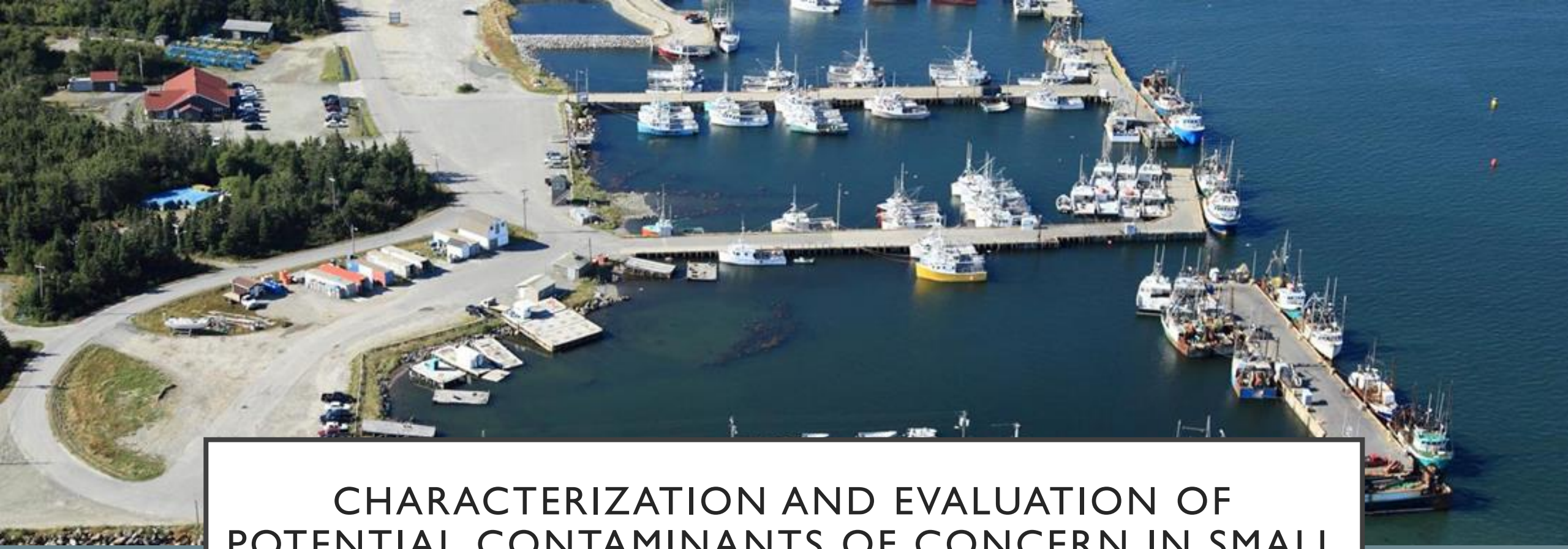


CHARACTERIZATION AND EVALUATION OF POTENTIAL CONTAMINANTS OF CONCERN IN SMALL CRAFT HARBOURS SEDIMENTS IN NOVA SCOTIA

Myriam Mora, Dr. Tony R. Walker - Dalhousie University

Rob Willis – Dillon Consulting Limited

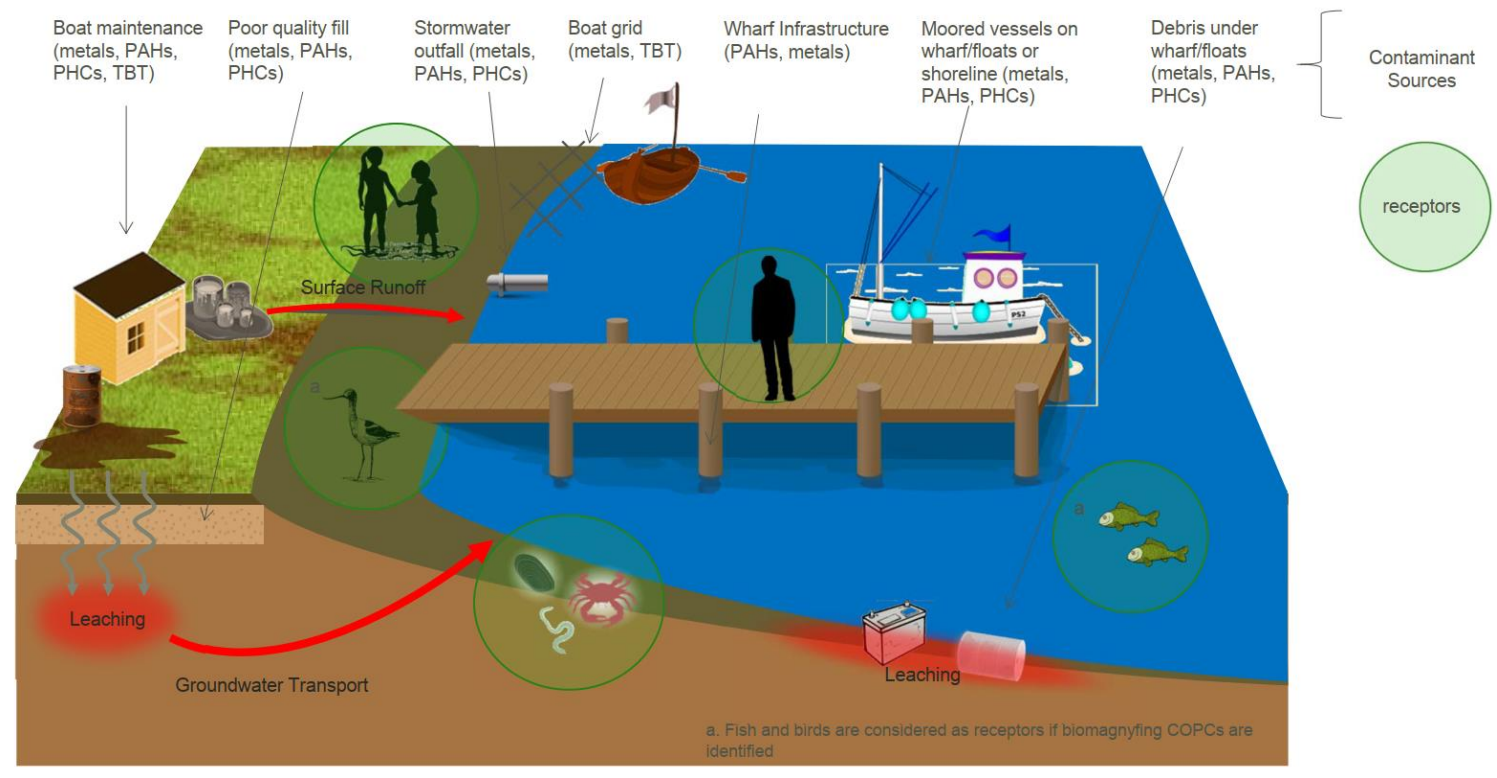
12th International SedNet Conference, June 2021

