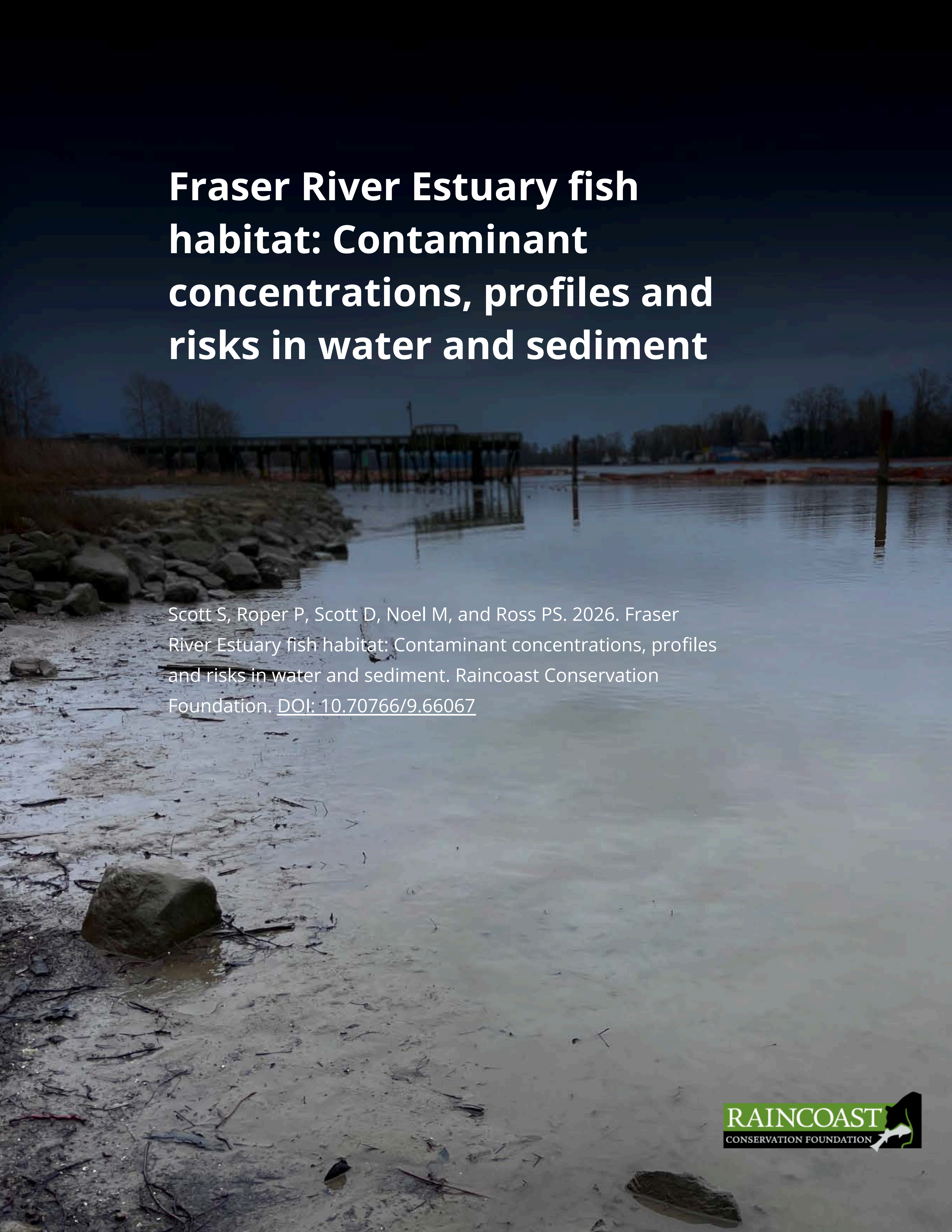
Fraser River Estuary fish habitat: Contaminant concentrations, profiles and risks in water and sediment



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Contributions by SGS Axys: Pam Mackenzie and Richard Grace.

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Executive summary

Water is essential for life, and steps are needed to understand, protect and restore its health in fish habitat throughout British Columbia. The Raincoast Healthy Waters program was launched in 2023 to establish community-oriented water pollution monitoring in select BC watersheds. In this study, we conducted a risk-based assessment of a suite of contaminants of concern in the Fraser River Estuary, an important feeding, rearing and migratory habitat for Pacific salmon.

Our team determined basic water properties (temperature, conductivity, pH, dissolved oxygen and turbidity) *in situ* at sampling sites on March 19, 2025. Water and intertidal sediment samples were then collected from 10 sites within the Fraser River Estuary, including five sites in the North Arm of the river, four sites in the South Arm of the river, and one site upstream in the Fraser River main stem. Two water samples (NA-OS and SA-TS) were submitted to both ALS and SGS-Axys for a comprehensive contaminant analysis including: coliform, nutrients (6), physical parameters, metals (37), pesticides (62), polycyclic aromatic hydrocarbons (PAHs; 76), pharmaceuticals and personal care products (PPCPs; 141), polychlorinated biphenyls (PCBs; 209), alkylphenol ethoxylates (APEs; 4), bisphenols (BPs; 6), per- and poly-fluoroalkyl substances (PFAS; 40), and sucralose. Analysis of 6PPD-quinone is pending. The remaining eight water samples were submitted to ALS Environmental for determination of coliform, nutrients (6), physical parameters, and metals (37). Sediment samples from all 10 sites were submitted to SGS Axys for comprehensive contaminant analyses: polycyclic aromatic hydrocarbons (PAHs; 76), polychlorinated biphenyls (PCBs; 209), polybrominated diphenyl ethers (PBDEs; 209), dioxins and furans (DFs; 19), alkylphenol ethoxylates (APEs; 4), bisphenols (BPs; 6), and per- and poly-fluoroalkyl substances (PFAS; 40).

Key findings

- We collected 10 water and 10 sediment samples in the Fraser River Estuary (March 19, 2025), and analysed these for water properties and a suite of inorganic and organic contaminants of concern.
- North Arm water samples had 1.4 times higher concentrations of most contaminants, with the exception of PPCPs, sucralose, and APEs that were 1.9 times higher in the South Arm water.

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- The number of contaminants detected in the North Arm water sample was 237 out of 587 measured, compared to the 213 contaminants that were measured in the South Arm (this does not include water quality parameters, physical contaminants, nutrients, or coliform bacteria).
- Average total sediment contaminant concentrations were 6.5 times higher in the North Arm than in the South Arm.
- The average number of contaminants detected in the North Arm sediment samples was 298 out of 420, compared to the 281 contaminants that were measured in the South Arm and the 269 that were measured in the upstream Main Stem site.
- Average sediment contaminant concentrations in both the North and South Arm were generally higher than the concentrations detected in the upstream MS-SL (Sapperton Landing) sample.
- In sediments, the NA-SS (Shaughnessy Street) sample had the greatest number of Environmental Quality Guideline exceedances, followed by the NA-OS (Oak Street):
    - There were **40** exceedances of Canadian Environmental Quality Guidelines in **sediment**, with 37 of these in the North Arm samples, and three in the South Arm samples. There were no exceedances in the sediment sample from the upstream MS-SL (Sapperton Landing) sample.
    - These sediment exceedances were dominated by Polycyclic Aromatic Hydrocarbons (PAH; 29), followed by Dioxins and Furans (DFs; 6), pesticides (n=3), Polychlorinated Biphenyls (PCBs; 1), and Polybrominated Diphenyl Ethers (PBDEs; 1).
    - There were **32** exceedances of Canadian Environmental Quality Guidelines in **water.** These were observed in both the North Arm (16) and South Arm (16), and **4** exceedances in the upstream MS-SL (Sapperton Landing) sample.
    - These water exceedances included Aluminum (Al; 10), Iron (Fe; 10), Silver (Ag; 2) and Ammonia (NH_3; 4).
    - There were **6** exceedances of Health Canada Recreational Use Guidelines for *E. coli*.
- Results suggest that the Fraser River Estuary is influenced by metals of upstream geological or glacial origin, coupled with anthropogenic activities in and above the North Arm.
- PAHs from industrial activities, road runoff and smoke are degrading North Arm fish habitat, while municipal wastewater, road runoff and industrial activities are degrading South Arm fish habitat.
- The consequences for fish health in this salmon rearing area are troubling and merit further investigation.

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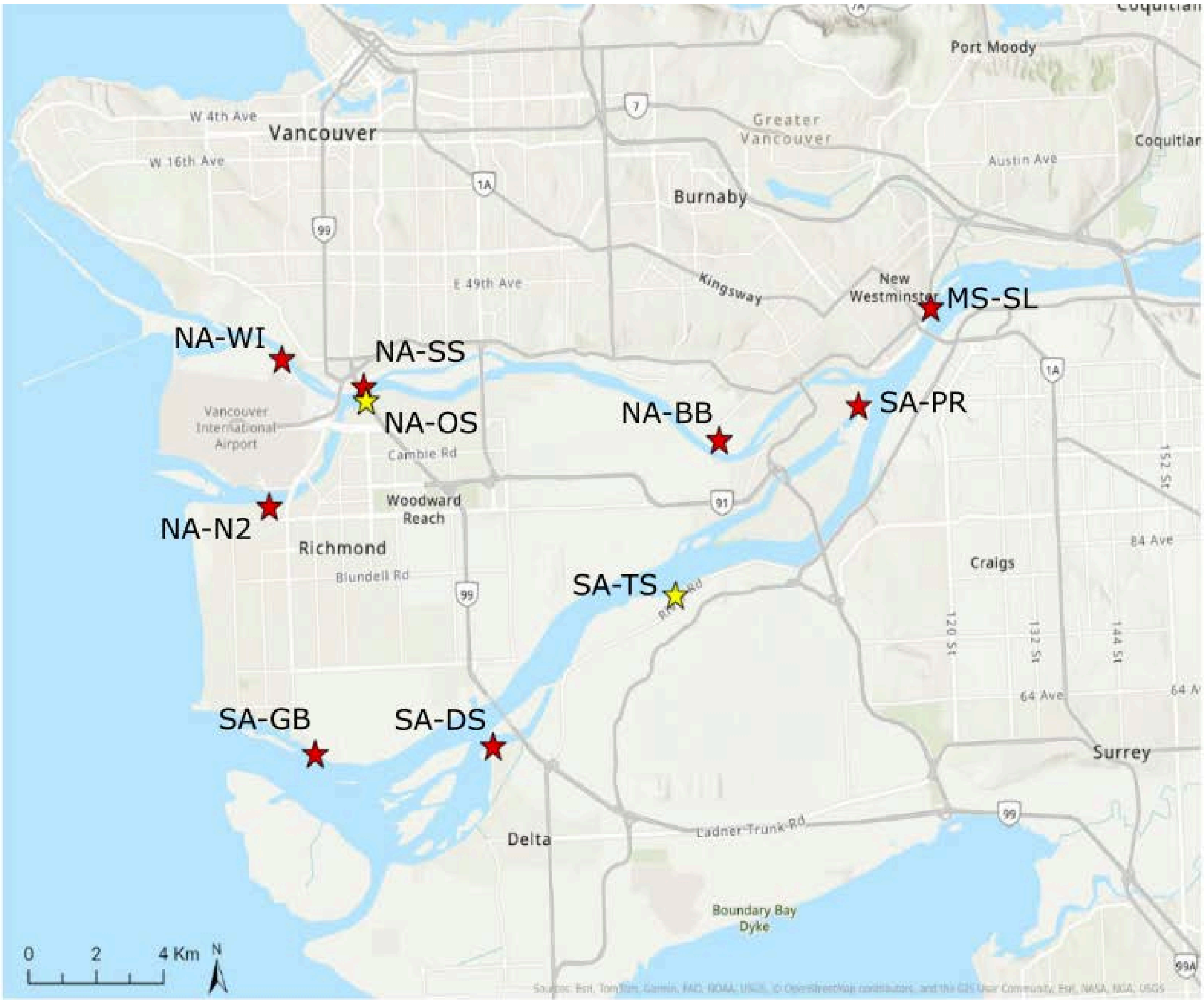
Figure 1: The Fraser River Estuary



The Fraser River Estuary stretches from New Westminster, through the tidal delta region, and out to the Strait of Georgia and Salish Sea. The estuary is the traditional territory of the Sto:lo, Musqueam, Tsawwassen, Kwantlen, and other Coast Salish peoples, who have lived, fished, and managed resources in this area for thousands of years. Their traditional use areas include the lower Fraser River, its tidal flats, marshes, channels, and floodplains, as well as the surrounding lands and nearshore coastal waters of the estuary. The estuary covers approximately 1,375 km^2, encompassing a mosaic of habitats including river channels, intertidal mudflats, salt marshes, eelgrass beds, and shallow bays. These habitats are critically important for salmon, providing rearing, migration, and overwintering areas for the five species of Pacific salmon. Juvenile salmon rely on the estuary for refuge, feeding, and growth as they transition from freshwater to the marine environment, while adult salmon use the lower river and tidal channels as migratory corridors to upstream spawning grounds. The estuary also supports other fish species, waterfowl, and aquatic invertebrates, making it a region of high ecological productivity. Sampling sites were distributed throughout the estuary to capture a range of habitats for our assessment, including areas of critical salmon rearing and migratory pathways (Map by Brooke Gerle / Raincoast Conservation Foundation).

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Acknowledgements

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Team

- Healthy Waters Program: Sam Scott and Peter Ross
- Lower Fraser Salmon Program: David Scott and Paige Roper

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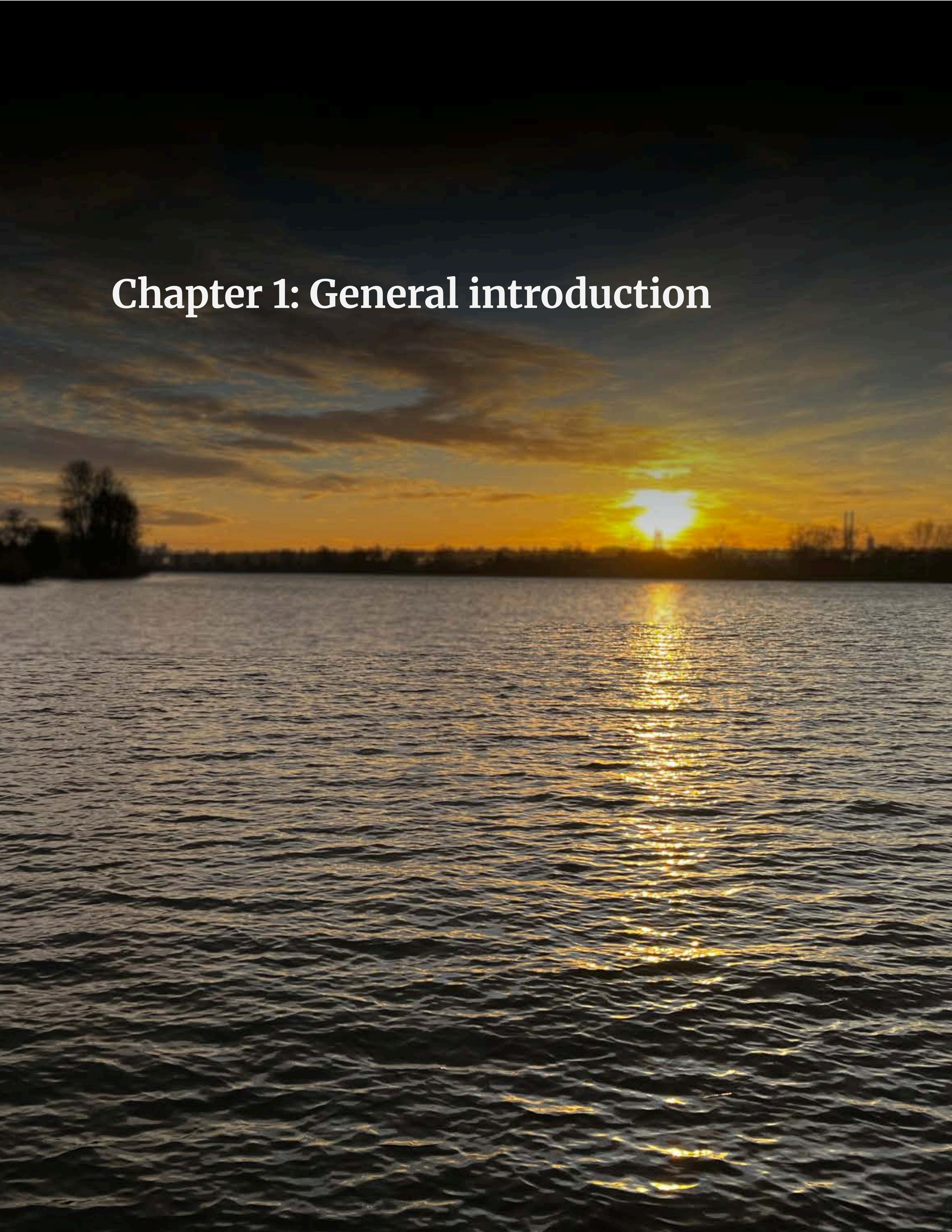
Chapter 1: General introduction



Background

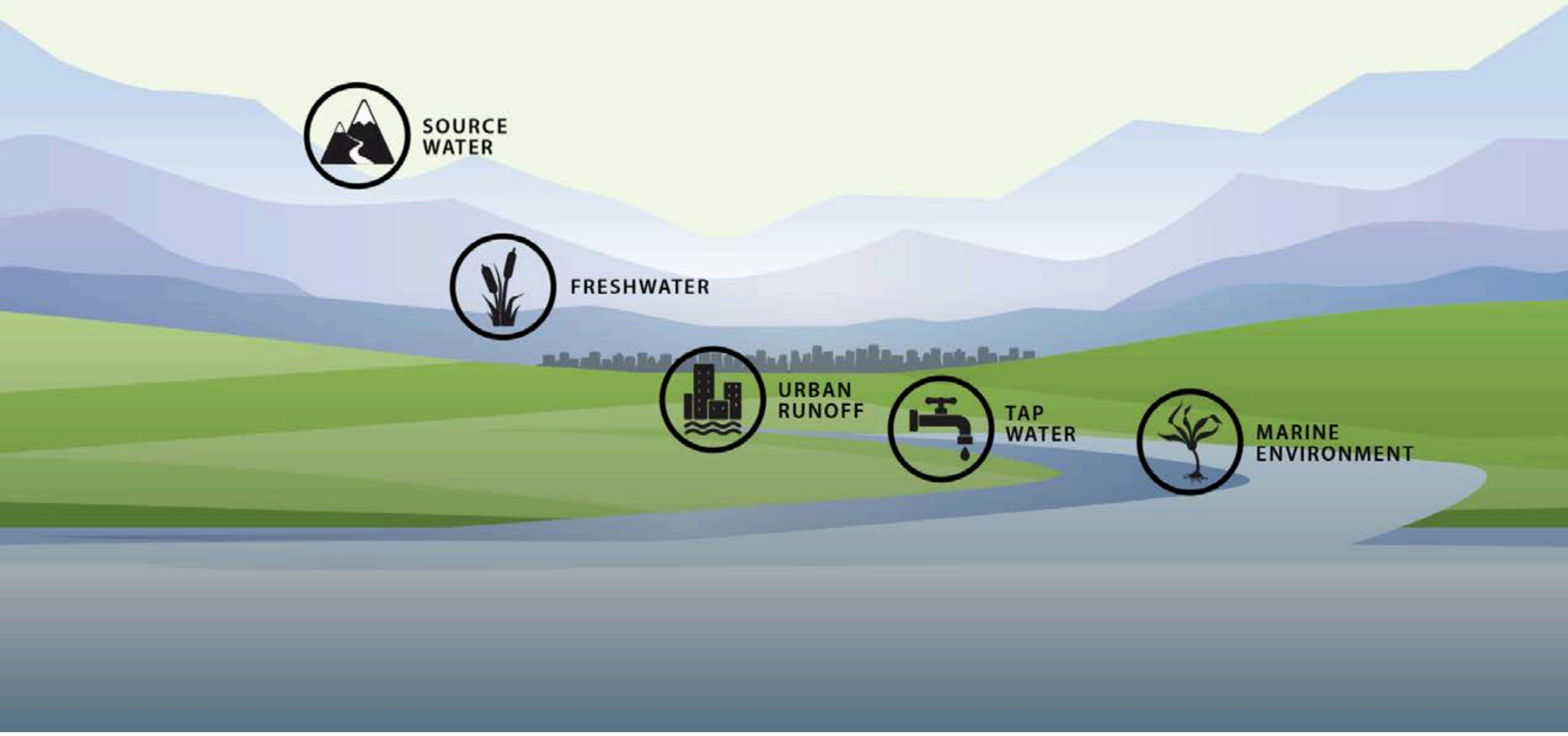
Raincoast's Healthy Waters Program (https://www.raincoast.org/waters/) delivers high-resolution, community-oriented water quality analysis to watersheds across southern British Columbia. The goal of Healthy Waters is to empower communities with the understanding of the status of water quality in their watersheds, to allow for local advocacy regarding both point and nonpoint source pollution.

Raincoast's Wild Salmon Program (https://www.raincoast.org/salmon/) is focused on ensuring that wild salmon thrive across their historic range at abundance levels that sustain wildlife and communities. The Wild Salmon Program addresses threats facing the survival of wild salmon. We offer solutions to the systemic problems that drive short-sighted and commodity-based decisions on the land, in the water, and over resources, by all levels of government.

Raincoast's Wild Salmon Program has been working in the Lower Fraser River to conduct research and restoration projects focused on juvenile salmon and their habitats. The Fraser River is home to an amazing diversity of salmon populations which spawn throughout the watershed each year. As juveniles, all Fraser salmon must migrate through the Lower Fraser and estuary, and some species and populations such as Harrison River Chinook use the area extensively for important feeding and growth opportunities prior to entering the ocean. Juvenile salmon growth is thought to be an important determinant of marine survival, therefore protecting and restoring these estuary habitats is important to salmon conservation.

