, GLERL, US ACOE, IN Dept. of Environment, NWS, State Meteorologists: IL, IN and WI.

USGS

Richard Whitman
Lake Michigan Ecological Research Station
Great Lakes Science Center
Porter, IN

Phone: (219) 926-8336 ext. 424
Fax: (219) 929-5792
Email: richard_whitman@usgs.gov

Questions and Answers

See Questions and Answers for Greg Olyphant on page 243.

Predicting the Need for Beach Closures in Real Time: Statistical Approaches and their Applicability to the Lake Michigan Shoreline

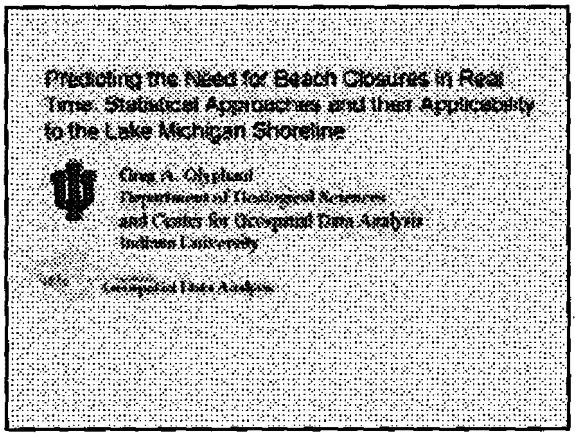
Greg Olyphant
Indiana University, Department of Geological Sciences

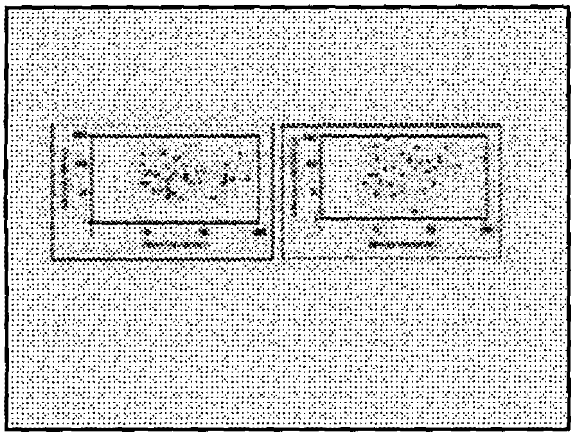
Biosketch

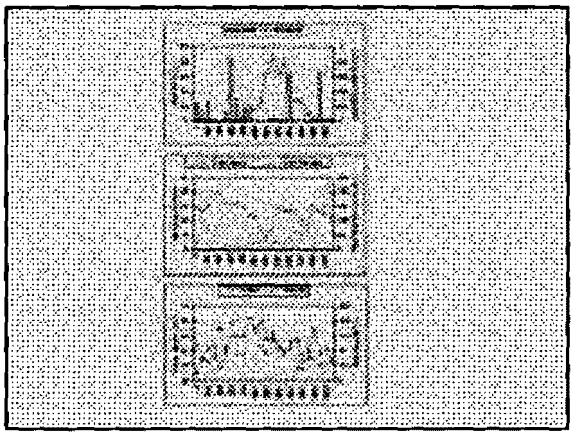
Dr. Olyphant has been a professor of hydrology at Indiana University (Bloomington) since 1980. He has been a member of the Interagency Task Force on *E. coli* (focused on the southern Lake Michigan shoreline) since its inception in 1995. He has published several papers that demonstrate the functional relationships between hydrometeorological conditions and bacterial concentrations in streams and beach waters. He has also served as a consultant to public health officials and park administrators on issues of water quality and methods for posting advisories and closures.

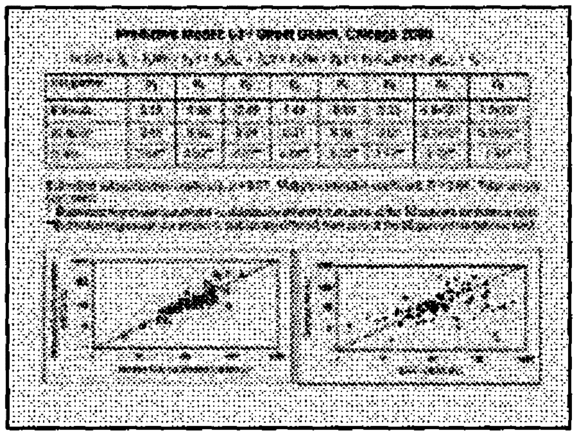
Abstract

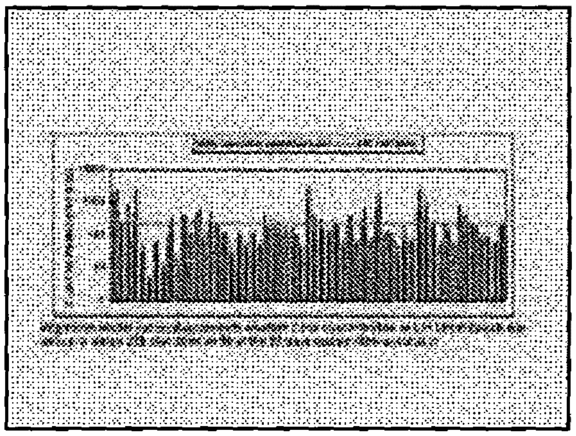
A long record of water quality data, from numerous beaches along the Lake Michigan shoreline, has shown that knowing what *E. coli* concentrations were on a given day (day of sample collection) rarely provides an accurate prediction of what the concentrations are on the next day (day of decision). This is because the concentrations in beach water strongly depend on short-term changes in prevailing hydrometeorological conditions. For example, during stormy periods, increased inflows of contaminated stream water, and stirring of bacterially laden sands in the nearshore zone can cause *E. coli* concentrations to spike for several hours. On the other hand, the concentrations can decline by an order of magnitude during calm weather when suspension is low and bacteria have been exposed to long periods of intense sunshine. A recent pilot study (63rd Street Beach, Chicago, 2000) has demonstrated that by continuously monitoring hydrometeorological conditions, a statistical model can be developed to accurately predict bacterial concentrations in beach water so that real-time decisions can be made about posting warnings and closures. Beach Act funds are being used to test and refine the modeling approach at two additional locations along the southern shoreline of Lake Michigan. An overview of the model formulation and summary of experimental results at the two new study sites will be the main focus of the current presentation.


Predicting the Need for Beach Closures in Real Time: Statistical Approaches and their Applicability to the Lake Michigan Shoreline
Greg A. Olyphant
Department of Geological Sciences
and Center for Geospatial Data Analysis
Indiana University
Geospatial Data Analysis



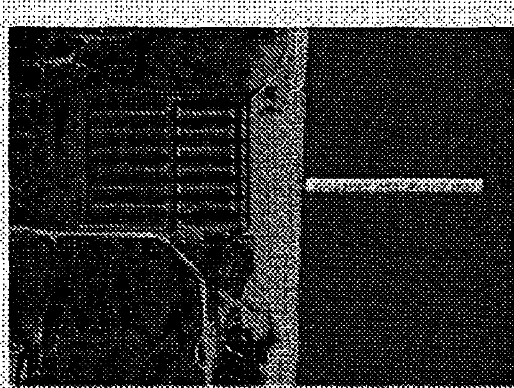


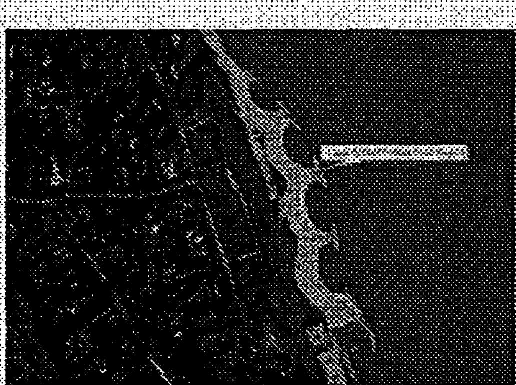


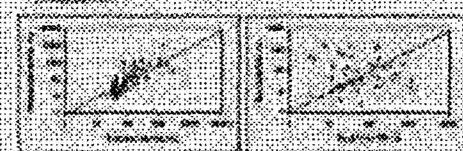


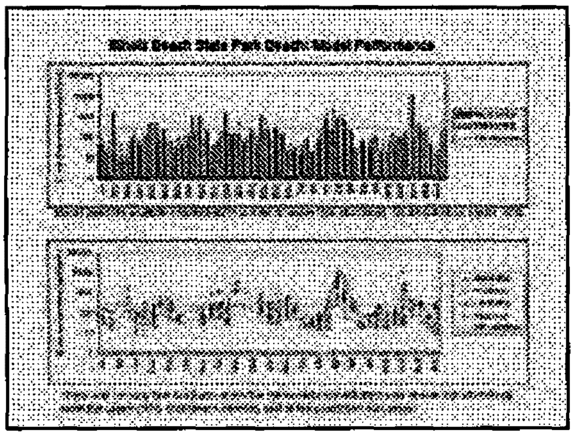
Some Recommendations that Should lead to an Improved Early Warning System for Beach Closures/Advisories

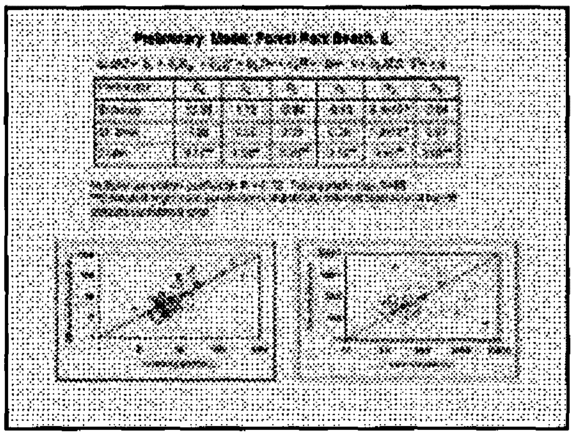
- Use electronic instruments that can be averaged/totalize over appropriate intervals for real-time forecasting.
- Deploy sensors in or near to the surf zone at each beach of concern.
- Place meteorological towers close to the beach(s) of concern.
- Install a gauge and other appropriate sensors at stream outlets (if one is near by) and monitor E.coli to develop a predictive model for outfalls from inland watersheds.
- 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 beach risk warnings or making closure decisions.

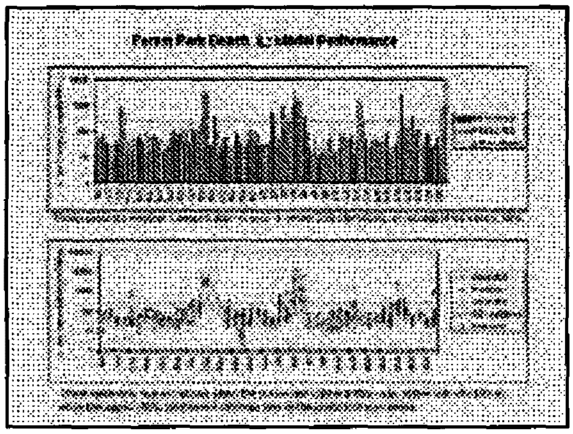


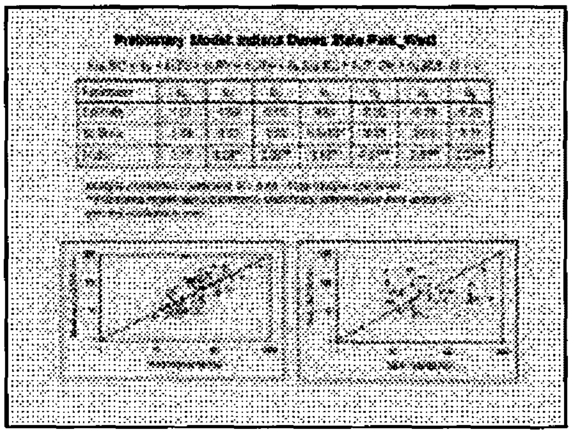


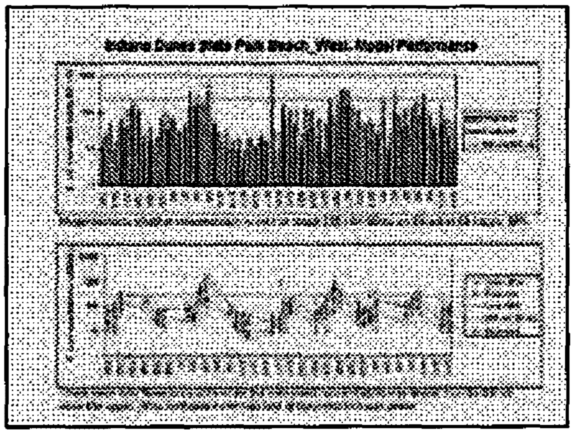


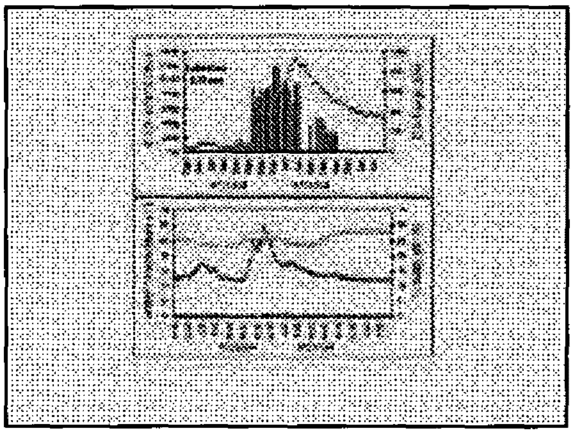


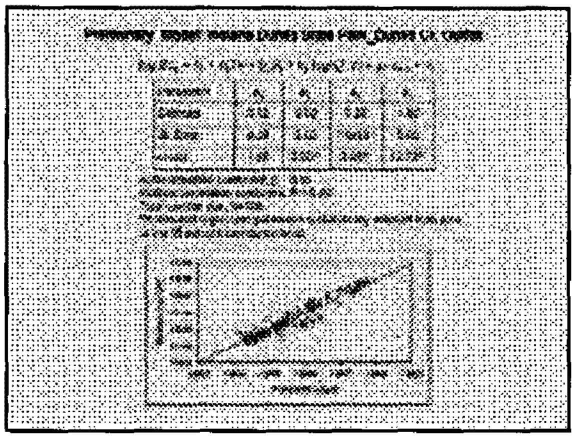


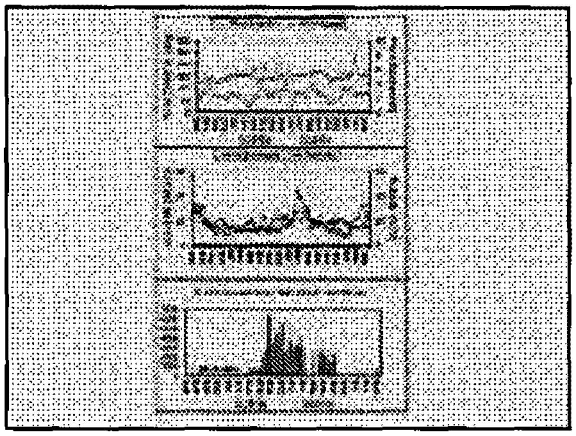


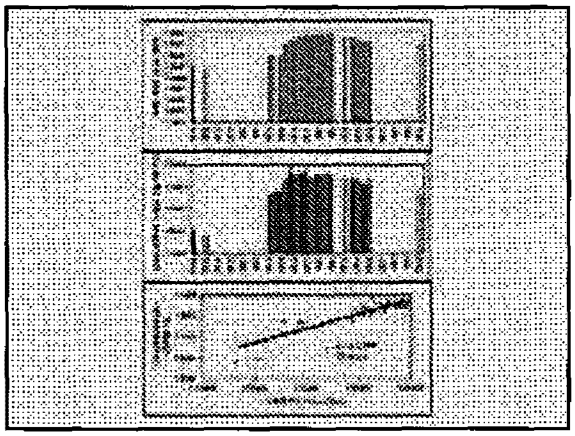


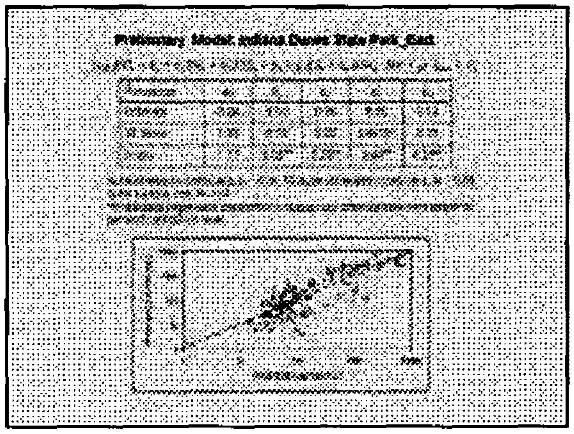


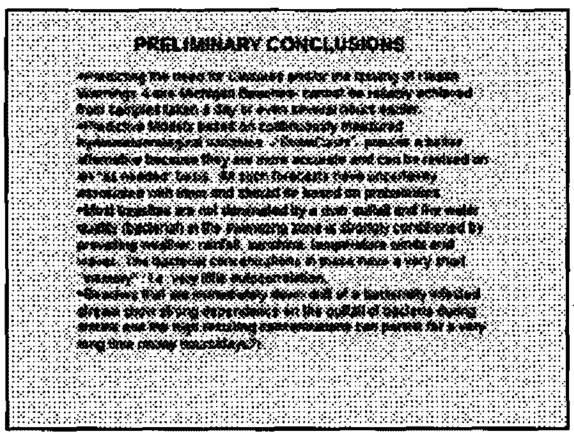











PRELIMINARY CONCLUSIONS

Questions and Answers

Q: You are located right next to United States Steel and some other steel manufacturers. Do the outfalls from the steel manufacturers located nearby have an effect on the beaches in the national park?

Greg Olyphant

The beach I'm talking about is not as close to the steel plants as the one Richard referred to in a previous slide. The U.S. steel plants are doing a good job of trying to improve their water quality and have invited the *E. coli* Taskforce (an interagency taskforce in Indiana) to incorporate their outfalls into the *E. coli* monitoring data that was collected for several years. I think the biggest culprits are the streams that are draining relatively large watersheds with a variety of land uses in them and have many sources of bacteria.

Q: U.S. Steel rechanneled the Grand Calumet River at one time, early in its history, so that the entire Grand Calumet River consisted of the effluent from the steel plant.

Greg Olyphant

The Grand Calumet is another issue. I thought you were referring to the Little Calumet River.

Q: Yes, I was talking about that too.

Greg Olyphant

The Grant Calumet is definitely another beast far to the west of us, and I haven't had the opportunity to look closely or model any of the beaches affected by its outfall.

Q (Steve Weisberg, SCCWRP): You (Greg) and Richard both made very compelling cases that your modeling efforts provide superior prediction to actual conditions than yesterday's measurements. I have a three-part question. First, do you think your models are sufficiently advanced that you would recommend that people should be using them in place of yesterday's samples for beach warnings? Second, are people using them in that case? Third, if they are not, what do you perceive as the biggest gap that keeps them from moving in that direction?

Greg Olyphant

I'll speak for the five cases that I have been involved in. Yes, I recommend that every beach initiate a monitoring program along with their existing monitoring program for water quality to monitor hydrometeorological conditions with an eye towards developing a forecasting model, but never cease actual water quality monitoring because that will be the basis for improving the ability of the model in the long haul, validating it in cases of possible litigation, and rejecting it if it's bad in the long haul. Basically, I think having one good correlation set in 2063rd beach, I was not very confident. But, having three additional sites this year at similar beaches that gave almost identical results makes me feel far more confident. However, I am not sure at all about ocean beaches because I have not had the opportunity to work in one of those.

Q: (Steve Weisberg) Are people adopting them at this point?

Greg Olyphant

I think Chicago beaches are moving towards predictive modeling. The interagency taskforce in the last meeting that I attended said that this is what we should be pushing. Every municipality should make the investment for the model, because the overall investment is not that great, but it would allow themselves to have a much more effective basis for warning the public and having a comfort factor of their own in regards to the decisions they are making. In Michigan, people are very uncomfortable with their decisions because they have seen the history of false positives.

Comment (Richard Whitman, USGS): It is difficult to isolate your individual questions because there are political, social, and health concerns that all interact in a manager's mind when he or she asks, "am I going to go with an untested, unvalidated by EPA tool in lieu of something that I know is safe?" If they allow people in the water, then as long as they use the EPA recommended guidelines and results from samples collected yesterday were good, then they feel they are okay legally in terms of protecting the public. I don't know anyone that will throw away the EPA guidelines and switch completely to the predictive mode. I think they will use the model as a supplement to the monitoring.

High Frequency Radar Provides Real Time Data for Enhancing Beach Monitoring Programs

Eric Terrill
Scripps Institution of Oceanography, University of California at San Diego

Biosketch

(Not submitted)

Abstract

(Not submitted)

Questions and Answers

No questions.

Rapid Measurement of Bacterial Fecal Pollution Indicators at Recreational Beaches by Quantitative Polymerase Chain Reaction

Richard Haugland
U.S. Environmental Protection Agency, Office of Research and Development

Biosketch

Dr. Haugland is microbiologist in the Microbiological & Chemical Exposure Assessment Research Division, National Exposure Research Laboratory, Office of Research and Development. He received a B.S. in Biology at Muskingum College and a Ph.D. in Developmental Biology at the Ohio State University. His past research has addressed diverse problems including improvement of nitrogen fixation in crops, biodegradation of hazardous chemicals in the environment, assessment of the microbiological quality of indoor environments, and most recently, water quality monitoring and homeland defense. A common component of all of these research activities has been the application and development new molecular technologies. Dr. Haugland joined the USEPA in 1991. Since then he has authored or co-authored over 20 publications and has received a number of awards for his work including the EPA bronze and gold medals.

Abstract

Previous studies have demonstrated that measurements by the membrane filtration (MF) method of Enterococcus fecal indicator bacteria in recreational beach water samples are correlated with swimming-associated gastroenteritis. This relationship currently serves as a basis for recommended guidance by the USEPA on unacceptable health risks associated with swimming in both fresh and marine waters. The MF method, however, requires at least 24 hours for results and during this delay swimmers may be exposed to unsafe waters. The quantitative polymerase chain reaction (QPCR) method is presently being evaluated as a possible alternative to MF. Water analyses using this technology can provide results in approximately 2 hours. In the summer of 2003, studies were conducted by several organizations including USEPA, Office of Research and Development, USEPA Region I, and the Southern California Coastal Water Research Project at both freshwater and marine beaches to determine the correlation between results of the QPCR and MF methods. Two of these studies also tested a newly developed assay for fecal indicator bacteria in the class Bacteriodetes and collected data on swimmer illness rates that are being compared with the QPCR and MF results. In recognition of the performance of this method to date, the USEPA Office of Water is considering its use as a reference method in performance evaluations of alternative nucleic acid tests for fecal contamination in ambient waters. This presentation will provide an overview of the QPCR method, describe its present application for beach water quality analysis and discuss the relationship between QPCR and MF measurements of enterococci based on comparative data from several studies.

1

Rapid Measurement of Bacterial Fecal Pollution Indicators at Recreational Beaches by Quantitative Polymerase Chain Reaction

Richard A. Haugland
USEPA, Office of Research and Development, National Exposure Research Laboratory

Presented at National Beaches Conference, October 13-15, 2004

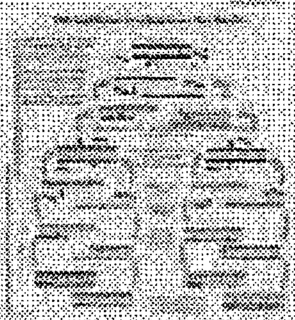
2

How Does Quantitative PCR Analysis Work?

Principles of QPCR Analysis

3

PCR: POLYMERASE CHAIN REACTION



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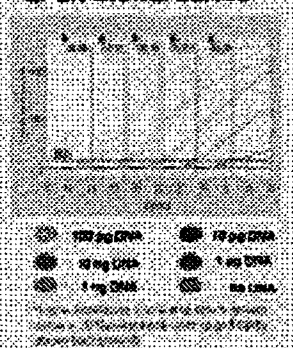
QPCR Growth Curves



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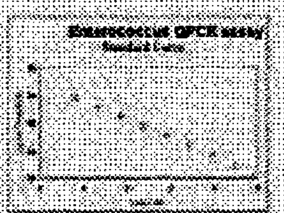
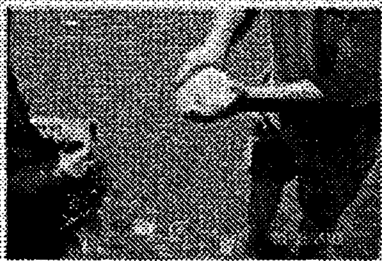


6

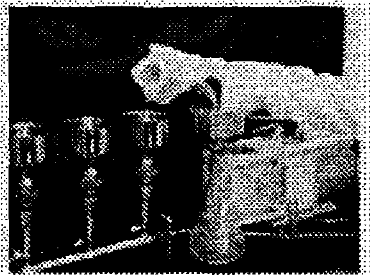
10 Steps and 2 Hours to Recreational Water Quality Results

Procedures for Quantitative PCR analysis of fecal indicator bacteria

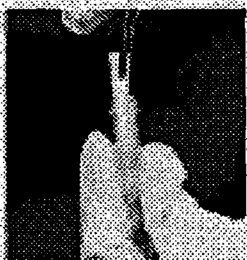
Step 1. Collect water sample



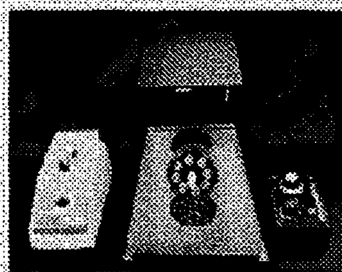
Step 2. Filter water sample



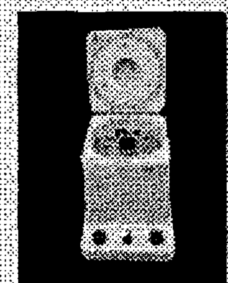
Step 3. Transfer filter to extraction tube containing glass beads, buffer and positive control DNA



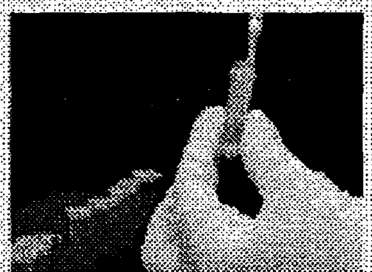
Step 4. Bead mill filter membrane for 1 min to break cells and release DNA



Step 5. Centrifuge briefly



Step 6. Recover liquid sample with released DNA from extraction tube



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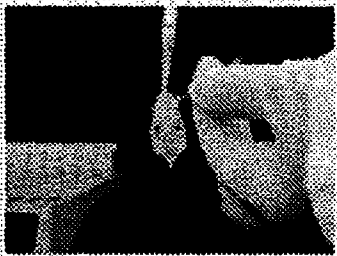
Step 7. Transfer sample to reaction tube containing PCR reagents

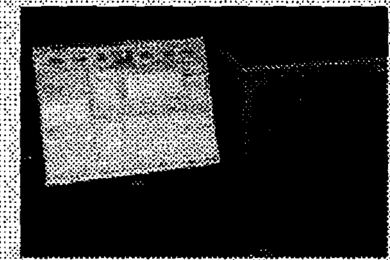


14

Step 8. Place reaction tube in real-time thermal cycler

15

Step 9. Run reaction in thermal cycler



16

Step 10. Import run data into spreadsheet and calculate target cells in sample

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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17

Epidemiological and Environmental Assessment Studies

QPCR vs. Membrane Filtration Results

18

U.S. EPA, N.E.E.A.R. Study, 2003-2007

- Two Freshwater Beaches in 2003:
  - [illegible]
  - [illegible]
- [illegible]
  - [illegible]
  - [illegible]
  - [illegible]
  - [illegible]
- [illegible]
- [illegible]

Southern California Coastal Water Research Project, Mission Bay Study, 2003

- [illegible]
- Water monitoring protocol similar to EPA study:
  - [illegible] sampling locations / beach
  - [illegible] sampling [illegible] / day
  - [illegible] days / week (weekends and holidays)
  - [illegible] weeks / beach
- Survey of swimming-associated health outcomes
- Same analysis of methods as EPA study – QPCR and Membrane Filtration for enterococci in water samples

2004 Rapid Methods Comparison Study

Organized by Southern California Coastal Water Research Project

Study Design

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

Future Advances in Methodology

- Elimination of Interferences
- Improved Positive Control Assays
- Bacteroides assay

Conclusions

- QPCR results to date show good correlation with results of the current MF method (particularly at high pollution levels) and also with health data
- The QPCR method may be useful at this time as a warning system for high pollution levels but confirmation with other methods is still recommended
- Results from ongoing epidemiological studies may lead to the development of new criteria for beach closings based on same day measurements by this method

Questions and Answers

No questions.

Recreational Water Testing by Rapid, High-Throughput Real-Time Quantitative PCR (QPCR) for Fecal Indicators

Jack Paar
U.S. Environmental Protection Agency, New England Region Lab

Biosketch

Mr. Jack Paar, III is Biologist with the US Environmental Protection Agency, New England Regional Laboratory, Office of Environmental Measurement and Evaluation, Ecosystem Assessment Unit, Ecology Monitoring Team, in North Chelmsford, MA. Mr. Paar majored in Oceanography at the US Naval Academy from 1975 to 1977. After honorable discharge from the Navy he transferred to Northeastern University (NU) in Boston, MA and participated in the Co-Op Education Program. Mr. Paar worked as a Student Biologist from 1979 through 1981 in the US EPA New England Regional Laboratory, Lexington, MA Biology Section. Assisting senior biologists in both field assessment and laboratory analysis he gained considerable experience in sediment oxygen demand assessments, whole effluent toxicity testing, and test organism culturing. Upon graduation in 1981with a B.S. in Biology Mr. Paar worked until 1990 as the Laboratory Manager of NU's Marine Science Center (MSC) in Nahant, MA. While at the MSC he worked as marine aquarist, rocky sub-tidal ecology research diver, research photographer, and diving safety officer. In 1990 Mr. Paar once again joined the ranks of the US EPA as a biologist. For 11 years he served as the EPA NPDES Regional Technical Advisory Committee Power Plant Assessment Biologist, also concentrating in sediment and aquatic toxicity testing. In 1995 Mr. Paar took over management and coordination of the US EPA Water Microbiology Laboratory and obtained qualification as the Regional Drinking Water Microbiology Laboratory Certification Officer overseeing and auditing the six New England State principal water microbiology laboratories for compliance with Safe Drinking Water Act regulations. Along with his colleagues he helped design biology laboratories in the new US EPA state-of-the-art Regional Laboratory and was one of the principal designers of a one-of-a-kind automated sediment toxicity test chamber. In 2002 Mr. Paar obtained sufficient funding and support to open a new Genomics Laboratory at the US EPA Lab focusing on Microbial Source Tracking and rapid fecal indicator assessment. In 2003 Mr. Paar obtained his certification as a Contracting Officer Representative and began contractor oversight as a Task Order Project Officer. He is currently directing genomic research by the Lockheed/Martin Environmental Service Assistance Team for superfund and non-superfund research, developing high through-put genotypic test methods using Real-Time PCR to quantify and identify dehalogenating bacteria at hazardous waste sites and fecal indicators and pollution sources in fresh and marine surface waters.

Mark Doolittle
U.S. Environmental Protection Agency, Northeast Regional Laboratory

Biosketch

Mark Doolittle is Senior Discovery Biologist for Lockheed Martin Environmental Assistance Team working as a contractor to the US EPA at the New England Regional Laboratory in North Chelmsford, MA under the direction of Jack Paar, US EPA Project Officer. Mr. Doolittle received his B.S. in Biology from S.E. Massachusetts University (subsequently re-named U-Mass/Dartmouth), his Masters in Microbiology from University of Tennessee/Knoxville, and completed doctoral graduate work in Molecular Biology at Vanderbilt University in Nashville, TN and in Environmental Sciences at U-Mass/Boston. He was awarded a Fulbright Scholarship to study the interaction of bacteriophage with bacterial biofilms at the University of Saskatchewan in Canada. He has worked in the industrial sector as a staff microbiologist in the Gillette Corporation Personal Care Product Division and in the public sector as a contract environmental microbiologist for the Massachusetts Department of Environmental Protection. As a graduate student at U-Mass Boston, he worked for the Metropolitan (Boston) District Commission (MDC), renamed the Department of Urban Parks & Recreation (DUPR), collecting beach water samples and analyzing them at the Massachusetts Water Resources Authority Laboratory (MWRA) at Deer Island. Several years later, the MDC hired him to manage the water quality monitoring program for the MDC's 19 marine and freshwater beaches during the summer bathing months in which he spent a lot of time trying to identify the sources of fecal contamination affecting the beach. In his current position for almost 2 years, Mr. Doolittle has worked on lab development and field testing of Real-Time PCR assays to quantify genomic DNA of fecal indicators and dehalogenating bacteria at Superfund sites.

Abstract

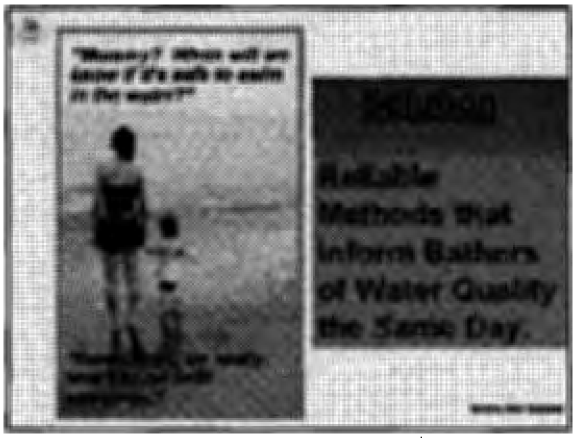
Current microbiological methods for determining water quality for recreational swimming and bathing at public and private beaches measure the number of culturable fecal indicator bacteria, Escherichia coli and Enterococci, per 100-mL volume. These methods which utilize Membrane Filtration (Standard Method 9222, EPA Modified *E. coli* Method, EPA Method 1600 for Enterococci) and Most Probable Number (Standard Methods 9223 Chromogenic-Fluorogenic Colilert or Enterolert) require incubation periods of 18 to 28 hours in addition to sample transport and processing times before verifiable counts of colony-forming-units (CFU) or Most-Probable-Number (MPN) of *E. coli* and Enterococci can be obtained. Due to the episodic nature of fecal contamination events (e.g., sewer and storm water drainage, etc.) and changes in the natural forces (e.g., wind, tides, river and spring flows, UV radiation, etc.) that transport, dilute, and irradiate surface waters, significant temporal and spatial variation can occur in the concentration of fecal indicators in recreational waters. EPA New England has developed a high-throughput DNA Isolation Procedure and Real-Time Quantitative-PCR Assays for identifying and quantifying *E. coli* in recreational waters. Purified DNA extracted from filter retentates of freshwater samples collected along the Charles River (Boston & Cambridge, MA) & Furnace Brook (Quincy, MA) and of marine samples collected at Carson Beach (So. Boston, MA) and Wollaston Beach (Quincy, MA) were analyzed by PCR and standard culturable assays. Numbers of Genomic Equivalents (GEQs) of *E. coli* were strongly correlated with numbers of culturable *E. coli* present in freshwater samples. Lower, non-optimal correlation was observed for *E. coli* GEQs versus CFUs in marine water samples, most likely due the increased rates of *E. coli* die-off in saltwater and temporal and spatial distance from fecal pollution sources. The log-transformed results of PCR analyses performed with two different *E. coli* PCR primer probe sets, one hybridization probe set (rod-A) and one hydrolysis probe set (uid-A), upon replicate aliquots of DNA extracts of the Charles River water samples, were plotted against results of culturable *E. coli* assays. The regression curves (i.e. equations) for both primer-probe sets were similar but the rod-A set had more consistent performance characteristics with a greater positive correlation factor and a GEQ/CFU ratio closer to 1.0. The robustness, specificity, and consistent performance of the rod-A PCR assay makes it a excellent candidate for implementation, real-time quantitative or MPN (presence/absence) formats used to screen recreational water samples for same-day detection of excessive levels of *E. coli*.

