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Biogeochemical cycling of polybrominated diphenyl ethers (PBDEs) in the Strait of Georgia

Yuanji Sun
Univ. of British Columbia, Canada, ysun@eoas.ubc.ca

Maria T. Maldonado
Univ. of British Columbia, Canada, mmaldona@eoas.ubc.ca

Roger Francois
Univ. of British Columbia, Canada, rfrancoi@eoas.ubc.ca

Biogeochemical Cycling of Polybrominated Biphenyl Ethers (PBDEs) in the Strait of Georgia

Presenter: Yuanji Sun (ysun@eoas.ubc.ca)

Supervisor: Dr. Roger Francois & Dr. Maria Maldonado

Apr 5th, 2018

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

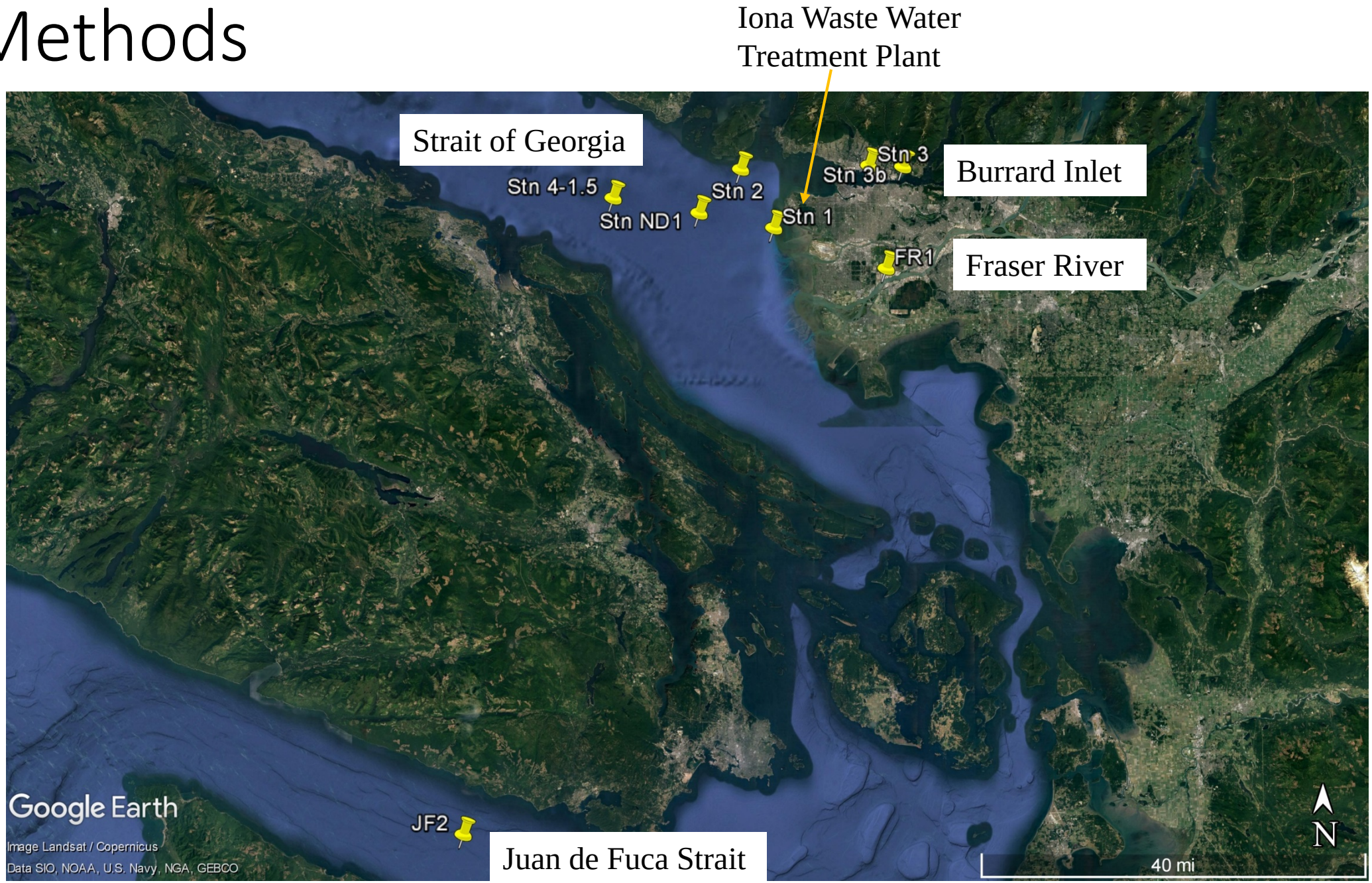
Key Questions

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

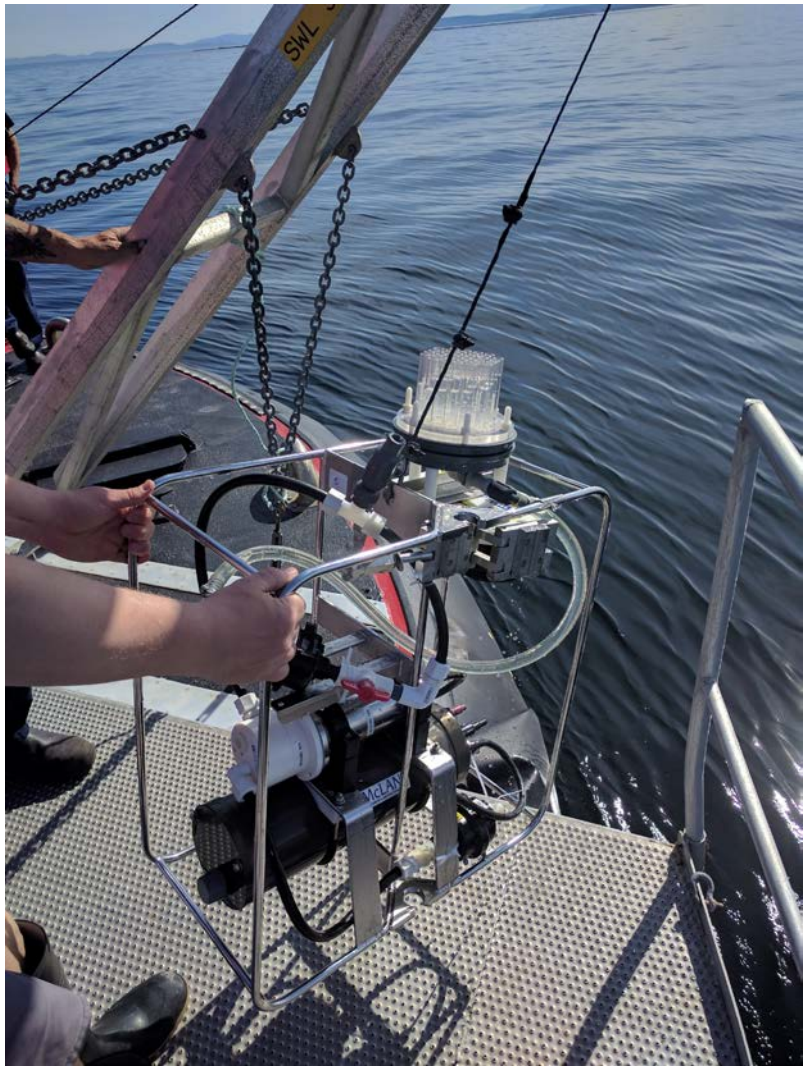
- Compare the relative importance of main sources of PBDEs to the Strait of Georgia