SMALL CRAFT HARBOURS (SCHs)

- Nationwide program run by Fisheries and Oceans Canada (DFO)
- SCHs are vital for the fishing industry, economy and have high socioeconomic and cultural importance for surrounding communities (DFO, 2019)
- There are 178 core and non-core SCHs in Nova Scotia

Source: Jarvis (2008)

SOURCES OF POLLUTION IN SCHS



Source: Meloche and McDonald (2018)

- Meloche and McDonald (2018) identified inadequate maintenance activities, poor wharf infrastructure, debris, low quality fill and stormwater discharge as main contaminant sources on SCHs

- These sources increase presence of pollutants like polycyclic aromatic hydrocarbons (PAHs), metals, polychlorinated biphenyls (PCBs) and petroleum hydrocarbons (PHCs) in SCHs sediments primarily through leaching, groundwater transport and land runoff

CANADIAN SEDIMENT QUALITY GUIDELINES

- They provide concentration benchmarks used to assess and determine the potential ecological risk of a contaminant (BC MOE, 2017)

- Thresholds are determined based on values in which adverse effects are likely to occur for biota

ATLANTIC RBCA
RISK BASED CORRECTIVE ACTION

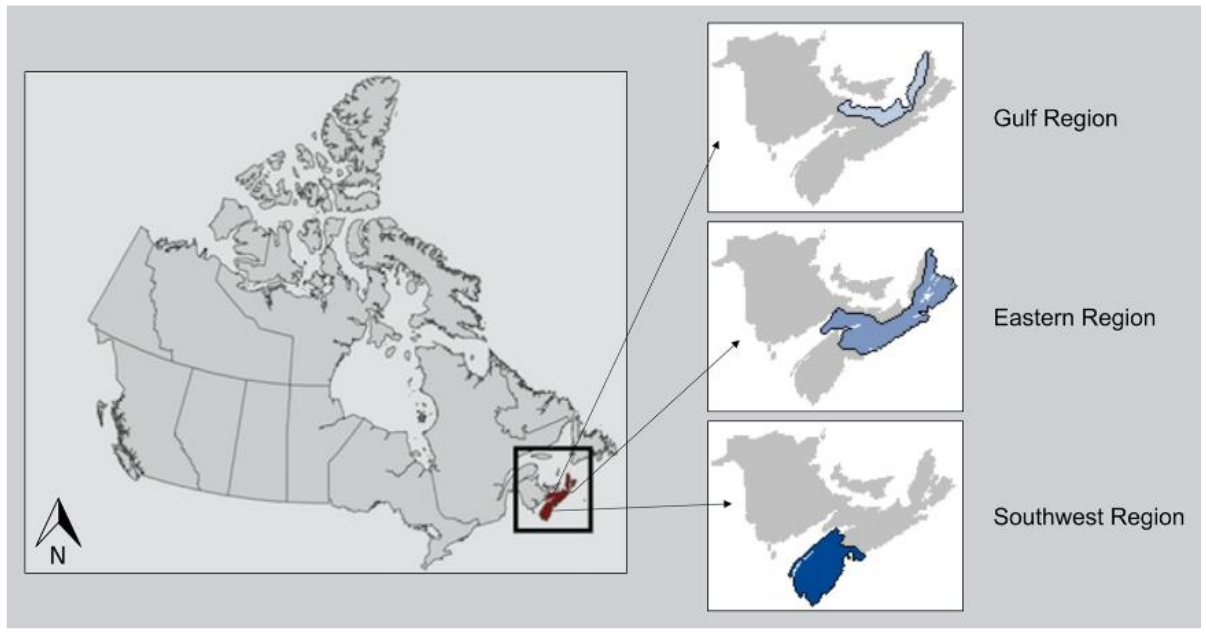
Source: Atlantic PIRI (2012)

Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

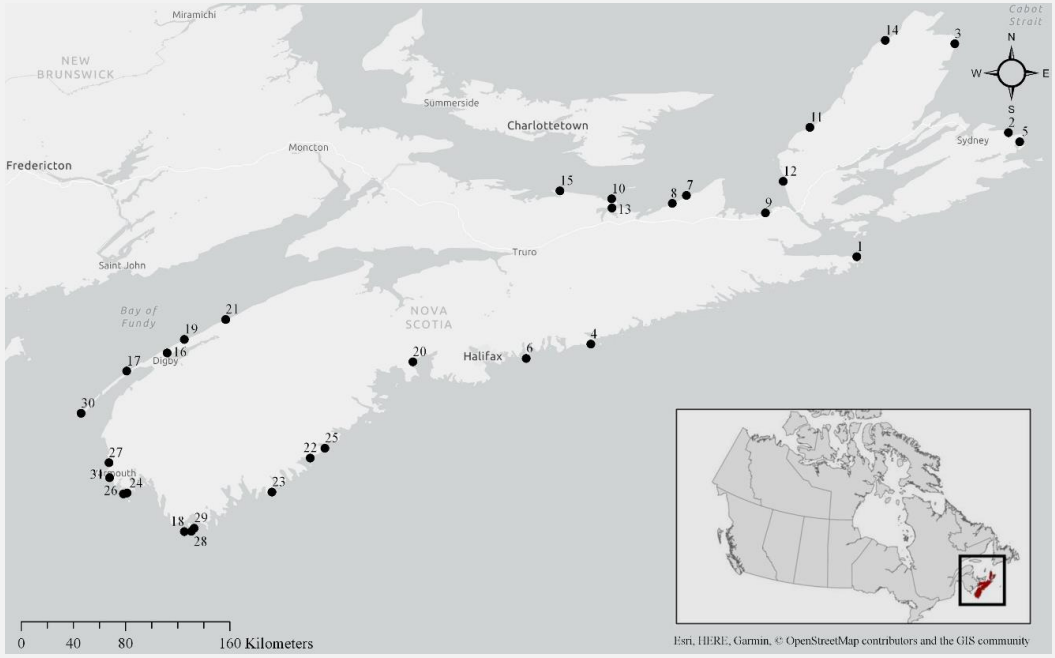
Source: CCME (2014)

RESEARCH SCOPE

Region	Number of selected SCH
Eastern	6 SCH
Gulf	9 SCH
Southwest	16 SCH



Source: Davis et al. (2018)

