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2020 Salish Sea Ecosystem Conference
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Apr 21st, 12:30 PM - 2:00 PM

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

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Sun, Yuanji, "Sources, sinks, dispersion and cycling of dissolved polybrominated diphenyl ethers (PBDEs) discharged in the Strait of Georgia" (2020). *Salish Sea Ecosystem Conference*. 82.
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THE UNIVERSITY OF BRITISH COLUMBIA



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SERVICES AND SOLUTIONS FOR A LIVABLE REGION



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

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Supervisors: Dr. Maria T. Maldonado & Dr. Roger Francois

April 21st, 2020

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

The screenshot shows the Nature website interface. At the top, the 'nature' logo is on the left, and navigation links for 'Home', 'News & Comment', 'Research', and 'Careers' are on the right. Below the logo, there are breadcrumb links: 'News & Comment' > 'News' > '2018' > 'Mar'. The main article title is 'Man-made pollutants found in ocean trenches' by Jane Qiu, dated 20 June 2016, with the location 'SHANGHAI'. A sidebar on the right contains 'Earth News' links, 'Contact us', 'Who we are', and 'Related BBC sites' including Earth Explorers, Wildlife Finder, BBC News, and Weather.

The screenshot shows the BBC website navigation bar with links for 'Sign in', 'News', 'Sport', 'Weather', 'Capital', 'TV', 'Radio', and 'More...'. A search box is located on the right side of the bar.

The screenshot shows the BBC Earth News logo with the tagline 'REPORTING LIFE ON EARTH'.

The screenshot shows a news article titled 'Banned flame retardants show up in new babies' by Jim Hanchett-Indiana, dated July 6th, 2017. The article is associated with 'BABIES' and 'INDIANA UNIVERSITY'. The author's name and the date are displayed below the title.

Arctic polar bear
By Matt Walker
Editor, Earth News



The screenshot shows the article's sharing and licensing information. It includes a 'Share Article' button with icons for Facebook, Twitter, and Email. A Creative Commons Attribution 4.0 International license logo is displayed, along with the text 'You are free to share this article under the Attribution 4.0 International license.' There is also a 'Follow Futurity' section with icons for RSS, Twitter, Facebook, and Email.

Trace amounts of flame retardants, banned in the United States for more than a decade, are still passing through umbilical cord blood from mothers to their babies. The chemicals are linked to a variety of health concerns including

