Quantifying and tracing material flux from Vancouver (British Columbia, Canada) to the coastal ocean, and its fate and impacts in the marine ecosystem

Brian Hunt, Sadie Lye, Dilan Sunthareswaran, Sophia Johannessen, Anna McLaskey, Rachel Scholes

Institute for the Oceans and Fisheries

University of British Columbia

PELAGIC
ECOSYSTEMS
LABORATORY

PICES November 2025

Land acknowledgement

This study was conducted on the unceded traditional territories of the Səl̓ílwətaʔ/Selilwitulh (Tsleil-Waututh), xwməθkwəy̓əm (Musqueam), and Skwxwú7mesh (Squamish) First Nations.

Research acknowledgements

- This presentation largely represents the thesis work of Sadie Lye and Dilan Sunthareswaran, as part of the Urban Oceans Project;
- Pelagic Ecosystem Lab members for assistance in field collections, lab processing, data analysis;
- Tsleil-Waututh Nation and Metro Vancouver – research guidance and feedback

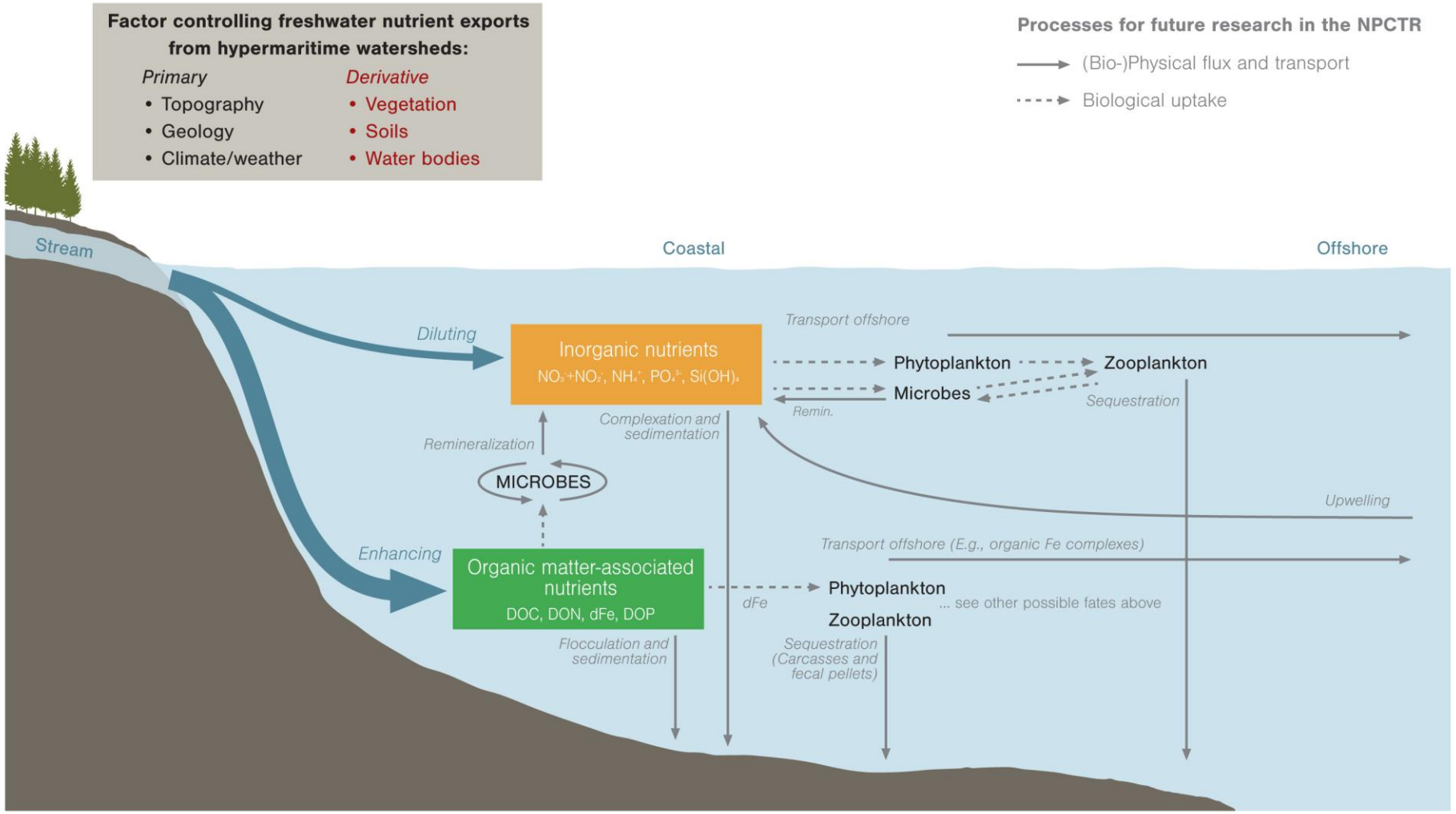
Funders

NSERC CRSNG

metrovancouver

PETER WALL LEGACY AWARDS
THE UNIVERSITY OF BRITISH COLUMBIA

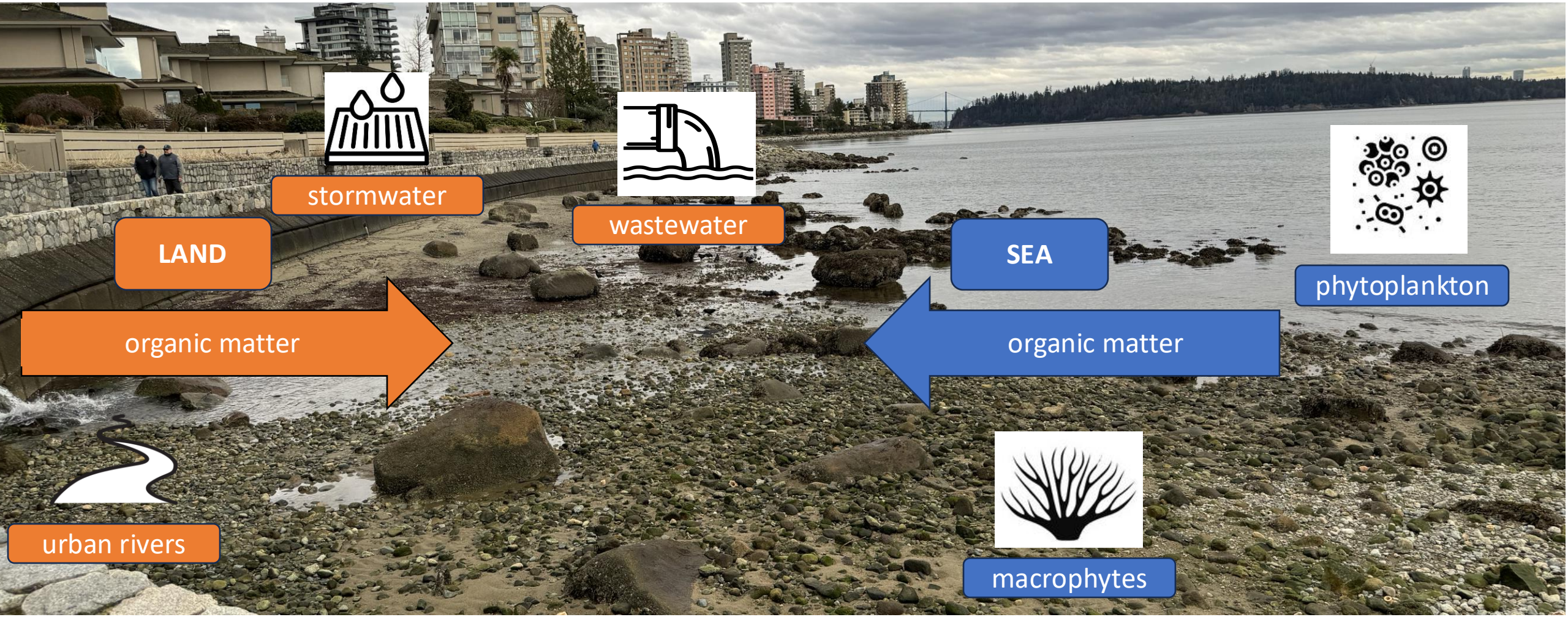
Elements of the land—ocean connection



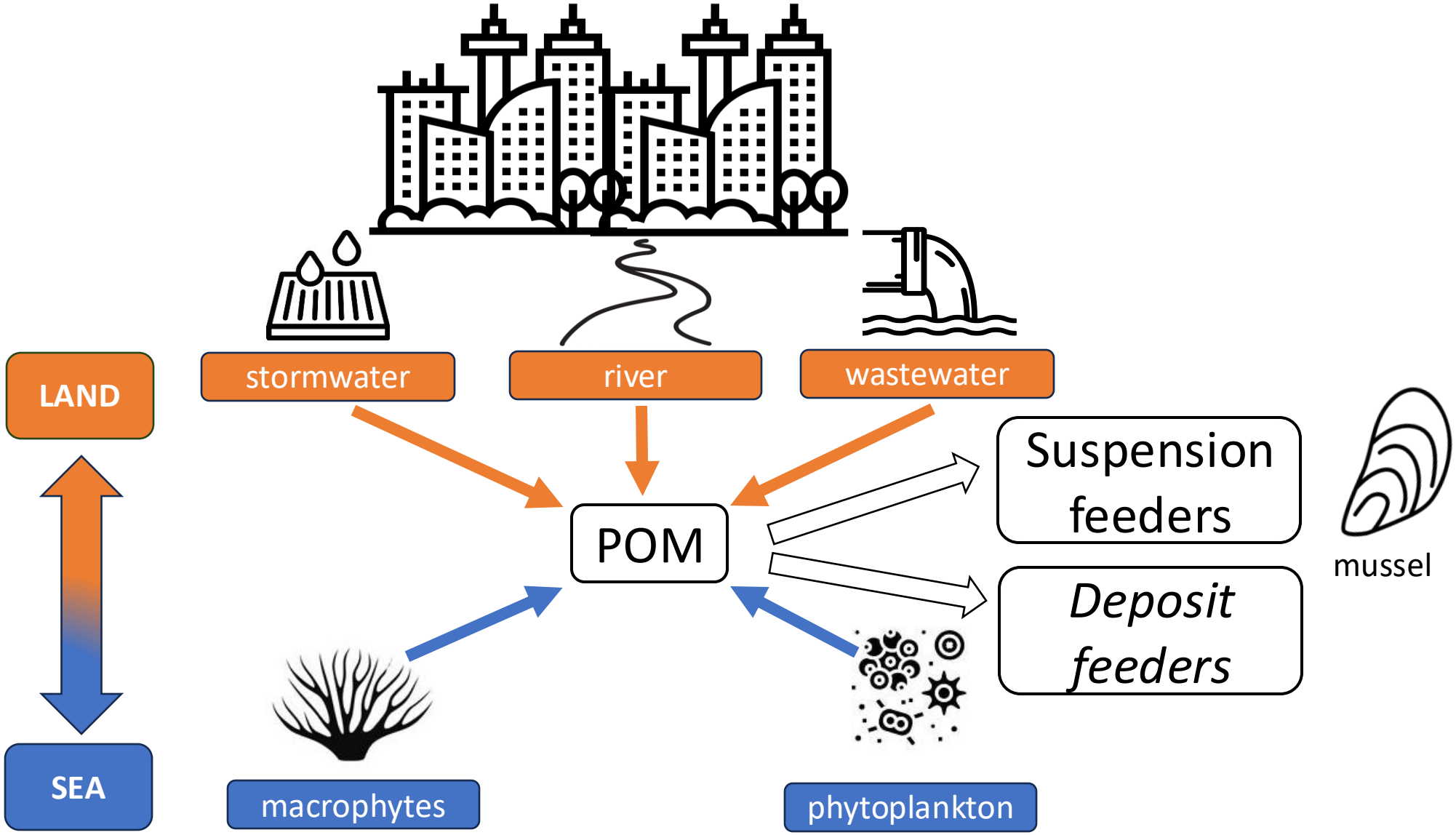
St. Pierre et al. Biogeosciences 2021; https://doi.org/10.5194/bg-18-3029-2021

Urban organic mater points of entry

Urban organic mater points of entry



Organic matter in the marine food web



Emergent questions and study aims

1. **How does urbanization transform organic and inorganic nutrient flux to the coastal ocean?**
   - *Determine the contributions and biogeochemical signatures of organic matter in stormwater, wastewater, and urban rivers*

Emergent questions and study aims

1. **How does urbanization transform organic and inorganic nutrient flux to the coastal ocean?**
   - *Determine the contributions and biogeochemical signatures of organic matter in stormwater, wastewater, and urban rivers*
2. **What is the fate of these materials in the marine environment?**
   - *Quantify the contributions of organic matter types to particulate organic matter (POM) in Metro Vancouver's coastal ocean*

Emergent questions and study aims

1. **How does urbanization transform organic and inorganic nutrient flux to the coastal ocean?**
   - *Determine the contributions and biogeochemical signatures of organic matter in stormwater, wastewater, and urban rivers*
2. **What is the fate of these materials in the marine environment?**
   - Quantify the contributions of organic matter types to particulate organic matter (POM) in Metro Vancouver's coastal ocean
3. **What is the impact of the transformed land—ocean connection on the marine ecosystem?**
   - *Uptake of urban organic matter by suspension feeders & health implications*

