

Saginaw Bay Coastal Initiative

Speaker Series

September 5th, 2008

SAGINAW BAY AND *ESCHERICHIA COLI*

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MICHIGAN STATE

UNIVERSITY

SAGINAW BAY



SAGINAW BAY



SAGINAW BAY



Photo by David Payne

SAGINAW BAY



Pollution

- Historical pollution to Saginaw Bay
 - Automotive
 - Chemical
 - Agricultural
 - Paper mills
 - Industrial
 - Human wastewater

Environmental Pollution

Sources

– Non Point Sources:

- Humans: On-site septic, recreational activities, runoff, etc
- Livestock and wild animals: Grazing, improper manure applications, livestock and animal waste

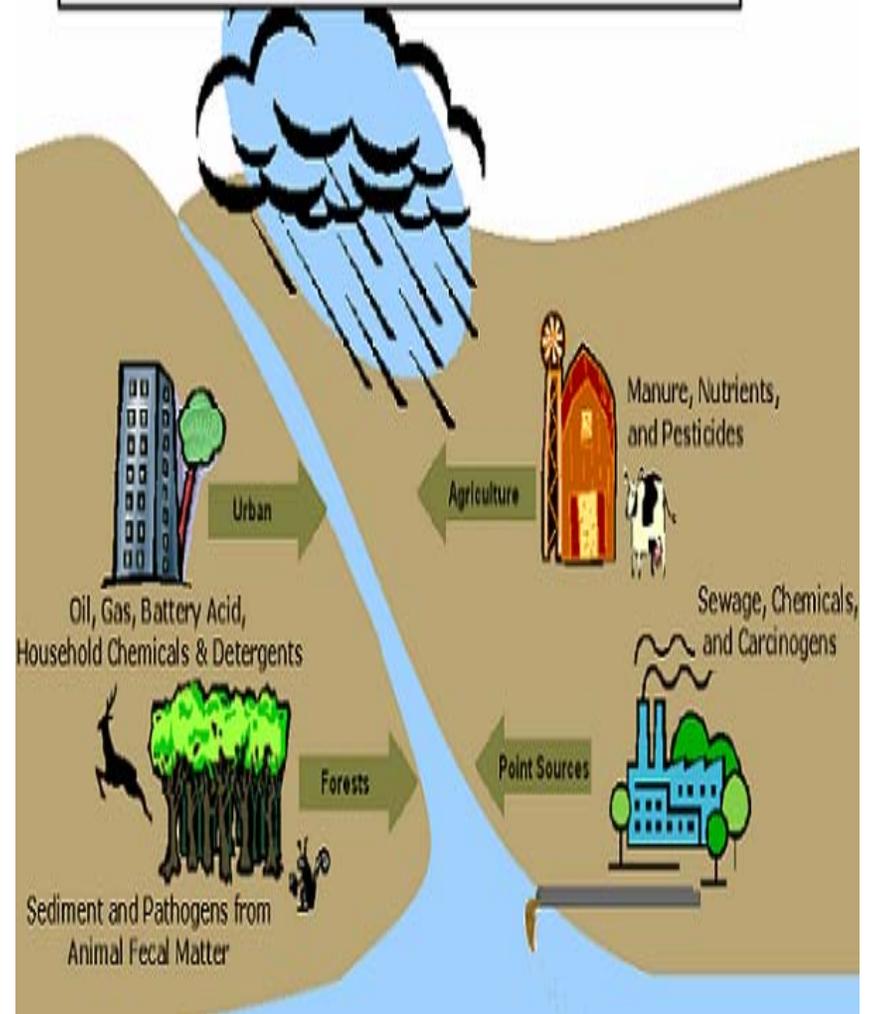
– Point sources:

- Waste water treatment plants, industrial outfalls

- **POINT SOURCE**



MAJOR NPS POLLUTION SOURCES



**MICHIGAN:
At the Center of the
Great Lakes**



Pollution Control

Refuse Act of 1899

Michigan's Stream Control Council- 1929

Water Pollution Control Act of 1948

Michigan approves Clean Water Bond-1968

Clean Water Act of 1972

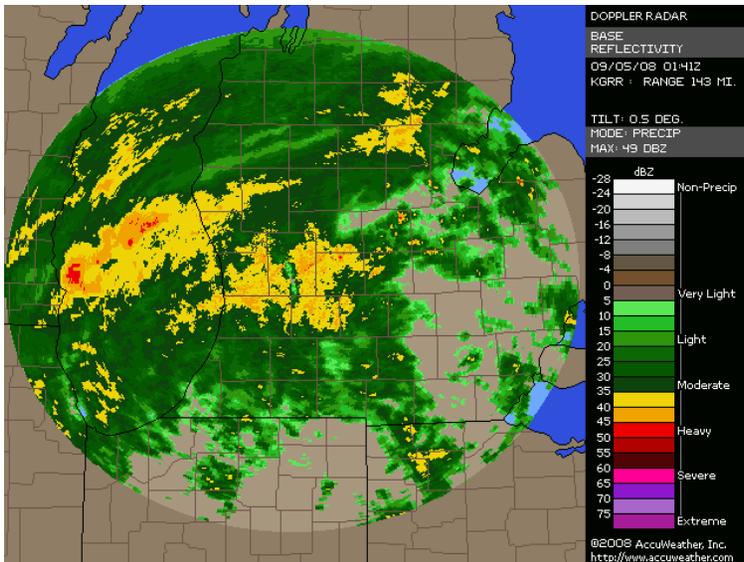
Multiple acts, bonds, and laws:1972-Present

Protecting Human Health

- Direct pathogen sampling
- Fecal pollution indicators should be:
 - Present in intestinal tract
 - Present when pathogens are present but in greater numbers
 - Have similar attenuation and survival rates
 - Not reproduce in the environment
 - Easy and quick to cultivate

Where are fecal indicators found?

