

# Polycyclic Aromatic Hydrocarbons in ocean sediments from the North Pacific to the Arctic Ocean

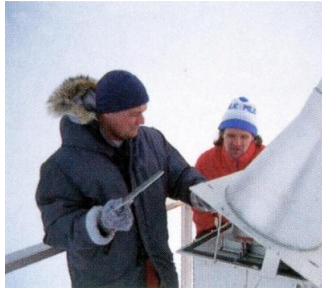
YUXIN MA<sup>1</sup>, CRISPIN HALSALL<sup>2</sup>, ZHIYONG XIE<sup>3</sup>, DANIJELA KOETKE<sup>3</sup>,  
WENYING MI<sup>3</sup>, RALF EBINGHAUS<sup>3</sup>, GUOPING GAO<sup>1</sup>

<sup>1</sup> College of Marine Sciences, Shanghai Ocean University, Shanghai  
201306, China

<sup>2</sup> Lancaster Environment Centre, Lancaster University, Lancaster,  
LA1 4YQ, UK ([\\*c.halsall@lancaster.ac.uk](mailto:c.halsall@lancaster.ac.uk))

<sup>3</sup> Helmholtz-Zentrum Geesthacht, Centre for Materials and  
Coastal Research GmbH, Institute of Coastal Research, Max-  
Planck Straße. 1, D-21502 Geesthacht, Germany

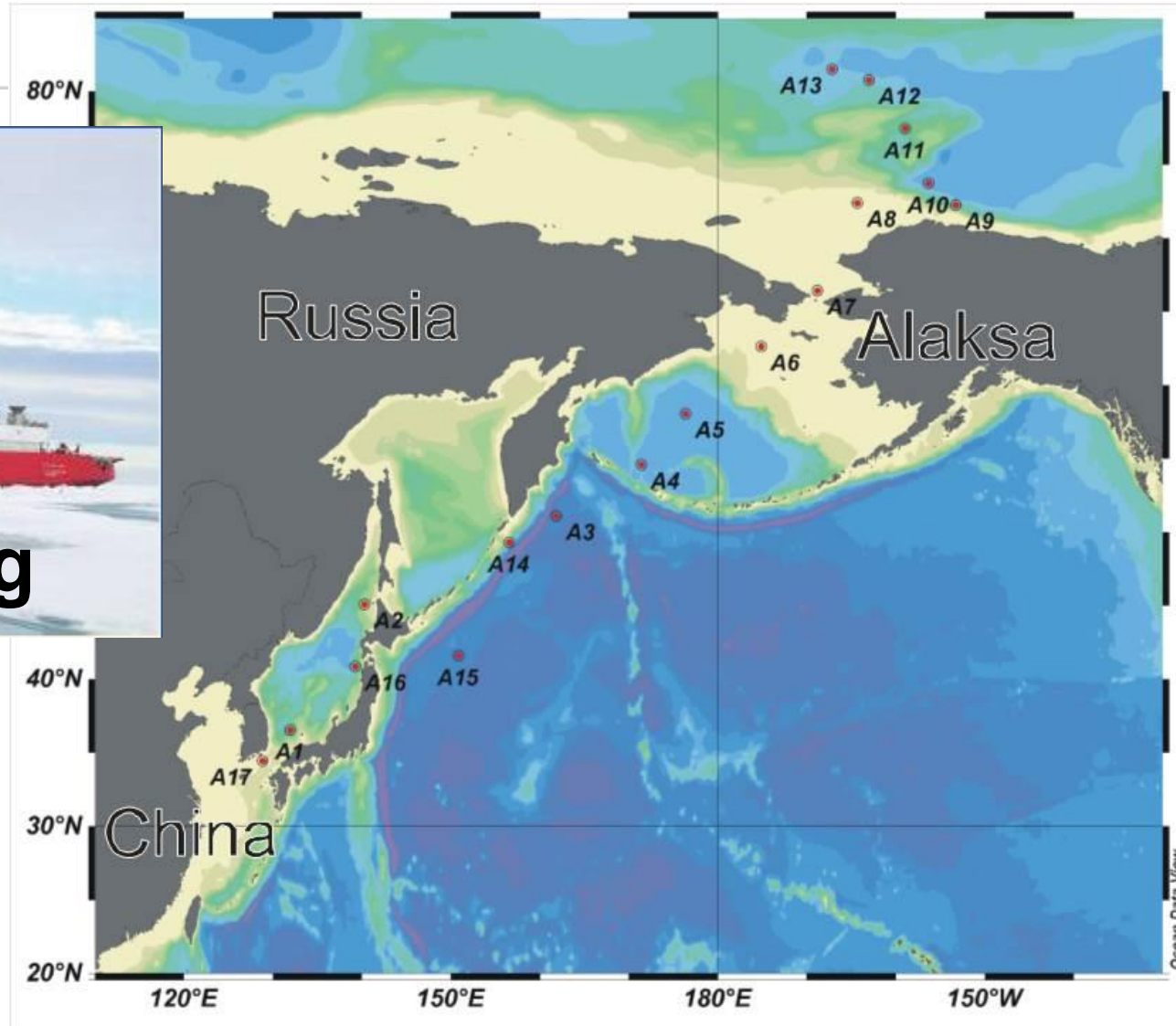
# PAHs – truly ubiquitous contaminants and useful markers of anthropogenic activities



# 'Snow Dragon' - cruises



Chinese National Arctic  
Research Expeditions  
(e.g. CHINARE2010, 2012)  
East Asia to the High Arctic  
(35° N to 82° N).



## Deposition of polycyclic aromatic hydrocarbons in the North Pacific and the Arctic

Yuxin Ma,<sup>1,2,3</sup> Zhiyong Xie,<sup>4</sup> Haizhen Yang,<sup>1</sup> Axel Möller,<sup>4</sup> Crispin Halsall,<sup>3</sup>  
Minghong Cai,<sup>2</sup> Renate Sturm,<sup>4</sup> and Ralf Ebinghaus<sup>4</sup>

Received 7 February 2013; revised 27 April 2013; accepted 6 May 2013.