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

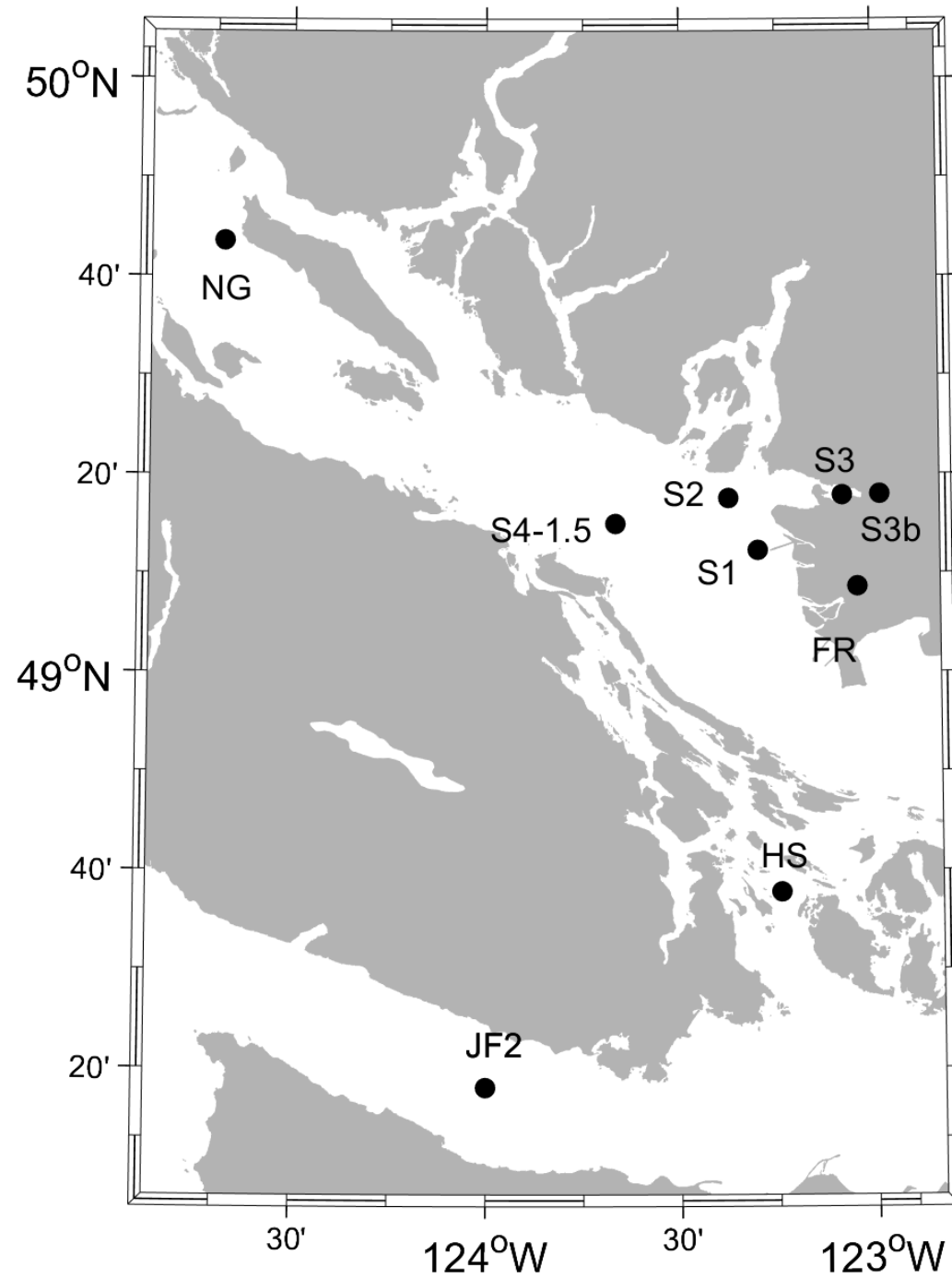
Key Questions

