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Sources, sinks, dispersion and cycling of dissolved polybrominated diphenyl ethers (PBDEs) discharged in the Strait of Georgia

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Sources, sinks, dispersion and cycling of dissolved polybrominated diphenyl ethers (PBDEs) discharged in the Strait of Georgia, Canada

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Why PBDEs?

- POPs with 209 congeners (tri-, tetra-, penta-, hexa-, etc.)
- Increasingly used in recent decades as flame retardants in many consumer products



- Wide dispersal, persistence, toxicity, and tendency to bioaccumulate up the trophic chain

(Image credit: Gadget Review, Independent Balkan News Agency, Herman Miller)

- Have been found everywhere in the world

Lack quantitative understanding of their biogeochemical cycling in the environment, particularly in the marine environment

Key Questions

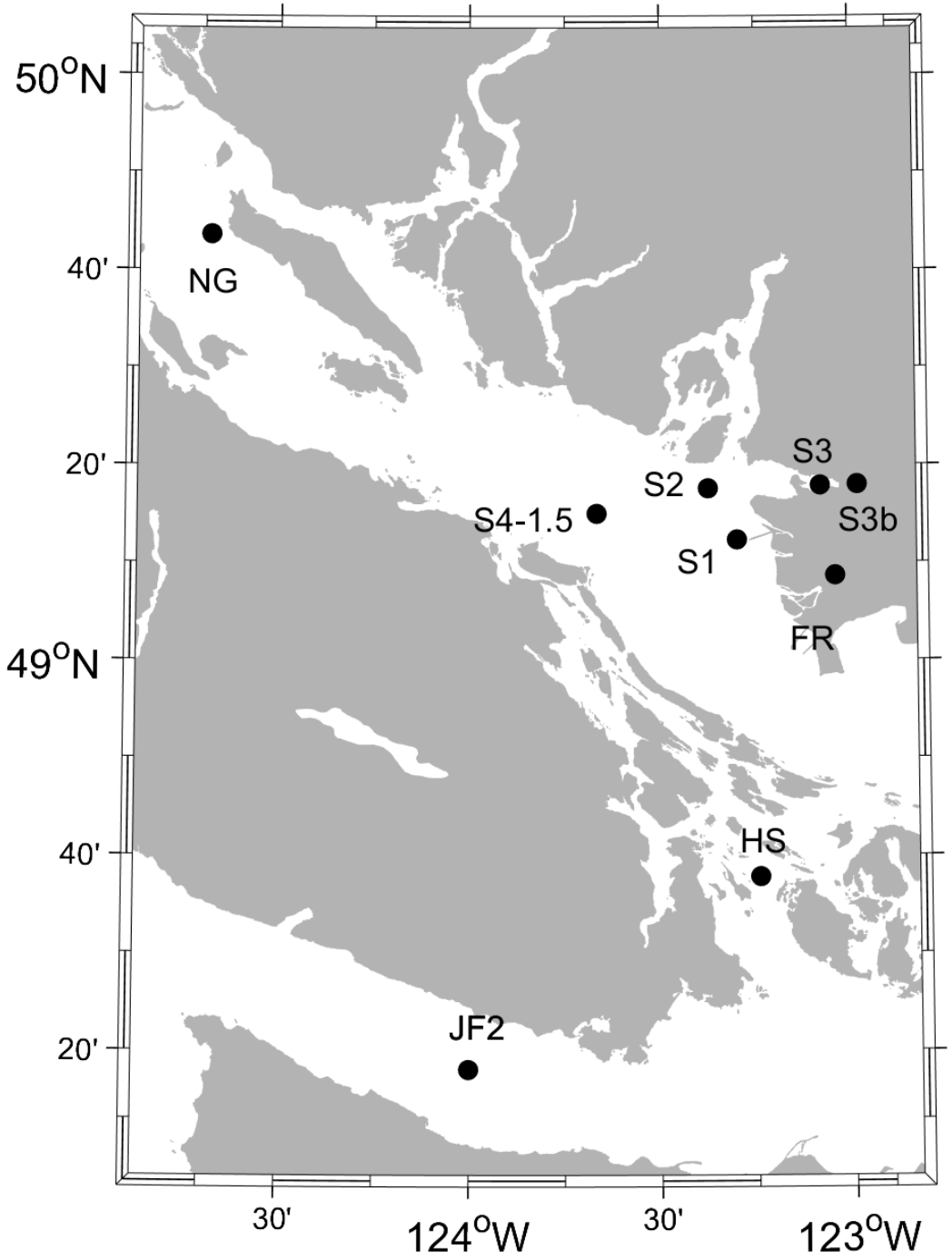
Quantify the sources, sinks and biogeochemical cycling of PBDEs in the coastal waters of British Columbia