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

Methods

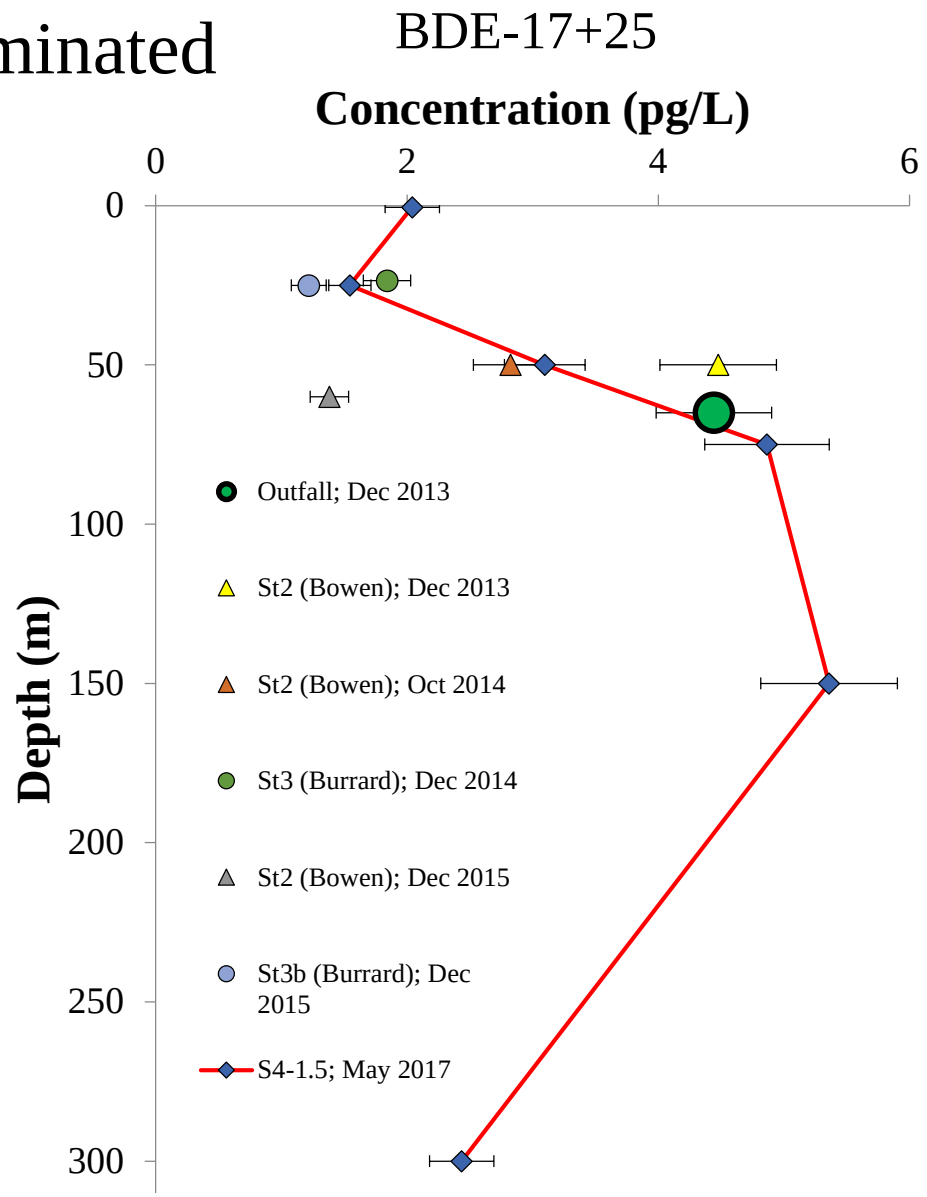

Iona Waste Water Treatment Plant
Strait of Georgia
Stn 4-1.5
Stn ND1
Stn 2
Stn 1
Stn 3
Stn 3b
Burrard Inlet
FR1
Fraser River
JF2
Juan de Fuca Strait
Google Earth
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
40 mi

