



Characterization and spatial distribution of organic contaminated sediment from historical industrial effluents to inform remediation decisions

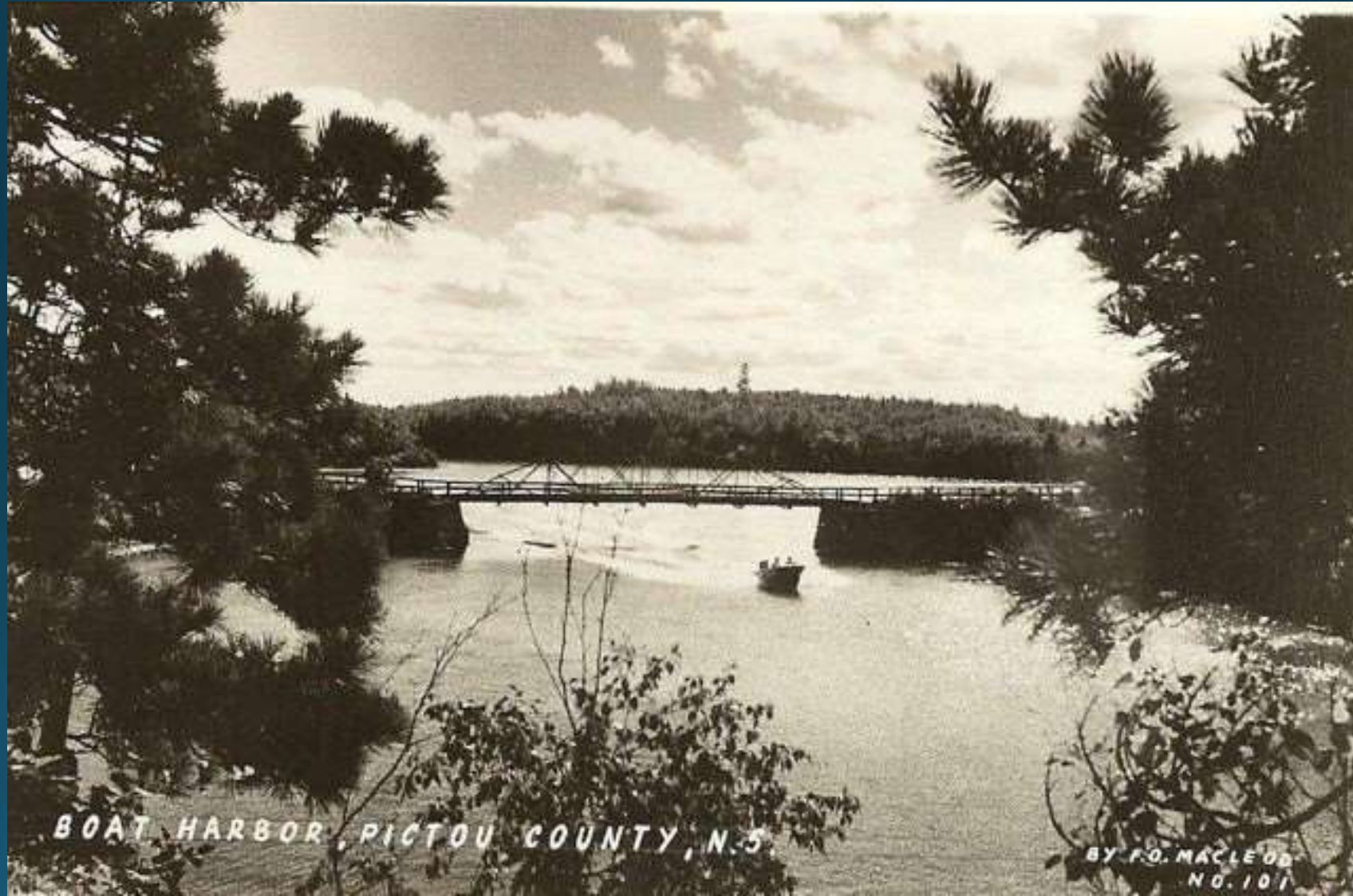
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Emily Davis, Craig B. Lake

Agenda

- Background (pre-mill)
- Background (post-1967 effluent treatment)
- Boat Harbour Remediation Project
- Sediment Chemistry Assessment
- Results and Discussion
- Recommendations
- Closing Remarks