US EPA Region I
New England Regional Laboratory

High-Throughput Q-PCR for Fecal Indicators

Disclaimer

Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.



Current Recreational Water Test Methods

Culturable Assays for *E. Coli* & Enterococci
- Membrane Filtration (24 H Incubation)
- MPN W/ Quantitray (18-28 H Incubation)

Reported Results:
- Informs Bathers of Yesterday's Water Quality

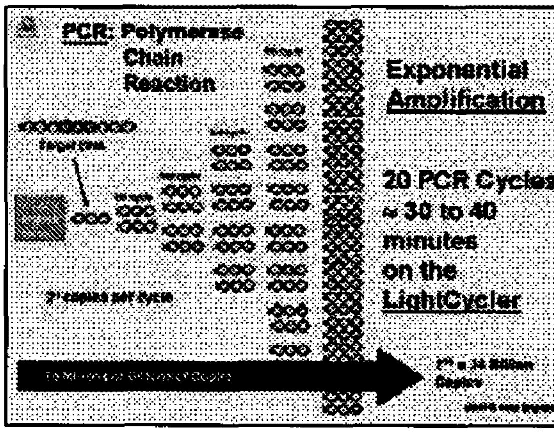
EPA Region I Genomics Project Goal

Develop and Validate . . .

- •Rapid
- •High-Throughput
- •DNA Isolation and Quantification
- •Fecal Indicator

. . . PCR Methods

PCR: Polymerase Chain Reaction

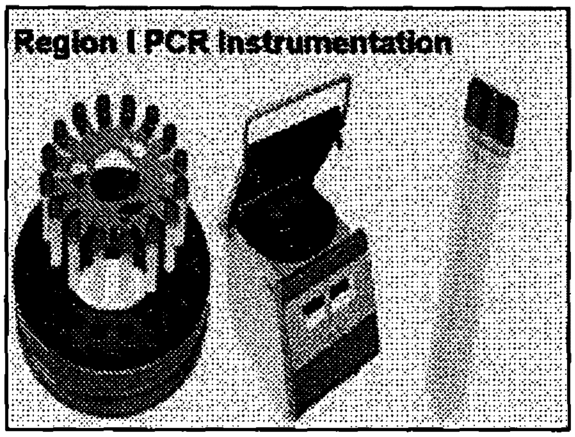


Exponential Amplification

20 PCR Cycles ≈ 30 to 40 minutes on the LightCycler

Technical Hurdles

- *Design & Synthesize Primers & Probes*
  Specific for Fecal Indicators
- *Consistently Remove or Suppress*
  PCR Inhibitors
- *Maximize Sample Equivalent Volumes* (SEVs)
  of Concentrated & Purified DNA
- *Simplify, Standardize & Keep it Quantitative*
  DNA Extraction & PCR Methods (Automate)

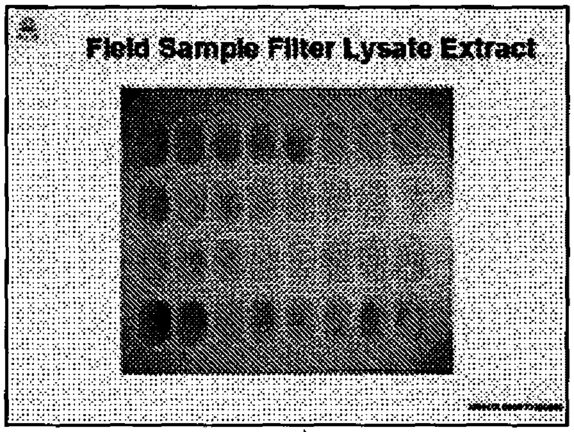


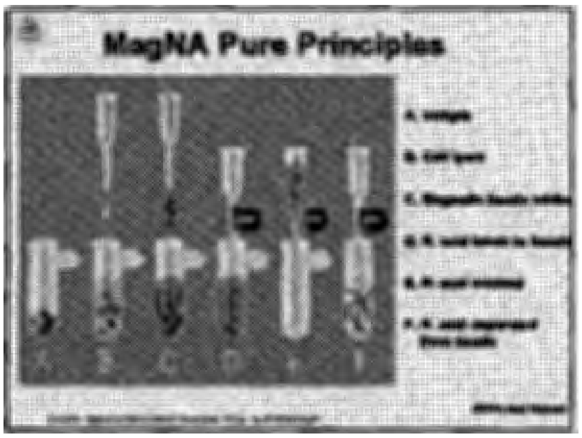
Clean DNA for PCR

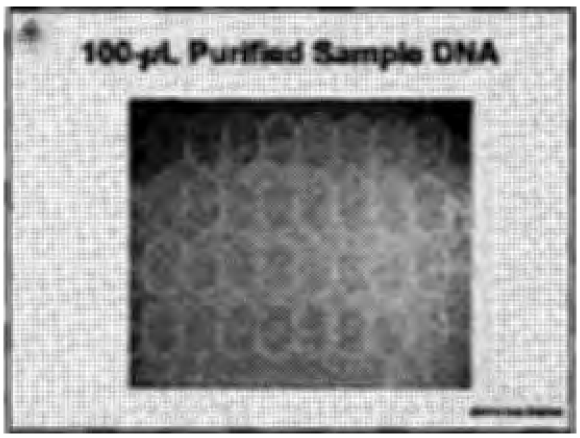
Marine & Freshwater Sample

MagNA Pure-LC DNA Isolation Protocol

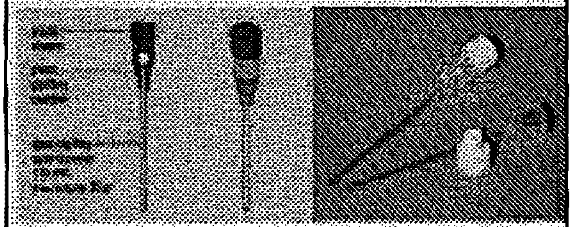
- **Vacuum Filter** 25 - mL
- **Bead Beat** in Lysis Buffer (MagNA Lyser)
- **Digest** 65 C (Omit Boiling?)
- **Pellet** Cell Debris
- **Transfer** Lysate to MagNA Pure LC
- **Extract / Purify** DNA
- **Elute** 100 - µL DNA extract (Conc. Factor = 250X)



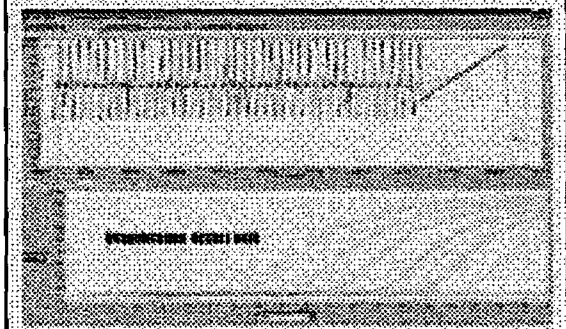




LightCycler Glass Capillaries



Fluorescence Detection



Processing & Analysis Times

- Sample filtering & DNA Extraction

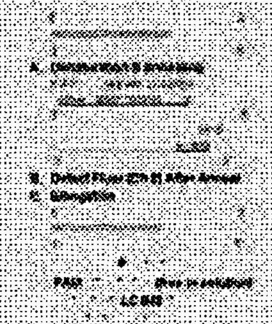
MagNA Pure Compact (8)	1.5 h	–
MagNA Pure LC (32)	—	2.5 h

- Loading of PCR reactions 0.25 - 0.5 h
- PCR thermocycling & data analysis 0.75 - 1.0 h
- Total Elapsed Time (8 - 32 samples) 2.5 - 4.0 h

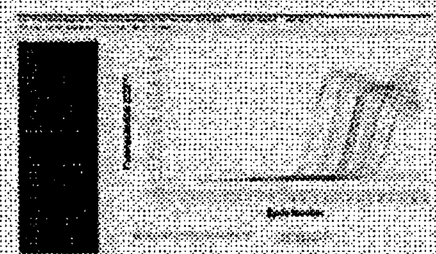
E. coli Primers & Probes

rod-A (mrd-B)

- Hybridization (FRET) Probes
- (FAM anchor & TAMRA sensor)
- 181-189 bp amplicon
- single-copy cell division gene

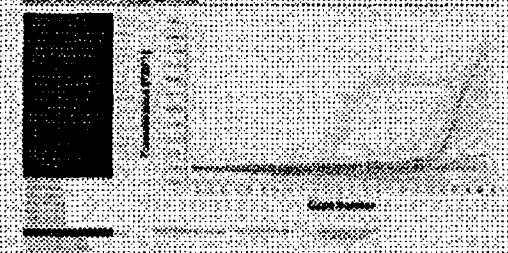


E.coli rod-A Assay Standard Quantitation Curves

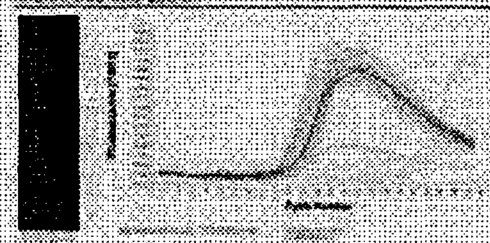


E.coli rod-A Standard Curve

E.coli rod-A Assay Primers&Probes Specificity



E.coli rod-A Assay Primers&Probes Robustness



E.coli rod-A Assay Attributes

- PCR Reactions
  ≤ 20-μL of 100-μL Eluate (SEV = 5 mL)
- MDL= 20 Genomic Equivalents(GEQs) of *E.coli* (≈10 cells)/100-mL
- GEQ:CFU ratio ≈ 2:1

Field Validation Challenges for E.coli rod-A Q-PCR Assay

In Marine and Freshwater...

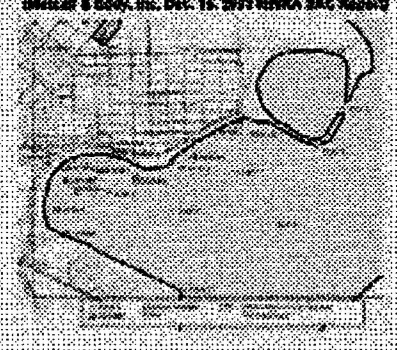
- Consistently & Accurately Isolate & Quantify *E.coli* DNA with High-Throughput
- Correlate Q-PCR Results with
  - Rates of GI Illness
  - Culturable *E.coli* Results & Safe Recreational Water Quality Limits

EPA Recreational WQ Standards Fecal Indicators (CFU/100-ml)

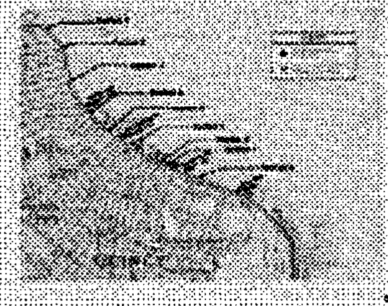
Upper Confidence Limit (%)		75	82	90	95
Fresh	E. coli SDM*	235	298	406	576
(8 ‰)	GeoMean	126			
	ENT. SDM	61	89	108	151
	GeoMean	33			
Marine	ENT. SDM	104	158	276	500
(19 ‰)	GeoMean	35			

*SDM – Single Day Sample Maximum

North Dorchester Bay CSO Sampling Sites



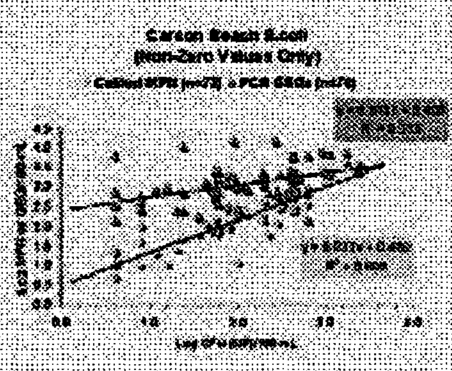
Wollaston Beach, Quincy, MA Sampling Sites

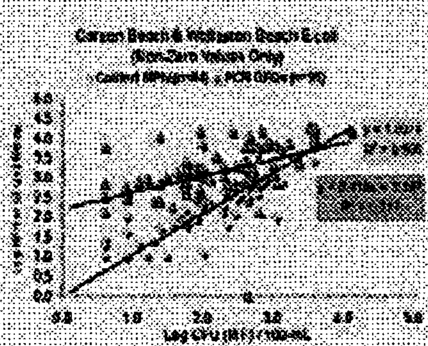


Q-PCR Comparison to "Gold Standards"

E. coli (EC)

- Membrane Filtration (Modified mTEC) Colony-Forming-Units (CFU)
- Idexx Quantitray 2000 (Colilert) Most Probable Number (MPN)
- MagNA Pure LC DNA Isolation & Q-PCR Genomic Equivalents (GEQs)

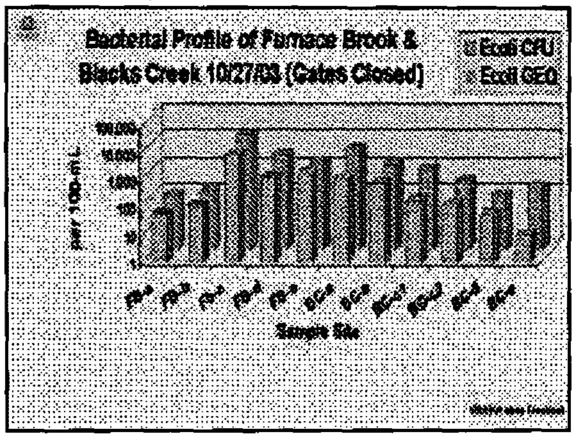


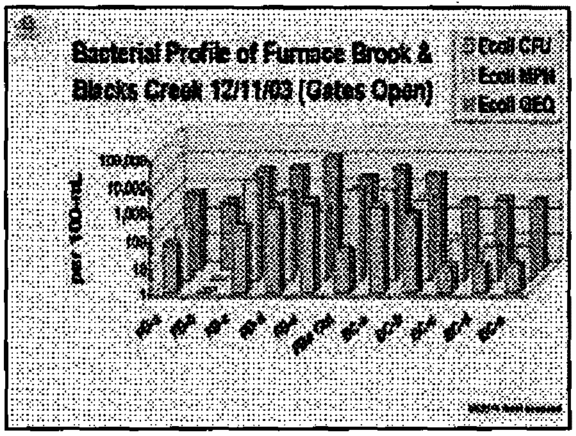


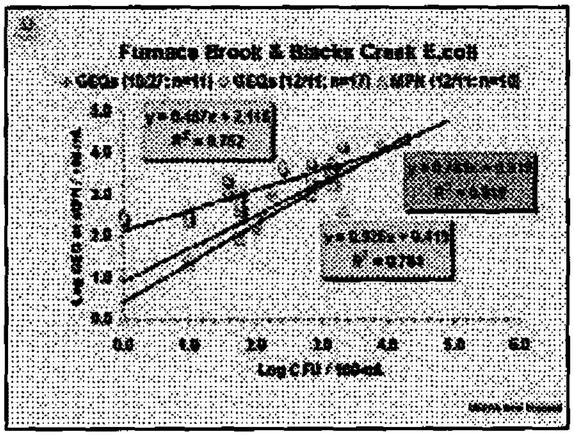
Summary of Marine Results

- Observed low correlation between Q-PCR (GEQs) & *E.coli* CFU & MPN
- Consistent with rapid die-off in saltwater
- *E. coli* Q-PCR Assay may still correlate with EPI Study results & Enterococcus CFU & MPN
- *E. coli* Q-PCR Assay may have utility along with Enterococcus Q-PCR

Furnace Brook Freshwater Sites







Charles River Testing Objective

Compare Q-PCR Quantification of *E. coli* GEQs in DNA Extracts using

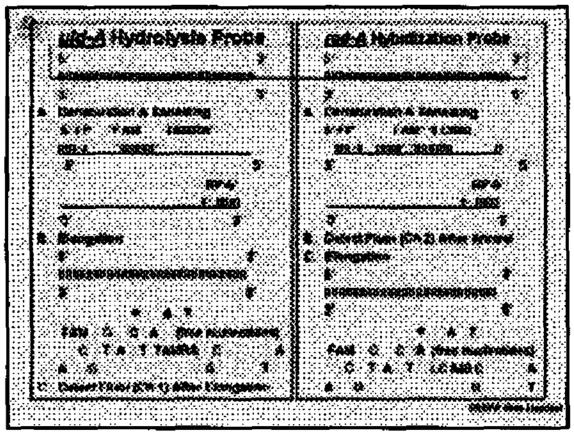
rod-a Hybridization Probe Set

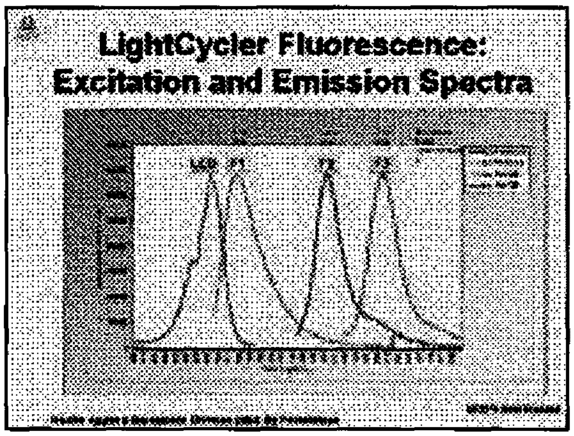
&

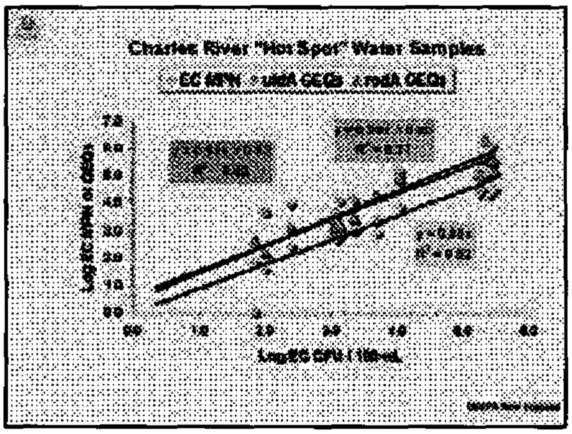
uid-a (TaqMan) Hydrolysis Probe Set

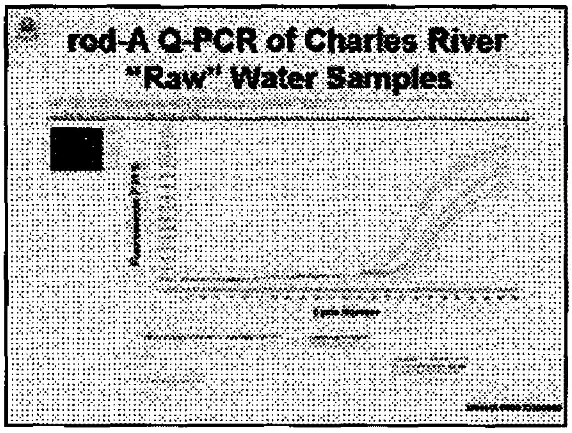
E.coli Primers & Probes

uid-A (gus-A)	*rod-A* (mrd-B)
• Single Hydrolysis (FAM-TAMRA) Probe • 117 bp amplicon • B-glucuronidase genes • Specific to *E.coli* & *Shigella* spp.	• Two Hybridization (FRET) Probes • (FAM anchor & TAMRA sensor) • 181-189 bp amplicon • single-copy cell division gene









CR "Raw" Water Q-PCR GEQs

CR No.	CFU /100-mL	CFU /20-uL	GEQ /20-uL	GEQ /100-uL*
217	144,000	28.8	200	1000
218	173,000	34.6	177	885
224	17,800	3.6	35	175
227	1,700	0.34	43	215
228	4,200	0.82	26	130
RS	235	0.05	>0.5	2.5

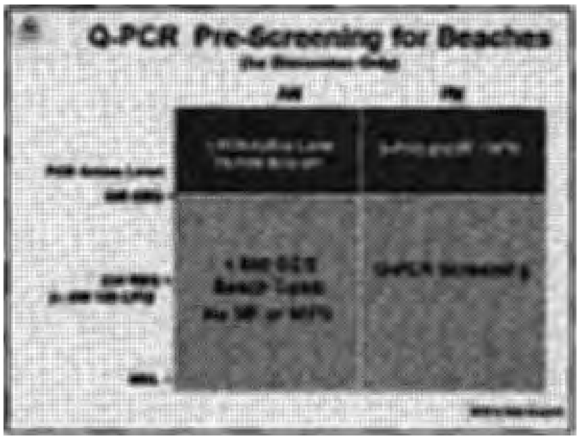
Summary of Freshwater Results

- Good Correlation between *E.coli* MF (CFU) & Q-PCR (GEQ)
- Exceedances of Safe Recreational Water Quality Limit for *E.coli* may be quantifiable by Q-PCR within 1-2 hr by assaying water sample directly

Value of PCR for Recreational Water Testing

Pre-screening of samples by Q-PCR will enable:

- Decisions to
  - perform or omit MF or Quantitray assays
  - adjust sample volumes of MF & MPN Assays
  - post beaches the same day
  - re-open a closed beach a day early
- Additional same-day sampling to verify persistence of contamination
- Continuous screening



Acknowledgments

Dr. Matt Liebman, EPA Region I, BEACHES Program
Mel Cote, EPA Region I, TMDL Program
Massachusetts Division of Parks & Recreation (DCR/MDC)
Roche Applied Sciences & Clinical Divisions
TibMolBiol, Inc & Fluoresentric, Inc.
MWRA & Metcalf & Eddy, Inc.
Drs. M. Shiaris & [illegible], University of Massachusetts/Boston
Dr. Sharon Long, University of Massachusetts/Amherst
Dr. Richard Haugland, US EPA, NHEERL, Cincinnati, OH
US EPA Region I, Regional Science Council

Funding

US EPA Region I TMDL FY02, 03, 04
US EPA Regional Geographic Initiative FY02, 03
US EPA ORD Regional Applied Research Effort FY 04

A Swimmable Future

Charles River PCR (GEQ) Ratios

Sample Collection Date	uid-A UKS	GEQ per CFU	GEQ per MPN	[illegible]	[illegible]	[illegible]
21-Jul-2004	Mean	[illegible]	[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]	SD	[illegible]	[illegible]
	n	[illegible]	[illegible]	n	[illegible]	[illegible]
18-Aug-2004	Mean	[illegible]	[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]	SD	[illegible]	[illegible]
	n	[illegible]	[illegible]	n	[illegible]	[illegible]

Charles River F-LFBs & F-LFMs

[illegible]	[illegible]	[illegible]	[illegible]
F-LFB	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]
[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]
[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
F-LFB	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]
[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]
[illegible]	Mean	[illegible]	[illegible]
	SD	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	n	[illegible]	[illegible]

Dilution of PCR Inhibition

[illegible] PCR Assay Sample Name	Sample Vol. (µL)	Calc. # EC GEQ/ Sample Vol.	Cross Pt (Cp)	Calc. # EC GEQs/ 100 mL
[illegible]	10	11	[illegible]	[illegible]
[illegible]	5	[illegible]	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	[illegible]	> 43	[illegible]
[illegible]	5	[illegible]	[illegible]	[illegible]
[illegible]	3	30	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EC DNA Recovery

2500 EC				
AC's Comp Sample	Mean %Rvry	SD	n	EC Bkgrd
FB	38.6	8.9	12	33
WB	50.2	10.5	12	38
CB	53.3	9.1	12	188
LB	22.1	10.8	12	14

EC DNA Recovery

QA/QC	E.coli		
	Mean % Recvry	Range of % Rcvry	n
Filter [illegible]	[illegible]	[illegible]	[illegible]
Filter [illegible]	[illegible]	[illegible]	[illegible]
PCR&[illegible]	[illegible]	[illegible]	[illegible]
PCR&[illegible]	NA	NA	
	CV	Range of CV	n
Lab Filter Dups	[illegible]	[illegible]	[illegible]
Lab PCR Kit Dups	[illegible]	[illegible]	[illegible]
Field Sample Dups	[illegible]	[illegible]	[illegible]
Temporal Field Dup	[illegible]	NA	1

Questions and Answers

No questions.

Thursday, October 14

10:20 a.m. – 12:00 p.m.

Concurrent Track II:

Changes on the Horizon

Session Nine:

New Health Risk Indicators

Comparative Testing of Rapid Microbiological Indicator Methods for Marine Recreational Water Monitoring

Stephen Weisberg
Southern California Coastal Water Research Project

Biosketch

Dr. Stephen Weisberg is Executive Director of the Southern California Coastal Water Research Project (SCCWRP) where he specializes in the design and implementation of environmental monitoring programs. He serves as chair of the Southern California Bight Regional Monitoring Steering Committee, which is responsible for developing integrated regional coastal monitoring for the Southern California Bight. He also serves on the Steering Committee for the US Global Ocean Observing System (GOOS), the National Oceanographic Partnership Program's Ocean Research Advisory Panel, the Alliance for Coastal Technology Stakeholder's Council, the State of California's Clean Beaches Task Force, the National Research Council Committee on Waterborne Pathogens and on Technical Advisory Committees for the University of Southern California Sea Grant Program and the Southern California Wetlands Recovery Program. Dr. Weisberg received his undergraduate degree from the University of Michigan and his Ph.D. from the University of Delaware.

Abstract

Current methods for enumerating indicator bacteria require an incubation period of 18 to 96 hours, during which time contaminated beaches remain open. Several technologies that have the potential to produce results in less than four hours are under development. Here we evaluated four of those technologies, including immunomagnetic capture with ATP quantification, flow cytometry, dual wavelength fluorimentry, and quantitative PCR (Q-PCR). Fifty-four blind samples encompassing a range of bacterial concentrations and matrix complexity were processed and compared to values obtained by standard culture-based methods performed at six reference laboratories. Each method was evaluated for speed, accuracy, sensitivity, precision, robustness across different matrices, as well as ease of use.

Questions and Answers

No questions.

Assay and Remote Sensor Development for Molecular Biological Water Quality Monitoring

Kelly Goodwin, Ph.D.
National Oceanic and Atmospheric Administration (NOAA), Atlantic Oceanographic & Meteorological Laboratories, Ocean Chemistry Division

Biosketch

Dr. Kelly Goodwin is a Principal Investigator with the National Oceanographic and Atmospheric Administration (NOAA) at the Atlantic Oceanographic and Meteorological Laboratories (AOML) in Miami, Florida. Dr. Goodwin received a B.S. degree in Neurobiological Sciences from the University of Florida. She received M.S. ('90) and Ph.D. ('96) degrees in Environmental Engineering Science from the California Institute of Technology in Pasadena. She received a minor in Oceanography from Caltech during a program in residence at the Scripps Institute of Oceanography ('93). From 1995-1998, she served as a National Research Council Postdoctoral Associate at the U.S. Geological Survey in Menlo Park, CA working on the microbial biogeochemistry of halocarbons. In 1999, she returned to Florida as a researcher with NOAA's joint institute with the University of Miami, the Cooperative Institute of Marine and Atmospheric Studies (CIMAS). She entered federal employment with NOAA in 2003 and became adjunct faculty to the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Her research interests include development and application of biotechnology to improve coastal water quality monitoring.

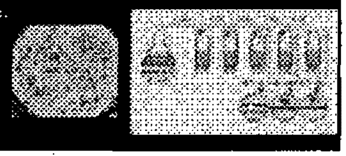
Abstract

Molecular tools are a promising means to provide rapid and accurate monitoring of coastal water quality. We are developing three nucleic acid hybridization assays to identify and monitor nuisance organisms (bacterial and algal) in coastal waters. A microplate assay returns a rapid colorimetric result and provides moderate throughput at relatively low cost. A Luminex Xmap™ system rapidly provides high throughput and the potential to screen for a large number of targets simultaneously. Electrochemical detection is a cutting edge technology suitable to the size, power, and cost requirements of remote sensing. An overview of the development and application of these technologies will be presented.

Assay and Sensor Development for Molecular Biological Water Quality Monitoring

Kelly D. Goodwin, Ph.D.
NOAA/AOML
Ocean Chemistry Division

Assays Need Improvement



Molecular Biological Approach

✓Sensitive
✓Specific
✓Microscope & Culture Independent

molecular probes for:

✓red tide dinoflagellates (*Karenia brevis*)
✓sewage-indicating bacteria

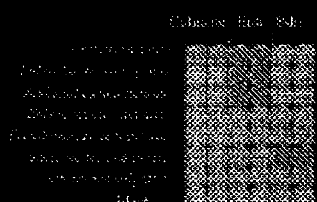
potential targets:

✓toxin genes
✓pathogens (vs indicators)

Goals:

✓provide early and accurate detection
✓source tracking capability
✓improve temporal coverage
✓aid ecological research
✓supply management tool
✓fast, convenient, economical

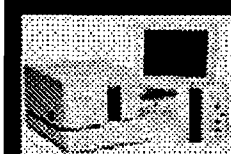
Microplate Assay



✓Specific
✓Detect Multiple Targets
✓Medium Throughput, Relatively Low Cost

please see poster

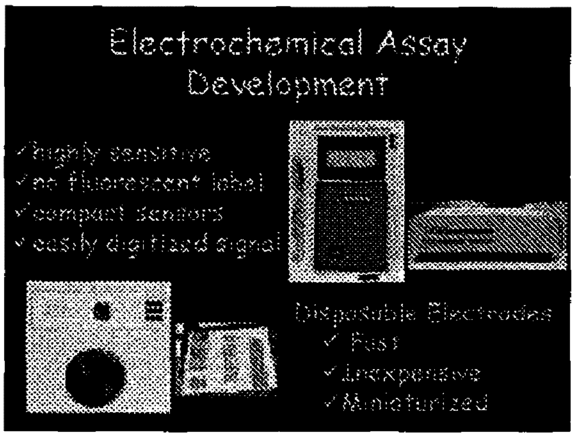
Luminex

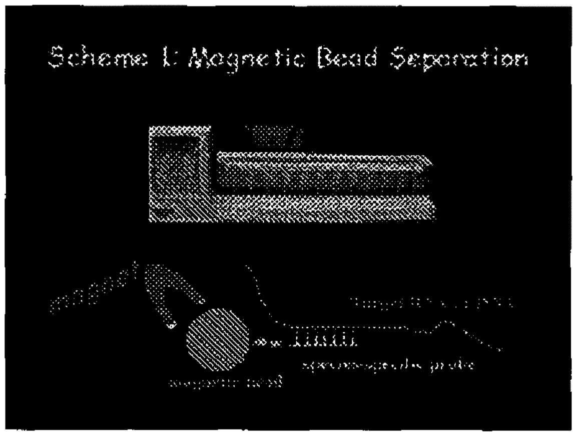


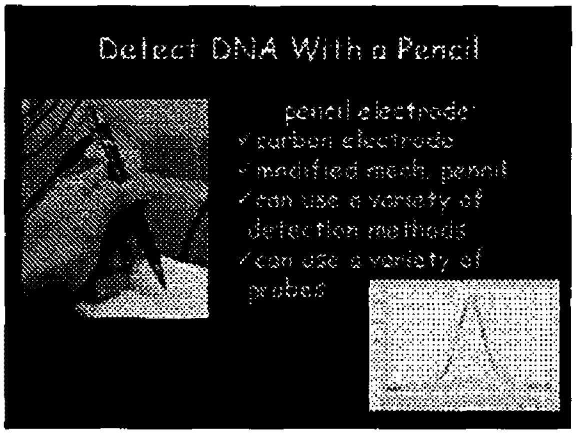
xMap™ technology, 100 assays performed in a single microplate well

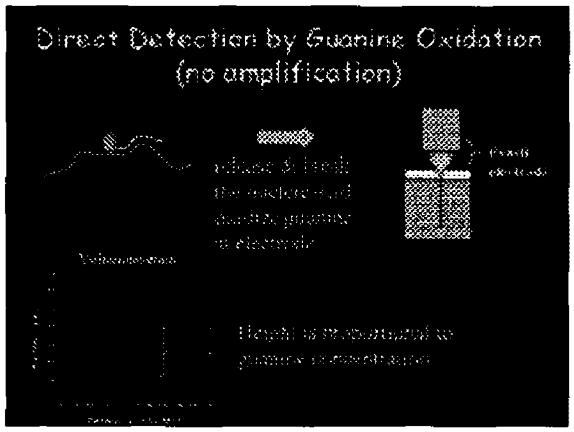
✓High Specificity
✓Quickly Detect Many Targets
✓High Throughput
✓Flexible and Relatively Inexpensive vs Microarrays

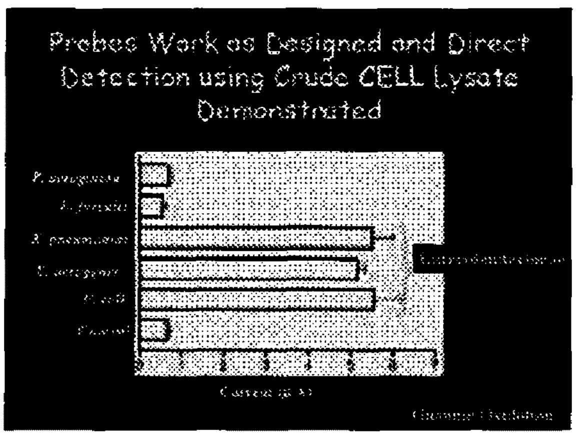
please see poster

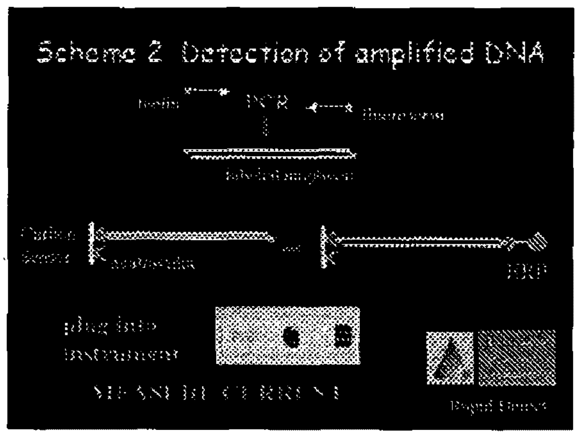

Electrochemical Assay Development
✓highly sensitive
✓no fluorescent label
✓compact sensors
✓easily digitized signal
Disposable Electrodes
✓ Fast
✓ Inexpensive
✓ Miniaturized