Methods

Urban organic matter sources

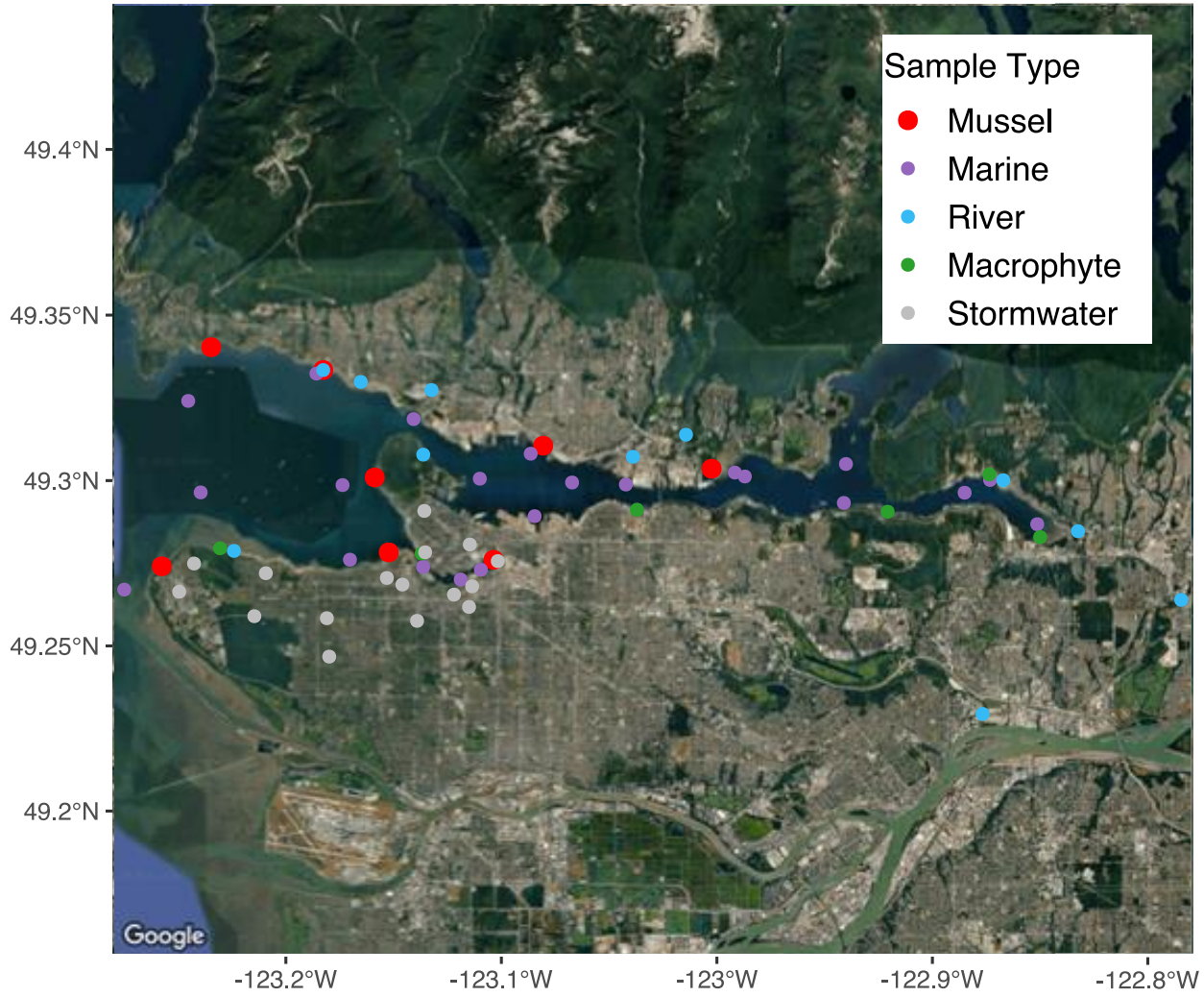
- Rivers – 12 sampled seasonally in 2023
- Stormwater – road runoff; 16 collections (Sep 2023 - Feb 2024)
- Wastewater sampled 5 WWTPs in Sep 2024

Marine organic matter sources

- Phytoplankton - surface POM
- Macrophytes – sampled ~ monthly

Suspension feeder

- Mussels – sampled monthly at 7 sites



Methods

Measurements:

Particulate organic matter & mussels

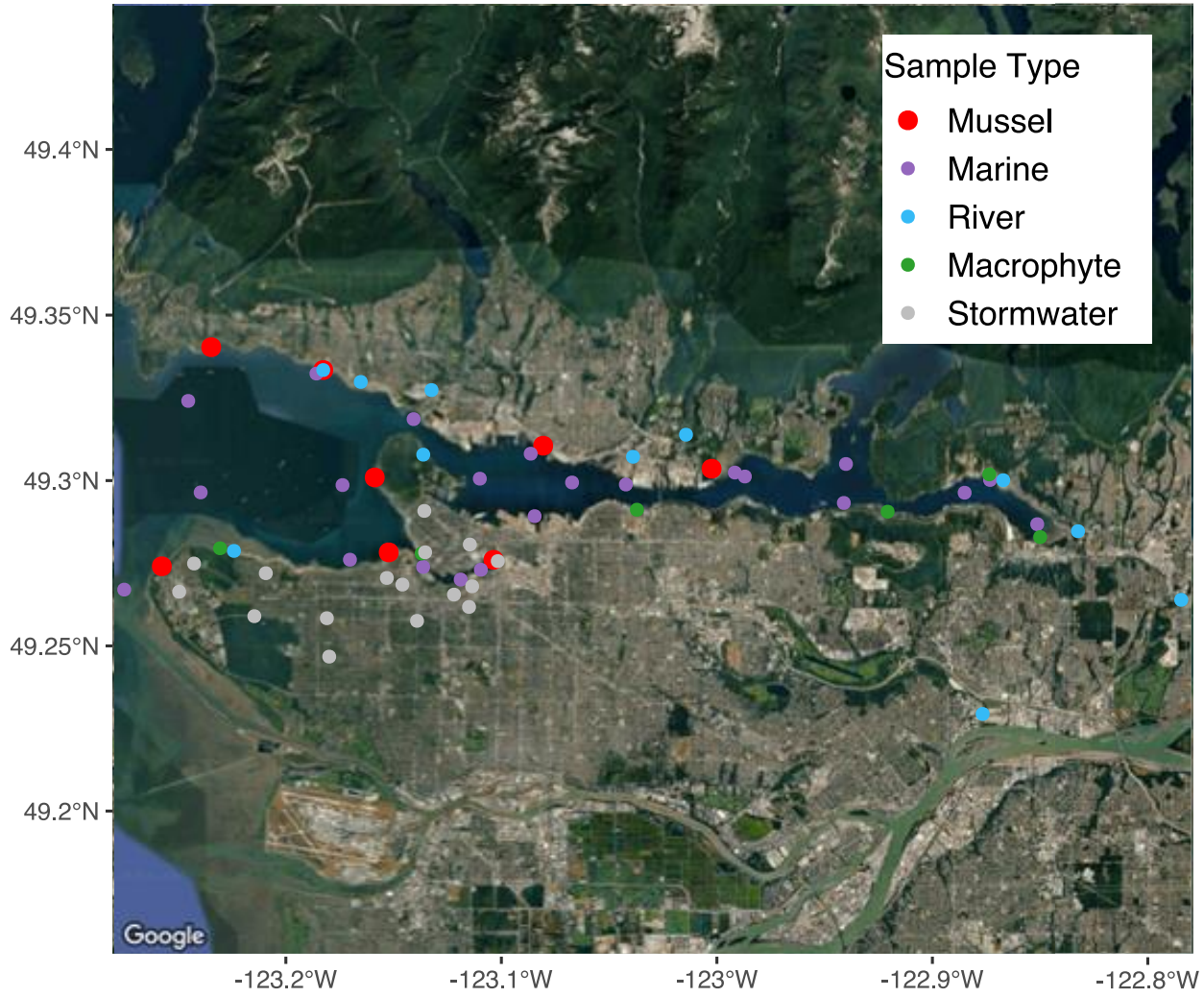
- C & N stable Isotopes ($\delta^{13}C$ & $\delta^{15}N$)
- Fatty acids (FA)
- Organic C & N content