A's'ek "*the other room*" (pre-mill, pre-1967)



Background

- A bleached kraft pulp mill ('the mill') has been operating in Pictou County, Nova Scotia since 1967
- Effluent is discharged into the Boat Harbour Treatment Facility, within a former tidal lagoon near and within the Mi'kmaq Pictou Landing First Nation (PLFN) community



Location of Boat Harbour in Pictou County, Nova Scotia relative to communities (e.g., Pictou, and Pictou Landing First Nation [PLFN])

Boat Harbour Treatment Facility (BHTF)



- Effluent ($>87,000 \text{ m}^3/\text{d}$)
- $>570,000 \text{ m}^3$ of unconsolidated contaminated sediment
- Inorganic and organic contaminants (metal[loid]s, polycyclic aromatic hydrocarbons [PAHs], dioxins and furans)

Components of the Boat Harbor Treatment Facility (BHTF), relative to the neighboring Pictou Landing First Nation (PLFN) community (©Google Earth)

Effluent Leak in 2014



Northern Pulp mill shut down due to effluent leak

Northern Pulp mill shut down due to effluent leak

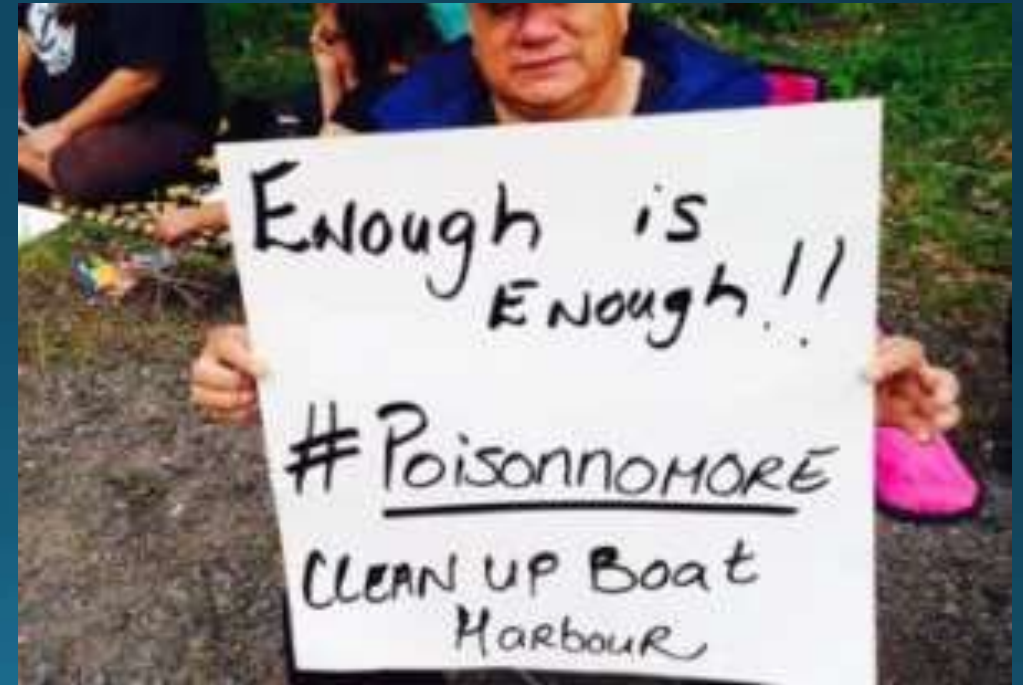


Leak detected around 7 a.m. near the pipe's landfall on the Pictou Landing side of the East River

CBC News · Posted: Jun 10, 2014 12:09 PM AT | Last Updated: June 10, 2014

<https://www.cbc.ca/news/canada/nova-scotia/northern-pulp-mill-shut-down-due-to-effluent-leak-1.2670721>

Triggered Protests



The Boat Harbour Act

- Effluent leak combined with 50 years of mistrust, triggered protests from PLFN and Pictou communities
- Government of Nova Scotia passed The Boat Harbour Act (2015)
- This law orders that Boat Harbour will cease to be used for the reception and treatment of effluent by January 31, 2020

BILL NO. 89

(as introduced)