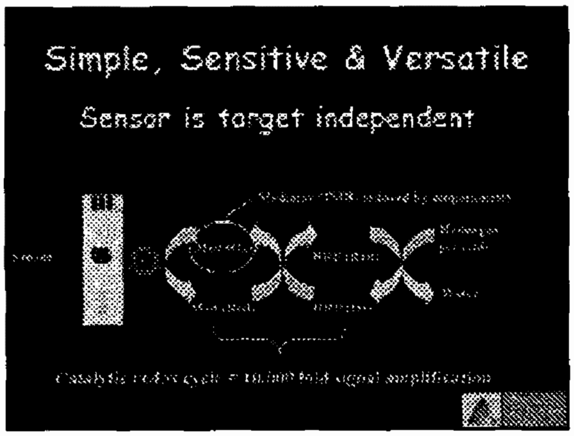

Scheme 1: Magnetic Bead Separation
magnet

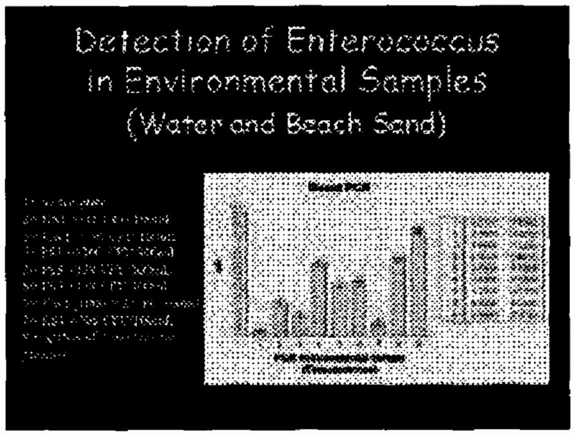

Detect DNA With a Pencil
pencil electrode
✓carbon electrode
✓modified mech. pencil
✓can use a variety of detection methods
✓can use a variety of probes

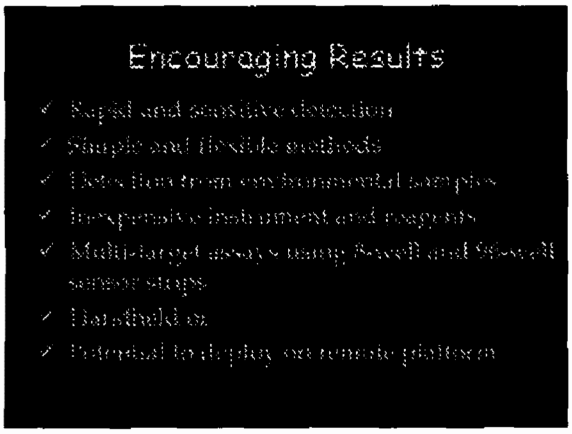

Direct Detection by Guanine Oxidation (no amplification)

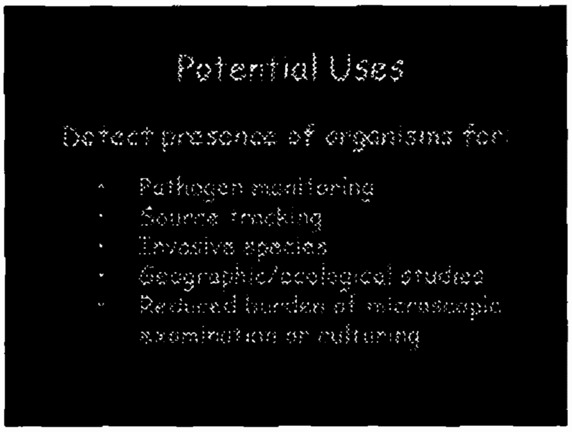

Probes Work as Designed and Direct Detection using Crude CELL Lysate Demonstrated

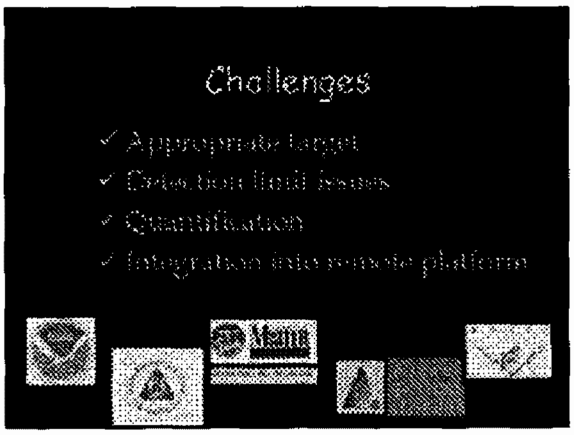

Scheme 2 Detection of amplified DNA
PCR
plug into instrument

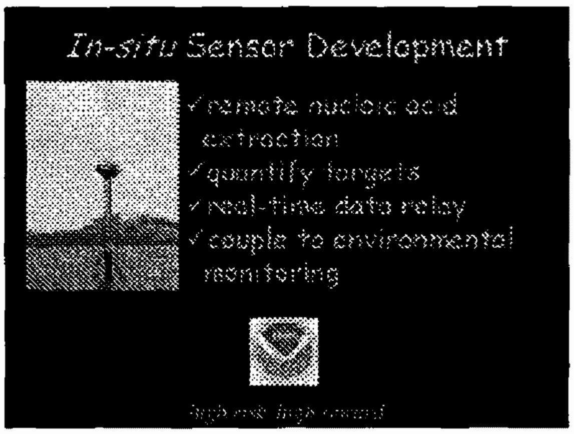

Simple, Sensitive & Versatile
Sensor is target independent


Detection of Enterococcus
in Environmental Samples
(Water and Beach Sand)


Encouraging Results
Rapid and sensitive detection
Simple and flexible methods
Detection from environmental samples
Inexpensive instrument and reagents
Multi-target assays using 8-well and 96-well sensor strips
Potential to deploy on remote platform


Potential Uses
Detect presence of organisms for:
Pathogen monitoring
Source tracking
Invasive species
Geographic/ecological studies
Reduced burden of microscopic examination or culturing


Challenges
Appropriate target
Detection limit issues
Quantification
Integration into remote platform


In-situ Sensor Development
remote nucleic acid extraction
quantify targets
real-time data relay
couple to environmental monitoring


Thanks To:

Questions and Answers

No questions.

Quantification of Enterovirus in Seawater in Imperial Beach, CA using Real-Time RT-PCR

Rick Gersberg
San Diego State University, School of Public Health, Coastal and Marine Institute

Biosketch

Dr. Richard M. Gersberg is currently a Professor (and Head of the Division) of Environmental and Occupational Health in the Graduate School of Public Health at San Diego State University (SDSU), and Director of the Coastal and Marine Institute at SDSU. He has an M.S. degree in biology from the University of Houston, and a Ph.D degree in microbiology from the University of California, Davis. Dr. Gersberg specializes in water quality research, and has broad experience working with both chemical and microbiological pollutants and risk assessments.

Abstract

A real-time reverse transcriptase-polymerase chain reaction (RT-PCR) method utilizing the MGB Eclipse Probe System Kit (Amersham Biosciences) was used to detect and enumerate enteroviruses in ocean water samples were taken at the Tijuana River mouth (near the San Diego, California-Mexico border) and Imperial Beach pier (0.85 mile north of the Tijuana River mouth in San Diego, California) during rain events and dry weather. The samples consisted of 1-4 L of ocean water. Viruses were then concentrated by filtration through a negatively charged filter followed by elution with sodium hydroxide. Following RNA extraction, RT-PCR, which included cDNA synthesis and real-time RT-PCR, was carried out on samples (in triplicate) using a BioRad iCycler real-time PCR system.

During rain events, the seawater samples appeared to contain inhibitors that effected real-time RT-PCR amplification; however diluting the cDNA samples diluted the inhibitors to such an extent that successful amplification could be achieved. For some of the samples, cDNA amplified by conventional RT-PCR, was cloned and sequenced to determine the specific type of enterovirus present in the samples. The relationship between indicator bacteria (fecal coliform and enterococci) densities and enterovirus concentrations was also determined to assess the validity of the bacteria indicator system for predicting viral levels in recreational beach waters of the U.S. influenced by contaminated runoff from Mexico. By relating the PCR-quantified densities to infectivity, our data were then evaluated in terms of a human health risk assessment for swimming or surfing at Imperial Beach, CA. The high sensitivity and high throughput capability of real-time RT-PCR should be useful in routine monitoring of viral pathogens in recreational beach waters for the assessment and protection of public health.

Questions and Answers

Q (Clay Clifton, County of San Diego Department of Environmental Health): When you say that the presence of the enterovirus was relatively low at Empirial Beach during dry weather, how did you define dry weather and what time of year were your samples taken?

Rick Gersberg

We had a dry summer, where it had not rained for a long period of time. So, we collected our samples during June, July, and August.

Rapid Detection of Enteroviruses in Environmental Samples using Real-Time Quantitative Reverse Transcriptase PCR

Rachel Noble
University of North Carolina at Chapel Hill, Institute of Marine Sciences

Biosketch

Dr. Rachel Noble is an Assistant Professor at the University of North Carolina at Chapel Hill, Institute of Marine Sciences in Morehead City, North Carolina. She previously held a joint appointment between the University of Southern California's Wrigley Institute for Environmental Studies and the Southern California Coastal Water Research Project and focused her work there on regional assessment of water quality along the Southern California shoreline, and detection of enteroviruses in stormwater impacted areas of the coast. In July of 2001, she moved from the West Coast to the East Coast, and there has focused upon the use of molecular techniques, such as Quantitative Polymerase Chain Reaction (Q-PCR) for identification of sources of fecal material in estuarine, coastal, and freshwater environments, for use in assessment of microbiological water quality. Dr. Noble's research currently focuses on the quantification of enteric human pathogens in a variety of environments, including recreational areas, shellfish beds, and commercial fishing areas. She is interested in relating the presence of known human pathogens such as enteroviruses, Vibrio vulnificus, and *Salmonella* sp., to levels of fecal coliforms, *E. coli*, and enterococci in recreational waters in order to better protect human health. Other current research foci are basin-scale determinations of pathogen persistence, fate and transport in estuaries, and the impacts of nutrient loading and eutrophication on pathogen survival and ecosystem health. Dr. Noble has also recently been involved in the development of real-time detection of both pathogens and indicators as tools for creating accurate hydrologic and probability-based models of estuarine and coastal systems.

Abstract

Routinely conducted water quality analyses neither provides indication as to the source of fecal contamination, nor do they relate directly to potential public health risk of those in contact with recreational waters. With the advent of new molecular techniques, human viral pathogens, such as enteroviruses, can be used as tools to identify the presence of human fecal contamination in aquatic environments, providing useful source tracking information and data for inclusion in microbial risk assessments. A Quantitative Reverse Transcriptase Polymerase Chain Reaction (QRT-PCR) approach has been developed to detect and quantify enteroviruses from environmental samples. The approach is more sensitive and rapid than traditional cell-culture based approaches and has been well tested in a variety of aquatic systems, providing quantification of human enteroviruses over a wide dynamic range (from as few as 1 to more than 1 million PFU equivalents) in less than 4 hours. Beyond method development, an important facet of this work has been to determine the relationship between the detection of genomic enteroviral RNA versus intact infectious viral particles, by conducting 1- and 2-step QRT-PCR assays on enterovirus genome equivalents versus infectious stocks of poliovirus seeded into environmental samples. Our results suggest a consistent ratio of genome equivalents to PFU, and that while the 1-step assays are slightly less sensitive, the use of the 1-step approaches are recommended because of the advantages of decreased operator handling of sensitive RNA samples, lower risk of cross contamination (due to handling), and more rapid results.

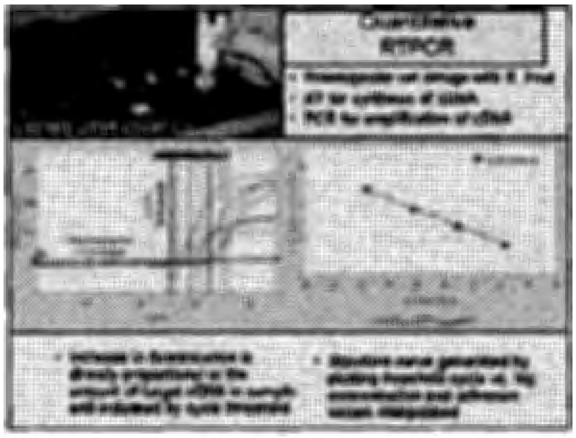
Rapid Detection of Enteroviruses in Environmental Samples using Real-time Quantitative Reverse Transcriptase PCR

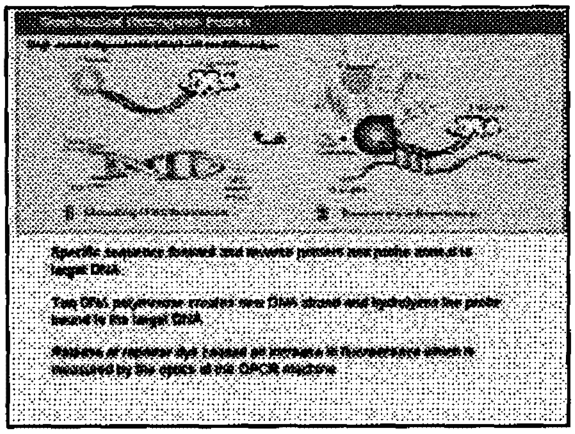
Rachel T. Noble
UNC Chapel Hill Institute of Marine Sciences

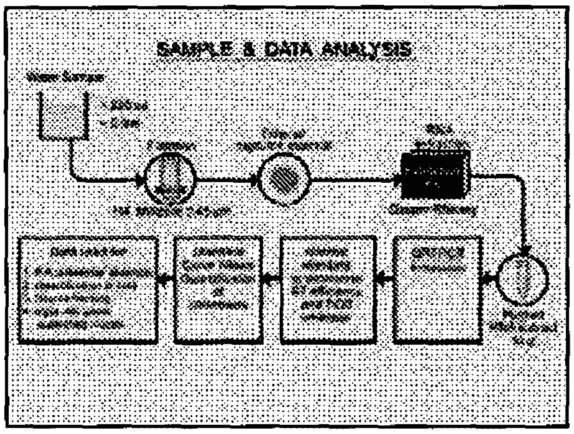
Recreational water quality

Protocol development: Main issues

- Concentration of sample to allow detection: Identify filter capable of high recovery
- Optimize recovery: Develop extraction approach that reduces inhibitory compounds
- Identify ways to reduce time required: 1-step vs. 2-step QRTPCR
- Need assay to be truly quantitative: Development of RNA internal standard
- Real world testing







Filtration efficiency: Enterovirus

- Speed of filtration vs. ability to capture organisms of interest
- Seed samples with known amount of virus and conduct QRTPCR

Filtration efficiency

- Trade-off between time spent filtering vs. sample recovery
- Have tested filters available on market, plus flocculation and precipitation techniques
- Have determined that the Type HA Millipore filter works best for collection of enteroviruses (small single stranded RNA viruses) from environmental samples
- Extract whole filter instead of eluting material

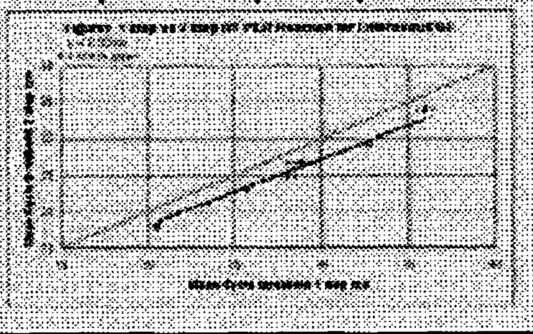
Optimizing the extraction approach

- Extraction protocols tested with a wide range of estuarine, freshwater, and seawater samples
- Extraction protocols tested in conjunction with filter choices

1-step vs. 2-step RTPCR?

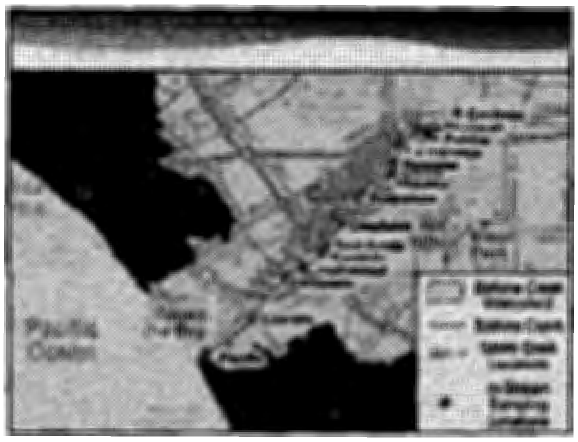
- For enterovirus detection, the first step of the sample analysis is "reverse transcription"
- This step can be conducted separately from the PCR reaction (2-step) or preceding the PCR reaction (in the same tube, called 1-step)
- 1-step = 1 tube, faster reaction
- 2-step RT-PCR is typically more sensitive than 1-step RT-PCR, but 1-step RT-PCR is faster
- Is the difference significant?

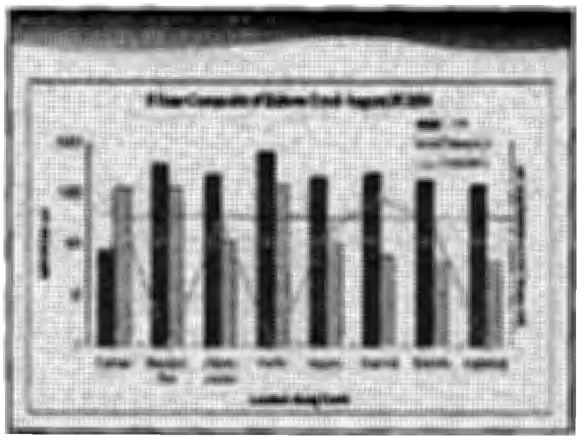
Comparison of 1-step vs. 2-step reactions

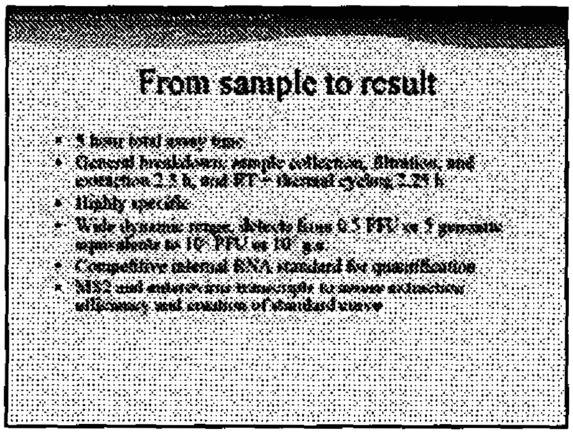


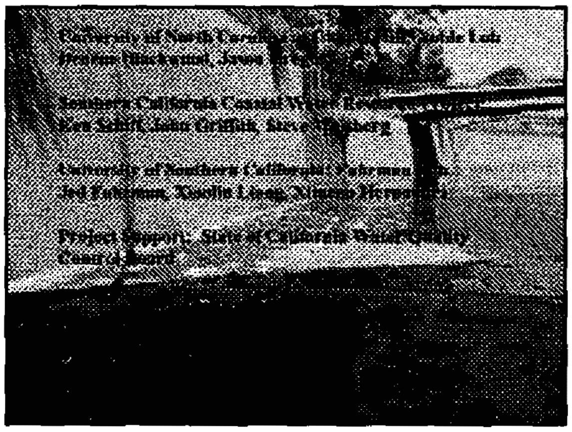
1-step vs. 2-step QRTPCR

- Compared the use of 1-step vs. 2-step QRTPCR approaches for the quantification of enteroviruses
- 1-step is faster and less prone to contamination, but not quite as sensitive as 2-step kits
- Components such as PVP and carrier material have been tested to improve the detection of enteroviruses by RTPCR
- Difference between 1-step vs. 2-step approaches is small (<5% variability and detection limits within 5 g.e.)
- Time advantage is large (saves PCR cycling time and sample transfer time)


Pacific
Ocean




From sample to result
• 5 hour total assay time
• General breakdown: sample collection, filtration, and extraction 2.5 h, and RT – thermal cycling 2.25 h
• Highly specific
• Wide dynamic range, detects from 0.5 PFU or 5 genomic equivalents
• Competitive internal RNA standard for quantification
• MS2 and enterovirus transcripts to assess extraction efficiency and creation of standard curve


University of North Carolina
Southern California Coastal Water Research
Ken Schiff, John Griffith, Steve
University of Southern California: Fuhrman Lab
Jed Fuhrman, Xiaolin Liang
Project Support: State of California Water Quality Control Board

Questions and Answers

Q (Stephan Weurtz, University of California at Davis): We have also adopted a system to take enteroviruses and we are using quantitative PCR. One of the differences is that we use a hollow-fiber ultrafiltration method that uses 100 liters. Your starting volume tends to be 5 liters or less. You also went to a very contaminated watershed. Do you think that you'll be able to catch the viruses, which are always going to be present in lower numbers than the indicators, using such a small starting volume?

Rachel Noble

You ask a very good question. One of the biggest issues that we have dealt with is the examination of hollow-fiber applications for concentrating the water samples is the volume. What is the final volume of actual material from the hollow fiber system?

Q (Stephan Weurtz): In the field we filter down to about 1.5 liters. Then we take that to the lab and through a second smaller version of the unit we end up with about 50 milliliters.

Rachel Noble

This kind of application is exactly what I conducted through a large part of my graduate work and dissertation work at USC, in Jed Fuhrman's lab. Basically, the issues are that we have been really moving our method toward something that is rapid. I'm sure that your recovery levels are higher than ours. But, the idea is that we are taking a small filter and a small volume, and from that we are able to get the final material that comes off of that filter extracted into a final volume of 50 microliters. So, while our filtration efficiency is not 100 percent, the loss of things beyond that, through the extraction procedure and onto the PCR allows us to have similar overall recovery rates as what you would find with hollow fiber and all the other ultrafiltration techniques. The trade-off is rapidity. I don't know how long it takes for you to do your 100 liter filtration, but there are obvious trade-offs. If you really want to understand whether or not you have a presence of enteroviruses in cleaner water samples, and you want to have a high recovery rate, you need to apply a larger volume filtration. In Ballona Creek (heavily contaminated), that is not necessary, but it is certainly necessary in other more pristine estuarine and coastal environments. This is just one way of going about things. There are other choices to be made, depending on what your question is.

Male-Specific Coliphages as Indicators of Fecal Pollution in Coastal Recreational Waters

Greg Lovelace
University of North Carolina at Chapel Hill, Department of Environmental Sciences and Engineering

Biosketch

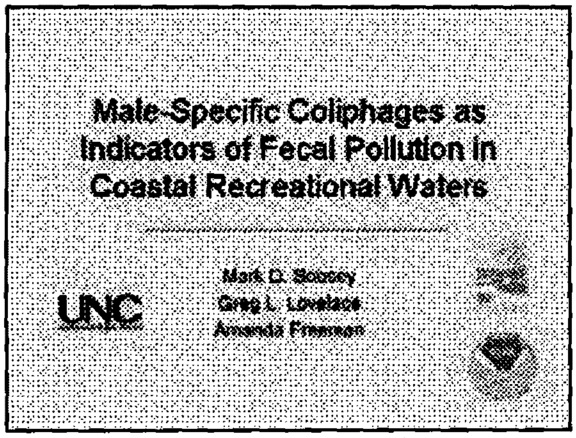
Mr. Greg Lovelace is an environmental biologist and field laboratory manager in the Department of Environmental Sciences & Engineering, School of Public Health, for the University of North Carolina at Chapel Hill. The field laboratory is located in the coastal town of Beaufort, North Carolina. Mr. Lovelace received his B.S. in Zoology from North Carolina State University in Raleigh. He worked as a laboratory technician for the City of Raleigh in the municipal sewage treatment plant and then joined the research team of Dr. Mark D. Sobsey. He has remained with Dr. Sobsey's team for the past 27 years. For the majority of that time, he has been Dr. Sobsey's sole researcher on the coast of North Carolina, performing research on microbial contamination of groundwater, shellfish, and shellfish-growing waters.

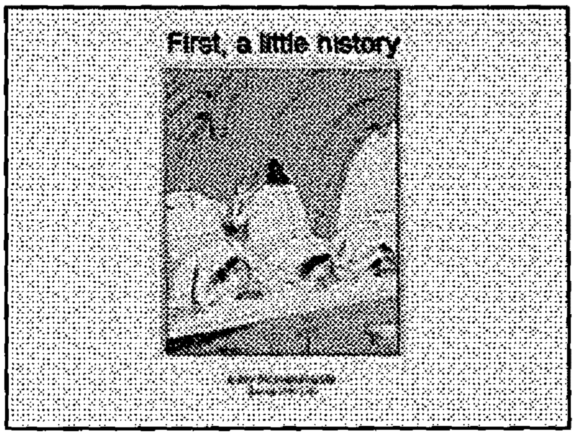
Abstract

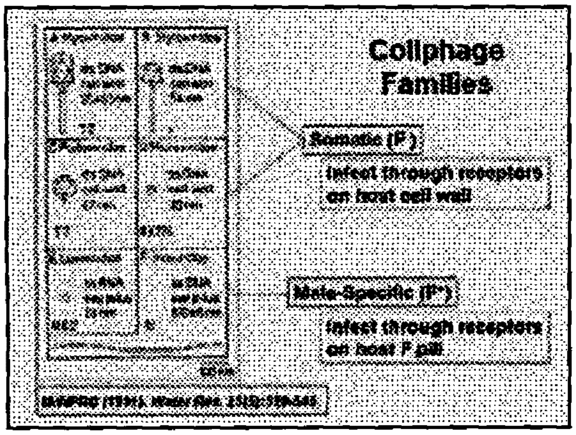
Microbial standards for recreational waters are based on levels of indicator bacteria. Because viruses are more resistant to sewage treatment methods and more persistent in marine waters than indicator bacteria, there is an urgent need for an indicator of viral contamination in recreational waters. Male-specific coliphages have properties that make them useful indicators to characterize recreational waters: They are easy to detect using simple microbiological techniques; they are usually detected relatively quickly (12-24 hours); and they can be separated into human and non-human groups.

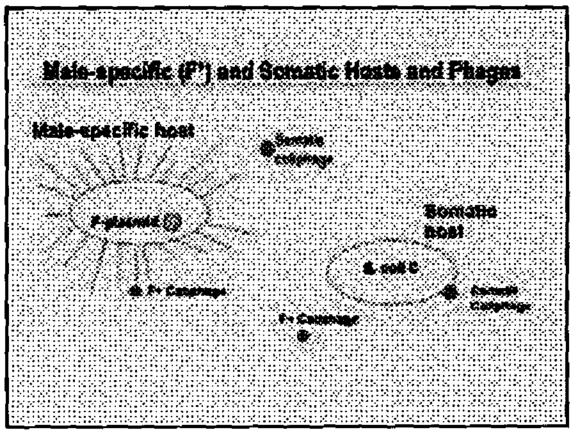
In a previous study we examined levels of somatic and male-specific coliphages in samples of water from six estuarine areas along the central NC coast collected from paired sites situated near to and more distant from point- and non-point sources of fecal pollution. Geometric mean levels of *E. coli* and enterococcus were predictably higher at sites nearer to pollution sources, and the same was generally true for levels of both types of coliphages. Coliphages were good indicators of fecal contamination, and when serotyped, they predicted human sources or both human and non-human sources of fecal contamination.

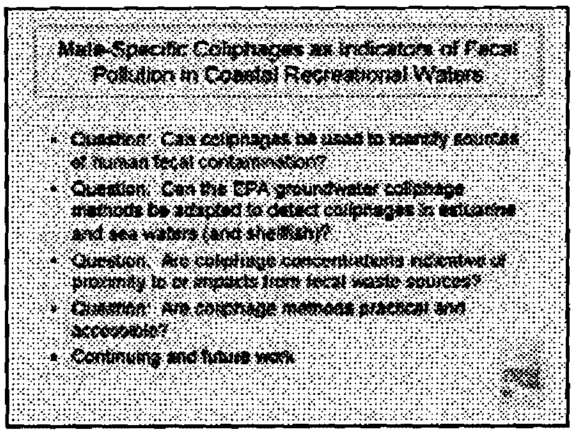
The aim of a current study with sampling stations in coastal marine waters of the USA is to further improve, validate and apply coliphage detection methods in estuarine recreational waters, including bathing beaches. The results so far indicate that the methods of coliphage detection work well in the estuarine waters tested. The ability to detect and quantify fecal contamination based on coliphage detection and quantification is being further investigated.

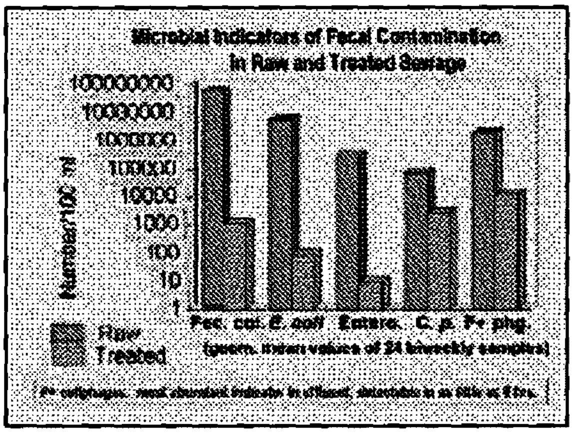

Male-Specific Coliphages as
Indicators of Fecal Pollution in
Coastal Recreational Waters
UNC
Mark D. Sobsey
Greg L. Lovelace
Amanda Freeman


First, a little history


Coliphage
Families
Somatic (F-)
Infect through receptors
on host cell wall
Male-Specific (F+)
Infect through receptors
on host F pili


Male-specific (F+) and Somatic Hosts and Phages
Male-specific host
F-plasmid
F+ Coliphage
Somatic
host
F+ Coliphage

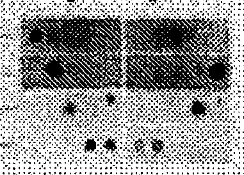

Male-Specific Coliphages as Indicators of Fecal
Pollution in Coastal Recreational Waters
Question: Can coliphages be used to identify sources of human fecal contamination?
Question: Can the EPA groundwater coliphage methods be adapted to detect coliphages in estuarine and sea waters (and shellfish)?
Question: Are coliphage concentrations indicative of proximity to or impacts from fecal waste sources?
Question: Are coliphage methods practical and accessible?
Continuing and future work


Microbial Indicators of Fecal Contamination
In Raw and Treated Sewage
100000000
10000000
1000000
100000
10000
1000
100
10
1
Number/100 ml
Fec. col.
E. coli
Entero.
C. p.
F+ phg.
Raw
Treated
(geom. mean values of 24 biweekly samples)

F+ Coliphage Genotyping by Oligonucleotide Probe Hybridization Assays

- Oligoprobes
  - Groups I, II III and IV F+ RNA
  - Also, three groups of F+ DNA
    - fd, M13 and CH prototypes
  - Label with non-radioactive probe
- Hybridization assays
  - F+ RNA: Hsu et al., 1995; Beekwilder et al., 1996
  - F+ DNA: Vinje et al., AEM, Oct. 2004

F+ RNA Coliphage genotypes



Study #1: Somatic and Male-specific Coliphages as Fecal Indicators

Can coliphages be used to quantify and identify sources of human fecal contamination?

- Double Agar Layer (DAL) assay technique for male-specific coliphages and somatic Salmonella phages
- Male specific host - *S. typhimurium* WG49
  - Later study: *E. coli* Famp
- Somatic host - *E. coli* C
  - Later study, CN13
- "Crystal coast" of North Carolina
- Three point source (P) and three non-point source (NP) study sites

Analysis of Bacteriophage Concentrations in Water Collected from Closed, Transition and Open Stations by the Kruskal-Wallis Nonparametric ANOVA Test

Bacteriophage Group/Station Type	No. of Samples	Mean of Ranks	P-value
WG49			
Closed	43	[illegible]	[illegible]
Transition	36	47.745	
Open	34	[illegible]	
Famp			
Closed	41	[illegible]	[illegible]
Transition	36	[illegible]	
Open	33	[illegible]	
CN13			
Closed	41	[illegible]	[illegible]
Transition	34	[illegible]	
Open	34	[illegible]	

Genotyping and Serotyping of F+RNA Coliphages

Field Site	Total Isolates	Unknown	Group I (MS-2)	Group II (GA)	Group III (QB)	Group IV (SP,FI)
North River	310	7	5	299	0	0
Foster's Bay	2785	2	[illegible]	163	46	0
Calico Creek	67,223	304	[illegible]	57,940	[illegible]	0
Jumping Run Creek	1,626	0	1,614	32	2	0
Taylor's Creek	4943	4	60	4882	1	0
Goose Creek	11,845	0	11,845	0	0	0

F+ RNA Coliphage Serotyping and Genotyping

Calico Creek and Taylor's Creek (P)

-majority were Type II (GA)

-impacted mostly by human fecal contamination: sewage treatment plant effluent

North River (NP)

-majority of were Type II (GA)

-impacted mostly by human fecal contamination: likely seepage from individual septic tanks

Foster's Bay (P), Jumping Run Creek and Goose Creek (NP)

-majority were Type I (MS-2)

-impacted by animal and human sources of fecal contamination

Study #1 Summary

- Type II F+ RNA coliphages, indicative of human sources, were detected at stations receiving both known point- and suspected non-point source input of human fecal waste
- Type I F+ RNA coliphages, indicative of a combination of human and non-human sources, were detected at stations thought to receive suspected non-point source input of human and non-human fecal waste

Study #1 Summary

- Coliphage occurrence and concentrations related to proximity to fecal contamination sources, based on sanitary survey and growing water classification for shellfishing
- F+ coliphage concentrations were predictive of human enteric virus contamination; enteric bacteria were not
  - data not shown

Study #2: Use of EPA Groundwater Methods for Coliphage Detection in Estuarine Water

- 3 detection methods: Single Agar Layer (SAL) assay, Direct Membrane Filtration (DMF), and MPN Enrichment
- Male-specific host - *E. coli* Famp
- Somatic host - *E. coli* CN13
- Estuarine water from eight geographically diverse sources in the National Estuarine Research Reserve System

Question: Are the methods effective in detecting coliphages in estuarine water?

