



## Module 24 Ambient Water Quality Criteria for Bacteria

- What are EPA's recommended bacteria criteria?
- What is important to know about when adopting & implementing the criteria?
- Is EPA developing new/revised criteria?

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## Why Do We Need Bacteria Criteria?

- ❖ Bacteria criteria help protect against disease from recreational exposure to water
- ❖ ~32% of coastal and Great Lakes beaches were closed or had an advisory posted for at least one day in 2006
- ❖ CDC continues to document cases of waterborne disease outbreaks in their 2006 "Surveillance" Report

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- Beach info from eBeaches and data submitted by participants in the BEACH Act grant program.
- Prior to 2004, EPA's Beaches Team surveyed beach managers every year for:
  - Accurate inventory of public beaches
  - Survey methods used by agencies to issue advisories
  - Document information on each advisory or closing
- 2,823 beaches surveyed in 2002
  - 2,445 in 2001
  - 1,021 in 1997
- 709 beaches closed or issued advisories due to bacteria
  - 580 in 2001
- When beaches close, bad things happen:
  - Lost tourism revenue
  - Lost public goodwill – people less likely to come back
  - Bad press
- Centers for Disease Control and Prevention report: "Surveillance for Waterborne Disease Outbreaks 2001-2002"
- 46% (30 outbreaks) of recreational outbreaks were associated with gastroenteritis.
  - 60% (18 outbreaks) of those were in swimming or wading pools.
- 12 outbreaks associated with gastroenteritis and in fresh water
  - No marine outbreaks
- July 2002 outbreak in Wisconsin (norovirus, *Cryptosporidium*, *Shigella*) was the first documented outbreak in the Great Lakes since reporting began in 1978 (44 people affected).



## Overall Objectives

- ❖ To provide an understanding of EPA's current §304(a) water quality criteria (WQC) for bacteria
- ❖ To provide important information regarding the adoption and implementation of the WQC for bacteria
- ❖ To provide an update on EPA's development of new/revised recreational WQC

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3

## Indicators

- ❖ EPA's recommended bacteria water quality criteria (WQC) are for indicator organisms
  - ◆ Indicators are not generally pathogenic themselves
  
- ❖ Pathogens are disease-causing microorganisms that include viruses, protozoa, and bacteria
  
- ❖ Monitoring for the many illness-causing pathogens is difficult and costly

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- Pathogens: disease causing microorganisms
  - Viruses, protozoa, bacteria
- Substantial cost and difficulty in measuring for individual pathogens
- So EPA's bacteria criteria are for indicators
  - Similar characteristics to pathogens (Life span, similar responses to environmental conditions, come from same species, etc.)
  - Not necessarily pathogenic
- Different concept than other criteria



## Criteria History

- ❖ **American Public Health Association's Committee on Bathing Places recommended total coliforms criteria for pools in 1924**
  - ◆ **No recommendations for beaches due to concern over public hysteria**
  
- ❖ **From 1948 to 1950, the US Public Health Service conducted health studies at beaches on Lake Michigan, the Ohio River, and Long Island Sound.**

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- American Public Health Association Committee on Bathing Places recommended total coliforms criteria for swimming pools in 1924
  - No recommendations for beaches due to concern over “public hysteria”

Report of the Joint Committee on Bathing Places of the A. P. H. A. and the Conference of State Sanitary Engineers, presented to the Public Health Engineering Section of the American Public Health Association at the Fifty-fifth Annual Meeting, at Buffalo, N. Y., October 12, 1926.

Can be found at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1321491>



## Criteria History

### ❖ Federal bacteria criteria recommendations first made in 1968

#### ◆ Fecal coliforms

#### ◆ Based on studies conducted 1948-1950

- Studies measured total coliforms

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- Fecal first proposed by the National Technical Advisory Committee to the Federal Water Pollution Control Administration

(full report at

[http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?\\_nfpb=true&\\_ERICEExtSearch\\_SearchValue\\_0=ED046708&ERICExtSearch\\_SearchType\\_0=no&accno=ED046708](http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_ERICEExtSearch_SearchValue_0=ED046708&ERICExtSearch_SearchType_0=no&accno=ED046708))

- Included recommendations for primary contact (200/400) and secondary contact (1000)
- Health studies conducted by US Public Health Service
- This is where the fecal coliform value of 200 cfu/100 ml comes from. They converted total coliforms values from the health studies to fecal coliforms using the ratio below.
- Ratio of fecal to total was determined by using ratio at Ohio River study in 1949 – 18%
  - Detectable health effect at 2300-2400/100ml
  - Halve it for safety's sake – 1150-1200/100ml
  - Multiply by 18% - 207-216/100ml
  - Go with 200/100ml
- Criteria almost immediately challenged by National Academy of Science (NAS), citing paucity of data



## Epidemiological Studies

❖ In 1972 EPA initiated a series of multiyear, comprehensive epidemiological studies at marine and fresh water bathing beaches

- 1 Are bathers at risk from contaminated waters?
- 2 What indicator has the greatest correlation to swimming-related health effects?