*2nd Session, 62nd General Assembly
Nova Scotia
64 Elizabeth II, 2015*

Government Bill

Boat Harbour Act

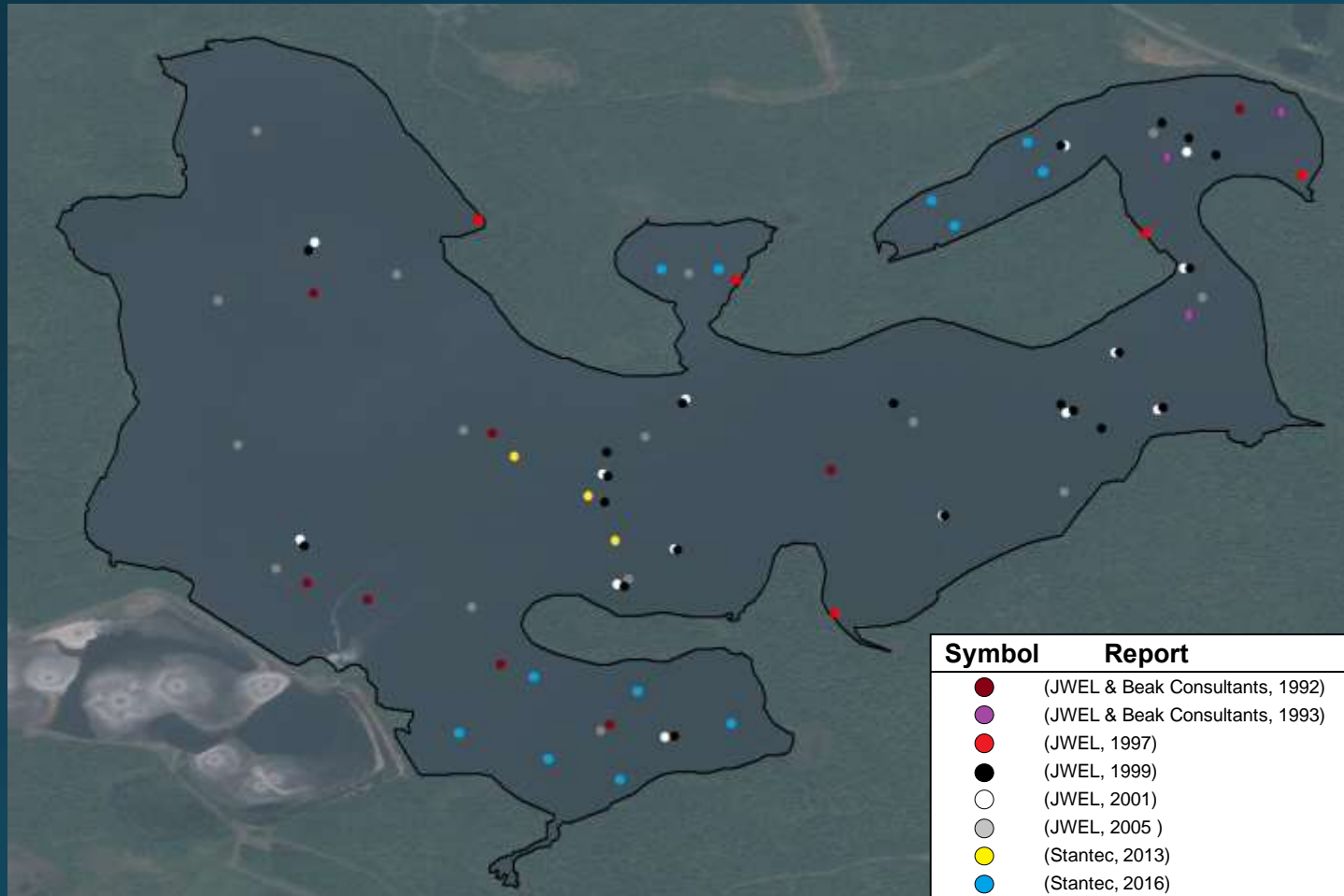
Boat Harbour Remediation Project

- Remediation commencing in 2020 by the province of Nova Scotia
- Boat Harbour will be returned to a pre-1967 tidal state
- Boat Harbour Environment Advisory Committee (BHEAC)
 - Federal and provincial government, universities and consultants helping NS Lands (responsible for managing remediation project)
 - Dalhousie University - spatio-temporally characterize impacted sediments, wetlands and marine ecosystems to help inform decisions for \$217 million (CAD) remediation program