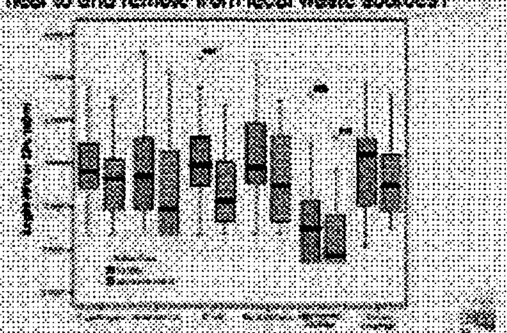
Table 1. Detection of coliphage in water samples using all methods

samples	All coliphages	Somatic coliphages	Male-specific coliphages
total	[illegible]	[illegible]	[illegible]
Detected	[illegible]	[illegible]	[illegible]
% Detected	[illegible]	100%	[illegible]

Table 2. Detection of coliphage in water using three different assay methods

	Somatic Coliphage			Male-specific Coliphage		
	Direct Membrane Filtration	Single Agar Layer	MPN Enrichment	Direct Membrane Filtration	Single Agar Layer	MPN Enrichment
total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detected	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Detected	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Question: Are indicator concentrations the same near to and remote from fecal waste sources?



Indicator Levels at Contaminated Versus Uncontaminated Sites

Wilcoxon Signed Ranks Test Results

Indicator		Uncontaminated vs. Contaminated	
Coliphages	Z	[illegible]	
	p	[illegible]	significant
Enterococci	Z	[illegible]	
	p	[illegible]	significant
E. coli	Z	[illegible]	
	p	[illegible]	significant
Fecal coliforms	Z	[illegible]	
	p	[illegible]	significant
Male-specific phage	Z	[illegible]	
	p	[illegible]	significant
Somatic phage	Z	[illegible]	
	p	[illegible]	not significant

Summary and Conclusions:

- The EPA-approved groundwater methods appear to work well for samples of estuarine water, with the MPN Enrichment Method detecting the greatest numbers of both somatic and male-specific coliphages.
- There appears to be significant differences in levels of bacterial and F+ coliphage viral indicators at contaminated versus uncontaminated sample sites on a site-specific basis; studies are continuing.

Proposed Plans for Dissemination of Coliphage Methods

Most effective field methods to be packaged into kits for coastal zone water quality managers, recreational water and shellfish sanitation programs to provide them with better microbial tools to:

- help protect bathers and shellfish consumers from human fecal contamination, including enteric virus exposures. (Human enteric virus studies in progress).
- to more specifically identify and distinguish human and animal fecal contamination impacts.
- to better assess and manage coastal development and its impacts and other environmental changes contributing to fecal contamination.

Ongoing Study Questions

- Among study sites, do water samples from stations near fecal contamination sources have the same or different concentrations of fecal indicators and enteric viruses than the stations remote from fecal contamination sources?
- Are particular groups of F+ RNA, F+ DNA and somatic coliphages reliable and consistent indicators of human or animal fecal contamination sources?
- Can coliphage methods be made practical and rapid for routine field use?
  - Simple coliphage culture and genotyping methods
  - Real-time quantitative (RT-PCR)

Greg Lovelace
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http://ciceet.unh.edu

Questions and Answers

Q (Jack Skinner, Stop Polluting Our Newport): My background in internal medicine. When testing patients for f-specific phage in the stool specimen, it is extremely rare to find it. It is almost like the ecology is different. Whereas, the enteroviruses multiply in the gut, but they do not multiple after they leave the body. How do you explain this?

Greg Lovelace

I have no explanation for that.

Q (Jack Skinner): The only thing I can think about is that it multiplies within the sewage system, but it is not really from human fecal material because there is nearby E. coli where it can replicate. But, I do not understand how you can quantify human (entero) viruses and correlate them with a number of f-specific phage because there is never any f-specific phage found in the human stool samples.

Greg Lovelace

You are right, and I don't know why that is. In response to your comment on male-specific coliphages multiplying in the sewage treatment system, I don't think they do that but I don't have proof of that right in front of me. If you would like to talk about this later, I can talk to Dr. Sobsey and we can try to answer your question.

Q (David Turbow): With the exception of the somatic coliphages, the concentrations were higher at the contaminated sites than at the uncontaminated sites. Why are the somatic coliphages an exception?

Greg Lovelace

I'm not sure. We are only half-way through the study, and that may change once we get more data.

Q (Clay Clifton, County of San Diego Department of Environmental Health): In one of the last slides you showed, was the correlation between the existing indicators and f+ male-specific coliphages good or bad? Since you said the research is continuing, I'm assuming the correlation was not good.

Greg Lovelace

Yes. We are finding that the male-specific coliphages do not correlate well with the bacterial indicators.

Q (Clay Clifton): Have you tested the coliphage alongside of any of the existing indicators in any of the epidemiology studies that were conducted over the past year or two?

Greg Lovelace

Yes. The Mission Bay epidemiology study that Jack Colford will be talking about did incorporate both the somatic and the f+ coliphages.

Thursday, October 14

1:20 p.m. – 3:00 p.m.

Concurrent Track II:

Changes on the Horizon

Session Ten:
Quantifying Swimmer Risk

EPA National Epidemiology Study

Timothy Wade, Ph.D.
U.S. Environmental Protection Agency

Biosketch

Dr. Tim Wade is an Epidemiologist with the US EPA in the Office of Research and Development, National Health and Environmental Effects Research Laboratory, Human Studies Division in Chapel Hill, North Carolina. Dr. Wade received his Ph.D from the University of California at Berkeley and is currently a postdoctoral researcher in USPEAs Human Studies Division. He has been a lead scientist on several large studies of the health effects of contaminated drinking water and recreational waters. Dr. Wade is also a principal investigator and lead epidemiologist of several studies examining the health effects of arsenic in drinking water being conducted in the Inner Mongolia region of China.

Abstract

The National Epidemiological and Environmental Assessment of Recreational Waters (NEEAR) is a multi-year study of recreational water conducted by the United States Environmental Protection Agency and the Centers for Disease Control and Prevention (CDC), designed to evaluate new rapid indicators of recreational water quality and to determine their relationship to health effects. These studies are the first to evaluate the relationship between health effects and rapid indicators of recreational water quality. This presentation will summarize data collection efforts and preliminary analyses for the Great Lakes beach sites. We conducted studies at three Lake Michigan beaches and a Lake Erie beach during the summers of 2003 and 2004. Interviewers asked beach-goers about swimming and other activities. Ten to 12 days after the beach interview, interviewers telephoned each household to ascertain health symptoms experienced in the days following the beach interview. At each beach water samples were collected at several transects at two depths, three times a day. Samples were tested for enterococci using the standard method (Method 1600) and for enterococci and Bacteroides sp. using novel methods including quantitative polymerase chain reaction (QPCR). Several other potential rapid methods of evaluating water quality were also evaluated. During 2003, at the Lake Michigan Beach, interviews with 2877 individuals were completed. At the Lake Erie beach, interviews with 2840 individuals were completed. The relationships between health symptoms and the traditional and rapid indicators will be fully evaluated and presented in detail. Updates on the summer of 2004 data collection efforts and analysis will also be presented.

This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

The National Environmental and Epidemiologic Assessment of Recreational Water:

The relationship between novel indicators of water quality and health

Timothy J. Wade
National Beaches Conference
October 14, 2004

BEACHES Act of 2000 from Congress

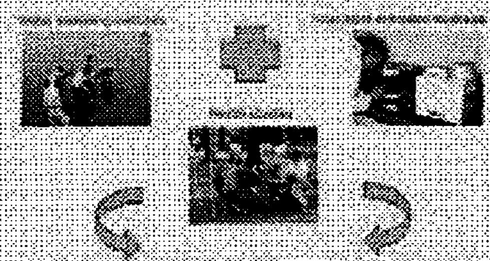
1. Determine microbial indicators for beach water quality
2. Develop efficient protocols for monitoring
3. Assess human health risks
4. Provide guidance to beach managers

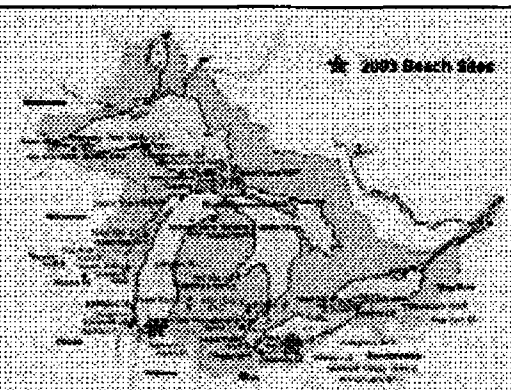
* Final Goal: New risk-based water quality guidelines & rapid monitoring methods for recreational waters.

Research Question

Is there an association between illness and recreational water quality as measured by rapid methods of determining water quality?

STUDY APPROACH

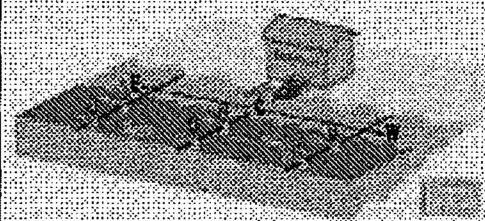




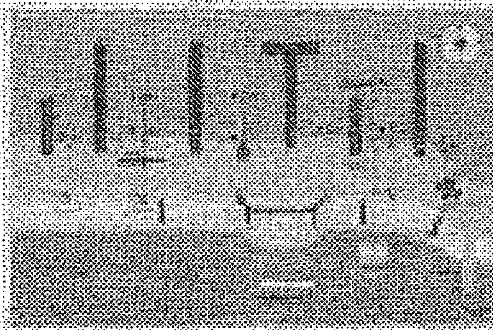
Water Sampling Strategy

* Taken 3 times daily → 8:00 AM, 11:00AM, 3:00 PM
* Two depths → .3 meters, 1.0 meter
* Modified sampling scheme according to beach area

Lake Michigan



Lake Erie



Water Quality Measures

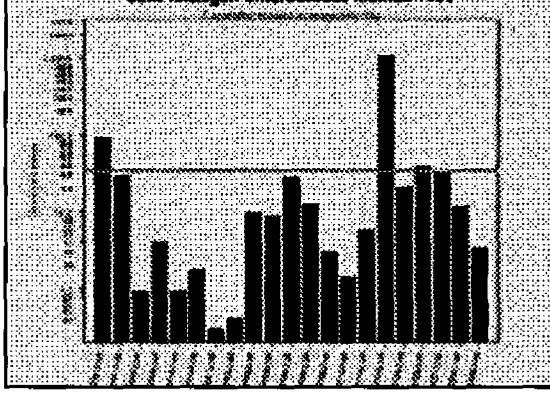
- Enterococci Method 1600
  - Current standard
  - Colony forming units 24-48 hrs
  - Intestinal tract bacteria, warm blooded animals
- QPCR: Enterococci and Bacteroides
  - Quantitative (real time) polymerase chain reaction
  - DNA based technology
  - Two hours
  - Intestinal tract bacteria
  - Bacteroides, 2-3 log higher density, anaerobe, dies in environment
  - Measured in cell equivalents (QPCRCE)

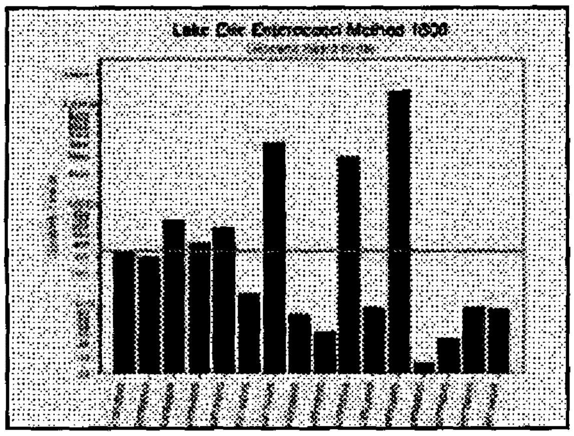
Exposures and Health Outcomes

- Exposures:
  - Any contact with water ("any contact")
  - Immersed body in water ("body contact")
  - Head under water ("head under")
- Outcomes
  - Gastrointestinal illness (GI), skin rash, earache, eye irritations, respiratory illness (URI)

2003 Data Collection

Lake Michigan	Lake Erie
May 31-August 3	July 27-September 14
29 days of surveying	18 days of surveying
2877 completed interviews	2840 completed interviews
67% completion rate	60% completion rate





Survey Results: Swimming

	Lake Michigan	Lake Erie
Any contact	75%	45%
Body contact	58%	27%
Head under	42%	18%
Water in mouth	18%	12%
Gagged on water	8%	3%
Swallowed water	7%	4%
Wave riding	9%	6%

Lake Michigan: Adjusted Odds Ratios for Swimming

	GI	URI	Eye	Rash	Earache
Any contact	2.22*	1.09	1.09	2.35*	1.40
Body contact	2.54*	1.08	1.19	2.44*	1.72
Head under	2.37*	1.08	1.25	2.42*	2.28*
*p<0.1					

Lake Erie: Adjusted Odds Ratios for Swimming

	GI	URI	Eye	Rash	Earache
Any contact	1.43*	1.08	0.65	1.23	1.74
Body contact	1.62*	1.03	0.62	0.86	1.46
Head under	1.68*	1.11	0.51	1.00	1.36
*p<0.1					

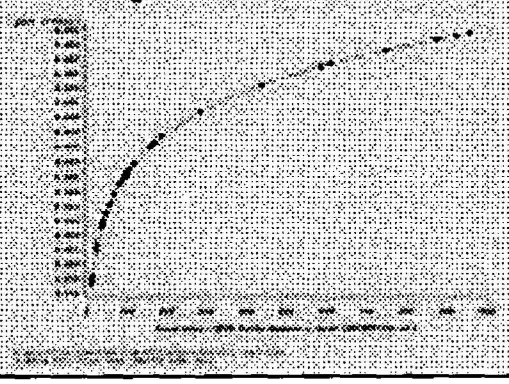
Lake Michigan: Trends for GI Illness

	Enterococcus Method 1600		Enterococcus QPCR		Bacteroides QPCR	
	OR*	P-trend	OR**	P-trend	OR**	P-trend
Any contact	1.11	0.43	1.78	0.04	0.88	0.11
Body contact	1.05	0.82	1.84	0.04	0.84	0.12
Head under	0.88	0.82	2.18	0.03	0.88	0.12
	[illegible]		[illegible]		[illegible]	

Lake Erie: Trends for GI Illness

	Enterococcus Method 1600		Enterococcus QPCR		Bacteroides QPCR	
	OR*	P-trend	OR**	P-trend	OR**	P-trend
Any contact	1.87	0.02	1.71	0.07	1.66	0.16
Body contact	1.58	0.15	2.08	0.07	1.95	0.08
Head under	0.88	0.90	1.51	0.37	2.10	0.08
	[illegible]		[illegible]		[illegible]	

Relationship between Enterococci QCPRCE and GI Illness: Lake Michigan and Lake Erie Beaches Combined



Risk of GI Illness: Method 1600

GI illness among Swimmers above vs. below daily geometric means of 33 cfu:

Enterococci (cfu/100ml)	GI Illness-Yes	GI Illness-No
>=33	70 (13.0%)	470 (87.0%)
<33	200 (10.6%)	1684 (89.4%)

OR (adjusted)=1.28 (95% CI: 0.95-1.73) p=0.11

Data Collection 2004

- Two Lake Michigan beaches
- Over 16,000 completed individual interviews
- GI illness-7%
- Swimming:
  - Any contact - 68%
  - Body contact- 52%
  - Head under - 37%
- RR for body contact (unadjusted)
  - 1.29 (95% CI 1.14-1.45)

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

Future Directions

- Better define risk to high risk groups such as children
- Evaluate other potential rapid indicators such as chemicals associated with sewage
- Studies in marine waters

The NEEAR Study Team

USEPA NHEERL:
Timothy J. Wade, Rebecca L. Calderon, Elizabeth Sams, Ann H. Williams
USEPA NERL:
Kristen Brenner, Alfred Dufour, Larry Wymer, Richard Haugland
Centers for Disease Control and Prevention
Michael Beach
USEPA Field Team:
Joel Hansel, Holly Ulrich, Ed Hudgens, Mike Schmitt, Mike Ray, Danelle Lobdell, Cass Andrews, Scott Rhoney, Beth Leonard, Walter Goyette
University of North Carolina:
Caroline Smith Huffman
Westat Corp.
Karen Davis Forte, Karl Patrick, Robert Clickner, Steve Dietz, and others too numerous to name
The Beaches Interviewers

Acknowledgements

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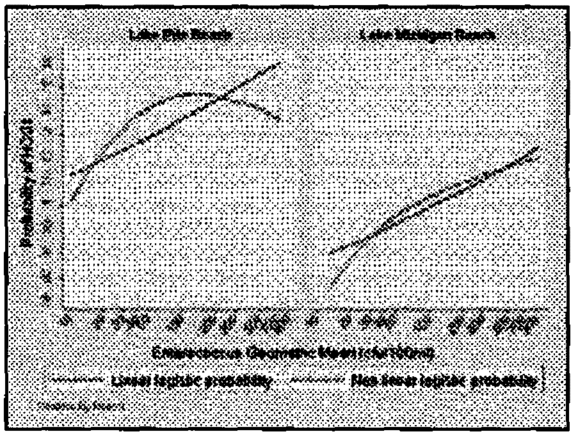
- Cuyahoga County Sanitary Engineering Division, Cleveland, Ohio
- EMSL Analytical, Inc. Laboratory, Westmont, New Jersey.
- Indiana Dunes National Park Service
- Cleveland Metroparks
- Cuyahoga County Board of Health



Interactions by Beach, Time in Water

	Estimate	p-value
Beach/QPCR CE	1.05	0.33
Time in Water/ QPCR CE	1.01	0.08
Trend at 5 min*	1.16	0.71
Trend at 30 min	1.46	0.23
Trend at 60 min	2.49	0.02

Questions and Answers

Comment (Katherine Field, Oregon State University): Concerning the non-detect level of the bacteroidides assay, that assay was actually designed as a tacman assay using an ABI machine. It was done that way at your original request because that is what you were originally doing. However, you then used it in the field in a completely different way in a different type of assay. That is why it didn't work very well. Anybody who would like to get some more recent information about the sensitivity of that, we have a more recent publication in Applied Environmental Microbiology that just came out this month.

Mission Bay Epidemiology Study

Jack Colford, MD, Ph.D.
University of California at Berkeley, School of Public Health

Biosketch

Dr. Colford is Associate Professor of Epidemiology in the University of California, Berkeley School of Public Health. Dr. Colford is a graduate of the Johns Hopkins School of Medicine (MD 1985) and the UC Berkeley School of Public Health (Epidemiology, 1996). He completed a residency in Internal Medicine and a fellowship in Infectious Diseases at the University of California, San Francisco. He was Chief Resident in Medicine at Stanford University Hospital. He is board-certified in both Internal Medicine and Infectious Diseases. He is the sole instructor in semester-long courses in advanced epidemiologic methods, intervention trial design, and meta-analysis and has received several teaching awards. He has taught for many years as a visiting professor each summer at the University of Michigan (meta-analysis) and the University of Zurich, Switzerland (epidemiologic methods). He has published numerous peer-reviewed articles on the health effects of waterborne diseases. While on sabbatical at WHO-Geneva last year, he co-authored a monograph published by the World Bank evaluating all published evidence of efficacy of water, sanitation, and health interventions. He is the Principal Investigator of four triple-blinded, randomized controlled trials of drinking water and health effects funded by the National Institutes of Health, the Centers for Disease Control, and the Environmental Protection Agency, and the University of California.

Abstract

Most epidemiology studies to establish health risk of recreational swimming have been conducted at locations where human sewage point sources are the primary source of fecal contamination. Here we conducted a study of health outcomes from swimming in Mission Bay (San Diego), CA where nonpoint runoff and animal waste are the primary fecal sources. We enrolled beachgoers, interviewed them about health conditions on the day of exposure and 14 days later, and collected water quality samples at sites linked spatially to participants_ location in the water. Both traditional (enterococcus, *E. coli*, total coliform) and novel candidate indicators (Bacteriodetes, coliphage, virus and traditional indicators measured using molecular rapid detection methods) were sampled four times each day at multiple locations on each of six beaches within Mission Bay. A total of 12,458 participants were enrolled and 8,790 (71%) completed the entire study. The principal health outcome was highly credible gastrointestinal illness (HCGI). Logistic models were used to analyze the data. We found an increased risk of HCGI illness among swimmers compared to non-swimmers (OR 1.31, 95% CI 1.01-1.71, p=0.045), but did not find associations between traditional microbial indicators and health. Preliminary analysis suggests that there was association with some of the novel indicators, though. The lack of association of traditional indicators with health outcomes emphasizes the importance of research into alternative indicators, particularly at sites where non-point sources are prevalent.

Mission Bay Epidemiology Study

SCCWRP
Southern California Coastal Water Research Program
Ken Schiff, Stephen Weisberg, John Griffith

University of North Carolina (UNC)
Mark Sobsey, Jan Vinje, Greg Lovelace, Doug Wait

Epidemiology
University of California, Berkeley
Jack Colford, Sukhi Sandhu
Timothy Wade, Catherine Wright

Environmental Protection Agency
Tim Wade

Harvard University
Alan Brookhart

Background

- Many prior epidemiologic studies of recreational water
- All but one of these focused on sewage dominated waters
- Mission Bay in San Diego gave us a unique opportunity for a different study setting
  - Limited circulation and mixing
  - Heavily used aquatic park
  - Receives numerous nonpoint sources
  - Non-human sources are dominant
  - Urban storm drains
  - More than 100 days of beach postings in 1998

Research Questions

- Did swimming in Mission Bay during the summer of 2003 affect the risk of an individual's subsequent development of health outcomes 10-14 days later?
- Did the levels of traditional microbial indicators correlate with symptoms?
- Did the levels of novel microbial indicators correlate with symptoms? (coliphage – male and somatic, Bacteroides, viruses)

Overview of design

- Prospective cohort (8,790 participants, 59% of goal)
- Health questions asked (in person) on day of exposure and 10-14 days later (by phone)
- Microbial indicators (most) measured throughout the day and linked to actual participant's swimming location
- 17% of water samples had enterococcus values>104

Health outcomes by category

- Gastrointestinal
  - nausea, vomiting, diarrhea, cramps, HCGI-1, HCGI-2
- Respiratory
  - cough, cough with phlegm, nasal congestion, sore throat, SRD
- Dermatologic
  - rash, scrapes
- Non-specific
  - fever, chills, earache, ear discharge, eye irritation

Exposures to water

- Water exposure vs. health outcomes
  - Any water contact (yes/no)
  - Among swimmers
    - Face under water (yes/no)
    - Time in water (continuous, categorical, & per 100 min increase)
    - Shoulders in water (yes/no)
    - Swallowing water (yes/no)
    - Water in the mouth (Y/N)
    - Gag or cough from water (Y/N)
    - Amount of water swallowed (continuous)

Microbial indicators

- Enterococcus
- Total coliforms
- Fecal coliforms
- Total:fecal ratio (derived value)
- *E. coli*
- Bacteroides
- *Enterococcus faecalis*
- Male-specific phage (composite daily sample)
- Somatic phage (composite daily sample)

Covariates used in adjusted models

- Age, gender, race
- Allergies, subsequent swimming, contact with shells
- Dug in sand, buried in sand, touched algae
- History of chronic GI illness, contact with GI illness
- Used insect repellant, sunblock
- Showered after beach
- Ate eggs, ate raw foods, ate other food at beach
- History of chronic respiratory disease
- Household income level

Analysis

- Logistic regression models used to estimate odds of illness in exposed group vs. odds of illness in unexposed group (i.e. odds ratio "OR")
- Adjusted models estimated using covariates (prior slide)

Participant characteristics (N=8790)

- Age
  - 0-5 14%
  - 5-12 21%
  - 12-30 27%
  - 30-55 34%
  - >55 4%
- Race
  - White 26%
  - Black 4%
  - Hispanic 60%
  - Other 10%

Symptom frequency (n=8790)

470-Sore throat	243-HCGI1
414-Eye irritation	223-Nausea
386-Cramps	213-Cough
373-Diarrhea	190-Earache
281-SRD	187-Vomiting
211-Fever	74-HCGI2
169-Skin rash	36-Ear discharge

Adjusted models for odds ratio
Any water contact
*p<0.05

Gastrointestinal	Miscellaneous
1.29 Diarrhea	1.07 Rash
1.11 Cramps	1.30 Eye irritation
0.98 HCGI1	1.08 Fever
0.90 HCGI2	1.00 Earache
0.86 Nausea	0.42 Ear discharge
0.83 Vomiting	
Respiratory	
0.97 SRD (sig resp disease)	
0.87 Sore throat	
0.75 Cough	

Adjusted models for odds ratio
Water on the face
*=p<0.05

Gastrointestinal	Miscellaneous
*1.33 Diarrhea	*2.18 Rash
1.24 Cramps	1.28 Eye irritation
1.13 HCGI1	1.08 Fever
1.31 HCGI2	1.09 Earache
1.27 Nausea	0.72 Ear discharge
1.02 Vomiting	
Respiratory	
1.00 Sore throat	
0.92 SRD (sig resp disease)	
0.73 Cough	

Water on the face, by age
Odds ratios for health outcomes
*=p<0.05

	Diarrhea	HCGI-1	Sore throat	Rash	Eye irritation
0-5	1.08	1.28	1.25	2.33*	0.68
5-12	2.29*	1.28	0.57	3.04*	1.44
12-30	1.88*	1.09	1.37	1.79	1.63
30-55	0.97	0.90	0.80	1.09	0.93
>55	Too few	Too few	Too few	Too few	Too few

Enterococcus (30 unit change)
Odds ratios for health outcomes
*=p<0.05

	Diarrhea	HCGI-1	Rash	Eye irritation	Sore throat
ln (daily geo mean-beach)	0.62	0.73	2.21	0.63	1.04
Max (daily-beach)	0.84	0.87	1.54	0.76	0.69

Coliforms, Total and Fecal (50 unit change)
Odds ratios for health outcomes
*=p<0.05

	Diarrhea	HCGI-1	Rash	Eye irritation	Sore throat
Total coliform-ln (daily geo mean-beach)	0.42*	0.62	2.96	0.57	1.13
Fecal coliform-ln (daily geo mean)	0.39	0.73	1.65	0.57	1.10

Bacteroides	Diarrhea – odds ratios-adjusted
Overall	0.48 (0.23, 1.03)
Age 0-5	2.54 (0.10, 2.77)
>5 - 12	0.56 (0.13, 2.43)
>12 - 30	0.31 (0.05, 1.79)
>30 - 55	0.48 (0.11, 2.20)
>55	Too few

Male-specific phage	Diarrhea-NO N(% of column)	Diarrhea-YES N(% of column)	HCGI-1-NO N(% of column)	HCGI-1-YES N(% of column)
<0.16	3283 (95.2%)	192 (4.8%)	3344 (96.3%)	132 (3.3%)
0.12	87 (95.6)	4 (4.4%)	89 (97.8%)	2 (2.2%)
0.25	4 (100%)	0 (0%)	4 (100%)	0 (0%)
0.31	20 (100%)	0 (0%)	20 (100%)	0 (0%)
0.49	5 (100%)	0 (0%)	5 (100%)	0 (0%)
0.77	37 (90.2%)	4 (9.8%)	37 (90.2%)	4 (9.8%)

Did swimming in Mission Bay during the summer of 2003 affect the risk of an individual's subsequent development of symptoms 10-14 days later?

- Yes but only for a few health outcomes and age groups
  - Of 14 health outcomes examined, rash was the only symptom consistently elevated
  - Of the symptoms examined, only two (diarrhea and rash) were significantly elevated for any age group
  - 5-12 year olds: increased diarrhea, rash
  - Those with higher degrees of water exposure had an increased risk after covariate adjustment for diarrhea
  - Compared to other studies, the risk of illness overall was lower both among those exposed to water and those not

Did the measured levels of any microbial indicators correlate with symptoms?

- Traditional indicators
  - Enterococcus: No
  - Fecal coliforms: No
  - Total coliforms: No
- Non-traditional indicators
  - Male-specific phage: Yes (but very small sample)
  - Bacteroides: No
  - Enterococcus Q-PCR: No

Microbial indicators and illness

- No relationship was found between traditional indicators and illness
  - Current water quality thresholds were not predictive of illness in Mission Bay in our study
- Mission Bay is a unique system relative to the other studies upon which standards were originally set
  - MB is enclosed, has long circulation times, and is non-point source
- Because of these difference, it is difficult to extrapolate these results to other settings

Questions and Answers

Q: You had 17 percent that exceeded the 104. How high were those exceedances?

Jack Colford

Ken Schiff, who is here, directed that aspect of the study.

Ken Schiff

The values were in the hundreds to the tens of thousands.

Q: I assume you looked at different sites throughout Mission Bay. Did you see differences between the east and west sides of the bay?

Jack Colford

Yes, there were differences in some of the beaches. But, I can't remember specifically what they were because the numbers were so small.

Risk Perception Bias and Self Reported Symptoms

Jay Fleischer, Ph.D.
NOVA Southeastern University, College of Osteopathic Medicine, Master of Public Health Program

Biosketch

Dr. Jay Fleisher received a B.S. Degree in Environmental Health Science from the City University of New York, an M.S. in Environmental Science from the City University of New York, an M.S. in Epidemiology from Columbia University's School of Public Health, and a Ph.D. in Environmental Epidemiology /Biostatistics from the Institute of Environmental Medicine, New York University. Dr Fleisher holds facility positions at both NOVA Southeastern University and the Center for Research into Environment and Health, Leeds University (United Kingdom). Dr Fleisher's main research interest is in the spread of infectious illness via contaminated recreational / potable waters and has been active in this area for the past 20 years. The focus of Dr Fleisher's research has been in the health effects of exposure to waters contaminated with domestic sewage, indicator organism variability, indicator organism – pathogen relationships, risk assessment, statistical water quality sampling protocols, assessing compliance, setting of microbial water quality standards, population health burden assessment, risk perception, and risk vs current standards. Dr Fleisher has advised numerous international committees, organizations, and government agencies on various aspects of these recreational water quality issues. In addition Dr Fleisher authored over 35 peer reviewed publications and 5 book chapters dealing with these water quality issues.

Abstract

Background

Epidemiologic studies of water associated illness sometimes have to rely on self-reported symptoms of the outcome illness(es) under study. Individual participant's perception of risk, in theory, can affect the validity of self-reported symptoms.

Methods

The magnitude and effect of possible "risk perception bias" was evaluated as part of a series of randomized trials designed to assess infectious disease transmission via exposure to marine recreational waters with modest sewage contamination. All study subjects were blinded to both their individual indice of exposure and the outcome illnesses under study.

Results

Of the five outcome illnesses studied, the effect of "risk perception bias" only affected one: Skin Ailments. Although analysis of crude rates of skin ailments showed the exposed group (bathers) to be 3.5 times more likely to report skin ailments relative to the non-exposed (non-bathers), when the data was stratified by any perceived health risk of bathing in such waters, this association was shown to be spurious in nature. Bathers having pre-conceived notions of any health risk due to the exposure were 10.63 times more likely to report skin ailments relative to the unexposed (non-bathers) (95% CI 2.36-47.8, P = 0.0002), while bathers without any pre-conceived notion of risk were no more likely to report skin ailments relative to non-bathers (OR = 0.60, 95% CI 0.11-3.24, P =

0.71). Further stratification by exposure grouping showed bathers with pre-conceived notions of excess risk to be 4.78 times more likely to report skin ailments relative to bathers without any notion of excess risk (95% CI 1.04-21.86, P = 0.03), while among non-bathers those with pre-conceived notions of risk were 3.70 times less likely to report skin ailments relative to non-bathers without any pre-conceived notion of risk (95% CI 0.70-19.60, P = 0.10).

Conclusions

This study shows that "risk perception bias" can be strong enough to lead to spurious associations in the presence of self-reported symptoms, and should be controlled for in future epidemiologic studies of recreational water associated illnesses and other water associated environmental exposures where the use of self-reported symptoms cannot be avoided.

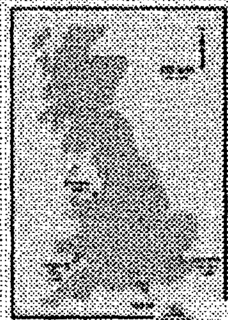
Perception Bias and Illness Associated with Bathing in Marine Waters

Randomized Trials of Bathers exposed to marine waters contaminated with various degrees of sewage contamination

- Goals: To substantially improve upon previous Prospective Cohort Designs by minimizing following sources of bias:
  - minimizing misclassification of exposure
  - Strengthening measures of outcome illness
  - Eliminate possible selection bias by use of randomisation
  - use all data collected in Analysis
  - improve estimates of Enterococci via use of replicated determination of every sample taken
  - Control for "Perception Bias"

Study Location

- Four year research programme
- Four beaches which passed EU Imperative Standards chosen by the DETR Committee



Recruitment

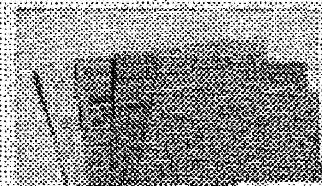
- Healthy adult volunteers were recruited in local shopping centres
- Publicity was given in the local press
- Volunteers signed a subject information sheet.