Water chemistry

- DOC, TDN, nitrate, phosphate, silicate

Analysed contributions of OM types to marine POM & mussels

- Bayesian mixing models using signatures of OM types



Inorganic nutrient and OM concentrations

	Data source	Location	$Si(OH)_4$ (µmol L^{-1})	PO_4^{3-} (µmol L^{-1})	NO_3^- (µmol L^{-1})	DOC (mg L^{-1})	TDN (mg L^{-1})	POC (mg L^{-1})	PN (mg L^{-1})
Stormwater	1	Metro Vancouver	8.88 ± 12.29	1.36 ± 2.53	8.81 ± 6.46	10.26 ± 13.55	2.41 ± 1.71	15.92 ± 21.46	0.81 ± 0.84
Urban Rivers	1	Metro Vancouver	114.98 ±168.91	0.40 ± 0.70	38.52 ± 31.95	4.57 ± 4.37	3.43 ± 2.94	0.97 ± 3.37	0.06 ± 0.08
Non-urban rivers	4	Central Coast of B.C.	0.047 ± 0.063	0.003 ± 0.003	0.007 ± 0.01	11.46 ± 4.66	0.198 ± 0.063	N/A	N/A
Wastewater	1	5 WWTPs in Metro Vancouver	N/A	N/A	N/A	N/A	N/A	0.07 ± 0.06	0.01 ± 0.01
CSOs	5	4 CSO locations in Metro Vancouver	N/A	N/A	11.73 ± 10.95	N/A	N/A	N/A	N/A
Fraser River	6	British Columbia	81.23 ± 0.12	0.125 ± 0.016	4.76 ± 0.28	3.24 ± 0.85	N/A	0.54 ± 0.11	N/A
Marine	7	Strait of Georgia, British Columbia	31.35 ± 15.18	0.81 ± 0.65	7.58 ± 9.25	N/A	N/A	N/A	N/A
	8	Strait of Georgia, British Columbia	N/A	N/A	N/A	0.74 ± 0.11	N/A	0.14 ± 0.098	N/A

1. This Study; 2. (MacDonald et al., 1997); 3. (Sakamaki & Richardson, 2008); 4. (St Pierre et al., 2021); 5. (Metro Vancouver Liquid Waste Services Environmental Management and Quality Control, 2024); 6. (Voss et al., 2014, 2015); 7. (Pacific Salmon Foundation, n.d.); (Johannessen et al., 2008)

