Collaborations to tell us about Baltimore harbor health and when it's safe to swim

Eric J. Schott

University of Maryland Center for Environmental Science

Stream Health Workgroup Meeting
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University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
INSTITUTE OF MARINE & ENVIRONMENTAL TECHNOLOGY

In partnership with
Baltimore DPW, Blue Water Baltimore, Healthy Harbor Initiative

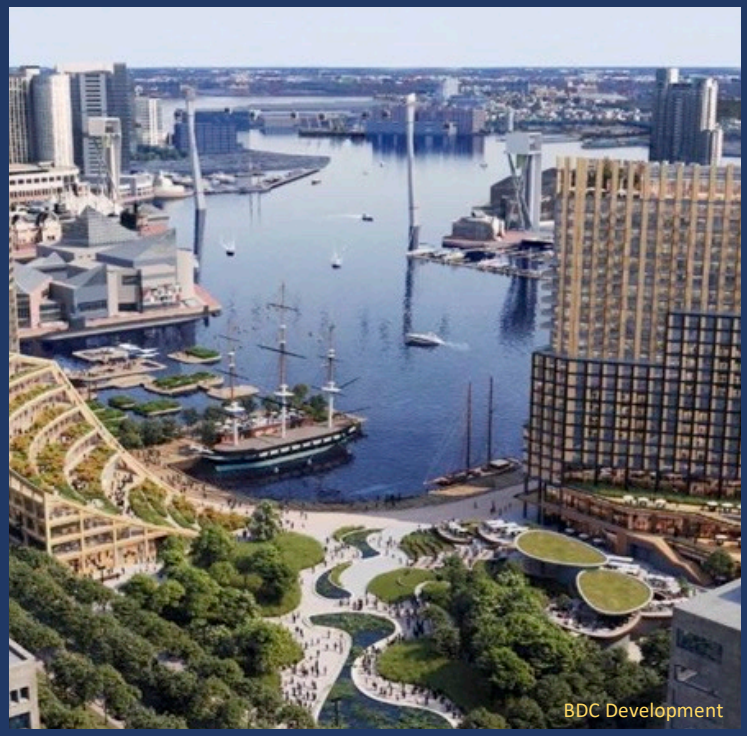
Institute of Marine and Environmental Technology

2024

When is this safe in Baltimore Harbor?

The future Baltimore Harbor has more water contact

The reimagined Middle Branch

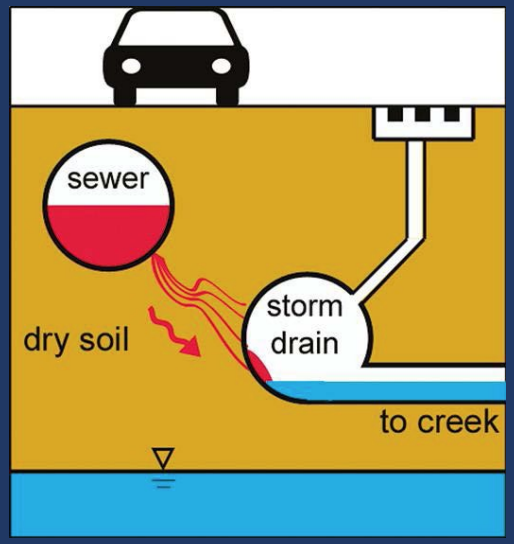


The new Inner Harbor Master Plan

Sewage seeps to the harbor

- 3000 miles of sewer lines
- 1.75 million residents
- 200 millions gallons/day

Even 99.5% containment means that 1 million gallons/day escapes




Wet weather overflow

Blue Water Baltimore


Dry weather seeps

publicworks.baltimorecity.gov/pw-bureaus/water-wastewater/wastewater/back-river

2002 Consent Decree

EPA United States Environmental Protection Agency

> WHEREAS, the United States alleges that Baltimore has violated and continues to violate Section 301 of the Clean Water Act, 33 U.S.C. § 1311, by discharging untreated sewage from its sewage collection system to the Back River, Patapsco River, and the Chesapeake Bay …

Over $1 billion committed by 2016

Little progress ending sewage overflows

2016 Renewed Consent Decree: With environmental advocates at the table

2010: Advocacy for a clean harbor

WATERFRONT PARTNERSHIP OF BALTIMORE

"Swimmable & Fishable by 2020"

Wikipedia

5 watershed associations merged

BLUE WATER BALTIMORE

WATERKEEPER® ALLIANCE MEMBER

Blue Water Baltimore

Infrastructure progress

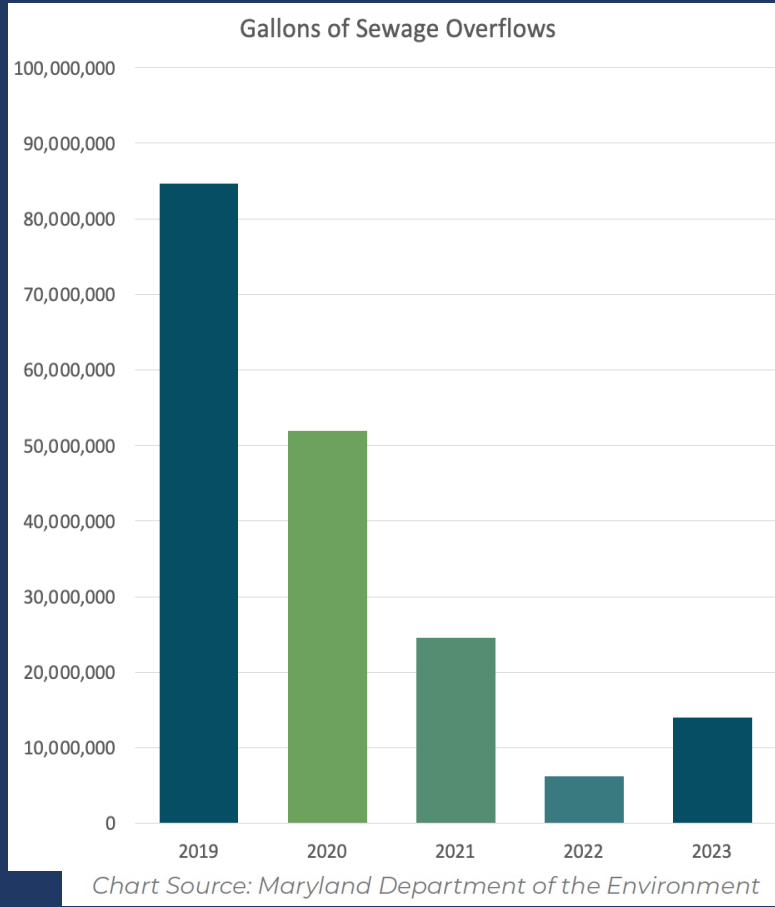
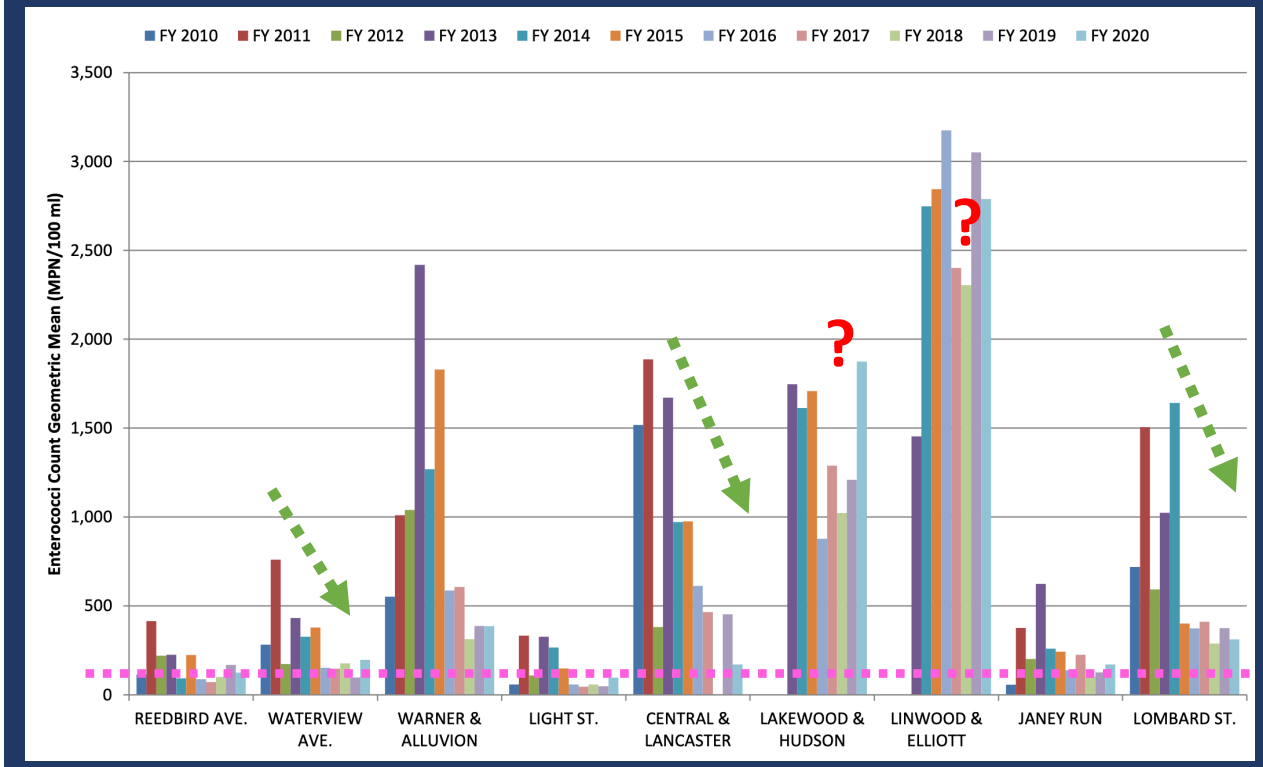