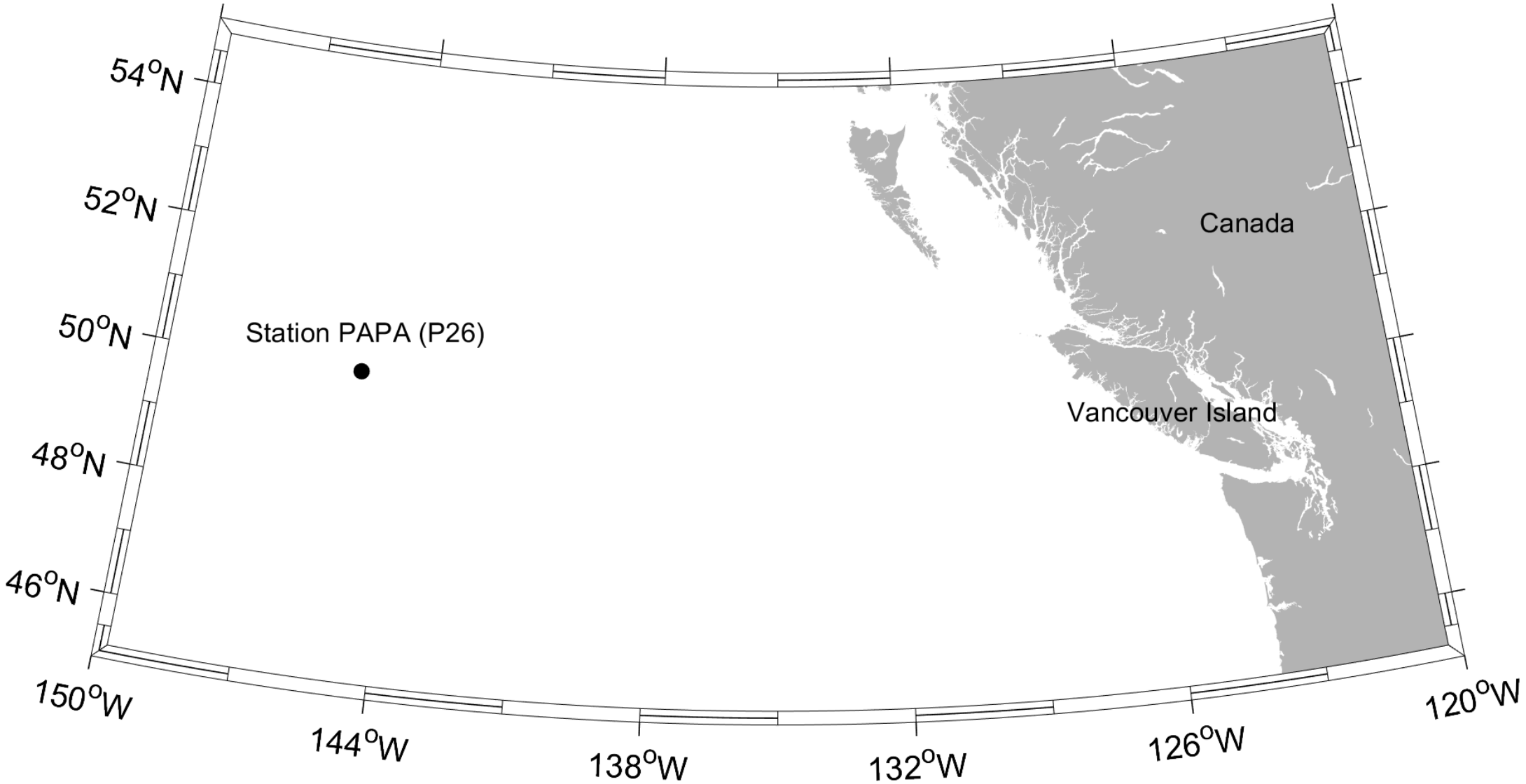
- Compare the relative importance of main sources of PBDEs to the Strait of Georgia (SoG)

- Contrast their removal to sediments by adsorption on sinking particles, bioaccumulation in the food chain, and export to the Pacific by circulation