- Almost all surface waters have some background of fecal indicators due to wildlife, with the levels increasing the closer you get to sewage/feces
- Rainfall can wash the fecal wastes and associated indicator bacteria into nearby water bodies



Sources of *E. coli* and Pathogens

Septic systems



Waste water/Sewage treatment



Animal farming operations



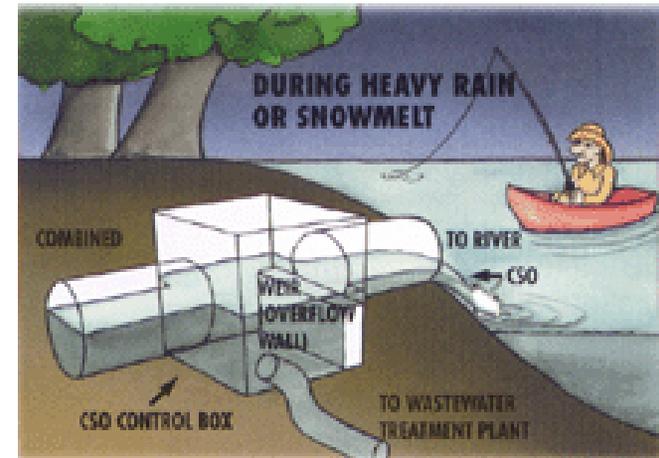
Agricultural run-off



Wildlife



Combined Sewer Overflow



Water quality standards

Criteria based on:

- Available science/literature
- Risk assessment
- EPA policy
- Public input
- Peer reviewed science

Standards/Criteria

- Recreational water quality standards
E. coli, enterococci, *Clostridium perfringens*

Water quality Standards/Criteria For Recreational Water

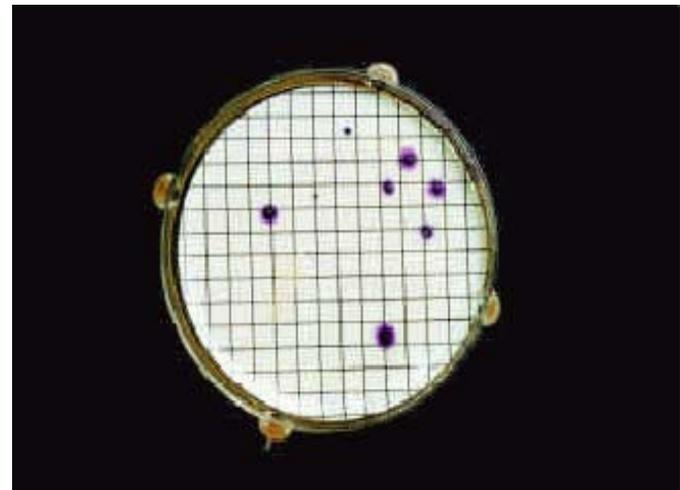
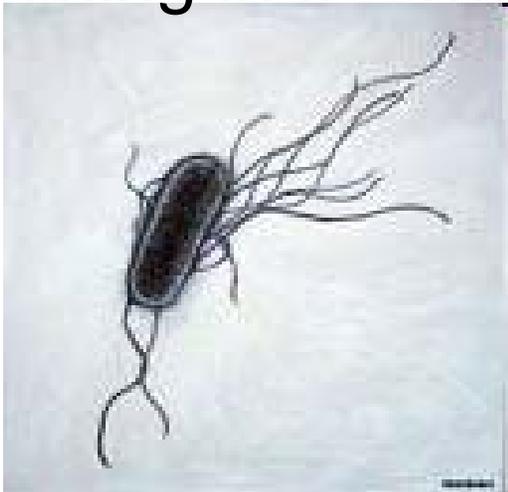
Indicator Geometric Means	Michigan	EPA
E. Coli CFU	<130/100ml	<126cfu/100ml
Enterococci CFU	None	<33cfu/100ml

*No standards established for *Clostridium perfringens*



E. coli

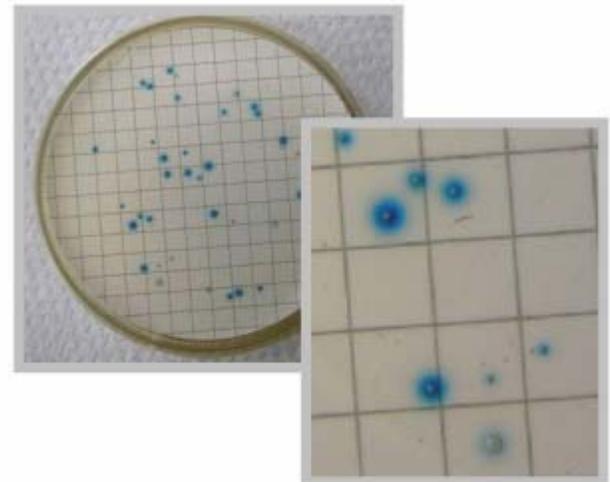
- Indicator of bacteriological quality in drinking and recreational waters
- Presence indicates the possible presence of pathogens
- High correlation with gastroenteritis associated with bathing in freshwater



Enterococci

Better indication of recent pollution because it dies slower than fecal coliforms in water and sediments