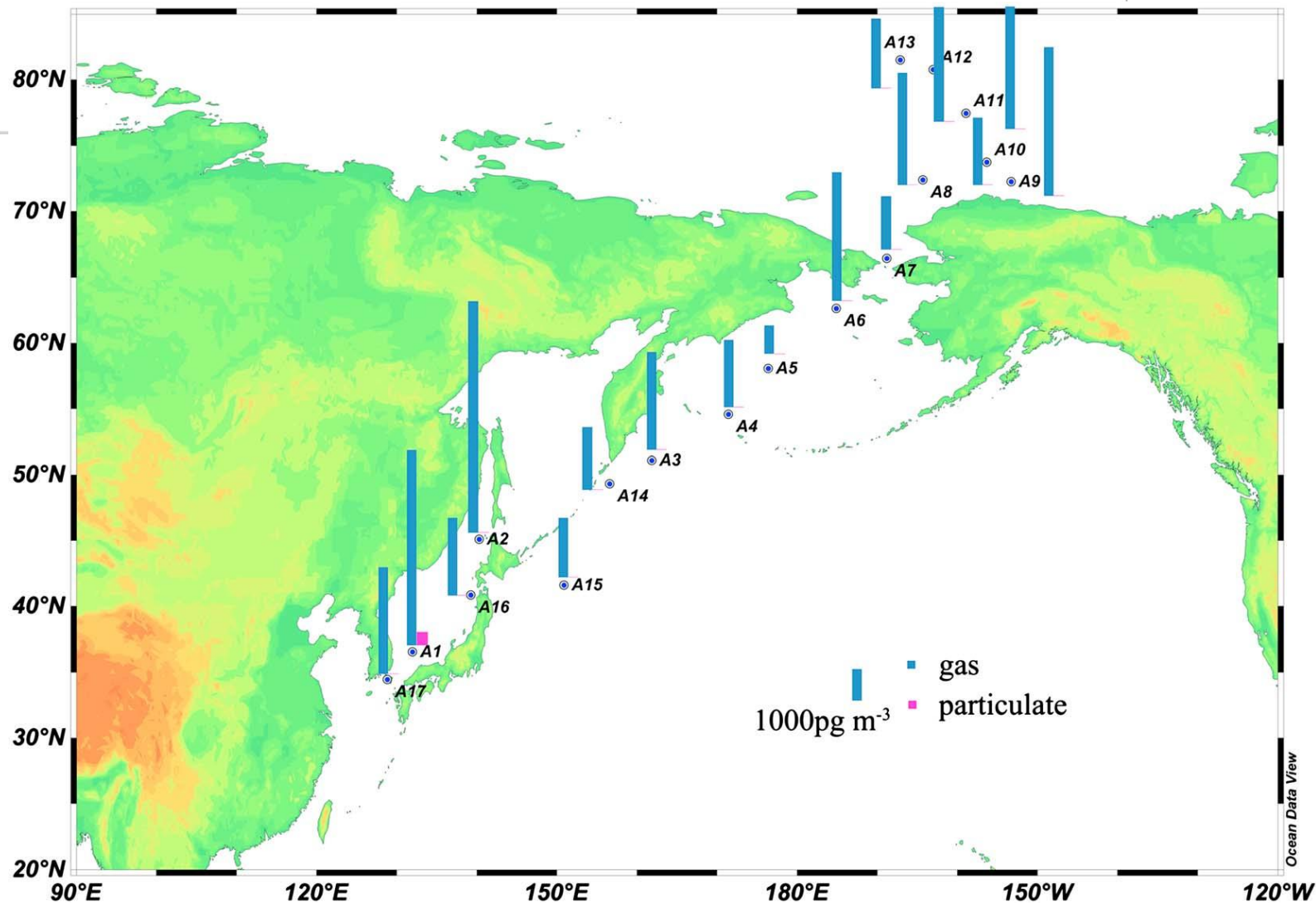


- *Air*: 1-2 days, ~500 m<sup>3</sup>,  
GFF + PUF/XAD-2

- *Seawater*: 0.5-1 day, ~900 L,  
GFF + PAD-3

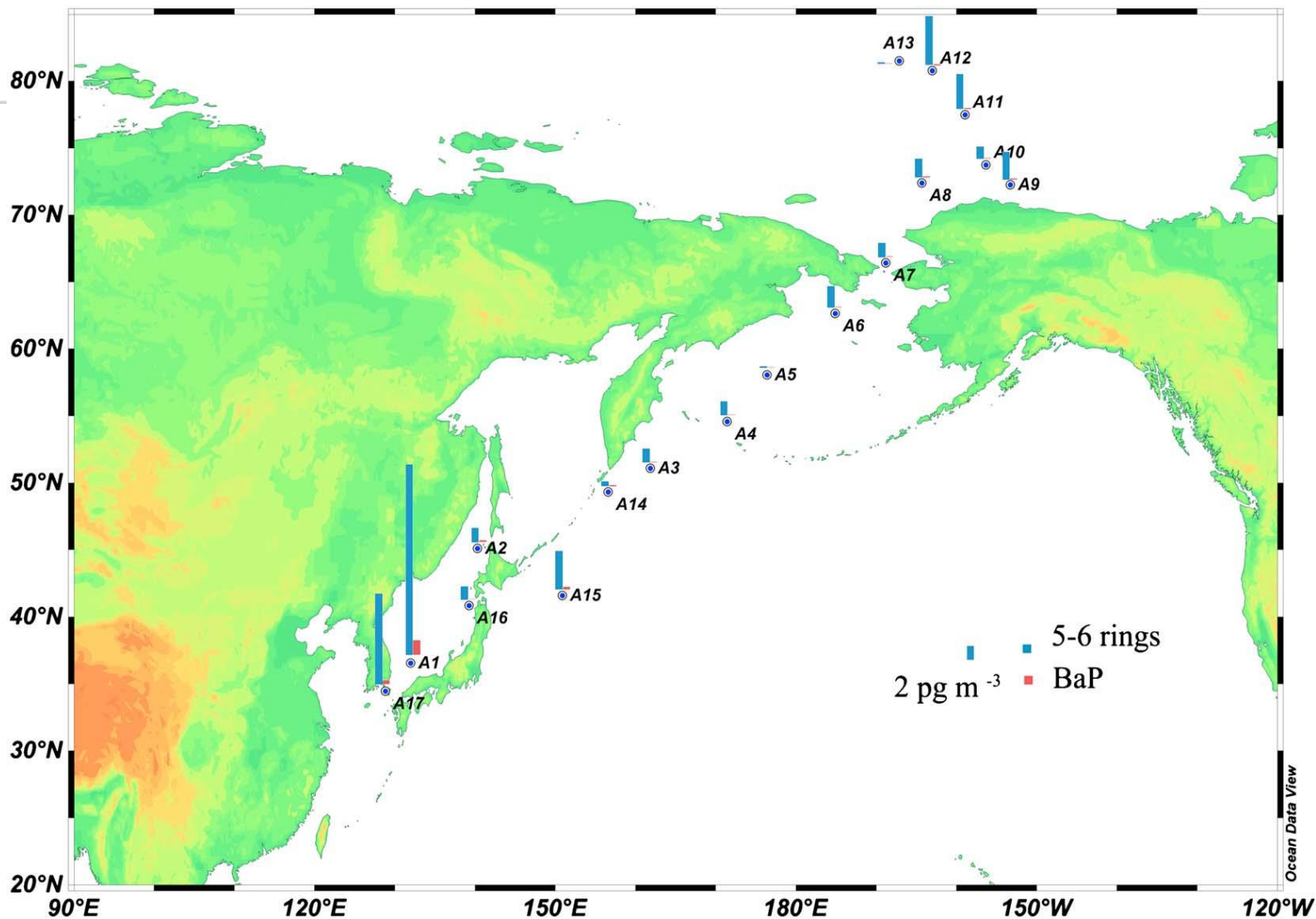