As part of our research, we wanted to better understand potential contaminant exposure for juvenile salmon in the Lower Fraser and estuary, a potential stressor for which until just recently there had been little study. We know that the vast majority of estuary habitats have been lost or disconnected, with few remaining intact marshes to support salmon. Therefore we have been working to restore marsh habitats across the Lower Fraser and estuary, with funding from the BC Salmon Restoration and Innovation Fund and the Aquatic Ecosystem Restoration Fund. As part of this work, we partnered with our Healthy Waters program to investigate potential contaminant exposure at our restoration sites as well as other reference sites across the area.

A watershed based approach to sampling



Healthy Waters

The Raincoast Healthy Waters program is a community-oriented water pollution monitoring initiative. We collect samples from five different categories of water in each of our partner watersheds: from source water, upstream of human impacts, down to the marine environment. We work with top service laboratories to analyse samples for 587 contaminant analytes. This high resolution approach to analysis generates data with low Detection Limits and enables an invaluable opportunity to identify activities within watersheds that are contributing to the degradation of fish habitat. Results help to inform opportunities for best practices within the watersheds and the restoration of healthy fish habitats.

The lessons learned from our partnering watersheds will contribute to a greater understanding of threats to water quality across British Columbia, and ultimately what policy changes can be implemented to preserve the quality of water for the future of salmon, whales, and people.

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Lower Fraser Research and Restoration - Wild Salmon Program

Raincoast has been conducting long-term monitoring of Fraser River juvenile salmon in partnership with xʷməθkʷəy̓əm (Musqueam) Environmental Stewardship Program, Ducks Unlimited, and three enlisted field crews. This builds on our understanding of juvenile salmon in one of Canada's most important estuaries, while helping us develop and answer questions about the juvenile life stages of salmon.

Raincoast has been busy with restoration projects in the Fraser River Estuary, an initiative that benefits from an assessment of the contaminants present in fish habitat in the area. This year, we completed construction on a previous restoration project at Woods Island, a conservation area that had lost its ability to function as salmon habitat after its initial restoration. Since increasing connectivity and deepening its channels, lowering elevation, and planting native species, we have improved marsh habitat and have already observed more salmon and native fish passage at this site.

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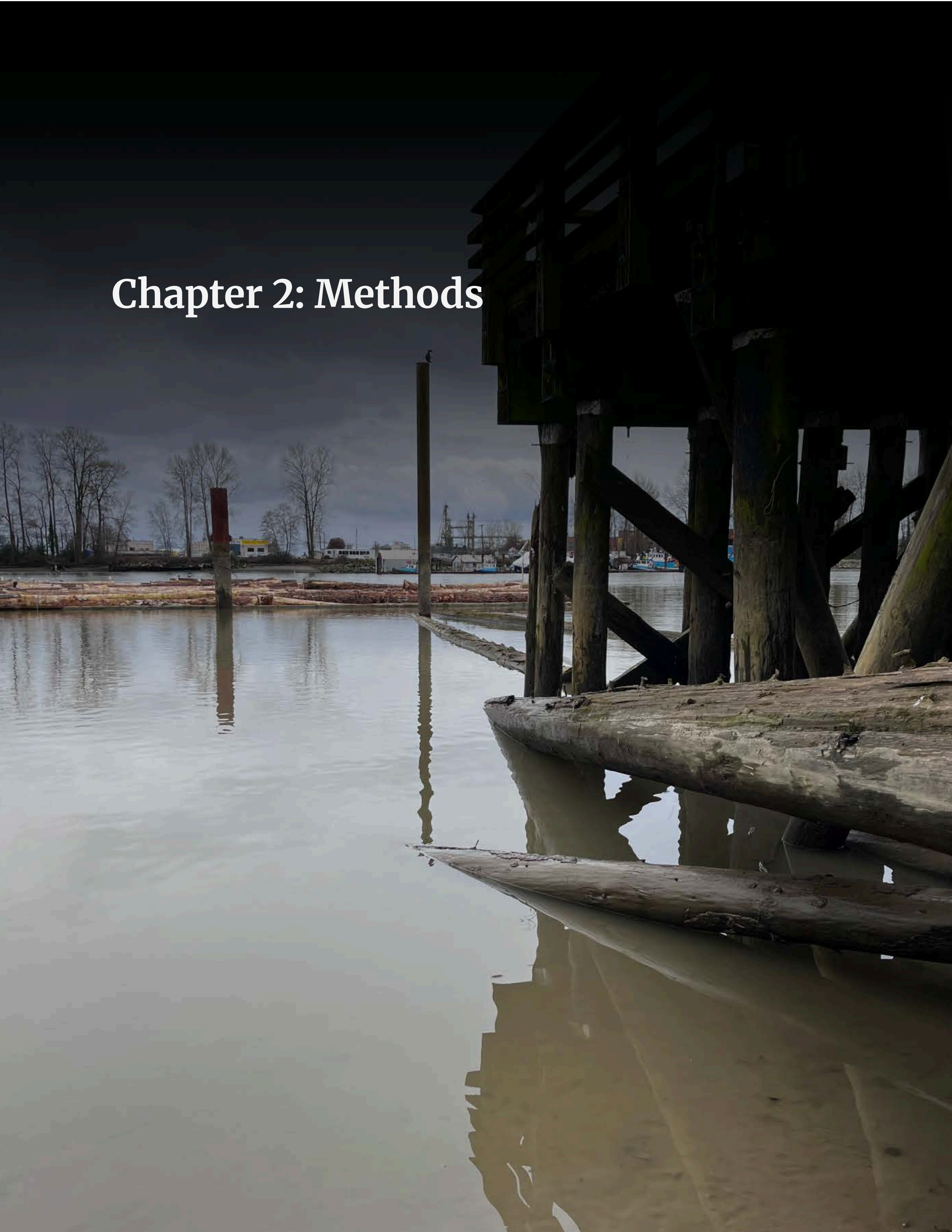
Chapter 2: Methods



Field sampling

A total of 10 water samples and 10 sediment samples were collected from field locations within the Fraser River Estuary on March 19, 2025 by the Raincoast team.

A portable water properties meter (YSI-ProDSS) was deployed to measure temperature, pH, conductivity, dissolved oxygen and turbidity.

Samples were submitted to service labs for additional analyses: ALS Environmental, SGS-AXYS, and the Raincoast Conservation Genetics Lab. Contaminant analytes were determined in water samples according to established protocols (see Table 2).

Table 1: Sampling sites in the Lower Fraser estuary

Sample ID	Site Name	Latitude/Longitude
NA-BB	Burnaby Big Bend	N 49.184637, W 122.981884
NA-SS	Shaughnessy Street	N 49.201453, W 123.125455
NA-OS	Oak Street Ref	N 49.198068, W 123.124777
NA-N2	Richmond No. 2 Comp	N 49.173515, W 123.165631
NA-WI	Woods Island Reference	N 49.209070, W 123.158367
MS-SL	Sapperton Landing	N 49.214284, W 122.893814
SA-DS	Deas Slough	N 49.113063, W 123.078428
SA-GB	Gilbert Beach	N 49.113184, W 123.150665
SA-TS	Tilbury Slough	N 49.147612, W 123.002079
SA-PR	Port Royal	N 49.191382, W 122.924770

Ten sites were sampled; five in the North Arm (NA) of the Fraser River, four in the South Arm (SA), and one in the Fraser River Main Stem (MS) above where the river splits. Sediment and water samples were collected from all 10 sampling sites.

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Water quality analyses

Table 2: List of analytes, analysis locations, analytical methods, instruments, and number of samples submitted to service labs

Analyte	Laboratory	Analytical Method	Instruments	No. samples analysed
Tier 1				
Temperature (℃)	in situ		YSI ProDSS	10
Dissolved Oxygen (%, mg/L)	in situ	optical sensor	YSI ProDSS	10
Turbidity (FNU)	in situ		YSI ProDSS	10
Conductivity (uS/cm)	in situ		YSI ProDSS	10
pH	in situ		YSI ProDSS	10
Tier 2				
Total Suspended Solids (TSS)	ALS Environmental	APHA 2540 D (mod)	gravimetry	2
Total Dissolved Solids (TDS)	ALS Environmental	APHA 2540 C (mod)	gravimetry	2
Hardness	ALS Environmental	APHA 2340B	calculated	10
Total Organic Carbon (TOC)	ALS Environmental	APHA 5310 B (mod)	combustion	2
Chemical Oxygen Demand (COD)	ALS Environmental	APHA 5220 D (mod)	colorimetry	2
Biological Oxygen Demand (BOD)	ALS Environmental	APHA 5210 B (mod)	dissolved oxygen meter	2
Nitrate	ALS Environmental	EPA 300.1 (mod)	ion chromatography	2
Ammonia	ALS Environmental	Method Fialab 100, 2018	fluorometry	10
Phosphate	ALS Environmental	APHA 4500-P F (mod)	colorimetry	2
Total Metals	ALS Environmental	EPA 200.2/6020B (mod)	Collision/Reaction Cell ICPMS	10

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Total coliform	ALS Environmental	APHA 9223 (mod)	MPN	10
Fecal coliform	ALS Environmental	APHA 9223 (mod)	MPN	10
E. coli	ALS Environmental	APHA 9223 (mod)	MPN	10
MST (in Development)	RCF Conservation Genetics Lab (PSEC)	In development		2
6PPD-quinone	Pending		LCMS	2
Tier 3				
Alkylphenol Ethoxylates (APEs)	SGS Axys Analytical	SGS AXYS METHOD MLA-004 Rev 07	GC-MS	5
Bisphenols	SGS Axys Analytical	SGS AXYS METHOD MLA-113 Rev 01	LC-MS/MS	5
Multiresidue Pesticides	SGS Axys Analytical	EPA 1699 (mod)	HRMS	5
Per and Poly-fluoroalkyl substances (PFAS)	SGS Axys Analytical	EPA 1633 Draft	LC-MS/MS	5
Pharmaceuticals and Personal Care Products (PPCPs)	SGS Axys Analytical	EPA 1694	HPLC/MS/MS	5
Polychlorinated biphenyls (PCBs)	SGS Axys Analytical	SGS AXYS METHOD MLA-210 Rev 01	GC-MS/MS	5
Polycyclic Aromatic Hydrocarbons (PAHs)	SGS Axys Analytical	EPA 8270/ EPA 1625	GC-MS	5
Sucralose	SGS Axys Analytical	MLA-116	LC-MS/MS	5

Two sites (NA-OS and SA-TS) were analysed for a comprehensive list of analytes in water.

Data handling

In some cases, contaminants were not detected in our water samples and concentrations were therefore considered to be 0 for the calculations of totals.

With each batch of samples, analytical laboratories ran blank samples (e.g. samples that go through the same laboratory processes as our environmental samples) that should, in theory, not contain any contaminants. However, in some cases, blank samples contained low concentrations of contaminants. These levels in blanks were subtracted from the concentrations measured in each of our environmental samples ('blank correction').

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Environmental Quality Guidelines

We interpreted contaminant concentrations using three sets of Canadian environmental quality guidelines (EQGs): provincial (British Columbia (BC)), federal, and those developed by the Canadian Council of the Ministers of the Environment (CCME). The latter CCME guidelines are derived in consultation with the environment ministers from the federal, provincial and territorial governments. Relevant EQGs and DWQGs are summarized in Appendix 1.

The British Columbia Ministry of Environment and Climate Change Strategy (BC MoECCS) has developed Water Quality Guidelines (WQGs) that are considered as protective for different water uses. We refer to WQGs and EQGs interchangeably to simplify the use of terminology from different sources across Canada. We apply EQGs for the protection of aquatic life (source, stream and river, and road runoff samples) and marine aquatic life (marine water samples). All approved BC WQGs can be found on the BC MoECCS website.

Federal Environmental Quality Guidelines (FEQGs) are developed to support emerging federal environmental quality monitoring, risk assessment and risk management activities, and are derived to complement those developed by the CCME. They are only available for a limited number of chemicals captured in this list of EQGs (Government of Canada 2024).

In addition, Working Water Quality Guidelines (WWQGs) are available for some contaminants for which a completed EQG is not yet available and can be obtained from various Canadian provincial and federal jurisdictions (primarily the Canadian Council of the Ministers of the Environment (CCME)).

It is important to note that exceeding a WQG/EQG or WWQG does not imply that unacceptable risk exists but rather that the potential for adverse health effects is increased (BC MoECCCS 2023). Conversely, EQGs may not fully capture the sensitivity of all species to different contaminants, such that adverse effects may occur in some species even at levels below a EQG. EQGs, therefore, serve as a benchmark based on best available evidence, and are subject to change as new evidence emerges.

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Table 3: Analyte classes and number of available Environmental (or Water) Quality Guidelines (EQGs or WQGs) and Drinking Water Quality Guidelines (DWGs) or Objectives

Analyte Class	Number of Analytes Measured	Federal EQGs	BC WQGs	CCME EQGs
Basic Water Properties	5	0	4	5
Coliform	3	0	0	0
Nutrients	4	0	4	4
Metals	37	4	20	17
PAHs	76	0	10	10
Pesticides	62	0	10	7
PPCPs	141	1	1	0
PFAS	40	1	1	0
PCBs	209	0	5	0
Alkylphenols	4	0	0	0
Bisphenols	6	1	1	0
Sucralose	1	0	0	0
6PPD-Quinone	1	0	1	0
Total	*587*	*7*	*56*	*43*

We applied three sets of EQGs to our water quality data: The Federal government's *Federal Environmental Quality Guidelines* (FEQGs), the BC Government's Approved *Water Quality Guidelines* (BC WQGs), and the Canadian Council of Ministers of the Environment's (CCME) *Canadian Environmental Quality Guidelines* (CCME CEQGs). These guidelines were all designed to protect aquatic life.

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Table 4: Analyte classes and number of available Environmental (for sediment) Quality Guidelines (EQGs or WSQGs)

Analyte Class	Number of Analytes Measured	Federal EQGs	BC WSQGs	CCME EQGs
Coliform	0	0	0	0
Nutrients	4	0	0	0
Metals	37	0	2	7
PAHs	76	0	14	13
Pesticides	62	0	3	5
PPCPs	141	0	0	0
PFAS	40	0	0	0
PCBs	209	0	1	2
PBDEs	40	8	13	0
D/Fs	19	1	1	1
Alkylphenols	4	1	1	1
Bisphenols	6	1	1	0
Total	*807*	*11*	*41*	*41*

We applied three sets of EQGs to our sediment quality data: The Federal government's *Federal Environmental Quality Guidelines* (FEQGs), the BC Government's Approved *Water Quality Guidelines* (BC WQGs), and the Canadian Council of Ministers of the Environment's (CCME) *Canadian Environmental Quality Guidelines* (CCME CEQGs).

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Table 5: Environmental Quality Guidelines (water) for PFAS (USA and Canada)

Compound	Guideline (mg/L)	Issuing Agency	Notes
PFOS	0.0068	Canadian FEQG	EQG - PFOA under development
PFOS	3	US EPA	DRAFT EQG - Acute
PFOS	0.0084	US EPA	DRAFT EQG - Chronic
PFOA	49	US EPA	DRAFT EQG - Acute
PFOA	0.094	US EPA	DRAFT EQG - Chronic

Very few Environmental Quality Guidelines are available for PFAS. A Canadian Federal EQG was set for PFOS, while a guideline value for PFOA is currently in development.

Table 6: Environmental Quality Guidelines (sediment) for PFAS (Canada)

Compound	Guideline	Issuing Agency	Notes
PFOS	None federally published for sediment	Federal – FEQGs (Canada)	Federal Environmental Quality Guidelines for PFOS (2018) provide water and tissue values but *no federal sediment value* available.
Other PFAS (PFOA, etc.)	None published	Federal – FEQGs (Canada)	No published FEQGs for PFOA or other PFAS in sediment to date.
PFAS	No ISQG or PEL values available	CCME – Canadian Environmental Quality Guidelines (CEQGs)	CCME sediment quality guidelines database currently contains no numeric thresholds for PFOS, PFOA, or related PFAS (freshwater or marine).
PFAS	No listed generic numerical values for PFAS in CSR Schedule 3.4	BC – Contaminated Sites Regulation (CSR) – Generic Sediment Standards	BC CSR's generic numerical sediment standards exist, but PFAS-specific values are not listed directly in published generic schedules; values may be derived on a site-specific or interim basis.

There are currently no Environmental Quality Guidelines for PFAS in sediment from Canadian Federal EQGs, CCME, or BC MoE.

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Chapter 3: Water quality

Water properties

Capsule

Basic water properties provided elementary information on the quality of fish habitat in the Fraser River Estuary.

Introduction

Water properties including temperature (℃), dissolved oxygen, conductivity, pH, and turbidity are commonly measured as a preliminary method of assessing the quality of fish habitat. Temperature and dissolved oxygen are of particular significance to fish - as increased temperatures and low dissolved oxygen are often associated with summertime fish kills (La, 2011), a particular concern for sensitive cold-water species such as salmonids. Conductivity and turbidity measurements can act as proxies for total dissolved solids (TDS) (Rusydi, 2018) and total suspended solids (TSS) respectively (Rügner, *et al,* 2013). These parameters can be relevant as increased TDS and TSS in a body of water can indicate contamination from road salt, nutrients, or flushing of disturbed sediments into the waterway. Unusual conductivity measurements suggest the need for more in-depth analysis for contaminants (Ribeiro de Sousa, 2014).

Methods

A YSI ProDSS was used to take measurements at each site of the following parameters: temperature (°C), dissolved oxygen (mg/L and %), specific conductivity (uS/cm), pH, and turbidity (FNU).

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Results

Table 7: Water property results for 10 of water samples collected in the Fraser River Estuary (March 2025)

Analyte	NA-BB	NA-SS	NA-WI	NA-N2	MS-SL	SA-DS	SA-GB	SA-PR	NA-OS	SA-TS
Temperature (℃)	7.2	5.8	6.6	6.2	5.0	5.5	5.6	5.1	6.0	5.3
Dissolved Oxygen %	87.8	88.4	90.5	87.2	89.1	87.8	89.2	88.5	89.8	87.9
Dissolved Oxygen (mg/L)	10.59	10.95	10.87	10.56	11.37	10.87	10.84	11.27	11.00	11.09
Conductivity (uS/cm)	117.7	3048	5526	5950	104.1	5042	8931	93.7	4670	970
pH	8.13	7.86	7.64	7.72	8.23	7.49	7.56	8.29	7.73	7.67
Turbidity (FNU)	96.54	43.71	26.84	18.95	14.92	11.71	11.48	96.89	25.33	19.86

DO = Dissolved Oxygen. uS/cm = MicroSiemens per cm. FNU = Formazin Nephelometric Units.

Conclusions

- Conductivity readings generally indicate that water samples collected in this study reflected either freshwater (MS-SL, SA-PR, and NA-BB) or brackish water (NA-SS, NA-WI, NA-N2, SA-DS, SA-GB, NA-OS, and SA-TS).
- Water, temperature, and pH were all within EQGs ranges for protection of aquatic life.
- Turbidity could not be assessed in relation to EQGs as it requires knowledge of background turbidity.

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Coliform bacteria

Capsule

Coliform bacteria in water indicate a potentially serious threat to human health. Coliform analysis was only performed on water samples. The highest counts of coliform for fecal coliform and *E. coli* were both detected in the road NA-SS (Shaughnessy Street) sample. There are no coliform Guidelines for Environmental Quality, such that Guidelines are derived typically to protect human health. There were six exceedances of the Health Canada Recreational Use Guidelines for *E. coli.*

Introduction

Coliform bacteria have historically been used to gauge water quality with respect to implications for human recreational use and drinking water consumption (van Elsas, et al., 2013). Most recently, the spotlight has been on counts (MPN of CFU) of the gram-negative coliform bacteria species *Escherichia coli* as an indicator of recent contamination with wastewater, and to determine the risk to human health posed by consumption and recreational use of waterways (Li, 2021). There are no Environmental Quality Guidelines for coliform bacteria, reflecting the general idea that these potentially pathogenic bacteria are not likely to present a risk to aquatic life.

Results

Table 8: Counts (MPN/100ml) of coliform bacteria in 10 water samples collected from the Fraser River Estuary (March 2025)

Analyte	NA-BB	NA-SS	NA-WI	NA-N2	MS-SL	SA-DS	SA-GB	SA-PR	NA-OS	SA-TS
Coliform, Total	>2420	>2420	>2420	>2420	>2420	2420	>2420	1120	>2420	>2420
Coliform, Fecal	214	1300	205	162	517	1200	1200	109	461	345
E. coli	102	**1410**	118	65.7	**517**	**488**	**816**	95.9	**387**	**285**

Highest counts of the three different categories of coliform bacteria that we tested were all measured in the NA-SS (Shaughnessy Street) sample. **Bold** indicates an exceedance of the Health Canada Recreational Use guideline.

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Table 9: Average coliform concentrations (MPN/100mL) ± SEM (Min=-Max) in water samples from the Fraser River Estuary

Analyte	Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm
Total Coliform	2420	2420 ± 0 (2420-2420)	2095 ± 281 (1120-2420)	1.2
Fecal Coliform	517	468 ± 192 (162-1300)	714 ± 247 (109-1200)	0.7
E. coli	517	417 ± 228 (66-1410)	421 ± 133 (96-816)	1.0

Conclusions

- The highest concentration *of E. coli* was detected in the NA-SS (Shaughnessy Street) sample, while the lowest concentration was detected in the NA-N2 (Richmond No. 2 Comp) sample.
- The highest concentration of Total Coliform was also found in the NA-SS (Shaughnessy Street) sample, while the lowest concentration was detected in the SA-PR (Port Royal) sample.
- *E. coli* values in six samples exceeded Recreational Use Guidelines set by Health Canada (>235 CFU/100ml). CFU and MPN are both methods for laboratory culture of bacteria, and can be used interchangeably with regards to Guideline values. The following samples exceeded this guideline:
    - NA-SS (1410 MPN/100mL)
    - MS-SL (517 MPN/100mL)
    - SA-DS (488 MPN/100mL)
    - SA-GB (816 MPN/100mL)
    - NA-OS (387 MPN/100mL)
    - SA-TS (285 MPN/100mL)
- The Health Canada Recreational Use Guidelines are for the protection of human health.
- There are no EQGs for coliform bacteria in water.