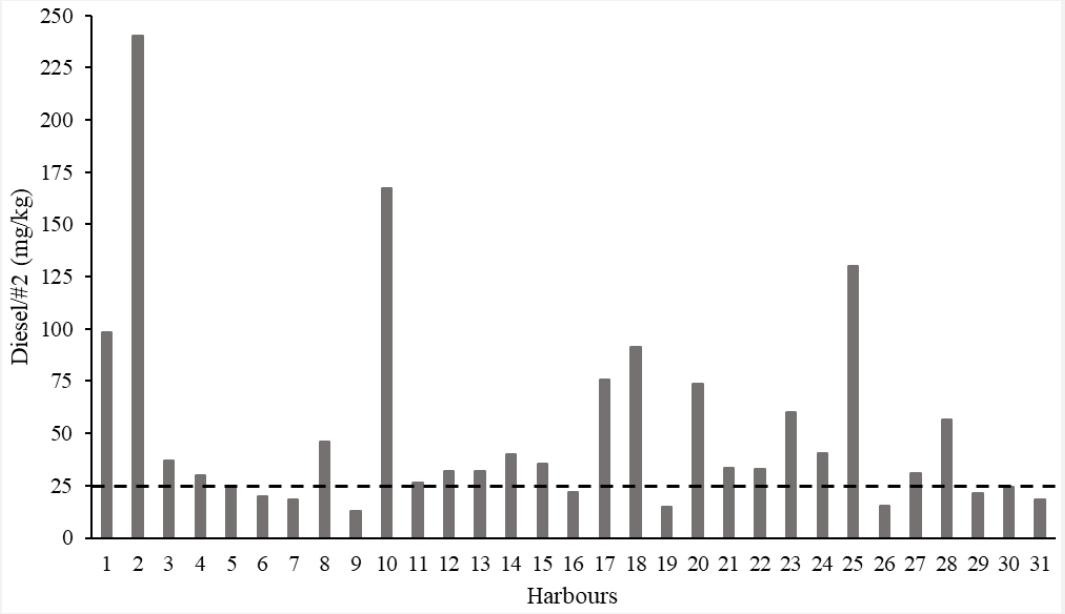


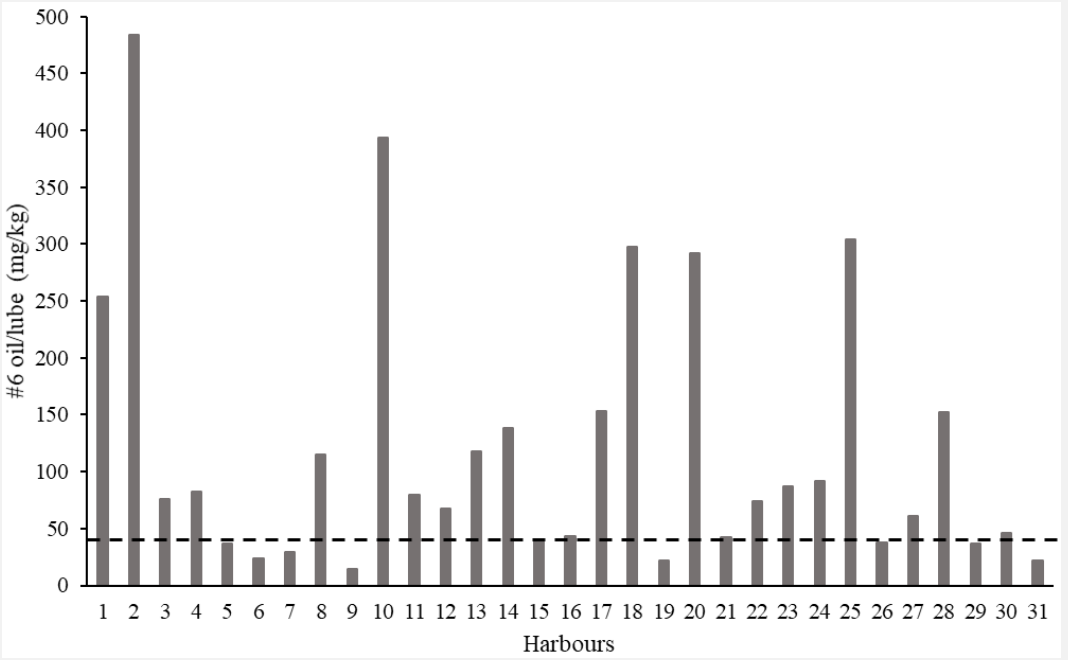
PHCs AND PCBs CHARACTERIZATION

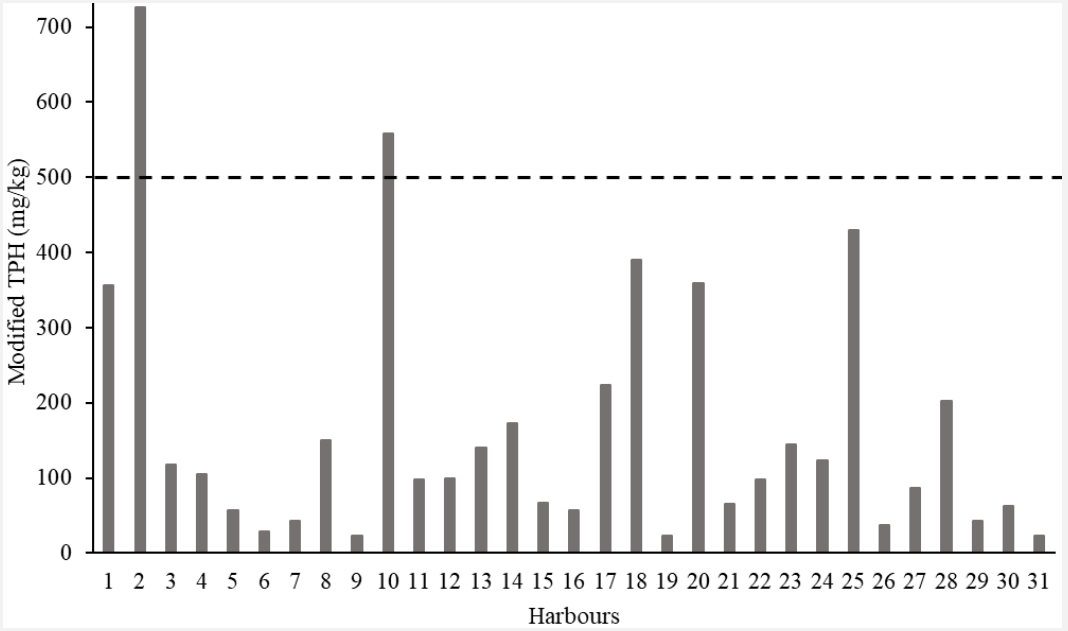
- Historical SCH data was acquired from Marine Sediment Sampling Program reports between 2000 and 2017 for 31 selected SCHs