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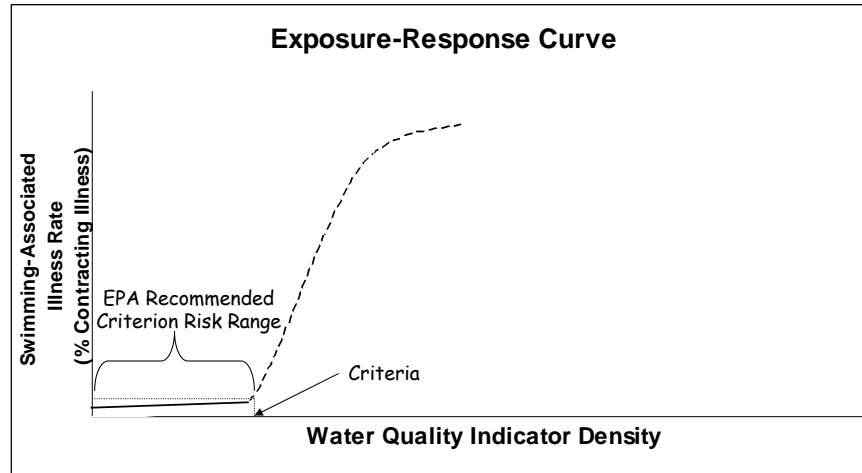
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7

- The studies had several goals:
  - To determine whether swimming in sewage contaminated water carries health risk for bathers
  - To develop quantitative relationship between water quality and health risk was obtained, two additional goals were to determined:
    - To identify bacterial indicator with greatest correlation to swimming-associated health effects
    - To develop criterion if correlation was found to be sufficiently strong

[Studies are described in the 1986 Bacteria Criteria document - <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>]

## Exposure-Response



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Theoretical curve demonstrating that there is some level of indicator density where the risk is “acceptable” with which there are still a low % of illness associated (before some threshold value where the acceptable risk is too high).

## Study Results

❖ Of the indicators measured during the studies, *E. coli* and enterococci showed strongest correlation to swimming-associated gastroenteritis

- ◆ *E. coli* and enterococci in fresh waters
- ◆ Enterococci in marine waters

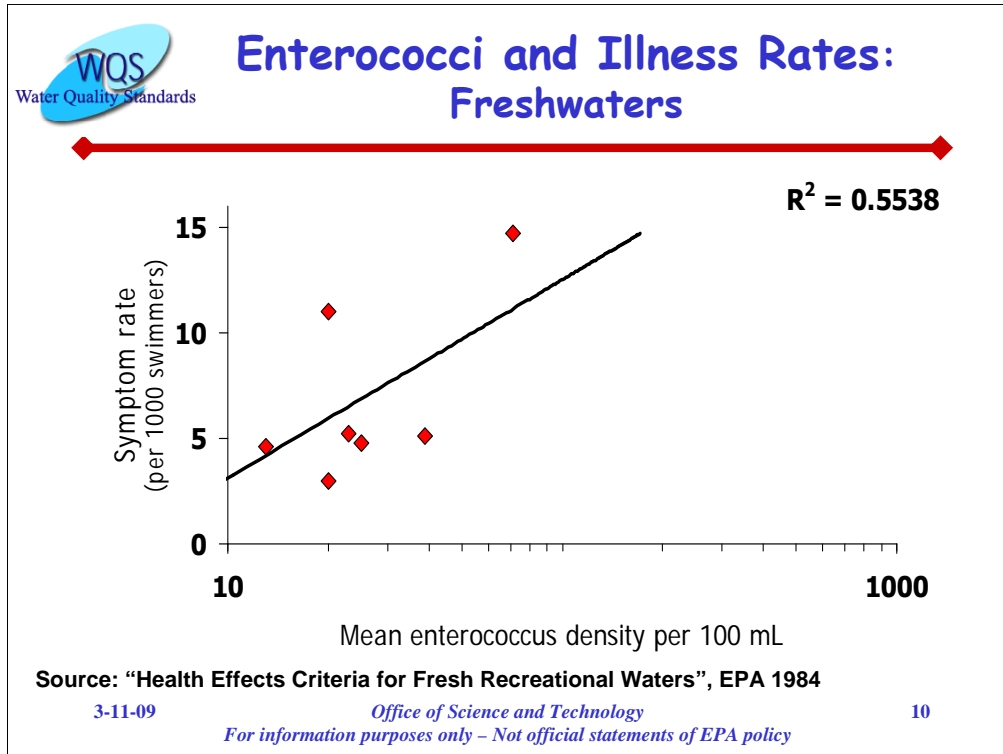
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• Multiple indicators of water quality were used to monitor the water. This is done because it was not known which indicator of water quality might show a quantitative relationship with swimming-associated health effects. This unique approach resulted in the selection of the best indicator based on the strength of the statistical relationship between the water quality indicator and a swimming-associated health effect.