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Nutrients and Physical parameters

Capsule

Nutrients can readily degrade fish habitat by increasing plant and algal growth and causing a subsequent reduction in dissolved oxygen. There were four exceedances each of CCME and BC water quality guidelines for ammonia. The highest concentration of both ammonia and Total Nitrogen were detected in the SA-TS sample. The lowest concentration of both ammonia and Total Nitrogen was found in the NA-N2 (Richmond No. 2 Comp) sample. There were no other exceedances of guidelines for nutrients.

Introduction

Nutrients such as nitrogen and phosphorus compounds can be naturally occurring, and are critical for the health and growth of plants and animals (CCME, 2016). However, nutrients from fertilizers and wastewater released into a body of water can cause eutrophication - a process which is characterized by an overgrowth of plants and algae and resulting in oxygen depletion (Putt, et al. 2019). Eutrophication poses a significant risk to aquatic life, as low oxygen levels create an inhospitable environment for the survival of fish - in particular salmonids who require relatively high levels of dissolved oxygen for survival and reproduction (Davis, 1975).

In addition, some nutrients such as total ammonia are considered to be acutely toxic to freshwater fish species at concentrations that vary by pH and temperature of the water (CCME, 2010).

Results

Table 10: Concentrations (mg/L) of physical and chemical properties in each water sample from the Fraser River Estuary (March 2025)

Analyte	NA-BB	NA-SS	NA-WI	NA-N2	NA-OS	MS-SL	SA-DS	SA-GB	SA-PR	SA-TS
Hardness	58.0	365	609	653	538	52.0	583	979	46.1	145
Solids, total dissolved [TDS]	-	-	-	-	2960	-	-	-	-	430
Solids, total	-	-	-	-	84.5	-	-	-	-	116

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suspended [TSS]										
Carbon, dissolved organic [DOC]	-	-	-	-	3.68	-	-	-	-	3.26
Carbon, total organic [TOC]	-	-	-	-	6.15	-	-	-	-	9.28
Biochemical oxygen demand [BOD]	-	-	-	-	<2.0	-	-	-	-	<2.0
Chemical oxygen demand [COD]	-	-	-	-	44	-	-	-	-	30

Table 11: Nutrient concentrations (mg/L) in each water sample from the Fraser River Estuary (March 2025)

Analyte	NA-BB	NA-SS	NA-WI	NA-N2	NA-OS	MS-SL	SA-DS	SA-GB	SA-PR	SA-TS
Ammonia, total (as N)	**0.0930**	0.0602	0.0245	0.0123	0.0400	**0.0313**	0.0944	0.0742	**0.0324**	**0.341**
Nitrate (as N)	-	-	-	-	0.165	-	-	-	-	0.146
Nitrate + Nitrite (as N)	-	-	-	-	0.165	-	-	-	-	0.146
Nitrite (as N)	-	-	-	-	<0.0200	-	-	-	-	<0.0050
Nitrogen, total	0.577	0.507	0.326	0.248	0.519	0.347	0.409	0.384	0.315	0.758
Phosphate, ortho-, dissolved	-	-	-	-	0.00788	-	-	-	-	0.00140

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(as P)										

Water samples were analyzed for the following nutrients: total nitrogen, nitrate (NO^{-3}), ammonia (NH_3), phosphate (PO_4^{3}) and nitrite (NO^{-2}). **Bold** indicates an exceedance of an Environmental Quality Guideline.

Table 12: Average ammonia and total nitrogen concentrations (mg/L) ± SEM (Min=-Max) in water samples from the Fraser River Estuary

Analyte	Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm
Ammonia, total (as N)	0.0313	0.046 ± 0.013 (0.012-0.093)	0.136 ± 0.060 (0.033-0.341)	0.3
Nitrogen, total	0.347	0.435 ± 0.056 (0.248-0.577)	0.4665 ± 0.086 (0.315-0.758)	0.9

Conclusions

- The highest concentration of ammonia was detected in the SA-TS (Tilsbury Slough) sample (0.341 mg/L), while the lowest concentration was found in the NA-N2 (Richmond No. 2 Comp) sample (0.0123 mg/L).
- The highest concentration of Total Nitrogen was found in the SA-TS (Tilsbury Slough) sample (0.758 mg/L), while the lowest concentration was found in the (Richmond No. 2 Comp) sample (0.248 mg/L)
- There were exceedances of both the CCME and BC Water Quality Guidelines for Ammonia in the following samples:
    - NA-BB (0.093 mg/L > 0.031mg/L)
    - MS-SL (0.313 mg/L > 0.026 mg/L)
    - SA-PR (0.0324 mg/L > 0.024 mg/L)
    - SA-TS (0.341 mg/L > 0.074 mg/L)
- Ammonia guidelines are calculated on an individual sample basis and derived from both temperature and pH values.
- Ammonia can be present in the aquatic environment due to agricultural runoff, municipal sewage treatment processes, and from the natural decomposition or organic material.
- There were no other CCME guideline exceedances for nutrients.
- There were no other BC water quality guideline exceedances for nutrients.

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Metals and minerals

Capsule

Metals can be present in water due to both natural and anthropogenic inputs. All samples exceeded the CCME guidelines for aluminum and iron. Two samples also exceeded CCME and BC guidelines for silver. The highest total concentration of metals was detected in the SA-GB (Gilbert Beach) sample, and the lowest total concentration was detected in the SA-PR (Port Royal) sample.

Introduction

Metals are present in aquatic environments as a result of both natural and anthropogenic sources, with baseline levels reflecting the unique geology of the area surrounding a body of water (Jadaa, et al., 2023). Anthropogenic sources of metal contamination in waterways may originate from industrial effluent, municipal wastewater, agricultural practices, and urban runoff.

Many metals are capable of impacting the health of aquatic life, with some representing a priority concern in fish habitat, including zinc (Giardina, et al., 2009) and copper (Malholtra, et al., 2020).

Results

Table 13: Metal concentrations (mg/L) in water for 10 sites in the Lower Fraser Estuary in March 2025

Analyte	NA-BB	NA-SS	NA-WI	NA-N2	MS-SL	SA-DS	SA-GB	SA-PR	NA-OS	SA-TS
Aluminum	**2.36**	**3.61**	**1.28**	**0.730**	**2.04**	**0.400**	**0.509**	**1.26**	**5.89**	**1.15**
Antimony	0.00024	0.000211	<0.00050	<0.00050	0.000127	<0.00050	<0.00050	<0.00010	<0.00050	0.000282
Arsenic	0.00146	0.00215	0.00144	0.000862	0.00114	0.00107	0.000818	0.000945	0.00334	0.00150
Barium	0.0354	0.0399	0.0250	0.0151	0.0319	0.0209	0.0181	0.0234	0.0441	0.0566
Beryllium	0.0000555	0.0000888	<0.00010	<0.00010	0.0000528	<0.00010	<0.00010	0.0000292	0.000138	0.0000324
Bismuth	<0.000050	<0.00010	<0.00025	<0.00025	<0.000050	<0.00025	<0.00025	<0.000050	<0.00025	<0.000050
Boron	<0.010	0.217	0.400	0.453	<0.010	0.358	0.620	<0.010	0.331	0.0714

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Cadmium	0.0000347	0.0000759	0.0000356	<0.000025	0.0000430	0.0000350	0.0000336	0.0000247	0.0000776	0.0000331
Calcium	15.0	37.9	49.3	52.1	13.8	47.1	73.9	12.4	47.3	25.9
Chromium	0.00435	0.00724	0.00255	<0.0025	0.00375	<0.0025	<0.0025	0.00230	0.0116	0.00268
Cobalt	0.00194	0.00286	0.00107	0.000587	0.00156	<0.00050	<0.00050	0.000946	0.00479	0.000970
Copper	0.00542	0.00954	0.00362	0.00262	0.00518	<0.0025	<0.0025	0.00368	0.0145	0.00410
Iron	**4.61**	**5.68**	**2.50**	**1.25**	**2.90**	**0.709**	**0.850**	**1.79**	**9.55**	**6.40**
Lead	0.00124	0.00209	0.000632	0.000410	0.00111	0.000298	<0.00025	0.000555	0.00308	0.00129
Lithium	0.00229	0.0113	0.0170	0.0188	0.00193	0.0151	0.0262	0.00138	0.0182	0.00347
Magnesium	4.99	65.6	118	127	4.26	113	193	3.68	102	19.6
Manganese	0.262	0.133	0.0978	0.0268	0.0859	0.0286	0.0307	0.0559	0.194	0.226
Mercury	0.0000053	0.0000078	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000125	<0.0000050
Molybdenum	0.000600	0.00129	0.00160	0.00178	0.000701	0.00159	0.00226	0.000661	0.00157	0.000927
Nickel	0.00680	0.00972	0.00372	<0.0025	0.00572	<0.0025	<0.0025	0.00370	0.0160	0.00370
Phosphorus	0.132	0.183	<0.25	<0.25	0.124	<0.25	<0.25	0.0600	0.304	0.0831
Potassium	1.16	20.0	38.1	43.3	1.10	36.2	61.4	1.00	31.0	5.73
Selenium	0.000109	0.000158	<0.00025	<0.00025	0.000123	<0.00025	<0.00025	0.0000936	<0.00025	0.000126
Silicon	7.73	10.4	5.08	4.11	6.62	3.81	4.06	5.20	14.6	7.48
Silver	0.0000286	0.0000592	**0.000147**	<0.000050	0.0000564	<0.000050	<0.000050	0.0000830	**0.00330**	0.0000113
Sodium	5.37	476	951	1040	3.42	896	1520	3.33	784	122
Strontium	0.0803	0.429	0.760	0.822	0.0758	0.717	1.16	0.0688	0.644	0.202
Sulfur	2.47	47.8	86.4	99.1	2.38	83.9	150	2.27	72.8	12.0
Thalliuml	0.0000190	0.0000220	<0.000050	<0.000050	0.0000174	<0.000050	<0.000050	0.0000125	<0.000050	0.0000104
Tin	<0.00010	<0.00020	<0.00050	<0.00050	<0.00010	<0.00050	<0.00050	<0.00010	<0.00050	<0.00010
Titanium	0.0799	0.163	0.0591	0.0316	0.0767	0.0185	0.0226	0.0494	0.255	0.0483
Uranium	0.000251	0.000464	0.000455	0.000453	0.000269	0.000498	0.000648	0.000216	0.000648	0.000242

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Vanadium	0.00570	0.00918	0.00346	<0.0025	0.00489	<0.0025	<0.0025	0.00317	0.0152	0.00362
Zinc	0.0120	0.0188	<0.015	<0.015	0.0173	<0.015	<0.015	0.00870	0.0301	0.0114
Zirconium	0.000276	0.000777	<0.0010	<0.0010	0.000442	<0.0010	<0.0010	0.000500	0.00119	0.000594
Total Metals	44.3	668	1250	1370	37.0	1180	2010	31.2	1069	201

Figure 2: Total metal concentrations (mg/L) in ten water samples collected from the Fraser River Estuary (March 2025)

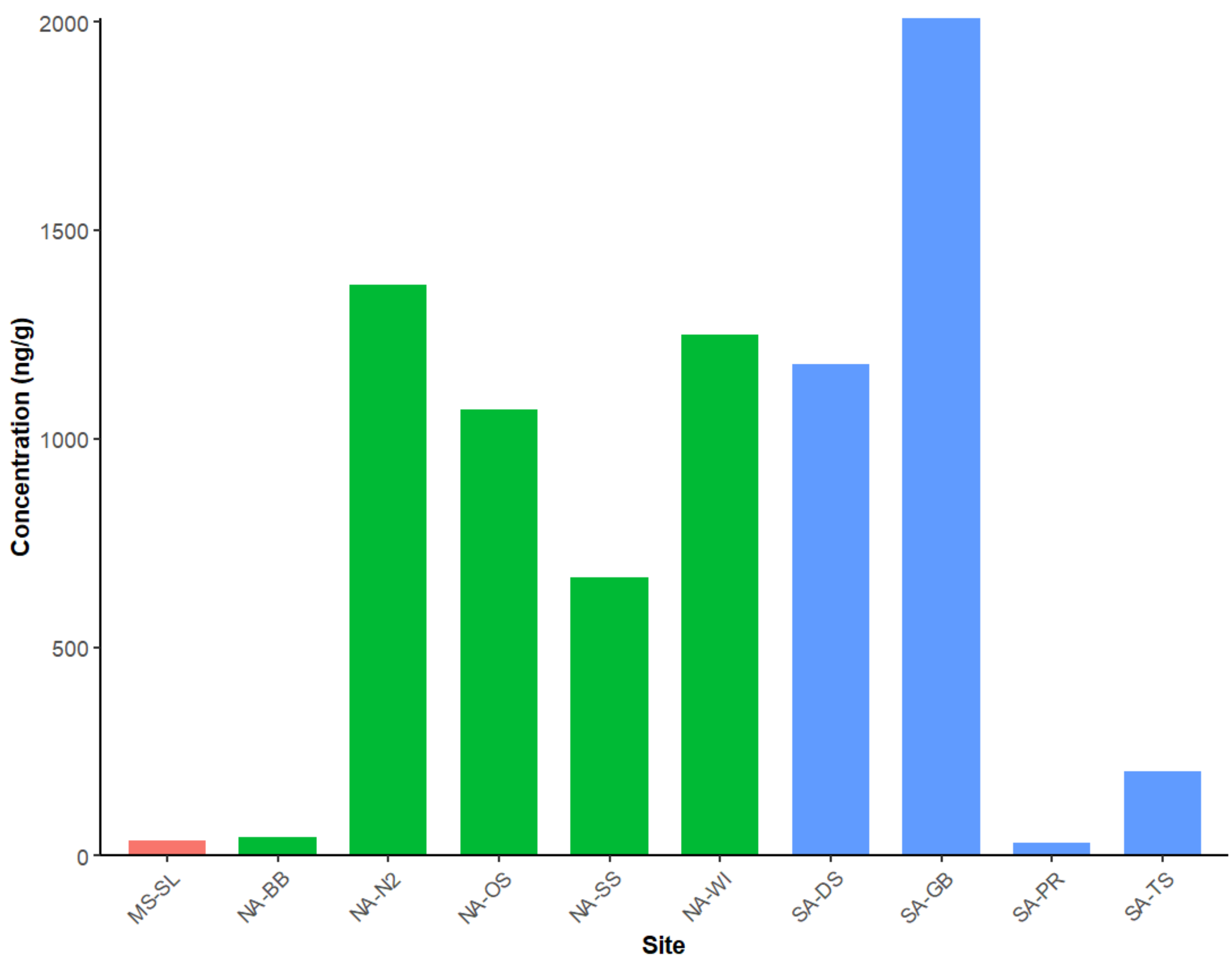

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Table 14: Average total metals concentrations (mg/L) ± SEM (Min=-Max) in water samples from the Fraser River Estuary

Analyte	Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm
Total Metals	37	880 ± 215 (44.3-1370)	856 ± 399 (31.2-2010)	1.0

Conclusions

- The highest total metals concentration was detected in the SA-GB (Gilbert Beach) sample, while the lowest concentration was found in the SA-PR (Port Royal) sample. This is likely related to the sample site distance from the marine environment and therefore the influence of salt water on metal concentrations.
- The aluminum concentrations detected in all samples were above the CCME Long Term Guideline for the protection of aquatic life (0.1 mg/L). It is possible that the elevated aluminum values are geological in origin.
- The iron concentrations detected in all samples were above the CCME Long Term Guideline for the protection of aquatic life (0.3 mg/L). It is possible that the elevated iron values are geological in origin.
- The silver concentrations detected at two sites (NA-WI (0.000147 mg/L), NA-OS (0.00330 mg/L)) exceeded the CCME guideline for the protection of aquatic life of 0.0001 mg/L.
- The iron concentration in all samples exceeded the BC MoE guideline for the protection of aquatic life of 1.0 mg/L, except for the SA-DS (Deas Slough) (0.709 mg/L) and SA-GB (Gilbert Beach) (0.850 mg/L) samples.
- The concentration of metals reported here represent the total metals present in the sample - which may not reflect the amount of bioavailable metals in the samples.

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Polycyclic Aromatic Hydrocarbons (PAHs)

Capsule

Polycyclic aromatic hydrocarbons (PAHs) were detected in both water samples collected from the Fraser River Estuary in March 2025. The total PAH concentration in the North Arm sample was found to be higher than the concentration measured in the South Arm sample. There were no exceedances of CCME or BC Guidelines for PAHs in either sample.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a complex group of compounds found in coal, petroleum and plant materials. They can enter waterways in the form of liquid petroleum products (gasoline, diesel, oil) or via the incomplete combustion of coal, oil, gas, wood garbage or other organic substances. They can occur naturally or as a result of human activities (anthropogenic). In Canada, forest fires are the single most important natural source of PAHs, while anthropogenic sources include residential wood heating, aluminum smelters, creosote-treated products, spills of petroleum products and metallurgical and coking plants (Government of Canada, ECCC and Health Canada, 1994; Marvin et al., 2021).

Hydrocarbons can enter aquatic ecosystems either directly through oil spills or discharges from vessels (Morales-Caselles et al., 2017) or indirectly through atmospheric deposition, runoff and discharge from wastewater treatment plants. Depending on their molecular size, PAHs vary in toxicity and have been classified as toxic under the Canadian Environmental Protection Act (CEPA).

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Results

Table 15: Concentrations (ng/L) of the top five PAH analytes detected in the North Arm (NA-OS)

	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	C4-Phenanthrenes/Anthracenes	33.2	2.7
2	Retene	26.5	3.1
3	Fluoranthene	11.2	3.2
4	Pyrene	9.01	2.8
5	Benzo[b]fluoranthene	7.7	5.9

The PAH compound with the highest concentration in the North Arm of the Fraser River Estuary was C4-Phenanthrenes/Anthracenes. The concentration of C4-Phenanthrenes/Anthracenes detected in the North Arm sample was found to be 2.7x higher than the concentration of C4-Phenanthrenes/Anthracenes detected in the South Arm sample.

Table 16: Concentrations (ng/L) of the top five PAH analytes detected in the South Arm (SA-TS)

	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	C4-Phenanthrenes/Anthracenes	12.5	2.7
2	Retene	8.54	3.1
3	Acenaphthene	3.82	0.8
4	Perylene	3.51	1.6
5	Fluoranthene	3.493	3.2

The PAH compound with the highest concentration in the South Arm of the Fraser River Estuary was C4-Phenanthrenes/Anthracenes.

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Table 17: Total PAH detections and concentrations (ng/L) in two water samples from the Fraser River Estuary

	North Arm	South Arm	Ratio North Arm: South Arm
Concentration (ng/L)	202.8	90.6	2.2
US EPA 16 Concentration (ng/L)	77.9	31.8	2.5
# detects	59	56	1.1

The North Arm sample (NA-OS) was found to have a higher total concentration of PAHs, as well as a greater number of total detected PAH analytes.

Conclusions

- The highest concentration of total PAHs was found in the North Arm (NA-OS) sample (202.8 ng/L).
- The highest number of analytes was also measured in the North Arm (NA-OS) sample (n=59).
- The top five PAHs contributing to the total concentration differed slightly between the North and South Arm samples - with three analytes in common: C4-Phenanthrenes/Anthracenes, Retene, and Fluoranthene.
- In both samples the highest concentration for an individual PAH compound was found to be C4-Phenanthrenes/Anthracenes.
- There were no exceedances of CCME or BC PAH guidelines for the protection of aquatic organisms in water.

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Pesticides

Capsule

Pesticides were detected in both water samples collected from the Fraser River Estuary in March 2025. The total pesticide concentration in the North Arm sample was found to be higher than the concentration measured in the South Arm sample. There were also a greater number of analytes detected in the North Arm (n=9) compared to the South Arm (n=4). There were no exceedances of CCME or BC Guidelines for pesticides in either sample.

Introduction

Pesticides have been developed to control, destroy or inhibit the activities of pests. They have a wide range of applications in agriculture such as insecticide to prevent crop damage and fungicides to prevent plant disease but also in forestry, industry as well as in our own backyards for lawn care or weed and insect control. In Canada, all pesticides used, sold or imported are regulated by Health Canada's Pest Management Agency (PMRA) (Health Canada, 2007).

While pesticides are mostly applied on terrestrial habitats, they can reach aquatic environments through overspray or drift during application, surface runoff, and through long range atmospheric transport and deposition. It is estimated that 10% of pesticides applied to soil reach non-target areas, leading to their widespread presence in surface waters worldwide (Schulz, 2004; Anderson et al., 2022).

Organochlorine pesticides (OCP) were heavily used from the 1940s to the 1980s, but have been restricted due to their persistence, toxicity and potential for bioaccumulation. Current-use pesticides (CUPs) were subsequently favoured as an alternative to OCPs, and have been widely applied in recent decades (Ding et al., 2023). These tend to be more water-soluble and may be more mobile in fish habitat (Harris et al., 2008).

Results

Table 18: Concentrations (ng/L) of the top five pesticides detected in the North Arm (NA-OS) water sample

Rank	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	Simazine	1.88	0.9
2	Permethrin	0.137	NA
3	4,4'-DDE	0.068	2.8
4	alpha-Endosulphan	0.045	NA
5	Chlordane, gamma (trans)	0.043	NA
6	HCH, alpha	0.034	NA
7	4,4'-DDD	0.023	NA
8	Hexachlorobenzene	0.014	NA
9	4,4'-DDT	0.003	NA

The pesticide with the highest concentration in the North Arm of the Fraser River Estuary was simazine. The only two pesticides detected in the North Arm that were also detected in the South Arm were simazine and 4,4'-DDE; ratios were unable to be determined for the other seven analytes. The South Arm was found to have a higher concentration of simazine, while the North Arm was found to have a 2.8x higher concentration of 4,4'-DDE.