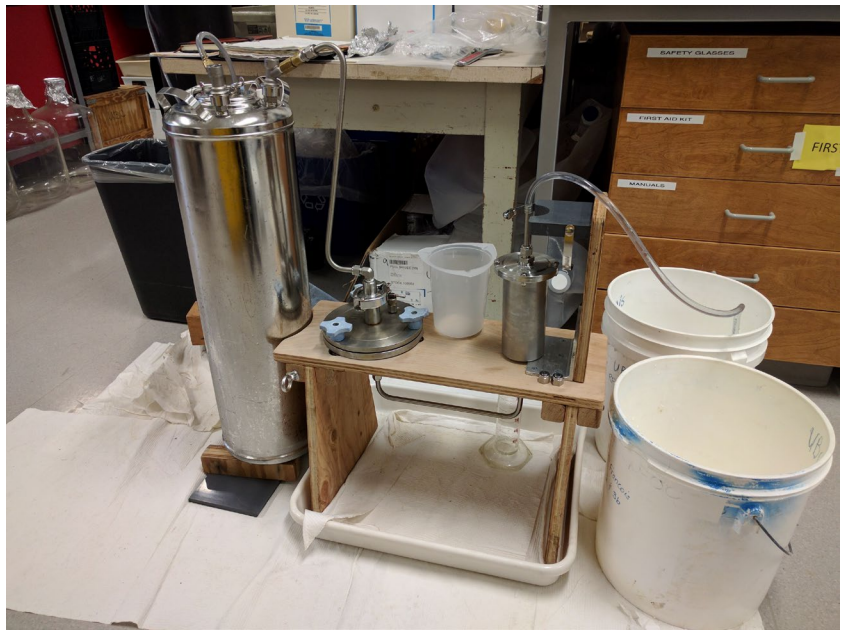
Method

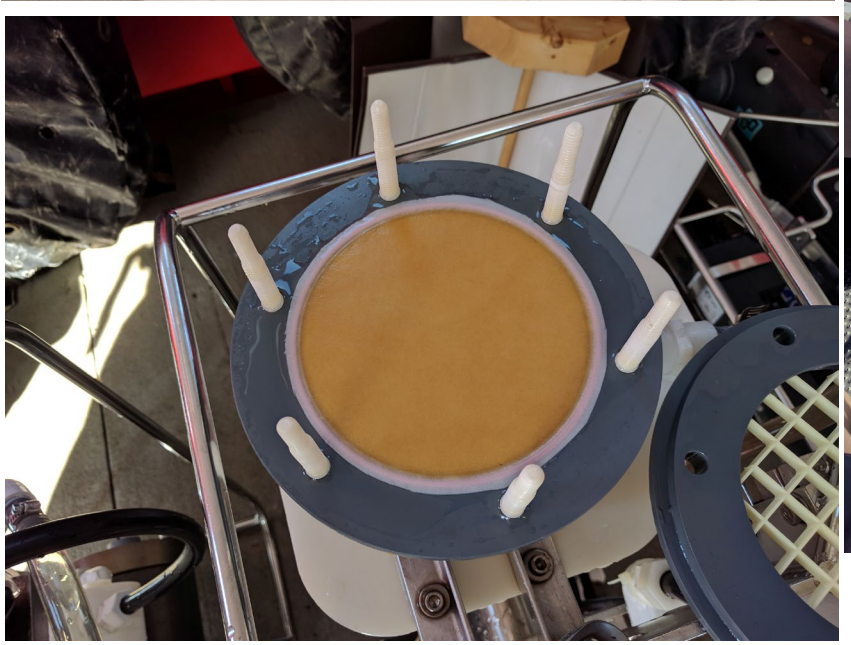
1. Sampling sites

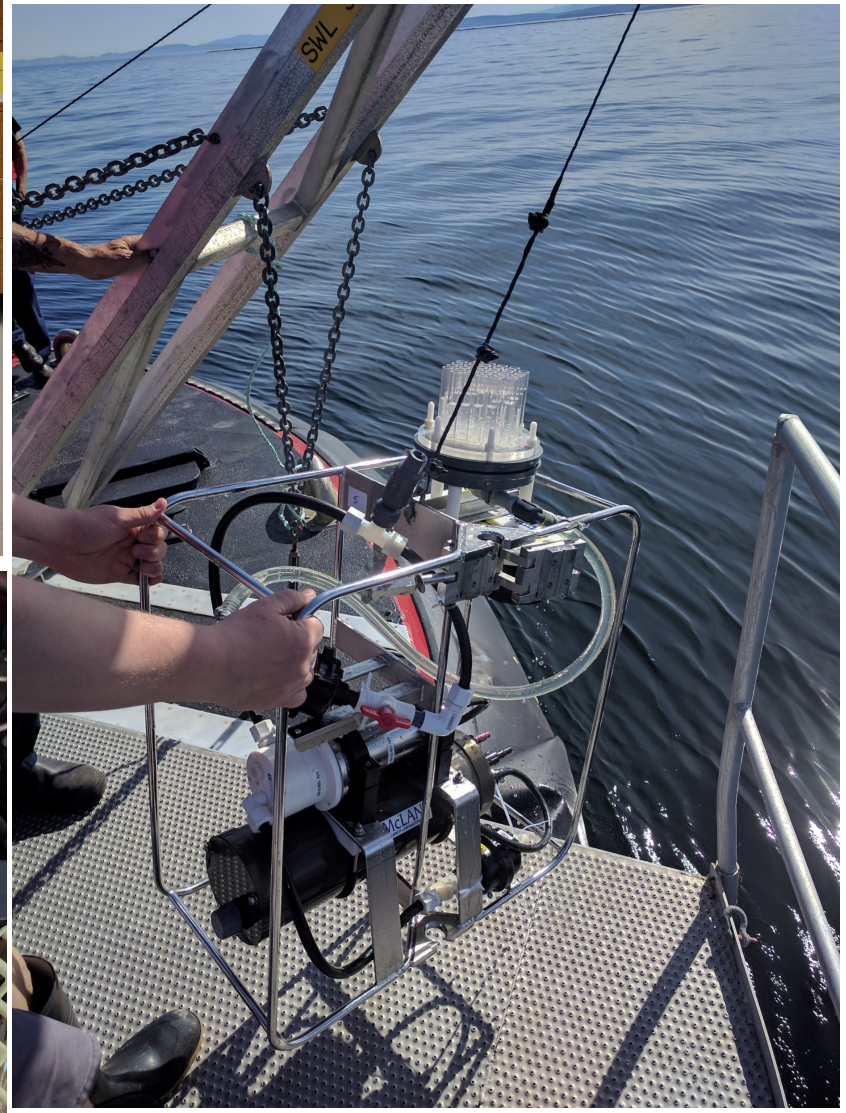



54°N
52°N
50°N
48°N
46°N
150°W
144°W
138°W
132°W
126°W
120°W
Station PAPA (P26)
Canada
Vancouver Island