Lye et al, in prep

Fatty acid concentrations

	Data source	Location	TFA (µg L^{-1})	EFA (µg L^{-1})	SFA (µg L^{-1})	MUFA (µg L^{-1})	PUFA (µg L^{-1})	DHA: EPA	C:N
Stormwater	1	Metro Vancouver	464.81 ± 463.74	68.64 ± 44.93	237.23 ± 218.93	144.22 ± 201.39	70.11 ± 45.2	0.05 ± 0.16	23.58 ± 6.52
River	1	Metro Vancouver	17.92 ± 14.53	1.48 ± 1.27	12.26 ± 11.1	3.44 ± 3.15	1.61 ± 1.38	0.4 ± 0.4	13.18 ± 2.98
Wastewater	1	5 WWTPs in Metro Vancouver *(effluent and influent)*	16341.72 ± 13017.81	1842.24 ± 1498.04	6909.51 ± 6335.19	7270.90 ± 5898.83	1872.30 ± 1513.69	0.64 ± 0.37	7.49 ± 2.38
Marine	7	Strait of Georgia B.C.	21.6 ± 1.4	4.8 ± 0.4	10.48 ± 6.88	3.99 ± 3.33	6.37 ± 6.03	0.95 ± 0.03	4.88 ± 0.89

1. This Study; 2. (Eganhouse et al., 1981a); 3. (Culliford, 2015) 4. (Sakamaki & Richardson, 2008); 5. (Vargas et al., 2011) 6. (Volkman et al., 1999); 7. (McLaskey et al., 2022b)

Lye et al, in prep

Stormwater vs. wastewater annual flux

Parameter		
Freshwater (km^3)	1.07	0.428
Nitrate (tonnes yr^{-1})	555.84	203.55
Dissolved organic carbon (tonnes yr^{-1})	10,439.05	4,400
Particulate organic carbon (tonnes yr^{-1})	16,197.8	12,000
Particulate Nitrogen (tonnes yr^{-1})	824.14	50.6
	This study	(Metro Vancouver Liquid Waste Services Environmental Management and Quality Control, 2024); (Johannessen et al., 2003); (Sutton et al., 2013);

Lye et al, in prep

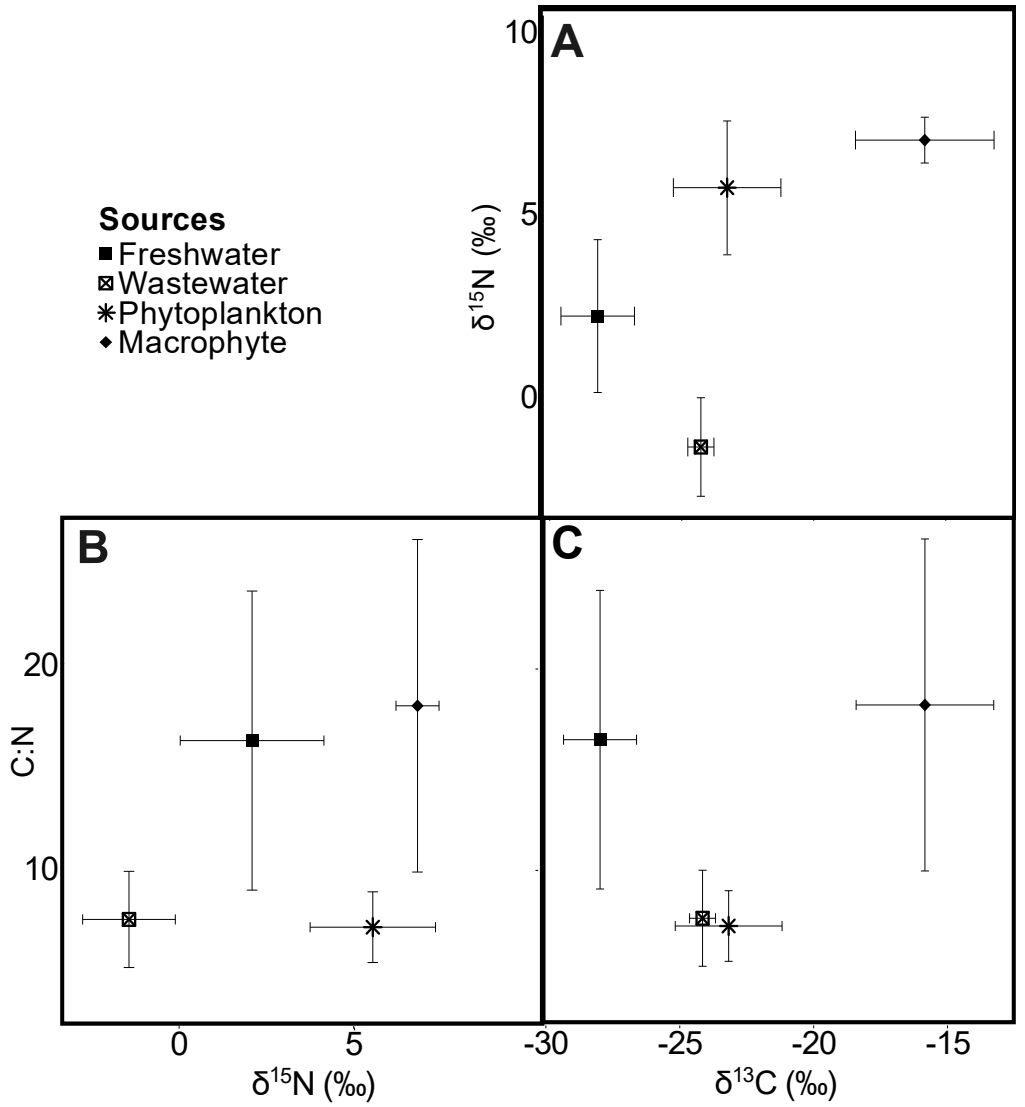
Signatures of urban & marine organic matter

