Baselines and Potential Effects of Mercury and Hydrocarbons in Beaufort Sediments and Biota

Beaufort Sea Environmental Assessment Results Forum
The First Two Years of Progress

Inuvik, NWT, February 19 to 21, 2013

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BREA and funding support for contaminant studies

BREA – Mercury $110k (2012)
Fishes, habitats and ecosystem linkages to oil and gas development in the Beaufort (Reist)

BREA – Hydrocarbons $164.2k (2012)
Baselines, accumulation, cycling and potential effects of hydrocarbons in Beaufort sediments and biota (Stern)

ESRF – Hydrocarbons $600k (2013, 2014, 2015)
Baselines, accumulation and cycling of hydrocarbons in Beaufort sediments and biota (Stern)

ArcticNet Ship time opportunities proposal $68k (4 ship days, 2012)
Effects of Climate Change on Carbon and Contaminant Cycling in the Arctic Coastal and Marine Ecosystems: Impacts, Prognosis and Adaptations Strategies (Stern)

Related projects

ArcticNet:

- Effects of climate change on carbon and contaminant cycling in the Arctic coastal and marine ecosystems: Impacts, prognosis and adaptations strategies

BP-IOL partnership

- Western high Arctic Integrated Regional Impact Study (IRIS - Stern). Planned assessment completion date is December 2013.

NCP:

- Temporal trends of mercury and halogenated organic compounds in Hendrickson Island seals and beluga

Circumpolar Flaw Lead (CFL) System Study:

- Funding for this project ended in March 2011; however, results will continue to published in the foreseeable future.

Research Objectives: Reist (Stern): Fishes, habitats and ecosystem linkages - Mercury

1) Establish the background levels and composition of mercury in both abiotic and biotic compartments of the Beaufort Sea outer shelf and slope regions (including lease blocks) prior to further oil and gas development.

2) Further our understanding of study of environmental pathways of mercury, including its delivery, transport, and elimination from Arctic marine ecosystems.

3) Understand the potential effects of development and differentiate those from other stressors (e.g. climate change).

Research Objectives: Hydrocarbons in Beaufort sediments and biota

1) Establish the background levels and composition of sentinel hydrocarbon compounds (HC) in both abiotic and biotic compartments of the Beaufort Sea outer shelf and slope regions (including lease blocks) prior to further oil and gas development.

2) Establish baseline measures of hydrocarbon metabolites in fish (i.e., determine nature and levels affecting key fishes).

3) Measure indicators of fish health and link these to hydrocarbon exposure and internal metabolite concentrations.

Research Objectives: Hydrocarbons in Beaufort sediments and biota

1) Generate maps and tables showing spatial distributions and concentrations hydrocarbon compounds
   - In select zooplankton, benthic invertebrates, fishes, and surface and suspended sediments

2) Conduct chemical and physical oceanographic measurements in tandem with collection of zooplankton and fishes
   - Determine how, e.g., increasing water temperatures and primary productivity may affect HC exposure.

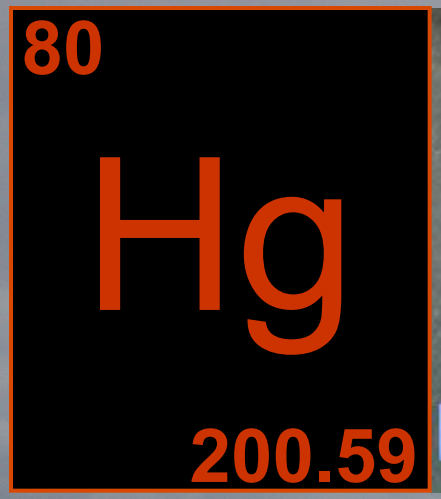
3) Use hydrocarbon biomarkers to establish their sources (natural seeps, terrestrial runoff, oil/gas combustion-related)
   - Responsibility in event of spills (shipping, drilling)

Analytical progress to date

	Total Hg	Methyl Hg	Stable Isotopes	Hydro-carbons	Trace metals	Other[1]
Surface sediment	Completed	-	Sent	Completed	Completed	Completed
Sediment cores	2013	2013	2013	2013	2013	2013
Zooplankton	Completed	Completed	Sent	Starting	-	-
Epifauna[2]	In progress	In progress	Sent	Starting	-	-
Infauna	2013	2013	2013	2013	-	-
Fishes	2013	2013	2013	2013	-	-