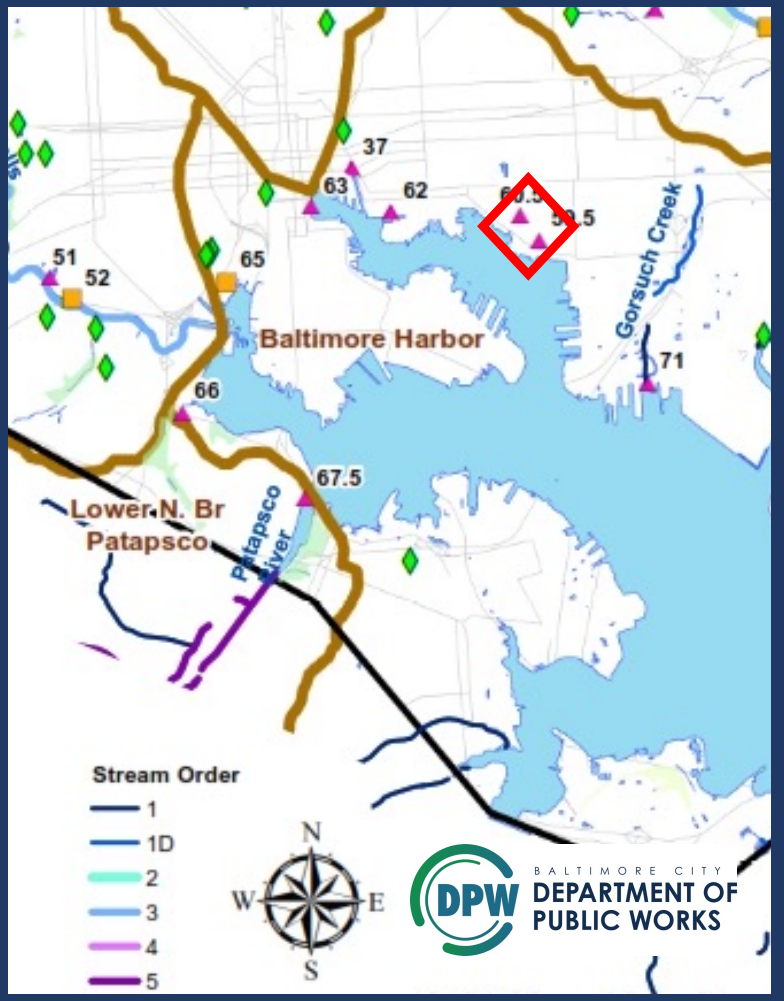
Chart Source: Maryland Department of the Environment

- Repaired misaligned sewer main 2023
- MD Env Service takeover of WWTPs 2023
- Re-establish operating procedures 2023