Table 19: Concentrations (ng/L) of the four pesticide analytes detected in the South Arm (SA-TS)

	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	Simazine	2.13	0.9
2	Endosulphan Sulphate	0.065	NA
3	4,4'-DDE	0.024	2.8
4	Hexachlorobenzene	0.019	0.7

The pesticide with the highest concentration in the South Arm of the Fraser River Estuary was simazine. The concentration of caffeine detected in the South Arm sample was found to be 0,9x the concentration

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detected in the North Arm sample. Endosulphan sulphate was not detected in the North Arm sample, so a ratio could not be determined.

Table 20: Total pesticide detections and concentrations (ng/L) in two water samples from the Fraser River Estuary

	North Arm	South Arm	Ratio North Arm: South Arm
Concentration (ng/L)	2.25	2.24	1.0
# detects	9	4	2.3

The North Arm water sample (NA-OS) was found to have a slightly higher total concentration of pesticides, as well as a greater number of total detected pesticide analytes when compared to the South Arm sample.

Conclusions

- The highest concentration of total pesticides was found in the North Arm (NA-OS) sample (2.25 ng/L).
- The highest number of pesticide analytes was also measured in the North Arm (NA-OS) sample (n=9).
- The identities of the detected pesticides differed somewhat between the North and South Arm samples - with two analytes in common: simazine and 4,4'-DDE; Simazine is under regulated use in Canada as of 2017; 4,4'-DDE is a breakdown product of DDT, a pesticide that has been banned in Canada since 1990.
- In both samples the highest concentration for an individual pesticide was found to be simazine.
- There were no exceedances of CCME or BC pesticide guidelines for the protection of aquatic organisms in water.

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Pharmaceuticals and Personal Care Products

Capsule

Pharmaceuticals and Personal Care Products (PPCPs) are a category of contaminants that can enter the environment via wastewater, and are typically not removed during treatment. PPCPs were only measured in the two water samples (NA-OS and SA-TS)

Introduction

Pharmaceuticals and Personal Care Products (PPCPs) comprise a wide range of products and chemical formulations. The common link among these compounds is their use in human health, veterinary health and personal care. Many PPCPs are introduced into the environment via wastewater streams, and are not reliably removed during treatment at wastewater treatment plants (WWTPs).

Pharmaceuticals may enter the environment by way of WWTP effluent, land-applied biosolids and/or septic tank failures (Metcalfe et al 2004). Monitoring of source water is deemed an important means of assuring the safety of drinking water, especially First Nations (Schwartz et al., 2021). However, the lack of Environmental Quality Guidelines and Drinking Water Quality Guidelines in Canada for PPCPs and internationally constrains a fulsome risk-based evaluation of environmental concentrations (Lee and Choi, 2019).

DEET (N,N-diethyl-meta-toluamide) is a widely used insect repellent. Amphetamine is a recreational drug, and used in medications for the treatment of ADHD.

Caffeine has been used as an indicator of human wastewater in the environment - as it is relatively stable and persistent in surface waters, but sucralose is increasingly used in its place.

Results

We detected 21 pharmaceuticals and personal care products in the two water samples collected within the Fraser River Estuary in March 2025.

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Table 21: Concentrations (ng/L) of the PPCP analytes detected in the North Arm (NA-OS) water sample

	Analyte	Concentration (ng/L)
1	Metformin	49.4
2	Caffeine	33.8
3	Theophylline	23.4
4	1,7-Dimethylxanthine	7.65
5	Acetaminophen	5.5
6	2-Hydroxy-ibuprofen	4.87
7	DEET	1.21
8	Gemfibrozil	1.17
9	Cotinine	1.17
10	Benzoylecgonine	1.02
11	Venlafaxine	0.64
12	Cocaine	0.434
13	Carbamazepine	0.405
14	Atenolol	0.305
15	Amphetamine	0.295

The PPCP compound with the highest concentration in the North Arm of the Fraser River Estuary was metformin. The concentration of caffeine detected in the North Arm sample was found to be 1.4x higher than the concentration of caffeine detected in the South Arm sample.

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Table 22: Concentrations (ng/L) of the PPCP analytes detected in the South Arm water sample (SA-TS)

	Analyte	Concentration (ng/L)
1	Caffeine	79.7
2	Metformin	35.6
3	Acetaminophen	33.1
4	Theophylline	29
5	2-Hydroxy-ibuprofen	18.9
6	1,7-Dimethylxanthine	10.9
7	Bisphenol A	8.65
8	Ibuprofen	5.8
9	Naproxen	4.34
10	Bisphenol A	3.93
11	DEET	2.41
12	Benzoylecgonine	2.25
13	Venlafaxine	1.42
14	Cotinine	0.795
15	Carbamazepine	0.663
16	Cocaine	0.582
17	Metoprolol	0.56
18	Citalopram	0.407
19	Clarithromycin	0.365
20	Atenolol	0.365
21	Diltiazem	0.355

The PPCP compound with the highest concentration in the South Arm of the Fraser River Estuary was caffeine. The concentration of caffeine detected in the South Arm sample was found to be 2.4x higher than the concentration of caffeine detected in the North Arm sample.

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Table 23: Concentrations (ng/L) of the top six PPCP analytes detected in the North Arm (NA-OS) and South Arm (SA-TS)

Analyte	Concentration North Arm (ng/L)	Rank North Arm	Concentration South Arm (ng/L)	Rank South Arm	Ratio North Arm: South Arm
Metformin	49.4	1	35.6	2	1.4
Caffeine	33.8	2	79.7	1	0.4
Theophylline	23.4	3	29	4	0.8
1,7-Dimethylxanthine	7.65	4	10.9	6	0.7
Acetaminophen	5.5	5	33.1	3	0.2
2-Hydroxy-ibuprofen	4.87	6	18.9	5	0.3

The PPCP compound with the highest concentration in the North Arm of the Fraser River Estuary was metformin. The PPCP compound with the highest concentration in the South Arm of the Fraser River Estuary was caffeine. The concentration of caffeine detected in the North Arm sample was found to be 0.4x the concentration of caffeine detected in the South Arm sample. The only contaminant that was detected at a higher concentration in the North Arm was metformin.

Table 24: Total PPCP concentrations (ng/L) and number of detections in water samples from the Fraser River Estuary

	North Arm (n=1)	South Arm (n=1)	Ratio North Arm: South Arm
Concentration (ng/L)	131	240	0.55
# detects	15	21	0.71

The South Arm sample (SA-TS) was found to have both higher total concentration of PPCPs, as well as a greater number of total detected PPCP analytes. Total pharmaceutical concentrations in the South Arm were 55% higher than in the North Arm, and the total number of analytes was 71% higher, likely an influence of the upstream Annacis Island Waste Water Treatment Plant (WWTP) situated approximately 4km upriver.

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Conclusions

- The highest total concentration of PPCPs was detected in the South Arm water sample (240 ng/L).
- The largest number of different PPCP analytes detected was found in the South Arm water sample (n=21).
- While the order of the top five analytes in the two samples differed, the identities of four out of the five top analytes were the same between the two samples.
- There are no EQGs available in Canada for any of the PPCPs we detected in water samples for the Fraser River Estuary.
- The only PPCP for which there is an environmental quality guideline is Ethinylestradiol (EE), which is used widely as one of the hormonal components of birth control - as it has been shown to negatively impact both reproductive and immune function in some fish species.

Per- and poly-fluoroalkyl substances (PFAS)

Capsule

Per- and poly-fluoroalkyl substances (PFAS) were detected in both water samples. The highest PFAS concentrations were observed in the North Arm (NA-OS) sample, with the lowest being in the South Arm (SA-TS) sample. Two different PFAS compounds were detected in the samples: PFOSA and PFOA. There are no available Canadian Environmental Quality Guidelines for PFOA or PFOSA in water.

Introduction

Per- and poly-fluoroalkyl substances (PFAS) are large group (~15,000 compounds) of human-made substances used in a wide variety of products such as food packaging, non-stick cookware, clothing, and cosmetics, but also lubricants, oil/water repellents, and notably - aqueous firefighting foams (AAAF; Barzen-Hanson et al., 2017). They are extremely stable and therefore persistent in the environment, which has led to the use of the term “forever chemicals” for this category of chemical.

PFAS can be released into the environment from point sources such as manufacturing plants, or sites where firefighting foams have been used. PFAS can also be released through consumer use and disposal of PFAS-containing products. PFAS has been found in all environmental compartments (Moller et al., 2010; ECCC and Health Canada, 2023).

Evidence of adverse effects on the environment and on human health has led Canada to prohibit the manufacture, use, sale, offer for sale and import of a limited number of PFAS including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic Acid (PFOA), long-chain perfluorocarboxylic acids and their salts and precursors under the *Prohibition of Certain Toxic Substances Regulations* and the *Canadian Environmental Protection Act* (CEPA) (ECCC and Health Canada, 2023b). Advancing regulatory aspects pertaining to rapidly emerging concerns about the many PFAS being detected in the environment is a current priority in Canada (Longpre et al., 2020).

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Results

Table 25: Concentrations (ng/L) of the top five pesticides detected in the North Arm (NA-OS)

	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	PFOSA	0.596	1.4
2	PFOA	0.048	0.8

The PFAS with the highest concentration in the North Arm of the Fraser River eEstuary was PFOSA. The only two PFAS detected in the North Arm were also detected in the South Arm. The South Arm was found to have a higher concentration of PFOA, while the North Arm was found to have a 1.4x higher concentration of PFOSA.

Table 26: Concentrations (ng/L) of the two PFAS compounds detected in the South Arm (SA-TS)

	Analyte	Concentration (ng/L)	Ratio North Arm: South Arm
1	PFOSA	0.441	1.4
2	PFOA	0.059	0.8

The PFAS with the highest concentration in the South Arm of the Fraser River Estuary was PFOSA.

Table 27: Total PFAS detections and concentrations (ng/L) in two water samples from the Fraser River Estuary

	North Arm	South Arm	Ratio North Arm: South Arm
Concentration (ng/L)	0.644	0.500	1.3
# detects	2	2	1.0

The North Arm water sample (NA-OS) was found to have a slightly higher total concentration of PFAS, the same number of PFAS analytes when compared to the South Arm sample.

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Conclusions

- The highest concentration of total PFAS was found in the North Arm (NA-OS) sample (0.644 ng/L).
- The number of PFAS analytes detected was the same in each of the two samples (n=2).
- The identities of the detected PFAS were the same between the North and South Arm samples; PFOSA and PFOA.
- In both samples the highest concentration for an individual pesticide was found to be PFOSA.
- There are no BC or CCME water quality guidelines for PFOA, PFOSA, or Total PFAS, however the values detected in the Fraser River samples fall well below the Health Canada Drinking Water Objective for total PFAS of 30 ng/L.

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Polychlorinated Biphenyls (PCBs)

Capsule

Despite having been targeted for phase out in Canada in 1977, with some closed uses allowed until December 31, 2029, industrial PCBs continue to be found in the environment, reflecting their stability and persistence. Polychlorinated biphenyls (PCBs) were detected in all ten water samples, with the highest concentration observed in the NA-SS (Shaughnessy Street) sample and the lowest in the MS-SL (Sapperton Landing) sample. One sample (NA-SS) exceeded both the CCME and BC Guidelines for total PCBs in sediment.

Introduction

Polychlorinated biphenyls (PCBs) comprise 209 congeners that are structurally related but have differing degrees of chlorination. The commercial production of PCBs began in 1929, after which they were heavily used in electrical and hydraulic equipment, as well as in paint additives, sealing and caulking compounds and inks. Due to their adverse health effects, the production of PCBs was banned in the late 1970s around the world (Othman et al., 2022). PCBs are among the first 12 Persistent Organic Pollutants (POPs) - often referred to as the "dirty dozen" - defined by the Stockholm Convention, an international treaty aimed at eliminating or restricting the production and use of POPs (UNEP, 2025).

PCBs were never produced in Canada, but were widely used, and are currently specified on the List of Toxic Substances under the Canadian Environmental Protection Act (ECCC 2010). Despite restrictions beginning in 1977, PCBs continue to pose a threat due to their persistence in the environment and their release from products that were manufactured before the ban, and/or were improperly disposed of (Othman et al., 2022). Closed use applications in the electricity generation sector may continue in Canada until final phase out in December 2029 (ECCC 2023). Military uses of PCBs may continue thereafter.

In British Columbia (BC), PCBs remain the number one contaminant of concern in marine food webs with the iconic killer whales being among some of the most-PCB contaminated marine mammals in the world (Ross et al., 2000). Regulatory steps in the 1970s and since have led to declining PCB concentrations in aquatic animals in BC (Ross et al., 2013).

The 209 individual PCBs have different degrees of chlorination, with each individual PCB containing between 1 and 10 chlorine atoms in their structure.

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Results

Table 28: Concentrations (pg/L) of PCB analytes by degree of chlorination detected in the North Arm (NA-OS)

Rank	Analyte	Concentration (pg/L)	Ratio North Arm: South Arm
7	Total Monochloro Biphenyls	0	0.0
5	Total Dichloro Biphenyls	14.5	2.6
4	Total Trichloro Biphenyls	45.88	4.8
2	Total Tetrachloro Biphenyls	104.63	4.7
1	Total Pentachloro Biphenyls	106.87	4.6
3	Total Hexachloro Biphenyls	79.37	4.5
6	Total Heptachloro Biphenyls	35.952	5.0
8	Total Octachloro Biphenyls	10.231	4.9
9	Total Nonachloro Biphenyls	1.69	3.0
10	Decachloro Biphenyl	0.53	2.4

The total PCB concentration in the North Arm sample is dominated by Pentachloro- and Tetrachloro-Biphenyls.

Table 29: Concentrations (pg/L) of PCB analytes by degree of chlorination detected in the South Arm (SA-TS)

Rank	Analyte	Concentration (pg/L)	Ratio North Arm: South Arm
7	Total Monochloro Biphenyls	3.2	0.0
6	Total Dichloro Biphenyls	5.5	2.6
4	Total Trichloro Biphenyls	9.58	4.8
2	Total Tetrachloro Biphenyls	22.03	4.7

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1	Total Pentachloro Biphenyls	23.37	4.6
3	Total Hexachloro Biphenyls	17.57	4.5
5	Total Heptachloro Biphenyls	7.252	5.0
8	Total Octachloro Biphenyls	2.091	4.9
9	Total Nonachloro Biphenyls	0.56	3.0
10	Decachloro Biphenyl	0.225	2.4

The total PCB concentration in the South Arm sample is dominated by Pentachloro- and Tetrachloro-Biphenyls.

Table 30: Total PCB concentrations (pg/L) and number of detections in water samples from the Fraser River Estuary

	North Arm (n=1)	South Arm (n=1)	Ratio North Arm: South Arm
Concentration (pg/L)	402	92	4.4
# detects	118	96	1.2

The North Arm water sample (NA-OS) was found to have a 4.4x higher total concentration of PCBs, as well as a greater number of total detected PCB congeners when compared to the South Arm sample.

Conclusions

- The highest concentration of total PCBs was found in the North Arm (NA-OS) water sample (402 pg/L).
- A greater number of PCB congeners was detected in the North Arm water sample (118 pg/L) compared to the South Arm sample (96 pg/L).
- In both samples the total concentration of PCBs was largely made up of Penta- and Tetrachloro Biphenyls.
- There were no exceedances of CCME or BC Total PCB guidelines for the protection of aquatic life.

Alkylphenol Ethoxylates

Capsule

Alkylphenol ethoxylates (APEs) are industrial grade surfactants that have been found in wastewater and industrial discharges. APEs were detected in both water samples collected from the Fraser River Estuary in March 2025. Concentrations in the South Arm sample were higher than the concentrations measured in the North Arm sample.

Introduction

Alkylphenol ethoxylates are non-ionic surfactants used in industrial and consumer applications. APEs and their breakdown products are considered estrogenic and can disrupt reproductive development in fish. These surfactants can be released into the environment via municipal and industrial discharges (Lalonde et al., 2021). Once released, APEs may reside in aquatic sediments and/or undergo some breakdown into shorter chain APEs; their half-life is estimated at over 60 years (Shang et al., 1999).

The endocrine-disrupting potential of APEs and their breakdown products in fish and wildlife has represented a concern in receiving waters around municipal wastewater treatment plants (La Guardia et al., 2001).

Results

Table 31: APE concentration (ng/L) in water samples from the Fraser River Estuary in March 2025

Analyte	North Arm (n=1)	South Arm (n=1)	Ratio North Arm: South Arm
4-Nonylphenol monoethoxylates	1.83	3.16	0.6
4-n-Octylphenol	0.886	0.966	0.9
Total APEs	2.72	4.13	0.7

The total concentration of APEs detected in the North Arm sample (NA-OS) was found to be 0.7x the concentration detected in the South Arm (SA-TS).

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Conclusions

- The highest concentration of all APEs were detected in the South Arm (SA-TS) water sample.
- The detected concentration of APEs in the South Arm water sample from the (4.13 ng/L) is well below the long-term CCME guideline for the protection of freshwater aquatic life for nonylphenol and its ethoxylates of 1000 ng/L.

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Bisphenols

Capsule

Bisphenols are plastic additives with widely reported estrogenic (endocrine disrupting) properties. Bisphenol A (BPA) was the only bisphenol compound detected in the Fraser River Estuary water samples. The concentration measured in the North Arm sample was 2.4x higher than concentration measured in the South Arm.

Introduction

Bisphenols are used widely in the manufacturing sector, and are primarily used in the production of plastics and resins. Both single and multi-use plastic containers are frequently produced using bisphenol compounds, the most popular of which is Bisphenol A (BPA). Bisphenols are endocrine-disrupting chemicals that have been found to negatively impact reproductive development in fish, amphibians, and mammals (Faheem and Bhandari, 2021; Marlatt, *et al.* (2022)).

BPA has come under intense regulatory scrutiny in recent years. The widespread use of these chemicals in food packaging, beverage containers, and in water delivery systems has led to exposure in the general population, and associations with adverse outcomes in humans (Rochester 2013).

Results

Water

Table 32: Bisphenol concentration (ng/L) in water samples from the Fraser River Estuary in March 2025

Analyte	North Arm (n=1)	South Arm (n=1)	Ratio North Arm: South Arm
Bisphenol A (ng/L)	6.73	2.8	2.4

The total concentration of bisphenols detected in the North Arm sample (NA-OS) was found to be 2.4x the concentration detected in the South Arm (SA-TS). The only bisphenol detected in the Fraser River Estuary was Bisphenol A.

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Conclusions

- The highest concentration of BPA was detected in the North Arm (NA-OS) water sample.
- A FEQG for BPA is set at 1400 ng/L, which is over 200x higher than the concentration we measured in the North Arm water sample.

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Sucralose

Capsule

Sucralose is a popular artificial sweetener (trade name '*Splenda*') used in foods and beverages. This analyte has become an important tracer of human waste in environmental samples. Sucralose was only measured in the two full suite water samples collected from the Fraser River Estuary, and it was detected in both.

Introduction

Sucralose (*Splenda*) is an artificial sweetener used in the production of sugar-free food and beverage products. Its popularity and its resistance to breakdown during the wastewater treatment process have led to its adoption as a useful tracer of human wastewater infiltration (Oppenheimer et al., 2011). It is not generally considered to be toxic, such that its utility as a tracer provides an opportunity to better understand the source of other more harmful pollutants in a given body of water.

Sucralose is not fully metabolized by the human body following consumption, and is not removed during the wastewater treatment process. Therefore, its detection in environmental samples indicates the presence of treated or untreated sewage (van Stempvoort et al., 2020).

Results

Water

Table 33: Sucralose concentration (ng/L) in water samples from the Fraser River Estuary in March 2025

Analyte	North Arm (n=1)	South Arm (n=1)	Ratio North Arm: South Arm
Sucralose (ng/L)	38.7	90.6	0.43

The total concentration of sucralose detected in the North Arm sample (NA-OS) was found to be 0.43x the concentration detected in the South Arm (SA-TS).

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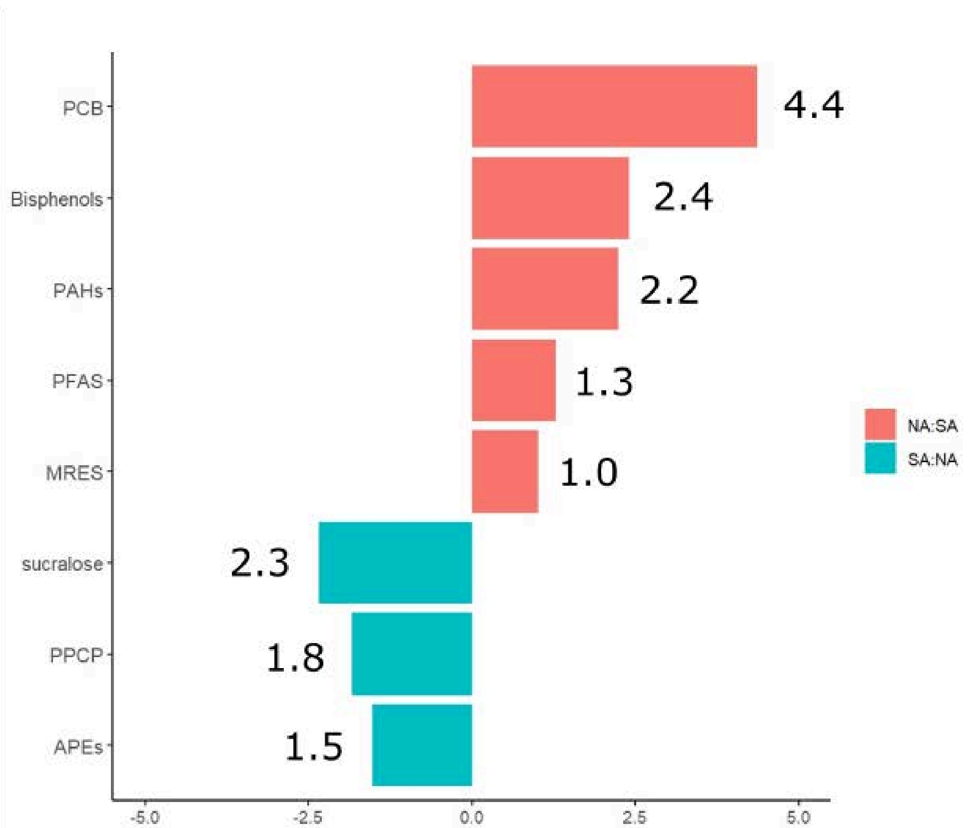
Conclusions

- The highest concentration of the artificial sweetener sucralose was detected in the South Arm (SA-TS) water sample.
- There are no current Canadian Environmental Quality Guidelines available for sucralose.