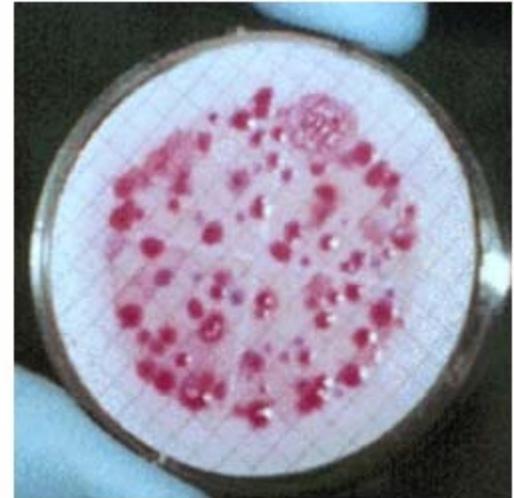
Higher correlation with gastroenteric disease related to swimming in fresh and marine waters than fecal coliforms



Clostridium perfringens

Indicator of persistent intestinal pathogens like viruses and oocysts of protozoa

Indicator of recent or long term inputs of fecal pollution and of chlorinated waters

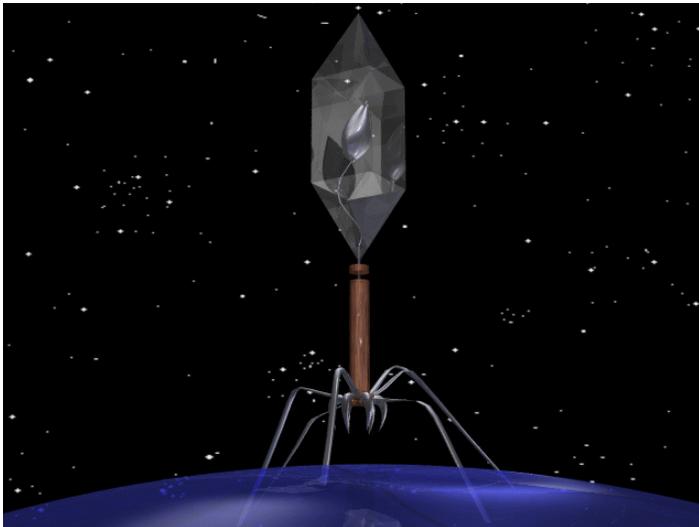


Coliphage

A virus that infects *E. coli*

A good indicator of enteroviruses due to:

- similar seasonal variation
- propensity for removal
- resistance to environmental stress



Microbial Source Tracking

- Indicator bacteria *E. coli* does indicate bacterial water quality but it has limitations
 - Does not provide source of pollution
 - often killed in sewage treatment process
 - correlated with GI illness but not to actual pathogens
- MST methods have developed using genetic approaches to identify source
- Different types of source tracking types
 - library dependent
 - host specific

Our Approach: host-specific markers

- Use multiple source tracking markers
- Host specific genetic marker (esp)
 - Differentiate Human/non human pollution
 - Traditional MF method and PCR used to detect the gene.
- Bacteroides: use PCR

What is PCR?

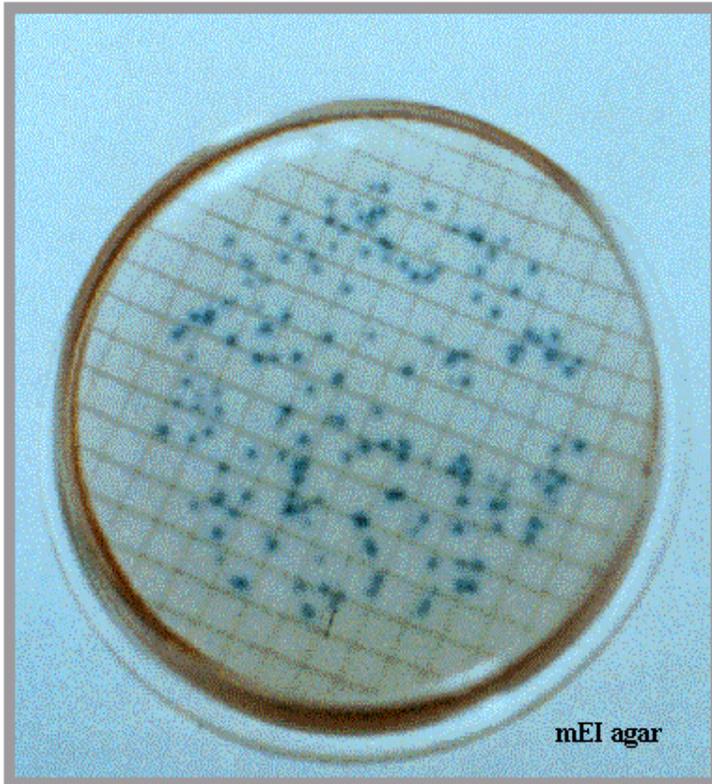
- Enzymatic reaction that makes many copies of DNA from single molecule
- 2^n copies of DNA from single molecule where $n = \text{No. of cycles}$



Enterococci esp

- EPA recommended
- Esp (Enterococcus surface protein) as human marker
- Only found in human feces
- Cause of urinary tract and gastrointestinal infection