2. Sample collection: dissolved & particulate PBDEs





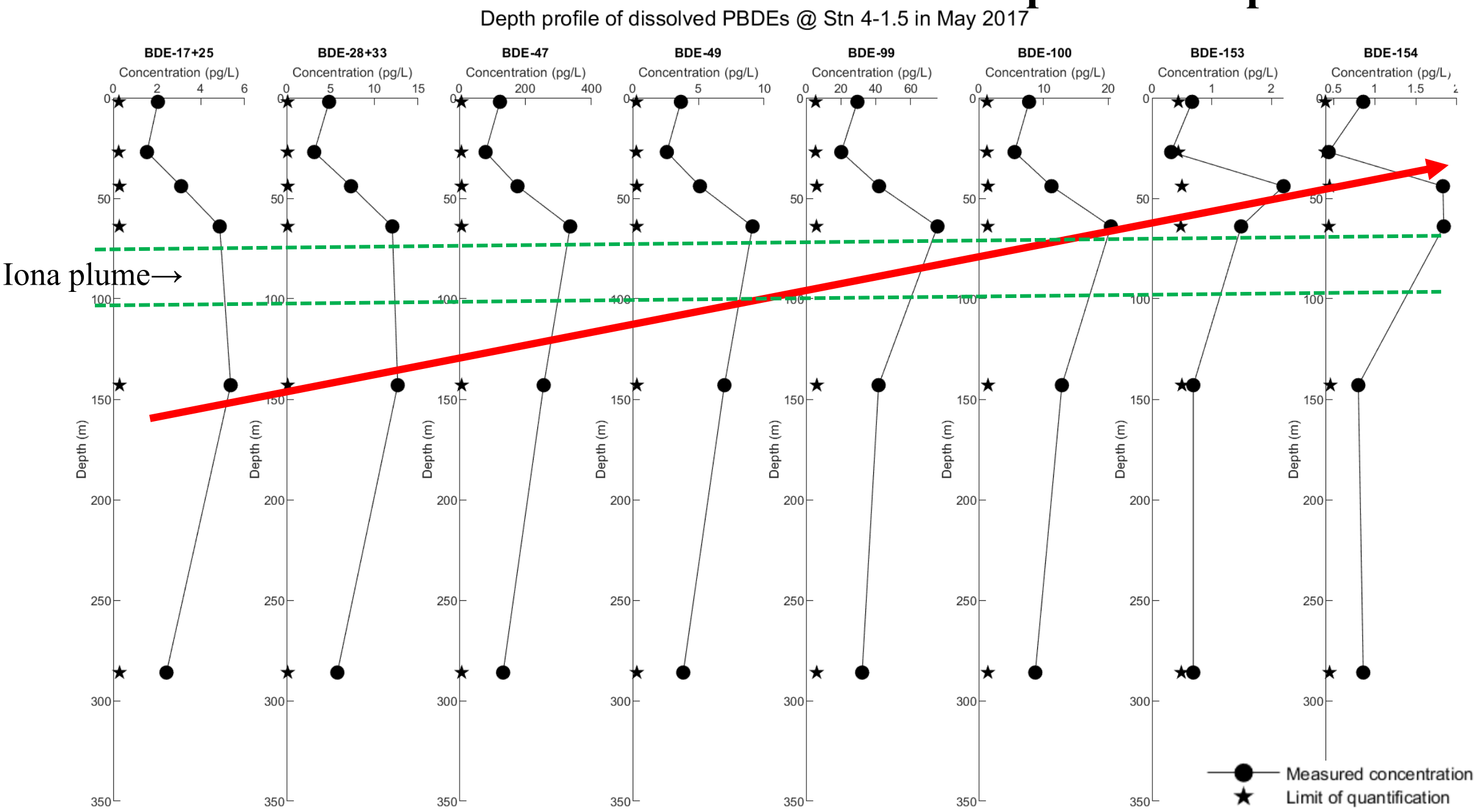


Environmental Behaviors of PBDEs in SoG