- Enterococci
- *E. coli*
- Klebsiella
- Enterobacter-Citrobacter
- Total coliforms
- *Clostridium perfringens*
- Fecal coliforms
- *Aeromonas hydrophila*
- *Vibrio parahaemolyticus*
- Staphylococci



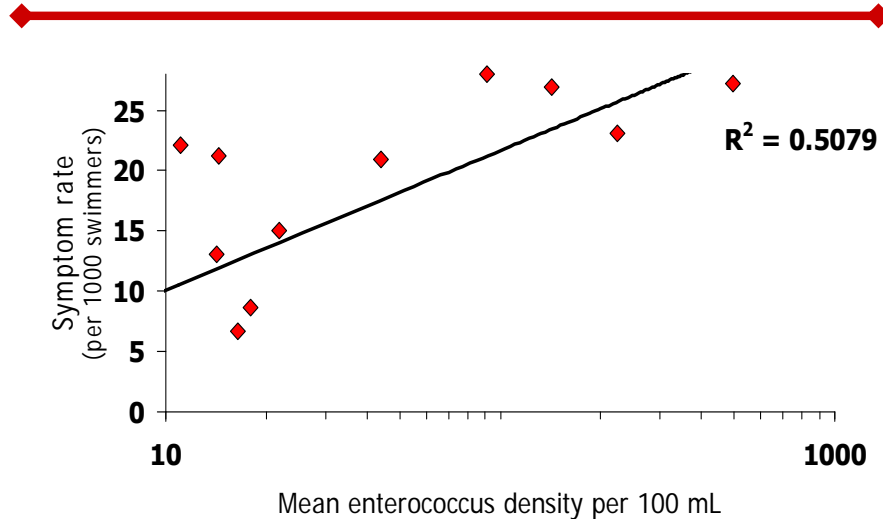
[Don't need to go over these in detail – just a graphic presentation] Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$$R^2=0.5538$$

Data are grouped by beach and summer.

$R^2$  of  $\geq .5$  is a positive correlation.

## Enterococci and Illness Rates: Marine Waters



Source: "Health Effects Criteria for Marine Recreational Waters", EPA 1983

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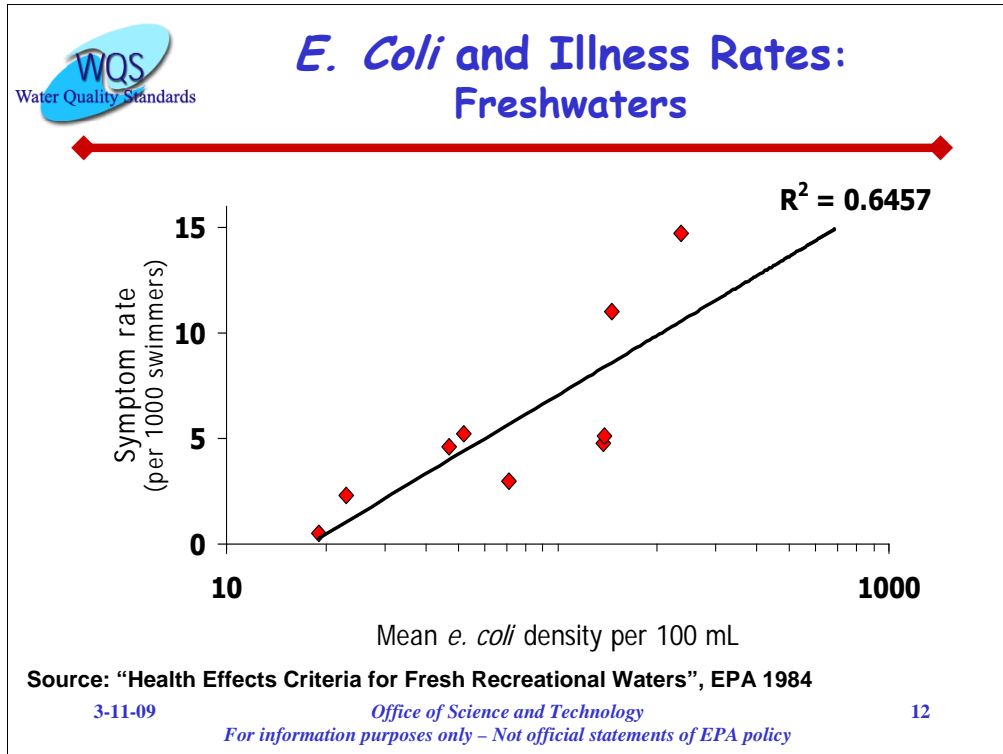
11

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Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$$R^2=0.5079$$