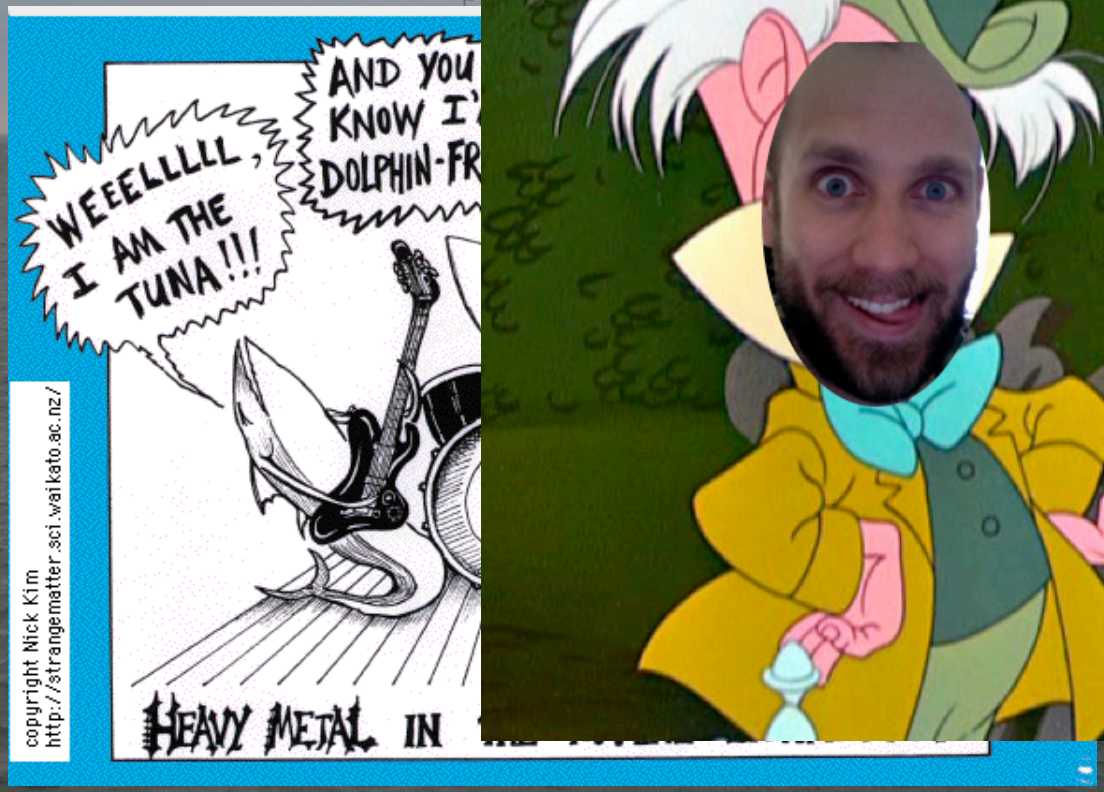
[1] Rock-Eval Analysis, grain size
[2] Where sufficient sample material permits analysis

Mercury (Hg)