Holistic Review

- Over 200 documents reviewed for relevant sediment organic chemistry data
- Only 12 relevant for this study
 - 8 reports related to BH and reference locations
 - 4 reports from downgradient receiving waters
- Organic chemistry data from BH sediment samples collected between 1992 and 2015
- PAHs and PCDD/Fs were primary organic parameters evaluated

Sediment Sampling Sites (1992-2015)



- Only 8 reports with organic chemistry
- 103 samples from 81 sites
- Various sampling methods (eg, core or grab; discrete or composite sample; sample depth)
- Overall, inadequate spatial coverage

Spatiotemporal coverage (1992-2015) of sediment sampling in Boat Harbour are indicated by coloured circles

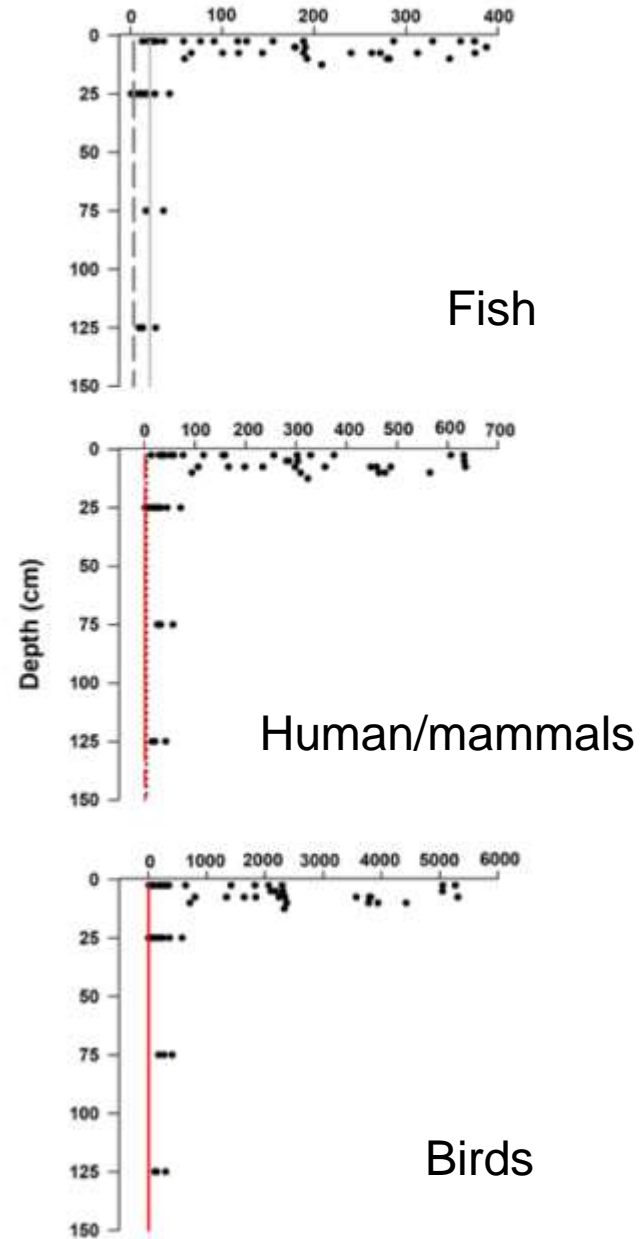
Analysis

- PAH and PCDD/F sediment concentrations were compared to Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines (SQGs) for sediment, soil, and tissue residue



Concentration vs. Depth

Total PCDD/Fs TEQ concentration in sediment (pg/g)



→ 54% of PCDD/F samples from shallow horizons (0-15 cm) leaving deeper horizons under-characterized

→ CCME SQGs for fish shown with using *solid horizontal line* for PELs (21.50 pg/g) and *dashed line* for ISQGs (0.85 pg/g)