Sewage overflows decline 2010-2020

Enterococcus per 100 ml, annual averages



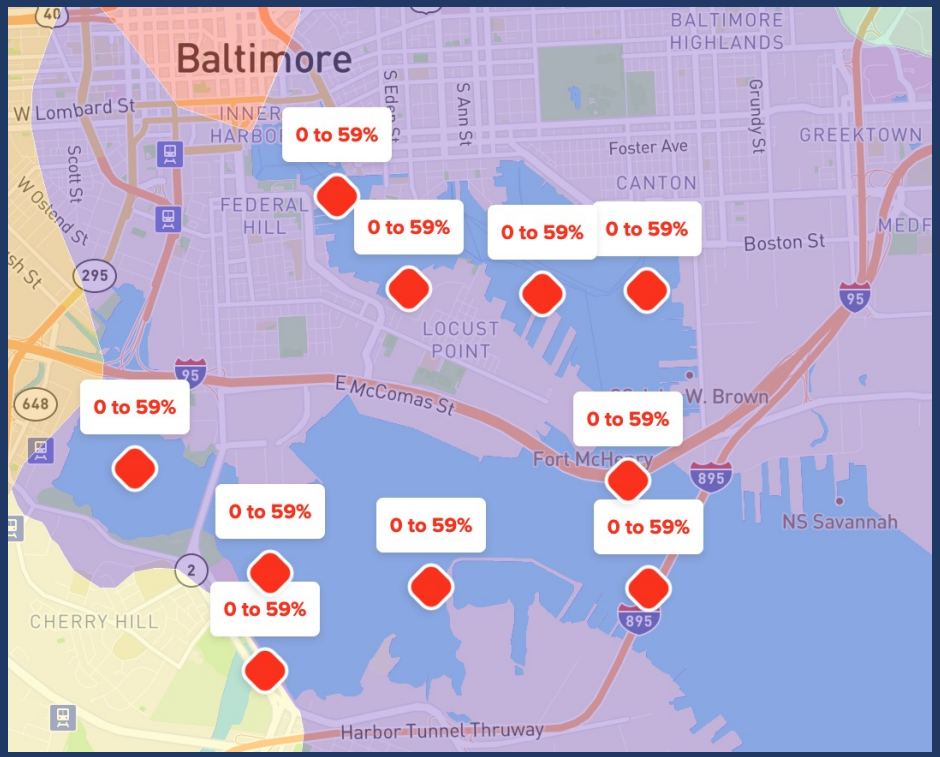


Improvement in the Harbor and Middle Branch

Enterococcus counts

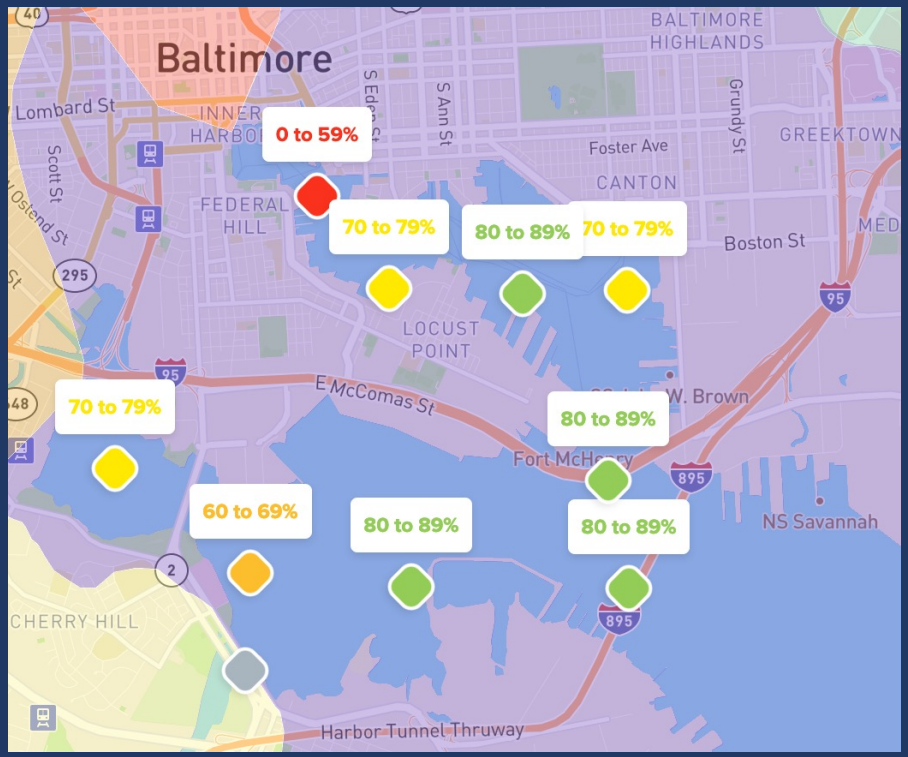
2015

< 60% passing



2020

70% - 89% passing



BLUE WATER BALTIMORE

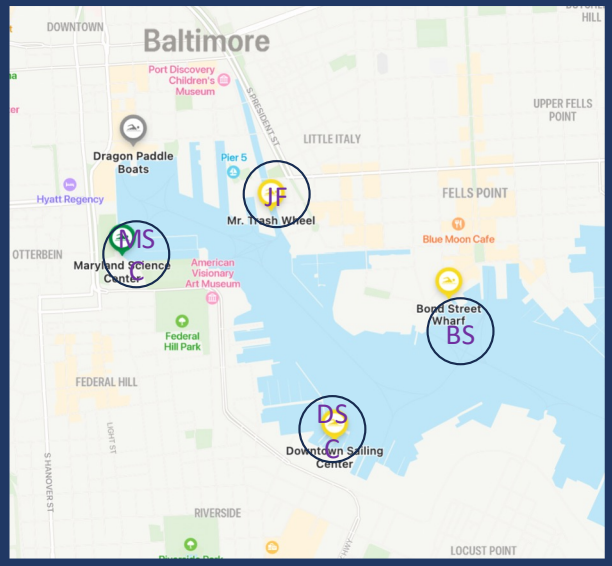
But, **when exactly** is it safe to be in the water?

Daily testing in action

Water collection →  → Results

24 hour, IDEXX methods

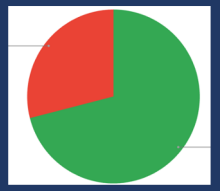
Daily testing, summer 2023, 2024, 2025



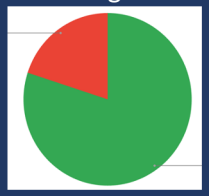
80% of days below threshold for contact

Science Ctr

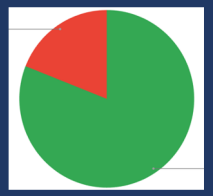
Jones Falls



Sailing Ctr



Bond St Wharf



Swimming based on yesterday's WQ data

Can we improve on culture-based monitoring

1) How can we know when it's safe to swim?
- Daily testing. But it takes 24 hours to get results

2) Are the currently-used FIB always the best indicators for sewage?
- There are other bacteria more specific for sewage

Chesapeake Bay Trust Pooled Monitoring Program

Research questions :

1) How do current FIB measurements and DNA-targeted measurements for human sewage compare?

2) Can DNA-based methods allow daily water testing to provide actionable information about the safety of recreational waters?