# $\Sigma_{18}$ PAHs in air ( $\text{pg m}^{-3}$ )



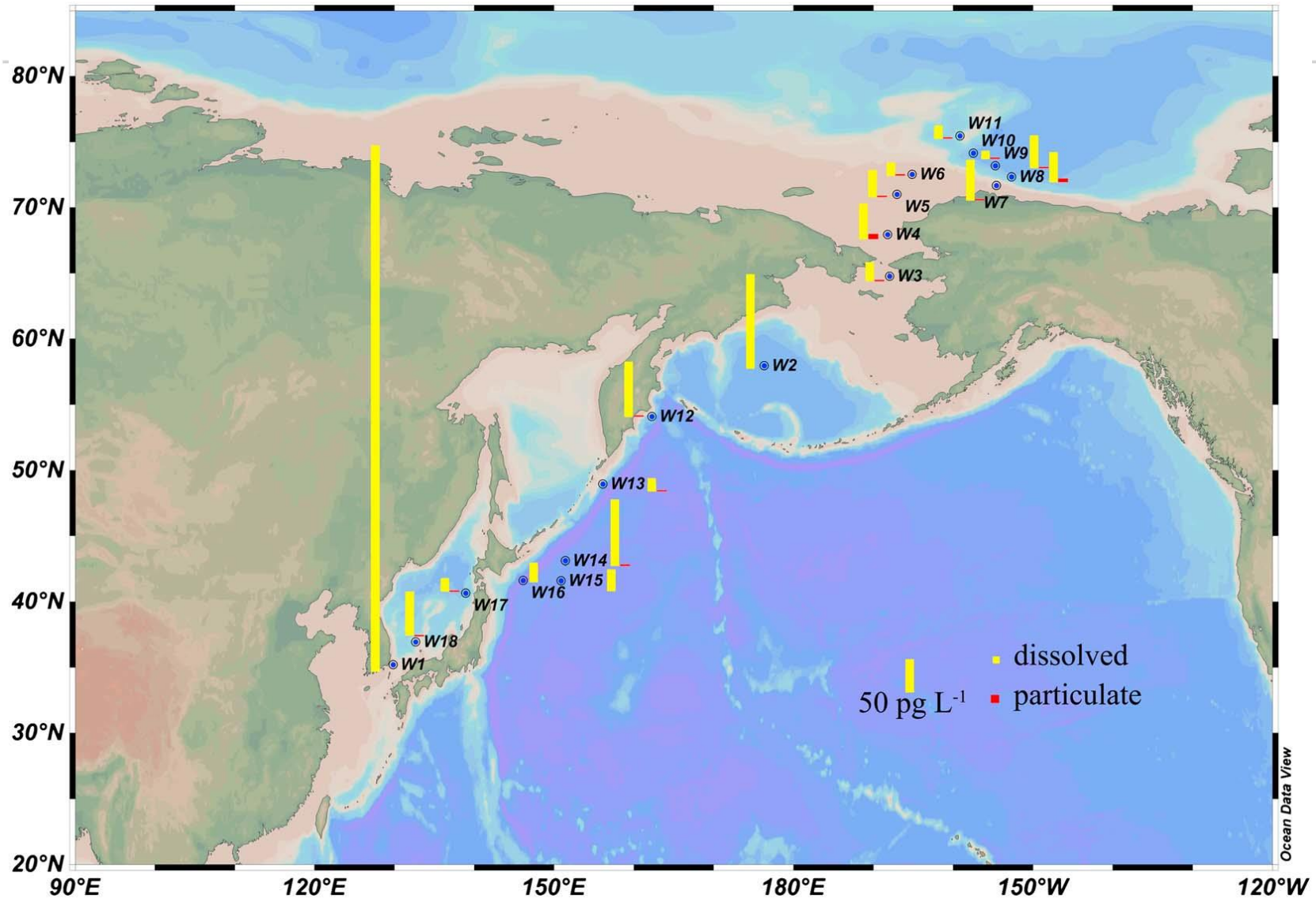
**Figure 1.** Concentrations of gas- and particulate-phase PAHs in the atmosphere ( $\Sigma_{18}[\text{PAHs}]_{\text{atm}}$ ) along the sampling cruise.