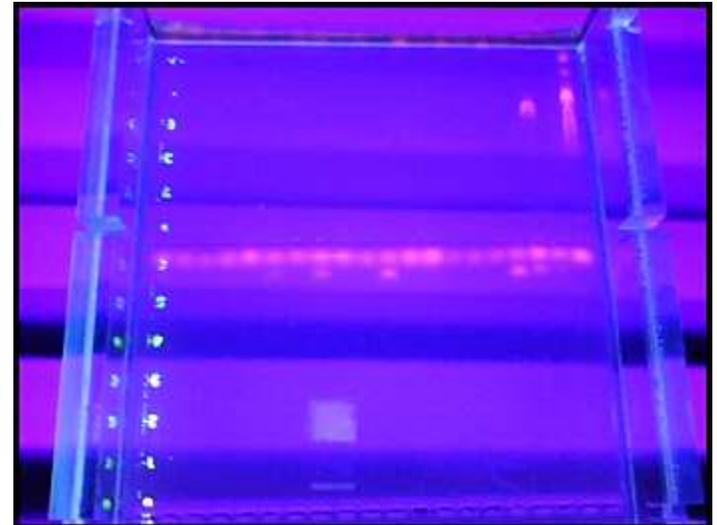
Enterococcus membrane filtration (MF)



**Colonies that
have a blue
halo are
counted as
enterococci.**

**This method has
been tested and
validated on
multiple species
and sources**

PCR product run through
agarose gel electrophoresis



BACTERIODES

- *Bacteroides* are specialists in the intestinal environment of animals.
 - These bacteria are anaerobes and can not grow in the presence of oxygen.
 - Specific genetic targets have been identified in cattle, humans and swine
 - Tested and validated on multiple species
-

Recent efforts

- Routine Beach monitoring
- Cladophora testing
- Sanitary survey tool
- WaterWatch website



SAGINAW BAY BEACHES-ROUTINE MONITORING

2008

IOSCO COUNTY

ARENAC COUNTY

HURON COUNTY

BAY COUNTY

Dyer Rd. Beach

Singing Bridge Beach

Twining Rd. Beach

Hammel Beach Rd. Access

Bessinger Rd. Beach

Foster Rd. Beach

Arenac County Park

Whites Beach

Pinconning Park

South Linwood Beach Township Park

Brissette Beach Township Park

Bay City State Recreation Area

Wenona Beach

McGraw County Park

Port Crescent State Park - Day Use

Bird Creek County Park

Jenks County Park

Lighthouse County Park

Port Crescent State Park - Camping Area

Oak Beach County Park

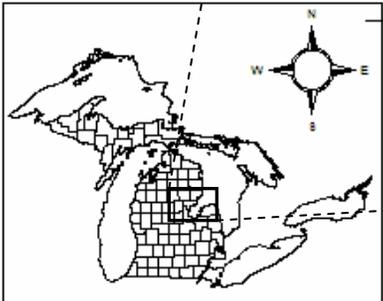
Thompson Park

Philp County Park

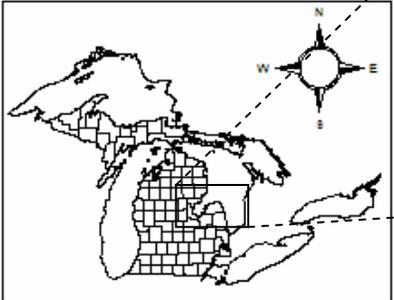
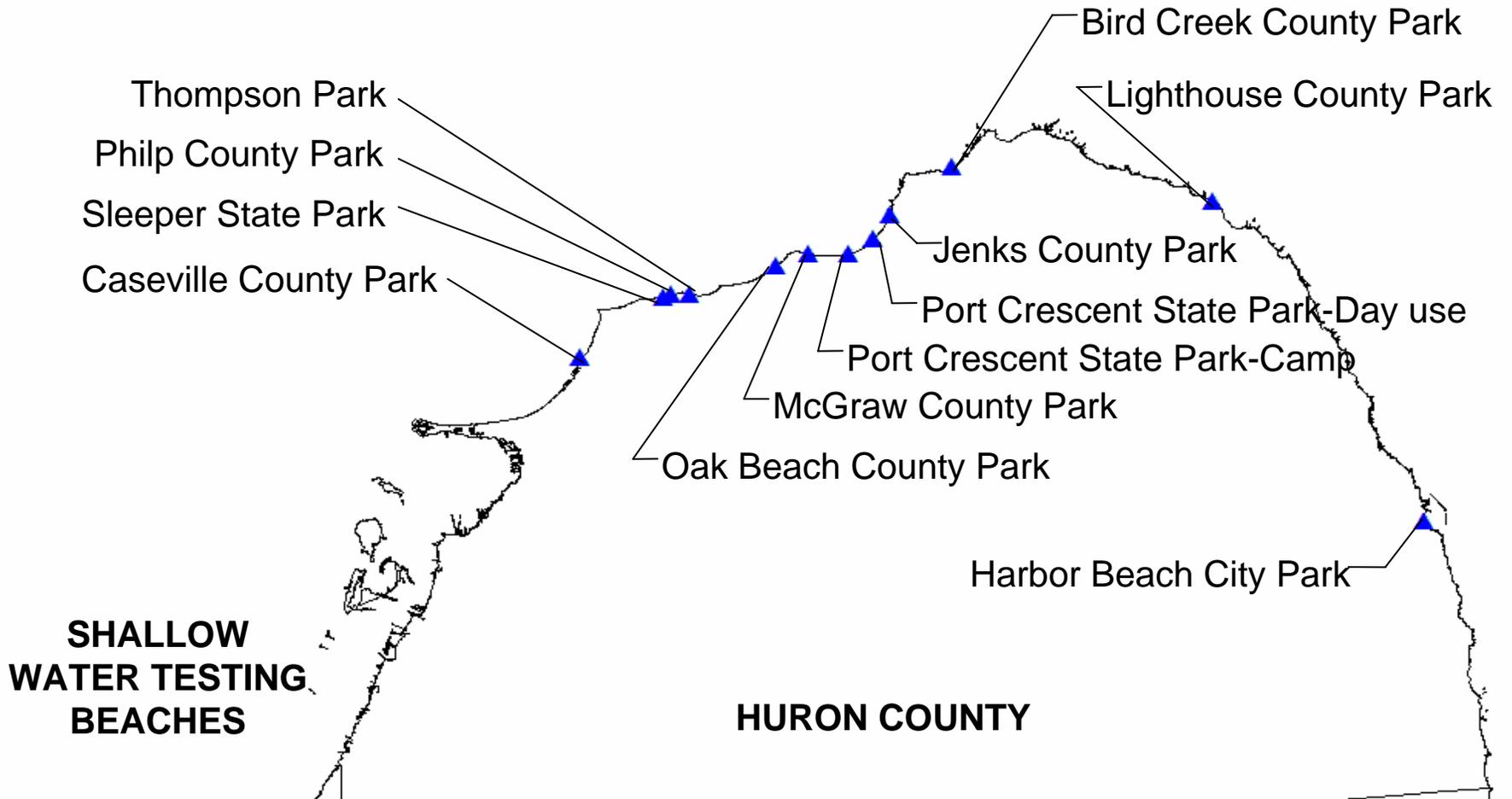
Sleeper State Park