Water quality summary

Figure 3: Differences were observed in the total concentrations of analytes between the North Arm and South Arm in March 2025



This figure compares how many times greater the total concentrations of the eight analyte classes are in the North Arm relative to the South Arm water samples. Those in pink being higher in the North Arm, and those in blue being higher in the South Arm.

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Chapter 4: Sediment quality

Polycyclic Aromatic Hydrocarbons (PAHs)

Capsule

Polycyclic aromatic hydrocarbons (PAHs) were detected in all 10 sediment samples, with highest concentrations in the NA-OS sample. The average concentration in the North Arm sample was found to be higher than the average concentration in the South Arm, and higher than the concentration detected in the Main Stem.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a complex group of compounds found in coal, petroleum and plant materials. They can enter waterways in the form of liquid petroleum products (gasoline, diesel, oil) or via the incomplete combustion of coal, oil, gas, wood garbage or other organic substances. They can occur naturally or as a result of human activities (anthropogenic). In Canada, forest fires are the single most important natural source of PAHs, while anthropogenic sources include residential wood heating, aluminum smelters, creosote-treated products, spills of petroleum products and metallurgical and coking plants (Government of Canada, ECCC and Health Canada, 1994; Marvin et al., 2021).

Hydrocarbons can enter aquatic ecosystems either directly through oil spills or discharges from vessels (Morales-Caselles et al., 2017) or indirectly through atmospheric deposition, runoff and discharge from wastewater treatment plants. Depending on their molecular size, PAHs vary in toxicity and have been classified as toxic under the Canadian Environmental Protection Act (CEPA).

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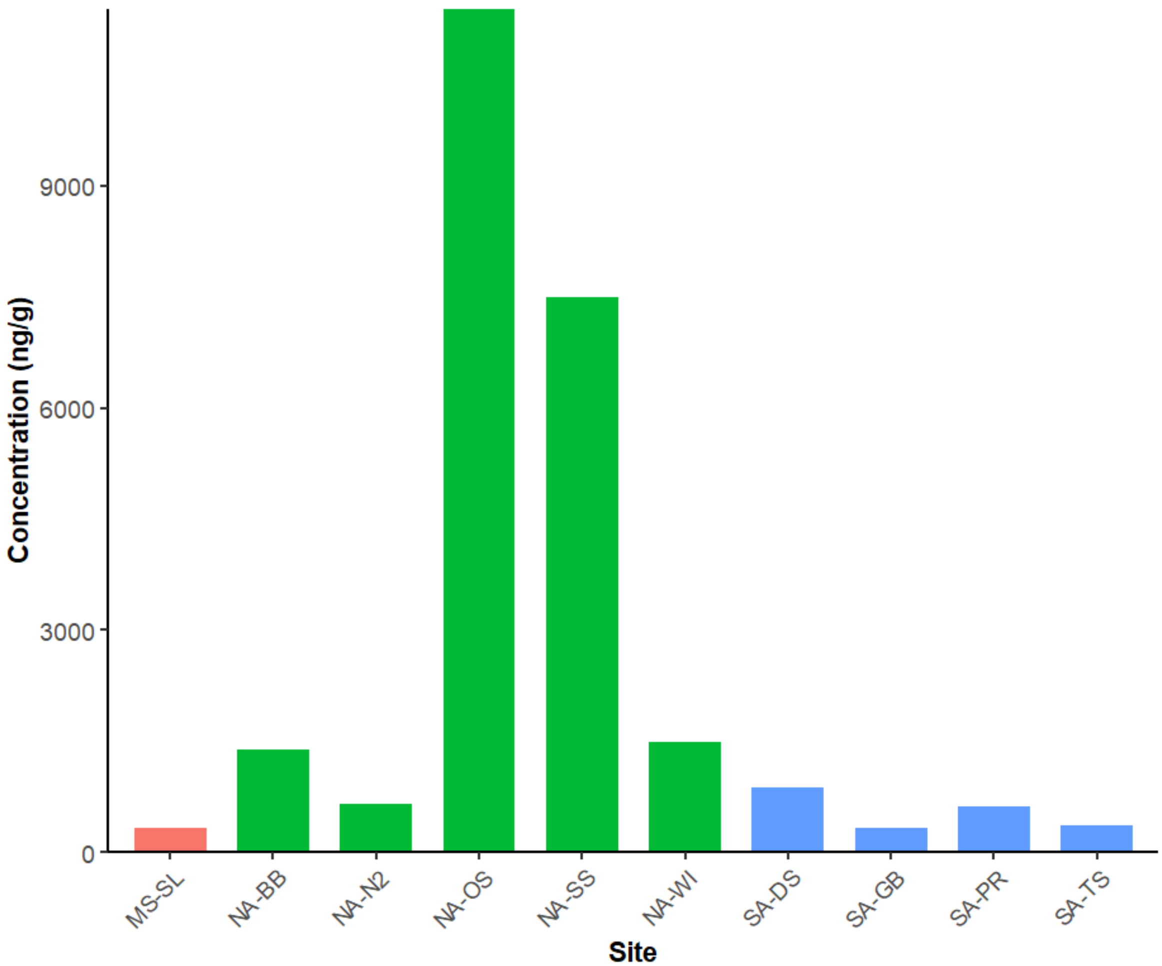
Results

Figure 4: Total PAH concentration in sediment sampled in the Fraser River Estuary (March 2025)



The highest total PAH concentration was detected in the NA-OS sample. Overall the highest total PAH concentrations were found in the North Arm (green) compared to the South Arm (blue) or Main Stem (red). Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 34: Comparison of average total PAH concentration (ng/g) +/- SEM (Min-Max) in sediments collected from the Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
327	4480 ± 1900 (647-11400)	544 ± 108 (330-867)	8.2	0.14

Average PAH concentrations in the North Arm were 8.2x higher than measured concentrations in the South Arm samples.

Table 35: Comparison of average PAH detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
72	76 ± 0 (76-76)	75 ± 0.43 (74-76)	1.0	0.06

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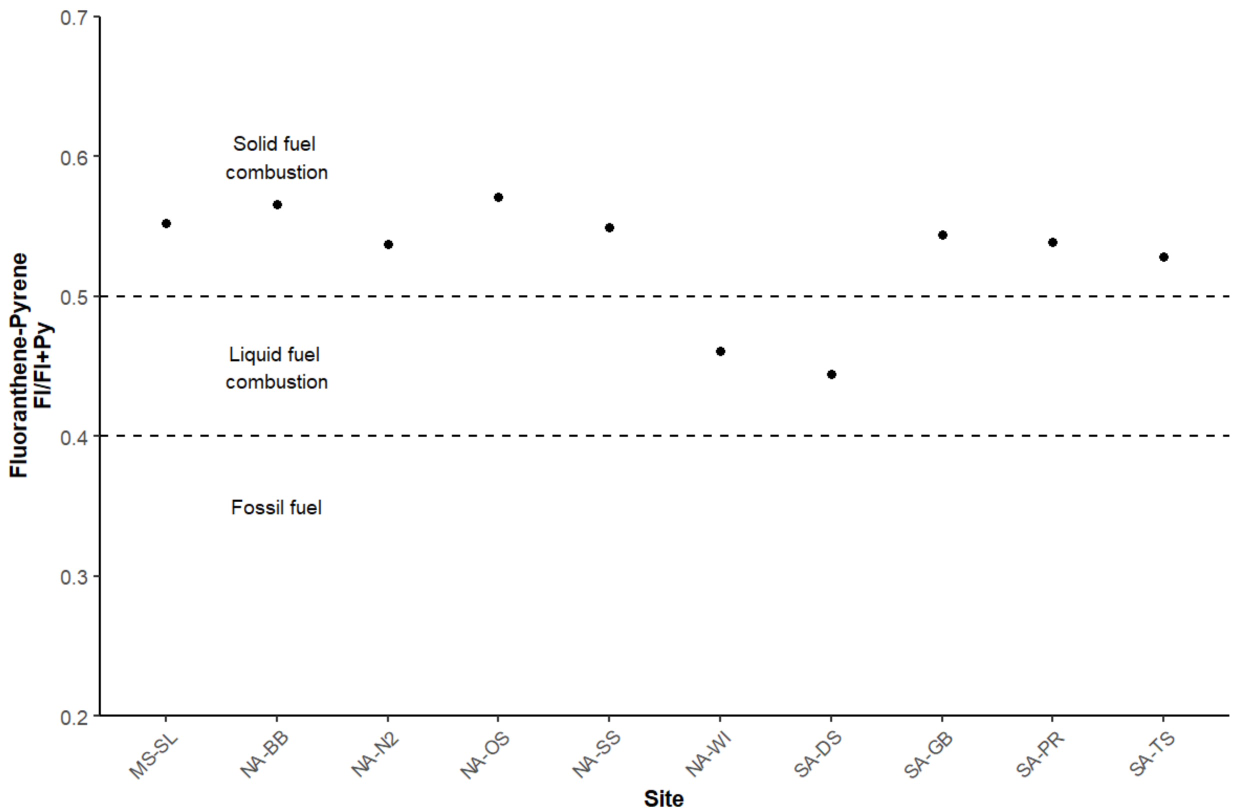
Figure 5: PAH profiles in sediment samples from the Fraser River Estuary (March 2025) identify putative sources of these contaminants



Ratios of certain PAHs can be used to evaluate sources. Most samples had a Fluoranthene - Pyrene ratio higher than 0.5 which indicates a major contribution of solid fuel combustion (ex. Wood, organic material, coal) to the source of the PAHs detected in these samples. Two samples (SA-DS and NA-WI) both had a ratio between 0.4 and 0.5, indicating that the major source of PAH contribution comes from liquid fuel combustion such as gasoline or diesel.

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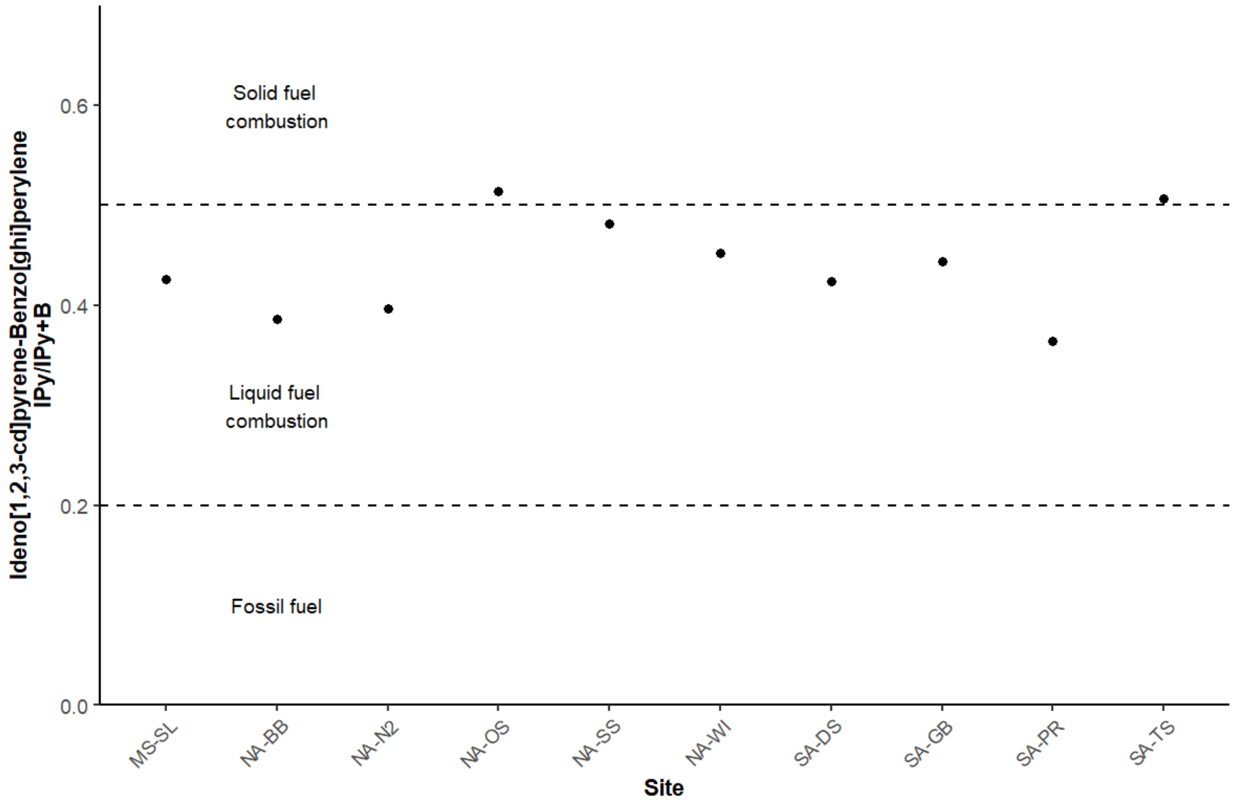
Figure 6: IPy/IPy+B profiles in sediment samples from the Fraser River Estuary (March 2025) identify putative sources of these contaminants



Ratios of certain PAHs can be used to evaluate sources. Most samples had a Ideno[1,2,3-cd]pyrene-Benzo[ghi]perylene ratio between 0.2 and 0.6 which indicates a major contribution of liquid fuel combustion (ex. Burning of gasoline or diesel for vehicle fuel) to the source of the PAHs detected in these samples. Two samples (NA-OS and SA-TS) both had a ratio above 0.5, indicating that the major source of PAH contribution comes from solid fuel combustion such as wood or coal.

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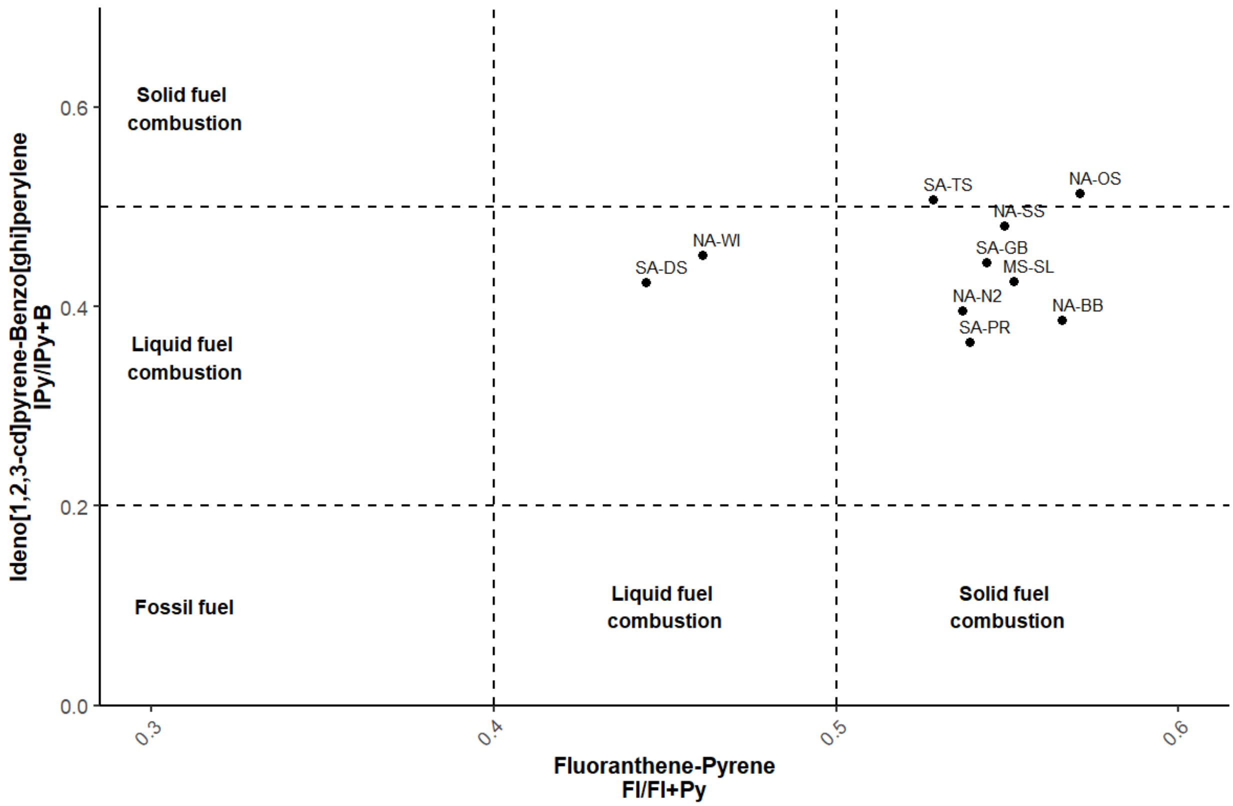
Figure 7: IPy/IPy+B and Fl/Fl+Py ratios in sediment samples from the Fraser River Estuary (March 2025) identify putative sources of these contaminants



This PAH biplot provides an indication of the provenance of the hydrocarbons detected in sediments in the Fraser River Estuary. For example, THe SA-TS and NA-OS samples fall into the solid fuel combustion category for both the IPy/IPy+B ratio, and the Fl/Fl+Py ratio, giving more evidence that the source of PAHs in those sediments is predominantly from the burning of solid fuels. Compare this with SA-PR, which falls into both solid fuel combustion from the Fl/Fl+Py ratio and liquid fuel combustion from the IPy/IPy+B ratio; this may suggest a mixed source for the PAHs in this sample, and others that fall into these ranges.

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Table 36: Exceedances of ISQGs and PELs in sediment samples collected from the Fraser River Estuary in March 2025

Sample ID	Analyte	ISQG (ng/g)	PEL (ng/g)	Detected (ng/g)	Exceeds ISQG	Exceeds PEL	Magnitude (× ISQG)
NA-OS	Phenanthrene	41.9	515	1180	Yes	Yes	28.2
	Fluoranthene	113	–	1200	Yes	No	10.6
	Pyrene	53	875	901	Yes	Yes	17.0
	Acenaphthene	6.71	88.9	292	Yes	Yes	43.5
	Fluorene	21.2	144	338	Yes	Yes	15.9
	Naphthalene	34.6	–	292	Yes	No	8.4
	Anthracene	46.9	–	222	Yes	No	4.7
	Benz[a]anthracene	31.7	–	235	Yes	No	7.4
	Chrysene	57.1	–	460	Yes	No	8.1
	Benzo[a]pyrene	31.9	–	133	Yes	No	4.2
	Dibenz[a,h]anthracene	6.22	–	18.1	Yes	No	2.9
	Indeno[1,2,3-cd]pyrene	37.0	–	66.8	Yes	No	1.8
	Acenaphthylene	5.87	–	24.8	Yes	No	4.2
NA-SS	Fluoranthene	111	235	1230	Yes	Yes	11.1
	Pyrene	53	875	1010	Yes	Yes	19.1
	Acenaphthylene	5.87	–	12	Yes	No	2.0
	Acenaphthene	6.71	–	32.9	Yes	No	4.9
	Fluorene	21.2	–	33.3	Yes	No	1.6

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	Phenanthrene	41.9	–	477.9	Yes	No	11.4
	Anthracene	46.9	–	64.2	Yes	No	1.4
	Benz[a]anthracene	31.7	–	209.9	Yes	No	6.6
	Chrysene	57.1	–	408.9	Yes	No	7.2
	Benzo[b]fluoranthene	88.8	–	207	Yes	No	2.3
	Benzo[a]pyrene	31.9	–	148	Yes	No	4.6
	Dibenz[a,h]anthracene	6.22	–	20.9	Yes	No	3.4
	Indeno[1,2,3-cd]pyrene	37.6	–	101.9	Yes	No	2.7
NA-WI	Acenaphthylene	5.87	–	12.2	Yes	No	2.1
	Benzo[a]pyrene	31.9	–	34.6	Yes	No	1.1
SA-DS	Phenanthrene	41.9	–	44.6	Yes	No	1.1

There were a number of exceedances of both ISQGs and PELs in sediment samples. These were largely found in the North Arm, with both the NA-OS and NA-SS samples having 13 exceedances.

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Conclusions

- The average PAH concentration in the North Arm samples was found to be 8.2x higher than the average concentration measured in the South Arm.
- Both the North Arm and the South Arm average concentrations were higher than was detected upstream in the single Main Stem water sample.
- Fluoranthene - Pyrene ratios in two of the samples (NA-WI and SA-DS) revealed that PAHs in these samples originated primarily from the combustion of liquid petroleum products, consistent with nearby vehicle emissions, at least for the road runoff sample.
- The Fluoranthene - Pyrene ratios revealed that PAHs in the majority of samples come from the combustion of solid fuel such as wood or plant material. This is consistent with wood burning for heating homes, local fires and wildfires as being major sources of PAHs in Canada (Berthiaume et al., 2021). Biomass burning in Asia has been shown to deliver PAHs to Canada through air masses traveling across the Pacific Ocean (Berthiaume et al., 2021).
- The only sample that exceeded the BC Guideline for Total PAHs for the sum of 13 parent PAHs in sediment for estuarine waters of 4,000 ng/g was the NA-OS (Oak Street sample) with a total PAH concentration of 5,362 ng/g.
- The NA-OS (Oak Street) sample had 13 exceedances of CCME Probable Effects Levels (PELs) (n=4) and Interim Sediment Quality Guidelines (ISQGs) (n=9).
- NA-SS - 13 exceedances of CCME PELs (n=2) and ISQGs (n=11).
- NA-WI - two exceedances of CCME ISQGs.
- SA-DS - one exceedance of CCME ISQGs.