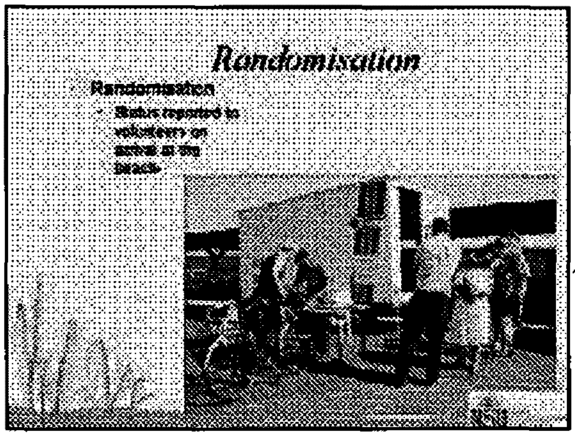
Interviews

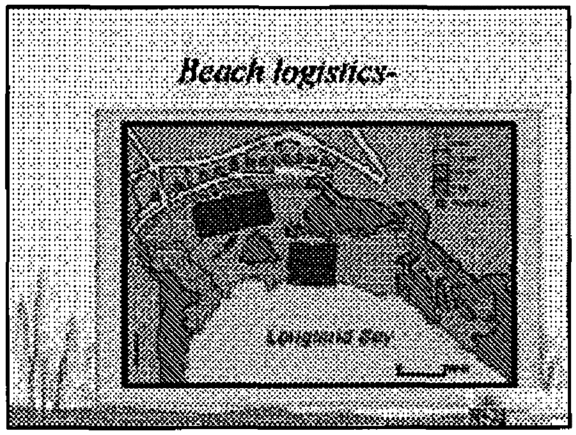
- 1-3 days prior, on the day and at 7 days post-exposure
- Medical examinations
- Clinical samples collected

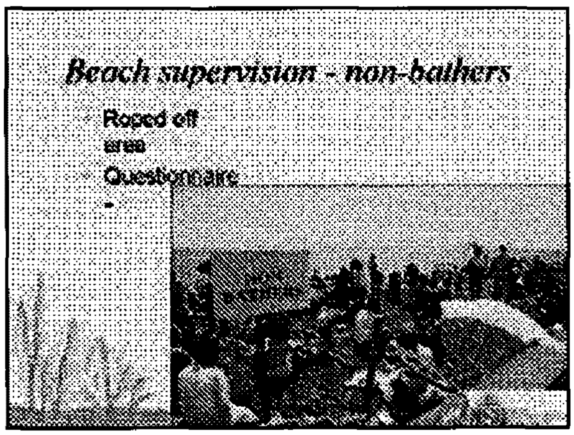
Questionnaire

- 4 part questionnaire
  - 1-3 days before
  - Exposure day
  - 7 days post exposure
  - 21 days post exposure




Randomisation
Randomisation


Beach logistics-


Beach supervision - non-bathers
Roped off area
Questionnaire


Beach Supervision - Bathers


Interviews-


The 'Free Lunch-


Exposure Measurement
Water quality
measured


Exposure Measurement


Post-Exposure Interviews
7 days post-exposure
Questionnaire administered
Further medical-

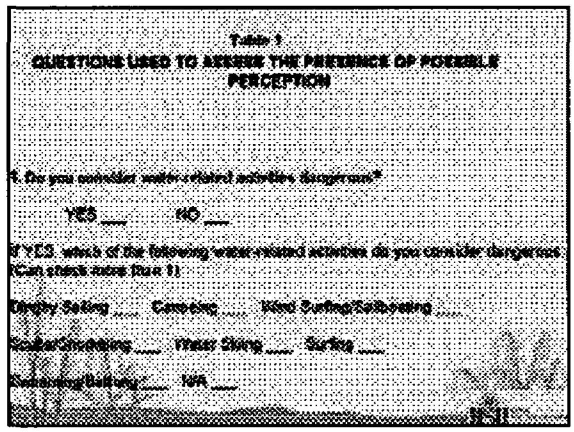
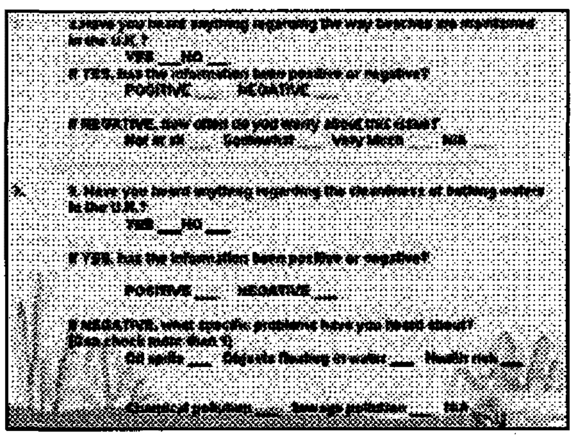
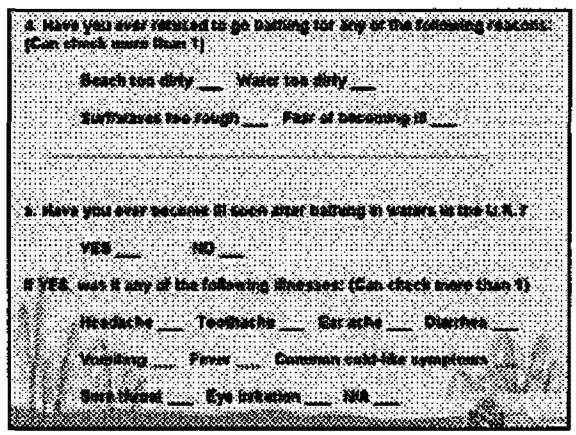
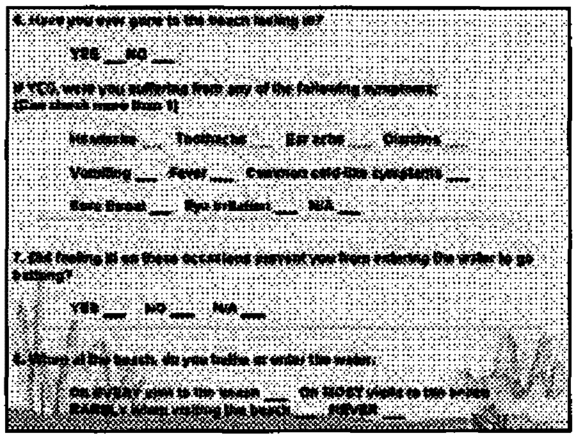
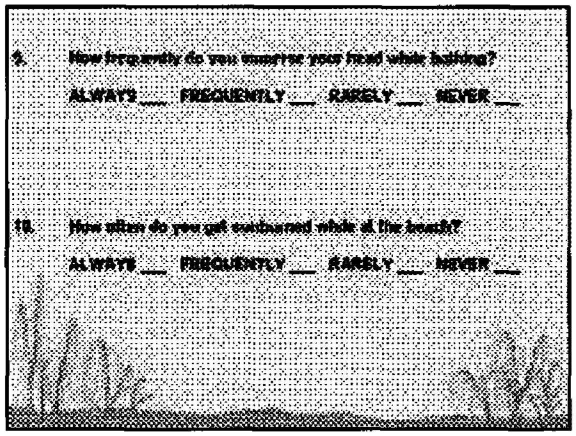


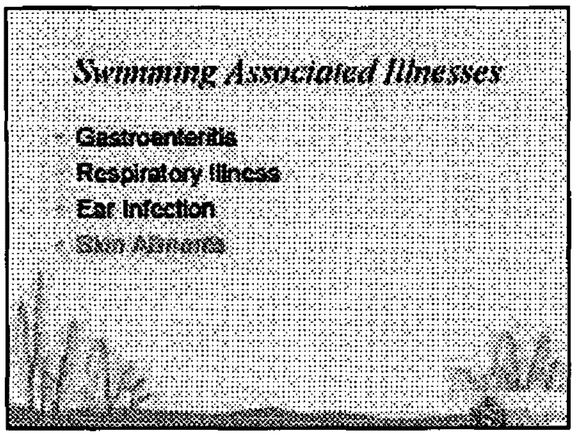
Table 1
PERCEPTION
YES ___ NO ___


YES ___ NO ___
If YES, has the information been positive or negative?
POSITIVE ___ NEGATIVE ___


4. Have you ever refused to go bathing for any of the following reasons: (Can check more than 1)
Beach too dirty ___ Water too dirty ___
Surf/waves too rough ___ Fear of becoming ill ___
5. Have you ever become ill soon after bathing in waters in the U.K.?
YES ___ NO ___
If YES, was it any of the following illnesses: (Can check more than 1)
Headache ___ Toothache ___ Ear ache ___ Diarrhea ___
Vomiting ___ Fever ___ Common cold-like symptoms ___
Sore throat ___ Eye irritation ___ N/A ___


6. Have you ever gone to the beach feeling ill?
YES __ NO __
If YES, were you suffering from any of the following symptoms:
(Can check more than 1)
Headache __ Toothache __ Ear ache __ Diarrhea __
Vomiting __ Fever __ Common cold-like symptoms __
Sore throat __ Eye irritation __ N/A __
7. Did feeling ill on these occasions prevent you from entering the water to go bathing?
YES __ NO __ N/A __
8. When at the beach, do you bathe or enter the water:
On EVERY visit to the beach __ On MOST visits to the beach
RARELY when visiting the beach __ NEVER __


9. How frequently do you immerse your head while bathing?
ALWAYS __ FREQUENTLY __ RARELY __ NEVER __
10. How often do you get sunburned while at the beach?
ALWAYS __ FREQUENTLY __ RARELY __ NEVER __


Swimming Associated Illnesses
Gastroenteritis
Respiratory Illness
Ear Infection
Skin Ailments

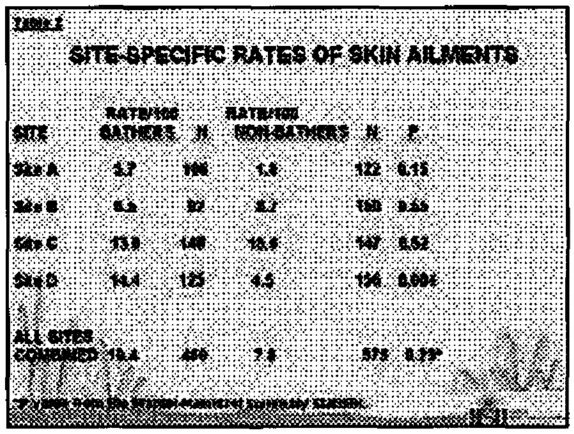


Table 2
SITE-SPECIFIC RATES OF SKIN AILMENTS
SITE RATE/100 BATHERS N RATE/100 NON-BATHERS N P
Site A 3.7 196 1.6 122 0.15
Site B 6.6 97 8.2 160 0.65
Site C 13.9 140 10.6 147 0.52
Site D 14.4 125 4.5 156 0.004
ALL SITES COMBINED 10.4 490 7.6 575 0.23*

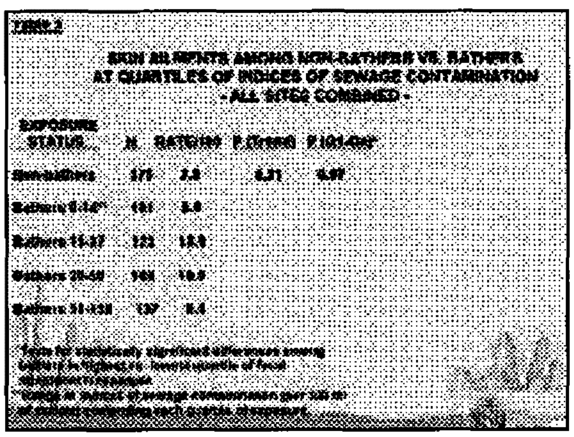
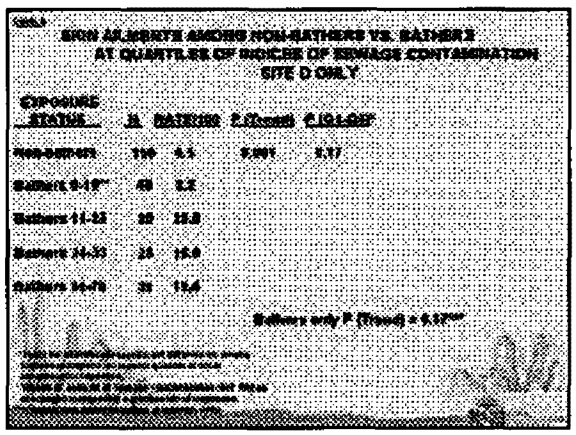
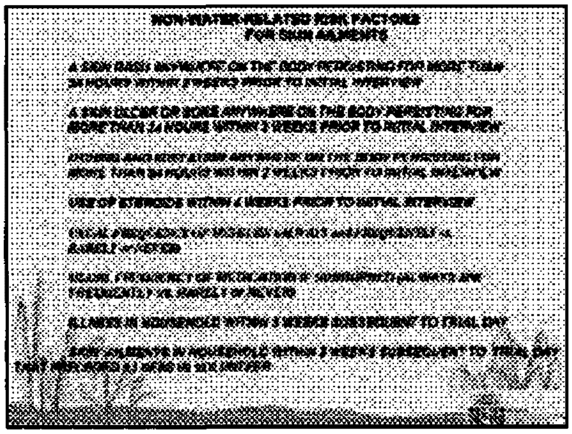
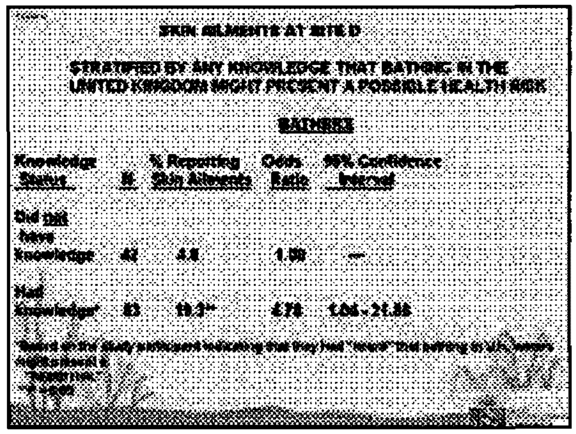
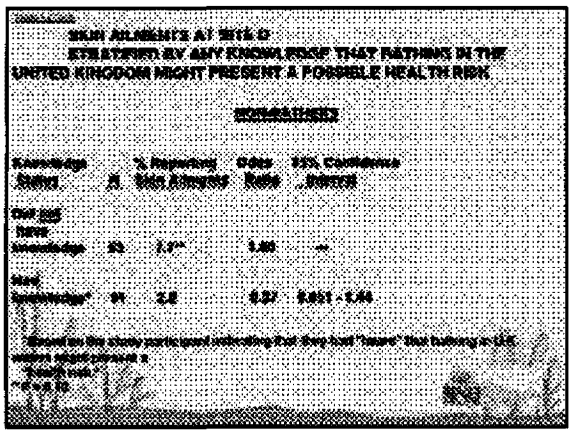


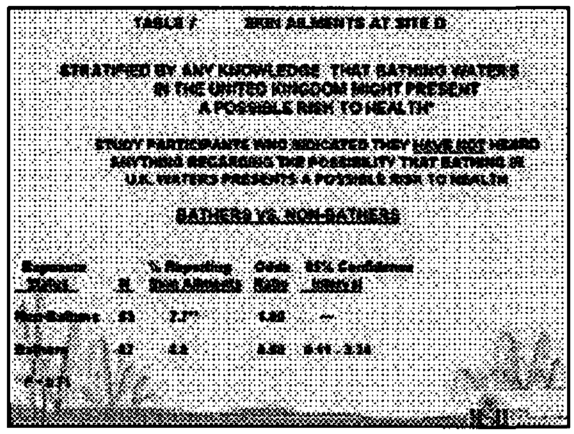
Table 3
SKIN AILMENTS AMONG NON-BATHERS VS. BATHERS
AT QUARTILES OF INDICES OF SEWAGE CONTAMINATION
- ALL SITES COMBINED -
EXPOSURE STATUS N RATE/100 P (Trend) P (Q1-Q4)

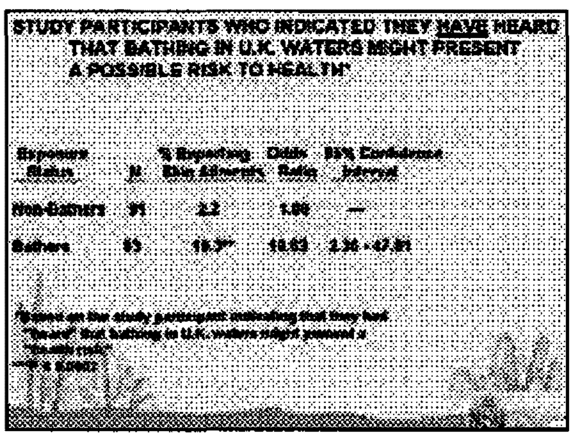

SKIN AILMENTS AMONG NON-BATHERS VS. BATHERS
AT QUARTILES OF INDICES OF SEWAGE CONTAMINATION
SITE D ONLY
EXPOSURE STATUS N RATE/100 P (Trend) P (Q1-Q4)


NON-WATER-RELATED RISK FACTORS
FOR SKIN AILMENTS
A SKIN ULCER OR SORE ANYWHERE ON THE BODY PERSISTING FOR MORE THAN 24 HOURS WITHIN 3 WEEKS PRIOR TO INITIAL INTERVIEW
USE OF STEROIDS WITHIN 4 WEEKS PRIOR TO INITIAL INTERVIEW
ILLNESS IN HOUSEHOLD WITHIN 3 WEEKS SUBSEQUENT TO TRIAL DAY


SKIN AILMENTS AT SITE D
STRATIFIED BY ANY KNOWLEDGE THAT BATHING IN THE UNITED KINGDOM MIGHT PRESENT A POSSIBLE HEALTH RISK
BATHERS
Knowledge Status
N
% Reporting Skin Ailments
Odds Ratio
95% Confidence Interval
Did not have Knowledge
42
1.00
—
Had Knowledge*
83


SKIN AILMENTS AT SITE D
UNITED KINGDOM MIGHT PRESENT A POSSIBLE HEALTH RISK
Knowledge Status
N
% Reporting Skin Ailments
Odds Ratio
95% Confidence Interval
Did not have Knowledge
Had Knowledge*


SKIN AILMENTS AT SITE D
STRATIFIED BY ANY KNOWLEDGE THAT BATHING WATERS
IN THE UNITED KINGDOM MIGHT PRESENT
A POSSIBLE RISK TO HEALTH*
BATHERS VS. NON-BATHERS
% Reporting Skin Ailments
Odds Ratio
95% Confidence


STUDY PARTICIPANTS WHO INDICATED THEY HAVE HEARD
THAT BATHING IN U.K. WATERS MIGHT PRESENT
A POSSIBLE RISK TO HEALTH*
Exposure Status
N
% Reporting Skin Ailments
Odds Ratio
95% Confidence Interval
Non-Bathers
91
2.2
1.00
—
Bathers
83

Questions and Answers

No questions.

Criteria Development: Beach Act Requirements and Schedule

Stephen Schaub
U.S. Environmental Protection Agency

Biosketch

Dr. Stephen Schaub is a Senior Microbiologist with the U.S. Environmental Protection Agency's Office of Water. He provides scientific support to Clean Water Act and Safe Drinking Water Act programs within the Office of Science and Technology. Dr. Schaub received a B.S. Degree in Bacteriology and Public Health from Washington State University and a M.S. and Ph.D. from the University of Texas (Austin) in Microbiology (Environmental Virology). For 20 years Dr. Schaub worked as a program manager and head of the Microbiology Research for the Department of the Army's Biomedical Research and Development Laboratory at Fort Detrick. He was responsible for supporting the Military's efforts to protect soldier health against exposures to microbial pathogens in water and wastewater. Since 1992 Dr. Schaub has been a Senior Microbiologist with the USEPA's Office of Water and supported regulation development for the new family of Enhanced Surface Water Treatment Rules. He has also been involved in determining and supporting research and programmatic needs for establishment of future recreational water quality criteria to protect against gastrointestinal illnesses and determining requirements for effective approaches to reduce microbiological pathogens for safe discharge of treated wastewater. He is currently responsible for development of new recreational water quality criteria and criteria for Crypotosporidium in drinking source waters. Dr. Schaub is the lead for development of microbiological pathogen risk assessment protocols for water-based media and is also the lead for the establishment of Agency-wide microbiological risk assessment guidelines.

Abstract

The Year 2000 BEACH Act Amendments to the Clean Water Act requires the USEPA to prepare new or revised 304(a) Ambient Water Quality Criteria for Recreational Waters by October 2005. Over the past 4 years the Agency has conducted a series of research efforts to provide data for use in establishing the new Criteria. Principal efforts have been the following: beach sampling studies to characterize impacts of spatial and temporal, as well as environmental, factors on indicator microorganisms distributions in beach waters; new epidemiology studies to characterize the acute gastrointestinal disease incidence from swimming exposures in fresh water; and identification and evaluation of new rapid enterococci methods and other fecal indicators for recreational water monitoring and characterization of their relationship to acute disease incidence. Over the next year the Offices' of Water and Research and Development will work together to establish new or revised fresh recreational water quality criteria based upon the above studies. The Criteria will utilize the new epidemiological information on recreational exposures and acute disease risks. The Criteria will also take advantage of the rapid quantitative polymerase chain reaction (QPCR) techniques to quantify indicator levels in less than 2 hours, which will allow beach operators to know the water quality conditions before swimmers even get to the beach. Additionally, the new criteria will identify improved mathematical approaches to characterizing the indicator to disease relationships and will provide more realistic sampling protocols to monitor the dynamic water conditions typical of beach waters. During the process of development of the Criteria the Agency will seek input from the States and other stakeholders to help fine tune the criteria to meet national health protection goals for fresh water recreational activities.

New Criteria Development: BEACH Act Requirements for 2005

Stephen Schaub, Ph.D.

USEPA, Office of Science and Technology Health and Ecological Criteria Division

Purpose of Briefing

- Provide background on legislative requirements of the Act and preparatory actions.
- Discuss activities and their status for application to criteria development

Legislative Background

- Overview
  - Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) amended the Clean Water Act to require revised 304(a) Ambient Water Quality Criteria be prepared in 2005
  - The Amendment describes a number of activities necessary to prepare the Criteria

Legislative Background (continued)

- Section 104(v)(a) amendment requires that actions be undertaken to conduct studies within 18 months of enactment to develop information regarding:
  - An assessment of potential human health risks resulting from exposure to pathogens in coastal recreation waters, including non-gastrointestinal effects **(Epidemiology of Recreational Water)**
  - Appropriate and effective indicators for improving detection, in a timely manner in coastal waters, of the presence of pathogens harmful to human health **(Rapid Fecal Indicators)**

Legislative Background (continued)

- Appropriate, accurate, expeditious, and cost-effective methods (including predictive models) for detecting in a timely manner in coastal waters, the presence of pathogens that are harmful to human health **(Water Monitoring)**; and
- Guidance for State application of the criteria for pathogens and pathogen indicators to be published under section 304(a)(9) to account for the diversity of geographic and aquatic conditions.

Legislative Background (continued)

- Prepare Revised Criteria under Section 304(a):
  - Not later than October 2005, after consultation with appropriate Federal, state, tribal and local officials, the administrator shall publish new or revised water quality criteria for pathogens and pathogen indicators (including a revised list of testing methods as appropriate) based on the results of the studies conducted under section 104 (v) for the purpose of protecting human health in coastal waters

Preparatory Activities

- **Epidemiology Studies**
  - Four prospective epidemiology studies were conducted on Great Lakes beach waters during the summers of 2003-04
  - Exposed (bather) & Control (non-bather) populations were recruited from beach users & illnesses were followed for up to 12 days after beach outings.
  - *Status*: Validating and analyzing data to determine illness rates and their demographic distribution

Preparatory Activities (continued)

- **Methods Development**
  - Evaluating molecular-based rapid analytical methods
    - quantify enterococcus & Bacteroides fragilis fecal indicators
    - these & current cultural method for enterococcus were used to monitor beach waters to correlate fecal contamination exposure levels for bathers during the prospective epidemiology studies
  - *Status*: Best new candidate method: quantitative PCR which detects and quantifies indicators within 2 hours from start of analysis

Preparatory Activities (continued)

- **Monitoring Considerations**
  - EPA's ORD-OW study evaluated spatial and temporal factors that influence beach water quality and their implications for protective water monitoring approaches
  - *Status*: Study showed that UV, tides, wind direction, waves, sample distance from shore, & rainfall can cause water quality to change rapidly & significantly (even daily) – impacts when, where, & how to monitor beach waters
  - Independent studies confirm that these & other factors influence variability of bathing water quality

Criteria Development – Part 1

- Develop Microbial Human Health Criteria Methodology
- Develop protocol for conducting microbial risk assessments to establish water criteria
- Conduct economic benefit analysis for criteria
- Develop improved approach to numerical criteria – EPA Workshop in Winter '05
  - Topics: evaluate composite sampling, arithmetic means, re-assess single sample maximums, ranges of acceptable water quality rather than hard numbers, others

Criteria Development – Part 2

- **New Criteria Document**
  - Many issues to consider and resolve
    - Studies of Great Lakes waters will be examined for applicability to all fresh waters
    - Improved correlations between gastrointestinal illness and fecal indicator levels
    - Rapid analytical methods (~2hr analysis) - know water quality before or during swimming day
    - Numerical Criteria - easy to understand & implement; improved health protection for various levels of exposure
    - Improved spatial and temporal sampling procedures and locations to characterize beach water conditions

Public and Stakeholder Review

- Review drafts of new Human Health Assessment Tools
- Review drafts of new/revised Criteria document
  - Federal, State, tribal, and stakeholder groups
  - Workgroup of EPA Regional and State representatives
  - FR notice and response to comments

Implications of the New 2005 Criteria and Relation to Other Beach Act Activities

- New Criteria are only for fresh waters; statistical analysis will characterize their national application.
- Beach Act allows 3 yrs for States to incorporate the Criteria into State standards
- Marine epidemiology-indicator studies slated for the future, but new marine criteria are years away
- Federal promulgation of the Beach Rule this fall is totally separate from the new Criteria of 2005

Questions and Answers

No questions.

Evaluation of Recreational Health Risk in Coastal Waters Based on Enterococcus Densities and Bathing Patterns

David Turbow, Ph.D.
Touro University International

Biosketch

(Not submitted)

Abstract

(Not submitted)

Evaluation of Recreational Health Risk in Coastal Waters Based on Enterococcus Densities and Bathing Patterns

David Turbow, Ph.D.
Assistant Professor of Health Sciences
Touro University International

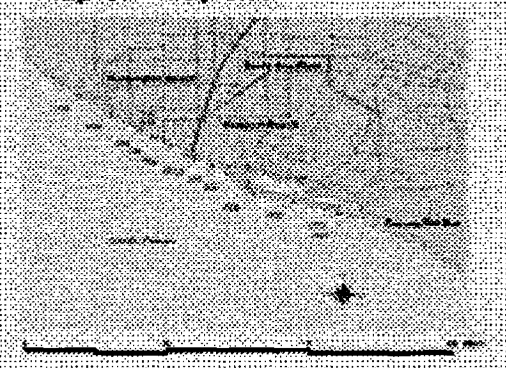
Publication

- Environmental Health Perspectives. 111(4): April 2003.
- Co-authors: Nathaniel Osgood, Sunny Jiang
- University of California, Irvine.

Motivation for Study/simulation

- Infectious disease rates in marine bathers often unmeasured/underreported.
- Need to characterize behavioral swimming patterns to improve risk management practices at recreational beaches (US EPA, 1998).
- Epi studies for recreational water exposure are expensive to conduct. Can use existing epi knowledge to ask important questions.
- Simulation objective methodology by which to estimate illness rates under exposure-related conditions (US EPA, 1998; IEH 2000).

Map of study site



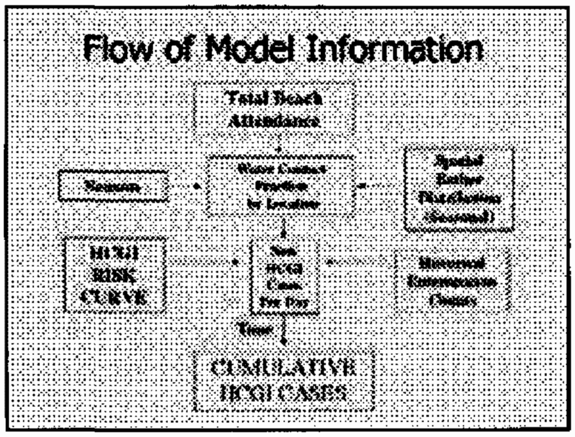
Study Goals

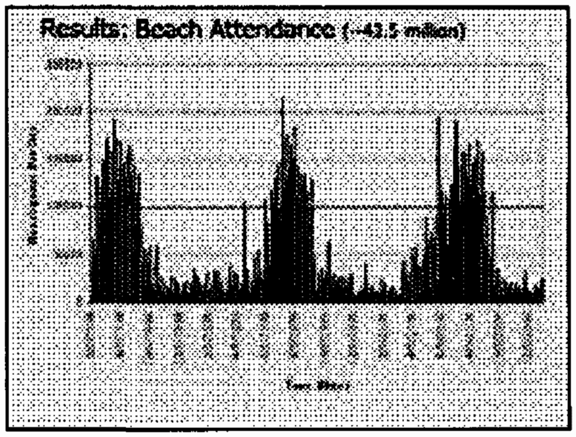
- Give probabilistic estimates of total bathers exposed to contamination by location.
- Estimate Highly Credible Gastrointestinal Illness (HCGI) rates in swimmers for particular beaches.
- Determine extent to which policy protects human health under current standards.

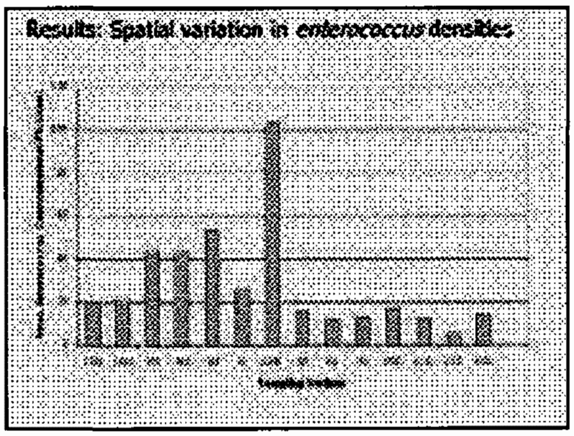
Goals of Simulation

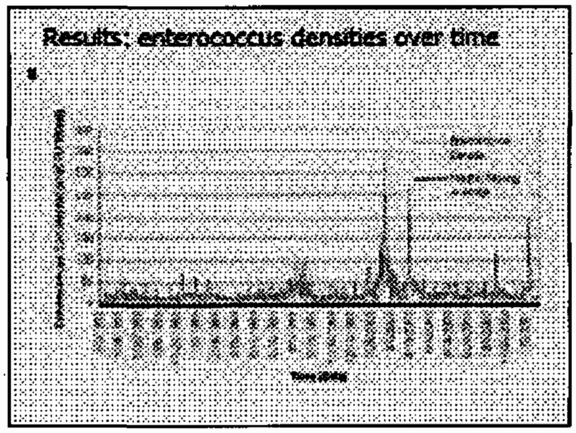
Calculate HCGI incidence under assumptions:

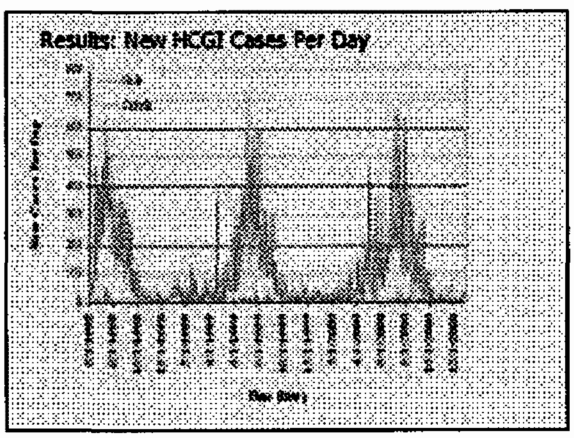
- "Dose-Response" for *enterococcus* (EC) and illness risk.
  - Sewage (Cabelli et al., 1982)
  - Storm Drain Runoff (Haile et al., 1999)
- Level of swimming activity at sampling locations.
  - Uniform vs. clustered distribution
- Fraction of beachgoers who bathe during beach closures.
  - 0% vs. 10%

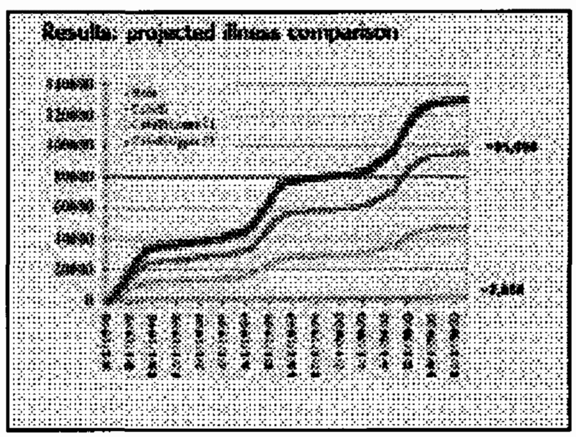

Flow of Model Information
Total Beach Attendance
HCGI RISK CURVE
Time
CUMULATIVE HCGI CASES


Results: Beach Attendance

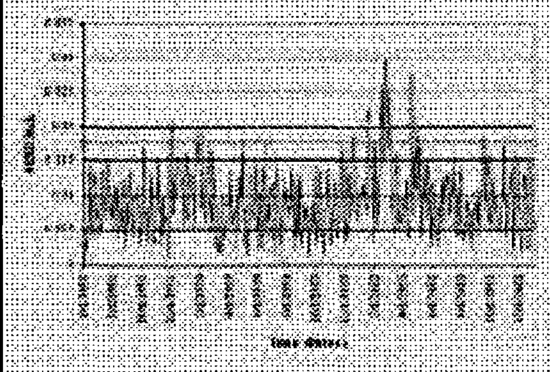

Results: Spatial variation in *enterococcus* densities


Results: enterococcus densities over time


Results: New HCGI Cases Per Day


Results: projected illness comparison

Results: Average daily HCGI risk



Results/Discussion

- Thresholds for acceptable mat risk when averaged over study period.
- Total # of illnesses related to seasonal water usage.
  - Higher total # summer illnesses
  - Higher *fraction* of winter illnesses
- Results sensitive to dose-response relationship.
- Smaller impact of spatial distribution of bathers.
- Results insensitive to bathing during beach closures.
- ~ 99% of illness cases occur when beaches open.

Conclusions

- Simulation shows that health risk is strongly related to seasonal WQ patterns, seasonal recreational water use.
- # of illnesses in model insensitive to bathing during beach closures
  - Discretion of health officials (Post or Close)
  - Enforcement of geometric mean standard
- Model is useful for identifying data needs, policy priorities.

Recommendations

- Strengthen year-round health protection policies (e.g. sewage spills vs. wet weather single exceedances)
- Heighten awareness of postings, advisories.
- Monitor bathing patterns to estimate exposure
- Expand self-reported illness databases.
- Conduct further epi studies (e.g. wet weather).

Limitations

- FC as an indicator
- Definition of "exposure". E.g. Single exposure, flat rates of seasonal recreation assumed
- Stationary model does not account for dynamics of disease transmission (susceptibility factors, repeat exposure, secondary transmission, pathogen shedding)

Acknowledgments

- Charles McGee (OCSD)
- Larry Honeybourne and Monica Mazur (Orange County Health Care Agency)
- Don Ito (California State Parks)
- John Blauer (City of Newport Beach Fire Department)
- Dennis Yunne (US Ocean and Safety)
- Steve Benson (City of HB Lifeguards)

Questions and Answers

No questions.

Thursday, October 14
12:00 p.m. – 1:20 p.m.
Lunch Speaker

Linking the Oceans and Human Health: Perspectives from the US Commission on Ocean Policy and the new NOAA OHH Initiative

Paul Sandifer
National Oceanic and Atmospheric Administration, National Center for Coastal Ocean Science, Hollings Marine Laboratory

Biosketch

Paul Sandifer's education includes a B.S. in biology from the College of Charleston (1968) and a Ph.D. in Marine Science from the University of Virginia (1972). After completing a 31-year career with the South Carolina Department of Natural Resources, including service as agency director under three Governors, in April of 2003 he moved to NOAA where he is Senior Scientist for NOAA's National Centers for Coastal Ocean Science. He is located at the Hollings Marine Laboratory in Charleston, SC.

Throughout his career, Dr. Sandifer has been involved in marine and natural resource policy and management, mission-oriented research and graduate education. He is author or co-author of numerous publications in aquaculture, coastal ecology, and marine biology and is a member of the graduate faculties of the College of Charleston and the Medical University of SC and an adjunct faculty member at the University of SC.