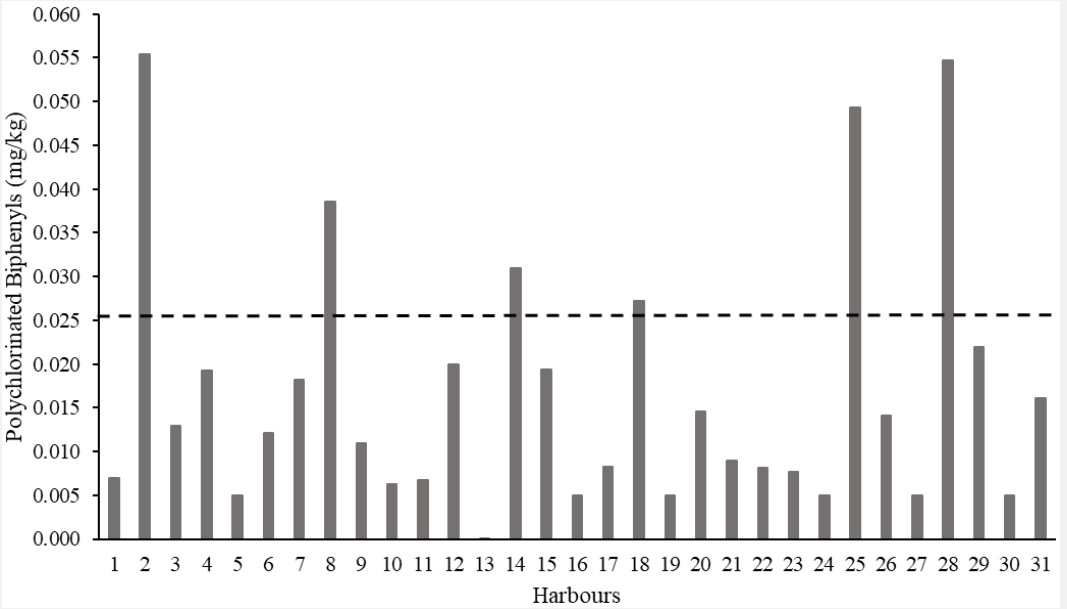
- A total of 528 sediment samples for PHCs and 531 samples for PCBs were used for this characterization

Parameters	Benzene
	Toluene
	Ethylbenzene
	Xylene
	Gasoline (C6 – C10)
	Diesel/#2 (C10 – C21)
	#6 oil/lube (C21 – C32)
	Total Petroleum Hydrocarbons
	Total PCBs

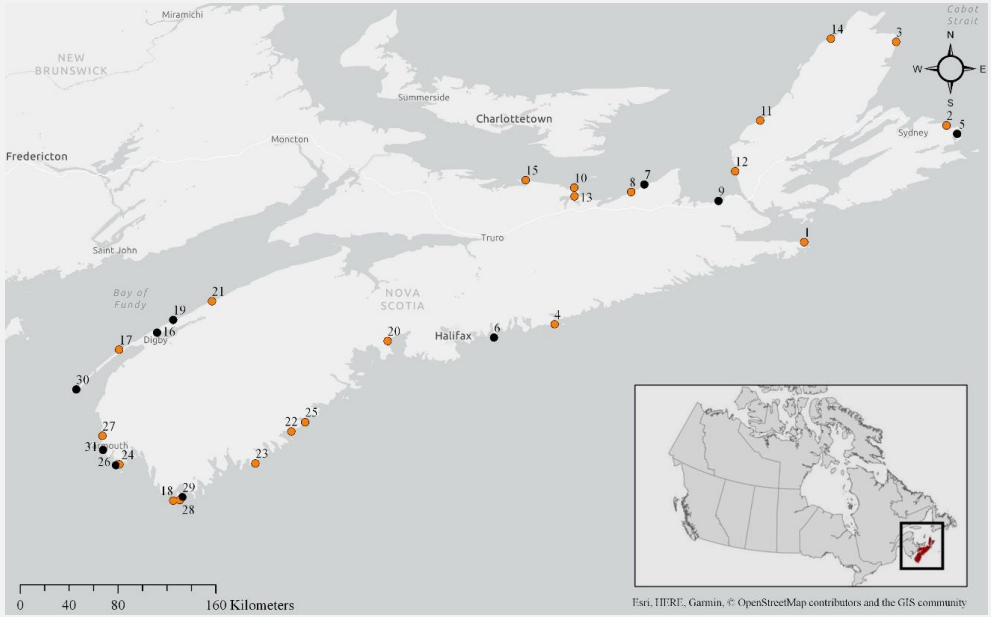

Diesel/#2 (mg/kg)
250
225
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Harbours


#6 oil/lube (mg/kg)
500
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Harbours

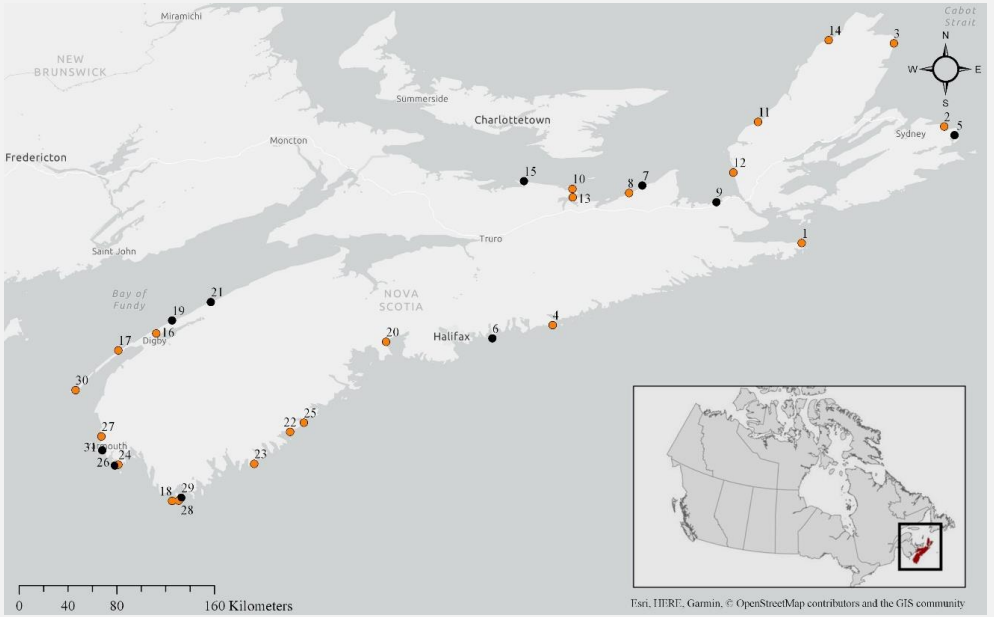

Modified TPH (mg/kg)
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Harbours


Polychlorinated Biphenyls (mg/kg)
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Harbours