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Pesticides

Capsule

The highest concentration of total pesticides was detected in the NA-N2 (Richmond No. 2 Comp) sample, and the lowest concentration was detected in the NA-WI (Woods Island) sample. The average concentration of total pesticides was found to be 1.4x higher in the North Arm samples when compared to the South Arm. There were three exceedances of CCME ISQGs for pesticides.

Introduction

Pesticides have been developed to control, destroy or inhibit the activities of pests. They have a wide range of applications in agriculture such as insecticide to prevent crop damage and fungicides to prevent plant disease but also in forestry, industry as well as in our own backyards for lawn care or weed and insect control. In Canada, all pesticides used, sold or imported are regulated by Health Canada's Pest Management Agency (PMRA) (Health Canada, 2007).

While pesticides are mostly applied on terrestrial habitats, they can reach aquatic environments through overspray or drift during application, surface runoff, and through long range atmospheric transport and deposition. It is estimated that 10% of pesticides applied to soil reach non-target areas, leading to their widespread presence in surface waters worldwide (Schulz, 2004; Anderson et al., 2022).

Organochlorine pesticides (OCP) were heavily used from the 1940s to the 1980s, but have been restricted due to their persistence, toxicity and potential for bioaccumulation. Current-use pesticides (CUPs) were subsequently favoured as an alternative to OCPs, and have been widely applied in recent decades (Ding et al., 2023). These tend to be more water-soluble and may be more mobile in fish habitat (Harris et al., 2008).

Results

We measured 26 different pesticides, including both legacy and CUPs in the 10 sediment samples collected within the Fraser River Estuary during March 2025.

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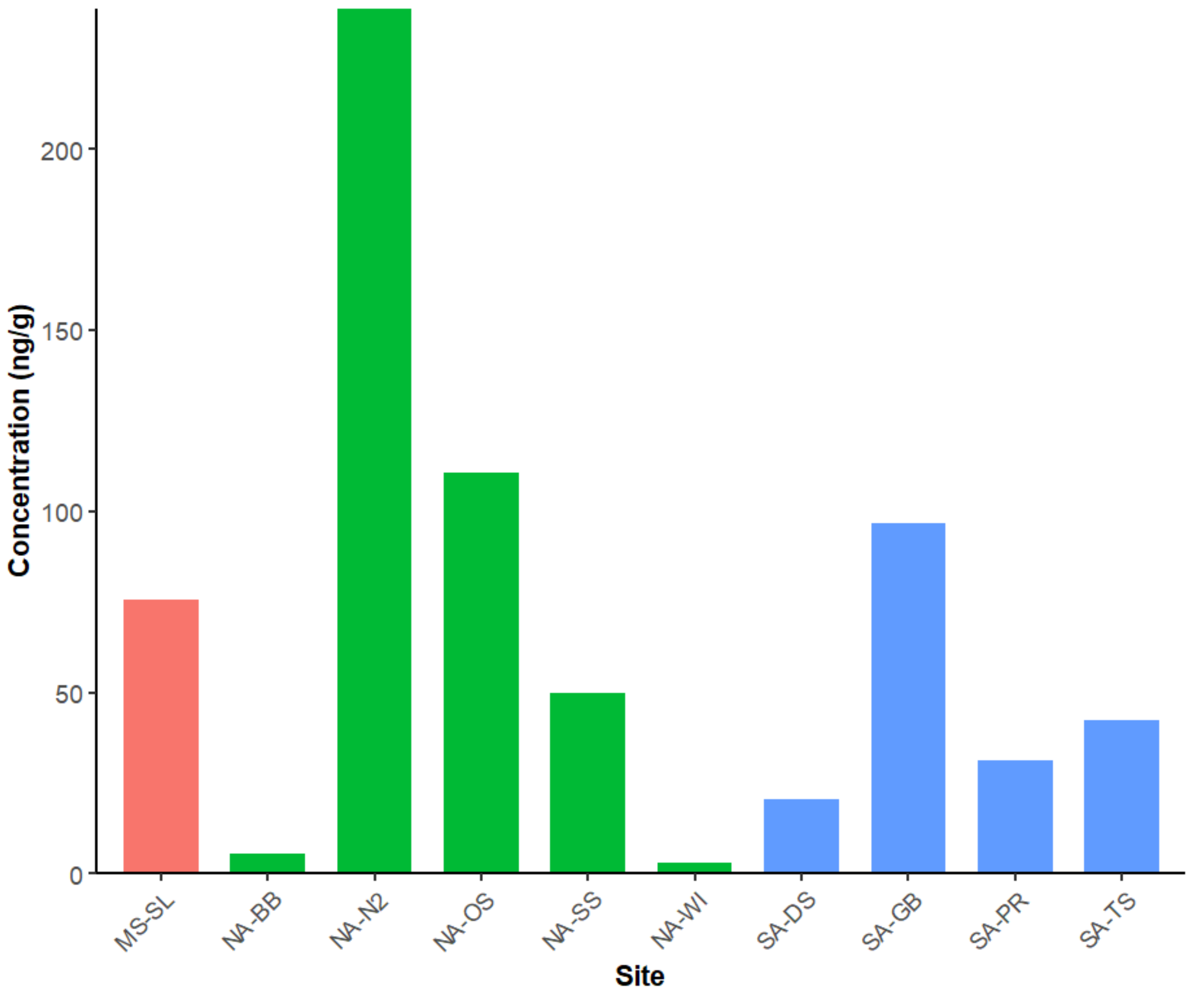
Figure 8: Total pesticide concentrations in sediment sampled in the Fraser River Estuary (March 2025)



The highest concentration of total pesticides was detected in the NA-N2 sample. Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

Table 37: Comparison of average total pesticide concentration (ng/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
75.6	81.5 ± 39.3 (2.92-239)	57.0 ± 16.5 (20.6-96.9)	1.4	0.51

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Average pesticide concentrations in the North Arm were 1.4x higher than measured concentrations in the South Arm samples.

Table 38: Comparison of average pesticide detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
18	26 ± 1.3 (23-30)	19 ± 1.4 (16-23)	1.4	0.02

Conclusions

- The highest total concentration of pesticides was detected in the NA-N2 (Richmond No. 2 Comp) sample, while the lowest average total concentration was detected in the NA-WI (Woods Island) sample.
- The average total pesticide concentration in the North Arm samples was found to be 1.4x higher than the average concentration measured in the South Arm.
- The North Arm average concentrations were higher than the concentration that was detected upstream in the Main Stem water sample, while the South Arm average concentration was lower.
- The average number of pesticide detections in the North Arm was higher than in the South Arm or in the upstream Main Stem sample.
- There were three exceedances of CCME ISQGs in the following samples:
- NA-SS*:*
    - 4,4′-DDE (2.9>1.42)
    - 4,4′-DDT(3.5>1.19)
- SA-TS*:*
    - 4,4′-DDE (3.88>1.42)
- There were no exceedances of BC Working Sediment Quality Guidelines for pesticides.

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Per- and poly-fluoroalkyl substances (PFAS)

Capsule

Per- and poly-fluoroalkyl substances (PFAS) were detected in all 10 sediment samples. The highest PFAS concentrations were observed in the NA-N2 sample, with the lowest being in the SA-DS sample. Eleven different PFAS compounds were detected across the 10 samples. There are no available Canadian Environmental Quality Guidelines for PFAS in sediment.

Introduction

Per- and poly-fluoroalkyl substances (PFAS) are large group (~15,000 compounds) of human-made substances used in a wide variety of products such as food packaging, non-stick cookware, clothing, and cosmetics, but also lubricants, oil/water repellents, and notably - aqueous film-forming foams (AFFF; Barzen-Hanson et al., 2017). They are extremely stable and therefore persistent in the environment, which has led to the use of the term “forever chemicals” for this category of chemical.

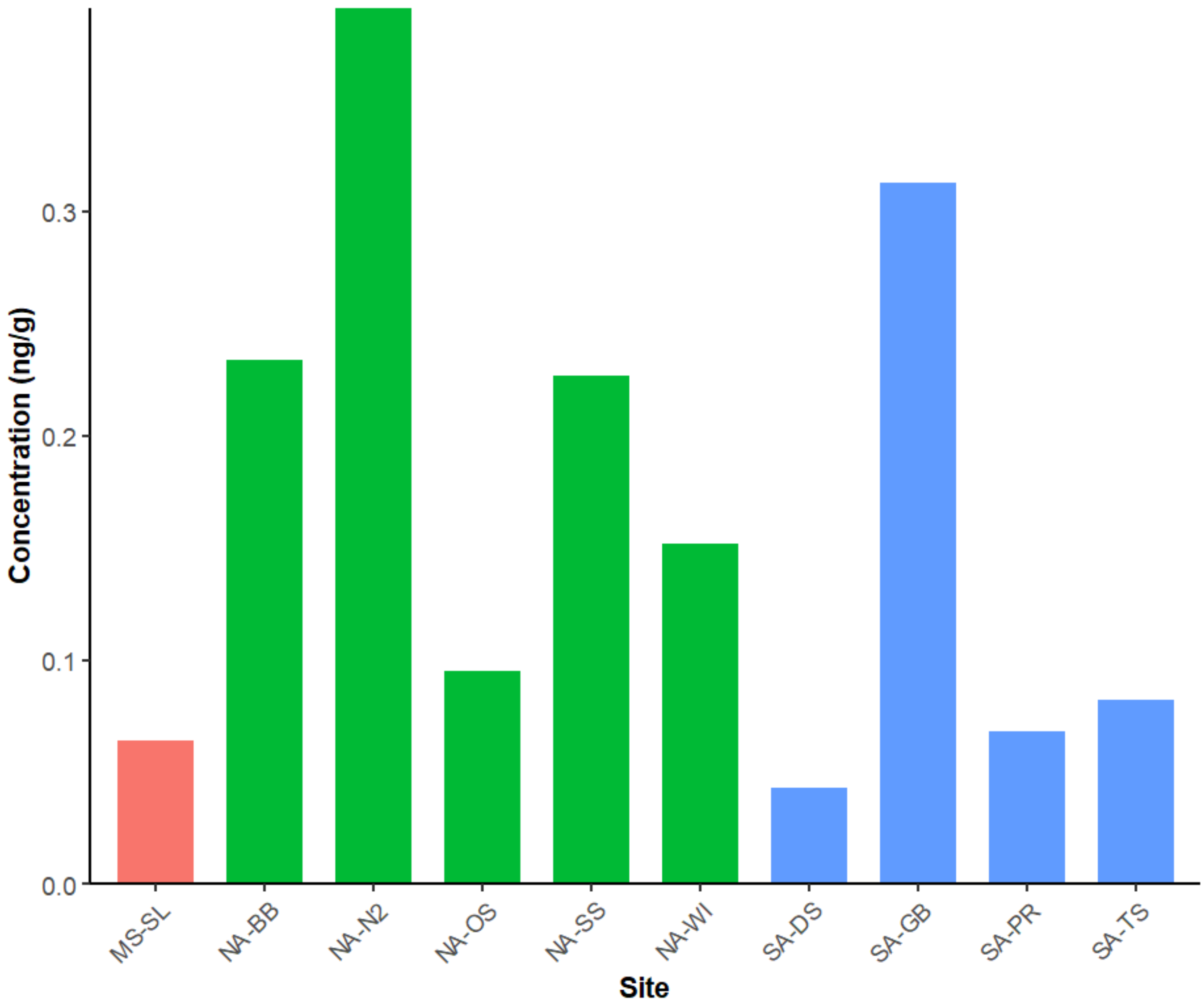
PFAS can be released into the environment from point sources such as manufacturing plants, or sites where firefighting foams have been used. PFAS can also be released through consumer use and disposal of PFAS-containing products. PFAS has been found in all environmental compartments (Moller et al., 2010; ECCC and Health Canada, 2023).

Evidence of adverse effects on the environment and on human health has led Canada to prohibit the manufacture, use, sale, offer for sale and import of a limited number of PFAS including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic Acid (PFOA), long-chain perfluorocarboxylic acids and their salts and precursors under the *Prohibition of Certain Toxic Substances Regulations* and the *Canadian Environmental Protection Act* (CEPA) (ECCC and Health Canada, 2023b). Advancing regulatory aspects pertaining to rapidly emerging concerns about the many PFAS being detected in the environment is a current priority in Canada (Longpre et al., 2020).

DOI: /10.70766/9.66067

Results

Figure 9: Total PFAS concentrations in sediment sampled in the Fraser River Estuary (March 2025)



The highest concentration of total PFAS was measured in the NA-N2 sample. The lowest concentration was measured in the SA-DS sample. Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 39: Comparison of average total PFAS concentration (pg/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
0.064	0.220 ± 0.045 (0.095-0.391)	0.127 ± 0.054 (0.043-0.313)	1.7	0.30

Average PFAS concentrations in the North Arm were 1.7x higher than measured concentrations in the South Arm samples.

Table 40: Comparison of average PFAS detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
2	3.2 ± 0.71 (1-5)	2.5 ± 0.75 (1-5)	1.3	0.57

The 11 PFAS compounds detected in the Fraser River Estuary samples were as follows:

- perfluorooctanesulfonic acid (PFOS)
- perfluorohexanoic Acid (PFHxA)
- Perfluorooctanoic acid (PFOA)
- Perfluorododecanesulfonic acid (PFDoS)
- N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)
- Perfluorodecanoic acid (PFDA)
- Perfluoroundecanoic acid (PFUnA)
- Perfluorotetradecanoic acid (PFTeDA)
- Perfluorododecanoic acid (PFDoA)
- Perfluorononanoic acid (PFNA)
- *N*-Methylperfluorooctanesulfonamide (*N*-MeFOSA)

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Conclusions

- The highest concentration of total PFAS was detected in the NA-N2 sample (0.391 ng/g), while the lowest concentration was detected in the SA-DS sample (0.043 ng/g).
- The average total PFAS concentration in the North Arm samples was found to be 1.7x higher than the average concentration measured in the South Arm.
- Both the North Arm and the South Arm average concentrations were higher than the concentration that was detected upstream in the Main Stem water sample.
- The average number of PFAS detections was found to be 1.3x higher in the North Arm compared to the average number of detections in the South Arm.
- There are no available Canadian Environmental Quality Guidelines for PFAS in sediment.

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Polychlorinated Biphenyls (PCBs)

Capsule

Despite having been targeted for phase out in Canada in 1977, with some closed uses allowed until December 31, 2029, industrial PCBs continue to be found in the environment, reflecting their stability and persistence. Polychlorinated biphenyls (PCBs) were detected in all ten water samples, with the highest concentration observed in the NA-SS (Shaughnessy Street) sample and the lowest in the MS-SL (Sapperton Landing) sample. One sample (NA-SS) exceeded both the CCME and BC Guidelines for total PCBs in sediment.

Introduction

Polychlorinated biphenyls (PCBs) comprise 209 congeners that are structurally related but have differing degrees of chlorination. The commercial production of PCBs began in 1929, after which they were heavily used in electrical and hydraulic equipment, as well as in paint additives, sealing and caulking compounds and inks. Due to their adverse health effects, the production of PCBs was banned in the late 1970s around the world (Othman et al., 2022). PCBs are among the first 12 Persistent Organic Pollutants (POPs) - often referred to as the “dirty dozen” - defined by the Stockholm Convention, an international treaty aimed at eliminating or restricting the production and use of POPs (UNEP, 2025).

PCBs were never produced in Canada, but were widely used, and are currently specified on the List of Toxic Substances under the Canadian Environmental Protection Act (ECCC 2010). Despite restrictions beginning in 1977, PCBs continue to pose a threat due to their persistence in the environment and their release from products that were manufactured before the ban, and/or were improperly disposed of (Othman et al., 2022). Closed use applications in the electricity generation sector may continue in Canada until final phase out in December 2029 (ECCC 2023) . Military uses of PCBs may continue thereafter.

In British Columbia (BC), PCBs remain the number one contaminant of concern in marine food webs with the iconic killer whales being among some of the most-PCB contaminated marine mammals in the world (Ross et al., 2000). Regulatory steps in the 1970s and since have led to declining PCB concentrations in aquatic animals in BC (Ross et al., 2013).

The 209 individual PCBs have different degrees of chlorination, with each individual PCB containing between 1 and 10 chlorine atoms in their structure.

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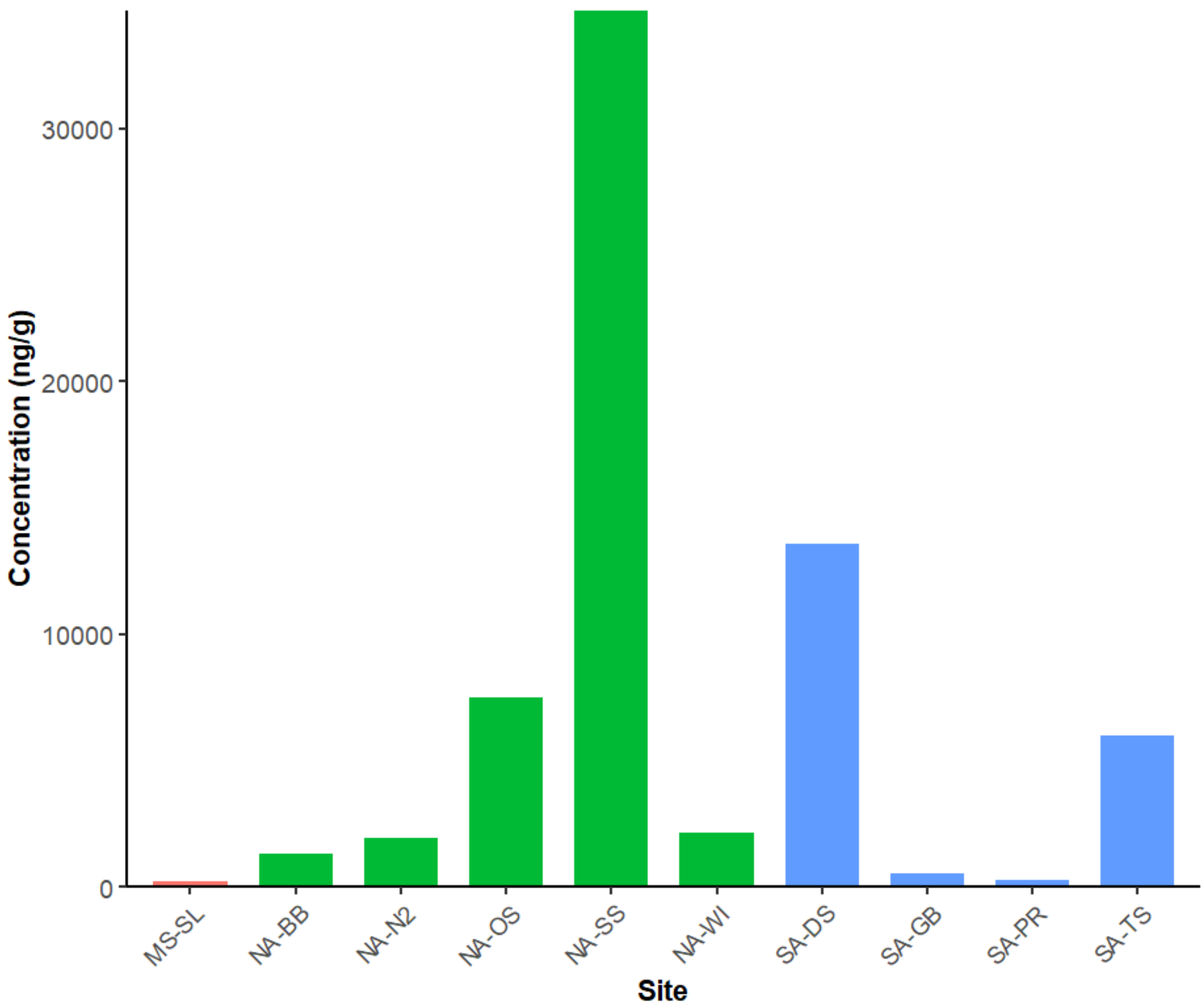
Results

Figure 10: Total PCB concentration (pg/g) in ten sediment samples collected from the Fraser River Estuary in March 2025



Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 41: Comparison of average PCB concentration (pg/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
230	9510 ± 5720 (1310-34700)	5100 ± 2700 (263-13600)	1.9x	0.56

Average PCB concentrations in the North Arm were 1.9x higher than measured concentrations in the South Arm samples.

Table 42: Comparison of average PCB detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
135	143 ± 1.61 (138-149)	143 ± 2.81 (137-152)	1.0x	0.97

Conclusion

- The highest total PCB concentration was detected in the NA-SS sample, while the lowest concentration was detected in the MS-SL sample.
- The average total PCB concentration in the North Arm samples was found to be 1.9x higher than the average concentration measured in the South Arm.
- Both the North Arm and the South Arm average concentrations were higher than the concentration that was detected upstream in the Main Stem water sample.
- The total PCB concentration detected in the NA-SS sample (34.7 ng/g) exceeds both the CCME ISQG (34.1 ng/g) and the BC Guideline (TOC-normalized) for total PCBs in sediment (29.8 ng/g).