Organic matter types had statistically different biogeochemical signatures

<u>Figure</u>

$\delta^{13}C$, $\delta^{15}N$ and C:N values

Freshwater = combined river + stormwater



Organic matter proportions in surface POM

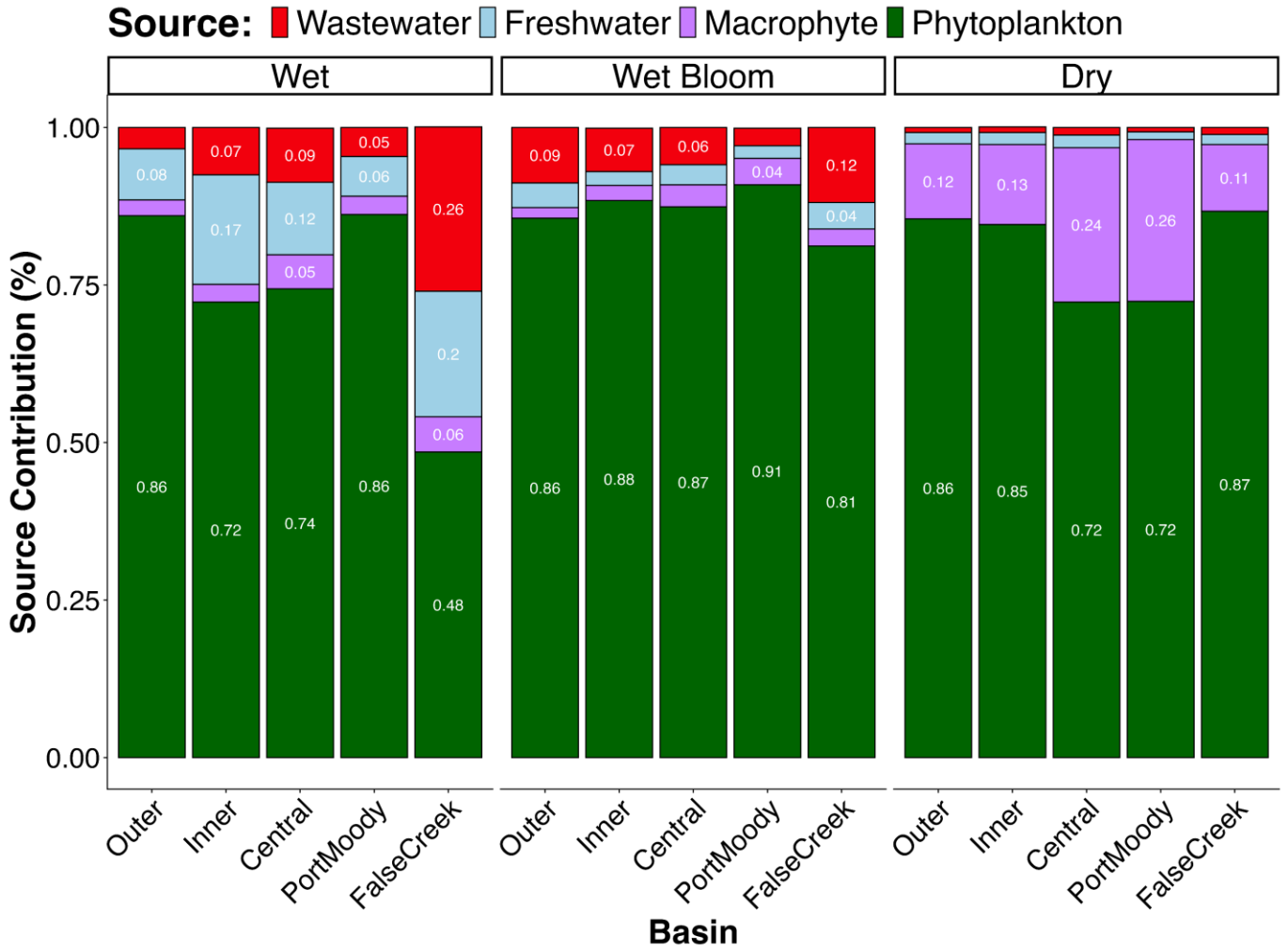
Isotope based mixing model estimates

Phytoplankton [ave = 80%]
- Highest during wet bloom (81-91%)
- Lowest in wet season (48-86%)

Macrophytes [ave = 8%]
- Highest in dry season (11-26%)

Freshwater [river+stormwater; ave = 6%]
- Highest in wet season (up to 20%)

Wastewater [ave = 6%]
- Highest wet & wet bloom seasons (up to 26%)