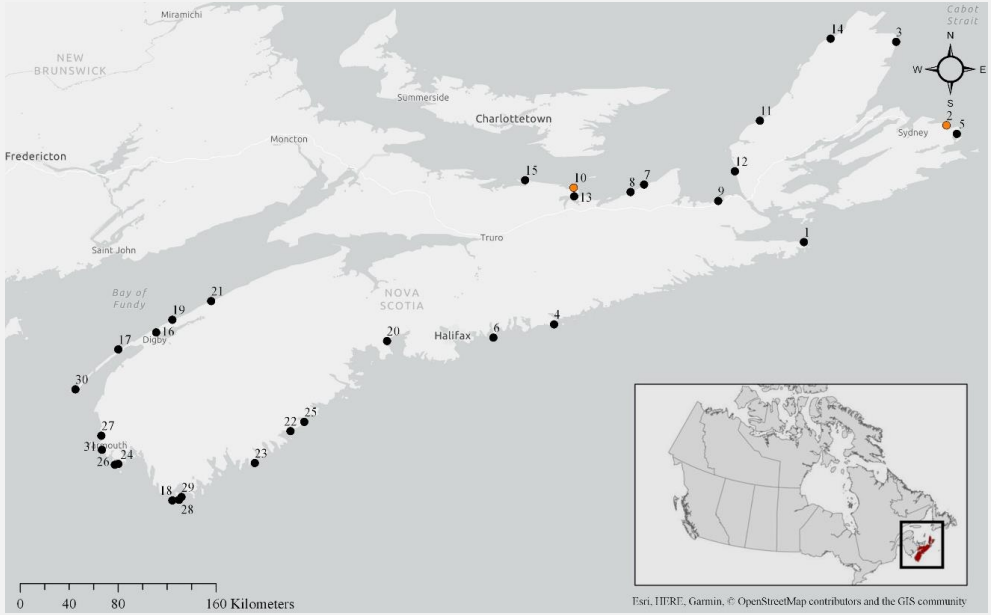
Diesel/#2



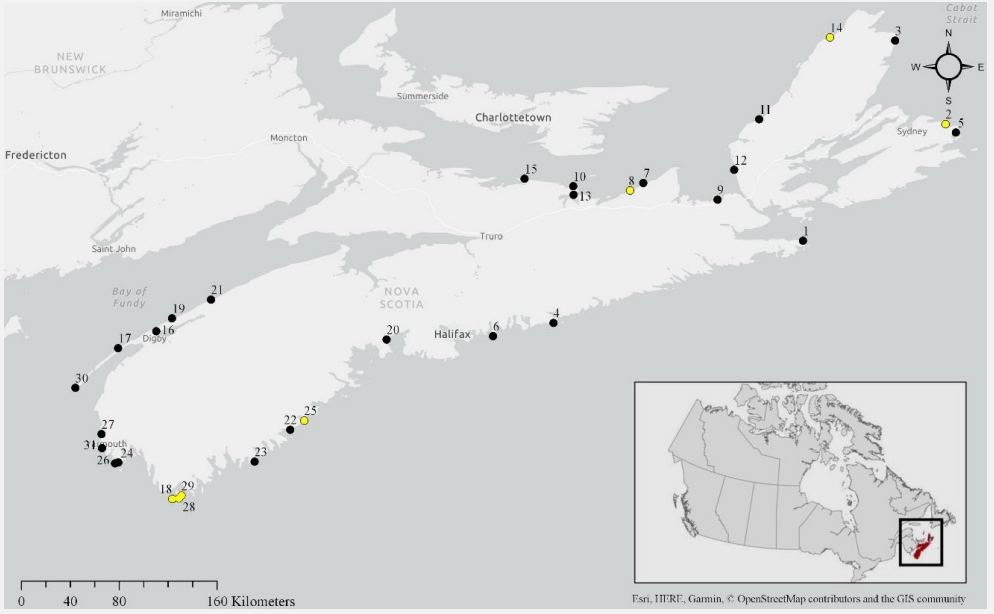
#6 oil/lube



TPH



Total PCBs



KEY FINDINGS

- Nearly half of the collected samples have exceedances for lube oil-resembling hydrocarbons across SCHs and 38% show exceedances of diesel-resembling hydrocarbons
- Only 7% of the samples exceed modified TPH screening level of 500 mg/kg, where benthic impairment is observed
- Results also suggest that PCBs concentrations do not pose a high risk to biota since they fall below CCME PELs and only 25% of SCHs exceed CCME ISQGs, which is a more conservative value

MULTIPLE CONTAMINANT ECOLOGICAL RISK EVALUATION

In Canada, the Federal Contaminated Sites Action Plan has established a Framework for Addressing and Managing Aquatic Contaminated Sites (FCSAP, 2019)

This study only covered the first four steps of the framework by identifying the aquatic site, carrying out a historical review, conducting an initial testing program and determining and initial site classification

METHODOLOGY 1: PROBABLE EFFECT LEVEL QUOTIENT

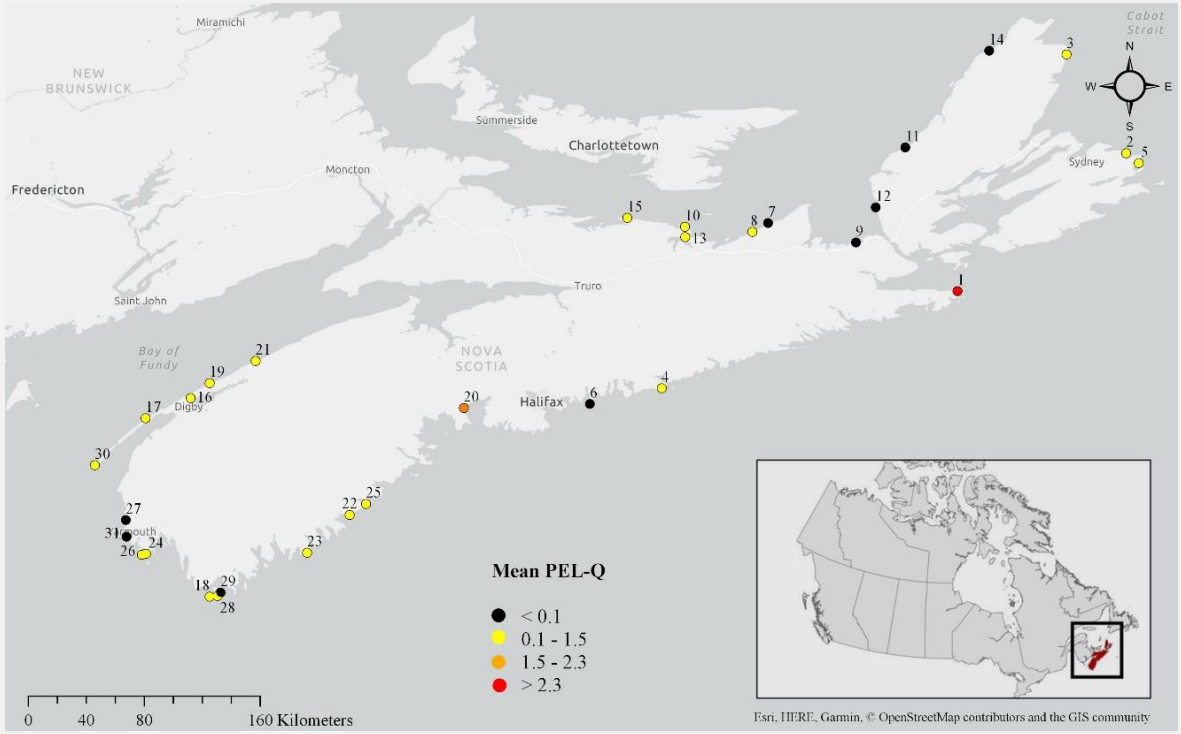
- Mean Probable Effect Level Quotient (mean PEL-Q) methodology established by Long et al. (1995) combines multiple contaminants found in sediments into a single value, while also providing likelihood of their toxicity