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DPW BALTIMORE CITY DEPARTMENT OF PUBLIC WORKS

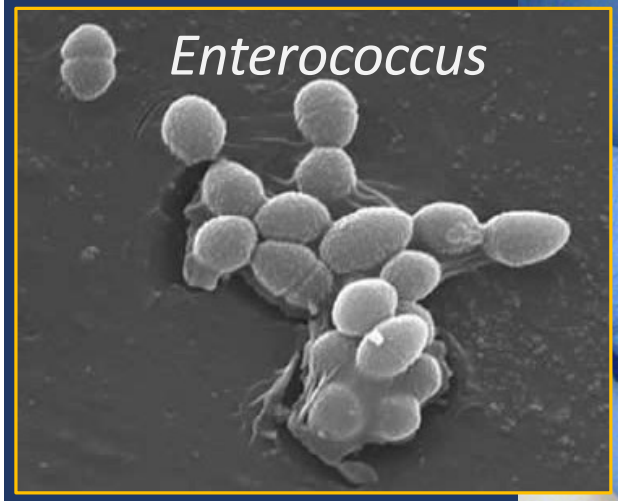
BLUE WATER BALTIMORE

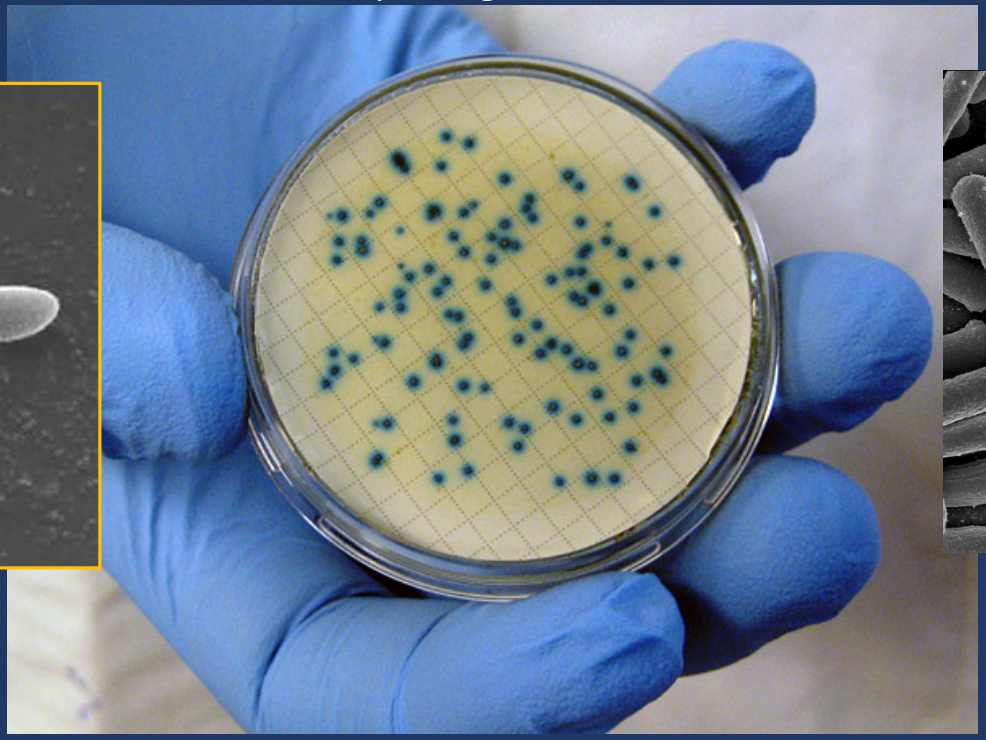
ZQ

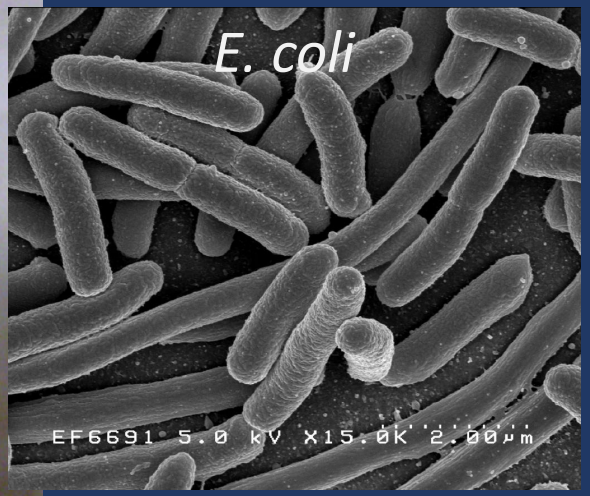
WATERFRONT PARTNERSHIP OF BALTIMORE

Monitoring for sewage contamination

- FIB = fecal indicator bacteria
- Semi-selective culture methods
- Facultative anaerobes
- Not pathogenic

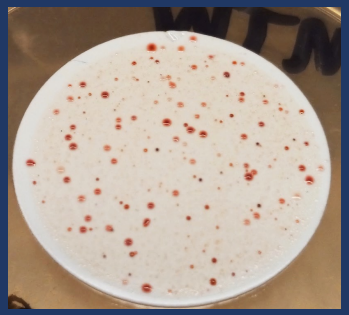




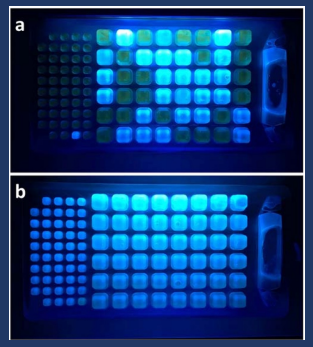


Enterococcus can be measured several ways

M-entero agar

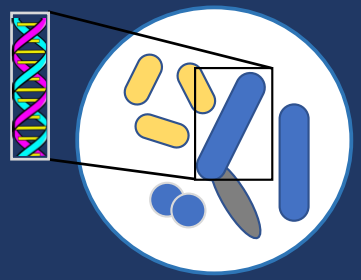


IDEXX



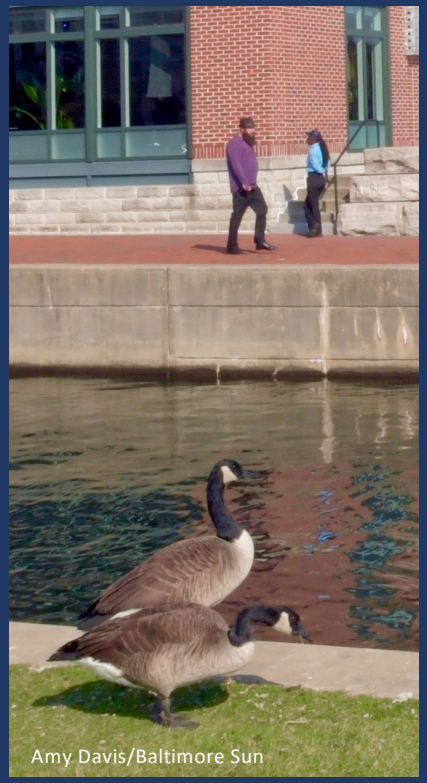
qPCR

EPA method 1611



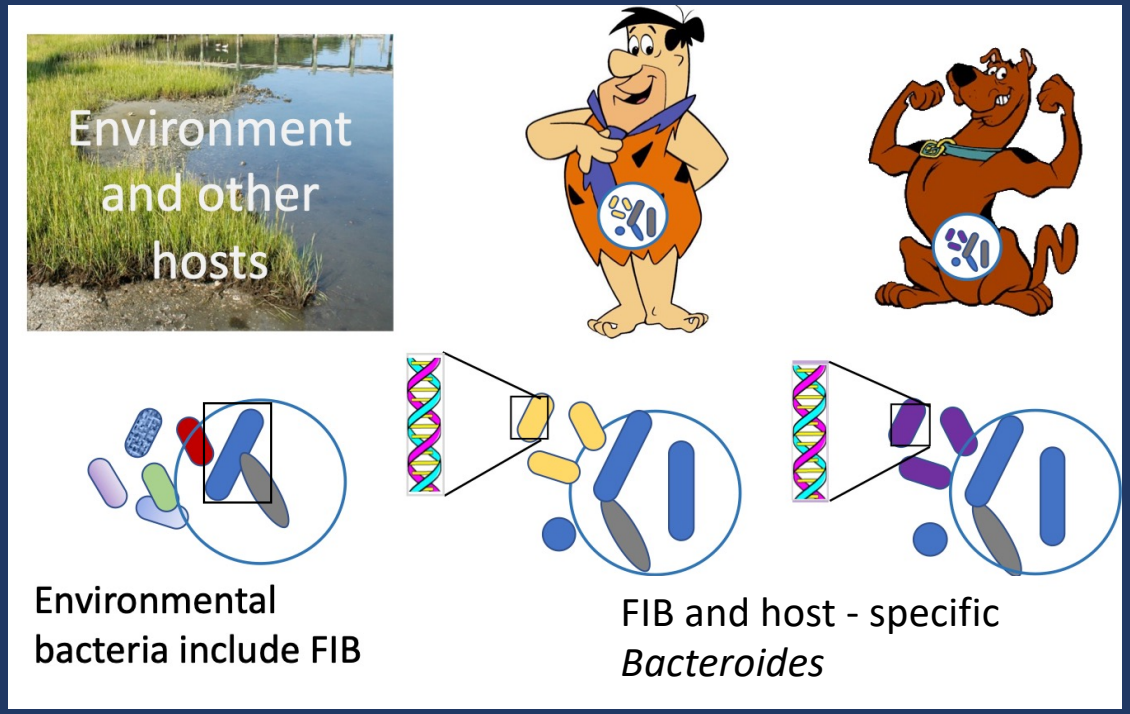
Process time	24 hours	24 hours	~6 hours
What is measured	Colony growth	Metabolic activity	Bacteria DNA
Data output	CFU	MPN	Genome copy #

Enterococcus can have multiple sources


Amy Davis/Baltimore Sun

(Upper photo: Cladophora in Baltimore: https://eyesonthebay.dnr.maryland.gov/hab/news_062404.cfm)

Bacteroides species are more host-specific than *Enterococcus*



Green et al. (2014)
Kildare et al. (2007)