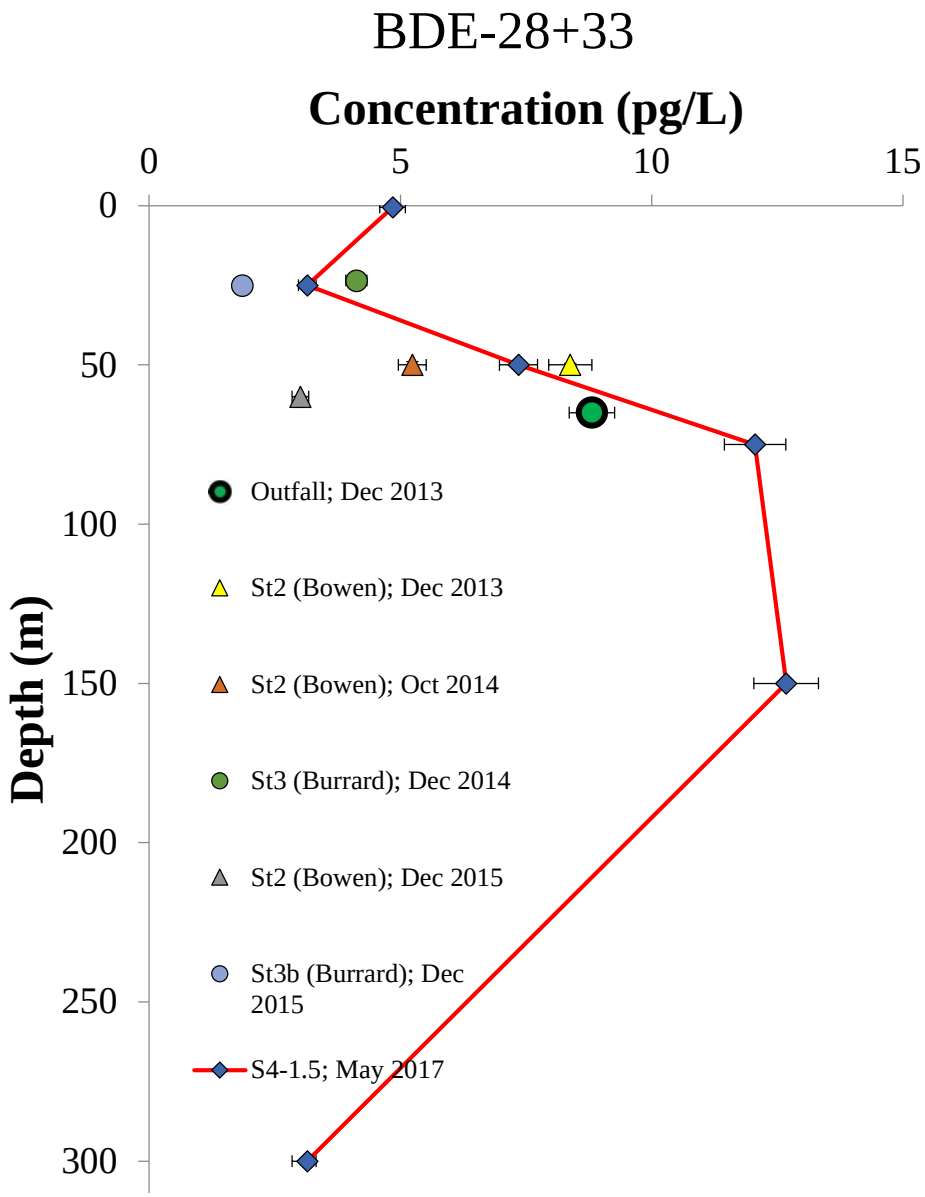
PBDE sampling in the Strait of Georgia



Dissolved PBDEs

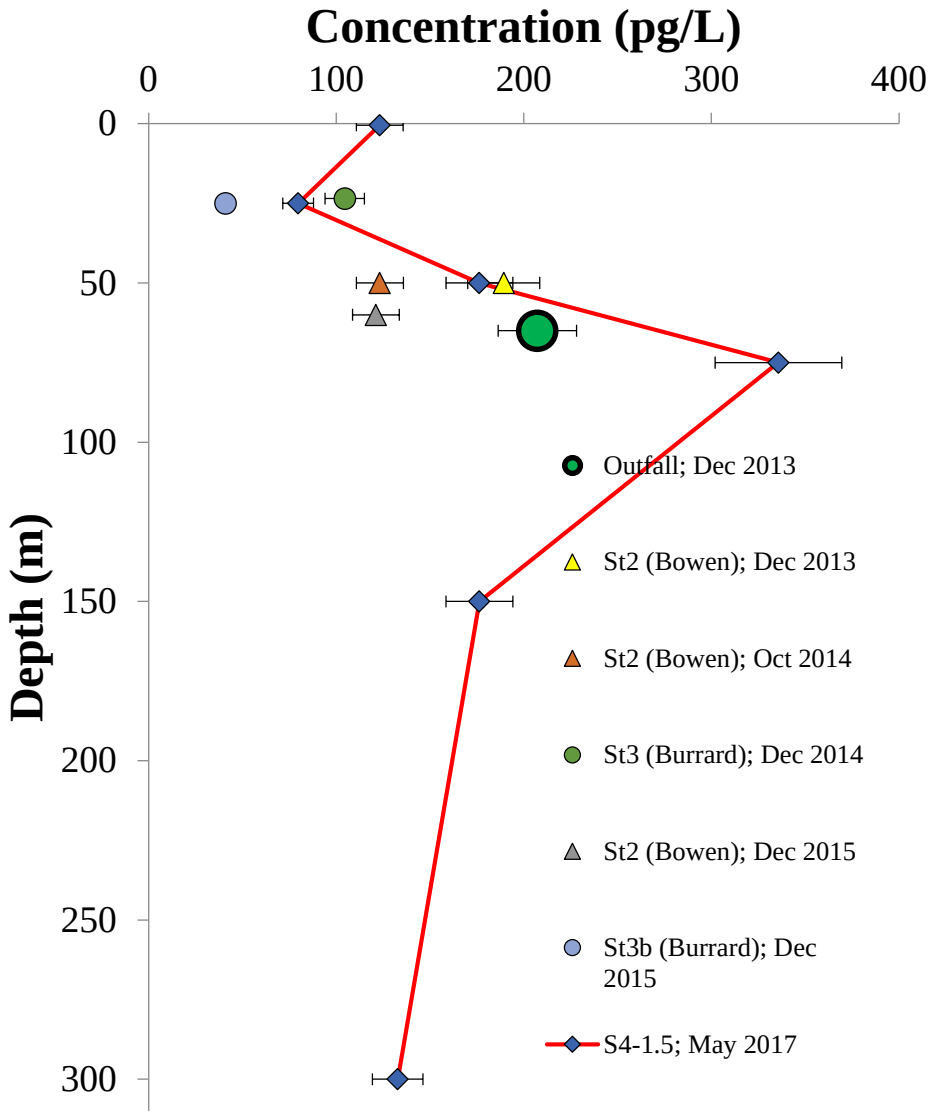
Tri-brominated



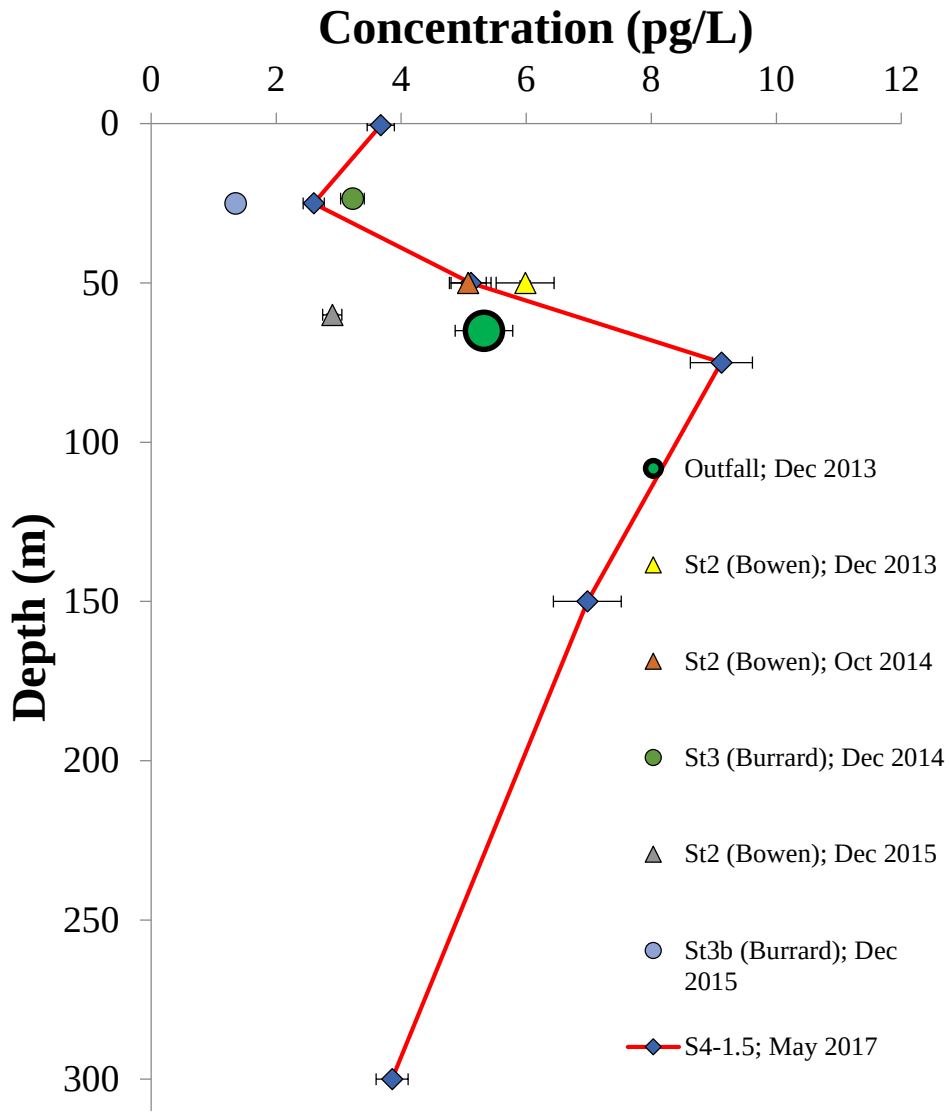


Tetra-brominated