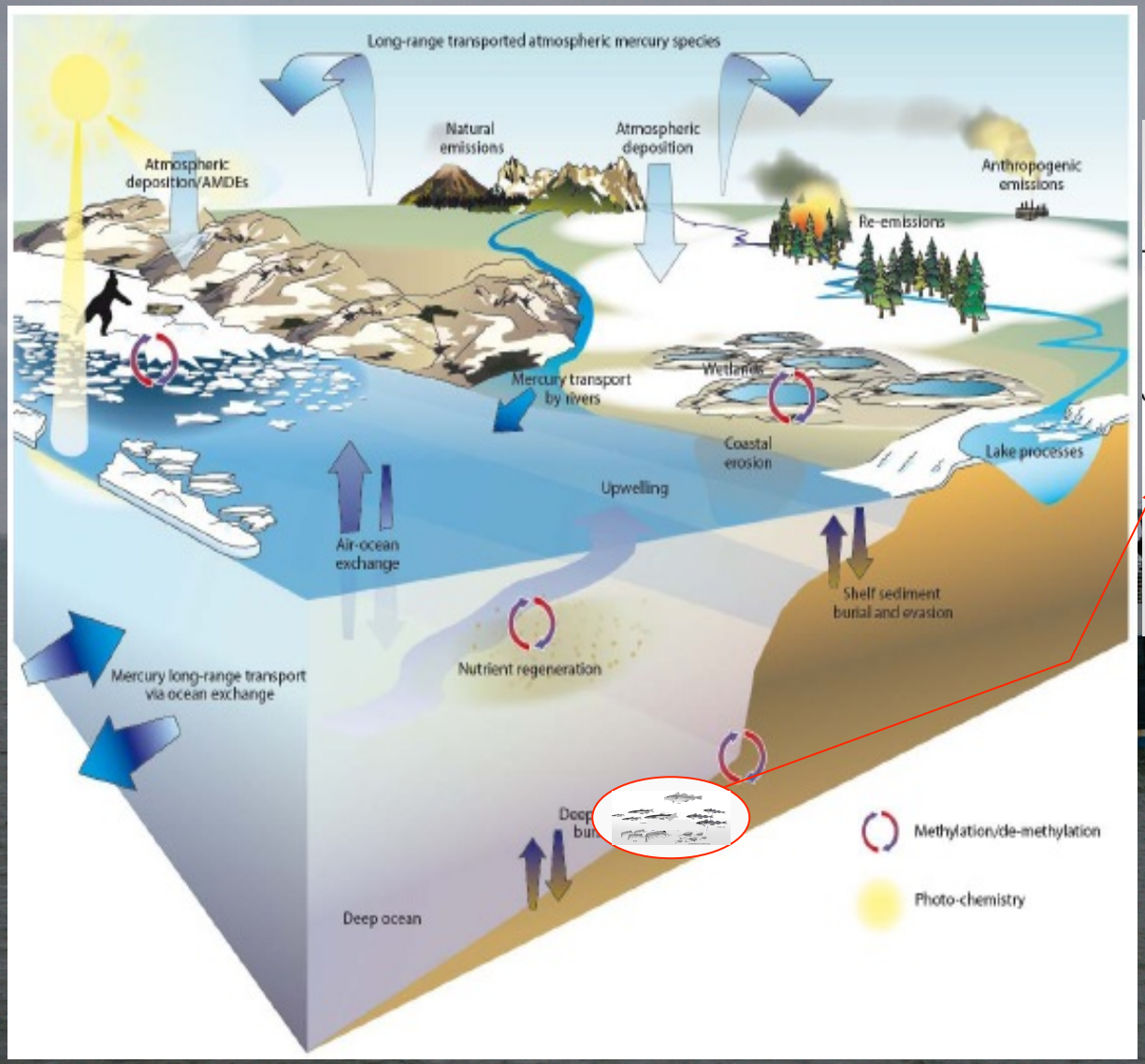

80
Hg
200.59

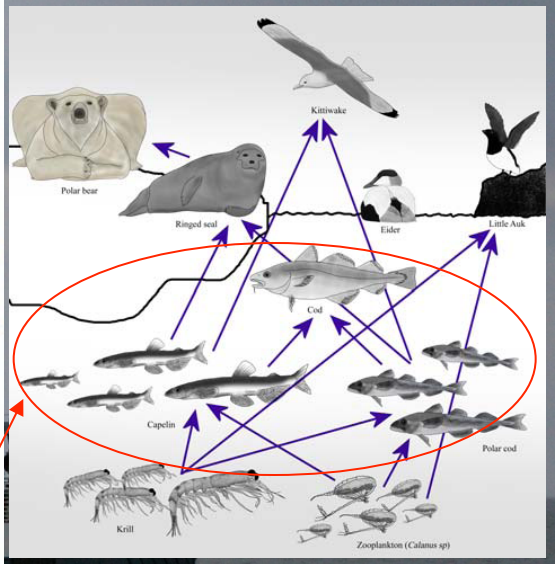

Hg


10/6

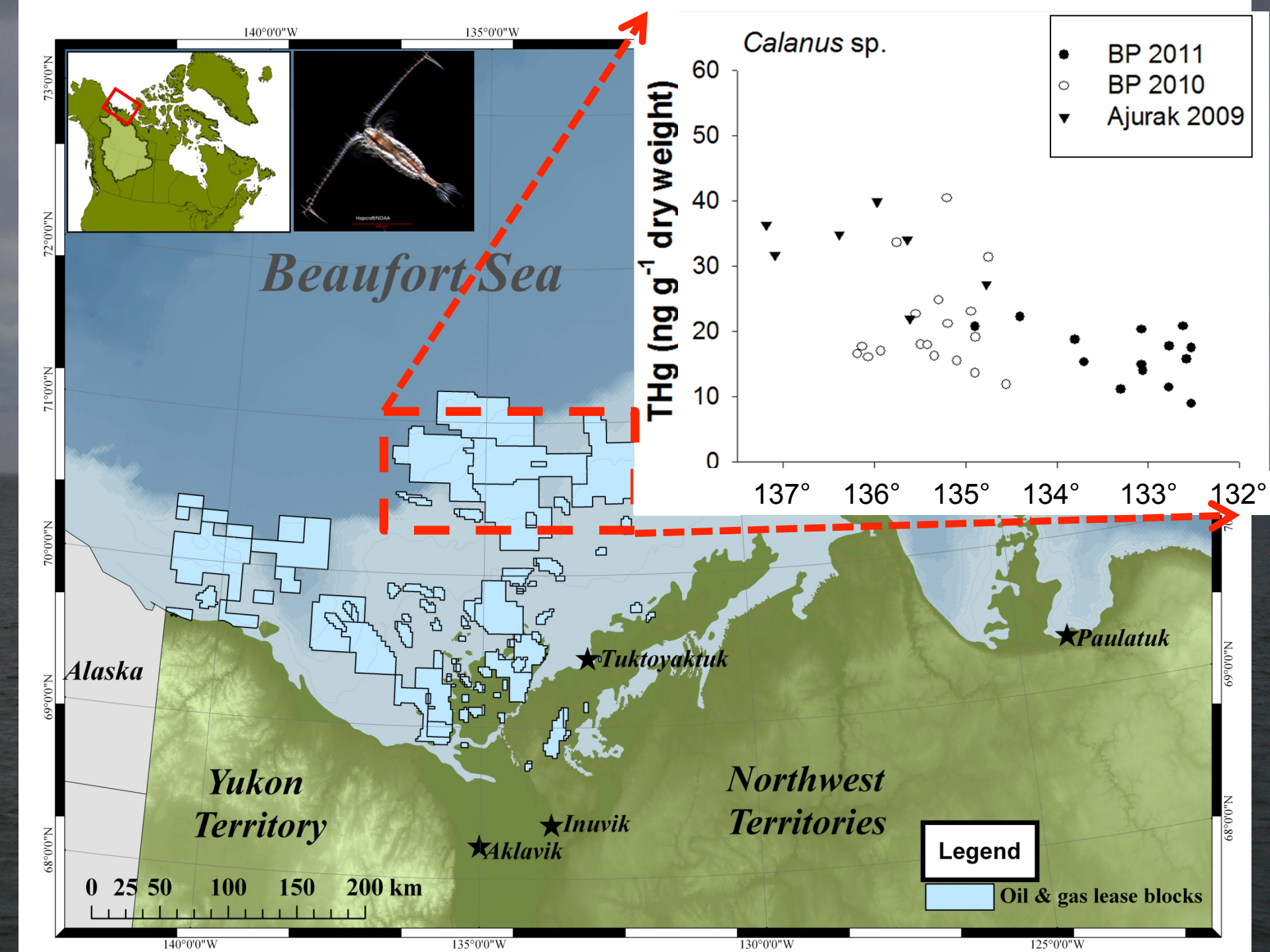

WEEELLLLL, I AM THE TUNA!!!
AND YOU KNOW I'
DOLPHIN-FR
HEAVY METAL IN
copyright Nick Kim
http://strangematter.sci.waikato.ac.nz/