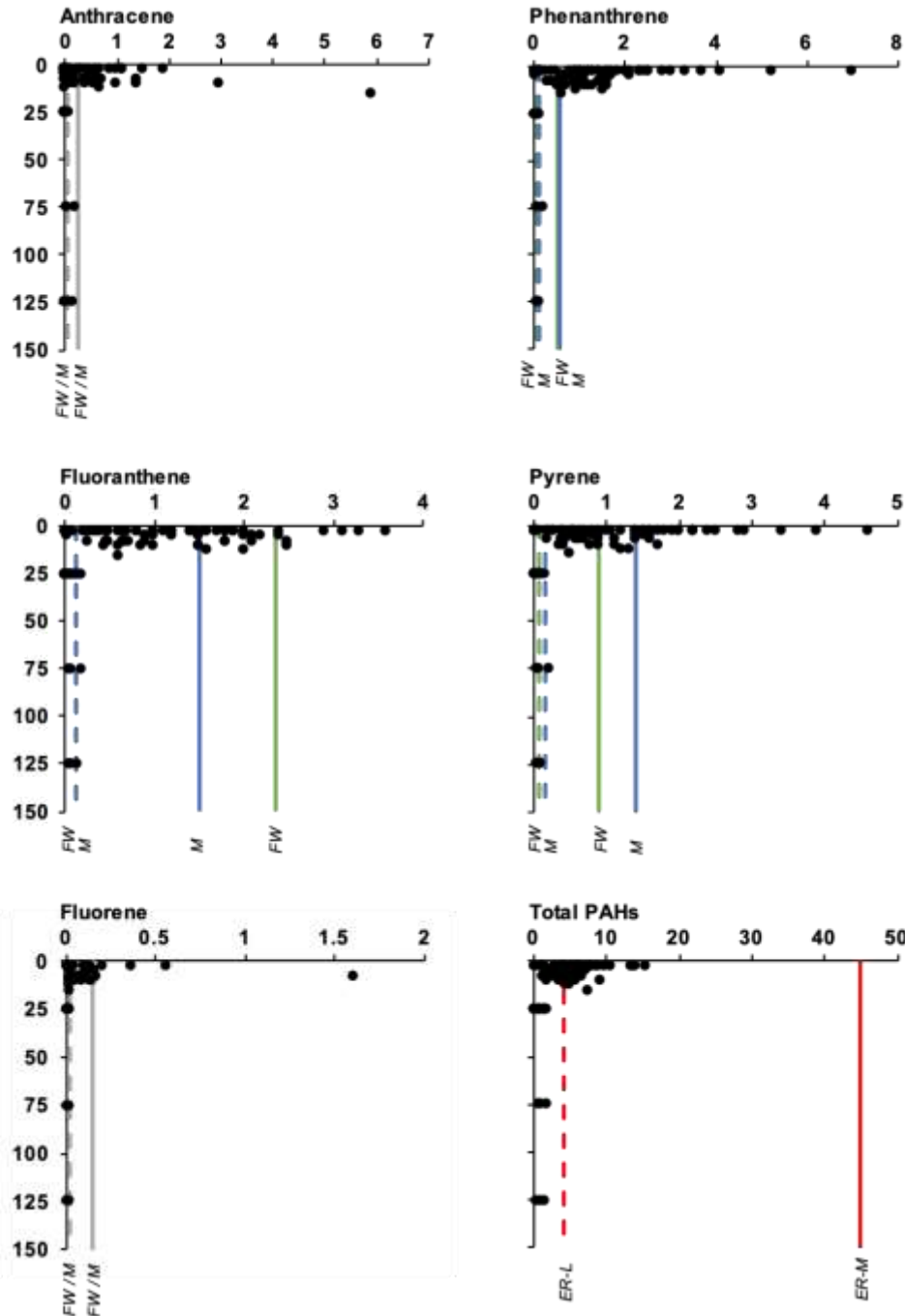
→ Soil quality guideline for protection of environmental and HH for all land uses shown with *black dotted horizontal line* (4.00 pg/g)

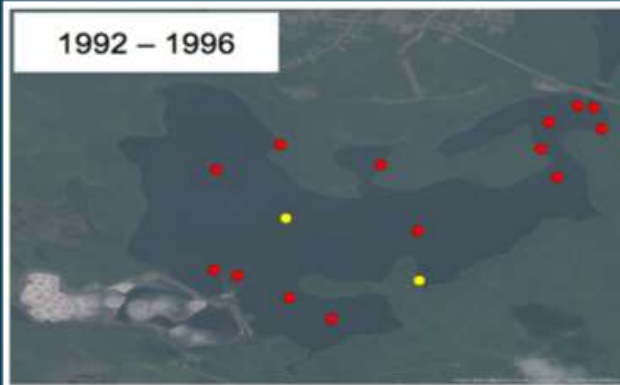
→ CCME tissue residue guidelines for protection of wildlife consumers of aquatic biota shown with *red dashed line* for mammals (0.71 pg/g) and *red solid line* (4.75 pg/g) for birds