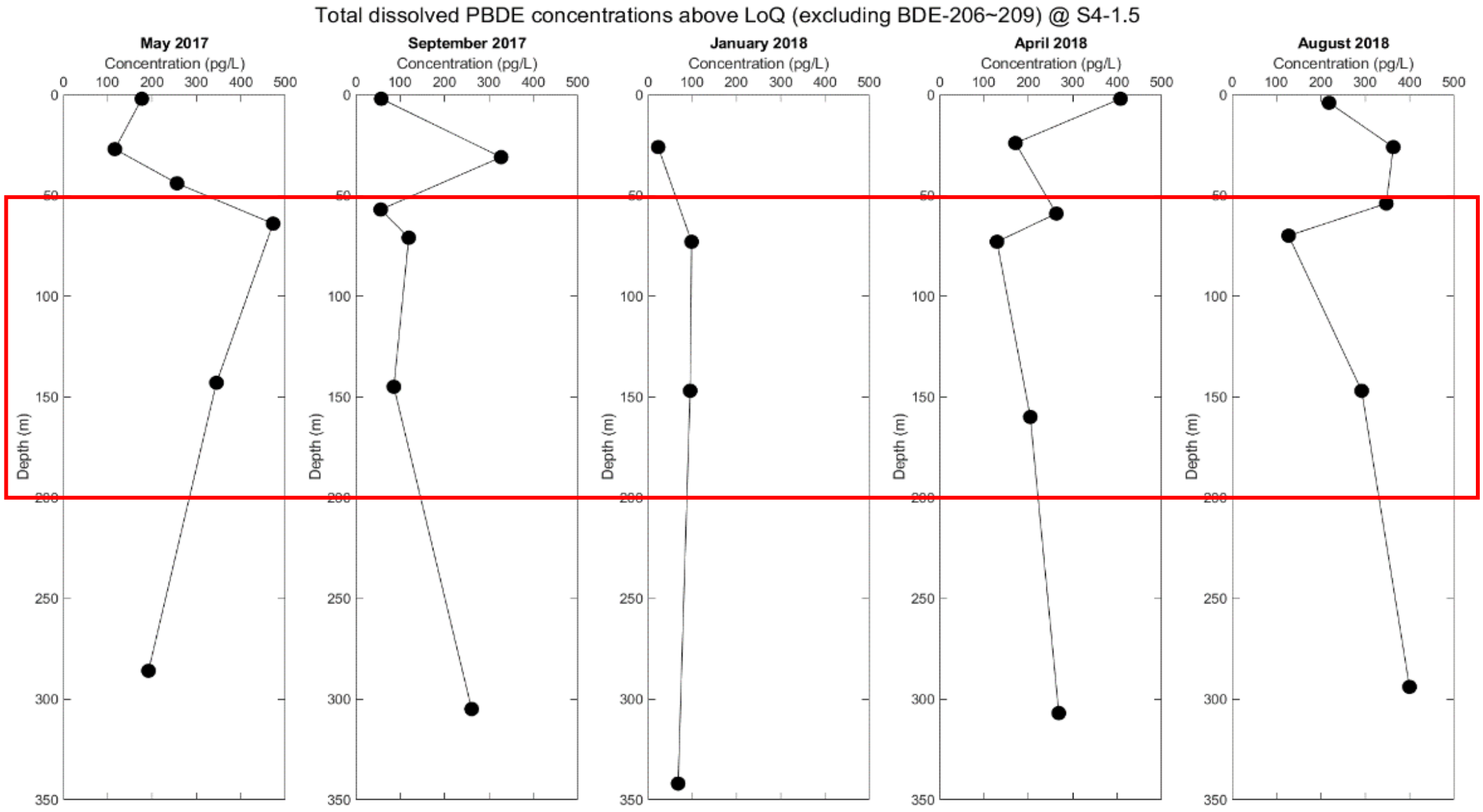
Iona plume is an important source of particulate PBDEs, not a direct source of dissolved PBDEs.