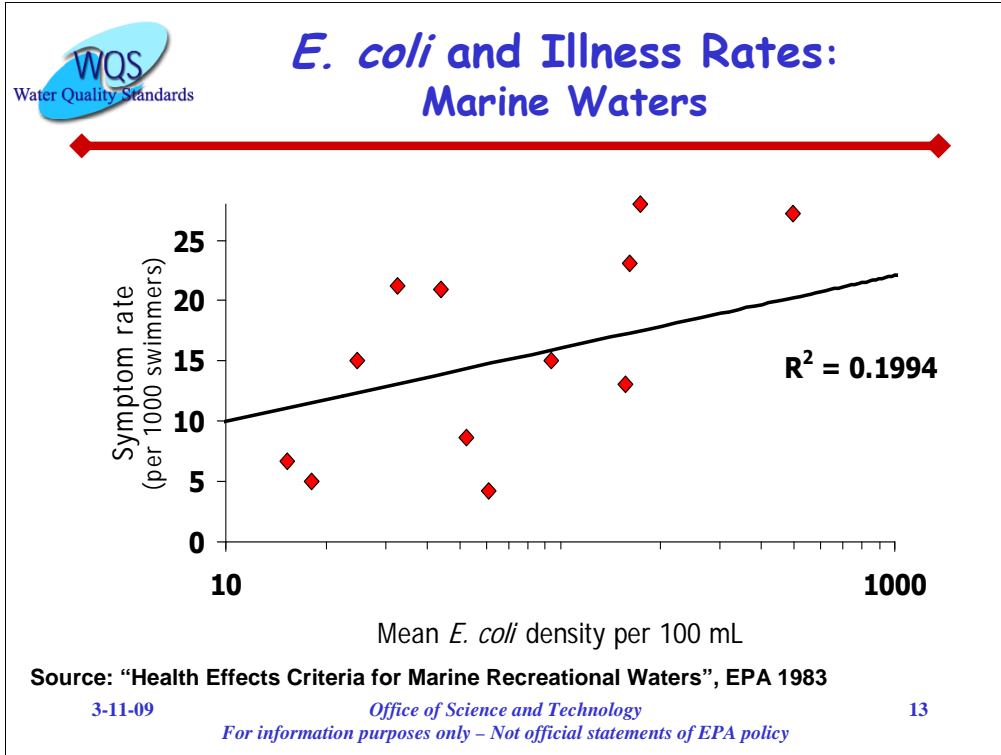
Data are grouped by beach and summer.



Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$$R^2=0.6457$$

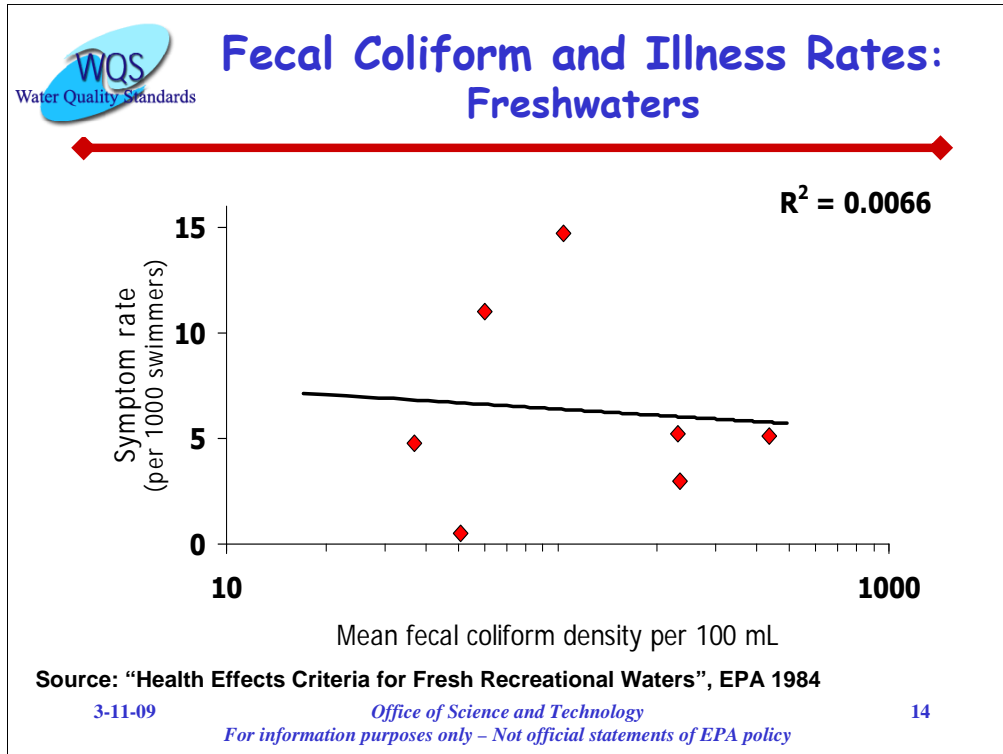
Data are grouped by beach and summer.



Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$R^2=0.1994$

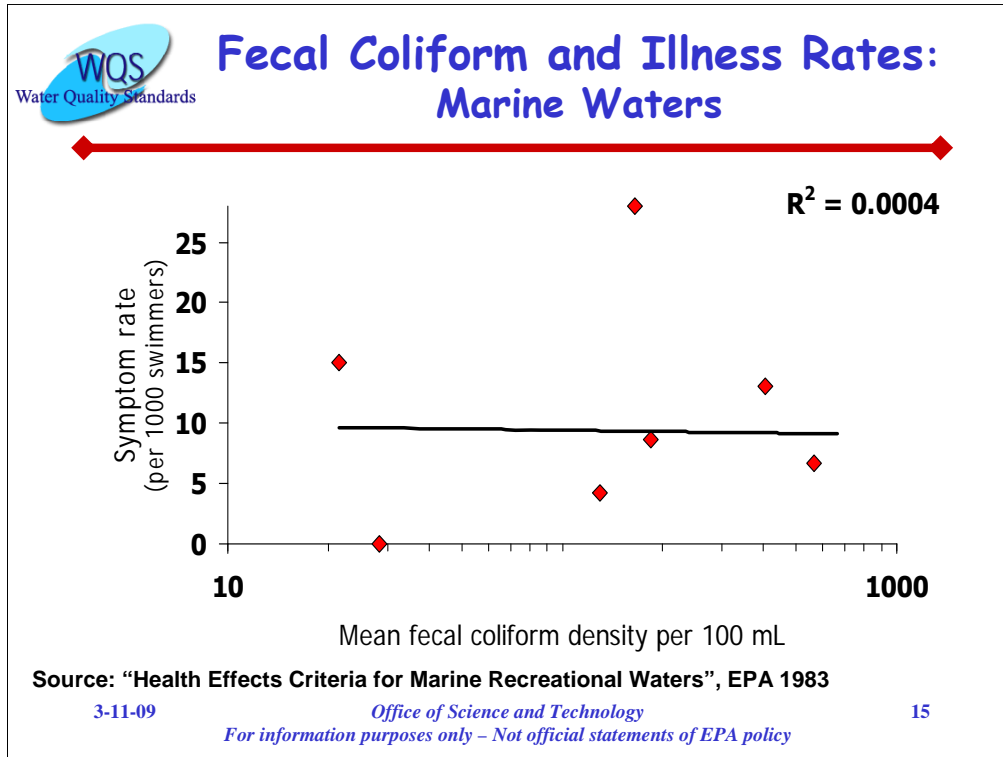
Data are grouped by beach and summer.



Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$R^2=0.0066$  (almost negative – FC not a good indicator)

Data are grouped by beach and summer.



Take home message of this set of slides: good correlations for Enterococci in fresh and marine waters and for E.coli in fresh water but NOT in marine waters. And very poor correlations for fecal coliform concentrations and illness in fresh or marine waters.

$R^2=0.0004$  (almost negative – FC not a good indicator)

Data are grouped by beach and summer.



## The Use of EPA's Recommended Criteria

❖ The criteria are used in two different, yet related ways:

- ◆ Protection of water bodies designated for recreational uses in state and tribal WQS
  - Used to derive permit limits, make listing decisions, and develop TMDLs
  
- ◆ Beach monitoring and notification programs
  - Protect public health
  - Aid in determining when to issue advisories or close beaches

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Water Quality Standards (WQS) are focused on source control and long-term assessment (303d, TMDLs, NPDES)

However, the BEACH Act requires grant recipients to base their beach decisions on water quality standards and are used to make short-term (daily) closure or advisory decisions at the beach.



## Bacteria Criteria in Water Quality Standards

❖ States adopt bacteria criteria to protect waters designated for recreation

◆ Primary contact recreation

➤ Seasonal and intermittent uses

◆ Secondary contact recreation

❖ States designate the majority of waters for primary contact

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States define in their own standards and varies by state, but generally:

• Primary Contact Recreation is understood to mean:

Water related recreational activities where there is a high degree of bodily contact with the water (e.g. where there is a high likelihood of incidental ingestion of water). Examples include, but are not limited to, swimming, rafting, certain kinds of kayaking, tubing, skin diving, surfing, water skiing, and water play by children.

• Secondary Contact Recreation is understood to mean: wading, fishing, boating (low likelihood of incidental ingestion).

• EPA does NOT have a 304(a) criteria recommendation for protection of secondary contact uses, but has historically approved numeric criteria to protect secondary contact that are 5 times the primary contact values (and even up to 9 times in a few cases).

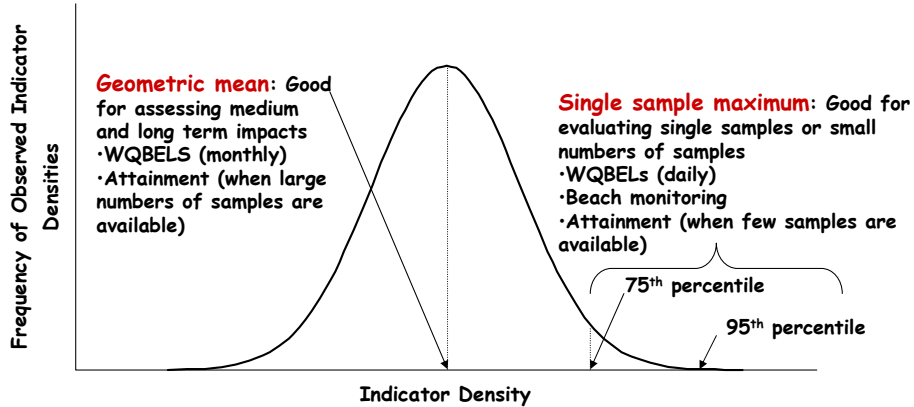
• Seasonal uses allow states to only apply the primary contact designated use and associated criteria during the recreational season typical of their state (e.g., May – Oct)

• States adopt separate bacteria criteria for shellfish and drinking water

## Components of EPA's Criteria

❖ *E. coli* and enterococci criteria have two components:

- ◆ Geometric mean
- ◆ Single Sample Maximum or Upper Percentile Value



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### Geometric mean

Central value along a set of measurements

### Single sample maximum

Value based on a percentile of the distribution around the chosen mean, which only a certain number of samples should exceed

From the 1986 Criteria document: “ To set the single sample maximum, it is necessary to specify the desired chance that the beach will be left open when the protection is adequate... A smaller confidence level [or a smaller chance] corresponds to a more stringent (i.e. lower) single sample maximum... This technique reduces the chances of single samples inappropriately indicating violations of the recommended criteria.