Concentration vs. Depth

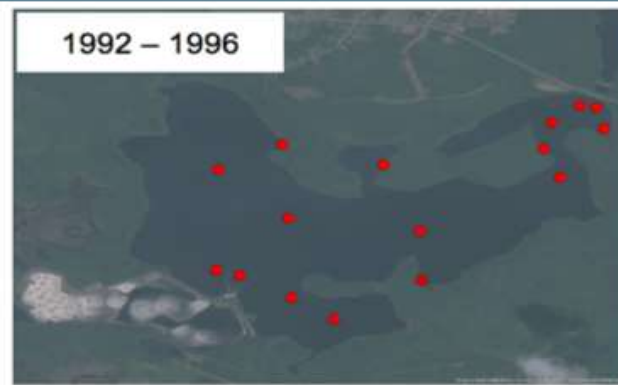
- 69% of PAH samples also from shallow horizons (0-15 cm) leaving deeper horizons under-characterized
- CCME freshwater (dark green) and marine (blue) SQGs shown with *solid horizontal lines* for PELs and *dashed lines* for ISQGs
- Grey represents when marine and freshwater SQGs are same
- Total PAHs, dashed line indicates ER-L (4.02 mg/kg) and solid line indicates ER-M (44.80 mg/kg)

PAH concentrations in sediment (mg/kg)