Dr. Sandifer is an Honorary Life Member of the World Aquaculture Society, a Fellow of the American Association for the Advancement of Science, and a recipient of South Carolina's highest civilian honor, the Order of the Palmetto. He has served on numerous boards and committees, including the Marine Board of the National Research Council, the South Atlantic Fishery Management Council's Scientific and Statistical Committee, the Atlantic States Marine Fisheries Commission (Chairman), and the founding Board of Directors of the South Carolina Aquarium. Currently, Dr. Sandifer serves on the US National Committee for the Census of Marine Life and on the Board of Directors for the Southeast Atlantic Coastal Ocean Observing System. In July of 2001, he was appointed by President George W. Bush to the 16-member US Commission on Ocean Policy, where he chaired the Commission's Stewardship Working Group, which dealt with issues involving management of living marine resources and pollution.

Linking the Oceans and Human Health

Perspectives From the US Commission on Ocean Policy and NOAA's New OHH Initiative

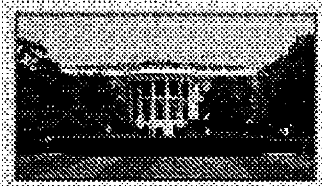
Paul A Sandifer

Senior Scientist, NOAA's National Centers for Coastal Ocean Science and Member, USCOP

The U.S. Commission on Ocean Policy

- [illegible]
- [illegible]
- [illegible] public meetings
- [illegible] regional site visits
- [illegible] witnesses
- [illegible] review process

What Happens Next?



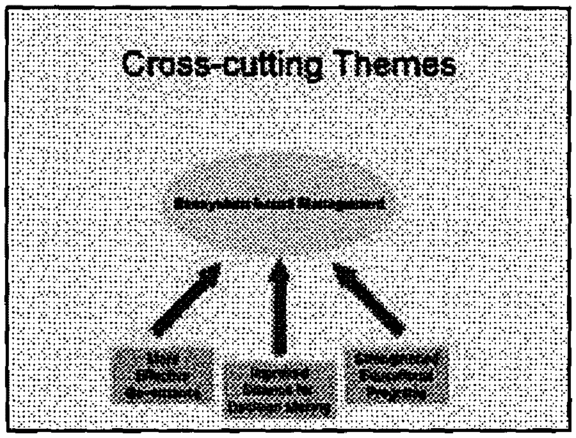
White House review: September 20 – December 19
Congressional action

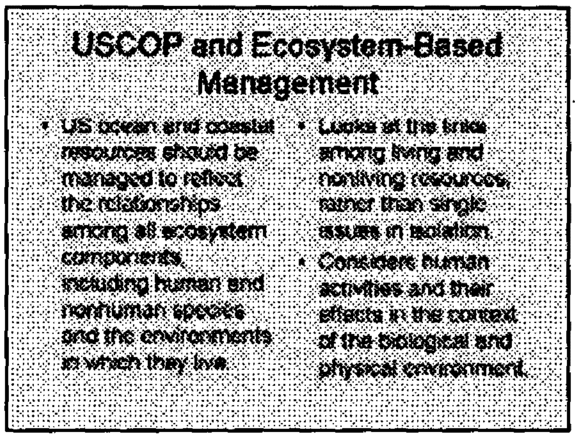
What We Found

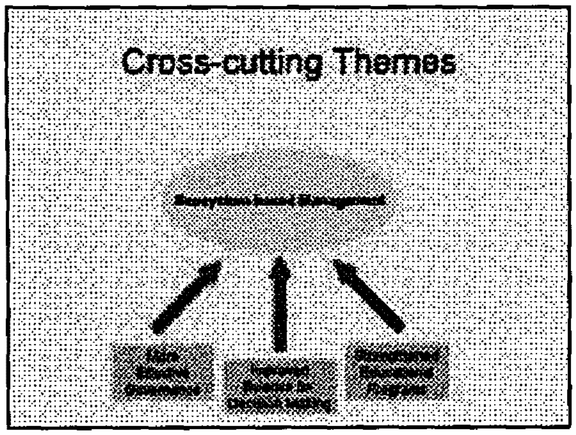
- Oceans and coasts are major contributors to the U.S. economy
- Ocean and coastal resources and ecosystems are in trouble
- The existing management structure is incompatible with the complexity of ecosystems

Specific Management Challenges

- Balancing economic growth and conservation along the coast
- Maintaining coastal and ocean water quality
- Achieving sustainable use of ocean resources
- Promoting international partnerships

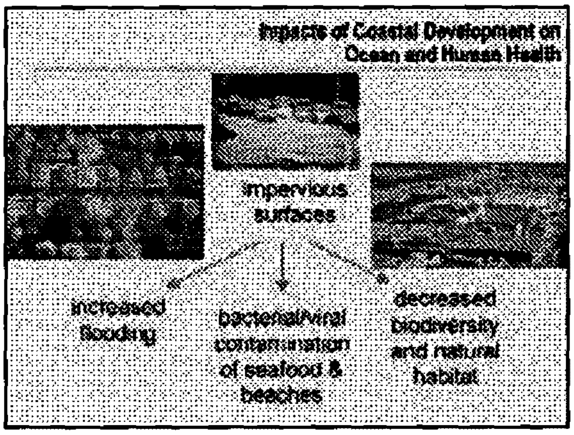

Cross-cutting Themes


USCOP and Ecosystem-Based Management
• US ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including human and nonhuman species and the environments in which they live.
• Looks at the links among living and nonliving resources, rather than single issues in isolation.
• Considers human activities and their effects in the context of the biological and physical environment.


Cross-cutting Themes


connections between
ocean health and human health


Human Threats to Ocean Health
• NPS pollution, stormwater runoff
• Coastal development, wetland loss
• Overfishing, ecosystem collapse
• Ballast water, invasive species


Impacts of Coastal Development on Ocean and Human Health
impervious surfaces
increased flooding
bacterial/viral contamination of seafood & beaches
decreased biodiversity and natural habitat

Ocean Threats to Human Health

- Illnesses transmitted through contaminated seafood or contact with ocean water
  - Viruses
  - Bacteria
  - Algae
- How humans play a role:
  - disposal of waste (viruses and bacteria)
  - increased nutrient runoff (harmful algal blooms)

Ocean Threats to Human Health

- Natural disasters caused by fluctuations in climate and weather
  - hurricanes
  - flooding
  - severe winds
  - distribution of disease-causing organisms
- How humans play a role:
  - increased emission of pollutants speeds up climate change including global warming and changes in ocean temperatures and currents

Ocean Benefits to Human Health

- Marine plants and animals provide beneficial medical uses
  - sources of pharmaceuticals
  - used as models in biological research that will benefit humans
  - greater biodiversity in ocean than on land
- How humans play a role:
  - increased pollution and waste decreases diversity
  - ballast water in international shipping ports brings new harmful marine species to our shores

Based on these and other issues, the Commission recommended that the Nation:

- Increase funding for ocean and coastal research, including socioeconomic studies, at least 2 fold
- Expand investments specifically in ocean exploration and oceans and human health research
- Implement the national Integrated Ocean Observing System (IOOS)
- Expand and integrate a national monitoring network, including better coverage of coastal areas

Maintaining Coastal and Ocean Water Quality

USCOP Recommendations:

- Use ecosystem- and watershed-based management approaches
- Maintain progress in controlling point sources
- Focus greater resources on nonpoint source pollution
- Expand efforts to control vessel pollution, marine debris, and invasive species

Maintaining Coastal and Ocean Water Quality

USCOP Recommendations:

- Expand and enhance coastal monitoring programs and increase interagency cooperation at federal, state, and local levels
- Develop and deploy sensors to accurately and quickly detect pathogenic microorganisms as part of the Integrated Ocean Observing System
- Implement a strong, nationally coordinated Oceans and Human Health research program

USCOP Recommendations for Oceans and Human Health

- Establish a national OHH initiative to examine connections among ocean health, ecosystem health, and human health
- Expand efforts to discover marine bioproducts, encouraging private sector partnerships and investments
- Develop improved methods for identifying and monitoring pathogens and toxins in ocean and coastal waters
- Fully implement all existing programs to protect human health from contaminated seafood and coastal waters

NOAA Oceans and Human Health Initiative

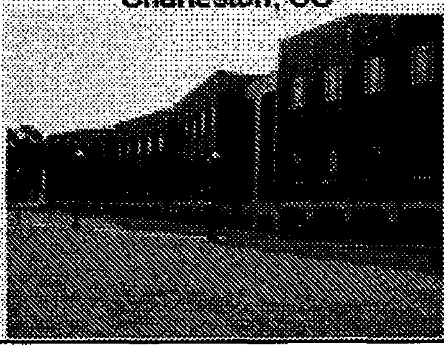
- Established by Congress in the FY03 Appropriations Act
- Funded at $8 M in FY03, $10 M in 04, and Senate committee mark for 05 is $20 M
- Program is located in NOAA's OAR (Oceanic and Atmospheric Research) Line Office
- Has three major components:
  - NOAA Centers of Excellence in OHH
  - External grants in OHH
  - Distinguished scholars

NOAA Oceans and Human Health Initiative

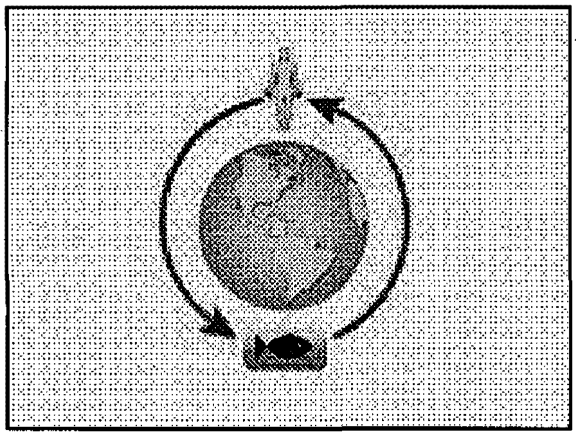
- Three CoE named via competitive process:
  - Great Lakes Environmental Research Lab in Ann Arbor, MI
  - Hollings Marine Lab in Charleston, SC
  - NW Fisheries Science Center in Seattle, WA
- Specific issues being addressed by the three CoE include:
  - infectious diseases
  - chemical pollutants
  - water quality and beach safety
  - seafood quality
  - harmful algal blooms
  - sentinel species
  - data management
  - education and outreach

Hollings Marine Laboratory Charleston, SC

Hollings Marine Laboratory Charleston, SC



HML
Hollings Marine Laboratory
NIST
MUSC



HML Focus Areas

- Assess the health status of key marine organisms using genomic technology
- Identify and quantify emerging chemical contaminants of concern in coastal waters and assess potential effects on marine organisms and humans
- Detect, identify and determine the sources and consequences of human pathogens in coastal waters
- Integrate results into a common ecological framework – tidal creek ecosystem

Public Concerns/Questions

- Are the fish and shellfish safe to eat?
- Is it safe to swim in the water?
- If not, what needs to be done to make swimming and eating seafood safe?

Questions and Answers

Q: What are the chances that the recommendations for adding money for research will be acted upon favorably?

Paul Sandifer

It is hard to tell, but it is clear that the Administration and Congress are interested. The Senate Committee gives approximately $454 million to NOAA; $206 million of that is new over fiscal year 2004's levels. This is a significant step. Money designated for oceans and human health is increasing.

Q (Rachel Noble, University of North Carolina at Chapel Hill): What is the level of interaction between NOAA and NSF, NIHS?

Paul Sandifer

There is interaction at the investigator level. The NOAA external advisory committee includes people from NSF and NIHS. Scientists will do a better job of collaborating than administrators will.

Comment (Kelly Goodwin): Concerning the $20 million funded by the Senate for Oceans and Health, NOAA's budget is not doing as well in the House.

Thursday, October 14

3:20 p.m. – 5:00 p.m.

Session Eleven: Plenary Panel Discussion

Introduction

Session Moderator: Steve Weisberg
Southern California Coastal Water Resources Project

Biosketch

Dr. Stephen Weisberg is Executive Director of the Southern California Coastal Water Research Project (SCCWRP) where he specializes in the design and implementation of environmental monitoring programs. He serves as chair of the Southern California Bight Regional Monitoring Steering Committee, which is responsible for developing integrated regional coastal monitoring for the Southern California Bight. He also serves on the Steering Committee for the US Global Ocean Observing System (GOOS), the National Oceanographic Partnership Program's Ocean Research Advisory Panel, the Alliance for Coastal Technology Stakeholder's Council, the State of California's Clean Beaches Task Force, the National Research Council Committee on Waterborne Pathogens and on Technical Advisory Committees for the University of Southern California Sea Grant Program and the Southern California Wetlands Recovery Program. Dr. Weisberg received his undergraduate degree from the University of Michigan and his Ph.D. from the University of Delaware.

Abstract

Current methods for enumerating indicator bacteria require an incubation period of 18 to 96 hours, during which time contaminated beaches remain open. Several technologies that have the potential to produce results in less than four hours are under development. Here we evaluated four of those technologies, including immunomagnetic capture with ATP quantification, flow cytometry, dual wavelength fluorimentry, and quantitative PCR (Q-PCR). Fifty-four blind samples encompassing a range of bacterial concentrations and matrix complexity were processed and compared to values obtained by standard culture-based methods performed at six reference laboratories. Each method was evaluated for speed, accuracy, sensitivity, precision, robustness across different matrices, as well as ease of use.

Panel Members

Denise Keehner
U.S. Environmental Protection Agency, Office of Science and Technology

Biosketch

Denise Keehner is the Director of the Standards and Health Protection Division in the Office of Science and Technology in the Office of Water. Her Division is the Headquarters Office responsible for the Water Quality Standards Program, the Beach Program, and, the Fish Advisory Program. Denise has been in this position since May 2003. Prior to her joining the Office of Water, Denise was the Director of the Biological and Economic Analysis Division (BEAD) in the Office of Pesticide Programs (OPP) and the acting Director of the Environmental Fate and Effects Division in OPP. She has been with USEPA at Headquarters for 26 years and has served in management positions since 1985.

Shannon Briggs
Michigan Department of Environmental Quality

Biosketch

Shannon Briggs has a B.S. is in Animal Science, Ph.D. in Pharmacology & Toxicology—all at Michigan State University. She started working with beach monitoring programs in 1999. She is currently the President of the Great Lakes Beach Association, which is an informal group of people from local, state, and federal agencies that conduct research or beach monitoring programs within the Great Lakes Region. They network daily with each other via a beachnet listserv. The web address for the Great Lakes Beach Association is http://www.great-lakes.net/glba/index.html. She currently manages over 30 individual beach monitoring grants with health departments and non-profit groups in Michigan. Beach monitoring grants in Michigan receive state funding from the Clean Michigan

Rachel Noble
University of North Carolina at Chapel Hill, Institute of Marine Sciences

Biosketch

Dr. Rachel Noble is an Assistant Professor at the University of North Carolina at Chapel Hill, Institute of Marine Sciences in Morehead City, North Carolina. She previously held a joint appointment between the University of Southern California's Wrigley Institute for Environmental Studies and the Southern California Coastal Water Research Project and focused her work there on regional assessment of water quality along the Southern California shoreline, and detection of enteroviruses in stormwater impacted areas of the coast. In July of 2001, she moved from the West Coast to the East Coast, and there has focused upon the use of molecular techniques, such as Quantitative Polymerase Chain Reaction (Q-PCR) for identification of sources of fecal material in estuarine, coastal, and freshwater environments, for use in assessment of microbiological water quality. Dr. Noble's research currently focuses on the quantification of enteric human pathogens in a variety of environments, including recreational areas, shellfish beds, and commercial fishing areas. She is interested in relating the presence of known human pathogens such as enteroviruses, *Vibrio vulnificus*, and *Salmonella sp.*, to levels of fecal coliforms, *E. coli*, and enterococci in recreational waters in order to better protect human health. Other current research foci are basin-scale determinations of pathogen persistence, fate and transport in estuaries, and the impacts of nutrient loading and eutrophication on pathogen survival and ecosystem health. Dr. Noble has also recently been involved in the development of real-time detection of both pathogens and indicators as tools for creating accurate hydrologic and probability-based models of estuarine and coastal systems.

Mark Gold, D.Env.
Heal the Bay

Biosketch

Mark Gold, D.Env., is Heal the Bay's Executive Director. Heal the Bay is an environmental group dedicated to making Santa Monica Bay and Southern California coastal waters safe and healthy for people and marine life. Dr. Gold's extensive work with water quality and coastal natural resource topics ranges from sewage treatment, contaminated sediments, legislative and environmental education issues to urban runoff, contaminated fish and wetland restorations. In 1996, working in conjunction with the Santa Monica Bay Restoration Project and the USC Medical Center, he was a co-author of the first epidemiological study of swimmers in runoff-polluted water. He also has co-authored several stormwater, contaminated fish and beach water quality bills and ordinances, and he created Heal the Bay's Beach Report Card®. He is a vice-chair of the Santa Monica Bay Restoration Commission, sits on the State Water Board's Clean Beach Advisory Group and served on the EPA's Urban Wet Weather Federal Advisory Committee. Dr. Gold also was appointed to the California Ocean Trust. Dr. Gold has bachelor's and master's degrees in biology from UCLA, and he received his doctorate from UCLA in environmental science and engineering in 1994.

Monica Mazur
Orange County Environmental Health

Biosketch

Monica Mazur is the Supervising Environmental Health Specialist for the County of Orange Health Care Agency's Ocean Water Protection Program. She has over 30 years experience protecting public health in this area. She oversees the day-to-day program operations including ocean water closure decisions. Ms. Mazur currently serves on numerous technical and advisory committees including the State Water Resources Control Board's Clean Beach Task Force and Beach Water Quality Working Group. Ms. Mazur has a bachelor's degree in Social Ecology from the University of California at Irvine. She is also a California State Department of Health Services Registered Environmental Health Specialist.

Question 1: After everything that you have heard here, what aspects of beach programs need the largest improvement given existing technologies? How can federal, state, and local programs work together most effectively?

Panelists' Responses

Denise Keehner

A year and a half into the beaches program as well as other programs, I can see interesting things that people just in the beaches program may not see. Also, by listening to these speakers here, I've helped form ideas on what EPA needs to do. When you ask what direction we need to head in, we need to ask ourselves what is the destination here. We need to collectively have the same sense of what the destination is. If we don't have a sense of that it is difficult to prioritize things. Its not about having affective advisories and closings, its to reach a point where we don't need advisories and closures because things are improved enough that its rare we need those things. Source tracking, making available better science, tracking where contamination is coming from and what can be done. I think about how things need to be integrated between programs. Are local departments engaged as much as they should be.

We need to invest in source tracking—improve science so that we can identify sources of fecal contamination and figure out what can be done to eliminate the source. We need to better integrate the beach program with water quality standards and Clean Water Act programs. We need to ask if state and local government as engaged as they should be. EPA needs to do more to identify the governments that are working well in an integrated way, to share experience of what works for success, such as how they handle closures and postings. The people closest to those issues need to share their experiences of how to integrate programs, what made it happen and what were the critical factors. EPA needs to do more to help those agencies be effective. EPA workshops are important because they help us see what really makes a difference in the environment. EPA should take the role of sponsoring workshops and other opportunities to get people talking.

But there is still value in getting better indicators and more rapid methods, and better linkages with indicator and human health risk. But, over the next several years, EPA needs to shift some resources to other areas that result in improved water quality over the near term.

Shannon Briggs

I sent an email regarding this question to the Great Lakes Association members. From their responses, I realized that we already have an email listserv locally. Richard Whitman suggested that we start utilizing this listserv, so we found someone to host it. It is called the great lakes information network, and it has been a wonderful tool. It's a great way to share information. For example, someone had seagulls on the beach. They noticed one day that the seagulls all were drunk. Then, the next day, all the seagulls were all dead. He asked what happened, so everyone saw the email and could learn about this together. It was a good way for people to learn. With an email listserv, everybody has a chance to input ideas. The Great Lakes listserv is open to everyone. Everyone can learn at the same pace.

I know that Charles Kovatch has a listserv for EPA beaches. How open is that to everyone? We have local health departments, USGS, and people from Canada using ours. I received comments from federal, nonprofit, state and local agencies, as well as from agencies in Canada. It's a great way to get info out.

I'm looking for existing technology to help standardize sampling. We should agree on the right way to sample. For example, some health departments use sampling rods when they sample, but do you stir the water up, or keep it still, sample upstream or downstream, sample in the morning or afternoon? How do you standardize these things? The sampling methods can affect whether beach will be open or not. I also think we should look at ankle deep water more—the swash zone. More people go into ankle-deep water than in chest-deep waters, so should we be collecting our sample at ankle-depth?

Also, we need to get better grip on the data. We need to figure out what to do with it and how to analyze it. How do we organize our schema so they make sense to the government and to the modelers, Its nice to have the data on a website, but then what do we do with it? We need to get a better strategy for organization and use of the data.

Mark Gold

I helped to write California's Beach Initiative and Beach Water Quality Act (AB 411). In California, we like waves and surf, and we like our wildlife alive. We have to have greater national consistency in our programs. For example, we will see a talk tomorrow asking why California and Hawaii do not count as far as having good beaches because we monitor and post more frequently. People in California monitor and post and close beaches more often than beaches in other states. A posting in California should mean the same as a posting in Florida. People that go to different states need to know what the postings mean.

You've seen the epidemiological studies. We need to put everything together to target the most at risk, the most exposed individuals. The children who swim or play in ankle-deep water are the most exposed. Those are the same populations that swim at creek mouths. The use of other multiple indicator criteria is important. We need clear definitions of high, medium and low risk. There needs to be at least weekly monitoring for low risk beaches, or why bother monitoring at all? And, there should be daily monitoring for high-risk beaches. Closing beaches after sewage spills needs to be mandated, not just recommended.

Posting exceedances of standards is a right to know issue, even if you don't know the source of bacterial contamination. When the source is unknown, posting an advisory is still the best thing you can do. If the source is unknown, closing may be a waste of time and effort.

Money is needed for all the research that needs to be done. There is a need for more research for epidemiological studies in Southern California. Would it ever hurt for EPA to do an epidemiological study on the west coast? The second major round of EPA epidemiological work does not include California. It needs to happen.

In addition, chronic exposure issues needs to be addressed, such as the surfer populations that are out there surfing every day all year long. The surfing population should be targeted for health risks and chronic exposures.

Rachel Noble

Data management issues are the high priority that agencies such as EPA and NOAA face. It needs to be addressed top down, and it needs to be handled quickly. The funding is important.

Researchers are constantly trying to come up with ways to come up with new ways to conduct research, and are constantly leveraging money from other projects for basic research that should be supported because we need to answer research questions. Funding is a big issue, especially to study real world problems. From the scientific perspective, the European Union (EU) and World Health Organization (WHO) have recently moved forward with the idea of testing for the specific species, *E. coli* and *E. faecalis* as indicators of fecal contamination, rather than relying on detection of the entire Enterococcus group. This move needs to be addressed in the Unite States. Communication between the United States, and EU and WHO needs to improve, there are redundant research studies being conducted that would benefit from the knowledge gained by others on the other continent. We can improve the way that we manage water quality, especially to help much of the undeveloped world in the area of public health. Urban runoff in relation to health risk is an important area. I live in an area where dual beneficial uses reign (areas where shellfish harvesting and recreational waters are side by side), and the idea that NOAA, EPA and the National Shellfish Sanitation Council don't communicate as far as their standards go (fecal coliforms for shellfish and *E. coli* for recreational waters), is a problem. There is little movement of them coming to a compromise. Communication between these organizations would help us improve things.

I also examine the process of managing recreational water quality monitoring programs and programs for TMDL development, and have found that the two groups don't communicate. TMDLs implemented upstream of the coastline are being run by agency representatives that don't communicate with the people managing the coastline. It's a matter of the number of hours in the day. These agencies are severely hampered by resources. I am also interested in seeing in situ monitoring stations, the use of remote sensing, and the use of predictive models for improving our management of coastal water quality. We (people in the water quality field) can link up to people who understand hydrology, land use, physical oceanography, and we can make use of predictive models for assessing water quality. The wind model, for example, could be utilized.

Monica Mazur

We find that we need more risk assessment and epidemiological studies on the west coast because it is uncertain if one study (the Santa Monica Bay Restoration Project's "A Health Effects Study of Swimmers in Santa Monica Bay") is transferable to other locations. However, there is a large need for more funding because our local programs (state, counties and cities) don't have enough money to do these studies. There is a net cost to the counties to administer the ocean and bay water quality programs and they don't have the money in some cases to do the routine year round monitoring, even with the state AB 411 monies and the EPA Beach Grant monies. NRDC reported in 2004 that California spent 3 million dollars last year on monitoring. In Orange County, we spent $3 million alone on monitoring. We need more funding for our NPDES and storm water programs, as well as for data management. The $3 million did not even include the cost for special watershed characterization studies. There are huge costs to monitor and sample watersheds. It can cost millions of dollars to do watershed studies and remediation for small areas. $10 to 15 million was spent to conduct the special studies and some remediation just in the Huntington Beach area.

There are equity issues when comparing state-to-state programs. We have so many postings in California, but is it because we are doing a better job of monitoring and posting and have stricter standards? We don't compare well to other states, many which aren't monitoring and posting for as long a coastline or for year round programs (back East, state monitoring programs may be for three months). We almost need a batting average approach that we can use to compare accurately and an even playing field for standardizing sampling and posting programs. But, we shouldn't apply same bacterial standards for different types of beaches. We have found that one size does not fit all. You have different risk levels and different contamination and use factors involved at different beaches. In California if you have good samples for a certain period of time (e.g., 2 years) you can stop sampling at that location. But, that isn't right either. Underground infrastructure ages and leaks may occur at any time, so sampling vigilance is necessary.

Data management and evaluation are other issues that we need to improve. We can't just collect the data; we need to do something with it. We have to ask, what does a sample represent, what time of day do we sample, how many samples do we collect per location, how far apart to we take the samples, where do we post the notices to the public, etc. There are a lot of issues based on those concerns that need to be standardized. As a priority, we should standardize bacteriological criteria and what the samples represent.

Audience Discussion

John Norton (California Water Resources Control Board)

Concerning monitoring programs, right now the way EPA is handling them is a disincentive for states to invest more in monitoring programs. States like California have very thorough monitoring programs. As an incentive I'd like EPA to lay out grading criteria for monitoring programs because many other states don't post advisories because they don't monitor very often. I'd like beach-mile-day to be the measuring unit used when EPA and others look at the number of closures and postings each state has, so that things are more comparable nationally. All areas need to be treated equally because the current method is not sufficient.

Mark Gold

EPA could consider funding only the programs that meet model criteria that everyone agrees upon.

Denise Keehner

We had intentions to make the data available this year but ran into some Internet technology (IT) issues with getting state data easily migrated into EPA's system.

Muriel Cole (Ocean.US)

We are a national office sponsored by nine agencies. Our purpose is to promote an integrated ocean and coastal observation system. I'd like to reiterate something Rachel mentioned, which is the need for cooperation and coordination among governments, agencies, nongovernmental organizations (NGOs), and academia. That is a priority.

David Rockwell (Great Lakes National Program Office)

We've been looking at data from the Department of Natural Resources (NRDC) web site. EPA should make data available. In one incident, Milwaukee, Wisconsin discharged water to Illinois beaches due to a heavy rainfall, then Illinois accused Milwaukee for closing Illinois' beaches. We should quantify a city's contribution to *E. coli* concentrations.

Steve Weisberg (Southern California Coastal Water Resources Project (SCCWRP))

This conference has brought together a wide array of people from different sectors. An impression is also made about who is missing: There is nobody here from the European Union (EU), Center for Disease Control (CDC), or shellfish organizations. We should look for other groups such as these to reach out to for guidance and for money.

Charles McGee (Orange County Sanitation District)

The Mission Bay study shows that one size does not fit all. Maybe standards don't mean the same thing in every location. We should use the Annapolis Protocol where people look at the situation, the beach, the inputs, and the fate and transport, and then design the monitoring program around that information instead of just trying to make the shoe fit. We need to look at each situation as situation-specific.

Mark Gold

The policy may apply and change depending on the risk level. If you have a highly populated beach, you might not close it after one high sample. There are flexibilities depending on the level of risk. The policy should be developed in a way that eliminates these conflicts.

Steve Weisberg

From what I have heard everyone say so far today, we want consistency, but we also want flexibility.

Toni Glymph (Wisconsin Department of Natural Resources)

Wisconsin didn't know that it was optional that we didn't have to monitor if there was a sewage outfall. For us, one of our frustrations is that since we are working with the local health departments and there are many different fiscal years, the money is needed and given at different times. We get the money from EPA in June, but we start monitoring in May and we can't charge back. So it would be nice if that could be corrected because the money is needed ahead of time when monitoring and work actually begin. Because of our small budgets and the limited availability of our Internet technology (IT) staff, money is tight. We give our staff a budget to work with, but we often have to change what we need them to do, requiring additional work, which is frustrating, because it wastes time and resources.

Roger Fugioka (University of Hawaii)

For over 20 years it has been reported that all streams in Hawaii have exceeded standards. It's difficult to understand why a state would accept a standard that it can't meet. Epidemiological studies do not apply everywhere, but the criteria are derived from those studies, therefore that is what states are supposed to use for their standards, regardless of whether the pollution is from point source or non-point sources. EPA has stated that 40 percent of coastal pollution is from non-point sources. Hawaii will use the EPA criteria, but why can't EPA consider the source of bacteria. This is similar to what was found during the Mission Bay study, where the pollution was from non-point sources. Hawaii says it will accept the EPA standards and wait to hear about new indicator standards, but I heard that the new indicator standards will not be out for a while.

Denise Keehner

Existing epidemiological studies are looking at the indicator organisms that seem most appropriate, and it can preclude us, but if a study is not done in the correct way, the studies are not consistent and it is difficult to use them to develop criteria. I'd like to look into the extent those epidemiological studies could be used. We can ask Steve Schaub about this.

Gregg Pettit (Oregon Department of Environmental Quality)

I understand that there is a desire for consistency among programs, such as for 303(d) listings. But one size does not fit all. In one year we looked at our data and dropped monitoring at some beaches in Oregon because those beaches met standards. Also, there were not many people in the water because the temperature is only approximately 55 degrees all year long. There are kayakers, but it's not the same magnitude as the number of beach users in California. Therefore, the appropriate program for one place may not be the same as for somewhere else. We need a program to continue monitoring so we can try to identify beaches with chronic problems.

Paul Sandifer (National Oceanic Atmospheric Administration (NOAA))

Communication should be broadened. One way to increase communication is to invite more people who are dealing with harmful algal blooms to the conference. They are a big problem in certain areas, like in reservoirs and in Florida. Some of the researchers are working along parallel tracks as the researchers working with human pathogens. Inviting more people to this type of conference may help to eliminate the redundant work that is done. That would provide benefits, and may help solve some problems and bring in a new perspective.

Rachel Noble

In labs in North Carolina, they are finding that the pathogens are attached to the algal blooms. This is a good reason to add those people.

Clay Clifton (County of San Diego, Department of Environmental Health)

I agree with the Hawaii comment, that we should "strike while the iron is hot." This week we've exponentially increased our collective knowledge on monitoring and indicators, but EPA is telling us that they are still several years away from modifying standards and changing criteria. It is frustrating and not inspiring. Maybe it is not the time to use a new indicator, but it is the time for EPA to make more specific recommendations on use of beach types and sample design and needs to make decisions on what should be mandatory and what should be discretionary.

Denise Keehner

The work that ORD is doing, with frequency and location of monitoring, will be put in a final report and a guidance document we are producing on monitoring. That is different from the new indicator ideas. New criteria involve a more standardized process. You may need to talk to someone else to find out if there are studies that have been done that will develop into marine criteria. Ask Steve or Rebecca if there are coastal studies on new indicators.

Shannon Briggs

In the Great Lakes, we often don't have the money to do what we want to do. Even though EPA may not be doing something, you should still bring the ideas to EPA and try to collaborate with them so they can work with you and you can share some of the money. They don't have the money to do everything, but we can get research together by patching together grants from different places to get the work done. For example, I take tests from the area and send them to Al Dufour so he knows what is going on. Working alone will not get as much done.

Clay Clifton

We have done that. We sent comments on the implementation guidance, but we don't know what our impact was.

Rebecca Calderon (USEPA, National Health and Environmental Effects Research Laboratory)

To respond to Steve's comments on the National Institute of Health (NIH) and CDC—CDC was invited to this conference, but they opted not to come. However, they are engaged with EPA. We have worked with both organizations, and NIH feels that unless you are doing something that deals with homeland security or bioterrorism, they are too busy to work with us. This isn't their priority. This program is an unfunded mandate. There is no great flowing of money to handle the Beaches program. The program is the result of money being brought together. The studies that are being done in our research and development office are scraped together with the funds we have. Even though the state people look at us as having lots of resources, it's difficult for us to get things done with the limited funding. If the Beaches Act does not get renewed, the program will go away because there are other pressing issues too. It is congress that makes appropriation decisions so we need to be sure that they have accurate information on the benefits to human health of the Beach program. In addition, EPA plans to do epidemiological studies in California in the next couple of years.

Sonia Nasser (County of Orange)

The Army Corps of Engineers (USACE) should be here too. We are doing massive watershed studies, but Orange County often has a problem because but the Corps is not authorized to study water quality and so they are not engaged with EPA. They have money to spend on the studies, but can't do water quality. A joint USACE and EPA water quality study would be helpful.

Steve Weisberg

I know that some of the other agencies aren't here because they have other priorities, but I'm glad you did try to contact CDC (to Rebecca Calderon).

Denise Keehner

Responding to the comment on the USACE—USACE is working in other states with other groups. There are areas where there is collaborative work going on with EPA and the Corps in the area of water quality. Whether you can get the Corps involved depends on the project. It is good if you can form that collaborative effort around it because the Corps has a lot of funding to bring to the table.

Question 2: We've heard new technological developments: what is the role of EPA in the development of these technologies and where should their priorities be placed?

Panelists Responses

Rachel Noble

There are so many promising things out there, we should look at them all and not close our eyes yet to new ideas. We can identify new successes for the future. At this point, from a research perspective, there are a lot of people working in different environments, such as the food industry and bioterrorism, that have a lot to offer, and we should cross those boundaries and really examine the available technologies. We haven't gone far enough from an academic perspective. For EPA, we need to make some basic decisions on 3 different levels: near term (now-2 years), medium (2-5 yrs), and long term (10-15 yrs) so that we can look at specific technologies as being promising within the right time frame. There are things out there applicable for use the near term, I won't just advocate quantitative PCR for enterococci determination, which I think is useful, because its not as low cost as some of the other technologies. There are molecular methods that are useful. The fluorescence-based measurements like the Idexx adapted technology, dual wavelength fluorimetry. We need to look at new applications of some of the available methods. For medium and long term, we should look at electrochemical applications for sensitive detection of microbes—there are several means of using electrochemical attributes of bacterial cells to concentrate and detect cells and this should be further examined. It is used in other fields such as space science and may have applications in water quality.

Monica Mazur

We look to EPA and the federal government for the big picture items we can't do locally. Concerning the money issue, to pay for all of the new technological developments, I think you need to bring all the researchers you can together and find a big sponsor, which in this case would be the EPA, to develop rapid indicator and source tracking techniques which are key. But, once you have the rapid indicators or other technologies, what do you do then? Will we just be more confused faster? The expectation of faster methods may lead the public to want everything done faster—collection, analyses, notifications and postings. The public may want more samples collected—temporal and spatial. What does this mean to us? Logistically, it still takes a while to make a sampling run. We collect 20–35 samples along one stretch of beach before going to the lab for analysis.