BDE-47

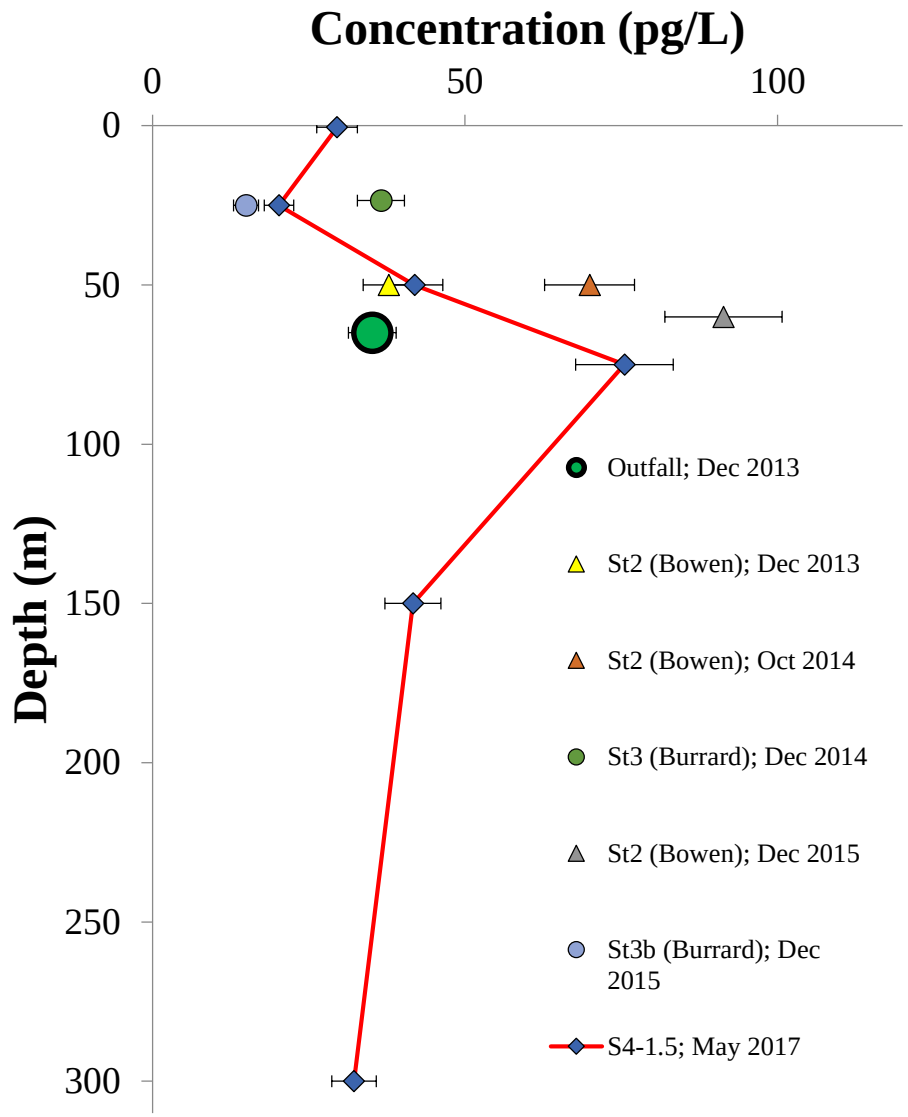


BDE-49

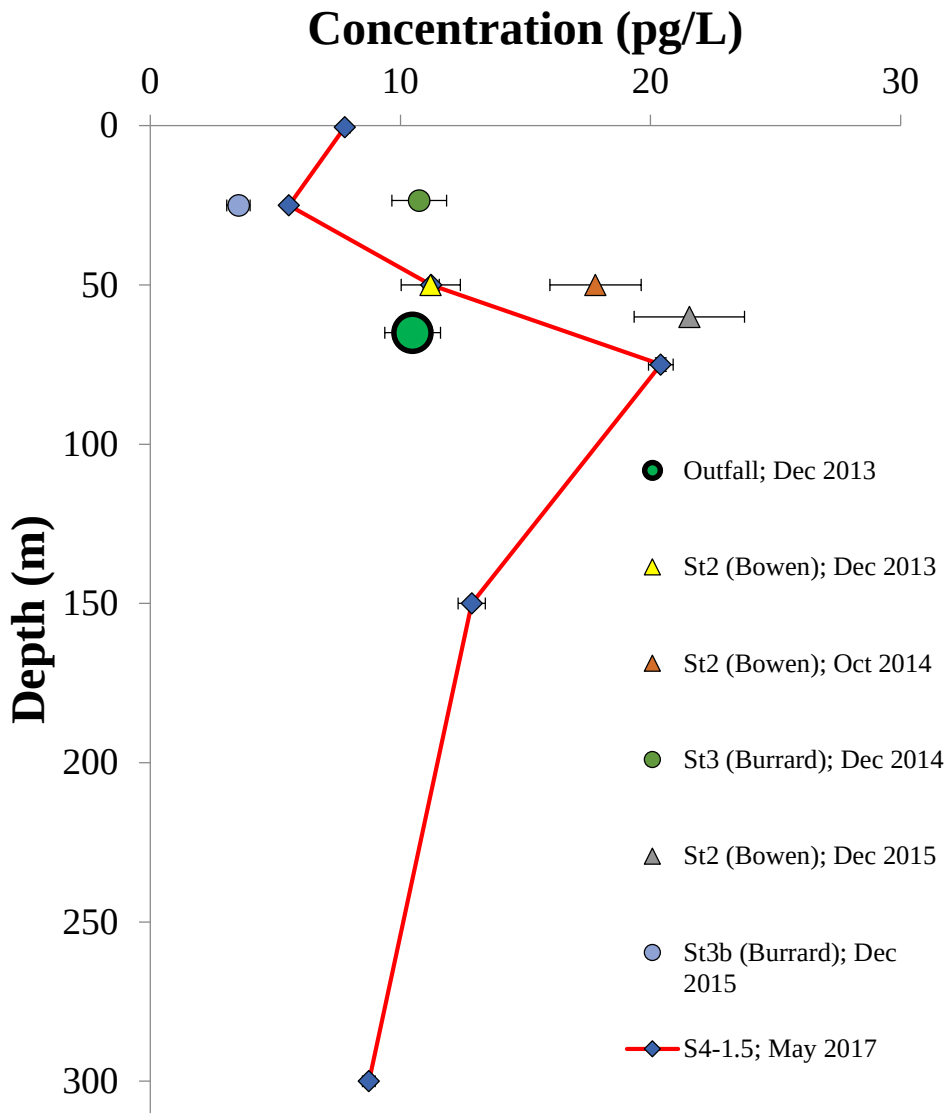


Penta-brominated

BDE-99

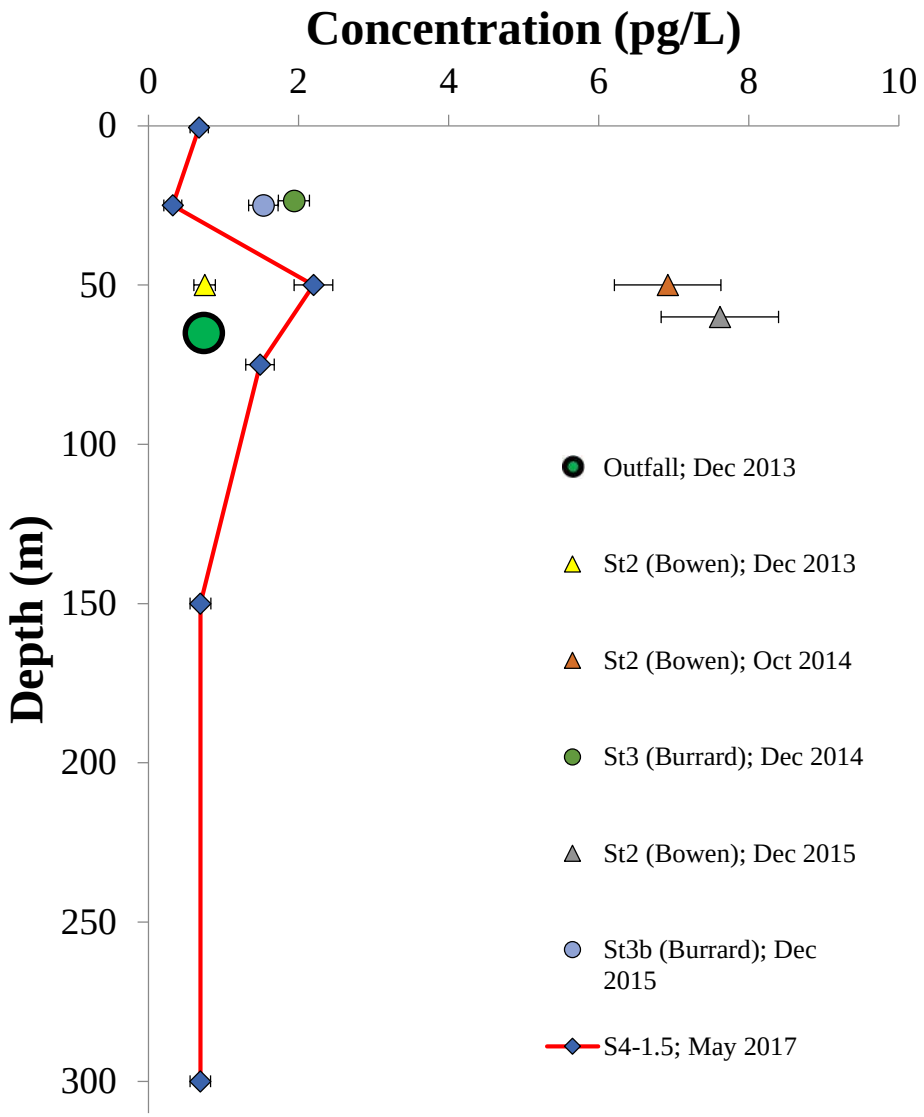


BDE-100

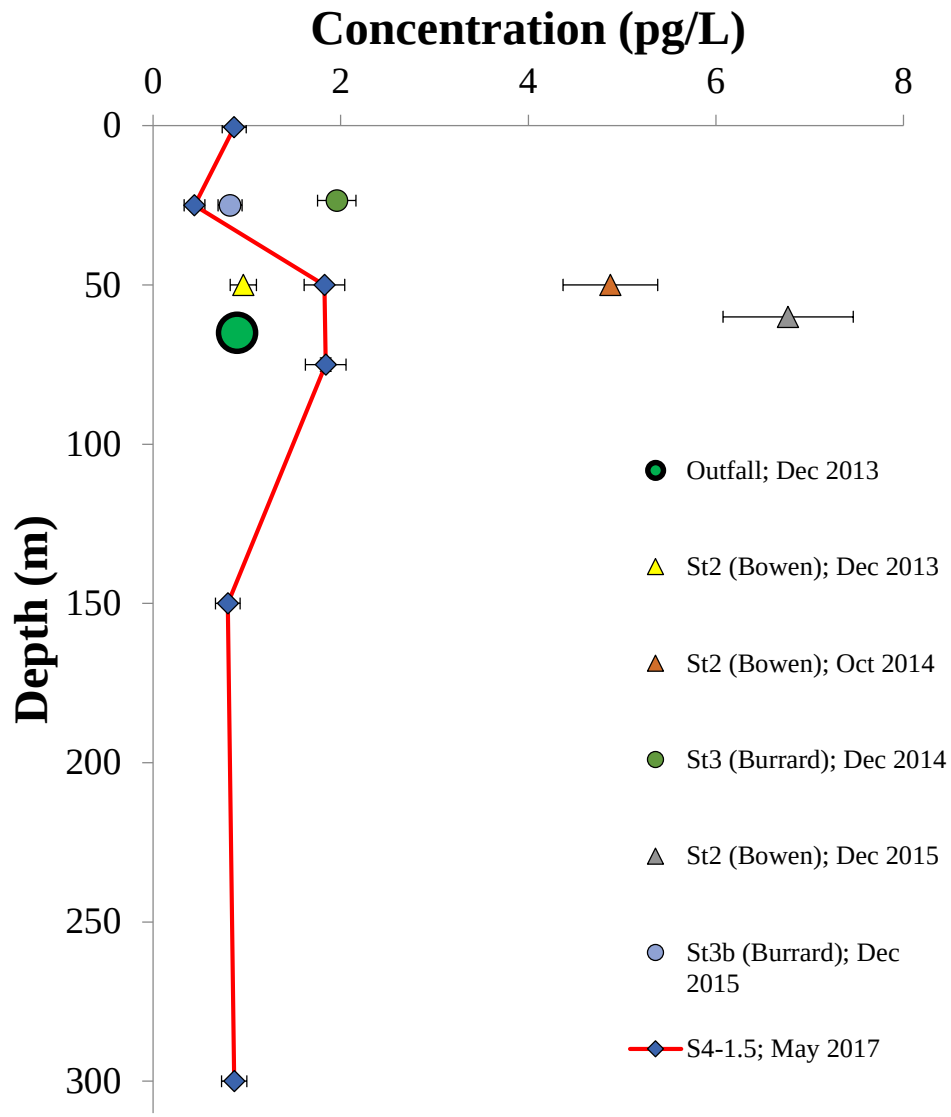