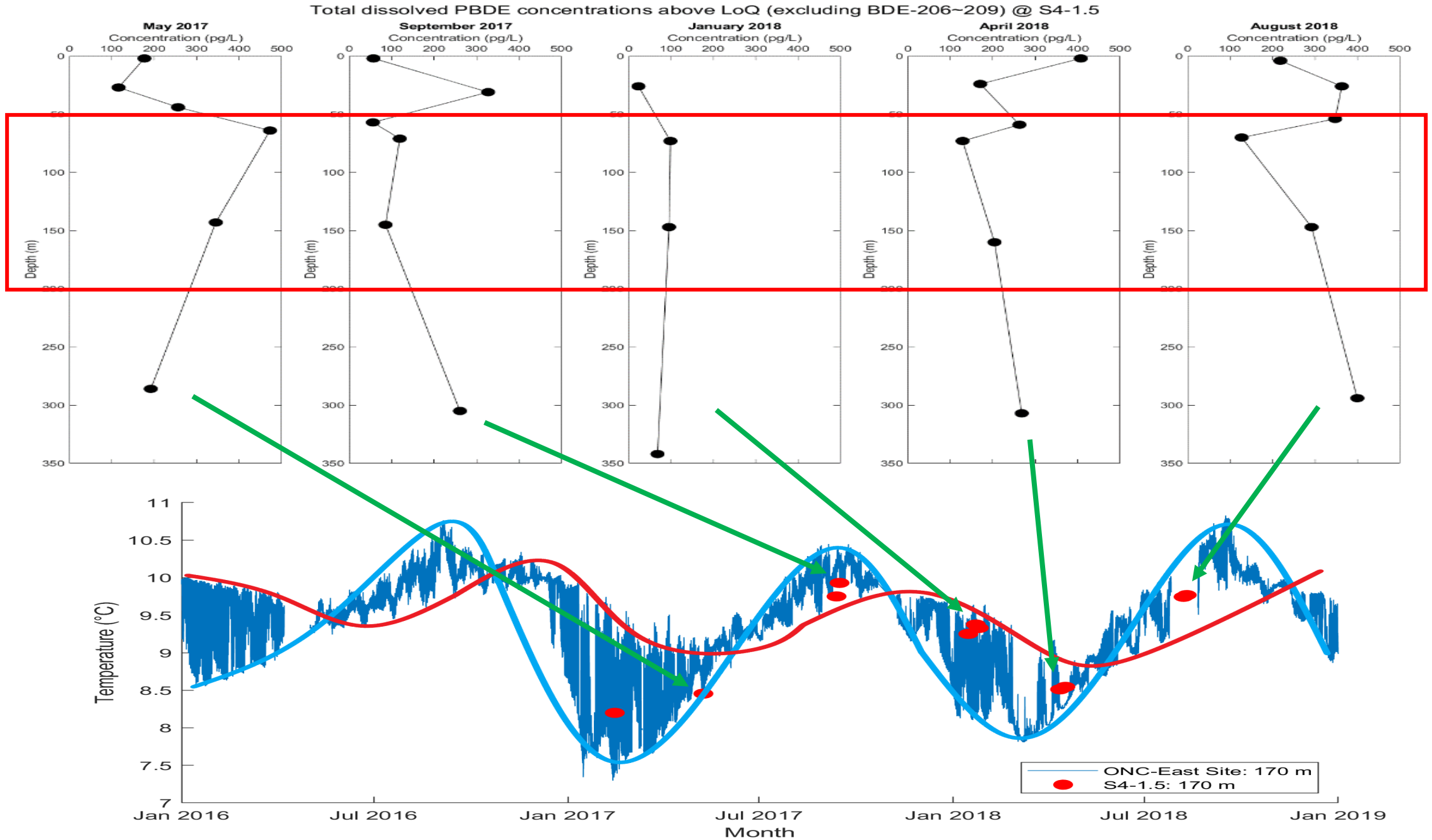
Total PBDEs (pg/L)		S1	S2	S4-	S3	S3b	NG	HS	JF2
[part]	>LoQ	189	0-97	2±3	29	0-124	6	-	-
	>LoD	190	1-97	4±3	35	8-130	7	-	-
[diss]	>LoQ	279	309±56	256±243	381	54-73	3±4	8	1±1
	>LoD	330	354±45	266±241	382	55-74	7±2	8	5±3