Are we analyzing for the right things and what do we do to solve the source identification problem? Or if it's a natural source, what do we do to "fix" the input, for example the bird sources? But first, we need the methods to determine for certain if it is a bird source at a particular beach.

You need the new methods to work with, but have to get to a point where they are used routinely. Methods acceptance by state and federal agencies are going so slowly now, and new indicators will add even more years to the process.

Shannon Briggs

Rapid methods are key. We get faster results and a new toy, but we can't look at it as the solution. Communities get exited about a new toy. Once they are more acceptable, usable, and cost effective, communities will be more interested in using them. Lots of private lake associations in our area want us to monitor local lakes. Funding is an issue, and we look at other sources of funding from anyone who is interested, including the army corps. The Department of Defense had a contract to look at nanotechnology, and they got people together and tried to get some money for that.

Health departments know they need change to keep up. An issue we face is if we are able to get rid of human sources of pollution, how do we get rid of other sources (i.e., sea gulls)? We could find other places for gulls to go, but we still have to deal with what they left behind—what is the risk assessment for that? What about other animal sources? What are the risks of those? And, how do we use the data?

Also, how do we use the data that we collect? And, we can't ignore the swash zone and the wet sand. That is where things wash up and the bacteria live. And everyone walks through it, and kids play in it. We need to focus on that.

Steve Weisberg

Can you clarify the issue of who is going to be the first kid on the block, who will be the kid with the new toy? Are you willing to do that and not wait for it to be verified and accepted? If the technology exits before EPA endorses it, will you use it?

Shannon Briggs

We are already doing that, such as with rapid tests.

Denise Keehner

In terms of the emerging technology, the rapid tests have real significance of implementation in our program. It will be interesting in how they play out. The more you look the more you find. If the rapid tests are affordable, there will be increased pressure to use them, and there will be more pressure for more testing, with more finding of impaired areas, and more issues with management. We will have more pressure to do source tracking, control releases, prevent overflows, and manage runoff. If we haven't done the research to understand what will mitigate those risks, we will be in trouble. It will trickle into lots of areas.

Concerning issue of differentiating between animal and human sources and which results in human health impacts, EPA should look at this. People will be asking questions on how fecal from animals compares to human impacts. It's a big question that needs more money to research. But, once we have some answers, EPA can then take on bigger issues with that.

Audience Discussion

Blake Traudt (Texas General Land Office)

Texas is in a unique position. My agency has no authority to implement the Beach Act. Our problem is we have a city that doesn't want to know what is in their water (our city doesn't want to know after 24 hours have passed). The rapid indicators would really be beneficial for that reason. A lot of local governments will want to know once those indicators are being used.

Shannon Briggs

In Michigan, I'm in a similar situation. I can't really test the beaches, or open or close them. I have to go to the health departments because they are the only ones with the authority to close or monitor the beaches. I try to highlight the health departments with the best programs so that the other health departments are envious and want to show that they have good programs as well. That way they all participate. Our senator got it passed that if you have a public beach you have to post a sign saying whether your beach is monitored or not. I pitted the mayors against one another. Now, all the health departments respond.

Toni Glymph

Denise made a comment that we'd be in a worse situation if our technology supersedes our guidance. Not only do we have to regulate beaches, but we also have to regulate the wastewater coming into it. This causes a problem for regulations because wastewater and beach water do not use the same indicator. We are shifting from fecal coliform to *E. coli* at our beaches. They are using new technologies that we can't regulate. It is not consistent with wastewater. Things are all over the board. We are forced to move forward, but we can't control things. How do we defend ourselves? What do we tell the public? We need guidance for wastewater effluents. How do they defend themselves and say they have to do something with no reason? We need more guidance and clearer rules.

Denise Keehner

That method has been validated by interlaboratory methods. The effluent wastewater has been validated scientifically, even though it has not been officially released yet or published.

Toni Glymph

They are going to use the Idexx ones because they are simple.

Charlie McGee (Orange County Sanitation District)

We should focus attention on rapid detection technologies. Jay Fleisher pointed out that no one at the beach was ever exposed to the limits that were set. We were looking at getting the information on water quality at the beach in the morning, and comparing it to the illness rate. Concerning methods, Rachel talked about three terms of approach. If we want to analyze a sample in a controlled stream we are required to use EPA methods. I hope we can improve on the already approved methods and start using those right away. Using the Connecticut Procedure approved, right away, for enterococci. Mark Gold had to leave, but he wanted to share that same idea.

Matt Liebman (USEPA Region 1)

Until yesterday, I was on the rapid indicator bandwagon. But then we will have a rapid method to get us confused more quickly. Stanly Grant talked about a plume of bacteria in Huntington that lasts for about 2 minutes and then goes away. We need to think about exposure. If we have a rapid method ocean observance system and can get 20 to 30 measurements per day, we would have a good sense of what the exposure is—what the water quality is and the potential illnesses. Would that result in an increase in postings and advisories?

Monica Mazur

This brings up the question of how often to sample and what standard do you use? It's important to understand what currents do with bacteria levels. With the ocean observing system used with the bacteria levels, you have a better idea of what is going on out there. But this can add to the confusion. If we simplify the method, who else will use it? Will locals and lifeguards monitor as well? This will bring about questions of who has the jurisdiction to put signs up. But, we still need the methods.

Steve Weisberg

One size doesn't fit all. Rapid indicators will push us to believe that even further. Once we have the rapid indicators, you still have different types of beaches. Some beaches have chronic sources, which the rapid methods won't help. With a chronic source, water quality may still change because of which way the wind is blowing. In cases like that, models will help determine where the pollution will be. Rapid indicators will help more with an unexpected problem and lead to quicker reaction, for example, by identifying a spill you didn't know about.

Rachel Noble

One thing to consider with rapid indicators is to demonstrate the relationship to pathogens quantitatively. Another thing to consider doing is to conduct an epidemiological study that involves humans, where people provide stool and blood samples, to see the actual pathogen, indicator, and disease relationship. Many epidemiologists can't believe this hasn't been done yet. It's a huge undertaking, though, but needs to be done.

Carl Berg (Hanalei Watershed Hui)

One problem is that the rapid test for enteric viruses may be worthless in tropical environments. One thing I see is a lack of consideration of pathogens associated with urine, not feces. There are many very serious diseases that come from wildlife, like *Giardia*, *Cryptosporidium*, and *Leptospira*, which have made people sick and/or have been fatal. We're not just dealing with skin rashes. In Samoa, we had an outbreak of leptosporosis, and we did blood testing of animals and people to find a better idea of the source. So, there are models here that can be used. We should ask EPA to pay more attention to other pathogens that aren't feces-related, but are potentially more deadly.

Rachel Noble

In North Carolina we are working on detection of other pathogens that are not routinely monitored but are becoming a problem due to changing climate and global warming issues. They deserve more attention.

Shannon Briggs

The issues that Carl Berg pointed out are an example of why we need to be connected by email, so we find out about these things right now and not every few years at a conference. You are limited with staff, resources, and time, and if we have an email system, that would help us communicate.

John Norton (California Water Resources Control Board)

I ask for old technology such as keeping sewage off the beach and in the pipe. EPA needs to make sure we have good reporting on sewage closures at beaches. Good sewage reporting provides the backbone of fixing the problem.

Shawn Ultican (Washington State County Health District, Kitsap County)

From all of the uncertainty that exists with the tools we are using, it seems misleading that we tell the public that we are keeping them from getting sick. We can't get there from here. We need to do what we can to correct long-term chronic sources, and then go in and do the surveys and determine the sources. We can't do that with the tools we have available now. In working at the county health district, the greatest asset is public trust. If I lose my credibility, then the money and science doesn't matter because the public will ignore the health advisories that I give them. I worry about making false claims. I am concerned that my credibility is being lessened by posting advisories and telling the public they will get sick if they swim, but if they continue to swim and they don't get sick, then they will stop listening to the advisories. Until we can accurately assess health risk, we should be concerned about taking those claims and putting advisories out there that we can't necessarily support. Is there credibility in what we do?

Steve Weisberg

Is there credibility? There are two parts to that. Our measurement systems are imperfect, so what is our responsibility to warn the public when there is a possible risk versus when we know that our science is right. We have had many comments made here today, but the most common ones I am hearing are (1) develop a better epidemiological relationship, whether it's looking at the number of beaches or the kind of beaches we are sampling—otherwise it's hard to make the statements that people will get sick if they get into the water; (2) standardization is important; (3) coordination is important; (4) rapid indicators are important; and (5) we need to make sure as we are developing this technology that we have some certainty and we develop guidance. In addition, we need more money, which might take coordination between other agencies.

Denise Keehner

One final thing I'd like to convey is to use common sense around communities where there is a chronic source of pollution and balance whether it makes sense spending time to precisely quantify the human health risk from that before taking some action. I wonder if that is the best use of that money, compared to going back and figuring out what we can do for something like fecal contamination. There are ways we can move in the direction of fixing the problem rather than spending millions precisely quantifying the risk. We can instead say we have an issue (human fecal contamination) and take some action to understand the source and mitigate it. Concerning public health, think of the old days when waste was dumped out of the window and into the streets. We didn't have a quantitative risk assessment back then, we had major health problems associated with dumping human waste and we did something about it. It's not a big leap to thin that what we are doing in our coastal areas is essentially the same, but into our waters instead of into the streets. We have many people moving to coastal areas, and we are developing those areas. Be careful about spending too much money trying to precisely quantify risk. Instead, let's use some of that money to take action to actually solve problems.

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Bad to the Bone:

Analysis of the Federal Maximum Contaminant Levels for Plutonium-239 and Other Alpha-Emitting Transuranic Radionuclides in Drinking Water

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Arjun Makhijani
Takoma Park, Maryland
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Main findings

The limit for gross-alpha contamination of drinking water is based on science that is over four decades old. It is an unsatisfactory basis for public health protection that is at variance with the content and intent of the safe drinking water regulations for radionuclides that were first promulgated in 1976. Specifically, the scientific understanding of how plutonium and other alpha-emitting, long-lived transuranic radionuclides behave in the human body, and of the magnitude of radiation dose they deliver to various organs, has changed a great deal, beginning with revisions first published by the International Commission on Radiological Protection in the late 1970s. The United States Environmental Protection Agency (EPA) first officially adopted these changes for assessment of radiation doses in its Federal Guidance Report 11, published in 1988. More changes have occurred since that time, which allow estimation of doses to people of various ages including infants.

EPA last reviewed its radionuclide standards in the year 2000 as part of a legally-mandated process. But despite the fact that it had been more than a decade since the publication of Federal Guidance Report 11, the EPA chose not to revise the maximum contaminant levels (MCLs) for alpha-emitting, long-lived transuranic radionuclides in that review. The next scheduled review of radionuclide MCLs in drinking water will occur in 2006.

This report provides an analysis of the changes in the dose estimates to the maximally exposed organ that have occurred since the MCL limits for radionuclides were first set in 1976. It presents the scientific underpinning for tightening the MCL for alpha-emitting, long-lived transuranic radionuclides by a factor of one hundred compared to the present gross alpha MCL of 15 picocuries per liter (pCi/L).

1. Drinking water maximum contaminant limits for plutonium-239 and other alpha-emitting, long-lived transuranic radionuclides are about a hundred times too lax.

The most recent science, as published by the EPA, indicates that the radiation dose to the most exposed organ, the surface of the bone, from drinking water contaminated to the maximum allowable limit is about a hundred times greater than the dose to what in 1976 was regarded as the maximally exposed organ (the marrow-free skeleton). This indicates that the drinking water standards are about a hundred times too lax, as measured by the intent of the regulations when they were first promulgated. The current MCL for each alpha-emitting, long-lived transuranic radionuclide separately is 15 picocuries per liter.

2. Drinking water regulations – when they were first set - explicitly included military sources of radionuclides – specifically, fallout from testing.

3. A much tighter MCL for alpha-emitting, long-lived transuranic radionuclides is needed to prevent lax approaches to cleanup of weapons sites.

Once drinking water is polluted to a few picocuries per liter, which is many times the indicated MCL by current science, it will be essentially impossible to remediate it. A stringent MCL is therefore needed as a guide to the United States Department of Energy (DOE) in its cleanup and as a preventive measure for protecting public water supplies.

4. The vast majority of public water systems will incur no costs from the proposed change and a few would incur a one-time monitoring cost.

Since the vast majority of public water systems have alpha-emitting, long-lived transuranic radionuclide levels orders of magnitude below the proposed MCLs (from weapons testing). They are not at risk for further contamination. No sampling, monitoring, or remediation is needed for these systems.

For public water systems that are hydrologically or hydrogeologically connected to DOE sites, where large amounts of plutonium waste were dumped or were disposed of, a one-time initial sampling and analysis should be done. If found clean, further sampling need not be conducted provided the DOE maintains a thorough water sampling program for surface and ground waters on site and reports the results publicly. It is presently mandated to do that, so no additional expenses would be incurred in this regard.

5. The relaxation of DOE goals in regard to cleanup and the lack of national cleanup standards necessitates an urgent revision of MCLs for alpha-emitting, long-lived transuranic radionuclides, if critical drinking water systems are to be protected for the long-term.

The timing and urgency of the main recommendation of this report, that MCLs for alpha-emitting, long-lived transuranic radionuclides be tightened by one hundred times (see below), derives largely from the very large inventories of alpha-emitting, long-lived transuranic radionuclides at several (DOE) nuclear weapons sites. Some wastes containing these radionuclides (both low-level and transuranic wastes) were dumped in unlined trenches in cardboard boxes and similar non-durable packaging in the early decades of the Cold War. The primary sites are in Idaho, Nevada, New Mexico, South Carolina, Tennessee, and Washington state. Further, the combined plutonium-238, -239, and -240 inventory contained in DOE high-level waste tanks at Savannah River Site is over a million curies. In 2004, Congress gave DOE the latitude to reclassify some of this waste. DOE can now grout high-level waste in place by reclassifying it as waste incidental to reprocessing. Congress set no limit on the total residual radioactivity content of the grouted waste. Since grouting is essentially irreversible, it is imperative the DOE implement the law in a manner that is compatible with the protection of the Savannah River, which is increasingly used by more people as a source of drinking water in South Carolina and Georgia.

Recommendations

The EPA is going to review the radionuclide standards for drinking water as part of a scheduled process in 2006. We urge the EPA to revise the drinking water regulations in regard to alpha-emitting, long-lived transuranic radionuclides. The Department of Energy should evaluate its cleanup and decommissioning efforts with a view to meeting the tighter standard.

1. The EPA should reduce its maximum contaminant levels for all alpha-emitting, long-lived transuranic radionuclides, combined, by one hundred times to an MCL of 0.15 picocuries per liter during its 2006 review of radionuclide standards for drinking water.

EPA should set a combined maximum contaminant level for alpha-emitting, long-lived transuranic radionuclides of 0.15 picocuries per liter. If only one of the radionuclides in question were present, then the limit for that radionuclide would be 0.15 picocuries per liter. The radionuclides included are: neptunium-237, plutonium-238, plutonium-239, plutonium-240, plutonium-242, americium-241, and americium-243. These changes should be made as part of the EPA's review of radionuclide standards in drinking water that is scheduled for 2006.

2. The DOE should fund a one-time baseline sampling and analysis for public water systems that are hydrologically or hydrogeologically connected to DOE sites with major plutonium wastes or dumps.

DOE sites with wastes buried underground or in tanks containing more than 100 curies of alpha-emitting, long-lived transuranic radionuclides should be considered to have potential risks to drinking water. These sites include the Savannah River Site, Hanford, Idaho National Laboratory, Los Alamos National Laboratory, Oak Ridge, and the Nevada Test Site. Testing of downstream water for the purpose of providing a baseline level of contamination is desirable and should be funded by the DOE since the tiny amounts of alpha-emitting, long-lived transuranic radionuclides in current water supplies are due to military-related atomic energy activities (fallout from testing).

3. The DOE should evaluate its on-site water monitoring from the point of view of the proposed standard and intensify it, if necessary. Resources for independent verification should be provided by the federal government.

The DOE currently carries out extensive surface and ground water monitoring. This may be sufficient for the purposes of providing assurance that downstream water resources continue to be protected from contamination with alpha-emitting, long-lived transuranic radionuclides. If not, the existing programs should be intensified.

The federal government should also provide states and public water system authorities that are hydrologically or hydrogeologically contiguous to DOE sites with the funds to conduct independent checks on DOE's on-site and off-site water monitoring. Such funds would better be provided through the EPA, rather than through the DOE, in order to assure the independence of the monitoring and the continuity of the funding.

4. A separate limit of detection of each alpha-emitting, long-lived transuranic radionuclide of 0.01 picocuries per liter should be set.

5. The DOE should make public the source code for the model that is used to assess the impact of residual radioactivity on food, water, and the environment.

Argonne National Laboratory developed a "family" of programs to assess the radiological impact of environmental contamination by radionuclides. The main one, called simply RESRAD, is used to assess the impact of residual radioactivity in the soil on human beings, by estimating radiation doses by a variety of pathways, such as food and water and re-suspended soil. Its source code is not public. It does not incorporate dose conversion factors for children, infants, or fetuses at various times in their development. Its internal structure and its effects on the resulting estimates of doses and risks are not available for independent scrutiny. We strongly recommend that the RESRAD source code be made public, so that it can be examined and improved in the manner of the operating system Linux. The government, of course, need not adopt any changes that are made by the public unless it finds them useful for implementing environmental regulations. But there is no reason for holding a source code paid for by taxpayer dollars secret, particularly as billions of dollars are being spent on cleanup decisions based on the results generated by the RESRAD program.

I. Introduction

The National Primary Drinking Water Regulations specify rules that will protect drinking water and will maintain it in a state that is safe to drink. In these regulations, 40 CFR 141.66 sets safe drinking water standards for radionuclides in public water supplies under the Safe Drinking Water Act.[1] These standards are set in two ways: by specifying maximum contaminant levels of drinking water or by specifying maximum allowable dose to the whole body or any organ as a result of ingestion of drinking water. However, as demonstrated below, the concentration limits currently in effect for alpha-emitting transuranic radionuclides in drinking water are grossly inadequate to protect public health. Achievement of reductions in concentration is necessary to protect public health.

The current maximum contaminant level (MCL) as set forth in 40 CFR 141.66(c) for gross alpha particle activity, including radium-226, but excluding uranium and radon, is 15 picocuries per liter. There is a sub-limit for radium-226 and radium-228, combined, of 5 picocuries per liter (including any naturally present radium-226 and radium-228). For instance, if water is contaminated with plutonium-239 alone, the level of contamination could reach as high as 15 picocuries per liter if no other qualifying alpha-emitting radionuclides were present. If radium-226 is present to the maximum allowable limit of 5 picocuries per liter,[2] then the rule allows a maximum contaminant level for gross alpha of 10 picocuries per liter. For instance, if plutonium-239 were the only alpha-emitting, long-lived transuranic radionuclide present, the MCL for plutonium-239 in this case would be 10 to 15 picocuries per liter, depending on the concentration of radium-226.

This standard was set in 1976, based on scientific assessments done in the late 1950s by the International Commission on Radiological Protection (ICRP) and the National Committee on Radiation Protection and Measurements (NCRP), a United States agency, and published as ICRP Publication 2 and in abbreviated form in the U.S. by the National Bureau of Standards as NBS Handbook 69.[3]

But the science has changed since then. As a result of these changes, as well as changes in the dose conversion factors adopted by the EPA since that time, dose estimates to the most exposed organ, while complex to assess, are far greater than those implied by the limit of 10 to 15 picocuries per liter when evaluated according to the methods specified in NBS 69.

[1] The text now published under 40 CFR 141.66 were formerly published under 40 CFR 141.15 and 141.16. (CFR = Code of Federal Regulations). See also SDWA.

[2] This assumes that no radium-228 is present. The radium MCL in the rule is set for the combined concentration of Ra-226 and Ra-228. The former is an alpha-emitter and the latter is a beta-emitter. Hence the latter is omitted from the gross alpha part of the rule.

[3] ICRP-2, 1959 & NBS 69. NBS 69, which also bears the series title NCRP Report No. 22, is a recommendation of the National Committee on Radiation Protection and Measurements, which is now known as the National Council on Radiation Protection and Measurements (NCRP). Tables and scientific discussion are drawn from ICRP-2, 1959. NBS Handbook 69 was published in 1959 and then again, with an added table and errata, in 1963. We cite NBS 69 throughout this report. The dose conversion factors, the scientific content, and other details in NBS 69 are the same as those in ICRP 2. ICRP 2 was published by the International Commission on Radiological Protection in 1959. The NCRP was (and is) a participating organization in ICRP.

It is therefore necessary that the MCLs of transuranics in drinking water be changed in order that the MCL remain within the spirit and framework of the standards as promulgated in 1976. This can be done based on the dose conversion factors that the EPA has since adopted and published in Federal Guidance Report 11,[4] which are the basis for present EPA regulation and risk estimation. They were published in 1988. The EPA has since published Federal Guidance Report 13. This is the most recent EPA scientific publication relevant to safe drinking water standards. The scientific basis of this guidance (ICRP 72)[5] has been adopted for some federal dose calculation purposes, but not yet sanctioned for use in regard to assessing doses from drinking water. In this report, we will consider the changes in the drinking water standards for alpha-emitting, long-lived transuranic radionuclides.

The basis for the needed MCL change is the potential danger that residual radioactive pollutants remaining after cleanup of the Cold War nuclear weapons production sites will pose to individuals in this generation and future generations. Of particular concern are the long-lived transuranic radionuclides neptunium-237, plutonium-238, plutonium-239, plutonium-240, plutonium-242, americium-241, and americium-243. All of these are man-made radionuclides.

II. National Primary Drinking Water Regulations - Radionuclides

In 1959, the National Bureau of Standards published its Handbook 69 (NBS 69), which established the maximum permissible average concentrations of radionuclides in air and water calculated on the basis of a 5 rem dose to the whole body, and a 15 rem dose to the most exposed organ, also called critical organ, for each pathway and solubility class.[6] As discussed below, a somewhat different method was used for bone-seeking radionuclides like radium-226 and plutonium-239. All these limits were established for radiation workers.[7]

ICRP 2 and NBS 69 also set forth the scientific approach for calculating these maximum permissible concentrations, with ICRP 2 providing significantly greater detail. A table adding data and correcting some errors in the 1959 version of NBS 69 was published in 1963, along with the original 1959 NBS 69 publication. In the text that follows, the term NBS 69 refers to this 1963 publication, since the EPA based its drinking water standards on it.

In March 1975, the EPA proposed, for the first time, National Primary Drinking Water Regulations for public water systems.[8] The proposed rules for radionuclides were published in August of that year.[9] The regulations for contaminants other than radionuclides were promulgated in December 1975;[10] the rules for radionuclides were promulgated in July 1976.[11] The MCLs and dose limits were

[4] FGR 11, 1988.

[5] ICRP-72, 1996.

[6] NBS 69.

[7] Until 1958 there were no separate radiation exposure limits for the public. They were the same as for workers. In 1958, the dose limits for the public were set at one-tenth the maximum allowable doses for workers (NBS 59 Addendum, page 5).

[8] Fed. Reg. 1975/03/14.

[9] Fed. Reg. 1975/08/14.

[10] Fed. Reg. 1975/12/24.

[11] Fed. Reg. 1976.

originally codified in 40 CFR 141.15 and 40 CFR 141.16, both of which have since been renumbered and consolidated, without change, into 40 CFR 141.66.[12]

In the final rule of July 1976, the EPA promulgated Maximum Contaminant Levels (MCLs) for radionuclides in public water systems either by directly specifying the MCL values (in picocuries per liter) or by specifying dose limits, which implied MCLs for drinking water, based on an adult water intake of two liters per day. The science underlying the standards was published in NBS 69. The drinking water limit for alpha-emitting radionuclides excluding uranium and radon, but including radium-226, was set at 15 picocuries per liter. There was a separate sub-limit for radium-226 and radium-228 of 5 picocuries per liter. For beta and photon-emitters the dose limit was 4 millirem per year (mrem/year) to the most exposed organ. (For radionuclides that are approximately uniformly distributed in the body, such as cesium-137 and tritium, the most exposed organ is considered to be the whole body.) The MCLs for beta- and photon-emitters were set according to the 4 mrem/year criterion, with a slight variation from this being adopted for tritium and for strontium-90. The limits for these categories have remained the same since that time.[13] Detection limits and analytical methods for radionuclides were set forth in 40 CFR 141.25.

The rule as originally promulgated discusses natural and man-made radionuclides separately. However, it does not explicitly discuss the alpha-emitting transuranic radionuclides that are the subject of this report, but specifies only a gross alpha MCL. The gross alpha limit excludes only uranium and radon and it automatically includes the alpha-emitting, long-lived transuranic radionuclides of concern here, as these radionuclides are explicitly listed in the tables in NBS 69.

The following statement indicates the intent of the regulation that first established maximum contaminant limits for man-made radionuclides in drinking water:

> Man-made radioactivity may enter the public water systems from a variety of sources. Such contamination is usually confined to systems utilizing surface waters. Past deposition of fallout materials from nuclear weapons tests, particularly strontium-90 and tritium, is probably the most important source of contamination. The dose equivalent to individual users of public water systems in some areas of the United States from this pathway is in the range of 1 to 2 millirem (mrem) per year. At present, the dose equivalent from public water systems contaminated by effluents produced in the nuclear fuel cycle is probably only a fraction of that due to fallout materials, though perhaps ranging up to 0.5 mrem per year. The dose equivalent from effluents released by medical, scientific, and industrial users of radioactive materials that enter the public water systems has not been fully quantified. Taken as a whole these users handle much smaller amounts of radioactivity than nuclear power facilities but (with the exception of tritium) their liquid releases and the resultant doses to man may be somewhat comparable.
>
> EPA recognizes that the national use of radionuclides in medicine and industry and the utilization of nuclear power to supply energy needs will unavoidably lead to some radioactivity entering the aquatic environment so that the quality of some surface waters is likely to decrease *slightly* in the future. *Even though the increase of radioactivity in drinking-*

[12] The changed numbering can be found in the 2004 edition of 40 CFR 141.

[13] The limits were first specified in 40 CFR 141.15 and 40 CFR 141.16. An MCL for uranium of 30 micrograms per liter was established on December 7, 2000, in 40 CFR 141.66 (e), based mainly on the heavy metal toxicity of uranium to the kidney. The revision to 40 CFR 141 was announced in Fed. Reg. 2000.

water will normally be small, the Agency believes that the risk of future contamination warrants vigilance. It is the intent of the proposed monitoring and compliance requirements to provide a mechanism whereby the supplier of water can be cognizant of changes in the level of radioactivity in its water sources, so that the appropriate remedial measures may be taken.[14]

While this passage does not explicitly mention nuclear-weapons-related activities and facilities, their inclusion is clearly indicated, notably from the fact that fallout from nuclear weapons testing is discussed as the most important source of surface water contamination. It is also clear from the discussion of fallout that the intent was to consider the most important sources of contamination. The mention of industrial users also does not exclude weapons facilities (which handle radioactivity in considerably smaller amounts when compared to reactor core and spent fuel inventories in the commercial nuclear power sector). It is implicit, therefore, that there was no intent to exclude alpha-emitting man-made radionuclides from the vigilance and concern of the regulations.

The understanding of what is the most exposed organ for alpha-emitting, long-lived transuranic radionuclides has evolved.

The level of doses at which concern and vigilance were warranted in regard to man-made radionuclides was a few millirem per year. The maximum contaminant level for photon- and beta-emitters was set to 4 millirem per year because they were considered to be the most important sources of man-made radioactivity:

> Considering the sum of the deposited fallout radioactivity *and additional amounts due to effluents from other sources currently in existence*, the total dose equivalent from made-made radioactivity is not likely to result in a total body or organ dose to any individual that exceeds 4 millirem per year...[15]

This quote shows that the sum of the doses from military and civilian activities was considered in evaluating the limit of 4 millirem per year that was set for beta- and photon-emitters in 1976. In fact, fallout was the single most important component of the dose from man-made radionuclides evaluated by the EPA.

The cancer fatalities from whole body exposure to 4 millirem per year from man-made beta and photon sources of radioactivity were estimated at between 0.4 and 2.0 deaths per year per million people exposed. This was comparable to the exposure to natural radium-226 and radium-228 estimated at 0.7 to 3 fatal cancers per year per million persons at the level of 5 picocuries per liter selected as the maximum contaminant level. The slightly higher fatality rate for radium (a factor of 1.2 to 1.8) at the allowable limit of 5 picocuries per liter must be seen in the context that it is a ubiquitous, naturally occurring radionuclide, with considerable variation in drinking water concentrations (which the EPA estimated at the time to be between 0.1 and 60 picocuries per liter).[16] The EPA imposed considerable costs on public water systems by requiring remediation of those systems that had levels of radium greater than 5 picocuries per liter in order to bring them to the

[14] Fed. Reg. 1975/08/14, page 34324, emphasis added.
[15] Fed. Reg. 1975/08/14, page 34325, emphasis added.
[16] Fed. Reg. 1975/08/14, page 34325.

regulatory level. Further, the EPA mandated testing of water supplies and established detection limits (at the 95 percent confidence limit) that were considerably below the MCLs set forth in the regulation.[17] The detection limits were set in order to ensure that the mandated MCLs would not be exceeded. In considering the mandated MCLs and detection limits, the EPA took technical, health, and economic considerations into account.

In looking to the future, the EPA did not anticipate that man-made radionuclides would result in a dose of more than 4 millirem per year from drinking water, because it believed that fallout would remain the main source and that this source would decrease with time due to the ban on atmospheric tests[18]:

> The 4 millirem per year standard for man-made radioactivity was chosen on the basis of avoiding *undesirable future contamination of public water supplies as a result of controllable human activities.* Given current levels of fallout radioactivity in public water supply systems and their expected future decline, and the degree of control on effluents from the nuclear industry that will be exercised by regulatory authorities, it is not anticipated that the maximum contaminant levels for man-made radioactivity will be exceeded except in extraordinary circumstances.[19]

There is no explicit exclusion of alpha-emitting transuranic radionuclides from this statement. Also, the National Primary Drinking Water regulations explicitly mention strontium-90 in fallout. Hence, the regulations explicitly took into account a man-made radionuclide from a military activity – nuclear weapons testing – in protecting public water supplies from radioactive contaminants. Further, the critical organ listed in NBS 69 for strontium-90 and for the transuranic radionuclides that are the subject of this report was the same – the bone.

The language of the regulation indicates that the MCL in the range of 10 to 15 picocuries per liter for the alpha-emitting, long-lived transuranic radionuclides set at the time would have corresponded approximately to a bone dose of a few millirem per year according to then-prevailing estimation methods. We show in the next section, *A. Bone dose estimation in ICRP 2*, that was indeed the case. However, present-day methods result in far higher dose estimates, as discussed below in the section after next, *B. Bone dose estimation, present-day dose conversion factors.*

A. Bone dose estimation in ICRP 2

Bone dose was estimated in ICRP 2 (and NBS 69) as dose to the skeletal bone without the marrow. The reference bone-seeking radionuclide used by ICRP 2/NBS 69 was radium-226 and the reference amount was 0.1 microcurie of radium-226 in the skeletal bone. The amount of energy deposited in the bone each year corresponded to an absorbed radiation dose rate of about 3 rad per year, not accounting for relative biological effectiveness (RBE) of alpha particles. ICRP 2 used an RBE = 10, thus yielding an annual dose for a 0.1 microcurie body burden of radium-226 of 30 rem per year,

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[17] Fed. Reg. 1976, page 28404.

[18] Of the nuclear weapons states, only China was testing in the atmosphere at the time. China conducted its last atmospheric nuclear test in 1980.

[19] Fed. Reg. 1975/08/14, pages 34325-34326, emphasis added.

according to the then-prevailing method of estimation.[20] Doses were calculated by estimating a whole-body or organ burden of the radionuclide assuming lifetime ingestion or inhalation at the MCL, for which values were given either in the workplace (40-hour workweek) or continuously (168 hours per week).

Some radionuclides, such the beta-particle-emitting strontium isotopes, were recognized even then to behave somewhat differently than radium-226 in the body in that they tended to concentrate in certain parts of the bone, while radium-226 is distributed less unevenly. Research since that time has validated that observation. For instance, the alpha-emitting, long-lived transuranic radionuclides tend to concentrate adjacent to the endosteal cells on the bone surface. Hence, these radionuclides deliver a considerably higher dose to the endosteal cells than would be indicated by an assumption of uniform distribution over a marrow-free skeleton.

In order to account for non-uniform distribution of several bone-seeking radionuclides, ICRP 2 suggested (and used) a factor of safety of 5 for such radionuclides when estimating maximum permissible levels of radionuclides in air and water for workers.[21] The effect of this safety factor was to reduce the maximum allowable dose for workers from alpha-emitting, long-lived transuranic radionuclides to 6 rem per year, compared to 30 rem per year for radium-226. Correspondingly, the maximum permissible concentrations were also reduced by a factor of five.

This intent to reduce the maximum permissible dose to the bone by a factor of about 5 can be confirmed by estimating the dose corresponding to the maximum permissible burden of plutonium-239 in the bone of 0.04 microcuries specified in NBS 69. Using a value of 5.15 MeV per alpha particle and an RBE = 10, the annual dose corresponding to a bone burden of 0.04 microcuries of plutonium-239 is about 5.5 rem per year. Since the whole body and organ burdens in NBS 69 are rounded, this is in close agreement with the figure of 6 rem inferred by applying the safety factor of 5 to the radium-226 dose of 30 rem.

The MCL for soluble plutonium-239 set in NBS 69 corresponding to the 6 rem per year bone dose would be 5×10^{-5} µCi/cc, or 5×10^{-2} µCi/liter, or 50,000 pCi/liter. The current drinking water limit of 15 picocuries per liter in the absence of radium-226 corresponds to a bone dose of about 1.8 millirem per year (or 1.2 millirem per year corresponding to 10 picocuries per liter, which is the MCL for plutonium-239 in the presence of radium-226 at its MCL of 5 picocuries per liter).[22]

The bone doses corresponding to 15 picocuries per liter for various alpha-emitting, long-lived transuranic radionuclides are shown in Table 1, estimated according to the method in NBS 69 which was the prevailing scientific understanding in 1976, when the EPA first promulgated the MCLs for radionuclides. All of these calculations follow NBS 69 in assuming soluble radionuclides when estimating doses to the bone from drinking water. An assumption of soluble forms of the radionuclides is reasonable (and in keeping with the regulation as originally promulgated) since it is likely that the radionuclides will be in that form if they are present in drinking water. The presence of insoluble colloidal forms is not excluded, but the likely presence of soluble forms makes it necessary to use the uptake coefficient for that form, which has been done throughout this report.

[20] ICRP-2, 1959, page 13 and FGR 11, 1988, page 18. The current value of the RBE, often called the quality factor in the regulatory context, for alpha particles is 20.
[21] FGR 11, 1988, pages 16-19.
[22] This assumes that no Ra-228 is present.