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Polybrominated Diphenylethers (PBDEs)

Capsule

PBDEs are a class of synthetic compounds historically used as an additive to flame retardant mixtures for use in consumer products such as foam, textiles, electronics, and textiles, and have been observed to have endocrine-disrupting effects and neurotoxicity. In this study, PBDEs were only measured in sediment samples due to their tendency to become particle bound. PBDEs were detected in all samples collected from the Fraser River Estuary in March 2025, with the highest concentration detected in the NA-SS (Shaughnessy Street Park) sample, and the lowest concentration detected in the SA-DS (Deas Slough) sample. The average concentration of PBDEs in the North Arm samples were found to be greater than the average detected concentrations in the South Arm samples, and higher than the concentration detected in the Main Stem sample.

Introduction

Polybrominated diphenylethers (PBDEs) are a synthetic, brominated class of aromatic compounds that were historically used as additives in flame retardant formulations for consumer products such as polyurethane foams, textiles, electronics, and plastics (de Wit 2002; Hale et al. 2003). Structurally, PBDEs consist of two phenyl rings joined by an ether linkage substituted with one to ten bromine atoms, yielding a total of 209 possible congeners (ATSDR 2017). Commercial formulations were defined by their average bromination level—commonly referred to as penta-, octa-, and deca-BDE mixtures. Penta- and octa-BDEs were listed under the Stockholm Convention in 2009, with deca-BDE added in 2017 (Stockholm Convention 2019). PBDEs were phased out of use in Canada beginning in the mid-2000s (Environment Canada 2010).

PBDEs are classified as persistent organic pollutants (POPs) due to their environmental persistence, long-range transport potential, and ability to bioaccumulate (de Wit 2002; UNEP 2019). Congeners with lower degrees of bromination are more volatile, more water soluble, and more prone to atmospheric transport, whereas highly brominated congeners tend to associate with particulates and sediments (Wania and Dugani 2003).

Bioaccumulation and biomagnification are key environmental concerns for PBDEs, as they preferentially partition into lipid-rich tissues and accumulate at higher trophic levels.

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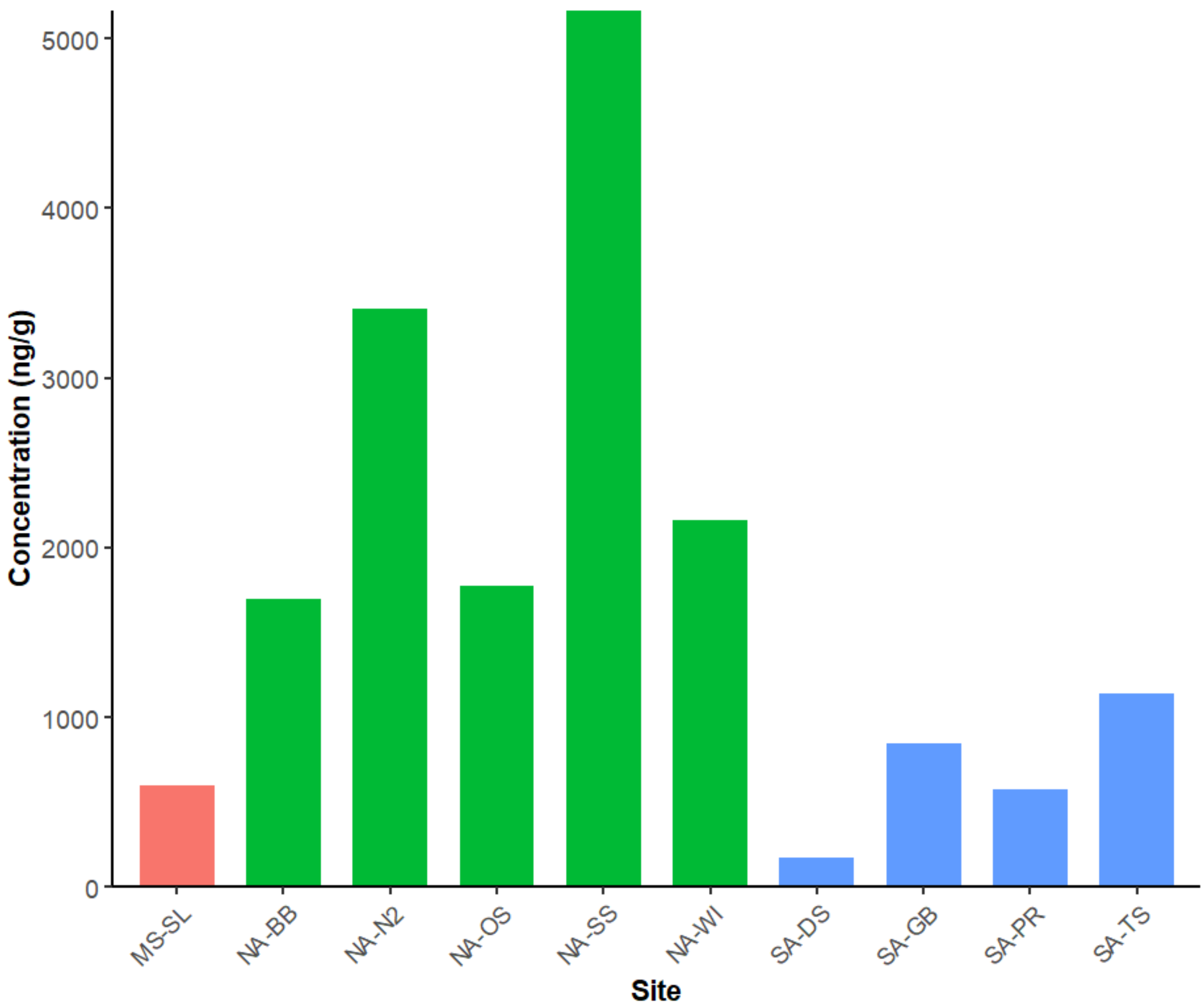
Elevated concentrations of PBDEs have been reported in Southern Resident Killer Whales (SRKWs) (Ross et al. 2006).

Results

Figure 11: Total PBDE concentration (pg/g) in ten sediment samples collected from the Fraser River Estuary in March 2025



Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 43: Comparison of average PBDE concentration (pg/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
595	2840 ± 588 (1700-5170)	684 ± 178 (172-1140)	4.2x	0.026

Average PBDE concentrations in the North Arm were 4.2x higher than measured concentrations in the South Arm samples.

Table 44: Comparison of average PBDE detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
24	28 ± 0.61 (26-30)	22 ± 1.3 (19-26)	1.3x	0.023

Conclusions

- Average PBDE concentrations in sediment samples from the North Arm were 4.2x higher than average PBDE concentrations detected in samples from the South Arm.
- The average concentration of Total PBDEs detected in the North Arm samples (2.84 ng/g) is well below the FEQG Sediment Quality Guidelines for the Protection of Aquatic Life of 3.7 ng/g for Total Sum of PBDEs. However, the concentration of total PBDEs at the NA-SS (Shaughessy Street) site (5.17 ng/g) exceeds this FEQG.
- The highest concentration of BDE-209 was measured in the NA-SS (Shaughessy Street) sample (3.75 ng/g) and does not exceed the FEQG Sediment Quality Guidelines for the Protection of Aquatic Life of 20.1 ng/g for BDE-209.

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Dioxins and Furans (DFs)

Capsule

Dioxins and furans (DFs) are persistent organic pollutants that fall into two structurally-related classes In this study, DFs were only measured in sediment samples due to their tendency to become particle bound. DFs were detected at the highest concentration in the NA-OS (Oak Street) sample, and at the lowest concentration in the MS-SL (Sapperton Landing) sample. There were seven exceedances of CCME Interim Sediment Quality Guideline (ISQG) for Toxic Equivalency Units (TEQs) for dioxins and furans.

Introduction

Dioxins and furans are structurally related classes of persistent halogenated organic contaminants, encompassing 210 congeners across two main families (75 polychlorinated dibenzo-*p*-dioxins [PCDDs] and 135 polychlorinated dibenzofurans [PCDFs]). These compounds are distinguished by the number and position of chlorine substituents on fused aromatic rings, with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) being the most toxicologically significant congener (ATSDR 1998; WHO 2005). They are produced primarily as unintentional by-products of combustion processes such as waste incineration and fuel burning, as well as from industrial activities—historically including chlorine bleaching in kraft pulp and paper mills prior to regulatory controls introduced in the late 1980s (Environment Canada 2001; UNEP 2013). Formation can also occur through natural processes such as forest fires and volcanic activity (UNEP 2013).

These contaminants are classified as persistent organic pollutants (POPs) due to their environmental persistence, low water solubility, and strong sorption to soils, sediments, and particulates, leading to significant bioaccumulation potential (ATSDR 1998; WHO 2005).

Toxic equivalency (TEQ) is used to express the combined toxicity of PCDD/F mixtures as a single value. Because each congener exhibits different toxicity, measured concentrations are weighted using Toxic Equivalency Factors (TEFs) established by the World Health Organization (WHO 2005).

For each congener, the measured concentration (pg/g) is multiplied by its corresponding TEF to derive a 2,3,7,8-TCDD equivalent concentration. The total TEQ for a sample is

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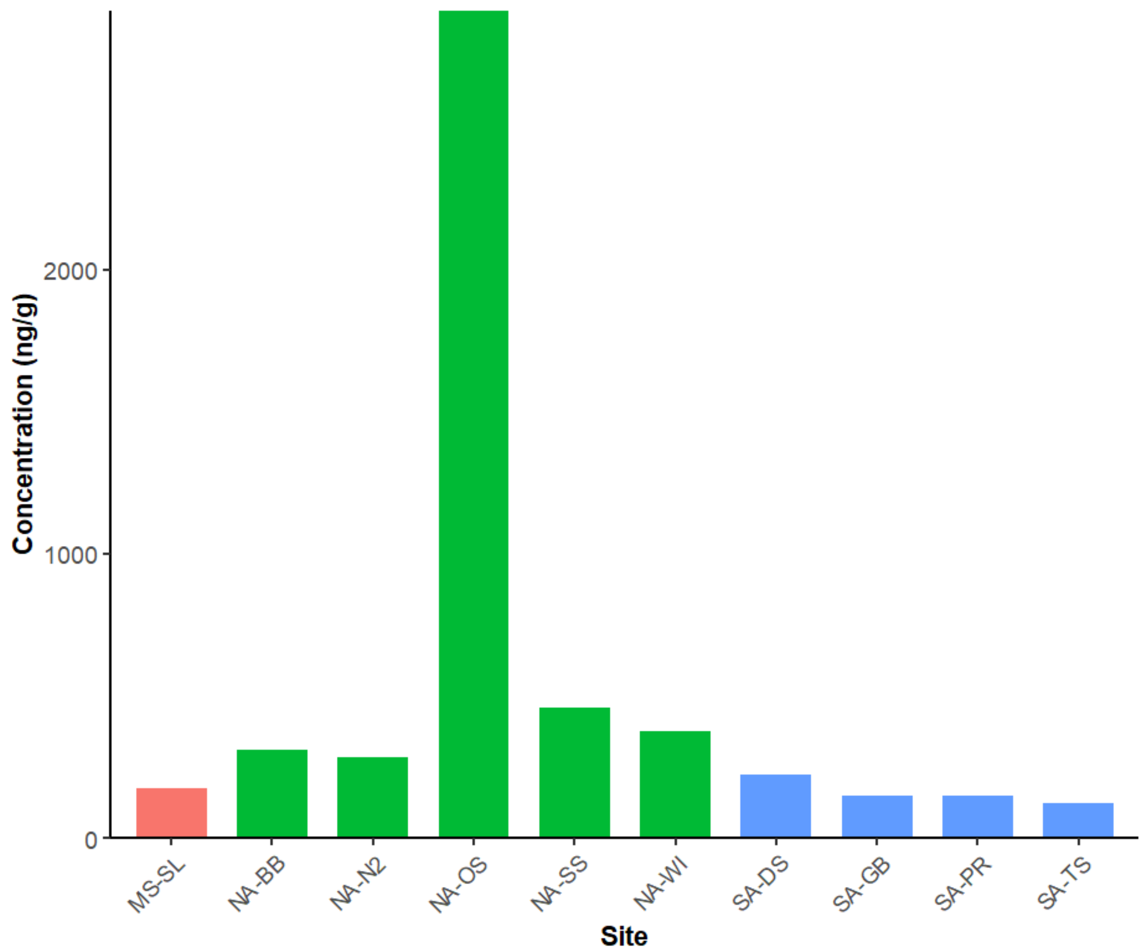
calculated as the sum of these individual contributions, which can then be compared with environmental quality guidelines (CCME 2001; WHO 2005).

Results

Figure 12: Total DFs concentration (ng/g) in ten sediment samples collected from the Fraser River Estuary in March 2025



The highest concentration of DFs was detected in the NA-OS sample. The lowest concentration was detected in the SA-TS sample. Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 45: Comparison of average PCDD/F concentration (pg/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
177	868 ± 458 (285-2910)	161 ± 18.7 (122-223)	5.4x	0.24

Average DF concentrations in the North Arm were 5.4x higher than measured concentrations in the South Arm sample.

Table 46: Comparison of average PCDD/F detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
17	19 ± 0 (19-19)	18 ± 0.23 (18-19)	1.0x	0.06

Conclusions

- The highest concentration of total PCDD/Fs was detected in the NA-OS (Oak Street) sample, while the lowest concentration was found in the SA-TS (Tilbury Slough).
- Average total PCDD/F concentrations in sediment samples from the North Arm were 5.4x higher than average concentrations detected in samples from the South Arm.
- There were six exceedances of the CCME ISQG for PCDD/Fs of of 0.85 pg/g TEQ:
    - MS-SL: Total TEQ = 0.812 pg/g
    - SA-PR: Total TEQ = 0.582 pg/g
    - NA-BB: Total TEQ = 1.87 pg/g Exceeds CCME guideline
    - NA-SS: Total TEQ = 2.76 pg/g Exceeds CCME guideline
    - NA-OS: Total TEQ = 7.21 pg/g Exceeds CCME guideline
    - NA-N2: Total TEQ = 1.39 pg/g Exceeds CCME guideline
    - NA-WI: Total TEQ = 2.83 pg/g Exceeds CCME guideline
    - SA-DS: Total TEQ = 1.64 pg/g Exceeds CCME guideline
    - SA-GB: Total TEQ = 0.77 pg/g
    - SA-TS: Total TEQ = 0.63 pg/g

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Alkylphenol Ethoxylates

Capsule

Alkylphenol ethoxylates (APEs) are industrial grade surfactants that have been found in wastewater and industrial discharges. APEs were detected in all 10 sediment samples collected from the Fraser River Estuary in March 2025. Average concentrations in the North Arm samples appeared higher than the average concentrations measured in the South Arm samples, and higher than the concentration measured in the Main Stem sample.

Introduction

Alkylphenol ethoxylates are non-ionic surfactants used in industrial and consumer applications. APEs and their breakdown products are considered estrogenic and can disrupt reproductive development in fish. These surfactants can be released into the environment via municipal and industrial discharges (Lalonde et al., 2021). Once released, APEs may reside in aquatic sediments and/or undergo some breakdown into shorter chain APEs; their half-life is estimated at over 60 years (Shang et al., 1999).

The endocrine-disrupting potential of APEs and their breakdown products in fish and wildlife has represented a concern in receiving waters around municipal wastewater treatment plants (La Guardia et al., 2001).

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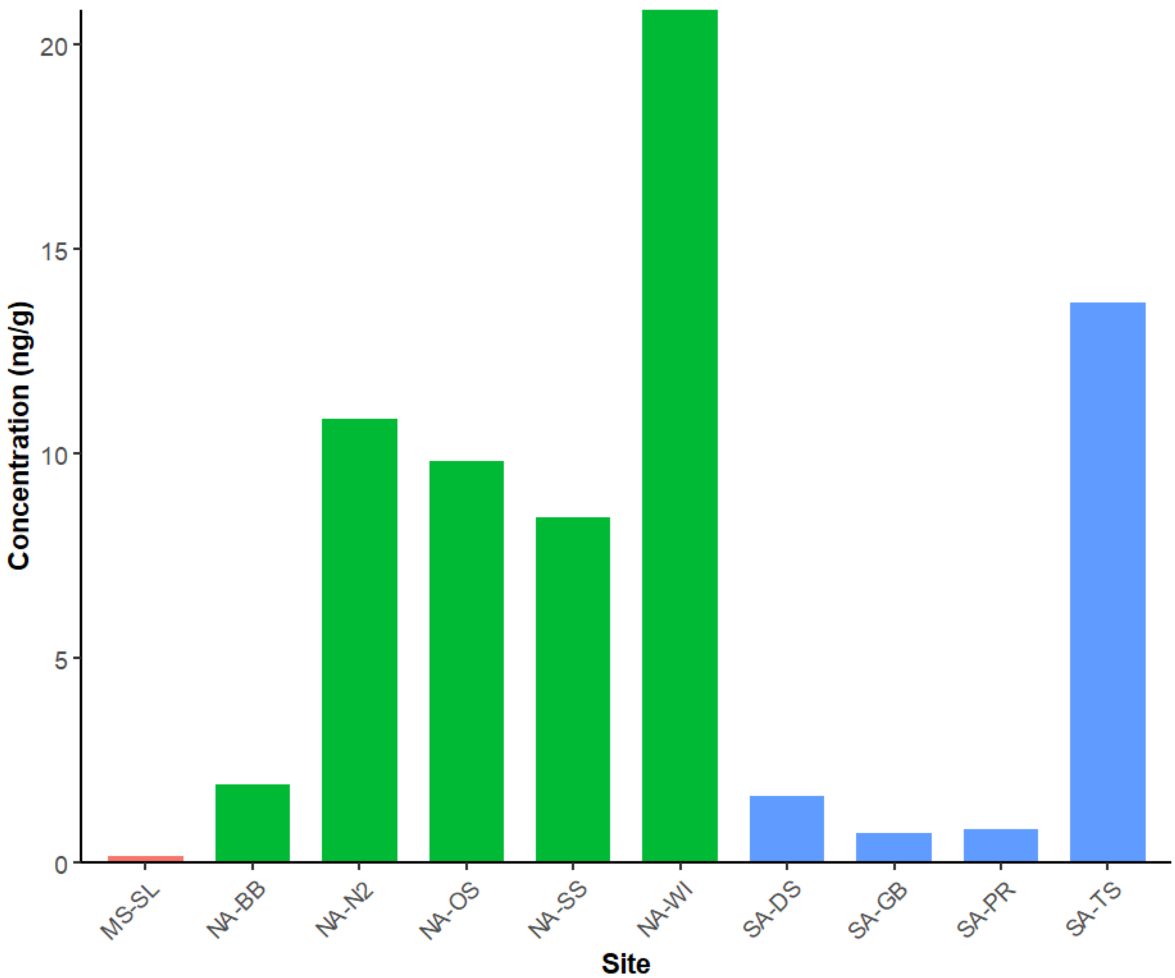
Results

Figure 13: Total APEs concentration (ng/g) in ten sediment samples collected from the Fraser River Estuary in March 2025



Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 47: Comparison of average APE concentration (ng/g) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
0.151	10.4 ± 2.73 (1.92-20.9)	4.23 ± 2.74 (0.741-13.7)	2.5	0.20

Average APE concentrations in the North Arm were 2.5x higher than measured concentrations in the South Arm samples.

Table 48: Comparison of average APE detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	North Arm (n=5)	South Arm (n=4)	Ratio North Arm: South Arm	P-value North Arm: South Arm
1	2 ± 0.18 (1-2)	1 ± 0.22 (1-2)	1.4	0.14

Conclusions

- The highest concentration of total APEs was detected in the NA-WI (Woods Island) sample, while the lowest concentration was detected in the MS-SL (Sapperton Landing) sample.
- Average APE concentrations in sediment samples from the North Arm were 2.5x higher than average APE concentrations detected in samples from the South Arm.
- Two APEs were detected in the Fraser River Estuary in March 2025: 4-Nonylphenols, and 4-n-Octylphenol.
- The average concentration of APEs detected in the North Arm samples (10.4 ng/g) is well below the CCME Freshwater Sediment Quality Guidelines for the Protection of Aquatic Life of 1400 ng/g for nonylphenol and its ethoxalates.

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Bisphenols

Capsule

Bisphenols are plastic additives with widely reported estrogenic (endocrine disrupting) properties. Bisphenol A (BPA) was the only bisphenol compound detected in the Fraser River Estuary. Average concentrations measured in the North Arm samples appeared to be higher than average concentrations measured in the South Arm, and higher than the concentration measured in the Main Stem sample.

Introduction

Bisphenols are used widely in the manufacturing sector, and are primarily used in the production of plastics and resins. Both single and multi-use plastic containers are frequently produced using bisphenol compounds, the most popular of which is Bisphenol A (BPA). Bisphenols are endocrine-disrupting chemicals that have been found to negatively impact reproductive development in fish, amphibians, and mammals (Faheem and Bhandari, 2021; Marlatt, *et al.* (2022)).

BPA has come under intense regulatory scrutiny in recent years. The widespread use of these chemicals in food packaging, beverage containers, and in water delivery systems has led to exposure in the general population, and associations with adverse outcomes in humans (Rochester 2013).