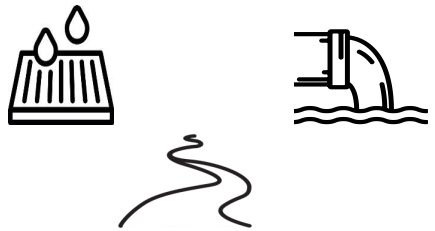
Organic matter proportions in mussels

Fatty acid biomarker approach

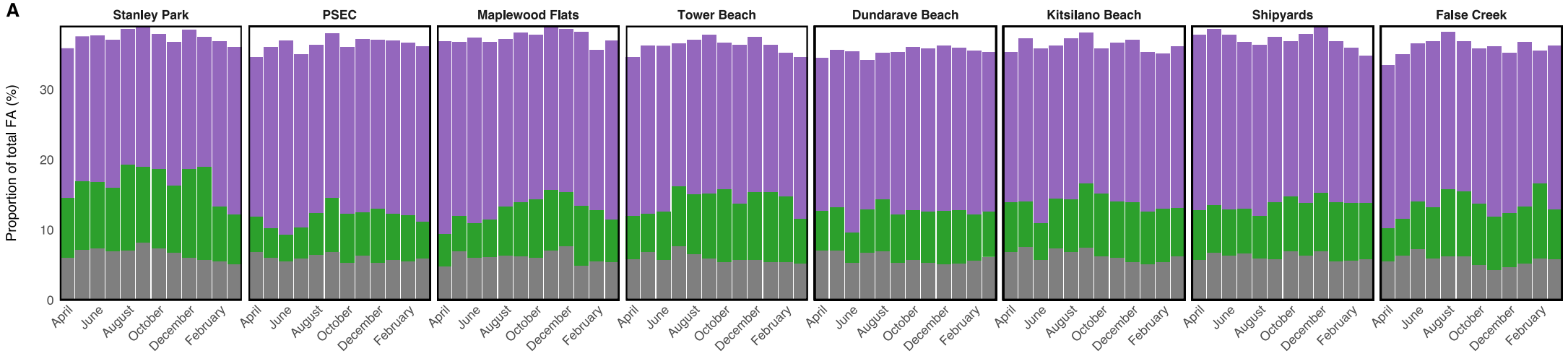
Fatty acid tracers of organic matter types identified by multivariate indicator analysis

- applied to estimate proportional contributions to mussel tissue

Organic Matter Type	FA Biomarker
Phytoplankton	22:6n-3
	16:2n-4
	16:1n-7
	14:0
Urban-Derived	24:0
	12:0
	ant:15:0
	20:0
	iso:15:0
	18:0
Macrophytes	20:3n-6
	20:4n-6
	22:5n-3



Organic matter proportions in mussels based on FA biomarkers



- Phytoplankton proportions were highest (55-68%)
- Macrophytes (16-27%)
- Urban-derived (16-18%)

Minimal effect of site or month – reflects hydrodynamic mixing through the region and mussel tissue turnover rates

Nutritional implications of urban-derived OM

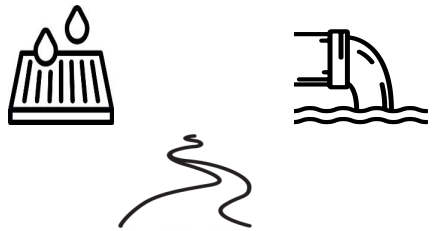
High proportion of saturated fatty acids

- Difficult to catabolize
- Insufficient to support stress tolerance and reproductive success
- Reduced cardiovascular health (and diabetes for humans)

Low DHA:EPA ratios

➢ Urban-derived OM sub-optimal for nutritional health

Organic Matter Type	FA Biomarker
Phytoplankton	22:6n-3
	16:2n-4
	16:1n-7
	14:0
Urban-Derived	**24:0**
	12:0
	ant:15:0
	20:0
	iso:15:0
	18:0
Macrophytes	20:3n-6
	20:4n-6
	22:5n-3



Summary

Stable isotopes and fatty acids effectively discriminate organic matter types

- validates their application as tracers of urban inputs in the marine environment

Spatial & seasonal variability of organic matter types in the ocean

- driven by freshwater run-off & phyto/macroalgae production cycles
- wet season associated wastewater inputs likely due to Combined Sewer Overflows

Urban derived OM was an important source for POM and mussels

- urban OM contributed on average 12 % to POM and 17% to mussels
- this urban OM has poor nutritional quality

Addressing study aims

1. **How does urbanization transform organic and inorganic nutrient flux to the coastal ocean?**
   - Amplifies OM & inorganic nutrient flux
   - Contribution of urban OM varies seasonally and spatially
2. **What is the fate of these materials in the marine environment?**
   - Uptake of urban OM by suspension feeding mussels reflects POM proportions
3. **What is the impact of the transformed land—ocean connection on the marine ecosystem?**
   - Can support food web production, however
   - Urban OM may negatively impact food web health


Thank you! Questions?
Contact: b.hunt@oceans.ubc.ca
PELAGIC
ECOSYSTEMS
LABORATORY