Hexa-brominated

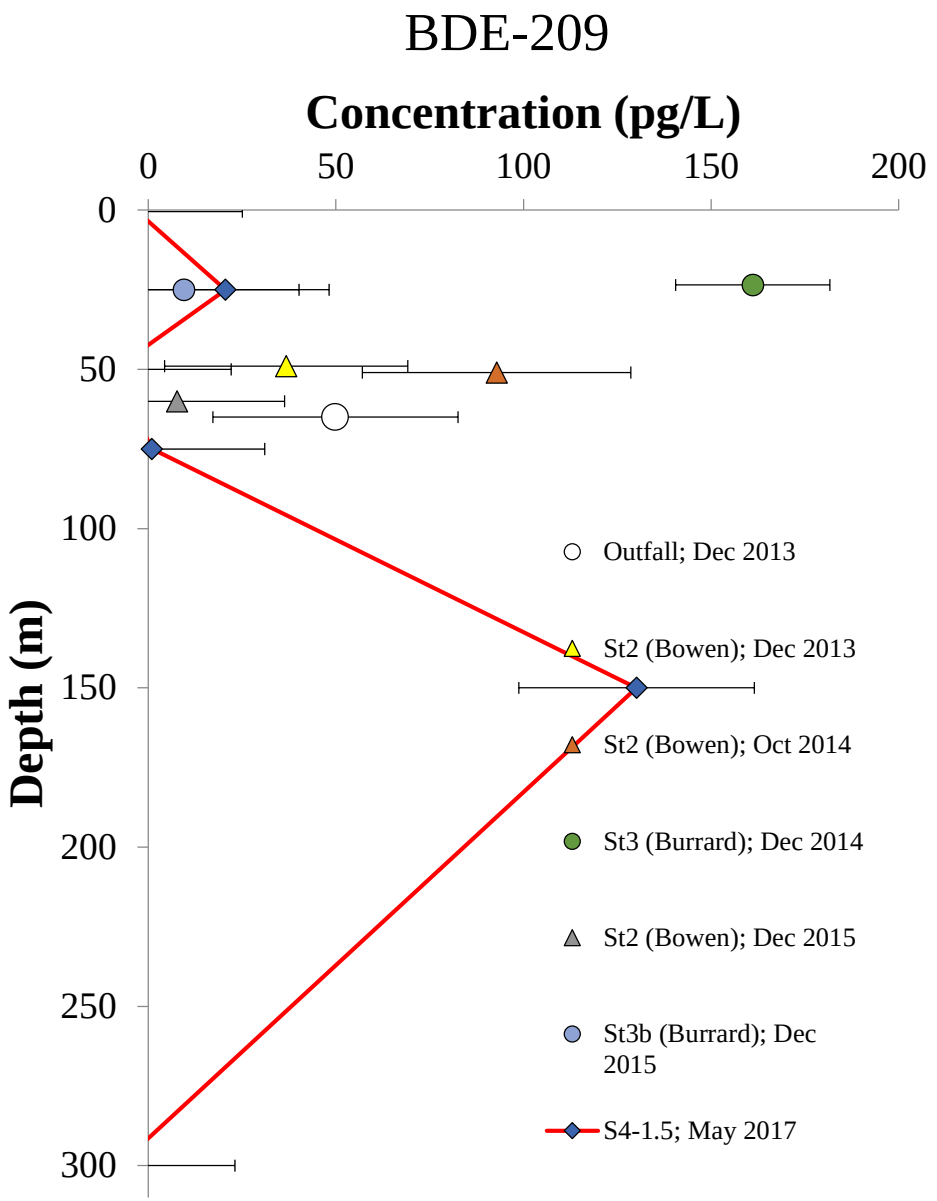
BDE-153



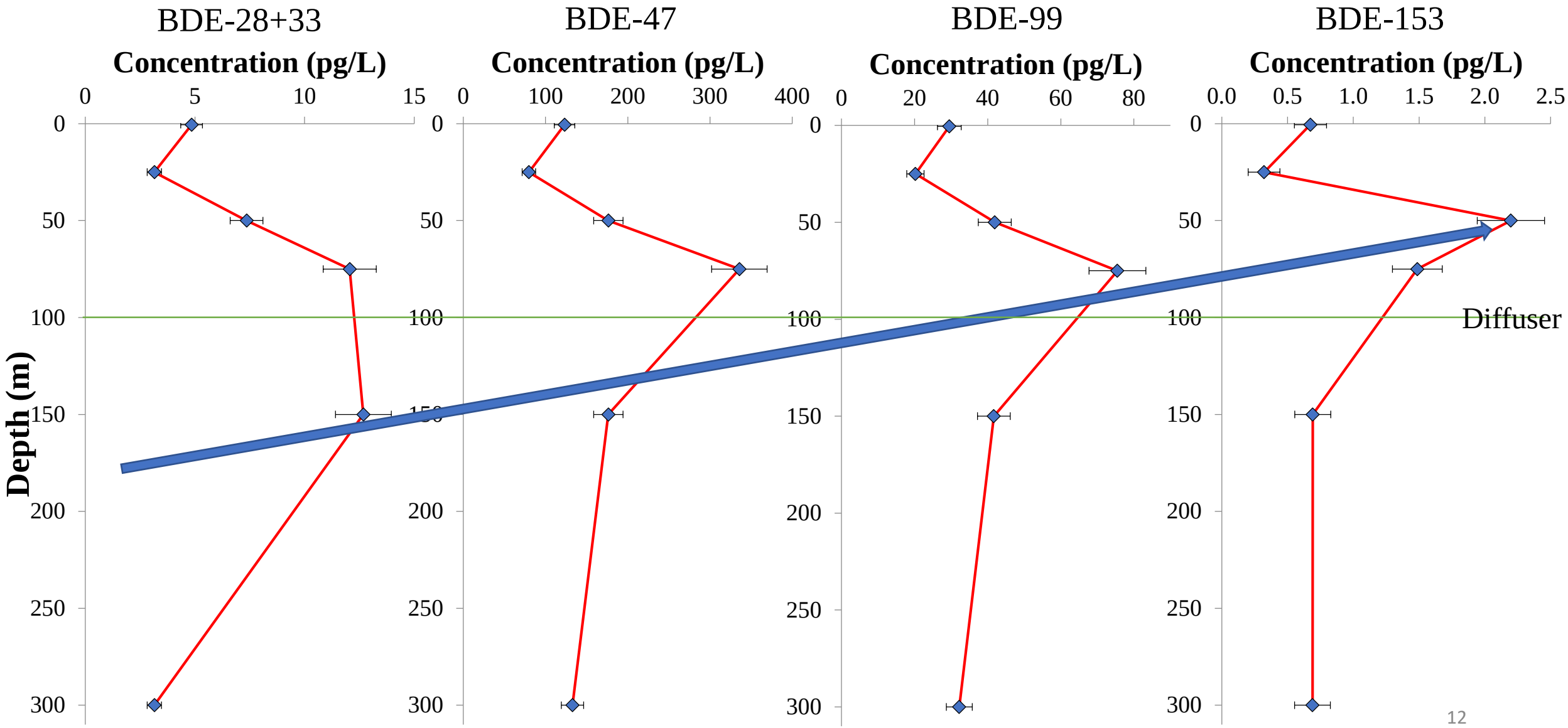
BDE-154



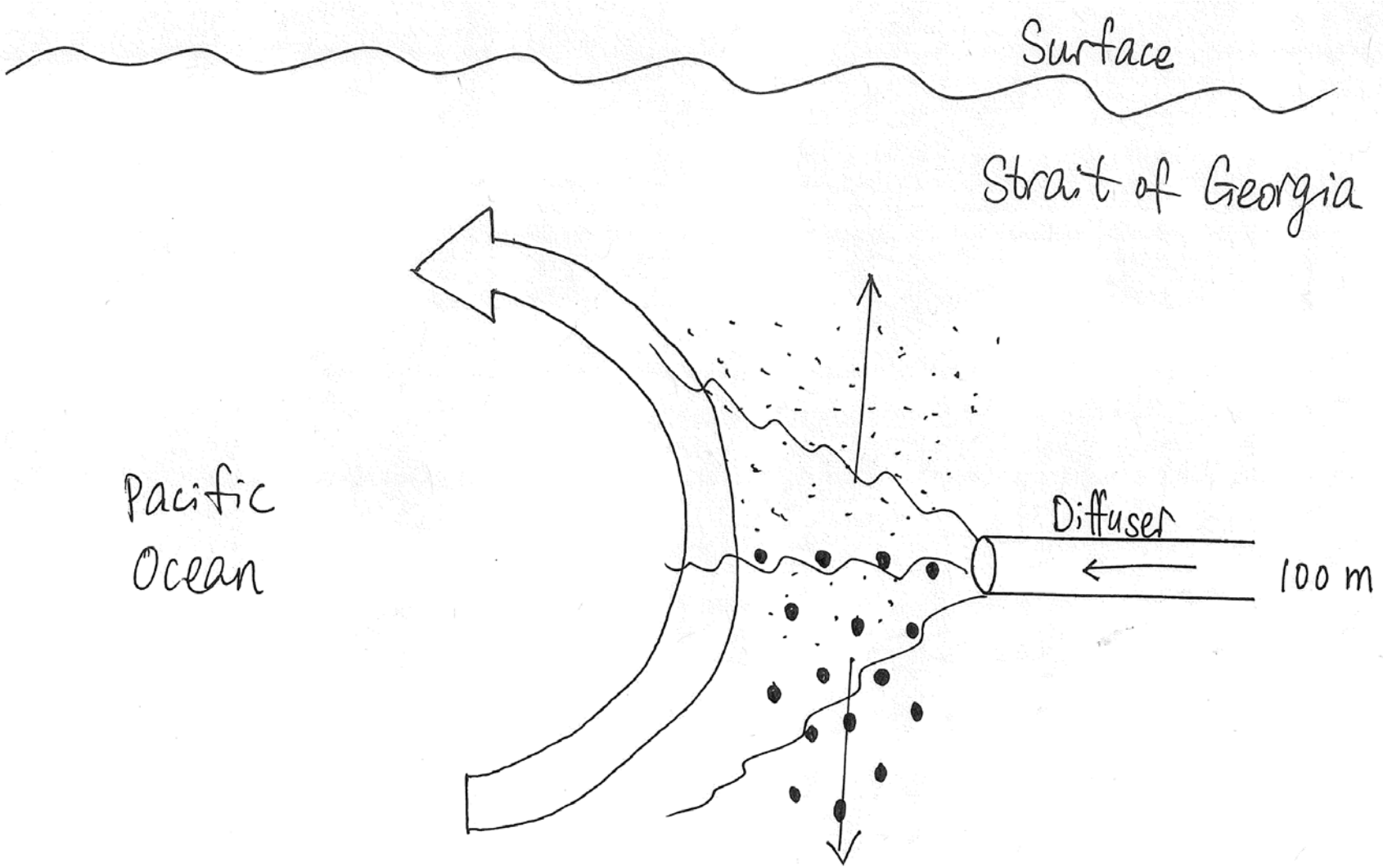
BDE-209 cannot be discussed due to high and variable blanks