Dissolved PBDEs in southern SoG come from desorption from particles

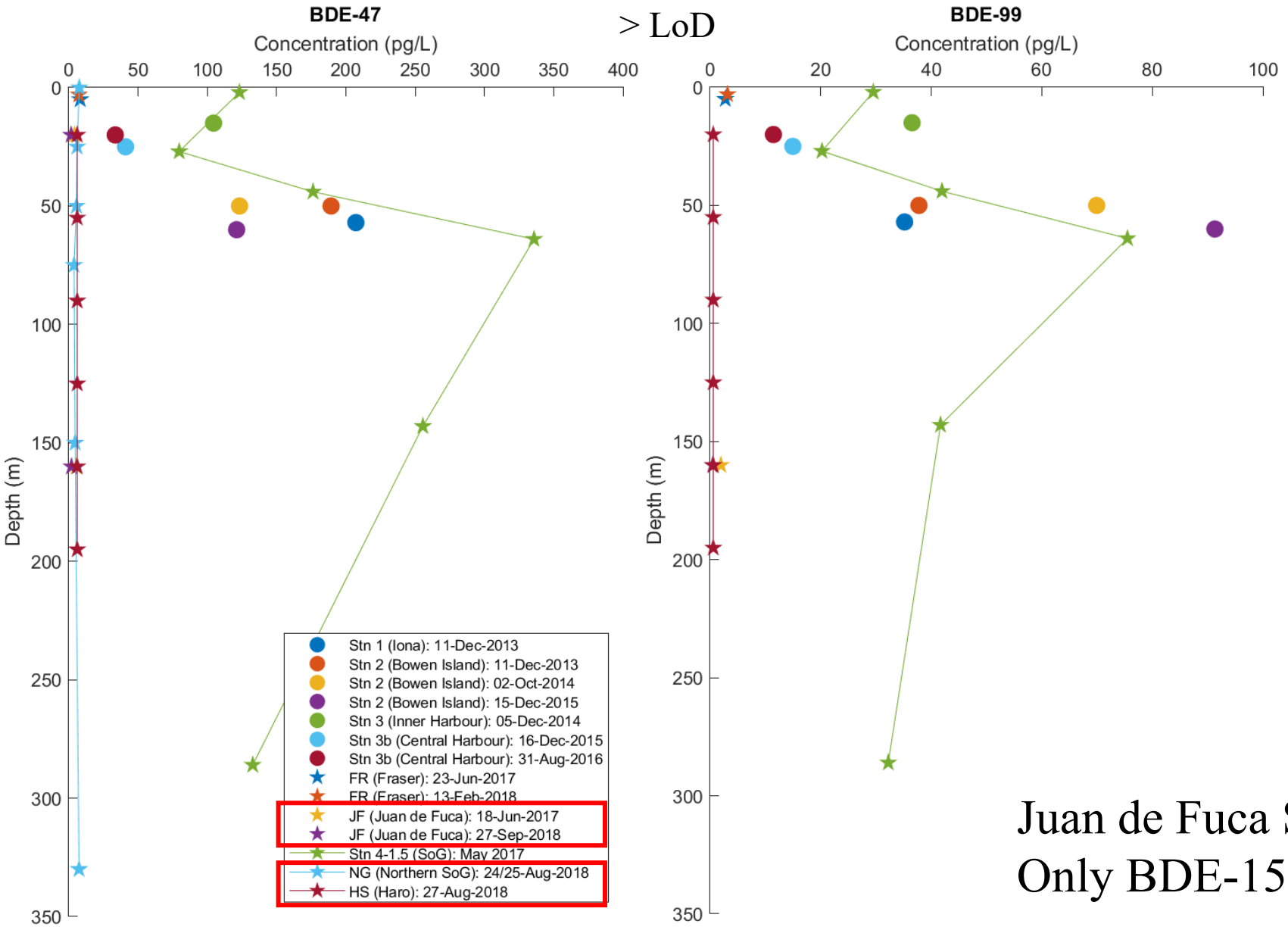


Dissolved PBDEs in southern SoG is influenced by water circulation

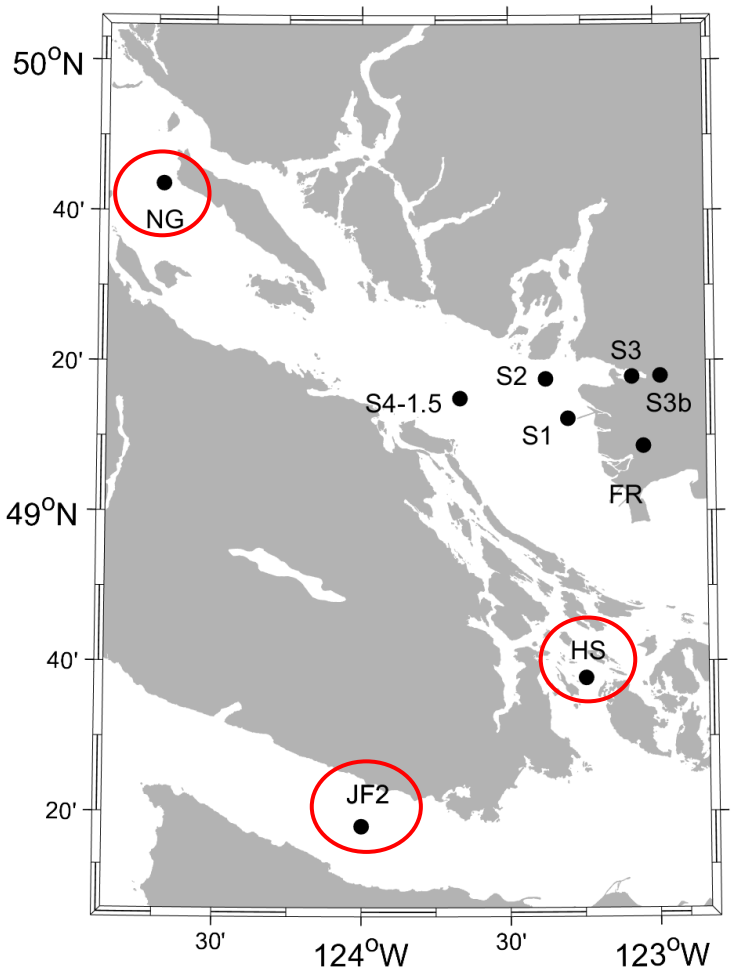



Total dissolved PBDE concentrations above LoQ (excluding BDE-206~209) @ S4-1.5
May 2017
September 2017
January 2018
April 2018
August 2018
Concentration (pg/L)
Depth (m)
Temperature (°C)
Month
Jan 2016
Jul 2016
Jan 2017
Jul 2017
Jan 2018
Jul 2018
Jan 2019
ONC-East Site: 170 m
S4-1.5: 170 m

Most PBDEs are removed to sediment while light congeners are exported to the Pacific Ocean