Caseville County Park

Harbor Beach City Park



n=25



n=12

Beach with Cladophora Collections

ARENAC COUNTY

Foster Rd. Beach

Arenac County Park

Whites Beach

Pinconning Park

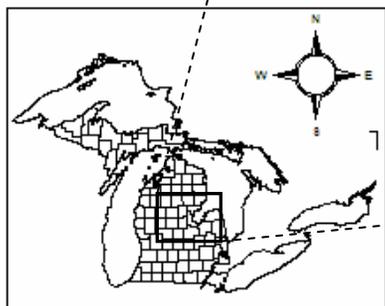
South Linwood Beach Township Park

Brissette Beach Township Park

Bay City State Recreation Area

Wenona Beach

BAY COUNTY



n=8

SAGINAW BAY
BEACHES TESTED FOR
SOURCE TRACKING

ARENAC COUNTY

Port Crescent State Park-Day Use

Caseville County Park

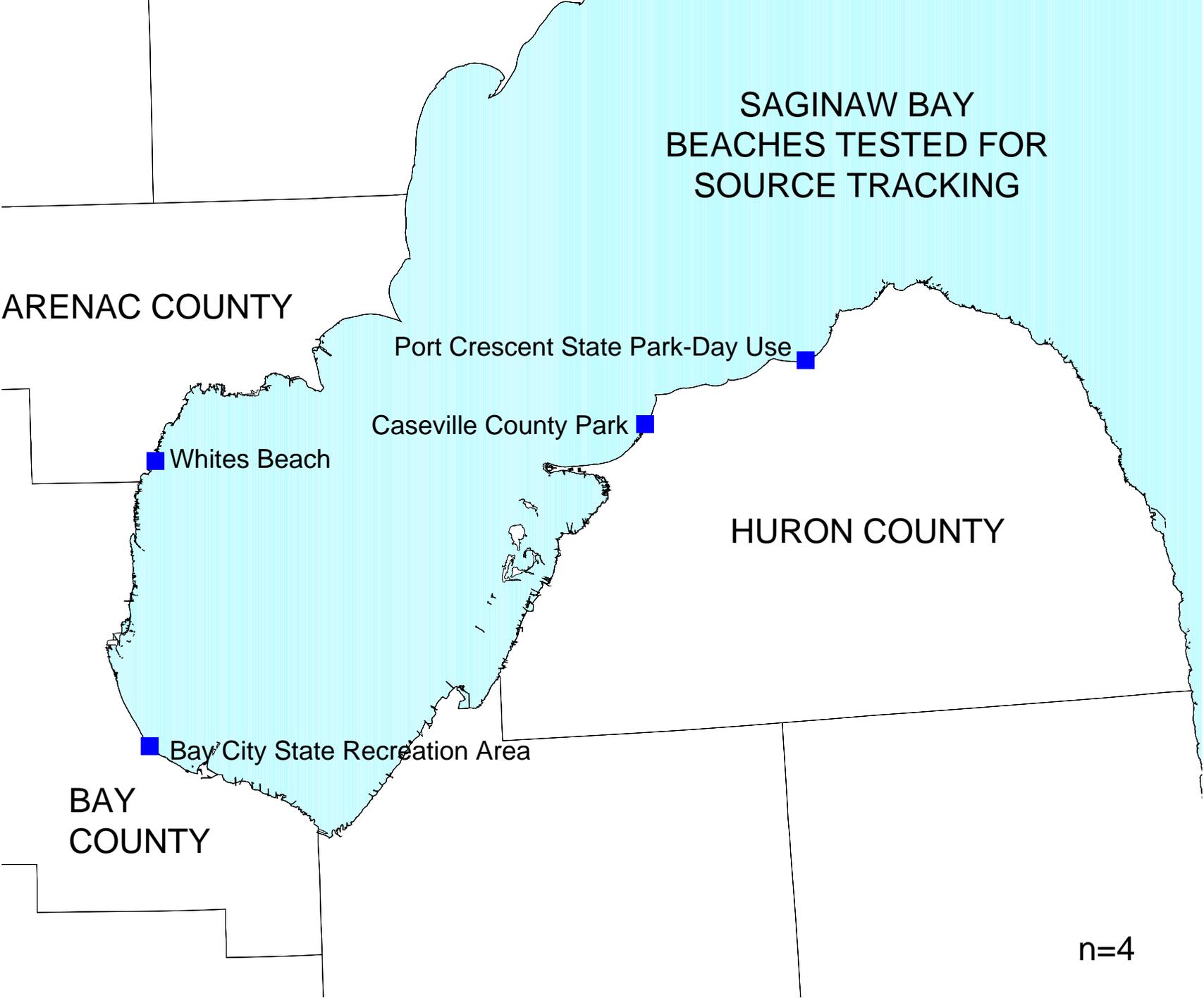
Whites Beach

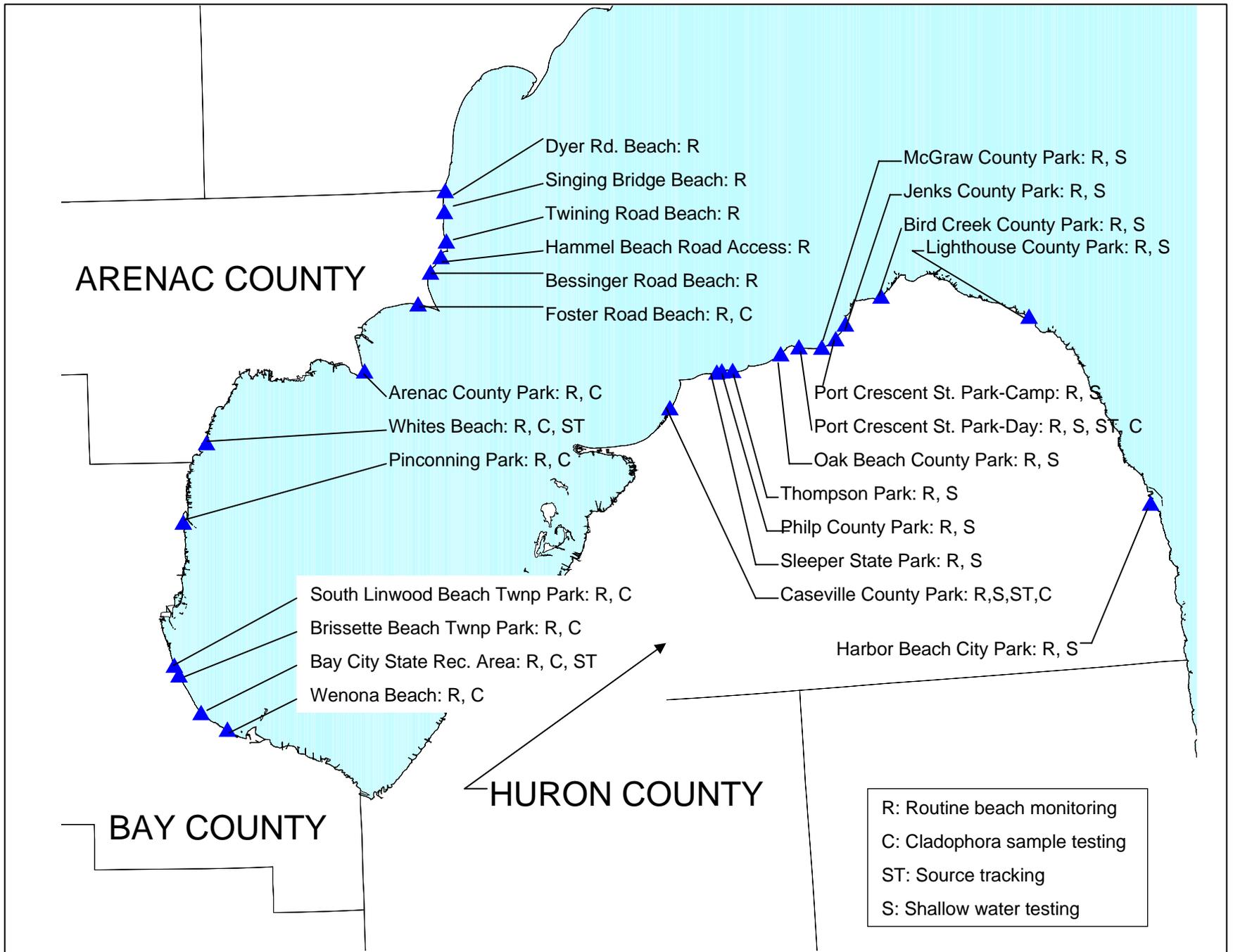
HURON COUNTY

Bay City State Recreation Area

BAY
COUNTY

n=4





ARENAC COUNTY

BAY COUNTY

HURON COUNTY

Dyer Rd. Beach: R

Singing Bridge Beach: R

Twining Road Beach: R

Hammel Beach Road Access: R

Bessinger Road Beach: R

Foster Road Beach: R, C

Arenac County Park: R, C

Whites Beach: R, C, ST

Pinconning Park: R, C

South Linwood Beach Twnp Park: R, C

Brissette Beach Twnp Park: R, C

Bay City State Rec. Area: R, C, ST

Wenona Beach: R, C

McGraw County Park: R, S

Jenks County Park: R, S

Bird Creek County Park: R, S

Lighthouse County Park: R, S

Port Crescent St. Park-Camp: R, S

Port Crescent St. Park-Day: R, S, ST, C

Oak Beach County Park: R, S

Thompson Park: R, S

Philp County Park: R, S

Sleeper State Park: R, S

Caseville County Park: R, S, ST, C

Harbor Beach City Park: R, S

- R: Routine beach monitoring
- C: Cladophora sample testing
- ST: Source tracking
- S: Shallow water testing

ROUTINE BEACH MONITORING

- 2008 Saginaw Bay beach data
 - Number of Closures: 27
 - Number of days closed: 176
 - Number of impacted beaches: 18
- State wide beach data 2008
 - Number of closures: 46
 - Number of days closed: 340
 - Number of impacted beaches: 31

BEACH TESTING RESULTS

The water quality of this public bathing beach is tested by the Huron County Health Department. Water quality test results may be obtained by contacting the Huron County Health Department at 989-269-9721, ext.148 8:00 AM - 10:00 AM, Mon thru Fri.