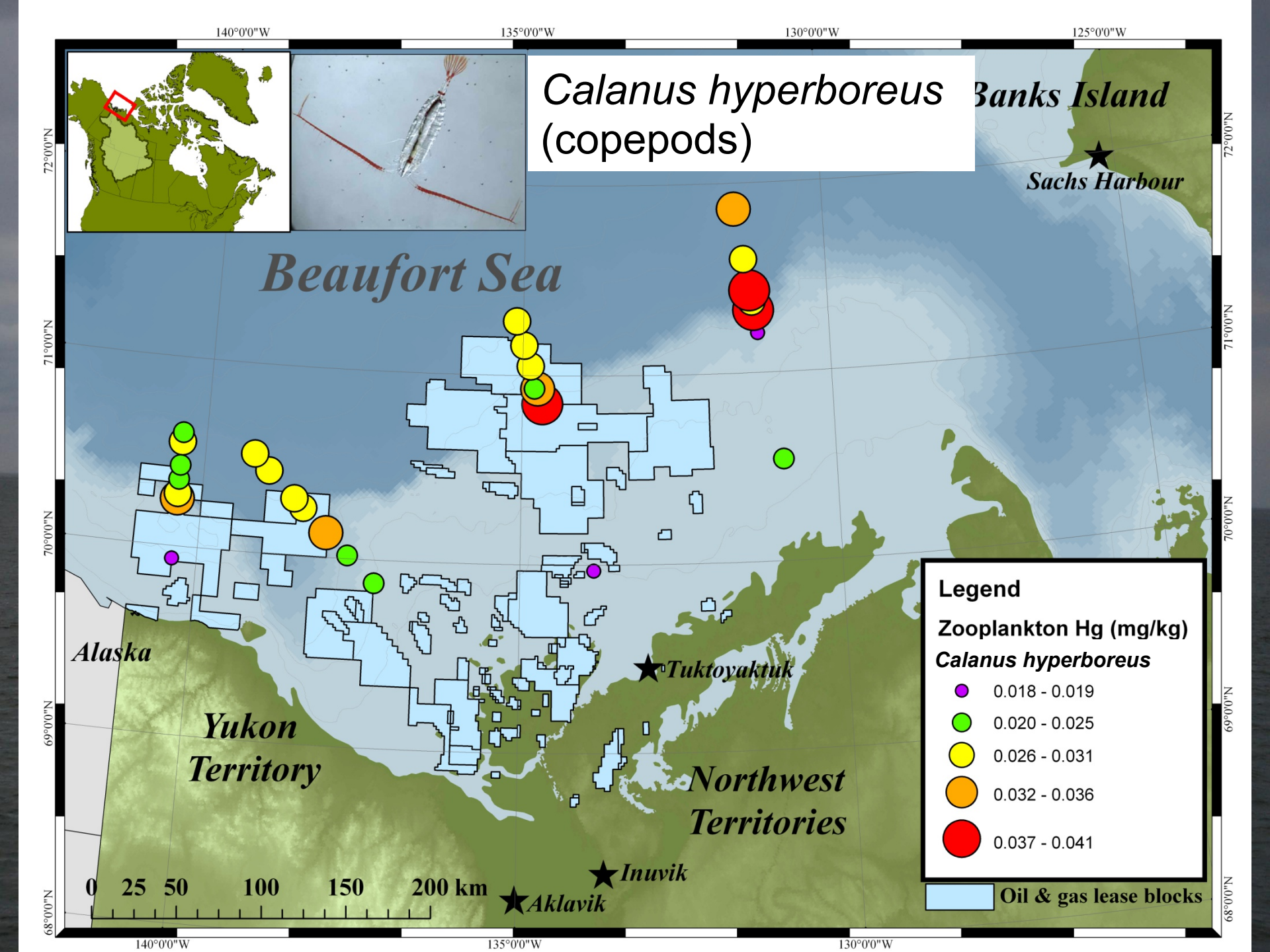
Mercury exists in a range of chemical forms as it cycles through the Arctic Environment