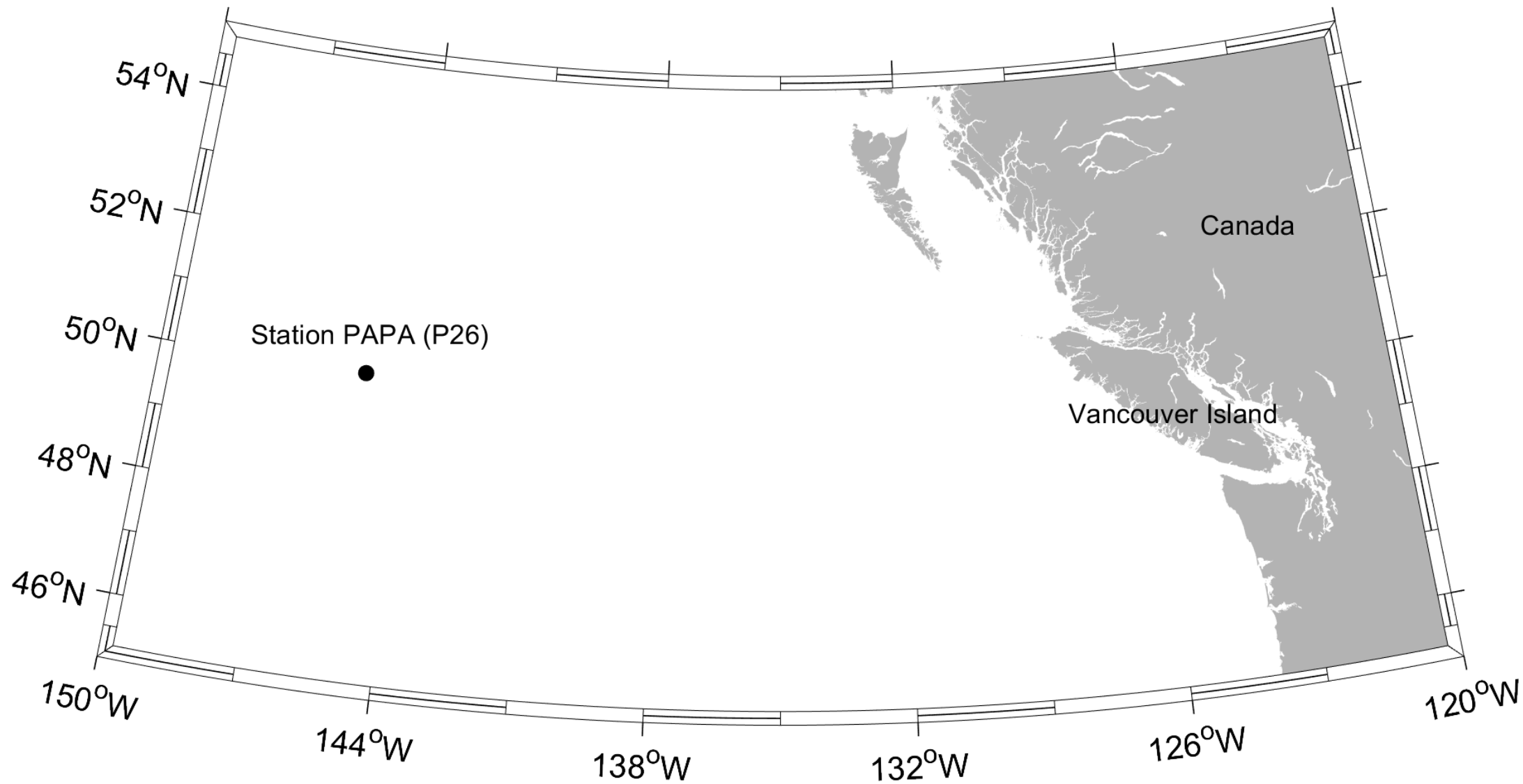
Quantify the sources, sinks and biogeochemical cycling of PBDEs in the coastal waters of British Columbia