Compare methods, daily testing

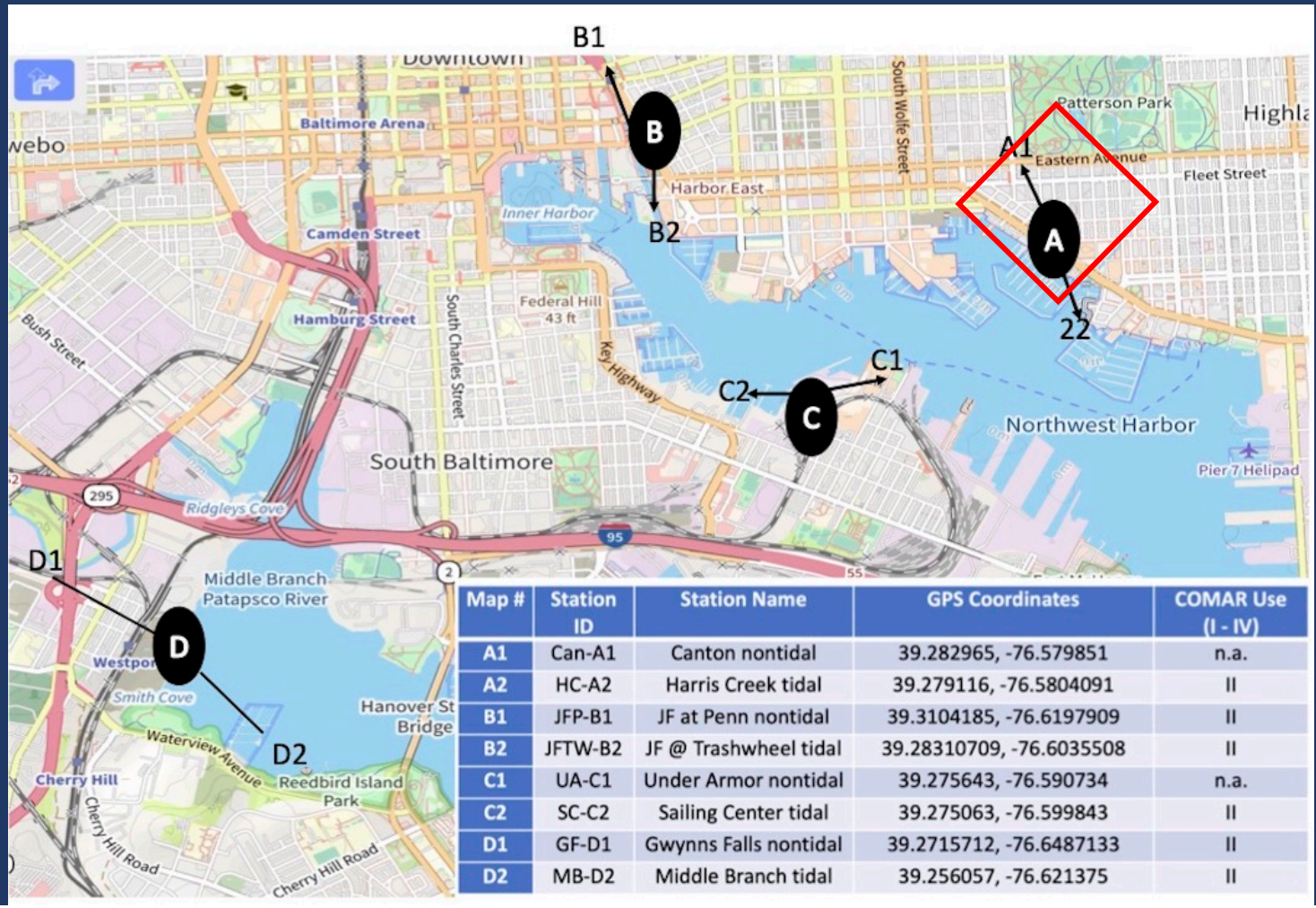
Study design:

Paired tidal and nontidal sites, four locations

Four-day repeated samples at each location
- collection by 9 am

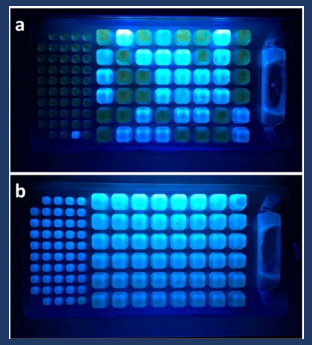
Three intervals in the recreational season
- July, Aug., Sept.

Preliminary data will be presented



Map #	Station ID	Station Name	GPS Coordinates	COMAR Use (I - IV)
A1	Can-A1	Canton nontidal	39.282965, -76.579851	n.a.
A2	HC-A2	Harris Creek tidal	39.279116, -76.5804091	II
B1	JFP-B1	JF at Penn nontidal	39.3104185, -76.6197909	II
B2	JFTW-B2	JF @ Trashwheel tidal	39.28310709, -76.6035508	II
C1	UA-C1	Under Armor nontidal	39.275643, -76.590734	n.a.
C2	SC-C2	Sailing Center tidal	39.275063, -76.599843	II
D1	GF-D1	Gwynns Falls nontidal	39.2715712, -76.6487133	II
D2	MB-D2	Middle Branch tidal	39.256057, -76.621375	II

Study Design



4 day periods of water collections

Culture method
- Enterolert

MPN per 100 ml data
QA/QC

Data archiving
Data visualization

Molecular methods
- Filtration (in duplicate)
- DNA extraction
- Storage at -80˚C

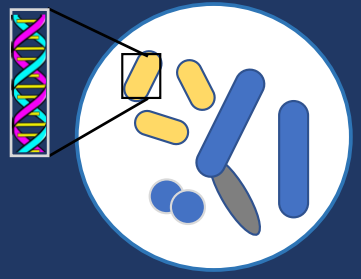
qPCR in batches
- Human, Canine, Avian

Data QA QC
Data archiving, visualization

- Correlation of FIB with qPCR data
- Investigate climate and weather impact
- Investigate reported SSO events
- Hypothesis testing

Human, canine

QA/QC

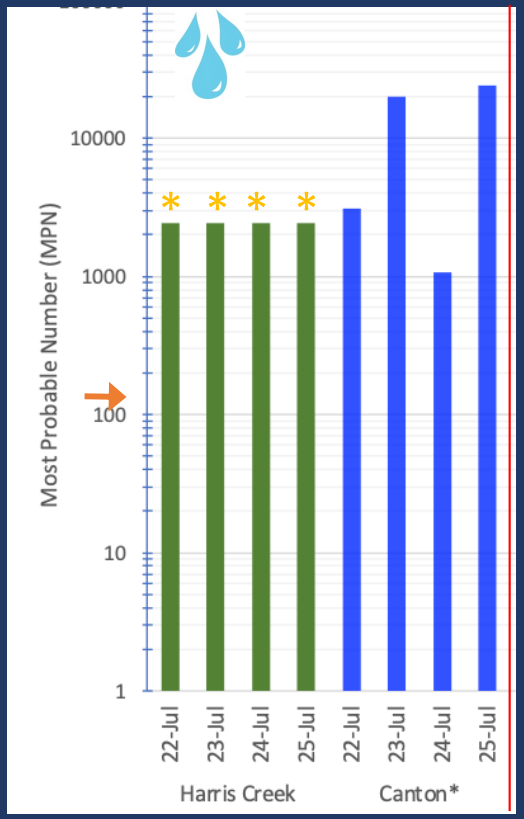


Harris Creek – Canton

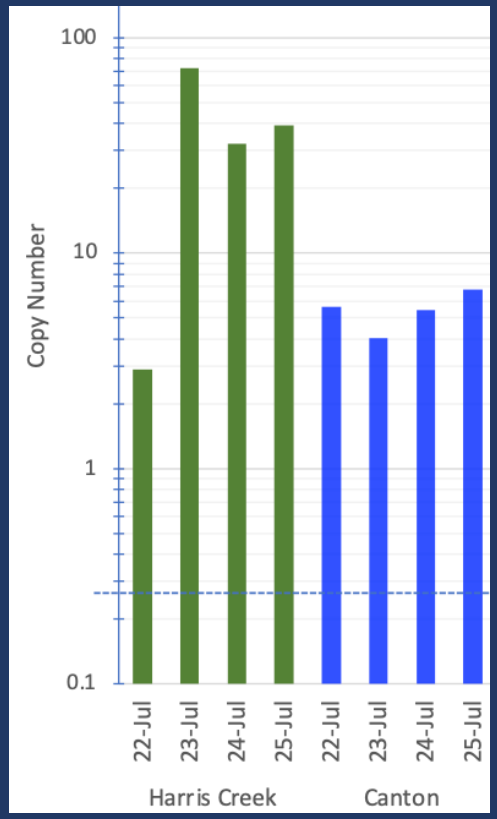
Chronically high FIB. Is this from a non-sewage source?