...A low confidence level (75%) was assigned to designated beach areas because a high degree of caution should be used to evaluate water quality for heavily used areas.”



# Primary Contact Recreation

## ❖ Current Fresh Water Criteria Recommendations

### ◆ Enterococci

Risk Level (% of swimmers)	Geometric Mean Density (per 100 mL)	Single Sample Maximum Allowable Density (per 100 mL)			
		75 <sup>th</sup> percentile	82 <sup>nd</sup> percentile	90 <sup>th</sup> percentile	95 <sup>th</sup> percentile
0.8	33	62	79	107	151
0.9	42	79	100	137	193
1.0	54	101	128	175	247

### ◆ E. Coli

Risk Level (% of swimmers)	Geometric Mean Density (per 100 mL)	Single Sample Maximum Allowable Density (per 100 mL)			
		75 <sup>th</sup> percentile	82 <sup>nd</sup> percentile	90 <sup>th</sup> percentile	95 <sup>th</sup> percentile
0.8	126	236	299	409	576
0.9	161	301	382	523	736
1.0	206	385	489	668	940

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Previous criteria-

Based on health studies that looked only at a risk threshold

Current criteria- Based on epidemiological studies that quantified risk.

Yellow highlight is the official recommendation (at 0.8% risk level) but we allow flexibility to adopt risk levels up to 1.0 % in freshwater

75% - Designated Bathing Beach

82% - Moderate Use Beach

90% - Light Use

95% - Infrequent Use



# Primary Contact Recreation

## ❖ Current Marine Water Criteria - Enterococci

Risk Level (% of swimmers)	Geometric Mean Density (per 100 mL)	Single Sample Maximum Allowable Density (per 100 mL)			
		75 <sup>th</sup> percentile	82 <sup>nd</sup> percentile	90 <sup>th</sup> percentile	95 <sup>th</sup> percentile
0.8	4	13	20	35	63
0.9	5	16	24	42	76
1.0	6	19	29	50	91
1.1	8	23	35	61	110
1.2	9	28	42	73	133
1.3	11	34	51	89	161
1.4	14	41	62	107	195
1.5	17	49	75	130	235
1.6	20	60	91	157	284
1.7	25	72	109	189	344
1.8	30	87	132	229	415
1.9	35	104	158	276	501

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Based on epidemiological studies that quantified risk.

Yellow highlight is the official recommendation (at 1.9% risk level) in marine waters.

[Note: Risk levels are different for freshwaters and marine waters because they tie back to the old fecal coliform values of 200 cfu/100 ml]

75% - Designated Bathing Beach

82% - Moderate Use Beach

90% - Light Use

95% - Infrequent Use

## What is the BEACH Act?

- ❖ **2000 Amendment to the Clean Water Act, for coastal and Great Lakes recreation waters**
  - ◆ Added sections 303(i) and 406
- ❖ **Key EPA requirements**
  - ◆ Ensure state adoption of coastal recreation water quality criteria for pathogens and pathogen indicators
  - ◆ Conduct research on pathogen indicators in coastal recreation waters and develop rapid methods
  - ◆ Publish performance criteria for monitoring and notification
  - ◆ Provide development and implementation grants to state, tribal and local authorities

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- Inland waters are those waterbodies that are not coastal recreation waters as defined by the Clean Water Act. Inland waters are typically freshwater but could include saltwater waterbodies (that are not also coastal recreation waters) as well.
- Coastal recreation waters are defined in Clean Water Act (CWA) section 502(21) and in EPA's implementing regulations at 40 CFR 131.41(b) as those Great Lakes and marine waters (including coastal estuaries) that are designated under section 303(c) of the Clean Water Act for use for swimming, bathing, surfing, or similar water contact activities. Inland waters or waters upstream from the mouth of a river or stream having an unimpaired natural connection with the open sea are not considered coastal recreation waters.
- In this context, the term "unimpaired" refers to a waterbody's unimpeded access to marine or Great Lakes waters, not to the water quality of any particular waterbody.



## The BEACH ACT Regulation

- ❖ Promulgated on November 16, 2004
- ❖ Best source of information on EPA's interpretation of the criteria for both coastal recreation waters and inland waters
- ❖ Preamble and technical fact sheets include some implementation language

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- Promulgated on November 16, 2004
- Adopted 1986 bacteria criteria for 21 states and territories
- Coastal recreation waters are defined in the rule (and in the BEACH Act)
- Each use intensity (SSM) category is defined
- Includes a compliance schedule provision for those states and territories covered by the rule

Preamble to the BEACH Act rule reflects EPA's current thinking on risk levels, use of the SSM, and non-human sources for BOTH coastal recreation waters and inland waters.