Depth Profiles in May 2017 in Strait of Georgia

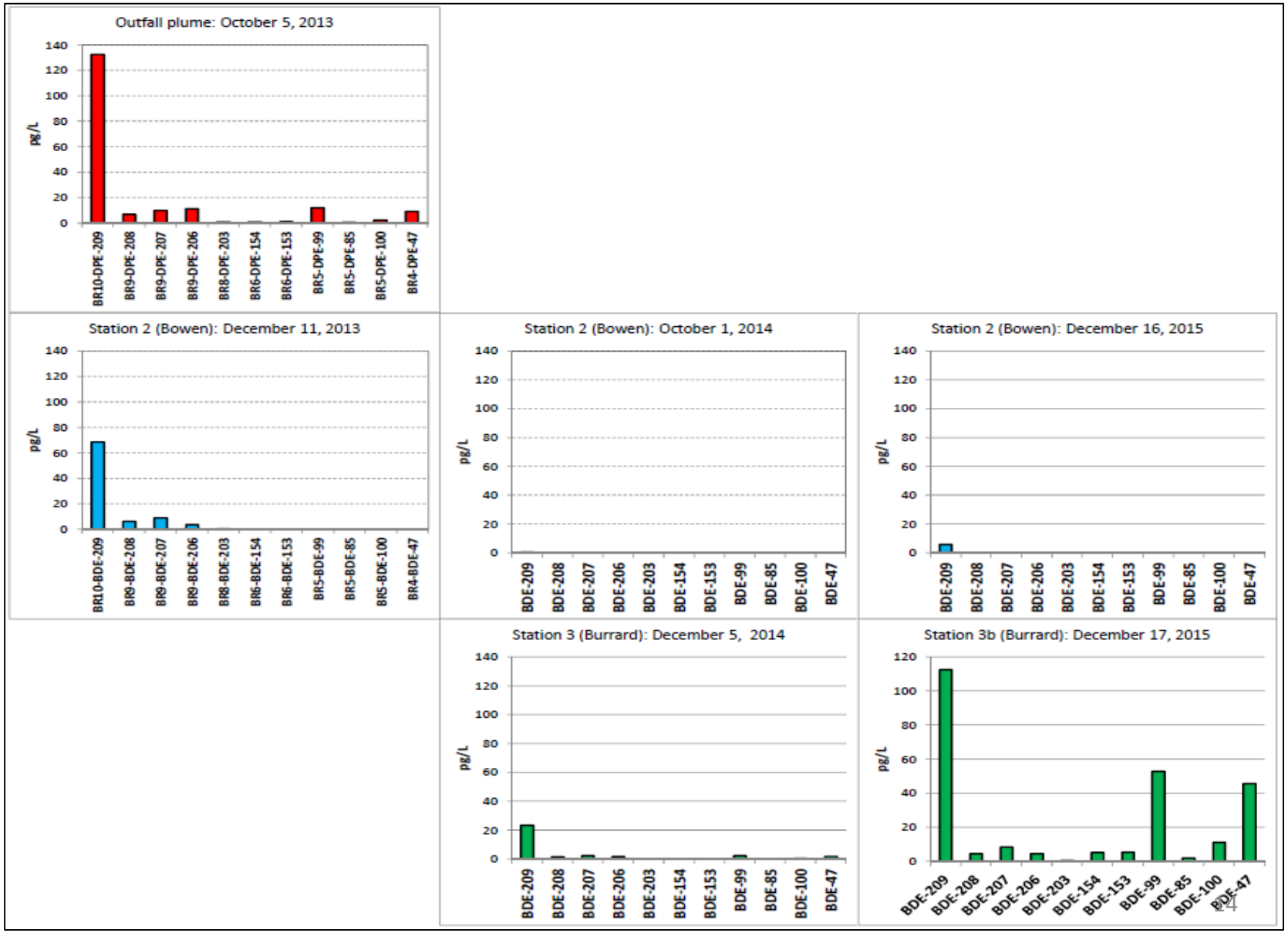


Slower desorption allows the particles to rise towards the surface as a result of the general estuarine circulation of SoG