Harris Creek - Canton
July

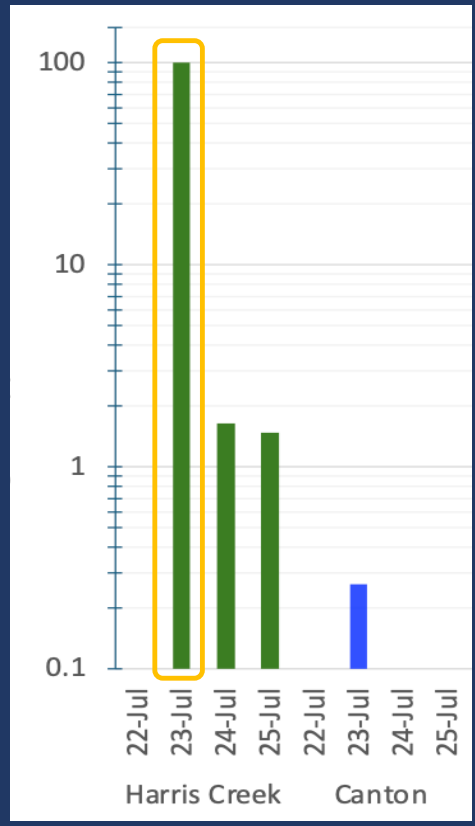
Enterolert



Human MST



Canine MST

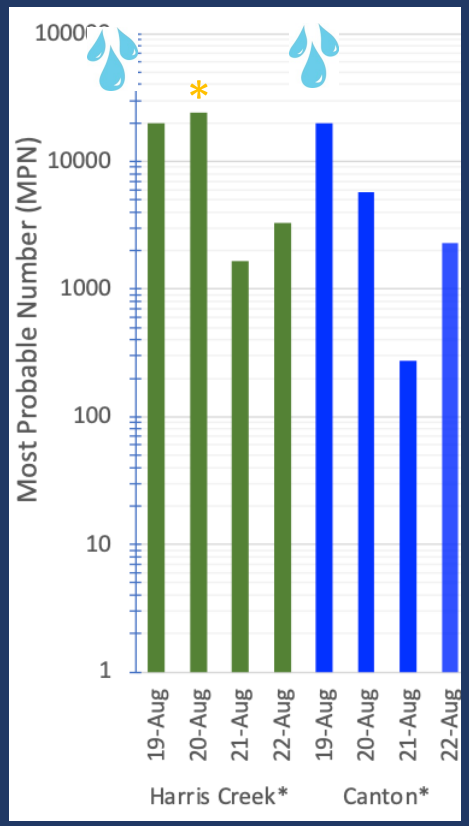


* Upper limit of Enterolert assay

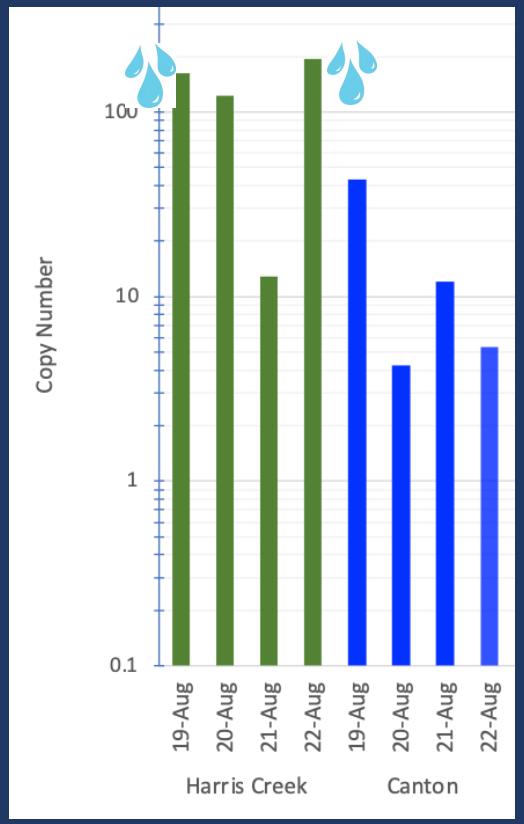
0.4 " rain late on July 22

Harris Creek - Canton
August