Information on the rule, including technical fact sheets, is available at criteria website (see later slide)



## Key Implementation Points: Risk Levels

### ❖ Risk Levels

#### ◆ EPA data support:

- up to 19 illnesses/1000 swimmers in marine water
- up to 10 illnesses/1000 swimmers in freshwater

#### ◆ Higher illnesses rates for protection of primary contact uses must be supported by data

#### ◆ No UAA required to move between risk levels

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- Risk level for primary contact recreation is at discretion of states/tribes (within the limits identified)
- Higher risk level would need epi data (or possibly quantitative microbial risk assessment) support



## Key Implementation Points: Geo Mean and SSM

- ❖ Geometric mean is value most closely linked to the illness rates
- ❖ Single Sample Maximum was not intended to be used as a “not to be exceeded” value

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See slides 26 and 27 for uses of Geo Mean and SSMs



## Geo Mean and SSM in BEACH Act Waters

- ❖ Must have both *Geo Mean* and *SSM* for all waters designated for primary contact rec
- ❖ Must use *SSM* for beach closure and advisory programs
- ❖ States have flexibility to:
  - Adopt some or all of the *SSMs*
  - Describe the applicability of the *SSM* for the various CWA purposes in their standards
- ❖ Do not have situations where neither *Geo Mean* or *SSM* apply
  - Federal promulgation does not include minimum sample size requirements for calculating the *Geo Mean*.

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Beach Act Rule requirements



## Geo Mean and SSM in Inland Waters

- ❖ Encourage states to include both a *Geo Mean* and *SSM* for all waters designated for primary contact rec
- ❖ Encourage states to use *SSMs* for making decisions in their public recreation area closure/advisory programs
- ❖ States have flexibility to:
  - Adopt any, some or all of the *SSMs*
  - Describe applicability of the *SSM* for the various *CWA* purposes in their standards
- ❖ Do not have situations where neither *Geo Mean* or *SSM* apply
  - Encourage states that have min. sample size requirements for calculating *Geo Mean*, but may not sample that often to consider *SSMs*

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Inland waters are not part of the BEACH Act Rule, but we have stated publicly that what is said in the BEACH Act Rule preamble is our best and most current thinking on implementation for both coastal and inland waters. Therefore, we cannot require this for inland waters, but we can “encourage” it.

## Uses of the SSM

- ❖ Beach advisory and closure programs;
- ❖ Waterbody assessment
  - ◆ Small datasets
  - ◆ When states collect “insufficient” (as defined by their regs) data to reliably average and compare to the geometric mean
  - ◆ Sources of short-term spikes (CSOs)
  - ◆ NPDES permits - deriving daily limits

EPA encourages states to clarify in their water quality standards how they will use the SSM component.

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BEACH Act rule preamble discusses these items for coastal recreation waters. Inland waters are not part of the BEACH Act Rule, but we have stated publicly that what is said in the BEACH Act Rule preamble is our best and most current thinking on implementation for both coastal and inland waters. Therefore, we cannot require this for inland waters, but we can “encourage” it.



## Key Implementation Points: Non-Human Sources

- ❖ **Non-Human source exclusions to the criteria can be allowed when:**
    - ◆ **The sources are only from non-human sources (supported by sanitary surveys/watershed characterization studies)**
  - AND**
  - ◆ **Those non-human sources are shown to pose no risk to human health (i.e., through an epi study)**
- States may use existing epi data in lieu of conducting their own studies**

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- A state needs to show (through sanitary surveys and epidemiological studies) that there are no human sources and that the non-human sources do not pose a human health risk
- Since the Experts Workshop Report (June 2007) was issued EPA is taking a more firm position on this exclusion. The experts could not conclusively say that non-human sources were less risky to humans and suggested that as a high priority research area for EPA.



## EPA's Current Focus

- ❖ Developing the science foundation for new/revised recreational water quality criteria
- ❖ To ensure that new/revised rec WQC are sufficiently protective of the public health

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BEACH Act required EPA to publish new/revised criteria for coastal recreation waters by Oct. 2005.

We are developing science foundation to do that- but we would like to develop the science foundation for new/revised rec water criteria in all waters designated for primary contact.



## Experts Workshop -March 2007

- ❖ Forty-three U.S. and international experts
- ❖ Identified Critical Path Research Needs
- ❖ 7 Workgroup Topics
  - ◆ Approaches to Criteria development
  - ◆ Pathogens, pathogen indicators, and indicators of fecal contamination
  - ◆ Methods Development
  - ◆ Comparing Risk (to Humans) from Different Sources
  - ◆ Acceptable Risk
  - ◆ Modeling applications for Criteria Development and Implementation
  - ◆ Implementation Realities

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See <http://www.epa.gov/ost/criteria/recreation/> for a copy of the Report on the Experts Workshop



## EPA's Critical Path Science Plan for New/Revised Criteria

- ❖ Describes research and science for establishing the scientific foundation for new/revised criteria
- ❖ Is an integrated approach to answering key science questions for scientifically sound criteria
- ❖ Completed in August 2007

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31

See <http://www.epa.gov/ost/criteria/recreation/> for copy of the Critical Path Science Plan and Criteria Development Plan & Schedule.