- 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

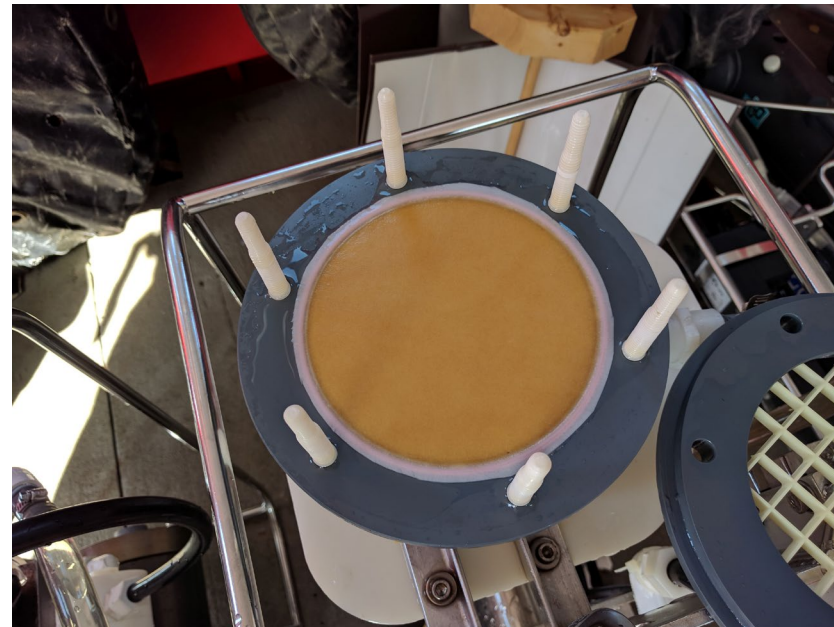
Method

1. Sampling sites





2. Sample collection: dissolved & particulate PBDEs



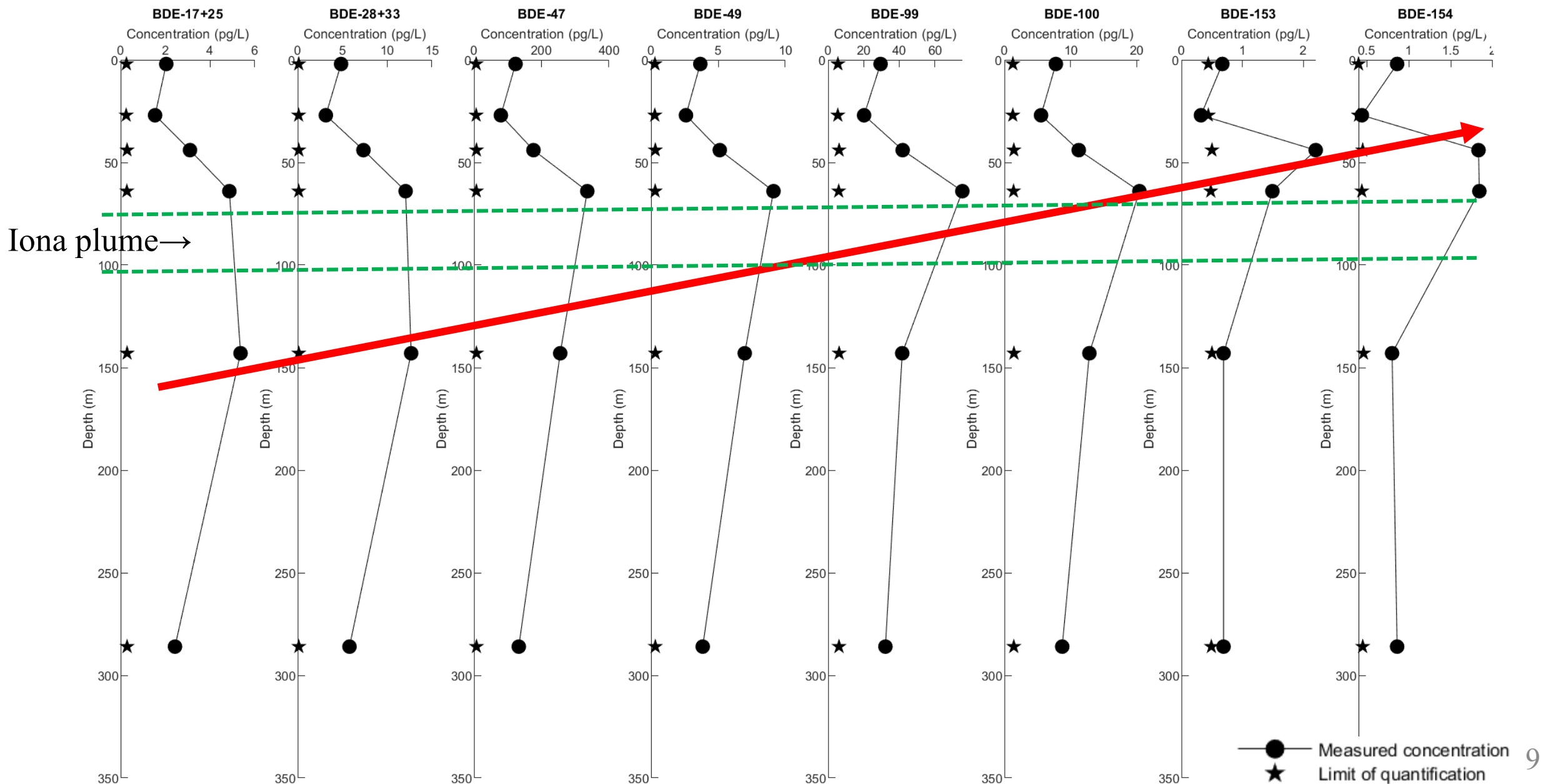