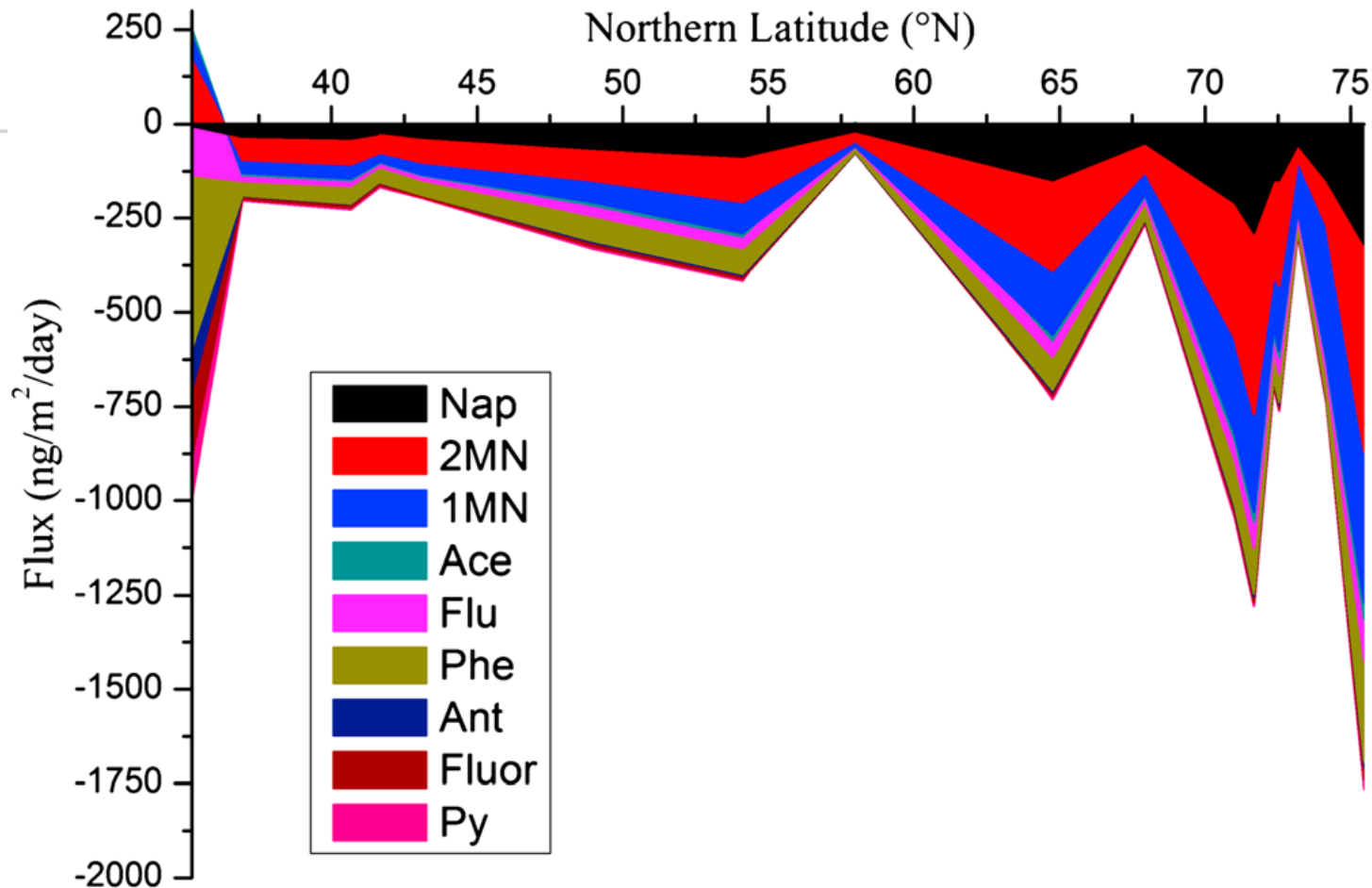
# 5-6 ringed PAHs in air



**Figure 2.** Concentrations of five- to six-ringed particulate-phase PAHs and BaP in the atmosphere along the sampling cruise.

# $\Sigma_{18}$ PAHs in water ( $\text{pg L}^{-1}$ )





**Figure 5.** Accumulated (sum) air-sea gas exchange fluxes of top nine PAHs versus latitude along the sampling transect. Negative (–) flux indicates deposition into the water column.



## RESEARCH ARTICLE

10.1002/2014JC010651

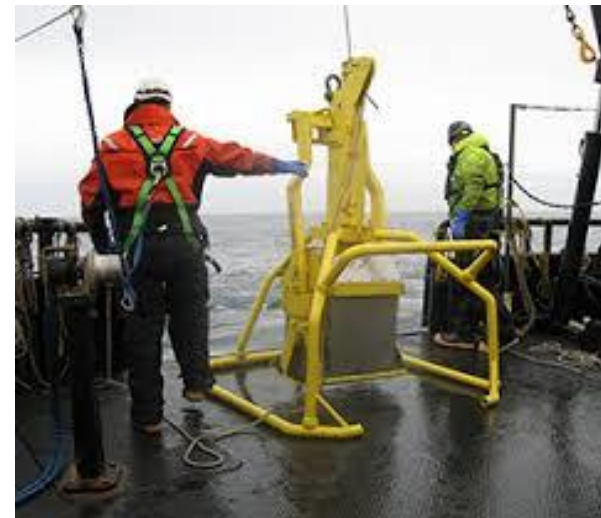
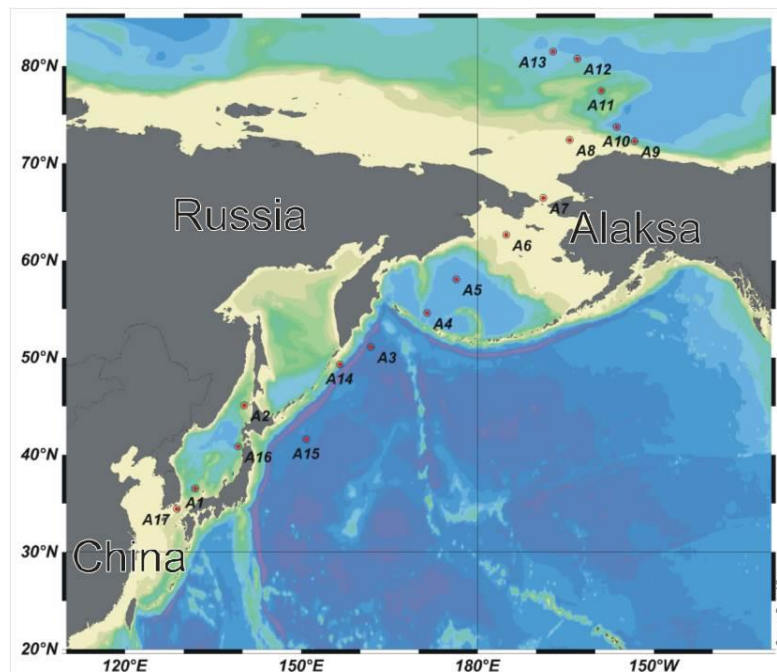
Persistent organic pollutants in ocean sediments  
from the North Pacific to the Arctic Ocean