The following information complies with the posting requirements set forth in Act 507 of the Public Acts of 2002, amending section 12541 of Act 368 of the Public Acts of 1978 (MCL 333.12541)

Test results can also be accessed 24 hours a day via the Department of Environmental Quality website at:
www.deq.state.mi.us/beach/

SHALLOW WATER TESTING

Water sampled at ankle deep water
Tested for indicators and esp



Greater risk
to children
due to
increased
exposure
and
weak
immune
system

CLADOPHORA & MUCK TESTING

- Tested for indicators and esp
- Cladophora receiving attention from MSU, GVSU, and NOAA



SEDIMENT TESTING

- Samples taken in the swash zone
- Tested for indicators and esp





SANITARY SURVEY

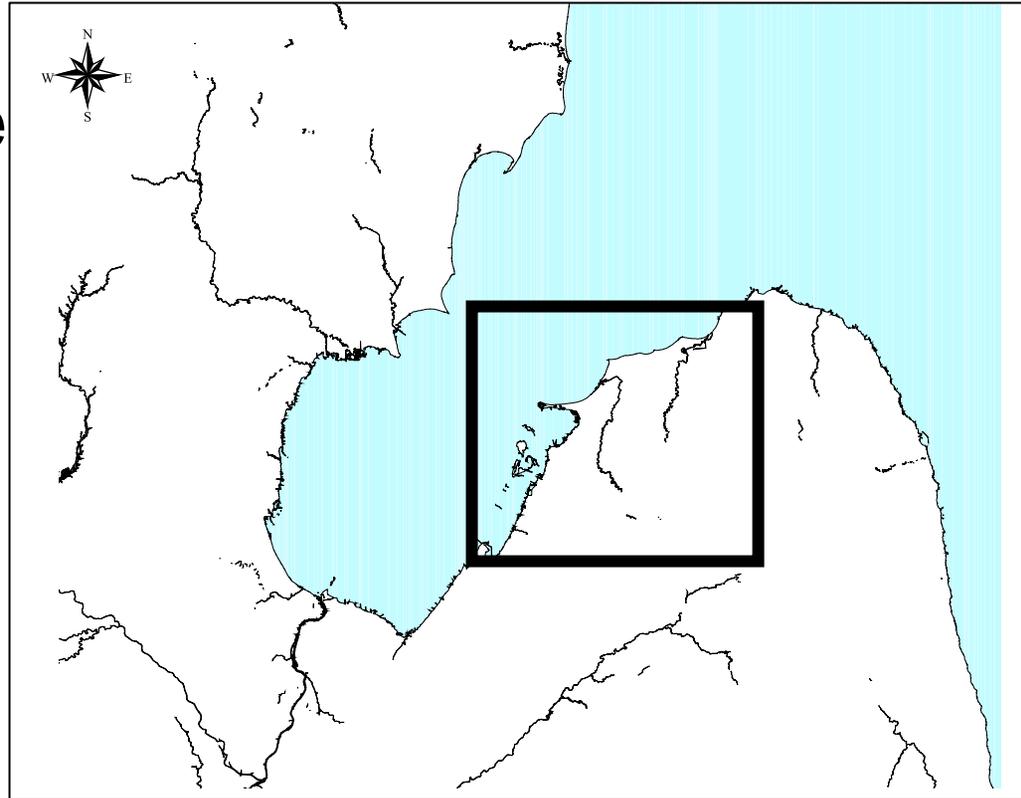
- EPA project tested in 2006, launched in 2007, available to all in 2008
- Means to help identify sources of unknown pollution
- Each sampling event
- Physical and environmental data not captured from *E. coli* results



Central
Michigan
District Health
Department

DEQ Efforts

- WQ study in the Pinnebog, Pigeon, and Shebeon Rivers
- Wet, dry, and source tracking sampling
- Land use impacts on phosphorus and *E. coli*