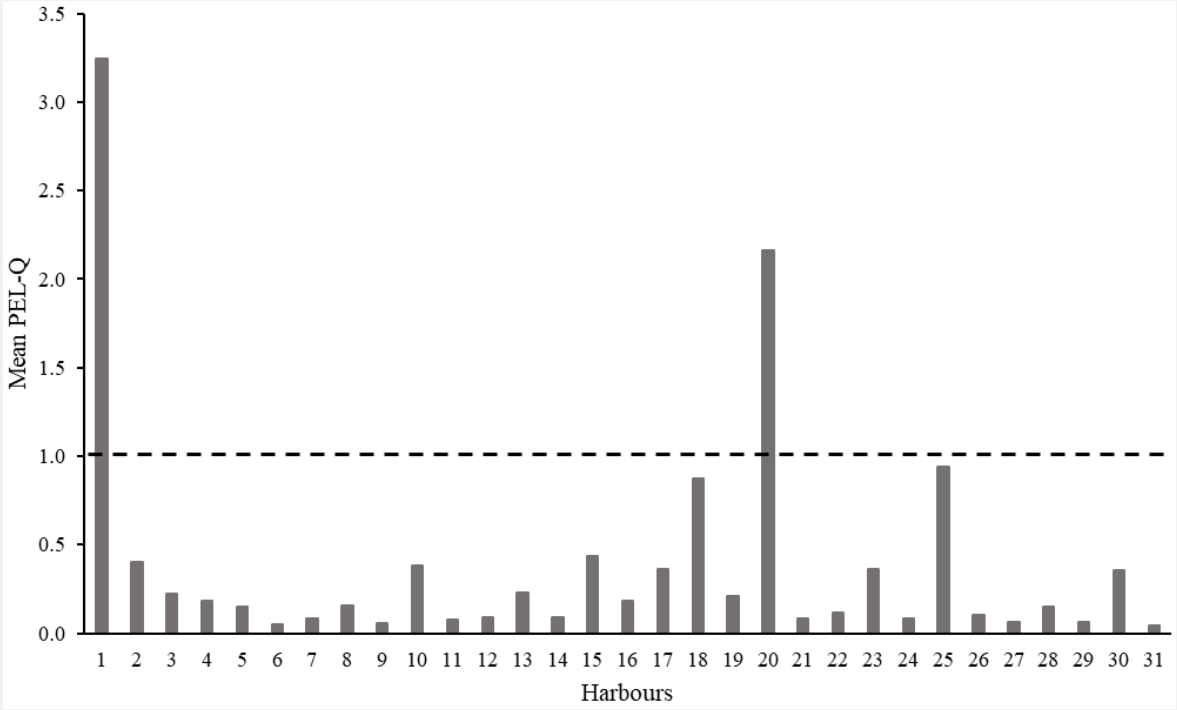
$$mean\ PEL - Q = \frac{\sum \frac{C_i}{PEL_i}}{n}$$

- For this approach, 22 parameters were used: 13 individual PAHs, 8 metals and total PCBs

- Based on Long et al. (2000), mean PEL-Q can be categorized into the following ranges: no risk (<0.1), low risk (0.11 – 1.5), moderate risk (1.51 – 2.3) and high risk (>2.3).

- These values correspond to with 8%, 21%, 49% and 73% likelihood of toxicity, respectively





METHODOLOGY 2: FREQUENCY AND MAGNITUDE OF EXCEEDANCES

To have comparable results across SCH, frequency of exceedances was reported as percentages in each SCH in percentages as opposed to quantity

Degree of difference is defined as how much is a concentration exceeding the established screening level. High results on a study area can indicate presence of a chemical in large quantities

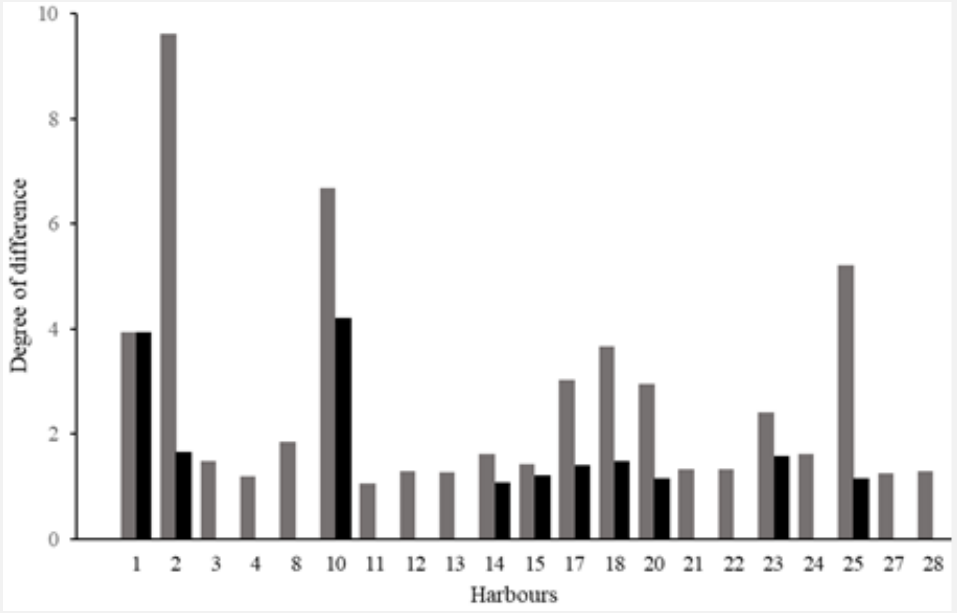
PHCs in SCHs were categorized as no risk, low, moderate or high to based on number and magnitude of exceedances