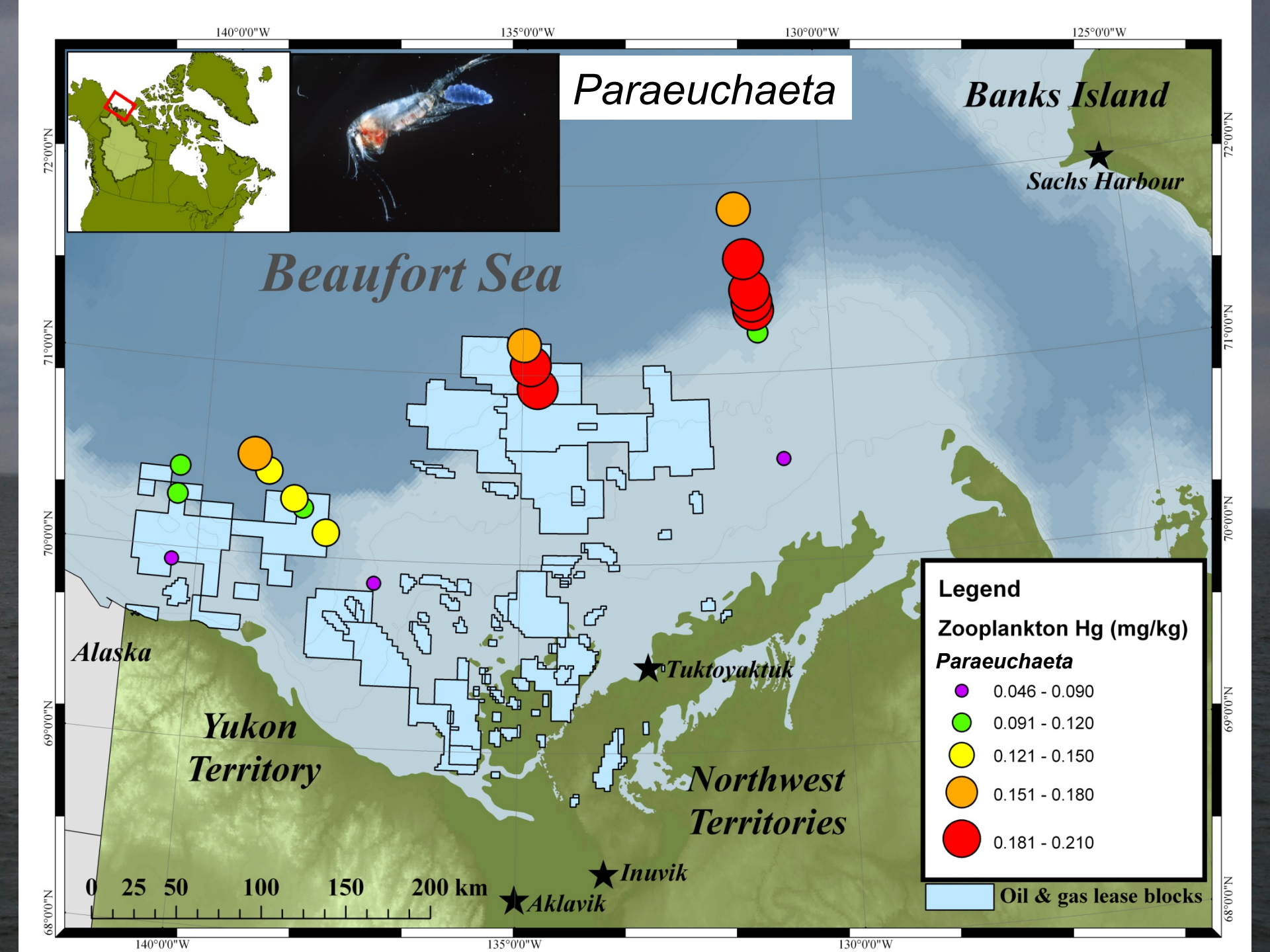




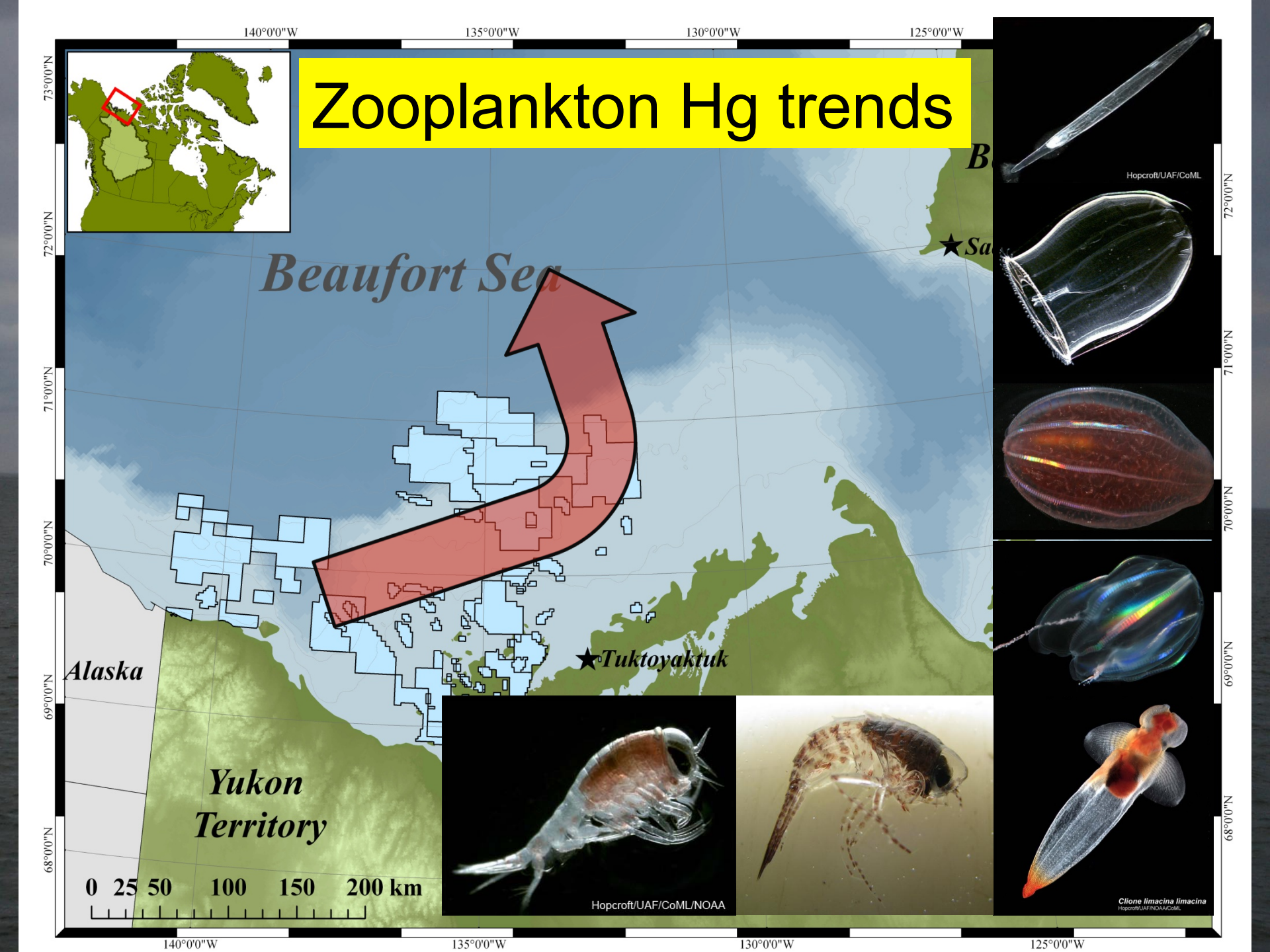
To date, virtually no information is available on biomagnification and bioaccumulation of mercury in deep water and shelf adult fishes