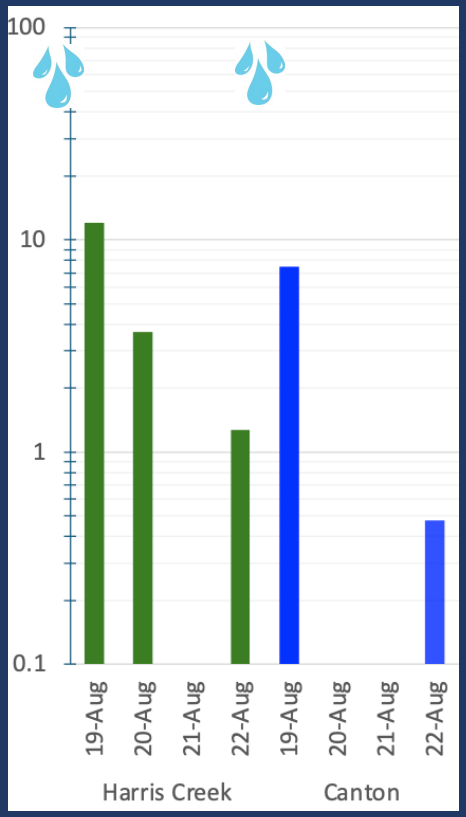
Enterolert



Human MST



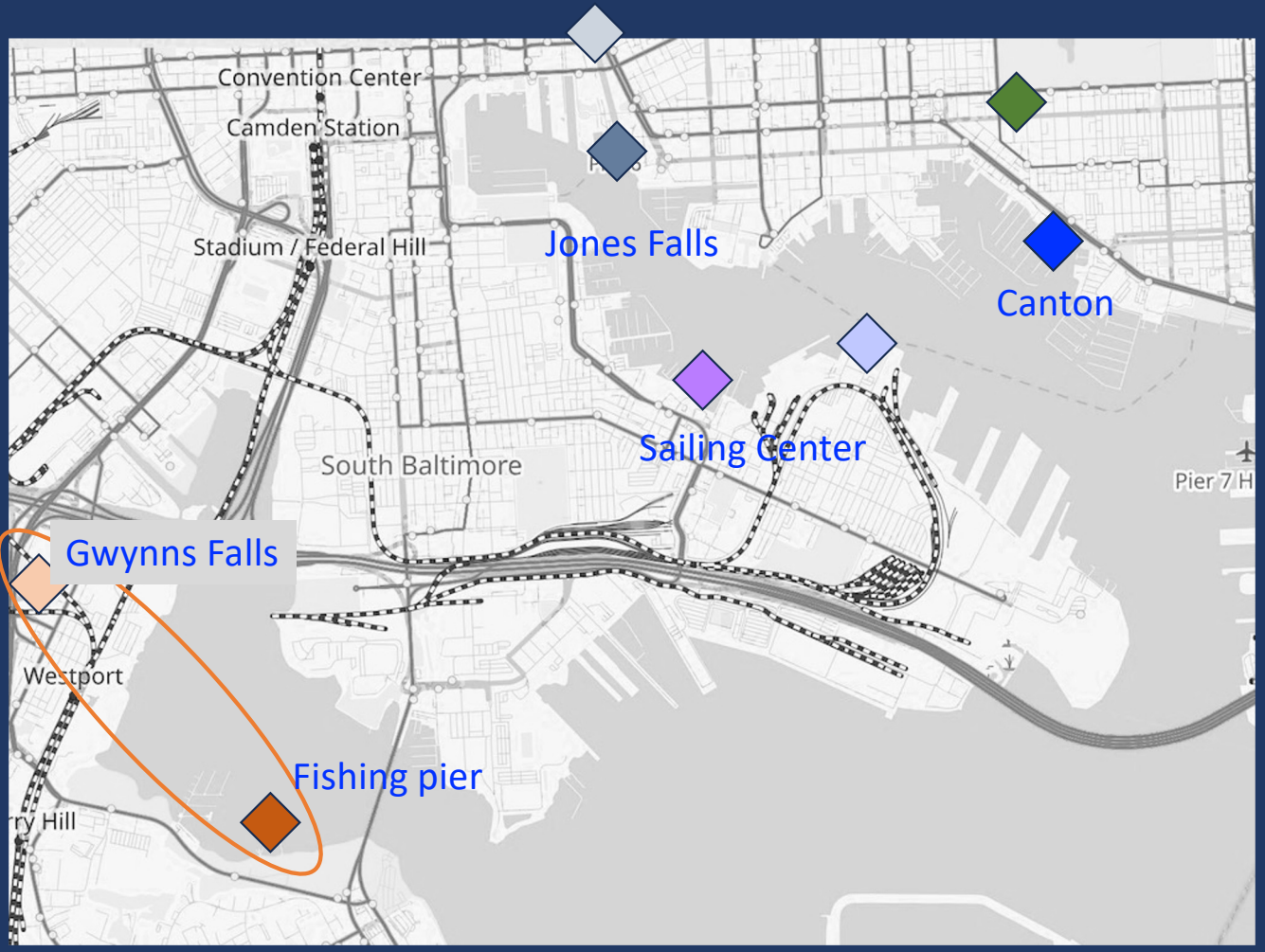
Canine MST



* Upper limit of enterolert assay

Rain late on Aug. 18.

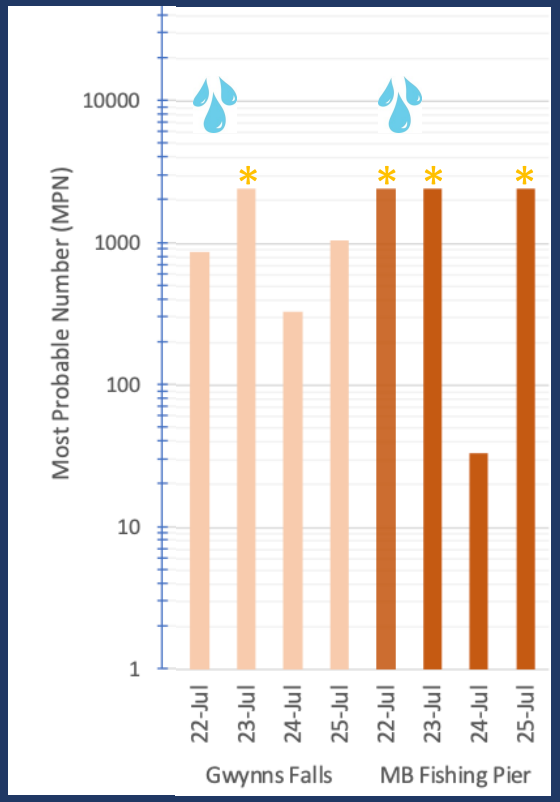
Middle Branch



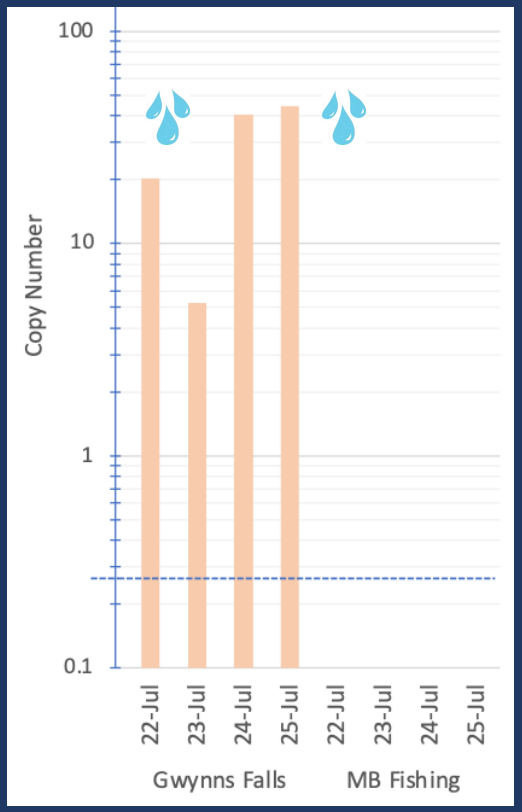
Middle Branch has rowing, fishing, and geese