## Key Points:

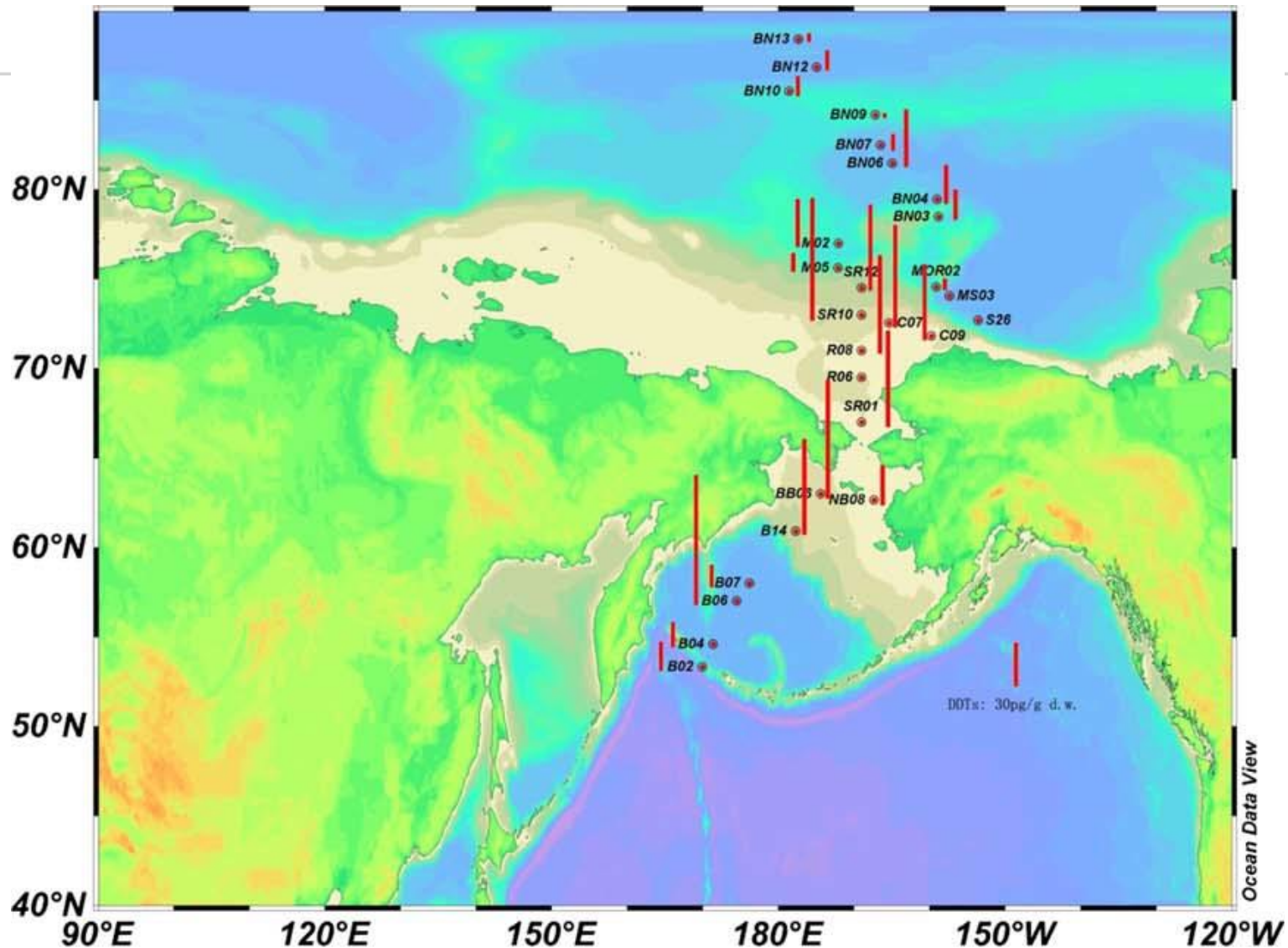
- Bering-Chukchi shelf sediments are an important regional sink for POPs
- Different chemical concentrations between shallow and deeper ocean regions
- Substantial chemical processing between surface waters and benthic sediments

Yuxin Ma<sup>1</sup>, Crispin J. Halsall<sup>2</sup>, John D. Crosse<sup>3</sup>, Carola Graf<sup>2</sup>, Minghong Cai<sup>4</sup>, Jianfeng He<sup>4</sup>,  
Guoping Gao<sup>1</sup>, and Kevin Jones<sup>2</sup>