ADJUSTED ATLANTIC RBCA SCREENING LEVELS

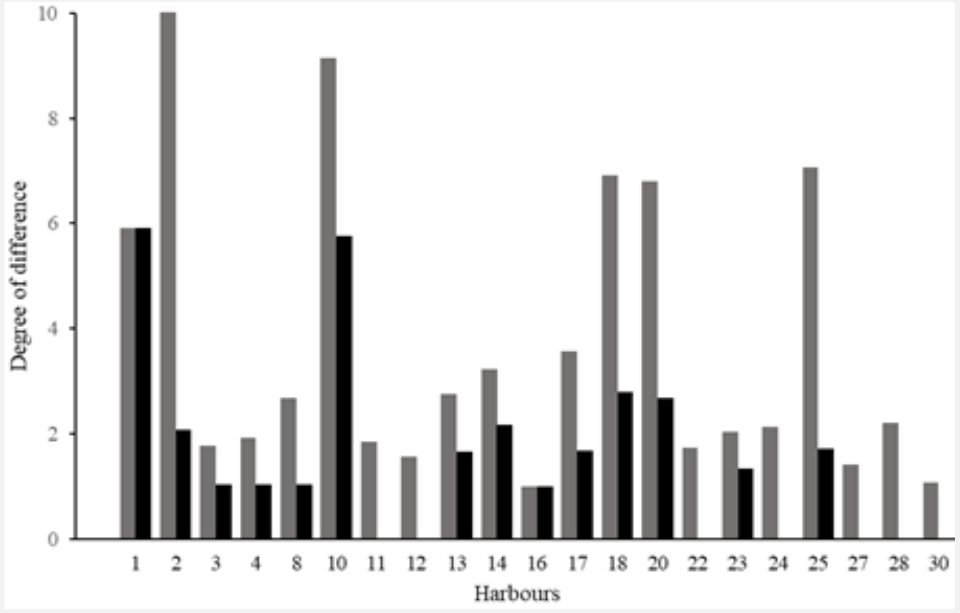
- Equilibrium partitioning allows for site-specific adjustments of screening levels based on total organic carbon (TOC) values

- Screening levels for PHCs categories can be multiplied by TOC percentage in a study area to get a specific threshold, as long as it does not exceed 500 mg/kg (Mroz et al., 2016; Atlantic PIRI, 2012)