## Goals of the Science Plan Research

- ❖ Assess Human Health Risk
- ❖ Develop Indicators
- ❖ Develop Methods
- ❖ Extrapolate Research Results

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1. **Assessment of Human Health Risk.** Conduct research (e.g., epidemiologic studies and quantitative microbial risk assessment [QMRA]) to allow for an assessment of potential human health risks (including non-gastrointestinal effects) in the general population, including children, from swimming-related exposure to different sources of fecal contamination (human versus non-human).
2. **Development of Indicators.[1]** Conduct research to identify appropriate indicators of fecal contamination to allow for a reliable correlation between indicator concentrations and health effects. Develop studies to evaluate temporal and spatial variability in indicator concentrations to appropriately characterize water quality and inform recreational water quality management decisions.
3. **Development of Methods.[2]** Conduct research to develop, evaluate and validate appropriate methods to measure indicators of fecal contamination to allow for a reliable correlation between indicator concentrations and health effects. Assess linkages between indicators and methods to ensure that they will be protective of the swimming use when implemented singly or in combination.
4. **Extrapolation of Research Results for Developing New or Revised Criteria.** Conduct appropriate studies to assess the influence of variability in geographic and aquatic conditions on indicator and method performance, and assess the suitability of indicators and methods for various CWA purposes (e.g., beach monitoring, assessments, TMDLs, and permitting). Develop, evaluate and validate predictive models and tools to understand the extent to which data from epidemiologic study sites can be extrapolated to other geographic locations and aquatic conditions; and examine the role of models as a tool in predicting water quality problems to assist in new or revised criteria implementation.
  - To inland waters and Nationally
  - For application in various CWA applications
  - To assist in implementing new/revised criteria

## Things to Expect

### ❖ 2007-2010

- ◆ **Additional Research into Indicators, Methods, and Epi Studies**
  - Indicators: Enterococci, *E.coli*, bacteroides, coliphage
  - Biomarkers: human, bovine
  - Methods: culture, qPCR, other
  - Epi studies: California, Alabama, Rhode Island, more...
- ◆ **Fate & Transport Studies**
- ◆ **Predictive Modeling**
- ◆ **Site Characterization Studies: sanitary surveys, use of Quantitative Microbial Risk Assessment**
- ◆ **Research to Support Extrapolation to Inland Waters**
- ◆ **Engaging Stakeholders on Implementation**

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Summer 2007 – EPA performed 2 marine epi studies – Goddard, RI and Fairhope, AL. EPA also supported an epi study at Avalon Beach (on Catalina Island) in California.



## Things to Expect (2)



### ❖ 2010-2012

- ◆ Develop New Recreational Water Quality Criteria
- ◆ Continue Engaging Stakeholders on Implementation

### ❖ 2012-

- ◆ New Criteria Published for Use by States and Tribes

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## For More Information

### ❖ EPA's Beach and Rec Criteria Web Pages

- ◆ [www.epa.gov/beaches](http://www.epa.gov/beaches)
  - > BEACH Act text
  - > Grants information
  - > Beach Guidance Document
  - > Local beach information
- ◆ [www.epa.gov/waterscience/criteria/humanhealth/microbial/#wqs](http://www.epa.gov/waterscience/criteria/humanhealth/microbial/#wqs)
  - > BEACH Act rule
    - Technical fact sheets
- ◆ [www.epa.gov/waterscience/criteria/recreation](http://www.epa.gov/waterscience/criteria/recreation)
  - > Experts Scientific Workshop Report and Executive Summary
  - > Critical Path Science Plan
  - > Criteria Development Plan & Schedule

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35

## Take Home Messages

- ❖ EPA's current §304(a) bacteria criteria are for *E. coli* and enterococci
- ❖ When using the '86 bacteria criteria, states and tribes have flexibility;
  - ◆ To make appropriate risk-based decisions
  - ◆ In using the single sample maximum component of the criteria
- ❖ EPA is developing new/revised criteria for publication in 2012

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36

## Study Question 1

❖ **Enterococcus causes illness in humans**

- ◆ True
- ◆ False

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37

## Study Question 1

❖ **Enterococcus causes illness in humans**

◆ True

◆ False

❖ **Enterococcus is an indicator of fecal contamination; it does not cause illness directly**

## Study Question 2

❖ **E. coli can be used as an indicator of fecal contamination in both fresh and marine waters**

- ◆ True
- ◆ False

## Study Question 2

❖ E. coli can be used as an indicator of fecal contamination in both fresh and marine waters

◆ True

◆ False

❖ E. coli is a valid indicator in fresh waters only

## Study Question 3

◆ According to the BEACH Act, “coastal recreation waters” include marine water, Great Lakes waters, and estuaries

- ◆ True
- ◆ False

## Study Question 3

❖ According to the BEACH Act, “coastal recreation waters” include marine water, Great Lakes waters, and estuaries

◆ True

◆ False

❖ The BEACH Act includes all coastal waters; it does not include waters upstream from the mouth of a river

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42