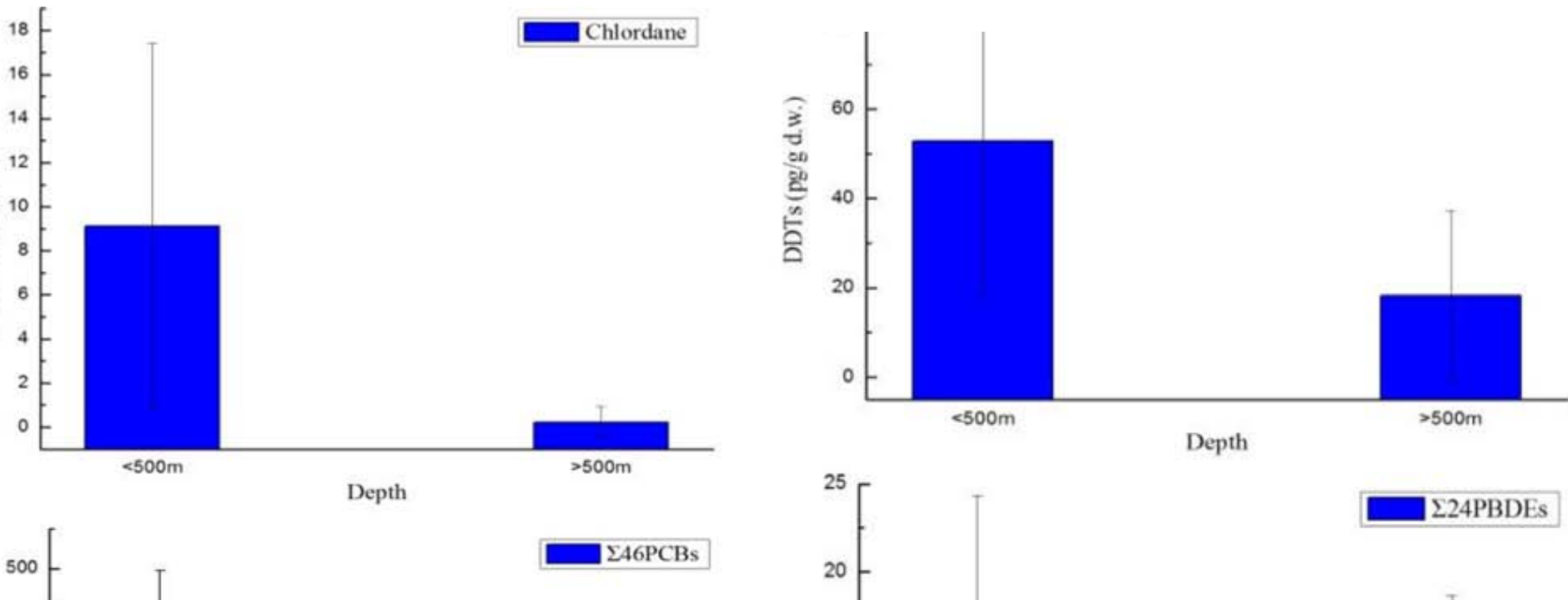
<sup>1</sup>College of Marine Sciences, Shanghai Ocean University, Shanghai, China, <sup>2</sup>Lancaster Environment Centre, Lancaster University, Lancaster, UK, <sup>3</sup>Department of Chemistry, Lancaster University, Lancaster, UK, <sup>4</sup>SOA Key Laboratory for Polar Science, Polar Research Institute of China, Shanghai, China



# DDTs in surficial ocean sediments (pg/g dw)



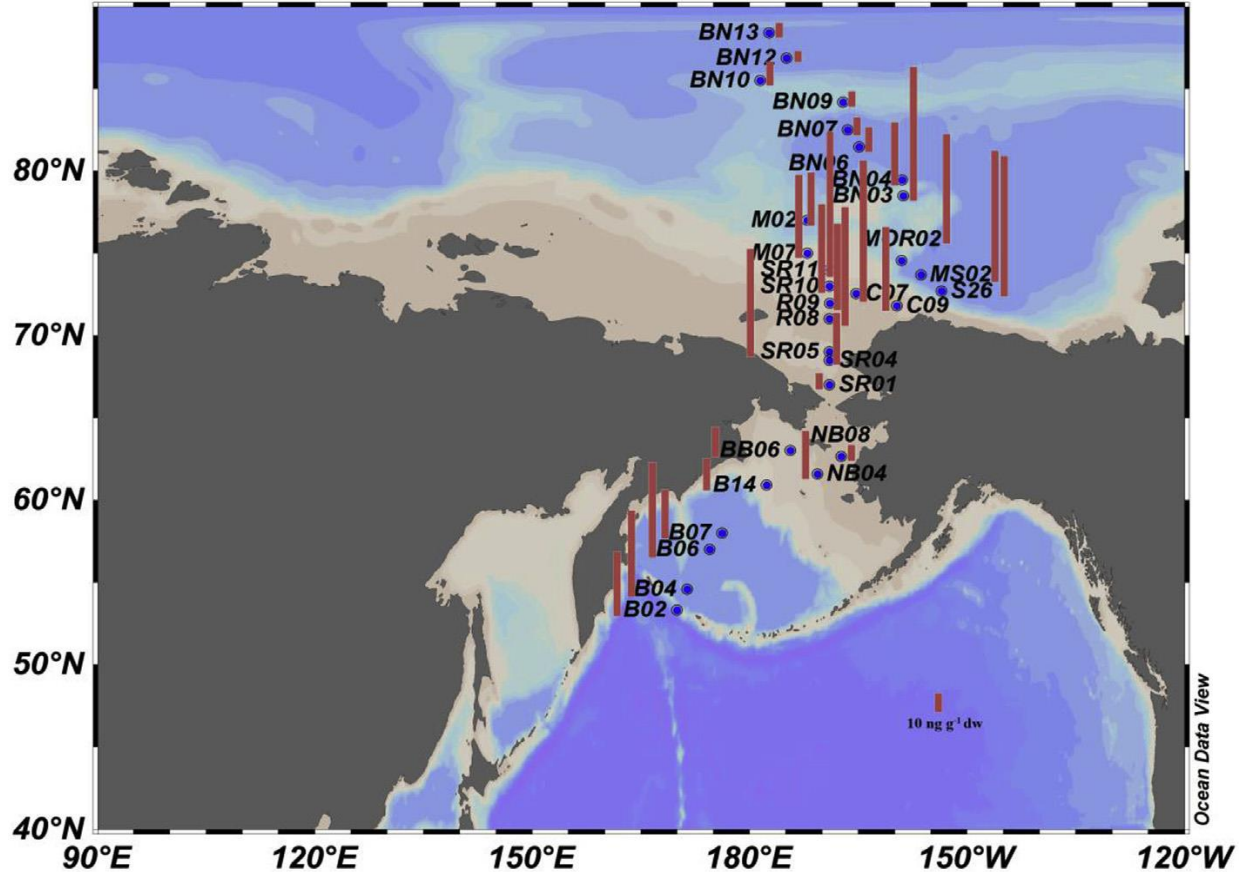
# Sediment depth and TOC content



A weak correlation is observed between organochlorine/PAH concentrations and organic carbon content of marine sediments