Table 1: Bone dose from alpha-emitting, long-lived transuranic radionuclides according to NBS 69 (ICRP 2)

Radionuclide	Bone dose at 15 pCi/L in mrem/y
plutonium-238	1.8
plutonium-239	1.8
plutonium-240	1.8
americium-241	1.8
neptunium-237	3.0

Note: These doses are estimated by proportionally reducing the doses for these radionuclides corresponding to the MCLs listed in NBS 69, which correspond to a bone dose of 6 rem per year. The figure of 6 rem for bone dose for alpha-emitting, long-lived transuranic radionuclides is derived by applying the safety factor of 5 to the bone dose of 30 rem for radium-226 (see text). NBS 69 lists the kidney as well as bone as the target organs for americium-241. We consider only bone-dose-related MCLs in this report. Plutonium-242 dose is the same as plutonium-239.

The NBS 69 (ICRP 2) calculations for bone dose are not directly comparable to present-day methods of dose estimation. NBS 69 specifies annual doses to the "bone," defined as the marrow-free skeleton. But Federal Guidance Report 11, which lays out methods of dose estimation that are the basis of EPA regulations at the present time, defines committed doses to two different parts of the bone – the "red marrow" and the "bone surface."[23] The latter is defined as the most exposed organ in Federal Guidance Report 11 for alpha-emitting, long-lived transuranic radionuclides because they concentrate adjacent to the endosteal cells, which are located on the bone surface. In other words, the understanding of what is the most exposed organ for alpha-emitting, long-lived transuranic radionuclides has evolved along with the methods of dose estimation since the MCLs were promulgated in 1976.

As shown in Table 1, the range of doses to the bone using a limit of 15 picocuries per liter for alpha-emitting, long-lived transuranic radionuclides estimated according to NBS 69 is approximately from 1.8 to 3 millirem per year. This is about the same as the doses estimated from man-made radionuclides, notably in fallout, in the safe drinking water regulation as promulgated in 1976. Hence we can infer that the intent of the rule was to limit the dose from drinking water to the maximum exposed organ, defined then as the bone, to approximately 2 millirem per year.

While the bone surface was not specified as a target organ for dose calculations in 1976, when the safe drinking water regulations were promulgated, it is possible to estimate the dose to the endosteal cells at a level of drinking water contamination of 15 picocuries per liter based on the NBS 69 dose conversion factors. For plutonium-239, the annual dose to the endosteal cells would be about 26 millirem per year.[24] The bone surface dose for the other radionuclides shown in Table 1 are about the

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[23] There is more recent federal guidance on the subject in *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13. Washington, D.C., Environmental Protection Agency, 1999 (hereafter cited as FGR 13). This report also uses the same two parts of the bone as the target organs for which doses are calculated.

[24] This estimate is derived by using a mass of 120 grams for the endosteal cells corresponding to an overall skeletal mass of 7,000 grams. Further, it is assumed that one-fourth of the energy is deposited in the 120-gram mass of the endosteal cells, with the rest being deposited in other parts of the bone. This mass of the endosteal cells is specified in Federal Guidance Report 11. This gives a ratio of dose to endosteal cells of $(7000/120)*0.25 = 14.6$. All calculations assume that the dose to the bone permitted under NBS 69 at the specified MCL was 6 rem per year. There is some imprecision

same, except for Np-237, for which the figure is about 44 mrem per year. These estimated doses, which take into account the evolution of scientific understanding in the years after 1976, are far higher than what the safe drinking water regulations allow. The implied dose to the endosteal cells is about a factor of 14.6 higher for plutonium-239. All of these calculations were done within the framework of NBS 69, which was (and continues to be) the scientific guidance for the safe drinking water regulation.

B. Bone dose estimation, present-day dose conversion factors

Scientific understanding of radiation doses and harm from intake of radionuclides has advanced considerably over the years. Regulations have also evolved to some extent, though at a slower pace. Specifically, in the 1970s, the International Commission on Radiological Protection (ICRP) published ICRP 26 and ICRP 30 followed by ICRP 48 in 1986. The scientific work in these publications was incorporated by the EPA into Federal Guidance Report 11 in 1988. The doses from alpha-emitting, long-lived transuranic radionuclides in the new guidance issued by the EPA are much higher than those estimated by NBS 69 methods. Federal Guidance Report 11 is the report that is the basis of current EPA regulatory dose estimation methods. We will estimate bone doses according to Federal Guidance Report 11 (FGR 11) in this section. Then we discuss the same problem using Federal Guidance Report 13 (FGR 13), which is the most recent EPA Guidance, but not yet in force for regulatory calculations for doses from air and water.

1. Bone doses according to FGR 11

As touched upon above, several major changes have transpired from NBS 69 to FGR 11 so far as this analysis is concerned:

- The quality factor, or RBE, was increased from 10 to 20.
- The bone was divided into two different target organs, the "bone marrow" and the "bone surface," as compared to a single organ, the marrow-free skeleton, in NBS 69.
- The division of the bone into two organs in FGR 11 allowed the omission of the safety factor of 5 that was used in NBS 69 to account for selective, non-uniform deposition in the bone of certain radionuclides.
- NBS 69 used annual doses, while FGR 11 provides the conversion factors for committed doses.[25]

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associated with the fact that the MCLs were rounded to one significant figure in NBS 69, but this is not significant in the present context.

[25] "Annual dose" corresponds to the amount of energy from ionizing radiation deposited in the target organ per unit mass of the organ in a single year. The dose in rem is then calculated by applying the RBE to the deposited energy. "Annual committed dose" corresponds to the amount of energy that would be deposited in the organ over the entire time that the radionuclide is present in the organ due to the intake of the radionuclide in a single year. If a radionuclide is eliminated rapidly from the body (say in a few days or weeks), as for instance is the case with tritium, then annual dose and committed dose are usually the same. But if the radionuclide is slowly eliminated from the target organ, over years or even decades (the latter is the case for alpha-emitting, long-lived transuranic radionuclides, their target organ being the bone), the dose to the bone from an intake in any given year is delivered over a period of decades after that. With the annual committed dose, the intake is over a year but the dose is delivered over a different period of time – and, in the case of alpha-emitting, long-lived transuranic radionuclides to the bone, a much longer period of time. Hence, the actual dose delivered to the person in the case of an intake of an alpha-emitting, long-lived transuranic radionuclide late in life (say a

While these technical changes are complex, it is possible to estimate the effect of the changes from NBS 69 to Federal Guidance Report 11 on doses in several different ways, each of which raises some technical issues. The approaches and issues are set forth in Table 2 using plutonium-239 as the reference alpha-TRU radionuclide.

Table 2: Approaches for deriving an updated drinking water limit for plutonium-239 that account for changes from NBS 69 to FGR 11

Approach	**Issues**	**Derived, updated Pu-239 MCL, pCi/liter**
1. Compare the NBS 69 annual bone dose to the FGR 11 bone surface annual committed dose	**Advantage**: Uses the prevailing dose framework at the time. **Disadvantages**: (i) For alpha-emitting, long-lived transuranic radionuclides, which have a long biological half-life, committed dose is not equivalent to annual dose. The actual cumulative dose over a lifetime is considerably less than the product of the years and the annual committed dose. (ii) Target organ is different – bone for NBS 69 and bone surface for FGR 11.	0.04
2. Compare NBS 69 cumulative bone dose over a lifetime at 15 pCi/L to actual cumulative bone surface dose estimated from FGR 11	**Advantage**: Closest to the intent of the regulation to limit doses to the most exposed organ. **Disadvantage**: Changes the target organ from marrow-free skeleton to bone surface.	0.08
3. Compare cumulative bone surface dose imputed from NBS 69 to bone surface dose as per FGR 11	**Advantage**: Compares the same target organ. **Disadvantage**: Changes the framework from maximally exposed organ, as defined at the time by prevailing science, to comparing bone surface dose, which was not explicitly defined in NBS 69.	12

Notes: For Pu-239, it is assumed that 63 percent of the committed dose is delivered in 50 years. The values in the last two rows correspond to a 70-year intake. The estimate in Federal Guidance Report 11 for bone "surface seeking alpha-emitters" is a factor of 12, but a value for Pu-239 is not specified. We estimate the ratio of cumulative bone surface dose from FGR 11 to NBS 69 for Pu-239 is a factor of 12.3, which is about the same as the value in FGR 11. This validates the approach used for the calculations in the last row of the above table.

Of these approaches, the first one is the least persuasive scientifically because it compares cumulative annual doses to cumulative committed doses. Since plutonium is eliminated from the bone very

few years before death) is less than the full committed dose and less than the dose that would be delivered from the same intake early in life.

slowly (with a biological lifetime of several decades), most of the dose from intakes in the last years of a 70-year reference lifetime would be delivered after the full lifetime of even a long-lived person (even if one considers a ~100 year life, for instance). Hence, only the latter two approaches are scientifically reasonable. Both yield values for MCLs for alpha-emitting, long-lived transuranic radionuclides that are far below 15 picocuries per liter. However, they yield values also an order of magnitude different from each other – 0.08 picocuries per liter and 1.2 picocuries per liter. The approach shown in the second row is the most close to the intent of the drinking water regulation because it compares cumulative dose over a lifetime to the most exposed organ as defined in 1976 (marrow-free skeleton) and the most exposed organ as currently defined (bone surface). The last approach compares dose to the same organ (bone surface), which has scientific merit. However, it is not in accord with the intent of the regulation to limit dose in that the prevailing views of the most exposed organ (marrow-free skeleton in 1976 and bone surface in 1988) are no longer being compared. Hence, the most appropriate value to use for a new standard based on Federal Guidance Report 11 would be 0.08 picocuries per liter. However, since this is no longer the most recent scientific guidance published by the EPA, this factor would also need to be considered in the review of MCLs for alpha-emitting, long-lived transuranic radionuclides when they are reviewed in 2006.

2. Bone doses according to FGR 13

The most recent regulatory guidance for estimating doses is based on dose conversion factors published in ICRP 72. These have been incorporated into Federal Guidance Report 13, including the compact disk supplement, which has dose conversion factors for various ages published in a database.[26] The dose conversion factors are age-dependent and can be used to estimate committed doses for the remainder of life from the age of intake to age 70 years. This allows the estimation of total dose over a lifetime corresponding to a water contamination at 15 picocuries per liter.

The dose conversion factors in Federal Guidance Report 13 are generally somewhat lower than those in Federal Guidance Report 11. Therefore the total dose to the bone surface using the newer dose conversion factors in Federal Guidance Report 13 is roughly a factor of two lower than that estimated using FGR 11. In addition to the change in the dose conversion factors, water intake variation with age also needs to be considered. The current drinking water MCLs are based on an adult intake of 2 liters of water per day, excluding the water content of food. However, the water intake of children is smaller and there is also some gender variation. Further, children have a greater intake of fluids, notably in the form of milk. Therefore, we have done the Federal Guidance Report 13-based dose calculation using two sets of intake rates for various ages that are published in the literature. The first set corresponds to fluid intakes, including milk. The second set includes only water intake. These assumptions about intake rates are show in Table 3 below:

[26] FGR 13, 1999 and 2002 (the latter for the CD supplement, rev.1).

Table 3: Drinking water assumptions for FGR 13 dose calculations

Age range, years	Fluid intake, including milk, liters/day (Case 1)	Water only intake, liters/day (Case 2)
0 to 4	1.3	0.7
5 to 14	1.3	0.95
15 to 70	1.95	1.65

Note: For Case 1, the main reference is ICRP 23, 1975. The fluid intake rate of 1.4 liters per day for 10 year-olds has been changed here to 1.3 liters per day for ages 0 to 14 years. For Case 2 the main reference is Smith and Jones 2003, which provides the most recent recommendations of the British National Radiological Protection Board.

When total fluid intake is considered (i.e., Case 1 above) the cumulative lifetime dose to the bone surface from plutonium-239 over a 70-year period is about 15,500 mrem. For Case 2, water intake only, the lifetime bone surface dose is about 12,000 mrem. The corresponding dose to the maximally exposed organ under NBS 69 (the marrow-free skeleton) is 126 mrem. These doses are calculated by applying dose conversion factors specified in the relevant publications to the intake of plutonium in drinking water over a 70-year period. This last figure of 126 mrem can be viewed as the intent of the original regulation in terms of the dose to the maximally exposed organ from drinking water contaminated with plutonium to the maximum allowable limit of 15 picocuries per liter. If we compare the value of 126 mrem to the dose to the maximally exposed organ as estimated by the methods specified in Federal Guidance Report 13, we find that for drinking water intakes corresponding to Case 1, the MCL of 15 picocuries per liter is about 123 times too high and for Case 2, it is about 95 times too high. Therefore the most recent science would indicate a tightening of the current MCL for plutonium-239 (15 pCi/L) by about 123 times to about 0.122 picocuries per liter in the case of fluid intake case (Case 1) and by over 95 times to about 0.157 picocuries per liter for water intake only (Case 2). The results for the other alpha-emitting, long-lived transuranic radionuclides are similar, since the dose conversion factors are quite close to those of plutonium-239, with the exception of neptunium-237, for which the dose conversion factors are about a factor of two lower.

III. Conclusions

The MCL for alpha-emitting, long-lived transuranic radionuclides should be reduced from 15 picocuries per liter to 0.15 picocuries per liter.

The analysis in this report shows that the MCL for alpha-emitting, long-lived transuranic radionuclides should be tightened by about a factor of 100 – that is, it should be reduced from 15 picocuries per liter to 0.15 picocuries per liter. A combined standard for all alpha-emitting, long-lived transuranic radionuclides will simplify the rule and reduce the cost of its enforcement. Moreover, since the plutonium isotopes among these dominate the total curie content of DOE waste and since the dose conversion factors for Pu-238, Pu-239, Pu-240, Pu-242, and Am-241 are nearly the same, using Pu-239 as a reference for deriving the combined standard MCL is reasonable from a health standpoint as well as cost-effective.[27]

In considering what should be the optimal value for a drinking water standard for alpha-emitting, long-lived transuranic radionuclides radionuclides, we have also examined the values for a plutonium-239 limit that exists in other standards. Specifically, the surface water standard of the State of Colorado is the most relevant, since that state has been host to one of the most important plutonium handling and processing facilities in the United States, namely, the Rocky Flats Plant, near Denver. The statewide standard for plutonium-239 for surface water is 0.15 picocuries per liter.[28] It is calculated on the basis of a 30-day rolling average – that is, 30 consecutive measurements are averaged; they may or may not be taken on consecutive days. Colorado's standard is based on the risk of one person in one million developing a cancer from consuming 2 liters of water per day for 30 years.[29]

The Colorado Department of Health, Water Quality Control Commission describes the background and the rationale for changing from 15 picocuries per liter to 0.15 picocuries per liter as follows:

> **Background** The Commission previously adopted a basic standard for plutonium of 15 pCi/L and had no basic standard for americium. A basic standard was considered in this hearing for americium because it is closely associated with plutonium and these two radionuclides generally occur together. The current basic standard of 15 pCi/L plutonium was calculated using methodologies in the 1976 National Interim Primary Drinking Water Regulations and was consistent with a goal of keeping exposures below 4 millirem per year. The Basis and Purpose indicated that it was necessary and important to restrict levels because of the difficulty of removing this radionuclide by conventional treatment procedures and because the potential adverse effect on human health suggests that extreme caution be exercised in its

[27] The dose conversion factor for Np-237 is lower than those of the other alpha-emitting, long-lived transuranic radionuclides by about a factor of two.

[28] Colorado Reg. 31, 2005. The State also sets standards for other radionuclides and considers different limits for different watersheds. We have not considered these issues, some of which result in more stringent and others of which result in more lax rules. We have simply used the State of Colorado's statewide surface water limit for Pu-239 as a guide for reference.

[29] CDPHE 2002.

release to State waters. Since plutonium is predominantly an alpha emitter, the basic standard was made consistent with the 15 pCi/L alpha standard....

Basis for Commission Decision Since the previous basic standard was set, several changes have occurred: 1) a new methodology for assessing carcinogens has become the standard practice, 2) new data have resulted in periodic updates to the slope factors used in this methodology, and 3) a more refined Commission policy on appropriate levels of protection for carcinogens has been developed. This latter risk-based policy also parallels a national trend towards risk-based approach to environmental cleanup standards.

The 15 pCi/L dose-based approach was calculated using a "reference-man" and considered exposure during his working life. It was an approach designed to address questions related to occupational exposure. It did not consider sex, age and organ-specific factors over a lifetime. In contrast, the new slope factor methodology, used in EPA's 1989 Risk Assessment Guidance for Superfund Sites, is more complete, more applicable to a general population and has become the standard practice for calculating risk.

The Commission adopted a basic standard of 0.15 pCi/L for plutonium and americium, calculated using a 1×10^{-6} risk level, based on residential use. This risk level is consistent with the Commission's policy for human health protection.[30]

This reasoning is based on CERCLA, the Superfund law, but is qualitatively in accord with the reasoning in this analysis. Specifically, the central scientific point of the Colorado rule is that the science has changed, indicating greater risk than previously assumed from exposure to plutonium and americium; therefore the maximum contaminant limits should be adjusted accordingly. Further, the specific value for plutonium and americium recommended in the Colorado rule is just a factor of two lower than the geometric mean of the two values in the last two rows of Table 2 above.

In view of the complexities created by the change from NBS 69 to Federal Guidance Report 13, an MCL for alpha-emitting, long-lived transuranic radionuclides of 0.15 picocuries per liter is reasonable and justifiable. The action we are recommending is consistent with the intent of the National Primary Drinking Water Regulations as originally promulgated and is directly within the framework of the regulation as promulgated then and as it stands at present.

The primacy of the health goal (rather than numerical limits) is clear from the EPA's own description of the Safe Drinking Water Act, pursuant to which the radionuclide maximum contaminant limits are set. Its fact sheet on the Act states:

US EPA sets national standards for tap water which help ensure consistent quality in our nation's water supply. US EPA prioritizes contaminants for potential regulation based on risk and how often they occur in water supplies. (To aid in this effort, certain water systems monitor for the presence of contaminants for which no national standards currently exist and collect information on their occurrence). US EPA sets a health goal based on risk (including risks to the most sensitive people, e.g., infants, children, pregnant women, the elderly, and the immuno-compromised). US EPA then sets a legal limit for the contaminant in drinking water or a required treatment technique.[31]

[30] Colorado Reg. 31, 2005, pages 138-139.
[31] EPA 2004.

By this standard, the 15 picocuries per liter limit for transuranic radionuclides is obsolete, not protective of public health, against the spirit of the Safe Drinking Water Act, and, as shown above, not in accord with the intent of the initial regulation. Because of this, the EPA should take up consideration of a tightened standard in its upcoming 2006 drinking water radionuclide review.

The 15 pCi/L limit for transuranic radionuclides is obsolete, not protective of public health, against the spirit of the Safe Drinking Water Act, and, as shown above, not in accord with the intent of the initial regulation.

Corresponding to the change in the MCL for alpha-emitting, long-lived transuranic radionuclides, there is also a need for a change in the detection limit. Table B in 40 CFR 141.25 should be modified to include a separate detection limit of 0.01 picocuries per liter for each alpha-emitting, long-lived transuranic radionuclide. This detection limit is well within the capabilities of present-day techniques. The current detection limit for these radionuclides is 0.001 picocuries per liter, according to Argonne National Laboratory. The errors at such low levels can be large however. The error at 0.01 picocuries per liter, the recommended detection limit, is estimated by Argonne National Laboratory to be 10 percent.[32]

We recognize that alpha-emitting, long-lived transuranic radionuclides are not ubiquitous in significant concentrations, unlike naturally occurring radionuclides like radium-226, thorium-232, and thorium-230. The vast majority of public water systems can therefore be exempted from routine monitoring requirements relating to alpha-emitting, long-lived transuranic radionuclides. The monitoring requirements for these radionuclides should be applied to public water systems that draw water from aquifers or surface water that have potential hydrologic or hydrogeologic connections to areas or facilities with waste tanks, waste burial pits, and other potential sources of alpha-emitting, long-lived transuranic radionuclides in combined totals in excess of 100 curies (see below).[33] Wastes disposed of at shallow and intermediate depths are included in this definition. Alpha-emitting, long-lived transuranic radionuclides that are contained in secure buildings with institutional controls would be exempt from this limit and the associated monitoring requirements.

We recognize that the main recommendation of this report, to set a separate standard for alpha-emitting, long-lived transuranic radionuclides, requires that the present gross alpha limit be split up into two parts – one for alpha-emitting, long-lived transuranic radionuclides and the other for naturally occurring alpha-emitting radionuclides. However, this is not a departure from the content or intent of the present rule, for several reasons.

First, the present rule itself does not have a single standard for alpha-emitting radionuclides. There is a sub-limit for radium-226 and radium-228 of 5 picocuries per liter. Since radium-226 is an alpha emitter, there is in effect a separate sub-limit for an alpha emitter up to maximum of 5 picocuries per liter (depending on how much radium-228, a beta-emitter, is also present). Second, the gross alpha

[32] ANL 1995, Chapter 7, Table 7.1.

[33] For instance, the 100 curie limit is equivalent to 1,000 metric tons of transuranic waste containing alpha-emitting, long-lived transuranic radionuclides at the lower limit of 100 nanocuries per gram. It would be equivalent to a larger mass of low-level waste, since the concentration in such waste (by definition) is less than 100 nanocuries per gram.

limit excludes uranium and radon. The limit of 30 micrograms per liter of uranium is set on the basis of heavy metal toxicity. However, this amount of uranium causes some amount of harm as a result of its radioactivity. Recent science indicates that the harm from the heavy metal aspects of uranium may be reinforced by its radioactivity. (See *Section VI. Other risks and radionuclides*, below). Hence, reconsideration of a variety of issues is warranted. In such reconsideration, it would be practical and less costly to separate out alpha-emitting, long-lived transuranic radionuclides. This is because the vast majority of water systems will not require any testing for alpha-emitting, long-lived transuranic radionuclides since they are not at risk.

IV. Costs

Public water systems are not at present contaminated at or near the requested MCL for alpha-emitting, long-lived transuranic radionuclides. A strengthened alpha-TRU drinking water standard is preventive rather than remedial. Only a small, one-time cost for an initial set of baseline samples is anticipated for those water systems that draw water from sources that include DOE sites with significant plutonium waste or soil contamination in drainage areas. We recommend that this one-time cost be borne by the DOE.

Public water systems are not at present contaminated at or near the requested MCL for alpha-emitting, long-lived transuranic radionuclides.

Since no known contamination of public water systems above 0.15 picocuries per liter of alpha-emitting, long-lived transuranic radionuclides exists, no further action would be required of public water systems and no further costs would be incurred provided there is sufficiently thorough monitoring by the DOE, coupled with remediation programs that are suited to free release of the sites in the long term. This will be sufficient to protect downstream surface waters and underground water systems. The DOE is supposed to carry out such monitoring in any case and therefore no additional, ongoing monitoring costs are anticipated.

The Department of Energy, which is responsible for management of almost all the wastes and materials that pose risks of water contamination with alpha-emitting, long-lived transuranic radionuclides, is supposed to take adequate remedial action at sites like the Idaho National Laboratory, Hanford, the Savannah River Site, and Los Alamos National Laboratory. If it does so, no remediation costs for public water systems would be required under our recommended changes to the National Primary Drinking Water Regulations.

The costs of not tightening the standards would be to signal that remediation of nuclear weapons sites with large inventories of plutonium in the waste could proceed without adequate attention to safe drinking water health protection goals. DOE could then remediate these sites and declare them cleaned up without reference to a science-based drinking water standard that corresponds to current understanding of plutonium movement and irradiation of the human body. Finally, some remediation actions could, in the long run, pollute the water above drinking water standards, and worse, be irremediable. No known technology could remediate vast bodies of water such as the Savannah

River or the Snake River Plan Aquifer if, once polluted, the aim is to reduce pollution from a few picocuries per liter to sub-picocurie per liter levels.

V. Estimating the impact of residual radioactivity

Vast areas of land and huge amounts of water remain contaminated with dangerous long-lived radionuclides from operations of nuclear weapons facilities.[34] The DOE has been given the task to clean up these sites. It is therefore of great importance that the levels of residual radioactivity meet strict standards that will protect the health of individuals of this and future generations that will be exposed to the residual contamination.

In the early 1990s, the DOE embarked on a cooperative process with the EPA to develop national cleanup standards, but the DOE pulled out of the process abruptly in 1996 without any plans for its resumption.[35] Since then, the DOE has proceeded on a site-by-site basis that has led to a welter of proposals for cleanup using various scenarios.

At the Savannah River Site in South Carolina, the DOE is grouting high-level waste in tanks as if it were low-level waste. This waste contains significant amounts of transuranic radionuclides. For instance, the residual waste in Tank 19, which has been grouted, had a concentration of plutonium 14 times above the EPA 100 nanocurie-per-gram limit for transuranic waste. DOE is grouting large amounts of plutonium in the tanks even though it has not yet obtained convincing evidence of the durability of grout. The tanks are buried underground in the watershed of the Savannah River, one of the most important rivers in the South Carolina-Georgia region. Experimental and field data leave room for considerable skepticism as to its performance. IEER's evaluation of the state of the research on grout indicates that the performance of grout remains highly uncertain. There is at present no sound basis, whether in experiment or in field data, to assume that leaving large amounts of grouted alpha-emitting, long-lived transuranic radionuclides in the tanks would be protective of the Savannah River.[36]

A large part of the urgency that our recommendations be incorporated into EPA's forthcoming review of MCLs for radionuclides in drinking water derives from the fact that, in 2004, Congress passed a law allowing DOE to reclassify residual high-level waste as incidental waste at its South Carolina and Idaho sites. The law did not set any limits as to the residual radioactivity in waste so reclassified.[37] Several long-lived radionuclides, including plutonium isotopes, strontium-90, and cesium-137, may be grouted in the tanks or disposed of in shallow saltstone vaults. A realistic framework to guide DOE's decision-making, so that it does not endanger crucial water resources, is therefore of urgent and immense importance.

The consequences of the DOE cleanup policy on the concentrations of residual transuranic contamination in the soil and their potential effect on the health of individuals are discussed in a study by IEER entitled *Setting Cleanup Standards to Protect Future Generations: The Scientific*

[34] OTA 1991.
[35] Nichols 1996.
[36] Smith 2004 and Makhijani and Boyd, 2004.
[37] PL 108-375, 2004, Sec. 3116.

Basis of the Subsistence Farmer Scenario and Its Application to the Estimation of Radionuclide Soil Action Levels (RSALs) for Rocky Flats, December 2001.[38] In this study, IEER showed that the specific assumptions about future use have a major impact on what are considered acceptable residual radioactivity levels. A large part of this result is because different future site use scenarios have different assumptions about the use of water and food from the contaminated area in question. Since some radionuclides, including the alpha-emitting, long-lived transuranic radionuclides discussed in this report, are very long-lived, a basic assumption that there will be loss of institutional control over the long-term is essential to sound planning and cleanup.

However, even the adoption of a subsistence farmer scenario as the basis for cleanup cannot assure that levels for residual radioactivity on contaminated sites will be set in a manner that is protective of health and the environment. This is because the translation of residual levels into radiation dose and risk estimates requires the use of complex models and assumptions about the behavior of radionuclides in the environment. For instance, the amount of rainfall, the mobility of radionuclides in specific soil conditions, the porosity of the soil, the solubility of the radionuclides under various circumstances, and the rate of soil erosion are among the critical parameters that need to be known and characterized.

At present, remediation levels are typically assessed by the use of a model developed by Argonne National Laboratory called RESRAD (for residual radioactivity).[39] This computer code is complex and has, over the years, been developed to consider pathways for movement of radioactivity in a sophisticated way. Yet, it does not contain libraries of dose conversion factors for, and thus does not account for, infants or for young people at sensitive times in their hormonal development or for the fetus at various stages of fetal development. The estimation of doses to various segments of the population at sensitive periods in their lives may also require consideration of how the environmental pathways and the systems in the human body are represented in the model's source code.

The RESRAD source code is closely held by the U.S. government; it is not public. Ostensibly, the official rationale is that since RESRAD is used for regulatory decisions, such as those that are made in the context of cleanup at nuclear weapons sites, it should not be made public. However, we do not accept this rationale. The code can be made public and can be an open source code, available for modification in the same manner as the Linux operating system source code. That has resulted in its improvement and efficiency, without problems actually creeping into mass use of the code as an operating system. The U.S. government can surely retain its version of the code for regulatory purposes while making the source code publicly available for examination and improvement. If at a certain stage, the code is improved in a manner that regulatory bodies such as the EPA consider it useful for regulatory purposes, they will freely be able to adopt the changes but will be under no obligation to so.

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[38] Makhijani and Gopal 2001.
[39] RESRAD.

VI. Other risks and radionuclides

New scientific work on radiation protection is currently emerging, for instance in relation to (i) protection of the embryo/fetus and infant, (ii) non-cancer effects of exposure to certain radionuclides, (iii) potential synergistic effects of exposure to certain chemicals, such as hormonally active chemicals, and exposure to radiation, (iv) the need for protection of key non-human species and ecosystems, and (v) the synergisms indicated for certain effects between the heavy metal toxicity component of uranium and its radiotoxicity. However, these are still emerging areas of concern, where the risks are not quantitatively well established. How such risks are to be considered in the context of a review of drinking water MCLs will be considered in a future IEER report.

Recent developments in radiobiology and health effects research have increased understanding of radiation doses during fetal development. They indicate that non-cancer health effects resulting from fetal exposure to radiation could be very important. For instance, ICRP 90 emphasizes that the central nervous system is especially vulnerable during a certain period of fetal development:

> ... [B]iological systems with a high fraction of proliferating cells show high radiation responsiveness. High rates of cell proliferation are found throughout prenatal development....Development of the central nervous system starts during the first weeks of embryonic development and continues through the early postnatal period. Thus development of the central nervous system occurs over a very long period, during which it is especially vulnerable. It has been found that the development of this system is very frequently disturbed by ionising radiation, so special emphasis has to be given to these biological processes.[40]

A variety of end points (disease outcomes) are at issue, from central nervous system development to cancer to birth defects to increased risk of miscarriages. Further, these end points raise the issue of the combined effects of other pollutants with radiation more insistently that ever before. For instance, one might ask about the potential for non-linear effects caused by exposure to both lead and radiation or mercury and radiation. One might also ask about the combined effects of exposure to endocrine disrupting chemicals and radiation in relation to a number of end points. These are areas still in a relatively early stage in the science compared to the understanding of radiogenic cancer induction. For these areas, which concern non-cancer end points as a result of fetal exposure, for instance, the conversion of the scientific data in publications such as ICRP 88 and ICRP 90 into regulations for health and environmental protection will take considerable time.[41] The EPA has not even published the necessary guidance documents as yet.

Recent research, much of it done at the Armed Forces Radiobiology Research Institute, pursuant to concerns about the health effects of depleted uranium, points to a surprising variety of harmful health effects of uranium. A recent literature survey by IEER summarized the situation as follows:

> The understanding of the risks of cancer due to radiation exposure from depleted uranium and kidney damage due to its heavy metal properties has expanded greatly in recent years. In addition, evidence is amassing that raises serious concerns regarding the impact of

[40] ICRP-90, 2003, page 9.
[41] ICRP-88, 2002; ICRP-90, 2003.

> chronic exposure to DU in relation to a number of other health issues. Studies in humans and animals have shown that uranium can concentrate in the skeleton, liver, kidneys, testes, and brain. In addition, rats implanted with DU pellets have also shown uranium concentrating in the heart, lung tissue, ovaries, and lymph nodes among other tissues. Research, primarily but not exclusively conducted since the 1991 Gulf War, indicates that exposure to uranium may be
>
> Mutagenic
> Cytotoxic
> Tumorigenic
> Teratogenic
> and Neurotoxic, including in a manner analogous to exposure to lead.
>
> Additionally... some research has also provided indications that there may be a synergistic effect between the heavy metal aspect of exposure to uranium and its radioactive effects....Current research conducted at the Armed Forces Radiobiology Research Institute (AFRRI) indicates that "[i]n the case of DU, cells not traversed by an alpha particle may be vulnerable to radiation-induced effects as well as chemically-induced effects." Additional work at the AFRRI has also shown that depleted uranium can cause oxidative DNA damage and thus provides the first indication that uranium's radiological and chemical affects might potentially play both a tumor initiating and a tumor promoting role. [42]

In other words, uranium may be a kind of radioactive lead, with serious health effects arising both from its heavy metal toxicity and its radioactivity. Should these risks be proven to be substantial, there may be a need to include new limits in the National Primary Drinking Water Regulations relating to the combined radioactive and heavy metal toxic effects of uranium.

There are also a variety of other issues associated with the potential interaction of hormonally active chemicals with radiation, and particular certain radionuclides, like iodine-129, which concentrates in the thyroid and crosses the placenta. The development of certain cancers, like breast cancer, is linked to hormonal systems, possibly to hormonally active chemical pollutants, and to radiation. Hence the issues associated with health protection in regard to certain cancers are likely to be much more complex.

Finally, there are issues that were once recognized but that appear to have been forgotten or ignored in the context of protection of public health from radiation. Consider the following passage from ICRP 2 that occurs in the context of a discussion of bone doses and the calculations that are the subject of this report:

> Certainly, if a major portion of the hematopoietic system were irradiated, e.g., concurrently from the spleen-seeking Po^{210} and from the bone-seeking Ra^{226}, the biological damage would be greater than if only a part of it were irradiated. *It has been shown that in some cases a synergistic effect results when several organs of the body are irradiated simultaneously.*[43]

Some of these synergistic effects are already implicit in the estimates of risk made from Hiroshima/Nagasaki survivors (since they received whole body radiation – i.e., all organs were

[42] Makhijani and Smith 2005, pages 9-10. Typos corrected.
[43] ICRP-2, 1959, page 14, emphasis added.

irradiated). However, others involving internal deposition and that selectively target certain organs may have more complex effects. This indicates that it is important to maintain regulations in the form of dose limits to maximally exposed organs in regulations relating to protection of public health, such as the National Primary Drinking Water Regulations (40 CFR 141), *Environmental Radiation Protection Standards for Nuclear Power Operations* (40 CFR 190), and *Environmental Radiation Protection Standards For Management And Disposal Of Spent Nuclear Fuel, High-Level And Transuranic Radioactive Wastes* (40 CFR 191). At the present time, there is still a significant amount of scientific work that remains to be done in a variety of areas before this framework can be changed into a better one from the point of view of health, environment, future generations, and the economy.

Consideration of changes in radiation protection in the medium- and long-term, that would take into account emerging scientific and risk issues such as those discussed in this section, is needed for a variety of reasons, some of which are mentioned above. However, this will be a complex and difficult task which must be done with due deliberation. It will also likely go far beyond safe drinking water standards. At the present time, the safety and protection of water resources from irreversible contamination with alpha-emitting, long-lived transuranic radionuclides as a result of ongoing activities by the Department of Energy cannot be allowed to be deferred to the longer, more comprehensive social, economic, and health discussion related to the protection of health from radioactive and toxic pollution. It must be considered as part of the EPA's 2006 review of standards for radionuclides in drinking water. A maximum contaminant level for plutonium that is 100 times too lax based on the intent and letter of the Safe Drinking Water Act must not be allowed to persist.

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