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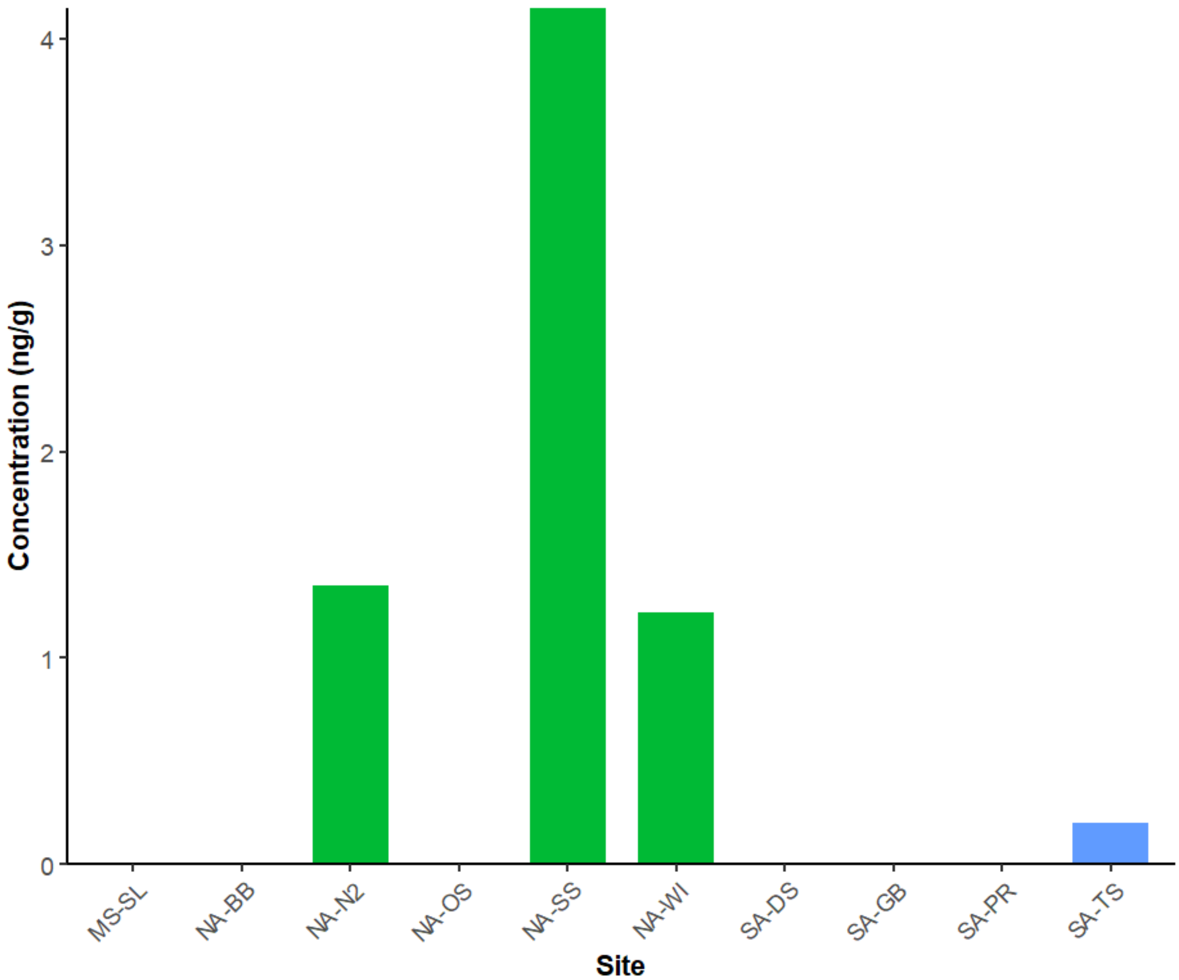
Results

Figure 14: Total bisphenol concentration (ng/g) in 10 sediment samples collected from the Fraser River Estuary in March 2025



Red represents the upstream Main Stem (MS) sampling site, green represents the North Arm (NA) sampling sites, and blue represents the South Arm (SA) sampling sites.

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Table 49: Comparison of average bisphenol concentration (ng/g) +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
0	1.34 ± 0.678 (0-4.15)	0.05 ± 0.043 (0-0.20)	27x	0.16

Average bisphenol concentrations in the North Arm were 27x higher than measured concentrations in the South Arm samples.

Table 50: Comparison of average bisphenol detections +/- SEM (Min-Max) in Main Stem, North Arm, and South Arm samples collected from the Fraser River Estuary in March 2025

Main Stem (n=1)	**North Arm** (n=5)	**South Arm** (n=4)	**Ratio North Arm: South Arm**	**P-value North Arm: South Arm**
0	0.6 ± 0.2 (0-1)	0.3 ± 0.2 (0-1)	2.4	0.35

Conclusions

- Average bisphenol concentrations in sediment samples from the North Arm were 27x higher than average bisphenol concentrations detected in samples from the South Arm.
- The only bisphenol compound that was detected in the Fraser River Estuary in March 2025 was BPA.
- A FEQG for BPA is set at 25 ng/g, which is much higher than the concentration we measured in the sediment samples from the Fraser River Estuary.

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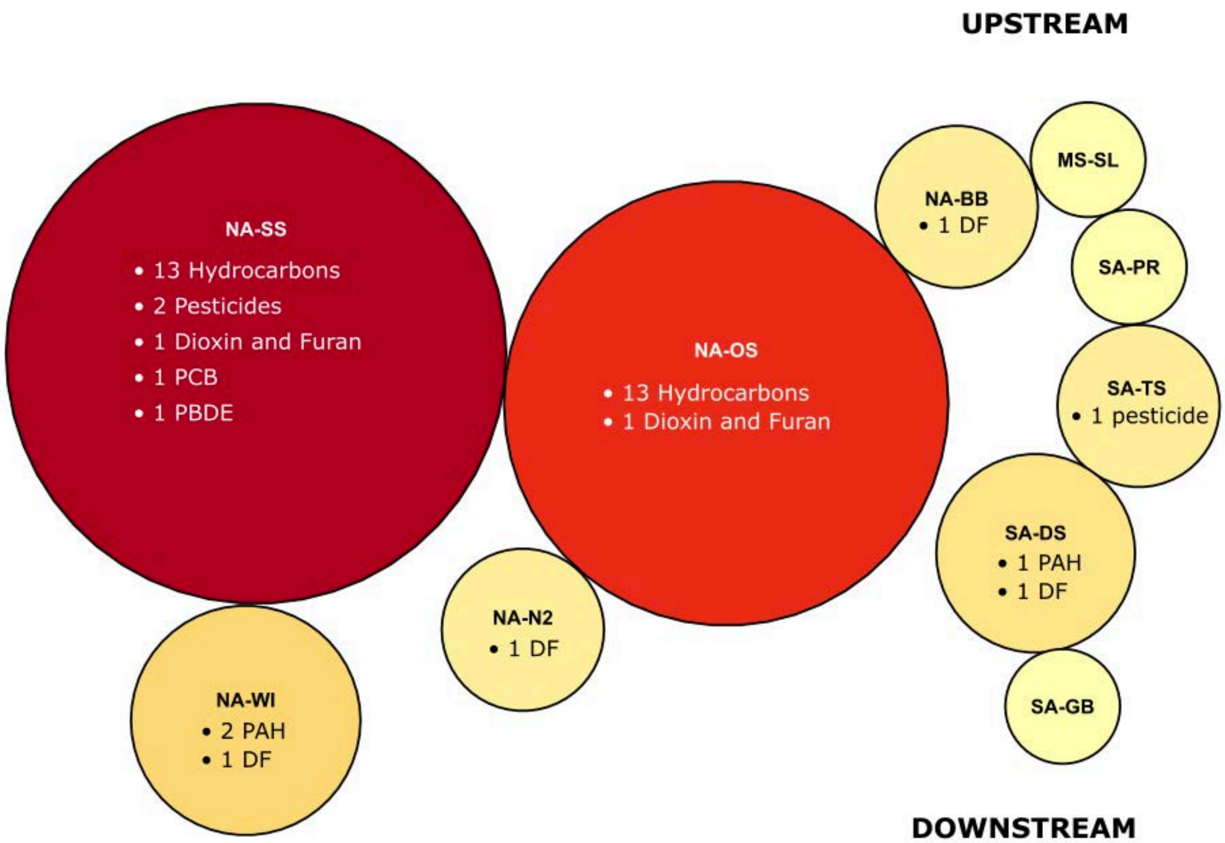
Sediment quality summary

Figure 15: The number of exceedances of Environmental Quality Guidelines in sediment samples from the Fraser River Estuary (March 2025) are depicted in this bubble plot



The larger the circle, the greater the number of Environmental Quality Guideline exceedances that were detected in each sample using circlepacking package in R (as in Bedward et al. 2024). NA-SS (North Arm - Shaughnessy Street) had the greatest number of EQG exceedances in sediment (n=18), and the second highest number of exceedances was found in the NA-OS (North Arm - Oak Street) sample (n=14). The circles in the figure are arranged from top right to bottom left in the order in which water flows through the two arms of the Fraser River. PAH=Polycyclic Aromatic Hydrocarbons; DF=Dioxins and furans; PCBs=Polychlorinated biphenyls; PBDEs=Polybrominated diphenylethers.

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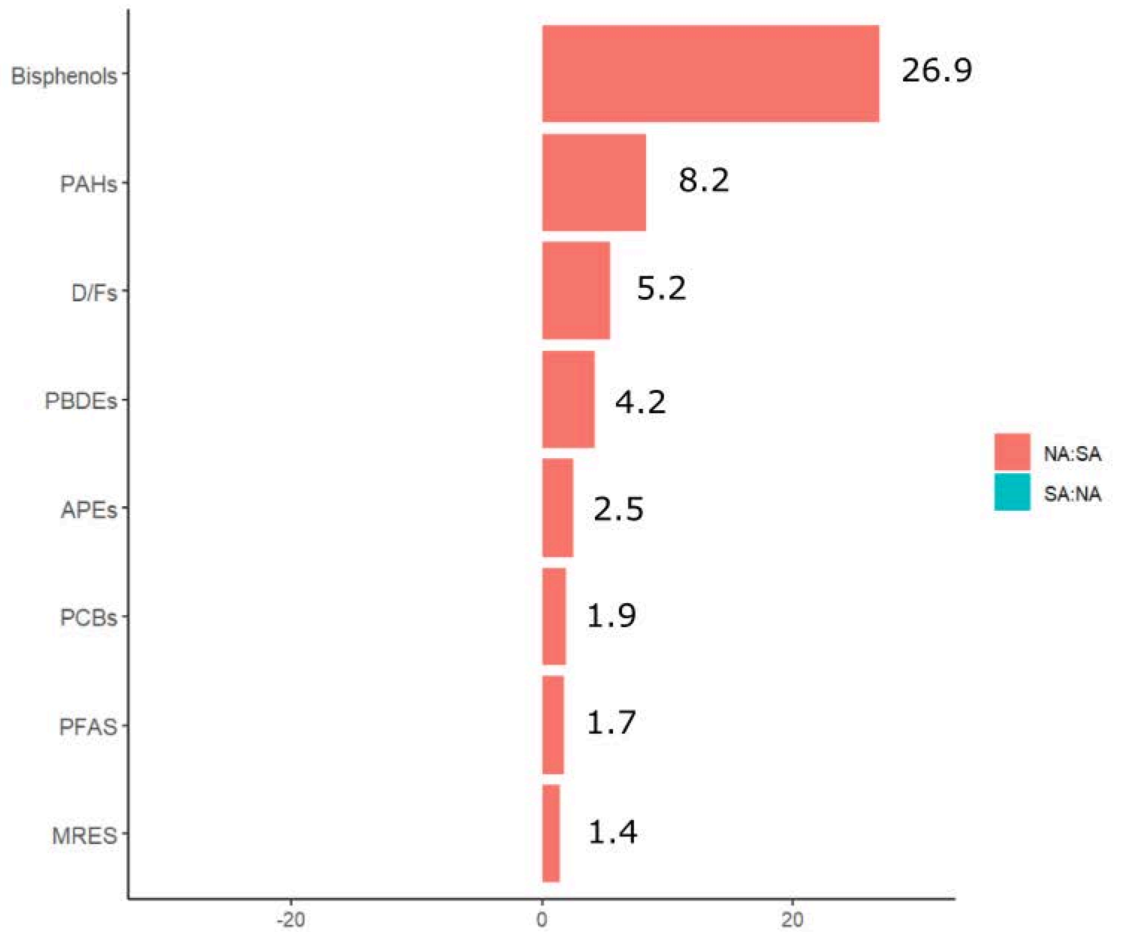
Figure 16: Differences were observed in the total concentrations of analytes detected in sediment samples between the North Arm and South Arm in March 2025



This figure compares how many times greater the total concentrations of the eight analyte classes are in the North Arm relative to the South Arm water samples. Those in pink being higher in the North Arm, and those in blue being higher in the South Arm. In sediment, there were no analyte classes that were observed at a higher concentration in the South Arm relative to the North Arm.

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Conclusions

The Fraser River Estuary is an ecologically diverse and important feeding and rearing ground for fish, invertebrates and seabirds, providing a staging area for migrating salmon and supporting resident killer whales in the adjacent Salish Sea. Complex mixtures of pollutants from urban areas and wastewater treatment plants threaten the health of salmon in BC and Washington (Lo et al., 2026; Meador 2014; Meador et al., 2024). The health of the Fraser River Estuary has been impacted by activities on the river and on adjacent lands. Over 3 million people live in the region, several wastewater treatment plants, over two-thirds of the agricultural production of British Columbia, a long history of log handling, sawmills and paper mills, and a variety of industrial and petrochemical plants.

The plethora of activities have had implications for the health of fish habitat. We detected between 213 and 237 contaminants in water and an average of 298 contaminants in North Arm sediment samples, an average of 281 contaminants in South arm sediment samples, and 269 contaminants in sediments from the upstream Main Stem site. The North Arm had more contaminants, higher concentrations of several contaminants, and more exceedances of EQGs compared to the South Arm.

There were 39 exceedances of Environmental Quality Guidelines in the North Arm sediment samples, these were dominated primarily by exceedances of PAH guidelines, but also pesticides, PCBs, Dioxins and Furans, and PBDEs (Figure 15). In contrast, there were only three exceedances of EQGs in sediments in the South Arm.

In water, the North Arm had higher concentrations of many analyte classes (n=5), compared to the South Arm sample (n=3) (Table 51). In sediments the North Arm had higher average concentrations across all measured analyte classes (n=8) compared to the South Arm (0; Table 52). This underscores the clear degradation of fish habitat in the North Arm, and the need for further study and for actions to identify and mitigate sources.

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Table 51: Summary of magnitudes of difference in concentrations in analytes between water samples collected from the North Arm and South Arm of the Fraser River

Analyte	North Arm	South Arm
PCBs	4.4	-
Bisphenols	2.4	-
PAHs	2.2	-
PFAS	1.3	-
MRES pesticides	1.0	-
sucralose	-	2.3
PPCPs	-	1.8
APEs	-	1.5
Average +/- SEM (Min-Max)	**2.3 +/- 0.6 (1.0-4.4)**	**1.9 +/- 0.2 (1.5-2.3)**

North Arm water samples were dominated by the more persistent and bioaccumulative classes of contaminants, while the South Arm had higher levels of the more water-soluble contaminants associated with domestic wastewater. PCBs: Polychlorinated biphenyls; PAHs: Polycyclic Aromatic Hydrocarbons; PFAS: Per and poly-fluoroalkyl substances, PPCPs: Pharmaceuticals and Personal Care Products; APEs: Alkylphenol Ethoxylates.

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Table 52: Summary of magnitudes of difference in concentrations in analytes between sediment samples collected from the North Arm and South Arm of the Fraser River

Analyte	North Arm	South Arm
Bisphenols	26.9	-
PAHs	8.2	-
Dioxins/Furans	5.4	-
PBDEs	4.2	-
APEs	2.5	-
PCBs	1.9	-
PFAS	1.7	-
MRES pesticides	1.4	-
Average +/- SEM (Min-Max)	**6.5 ± 3.0 (1.4-26.9)**	**-**

North Arm sediment samples had higher levels of particle-active contaminants compared to the South Arm. This is likely due to a combination of industrial discharges and activities influencing the North Arm, currents and sedimentation rates. PBDEs: Polybrominated diphenyl ethers; PCBs: Polychlorinated biphenyls; PAHs: Polycyclic Aromatic Hydrocarbons; PFAS: Per and poly-fluoroalkyl substances; APEs: Alkylphenol Ethoxylates

Restoration of fish habitat is underway in several locations in the Fraser River Estuary, the Lower Fraser Valley and upper reaches of the Fraser River watershed. These activities feature the removal of barriers, the modification of flood controls, the creation of shoreline complexity, and the revival of indigenous plant species in riparian zones. Such structural features enrich and restore fish habitats. However, a legacy of industrial activities, contamination by persistent pollutants banned decades ago, a number of contaminated sites, and ongoing discharges of road runoff, agro-forestry pesticides, industrial pollutants and municipal wastewater all contribute to degraded fish habitat health.

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List of acronyms

Abbreviation	Meaning
APE	Alkylphenol ethoxylates
BC EMA	British Columbia Environmental Management Act
CCME	Canadian Council of Ministers of the Environment
CEC	Contaminants of Emerging Concern
CEPA	Canadian Environmental Protection Act
CUP	Current-use pesticide
DF	Dioxins and Furans
DO	Dissolved oxygen
DRIPA	Declaration on the Rights of Indigenous Peoples Act
ECCC	Environment and Climate Change Canada
MOE	Ministry of Environment
MST	Microbial Source Tracking
NP	Nonylphenol
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenylethers
PCB	Polychlorinated biphenyls
PFAS	Per- and Poly-fluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
POP	Persistent organic pollutant

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PPCP	Pharmaceutical and personal care products
PVC	Polyvinyl chloride
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
TWP	Tire wear particle
WQGs	Water Quality Guidelines
WQI	Water Quality Index
WWTP	Wastewater treatment plant

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Appendix

Appendix 1: Environmental and Drinking water quality guidelines relevant for the present study. These guidelines were retrieved in May 2024.

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs[2]		Drinking WQGs
		Freshwater	Marine	Freshwater	Marine	
Basic Water Properties						
Temperature	-	19 C(short-term)	+1°C per hour change from background	narrative	max change of +0.5°C per hour	-
pH	-	6.5-9.0	7.0-8.7	6.5-9.0	7.0-8.7	7.0-10.5
Dissolved oxygen	-	>8.0 mg/L (long-term) >5.0 mg/L (short-term)	-	6.5-9.5 mg/L	80 mg/L	-
Conductivity	-	-	-	-	-	-
Turbidity	-	-	-	narrative	narrative	≤ 1.0 NTU
Metals (mg/L)						
Aluminum, total	-	variable	-	0.005 if pH < 6.5	-	2.9
Lead, total	-	3 when ≤ 8 mg/L CaCO3 (short-term)	<140 ug/L	equation	-	0.005
Nutrients (mg/L)						
Nitrate (as N)	-	3.0 (long-term) 32.8 (short-term)	3.7 (long-term)	550	200 (long-term) 1500 (short-term)	10
Nitrite (as N)	-	table	0.02 when Cl- ≤ 2 (long-term) 0.06 when Cl- ≤ 2 - (short-term)	0.06	-	1.0
Ammonia (Total as N)	-	table	table	table	-	-
Phosphate	-	0.015 (long-term)	-	-	-	-
Coliform						
Total coliform	-	-	-	-	-	0
Fecal coliform	-	-	-	-	-	0
E. coli	-	-	-	-	-	0

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PAHs (ug/L)						
Naphthalene	-	1	-	1.1	1.4	-
Acenaphthene	-	6	6	5.8	-	-
Fluorene	-	12	12	3	-	-
Anthracene	-	4	-	0.012	-	-
Phenanthrene	-	0.3	-	4.4	-	-
Fluoranthene	-	4	-	0.04	-	-
Pyrene	-	0.02	-	0.025	-	-
Chrysene	-	-	0.1	-	-	-
Benzo-a-anthracene	-	0.1	-	0.018	-	-
Benzo-a-pyrene	-	0.01	-	0.015	-	0.04
PCBs (ng/L)						
Total PCBs	-	0.1	-	-	-	-
PCB-105	-	0.09	-	-	-	-
PCB-169	-	0.06	-	-	-	-
PCB-77	-	0.04	-	-	-	-
PCB126	-	0.00025	-	-	-	-
Bisphenols (ug/L)						
BPA	1.4	-	-	-	-	-
Alkylphenols (ug/L)						
4-Nonylphenols	-	1 (long-term)	-	-	-	-
PFAS (ug/L)						
Perfluorooctane Sulfonate (PFOS)	6.8 (fresh)	3.4	-	-	-	0.6
Perfluorooctanic acid (PFOA)	-	-	-	-	-	0.2
Pesticides (ug/L)						
Atrazine	-	1.8[3]	-	1.8	-	5
Chlorothalonil	-	-	-	0.18	-	-
Cyanazine	-	2	-	-	-	-
Chlorpyrifos	-	0.02	0.002	-	-	90
Diazinon	-	0.0043	-	-	-	-
Dimethoate	-	-	-	6.2	-	20
Endosulfan	-	0.0007 (active ingredient)	-	0.06 (short-term) 0.003 (long-term)	0.09 (short-term) 0.002 (long-term)	-
Malathion	-	0.1	-	-	-	290

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Metribuzin	-	1[3]	-	1.0	-	80
Permethrin	-	0.004[3]	-	0.004	0.001	-
Picloram	-	29	-	-	-	-
Simazine	-	10[3]	-	10	-	10

[1] Federal EQGs apply to both fresh and marine waters unless otherwise stated. [2] CCME EQGs are reported for long-term effects unless otherwise stated. [3] Represents CCME guidelines that the BC government has adopted as working water guidelines

Appendix 6: Health Canada Screening values for nine different PFAS compounds

Compound Name	Acronym	Screening value (mg/L)	Screening value (ug/L)
perfluorobutanoate	PFBA	0.03	30
perfluorobutane sulfonate	PFBS	0.015	15
perfluorohexanesulfonate	PFHxS	0.0006	0.6
perfluoropentanoate	PFPeA	0.0002	0.2
perfluorohexanoate	PFHxA	0.0002	0.2
perfluoroheptanoate	PFHpA	0.0002	0.2
perfluorononanoate	PFNA	0.00002	0.02
6:2 fluorotelomer sulfonate	6:2 FTS	0.0002	0.2
8:2 fluorotelomer sulfonate	8:2 FTS	0.0002	0.2

Adapted from
https://www.canada.ca/en/services/health/publications/healthy-living/water-talk-drinking-water-screening-values-perfluoroalkylated-substances.html

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Fraser River Estuary fish habitat: Contaminant profiles and concentrations in water and sediment

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