Environmental Behaviors of PBDEs in SoG

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 |

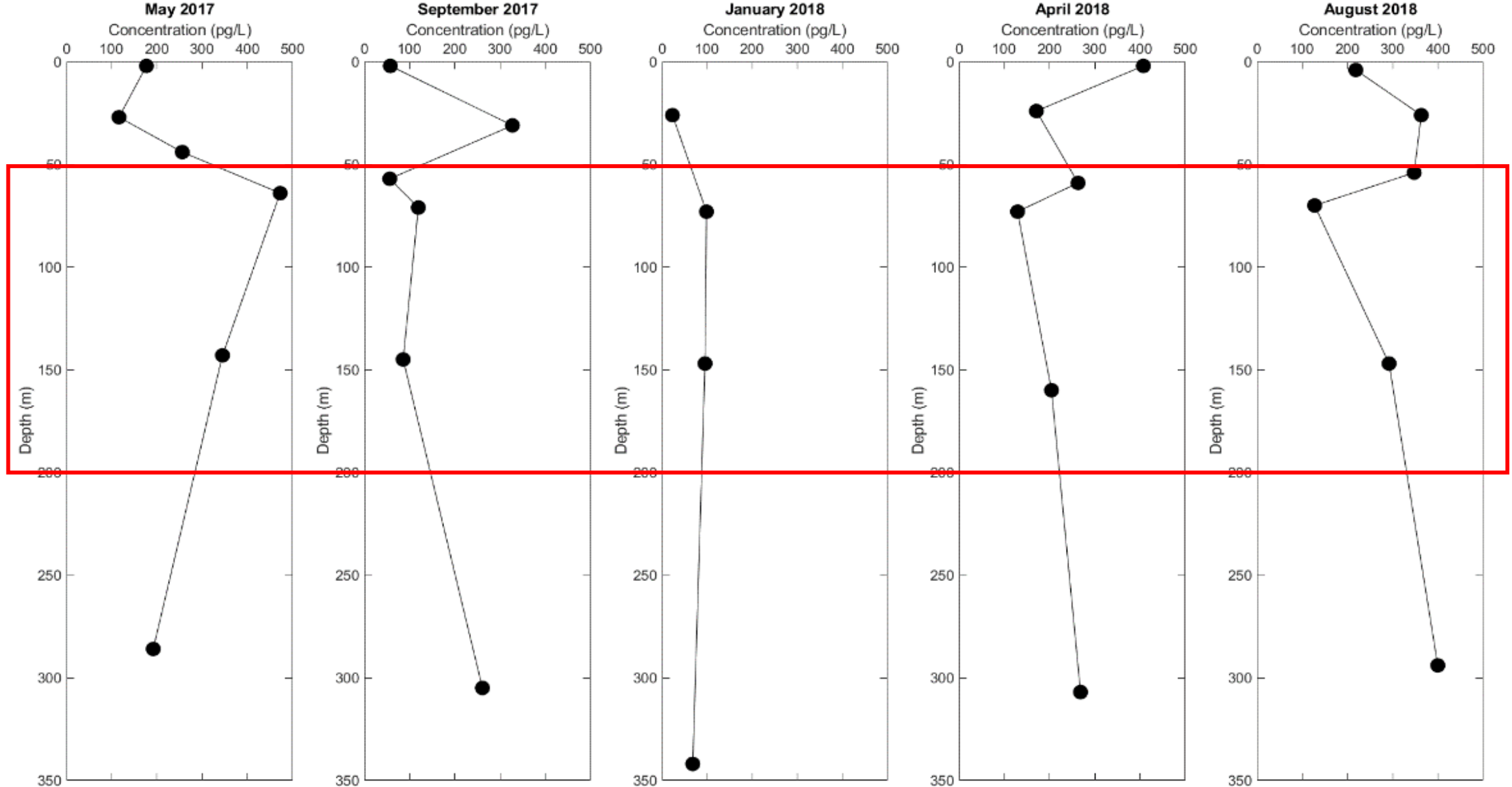
Dissolved PBDEs in southern SoG come from desorption from particles