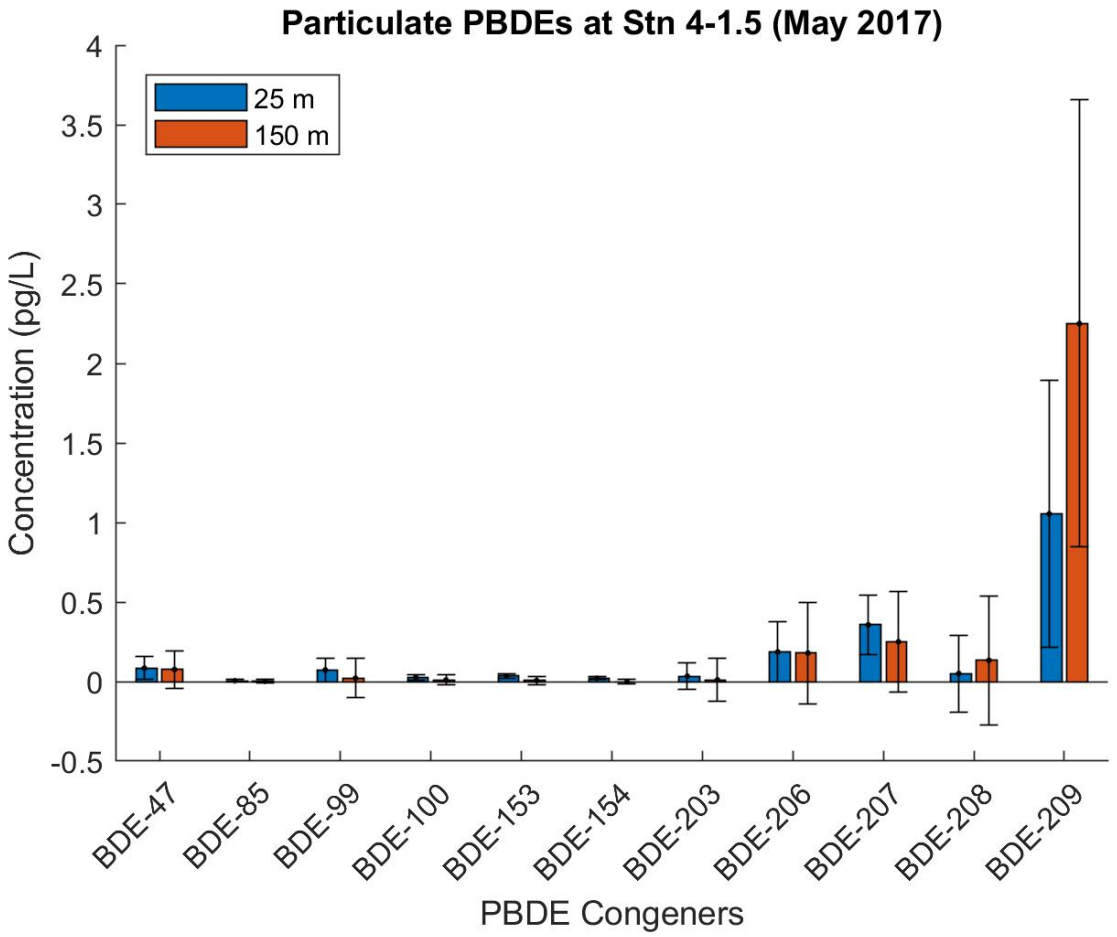


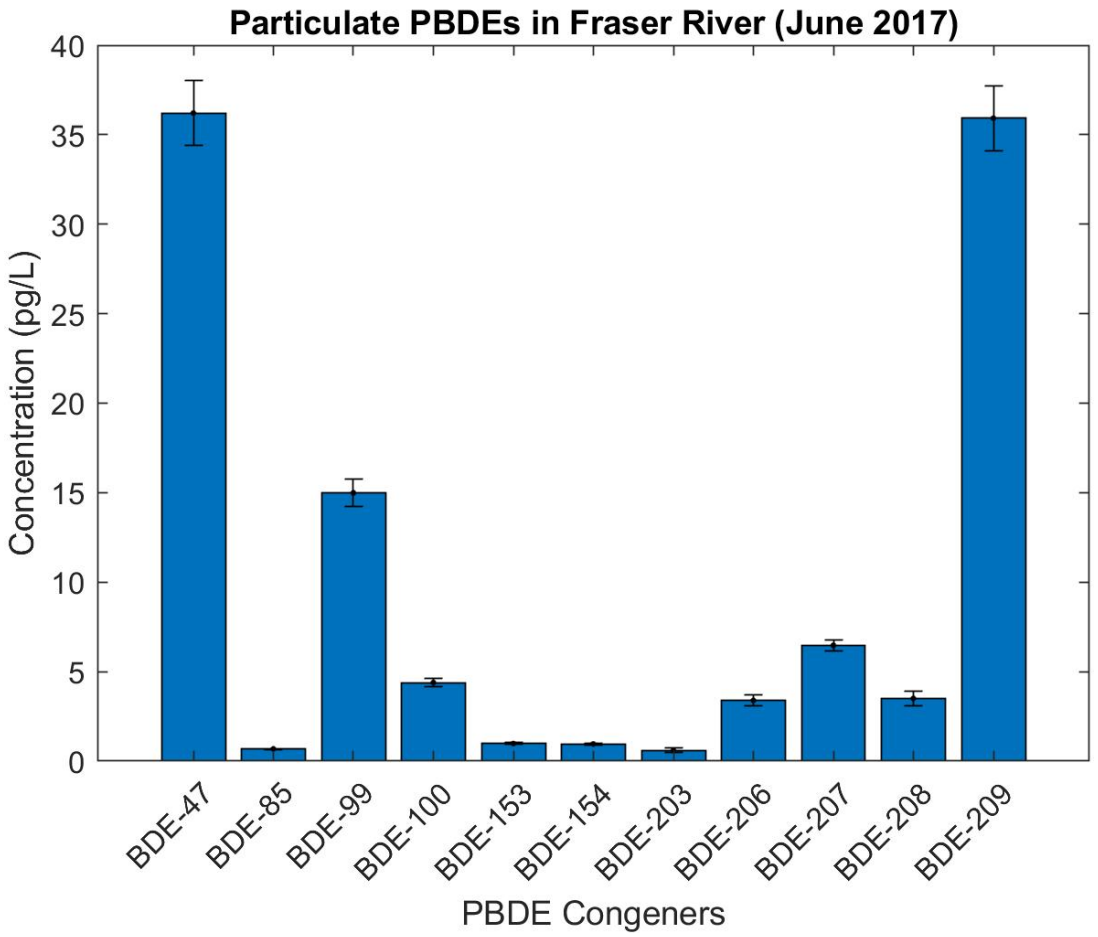
Particulate PBDEs

- Low concentration.
- High temporal & spatial variability.