## Polycyclic aromatic hydrocarbons in ocean sediments from the North Pacific to the Arctic Ocean<sup>☆</sup>

Yuxin Ma <sup>a</sup>, Crispin J. Halsall <sup>b,\*</sup>, Zhiyong Xie <sup>c</sup>, Danijela Koetke <sup>c</sup>, Wenying Mi <sup>d</sup>,  
Ralf Ebinghaus <sup>c</sup>, Guoping Gao <sup>a,\*\*</sup>



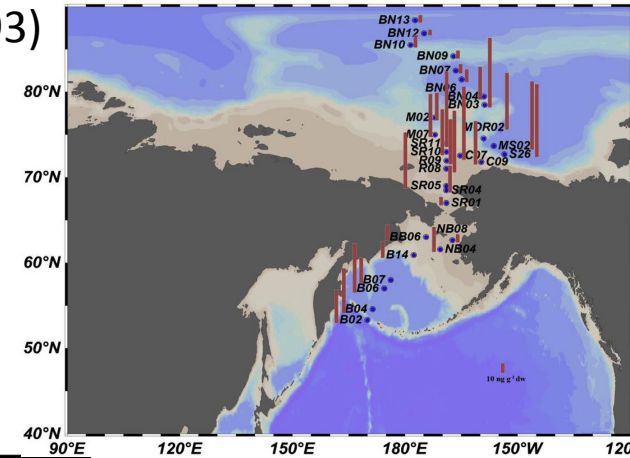


## $\Sigma_{16-20}$ PAHs concentrations in marine sediments

North Sea (700–2700 ng g<sup>-1</sup>) Klamer & Fomsgaard (1993)

Baltic Sea (9.53–1870 ng g<sup>-1</sup>) Witt (1995) Mar. Poll. Bul.

## $\Sigma_{18}$ PAHs concentrations along the cruise transect (ng g<sup>-1</sup>) -this study



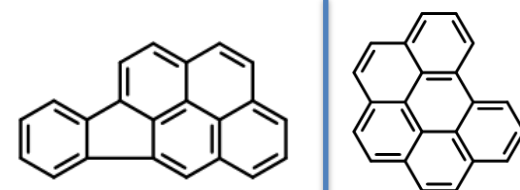
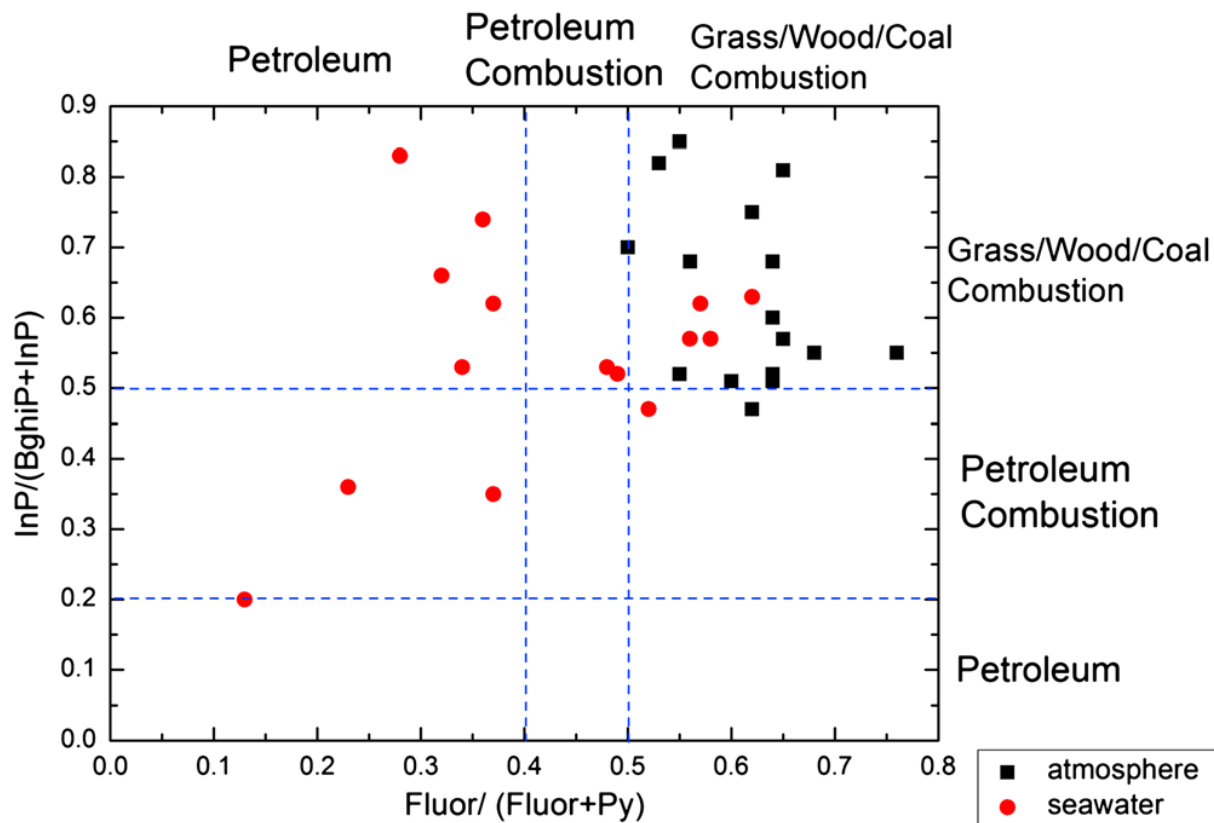
	Range	Median	Mean
Bering Sea	26.2–51.2	40.4	39.5
Bering Strait	8.5–25.8	16.5	16.8
Chukchi Sea	8.8–78.3	47.0	49.7
Canada Basin	58.9–75.5	70.5	68.3
Central Arctic Ocean	5.8–33.9	9.7	13.1
Entire Cruise	5.8–78.3	34.2	37.3