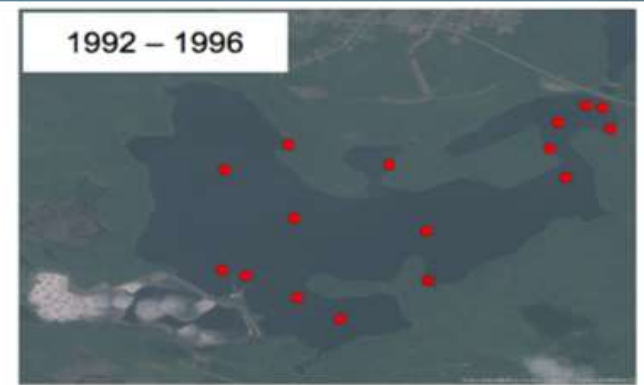




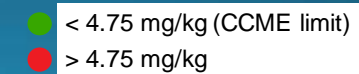
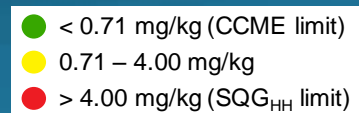
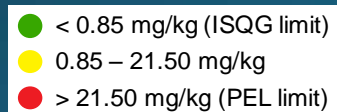
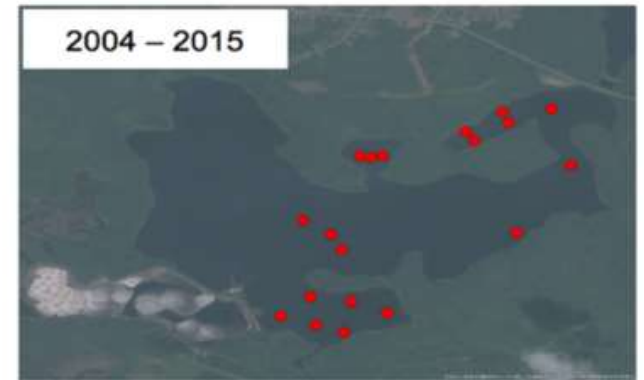
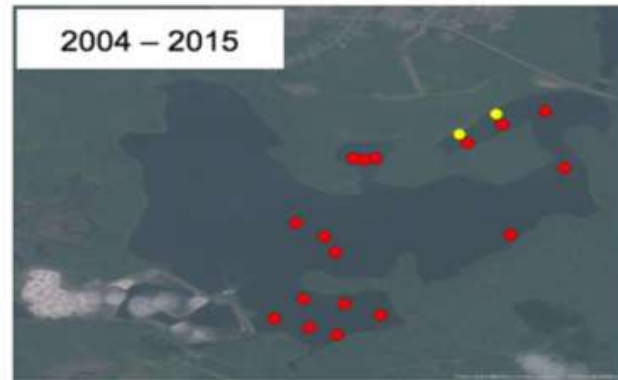
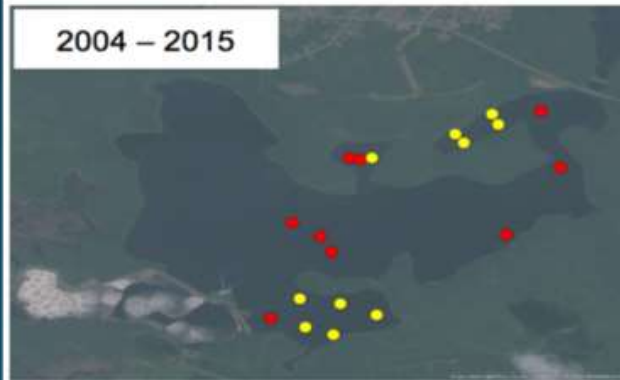
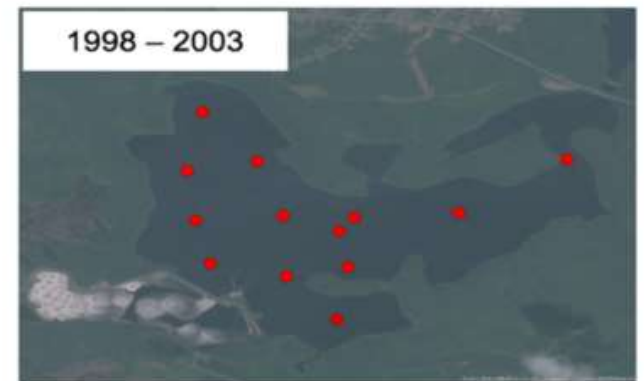
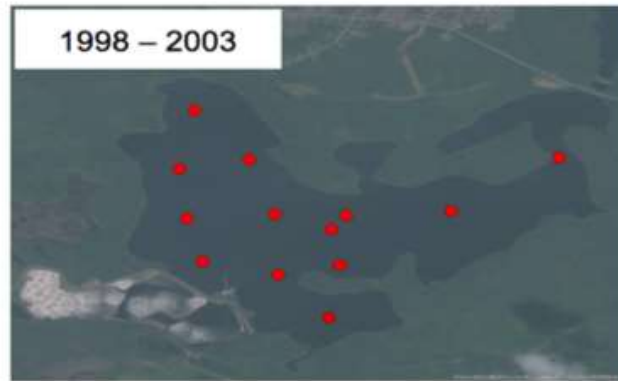
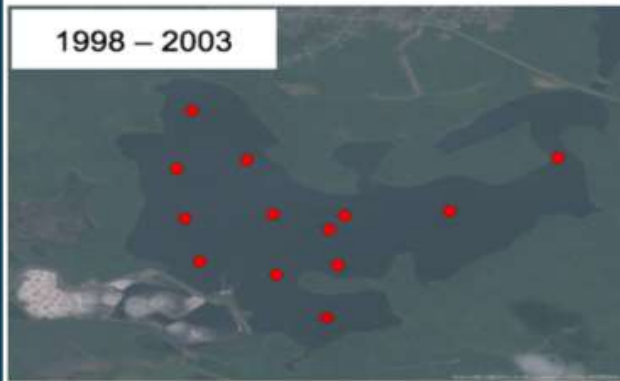
Fish