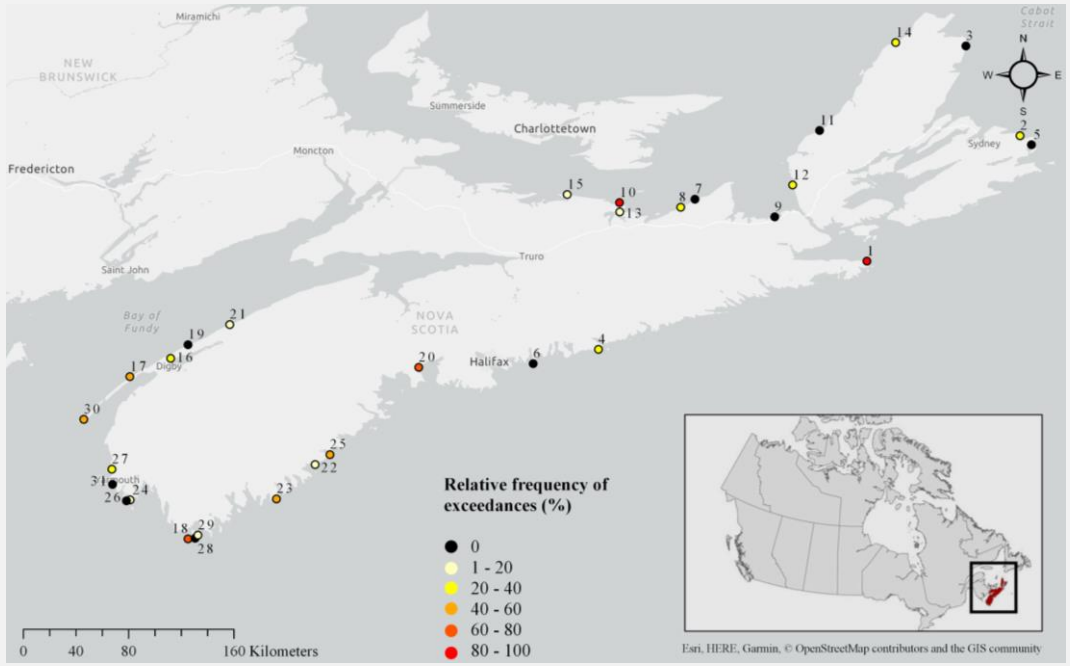
Diesel/#2



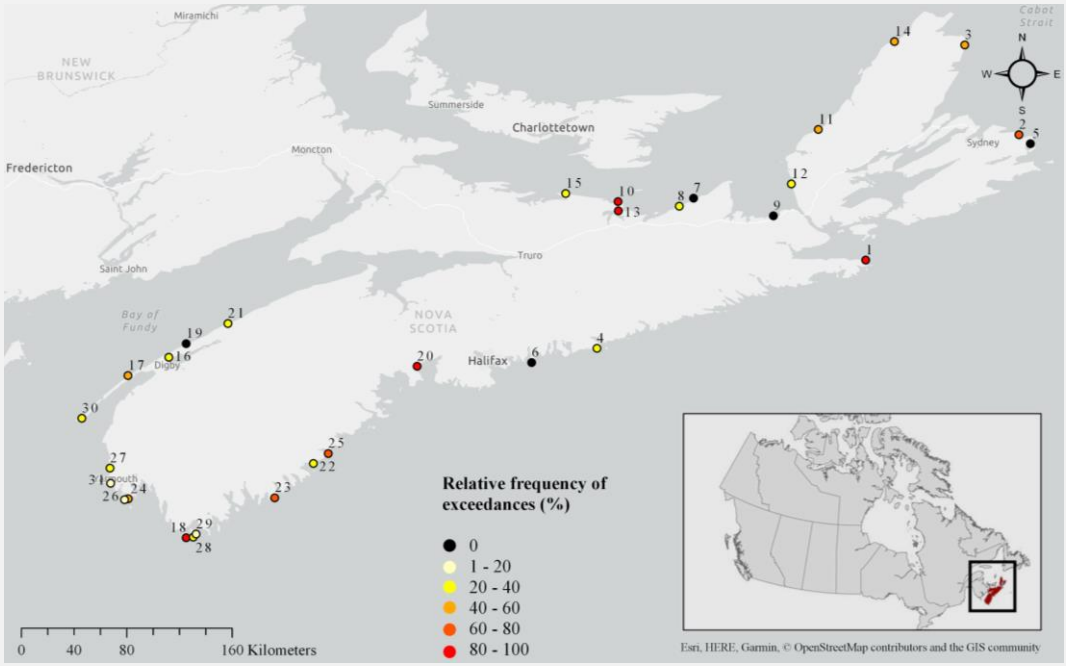
#6 oil/lube



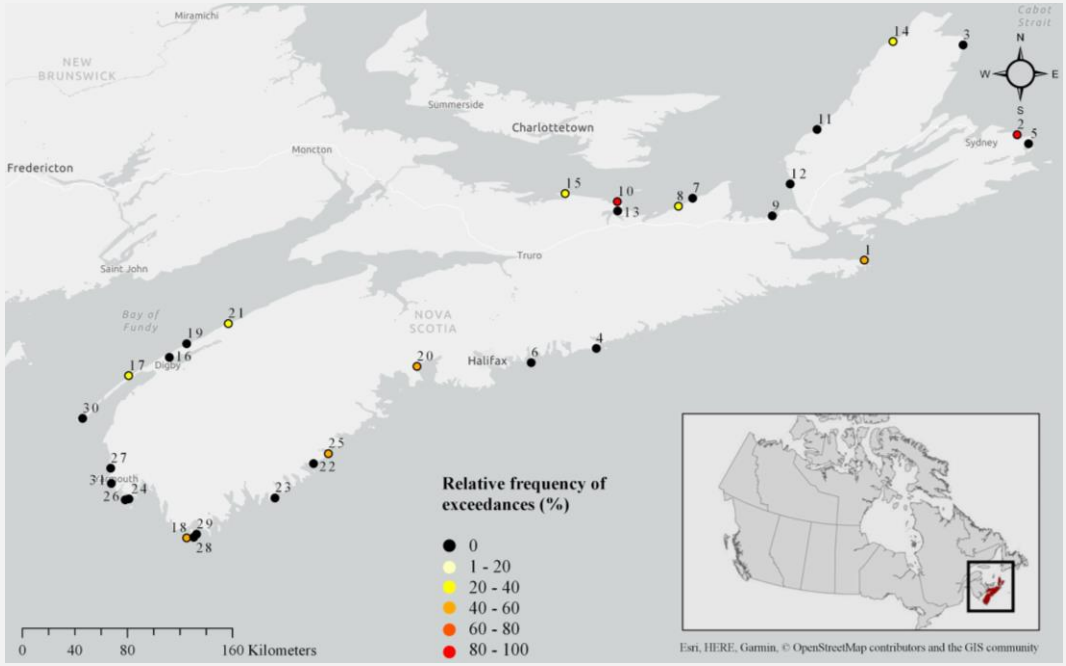
Diesel/#2



#6 oil/lube



TPH



CONCLUSIONS

Most SCHs show negligible to low risk of impact to biota

While urgent action is not needed, monitoring is recommended for moderate risk SCHs to confirm that pollution is not increasing, and to potentially identify and control sources of contamination

Integrated results inform harbour authorities about historical and current state of SCHs, so future risk-management options can be developed and prioritized to comply with established environmental quality standards

Selected references

- Atlantic PIRI (Atlantic Partnership in Risk-Based Corrective Action Implementation) (2012*). Atlantic RBCA (Risk-Based Corrective Action) Version 3: Ecological Screening Protocol for Petroleum Impacted Sites in Atlantic Canada – Scientific Rationale.* Retrieved from: http://www.atlanticrbca.com/wp-content/files_mf/1398280422EcoRBCA_Scientific_Rationale_Aug_1.pdf
- BC MOE (British Columbia Ministry of Environment) (2017). *Environmental Quality Standards*. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/fact-sheets/fs13.pdf
- DFO (Department of Fisheries and Oceans) (2019). *Small Craft Harbours Program*. Retrieved from: http://www.dfo-mpo.gc.ca/sch-ppb/aboutsch-aproposppb/index-eng.html
- Dillon Consulting Ltd. (2015*). Marine Sediment Sampling Program Pinkney's Point Small Craft Harbour (SCH #1241, DFRP 02400) Yarmouth County, Nova Scotia*, Public Works and Government Services Canada, Halifax, NS.
- CCME (Canadian Council of Ministers of the Environment) (2014*). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Retrieved from: http://ceqg-rcqe.ccme.ca/download/en/317
- Davis, E., Walker, T.R., Adams, M., Willis, R. (2018) Characterization of polycyclic aromatic hydrocarbons (PAHs) in small craft harbour (SCH) sediments in Nova Scotia. Canada. *Marine Pollution Bulletin*. 137: 285-294.
- FCSAP (Federal Contaminated Sites Action Plan) (2019). *Framework for Addressing and Managing Aquatic Contaminated Sites Under the FCSAP*. Retrieved from: https://www.dfo-mpo.gc.ca/pnw-ppe/fcsap-pascf/docs/1-eng.htm
- Jain, R., Urban, L., Balbach, H. Webb, M.D. (2012). *Handbook of Environmental Engineering Assessment*. Butterworth-Heinemann.
- Jarvis, D. (2008). *Clark's Harbour*. Retrieved from: https://www.flickr.com/photos/archer10/2332388086/
- Long, E. R., MacDonald, D. D., Smith, S. L., & Calder, F. D. (1995). Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19, 81–97.
- Long, E. R., Field, L. J., & MacDonald, D. D. (1998). Predicting toxicity in marine sediments with numerical sediment quality guidelines. Environmental Toxicology and Chemistry. 17, 714–727.
- Long, E. R., MacDonald, D. D., Severn, C.G., & Hong, C.B. (2000). Classifying probabilities of acute toxicity in marine sediments with empirically derived sediment quality guidelines. Environmental Toxicology and Chemistry. 19(10), 2598-2601
- Meloche, L., & Mcdonald, C. (2018, May 10). *Risk Management of a Small Craft Harbour in British Columbia* [Presentation]. Bettering Environmental Stewardship & Technology Conference 2018. Whistler, British Columbia, Canada. http://bceia.com/best/wp-content/uploads/2018/05/Meloche_McDonald.pdf
- Mroz, R., Klee, U., & Willis, R. (2016, April). *Petroleum Hydrocarbon Sediment Quality Guidelines* [Presentation]. Real Property Institute of Canada Federal Contaminated Sites National Workshop. Montreal, Quebec, Canada. https://www.rpic-ibic.ca/documents/2016_FCS_NW/Presentation/45_Mroz_EN.pdf
- Walker, T. R., MacLean, B., Appleton, R., McMillan, S., & Miles, M. (2013). Cost-Effective Sediment Dredge Disposal Options for Small Craft Harbors in Canada. *Remediation Journal*, 23(4), 123–140. https://doi.org/10.1002/rem.21371
- Walker, T.R., Willis, R., Gray, T., MacLean, B., Mcmillan, S., Leroy, M., Appleton, R., Wambolt, N., Smith, M. (2015). Ecological Risk Assessment of Sediments in Sydney Harbour, Nova Scotia, Canada. *Soil and Sediment Contamination: An International Journal*. 24(5): 471-493.
- Zhang, H., Walker, T. R., Davis, E., & Ma, G. (2019a). Spatiotemporal characterization of metals in small craft harbour sediments in Nova Scotia, Canada. *Marine Pollution Bulletin*, 140, 493–502. https://doi.org/10.1016/j.marpolbul.2019.02.004
- Zhang, H., Walker, T.R., Davis, E., Guofeng, M. (2019b) Ecological risk assessment of metals in small craft harbour sediments in Nova Scotia, Canada. *Marine Pollution Bulletin*. 146: 466-475.

Myriam Mora, B.Eng.

Master of Environmental Studies Candidate

myriam.mora@dal.ca

DALHOUSIE UNIVERSITY

ASPIRE

Mitacs