Gwynns - Fishing Pier
July

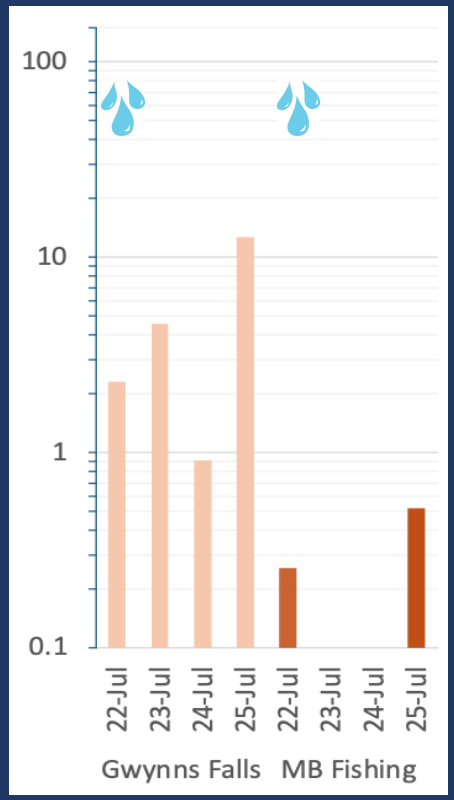
Enterolert



Human MST



Canine MST

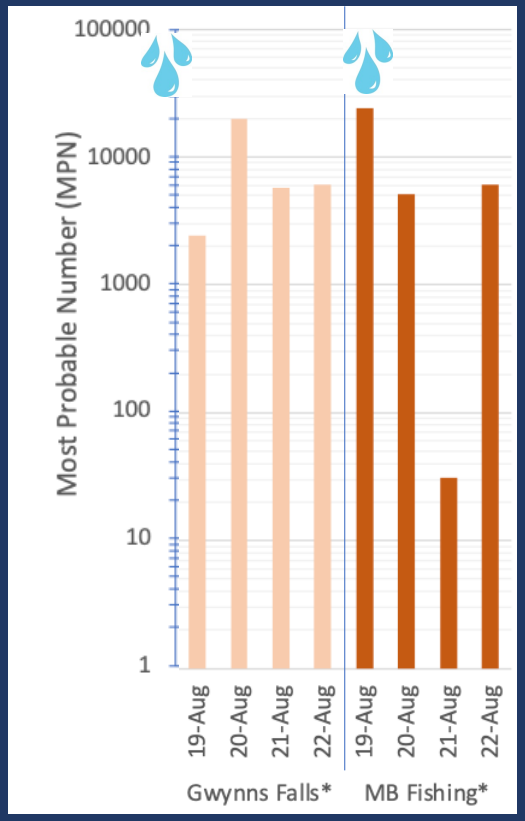


* Upper limit of Enterolert assay

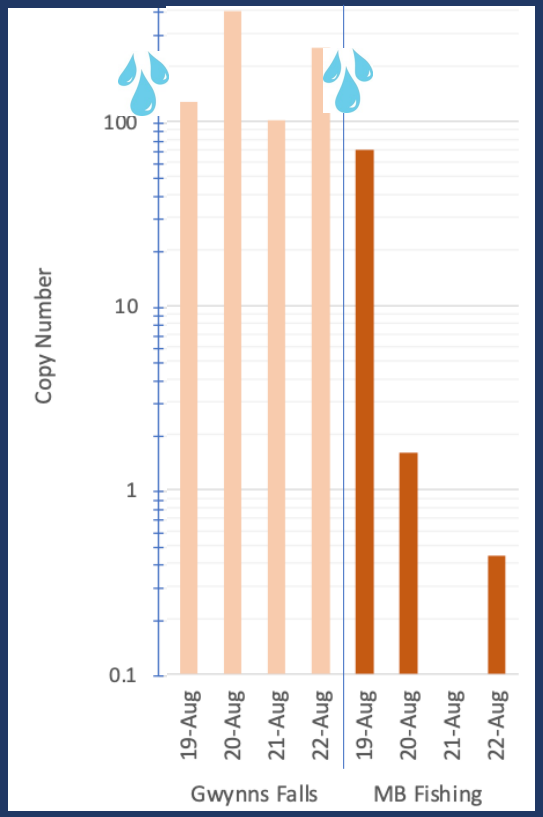
0.4 " rain late on July 22

Gwynns - Fishing Pier
August

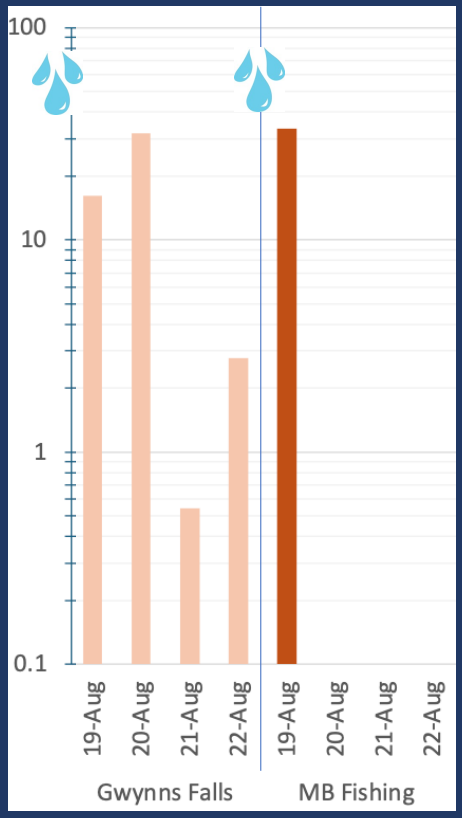
Enterolert



Human MST



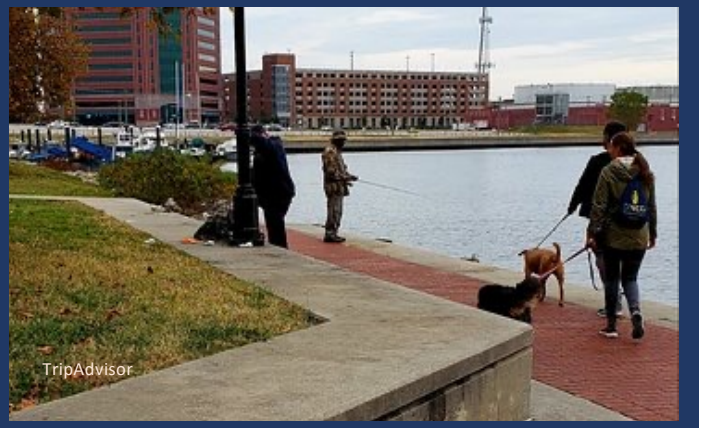
Canine MST



Rain late on Aug. 18

Summary

- **Rainfall effects**
  Similar to what was observed before.
- **Compare paired Tidal / Nontidal**
  Tidal lower than nontidal. Dilution effects.
- **Compare trends of Enterolert vs qPCR**
  More zeros with MST methods.
- **Human and canine**
  Canine signal less common, highest at Harris Creek after rain.



Next

Research and development

Investigate new qPCR targets

- Total enterococcus
- Birds, deer
- Rats?

PCR methods have a wide range of assay quantification. 1 to 1 million.

Build diagnostic capacity

Engaged working group

- Non-profits
- Academia
- Municipal

Private lab

Technician training

Shared/pooled resources

Thanks

Mariah Mckenzie
Morgan Thomas

Van Sturdevant, Joan White, Kim Grove

Brent Whitaker
Morgan Shapiro

Alice Volpitta, Sarah Holter

Allison Blood
Adam Lindquist

Back to the hypotheses

- **H1**) Combining MST and FIB methods will allow a qualitative assignment of the relative proportion of human versus non-human FIB in a given water sample.

  Human MST marker did not always track with Enterolert

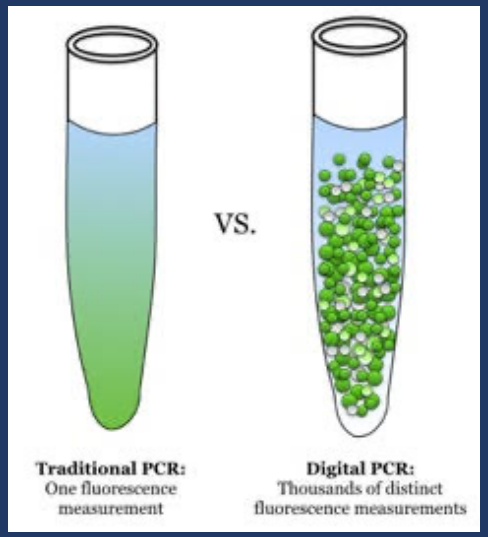
- **H2**) Daily testing, using both FIB culture and PCR methods to detect human vs non-human fecal bacteria, will show that high FIB counts do not always correspond to high human MST (Bacteroides) signals.

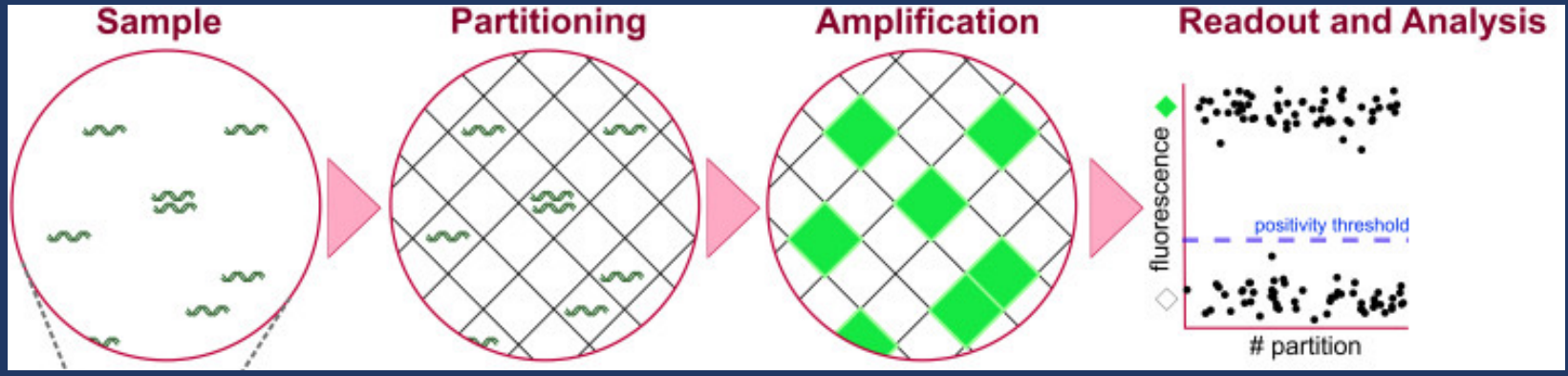
  This is true especially at the Sailing Center and Middle Branch

- **H3**) Daily testing of water quality will provide knowledge about the duration and drivers of sewage-derived bacteria and other FIB in tidal water that could not be achieved with weekly testing.

  The decay rate of MPN and MST signals can be seen to differ in August at the Sailing Center and Middle Branch

Digital PCR (dPCR)





https://pmc.ncbi.nlm.nih.gov/articles/PMC12278255/