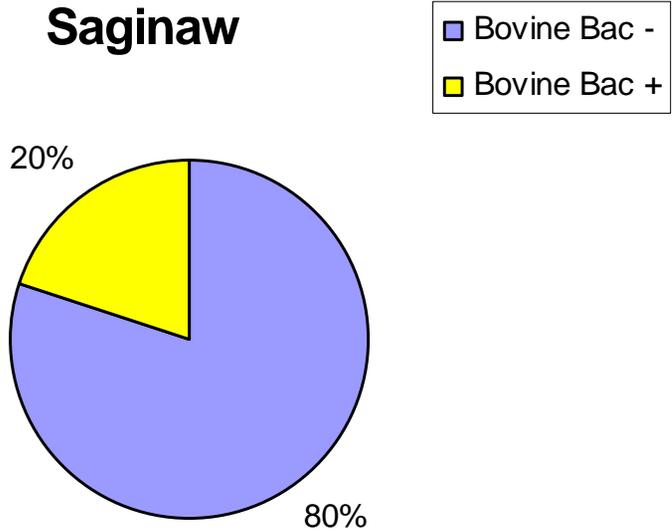


Recent Efforts of MSU

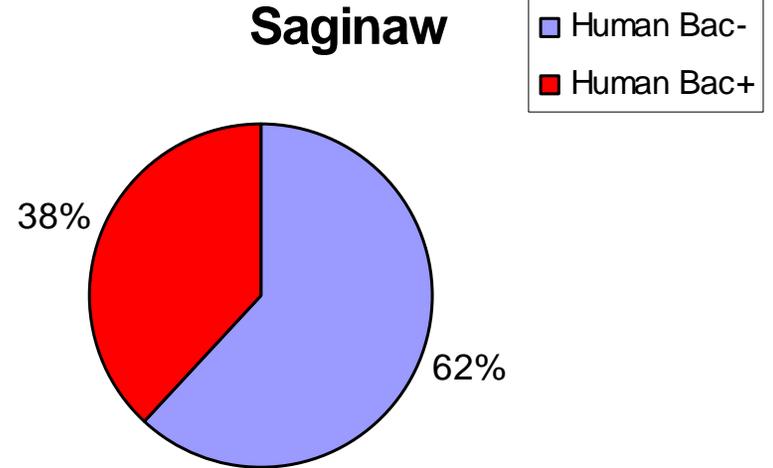
- Muck testing in 2006
 - Fecal indicators present in 2 of 2 samples
- Water and Muck testing in 2007
 - Fecal indicators present in 6 of 6 samples
- Water, Muck, sediment, and Cladophora source tracking in 2008
 - Still in progress

Prevalence of Human and Bovine Markers

Saginaw

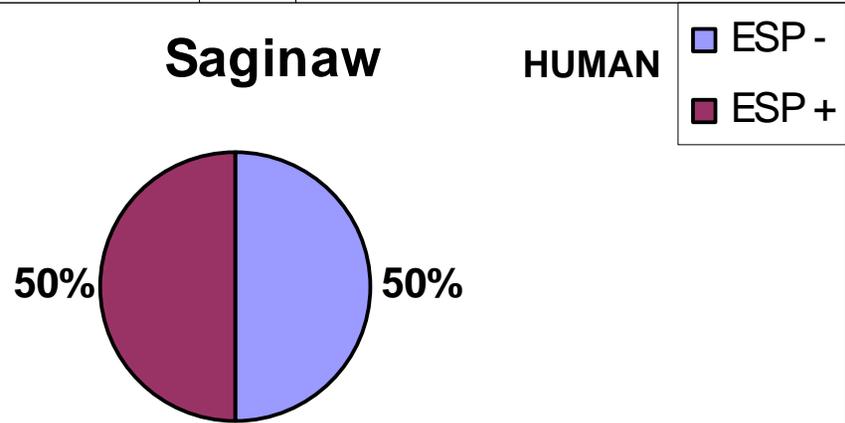


Saginaw



Saginaw

HUMAN



WATER WATCH



Department of
Community Health

- Used to identify possible illnesses associated with recreational and drinking water exposures
- Information used to coordinate illness and environmental data to detect potential health risks and outbreaks in the Saginaw Bay area and implement appropriate public health interventions
- Not being used to its fullest by the public

What does this mean?

- Health concerns of *E. coli*
- Enterococci vs. *E. coli*
- Children are at a greater risk of becoming ill from polluted water
- Regulation/policy based on economics not public health
- Minimum detection limit-a positive is positive but what does that mean; what does a negative result mean

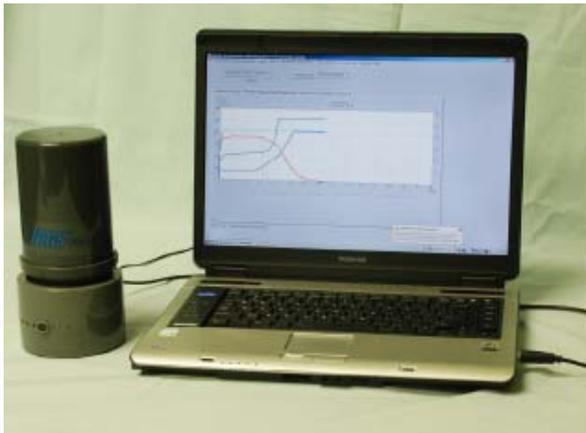
Human health and WQ

- When illness and pathogen detected-hard to attribute to water exposure because of the many transmission routes, even in severe cases



Where do we go from here?

- Rapid detection methods
- Storm water remediation
- Direct pathogen testing
- Transport models
- Forecasting models



Where do we go from here?

- Enterococci QPCR
 - pros: has been shown to be more strongly correlated with illness than the culture methods
 - Cons: cost of equipment, training, and still time delay
- Alternate indicators and increased sensitivity
- Need to quantify in order to present real risk

Most Promising tools are microbial host-specific markers

**A. ESP in Enterococci
For human sewage detection**

**B. Adenoviruses, distinguishes
Human from Cow**

**C. Bacteroides Bacteria: human and
cow systems being tested and
a bird marker may be available soon**

D. Use of toolbox approach to obtain whole picture



TOOLBOX APPROACH



CLEAN WATER

WE ALL WANT IT...



WE ALL NEED IT!

THANK YOU

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Water Quality and Environmental
Microbiology Laboratory
MICHIGAN STATE UNIVERSITY