Depth profile of dissolved PBDEs @ Stn 4-1.5 in May 2017

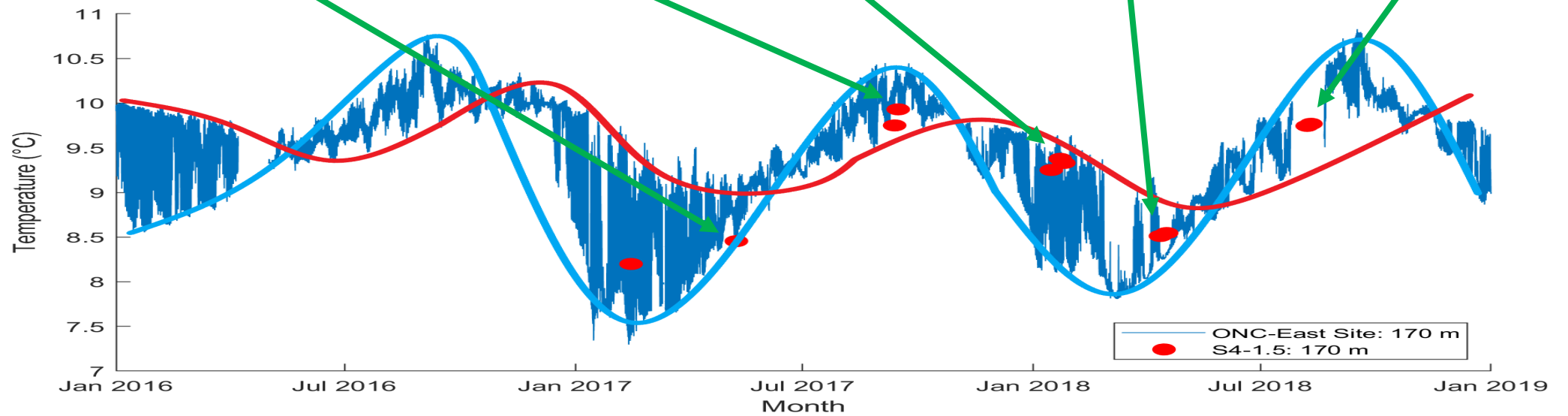
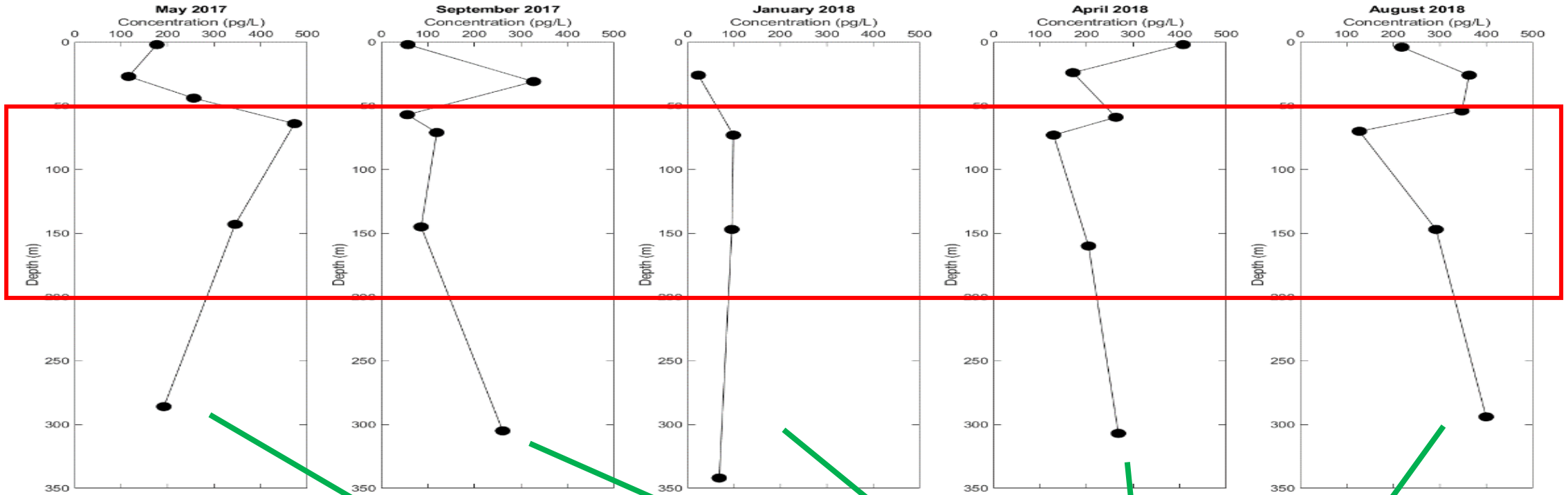