Fraser River is an important source of particulate PBDEs into SoG





Particulate PBDE Flux

The PBDE discharge is increasing during the past 10 years

Depth [m]	Part. BDE-209 [pg/m^3]	^{234}Th Flux [dpm/(m^2d)]	BDE-209 Flux [pg/(cm^2yr)]
25	1054 ± 838	1286 ± 36	79 ± 64
150	2250 ± 1405	7186 ± 193	380 ± 243

Particulate PBDE flux calculated from literature between 2003 and 2005 (Grant et al 2011)

Congener	PBDE concentration in surface sediment [pg/g]	Sedimentation rate [g/cm^2/year]	PBDE sedimentation rate [pg/(cm^2yr)]
BDE-209	726	0.1	73

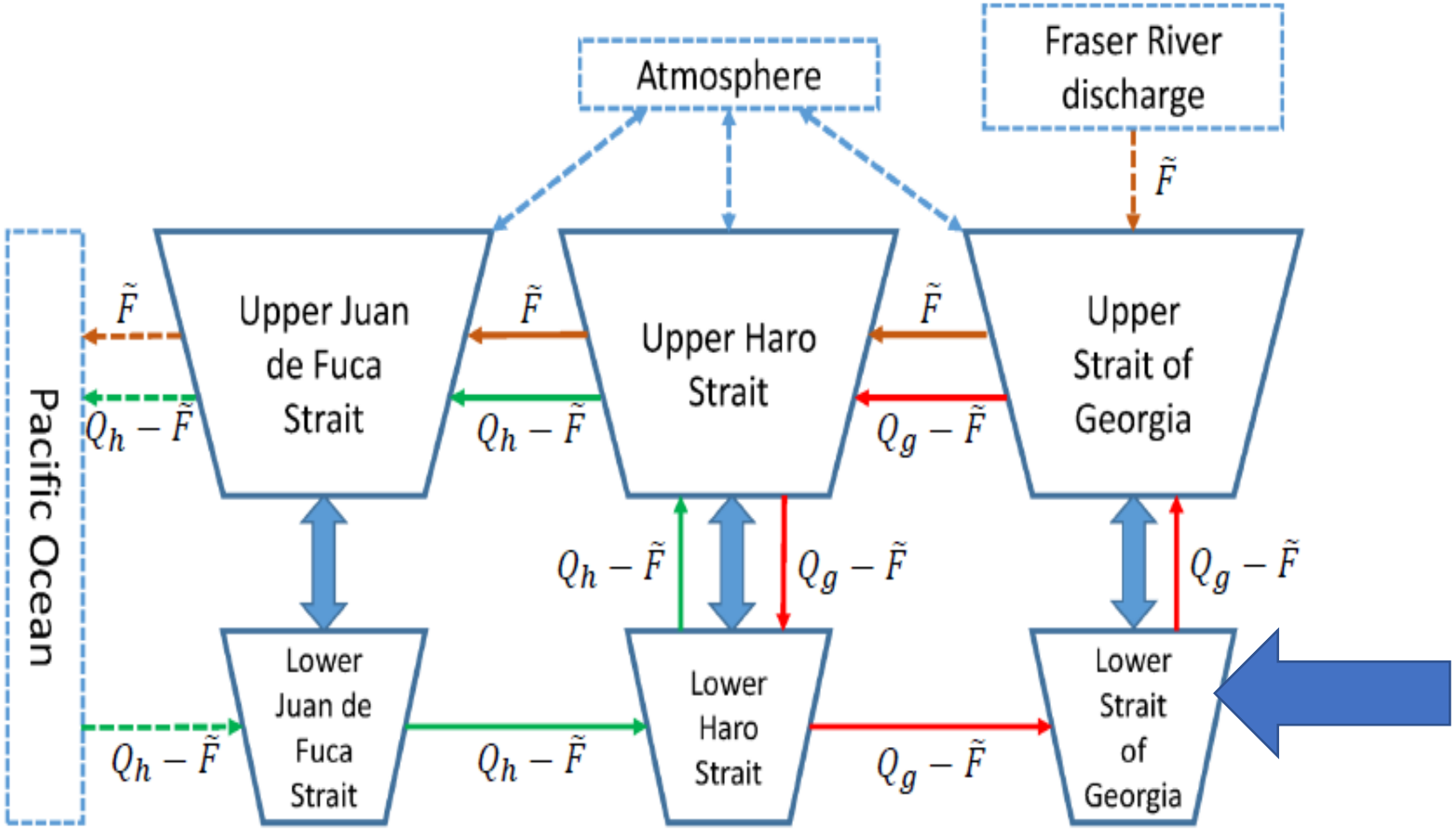
Box Model Simulation

Iona Plume Input data (10 years ago)

Congener	Flux (g/yr)
BDE-47	4100
BDE-99	4800
BDE-209	12000
Total PBDEs	24000

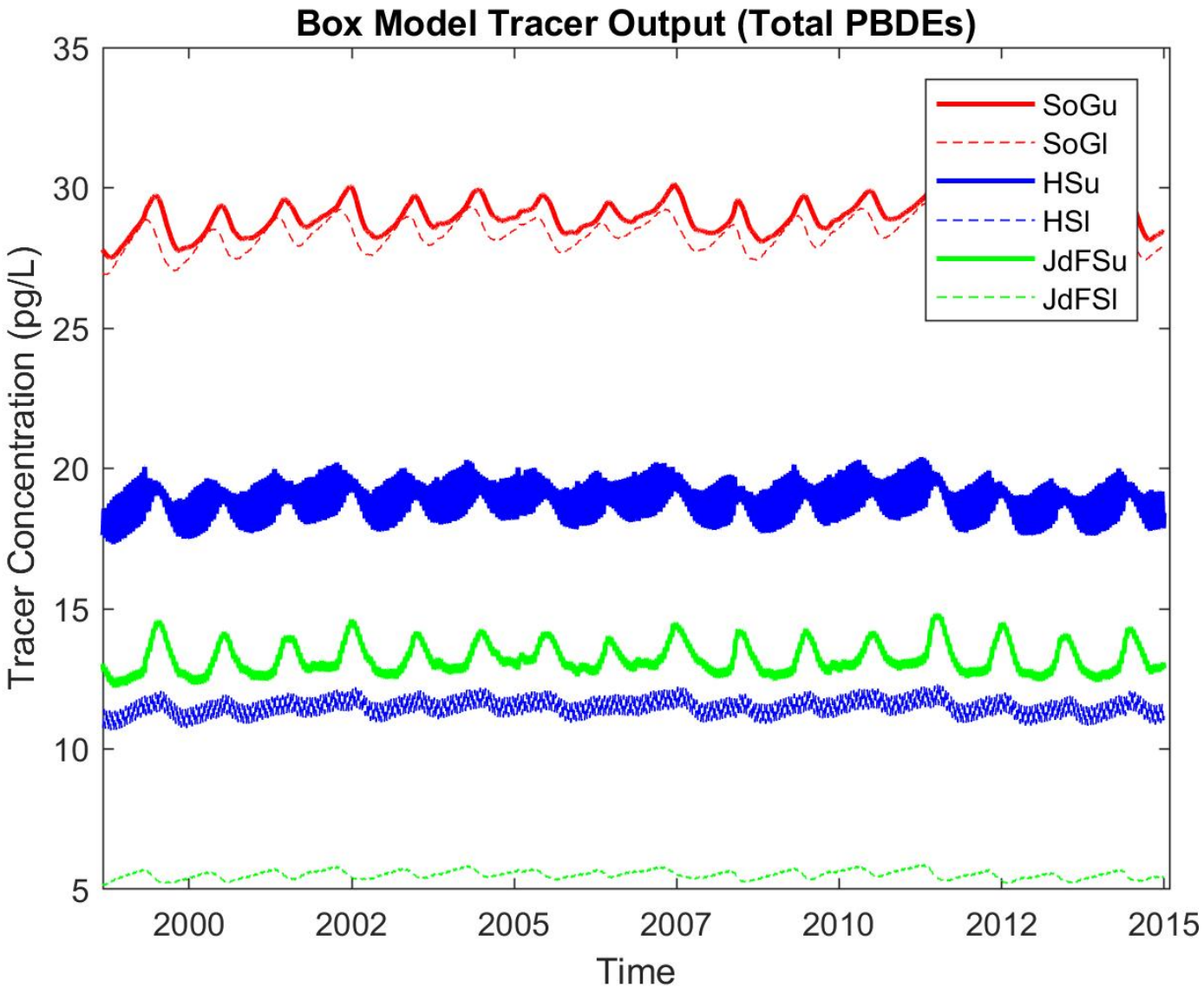
+ Fraser River input

(Dinn et al 2012, Johannessen et al 2015)



(Wang 2015)

Modeled results confirm other input sources



Total PBDEs measured in SoG:

280 pg/L

Total PBDEs in Haro Strait:

6.18~29.7 (average 18.1±10.4) pg/L upper box

1.75~14.7 (average 6.46±5.66) pg/L lower box

(Frouin et al 2013)

Conclusion

1. Dissolved PBDEs: high concentration, low temporal & spatial variability

   Particulate PBDEs: low concentration, high temporal & spatial variability

2. Slower desorption allows the particles to rise towards the surface as a result of the general estuarine circulation of SoG

3. Fraser River & atmospheric deposition are important sources to SoG

4. PBDE flux and box model confirm higher PBDE discharge in recent years, and/or an additional yet unidentified source (maybe run-off from roads).

Acknowledgement

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