A runoff-based vulnerability analysis to examine and communicate the dynamics of bacteria pollution events in the Gulf of Maine

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https://umaine.edu/mitchellcenter/safe-beaches-and-shellfish-beds/
Motivations and Questions

• Coastal contamination by fecal coliforms account for many unpredicted clamflat closures during peak harvest season.

• Current closure regulations are based on a “one size fits all” rule: 2” rainfall in 24 hours triggers closure, often for 2 weeks.

• Not every clamflat is the same, nor watersheds, nor rainstorms.

• Can we improve the capacity to tailor closure rules for local conditions?

• Can we do this efficiently over the entire Maine coast?
Step 1: find watershed and estuary characteristics that coincide with contamination frequency

Source of fecal coliform

Delivery by rivers, overland flow

Residence time in estuaries

Data from:
- Maine office of GIS
- USGS National Hydrography dataset
- NRCS SSURGO Database
Step 1: find watershed and estuary characteristics that coincide with contamination frequency

Source of fecal coliform  Delivery by rivers, overland flow  Residence time in estuaries

- Estuaries with urban watersheds have statistically significant higher risk
- Keep in mind: coliform sampling is biased toward contamination events
Step 2: estimate the timing and magnitude of major runoff events driving clamflat contamination

Sub-questions:
- How much runoff is brought to the estuary?
- How long does it take to get there?
- How long does it take to flush the runoff?

Landscape metrics used to model runoff production, routing, and travel time
Step 2: estimate the timing and magnitude of major runoff events driving clamflat contamination

Sub-questions:
• How much runoff is brought to the estuary?
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Runoff production and flow time maps are then used to estimate runoff volume delivered to estuaries.
Step 2: estimate the timing and magnitude of major runoff events driving clamflat contamination

Sub-questions:
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• How long does it take to flush the runoff?

Estimate the capacity of an estuary to flush contaminated water by tidal power (Ketchum, 1951)

Flushing time: number of tidal cycles required to effectively flush storm runoff (Arons & Stommel, 1951)
Step 2: estimate the timing and magnitude of major runoff events driving clamflat contamination

Sub-questions:
- How much runoff is brought to the estuary?
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- How long does it take to flush the runoff?

Longitudinal profile of estuary:
- River outlet
- Tidal range
- Subtidal volume

Cell length = travel length in one tidal cycle

in 3D:

St. George
Can we improve the capacity to tailor local closure rules?

Initial results
- Larger rivers = more runoff = longer flushing time
- Larger estuaries = greater flushing capacity
- Shallow estuaries = faster flushing for small rainfall events
Can we improve the capacity to tailor local closure rules?

Gulf of Maine results
• Model results: for majority of locations, runoff flushes sufficiently before two weeks for a 2”, 24 hour rainstorm
• Some estuaries are highly sensitive to storm intensity
• High concern areas: urbanized watersheds draining into estuaries with poor flushing capacity
• **Exploratory method**, proof of concept, does not replace models studying hydrodynamics and bacterial survival!

### Flushing times:

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(green: 2”, white: 4” rain in 24 hrs)
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**Flushing times:**
- **3Wk**
  - Presumpscot r.
  - Sheepscot r.
  - Kennebunk r.
  - St. George r.
  - Union r.
- **2Wk**
  - Mousam r.
  - Cobbosseecontee st.
  - Ducktrap r.
  - New Duck br.
  - Orland r.
  - Machias r.
- **1Wk**
  - Royal r.

**West**
(green: 2”, white: 4” rain in 24 hrs)

**East**

Black: estuary zones affected by runoff
Stars: urbanized watersheds with poor flushing capacity
Can we improve the capacity to tailor local closure rules?

Conclusions
• Metrics for contaminant source, delivery, and residence are statistically significant for identifying closure risk
• Watershed-estuary systems with high contaminant source, rapid delivery, and poor flushing are most sensitive
• Mitigation attempts must come from source and delivery

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Can we improve the capacity to tailor local closure rules?

What needs doing
- Regular sampling at more locations, especially river outlets
- Calibrate models by salinity data, coliform scores
- Quantification of shoreline sources
- Comparison with estuary-scale circulation models

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References

- Maine office of GIS
  - http://www.maine.gov/megis/catalog/
- USGS National Hydrography dataset
  - https://nhd.usgs.gov/
- NRCS SSURGO Database
  - https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627