Dissolved PBDEs in southern SoG is influenced by water circulation

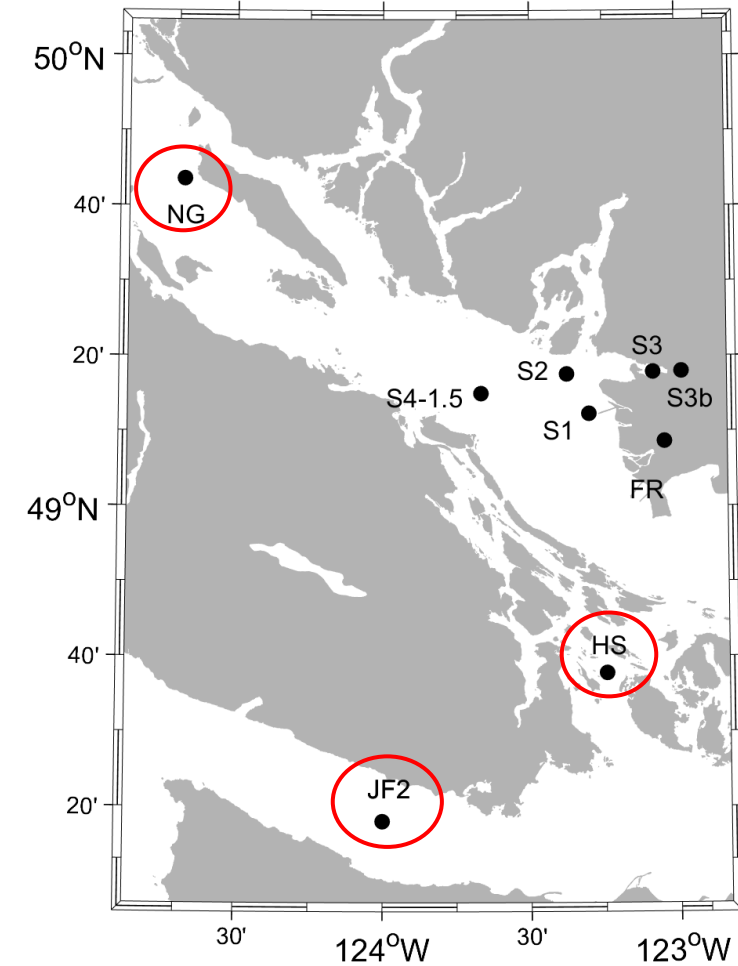
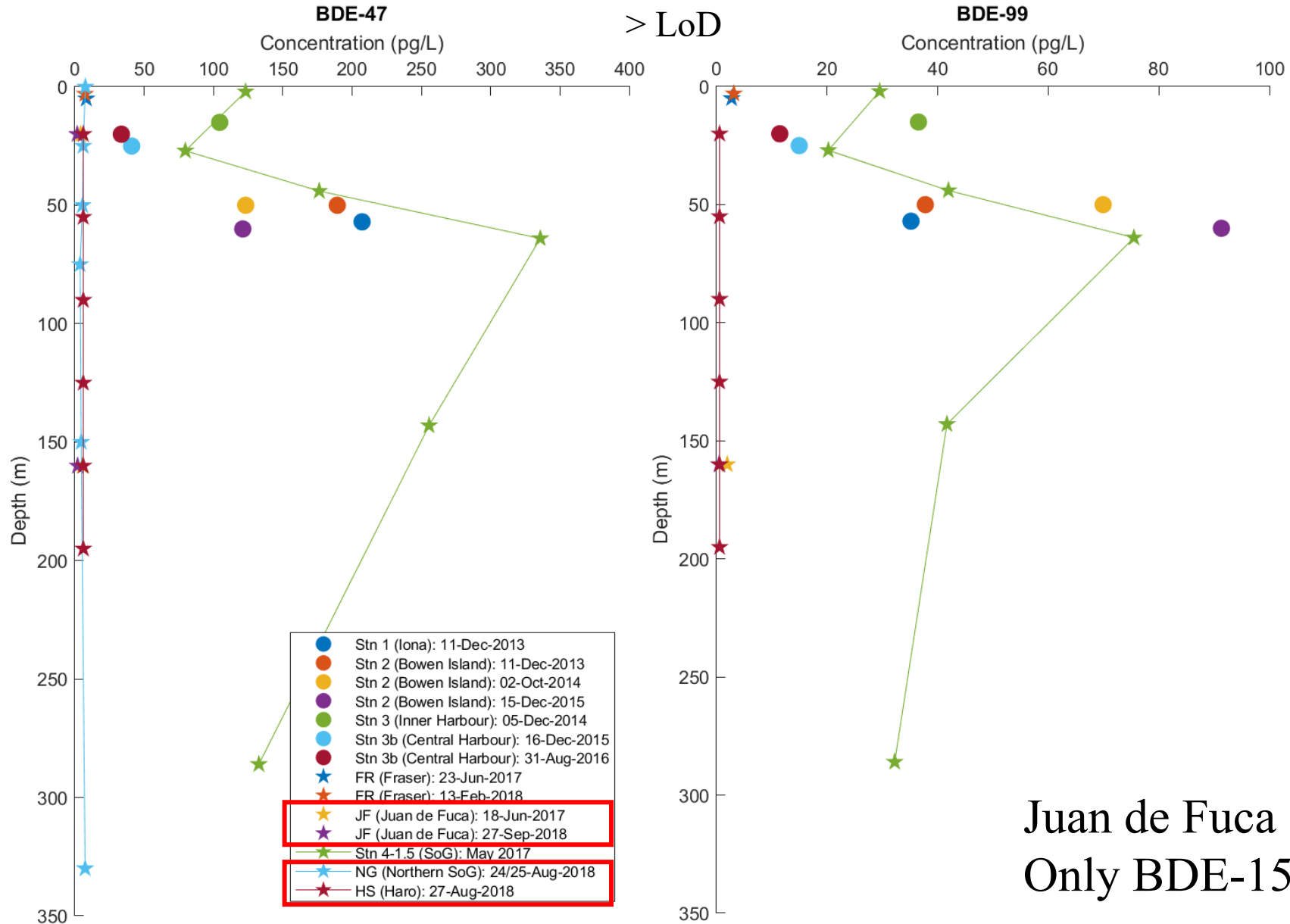
Total dissolved PBDE concentrations above LoQ (excluding BDE-206~209) @ S4-1.5