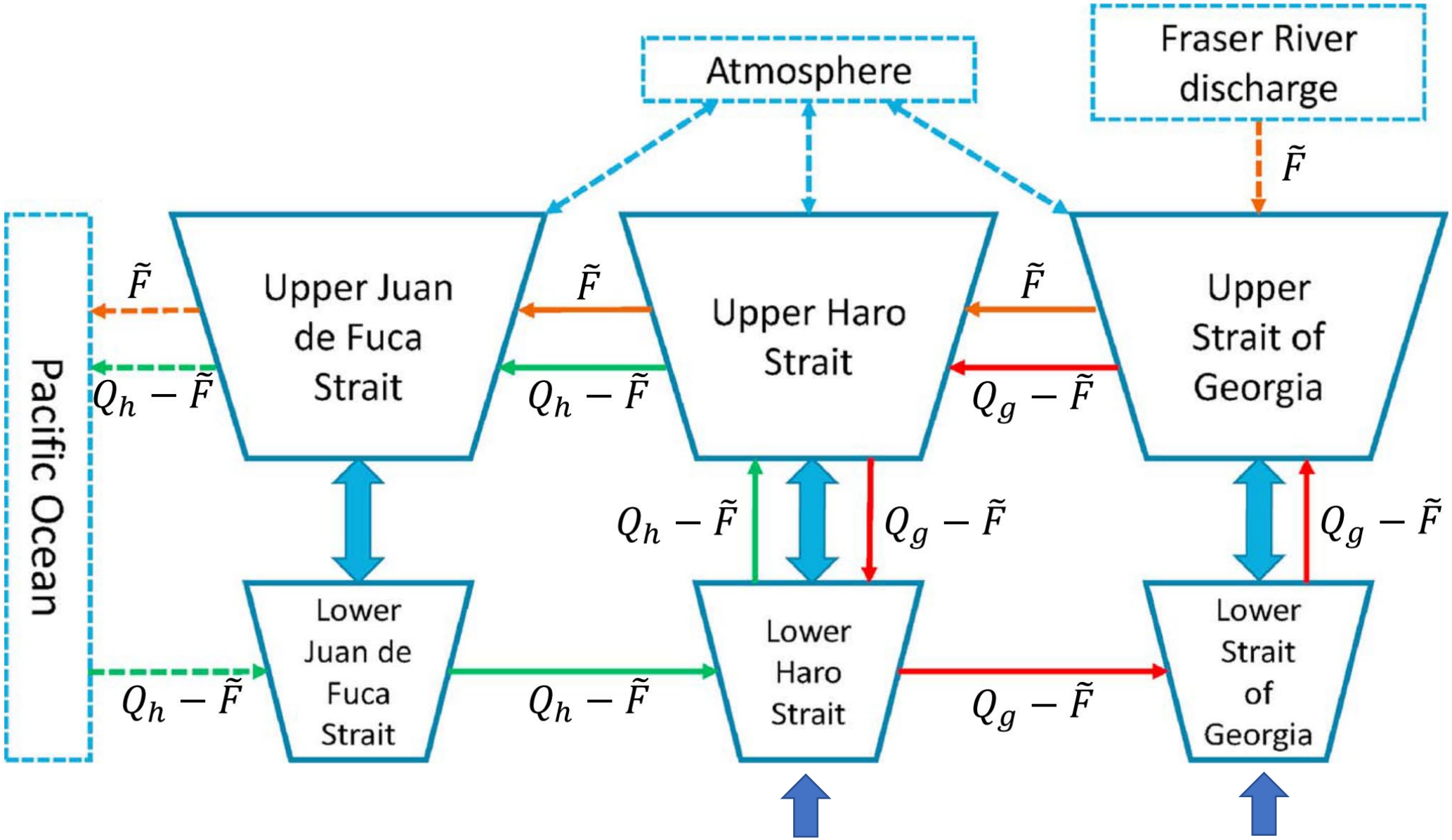


> LoD



Juan de Fuca Strait:
Only BDE-15, 28+33 > LoQ.

Salish Sea Box Model



(Wang et al., 2019)

Additional sources or increase discharge from Iona may exist, or our measured concentrations are not representative.

Model inputs: Vancouver & Victoria WWTPs in 2004 (Dinn et al., 2012)

Fraser River in 2017-2018

Model outputs:

BDE-47			BDE-99		
Location	Predicted (pg/L)	Measured (pg/L)	Location	Predicted (pg/L)	Measured (pg/L)
Upper SoG	6.5	165	Upper SoG	5.6	59
Lower SoG	6.4	141	Lower SoG	5.7	40
Upper HS	4.8	6.1 (composite)	Upper HS	3.9	0.6 (composite)
Lower HS	3.6	6.1 (composite)	Lower HS	2.6	0.6 (composite)
Upper JF	3.6	1.7	Upper JF	2.7	<LoD
Lower JF	2.0	2.0	Lower JF	1.1	0.5

Conclusions

1. Sources: Iona WWTP, Burrard Inlet, etc.
2. Dissolved PBDEs in southern SoG comes from desorption from particles.
3. Dispersion: Estuarine circulation (including tides) leads to substantial temporal variability of dissolved PBDEs concentrations in southern SoG.
4. Fate: Most PBDEs are removed to sediment while light congeners are exported to the Pacific Ocean in the dissolved form.
5. The box model suggests additional/increasing PBDE inputs.

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