Svalbard coastal sediments (25–38 ng g<sup>-1</sup>)

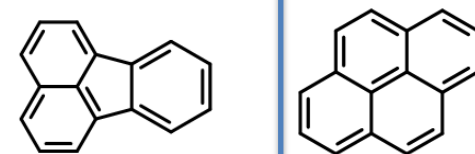
# Use of PAH ratios for source discrimination

Critical appraisal: Galarneau, E. (2008) Atmos. Environ. 42, 8139

Yunker, M. et al (2002) Org. Geochem. 33, 489



InP 276 B[ghi]P



Fluor 202 Pyrene

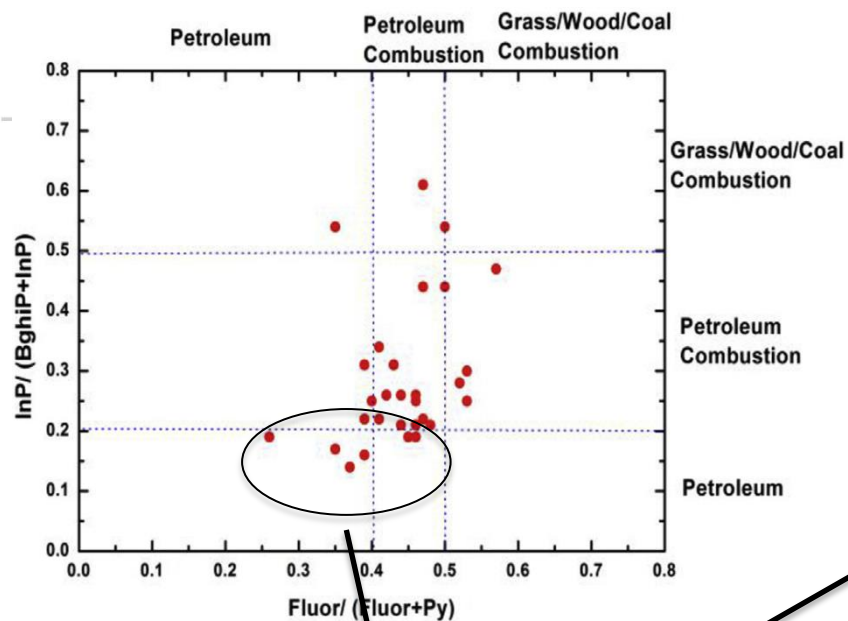
Indeno[1,2,3-cd]pyrene (InP)

Benzo[ghi]perylene (B[ghi]P)

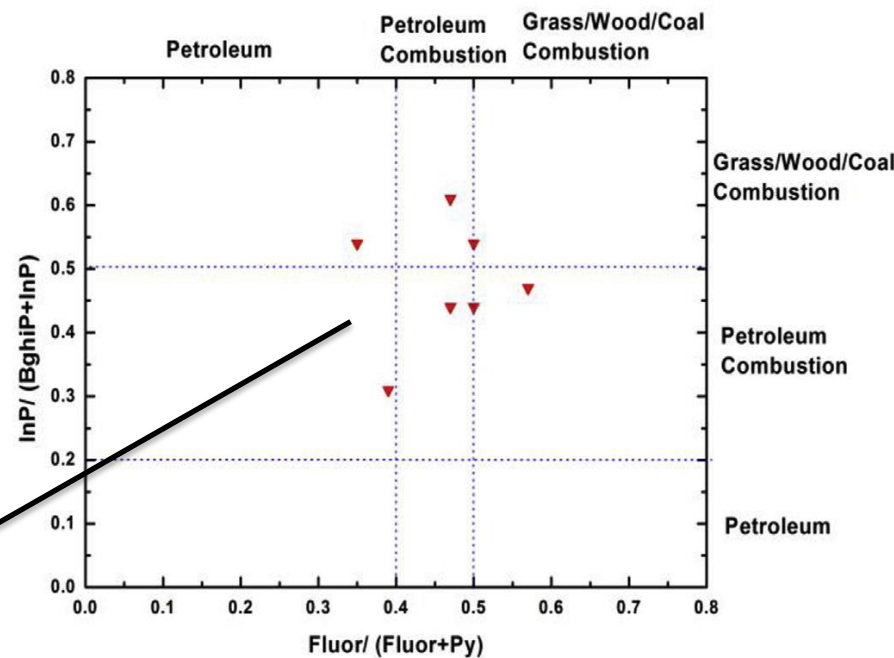
Fluoranthene (Fluor)

Pyrene

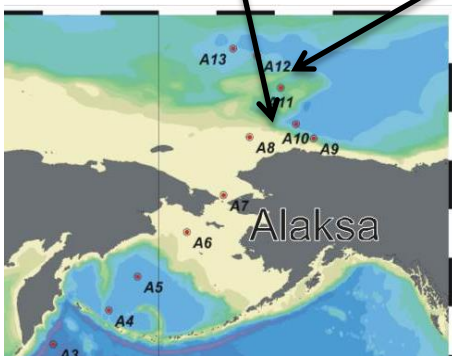
# PAH isomer ratios as indicators of sources



entire cruise



central Arctic Ocean



Exposed coal seams  
on Ellesmere Island  
'allochthonous' coal

# Summary

- PAHs in air and surface marine waters at lower latitudes reflect anthropogenic combustion processes, but the picture is blurred at much higher latitudes (central Arctic Ocean) due to biomass combustion during the cruise period (summer).
- In the coastal seas of the Chukchi/Beaufort Sea region petrogenic sources dominate the PAH profile in sediments, whereas in the deeper Arctic Ocean the profile differs.
- Better engagement between geochemists ('sediments') and pollution scientists ('air/water')!