Total dissolved PBDE concentrations above LoQ (excluding BDE-206-209) @ S4-1.5

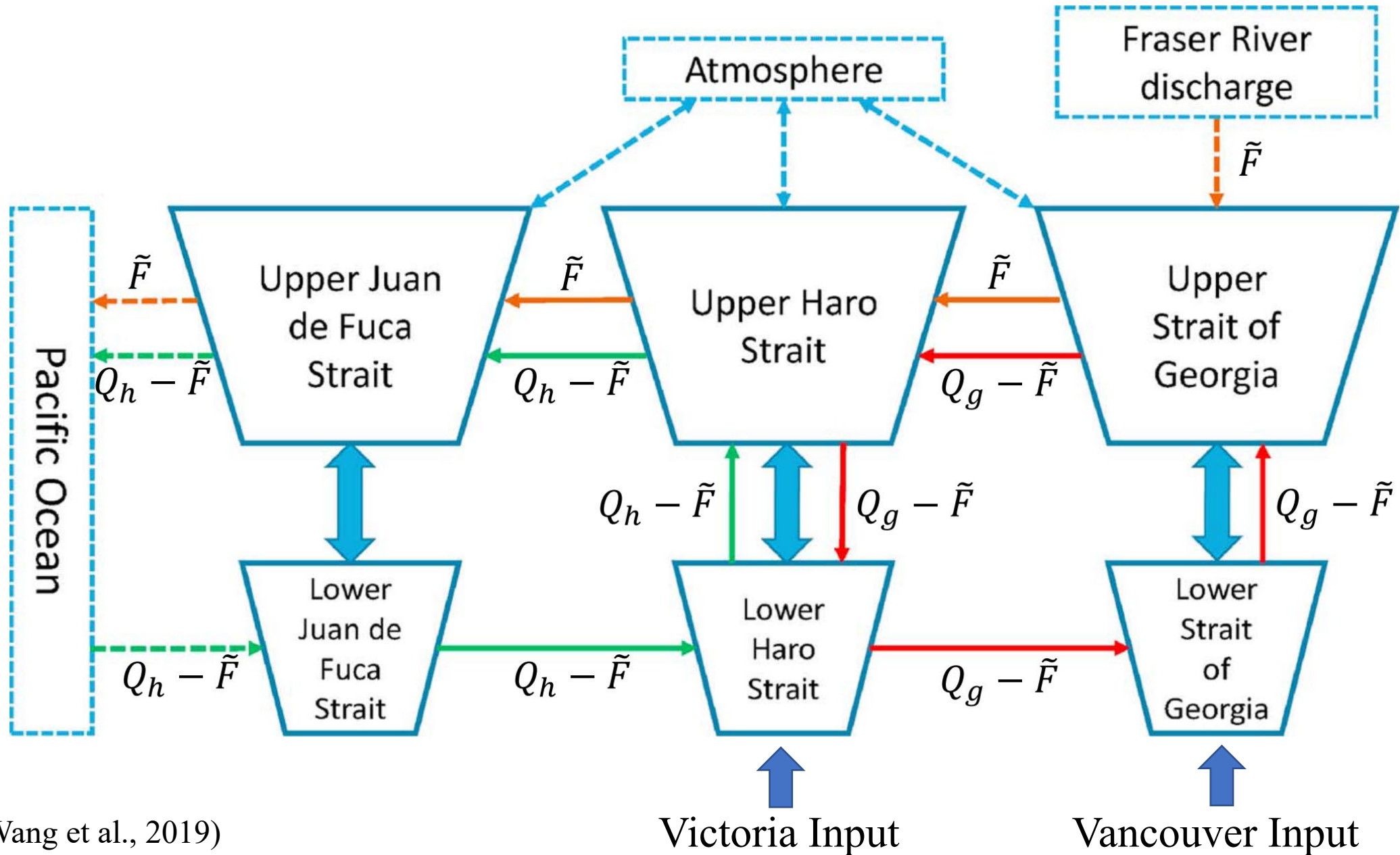


Most PBDEs are removed to sediment while light congeners are exported to the Pacific Ocean



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.

Acknowledgement

Faculty & staff

Dr. Roger Francois

Dr. Maria Maldonado

Dr. Rich Pawlowicz

Maureen Soon

Jian Guo

Chris Payne

Larysa Pakhomova

Metro Vancouver

Students

Cheng Kuang

Iselle Flores Ruiz

Samuel Stevens, etc.

*All crew members in CCGH *Siyay* and *Moytel*, CCGS *Vector* and *John P. Tully*.*

All members in Maldonado/Tortell's and Pawlowicz's lab group

Thank you!