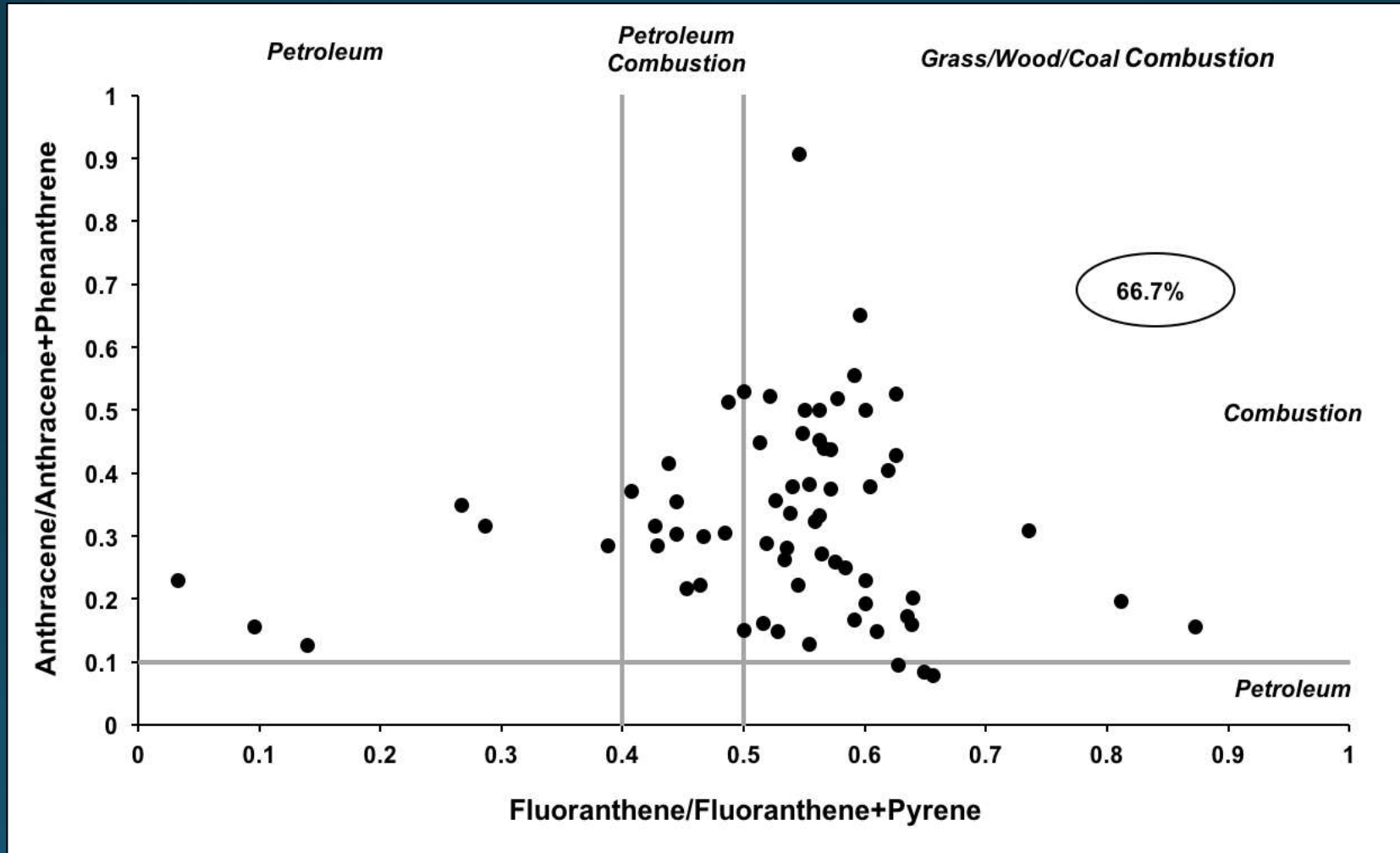
Human/ Animals



Birds



PAH Source Apportionment



Sources of Organic Contaminants

- Results indicate mill effluents as primary source of contaminant loadings in BH
- Other *potential* contaminant sources:
 - Atmospheric deposition from local point source emitters (eg, mills smokestacks, thermal generating station)
 - Effluent discharged from a chlor-alkali facility between 1971-1992

Recommendations

- More detailed sediment sampling (eg, piston coring, discrete sampling across vertical horizons, dating and greater spatial coverage), should be conducted in BH prior to remediation
- Replicate sampling post-remediation (ie, before and after study) to monitor changes in BH
- Baseline monitoring at reference or control sites is critical to establish benchmarks for comparing contaminated sites pre- and post-remediation

Closing Remarks

- Decades of pulp mill effluent releases has resulted in large quantities of unconsolidated sediment being deposited in BH
- Gaps and limitations exist in historical data (eg, various sampling techniques)
 - However still useful for remediation planning
- Dioxins and furans are priority contaminants of concern due to frequent SQG exceedances, persistence and toxicity
- More detailed sediment sampling required in BH prior to remediation to better delineate contaminated sediment and to estimate volumes for treatment or disposal

Thank you!

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