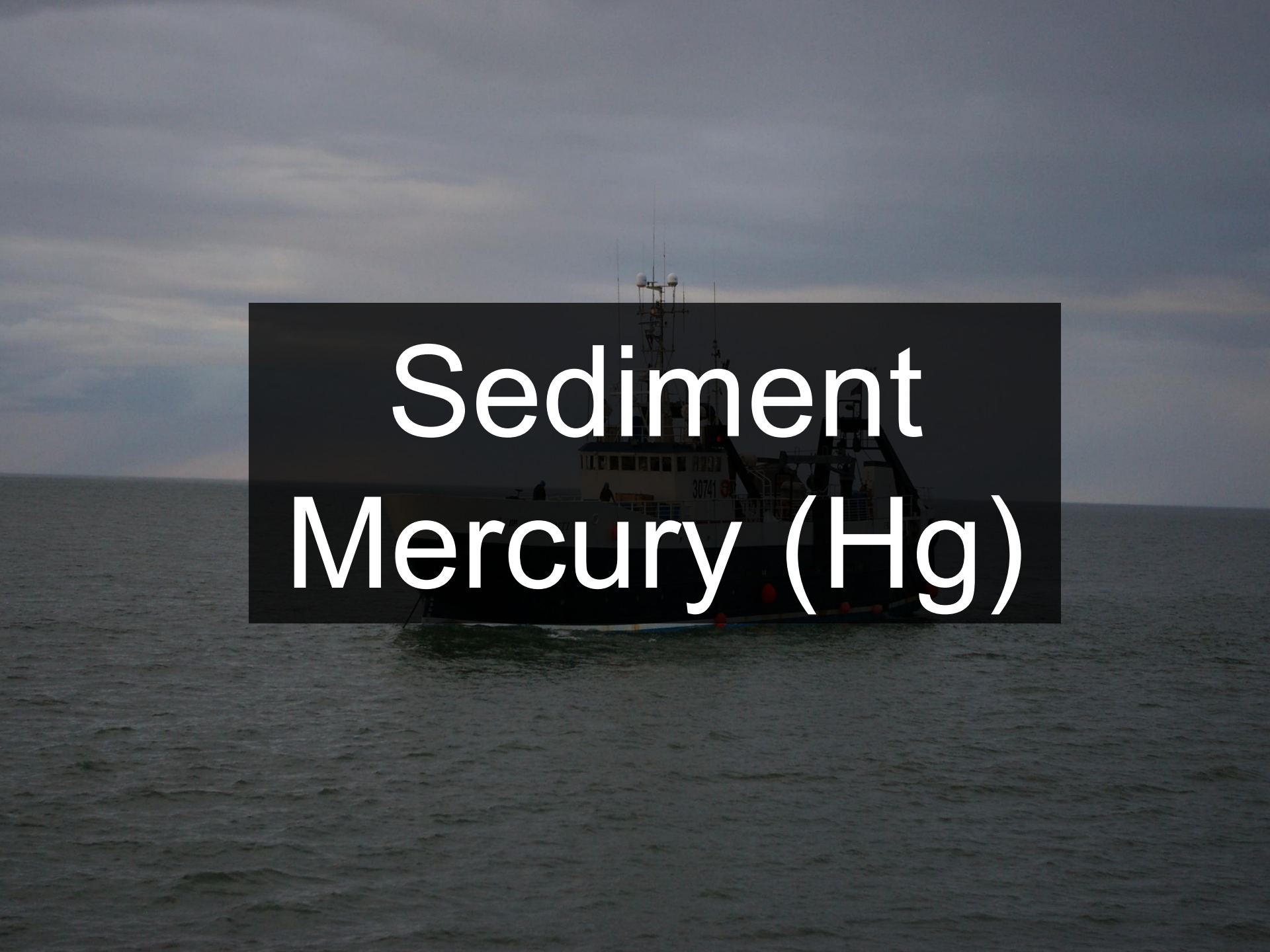

Calanus sp.
BP 2011
BP 2010
Ajurak 2009
THg (ng g-1 dry weight)
60
50
40
30
20
10
0
137°
136°
135°
134°
133°
132°
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
73°0'0"N
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N
Beaufort Sea
Alaska
Yukon Territory
Northwest Territories
Tuktoyaktuk
Paulatuk
Inuvik
Aklavik
0 25 50 100 150 200 km
Legend
Oil & gas lease blocks


Calanus hyperboreus
(copepods)
Banks Island
Sachs Harbour
Beaufort Sea
Alaska
Yukon
Territory
Tuktoyaktuk
Northwest
Territories
Inuvik
Aklavik
0 25 50 100 150 200 km
Legend
Zooplankton Hg (mg/kg)
Calanus hyperboreus
0.018 - 0.019
0.020 - 0.025
0.026 - 0.031
0.032 - 0.036
0.037 - 0.041
Oil & gas lease blocks
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N

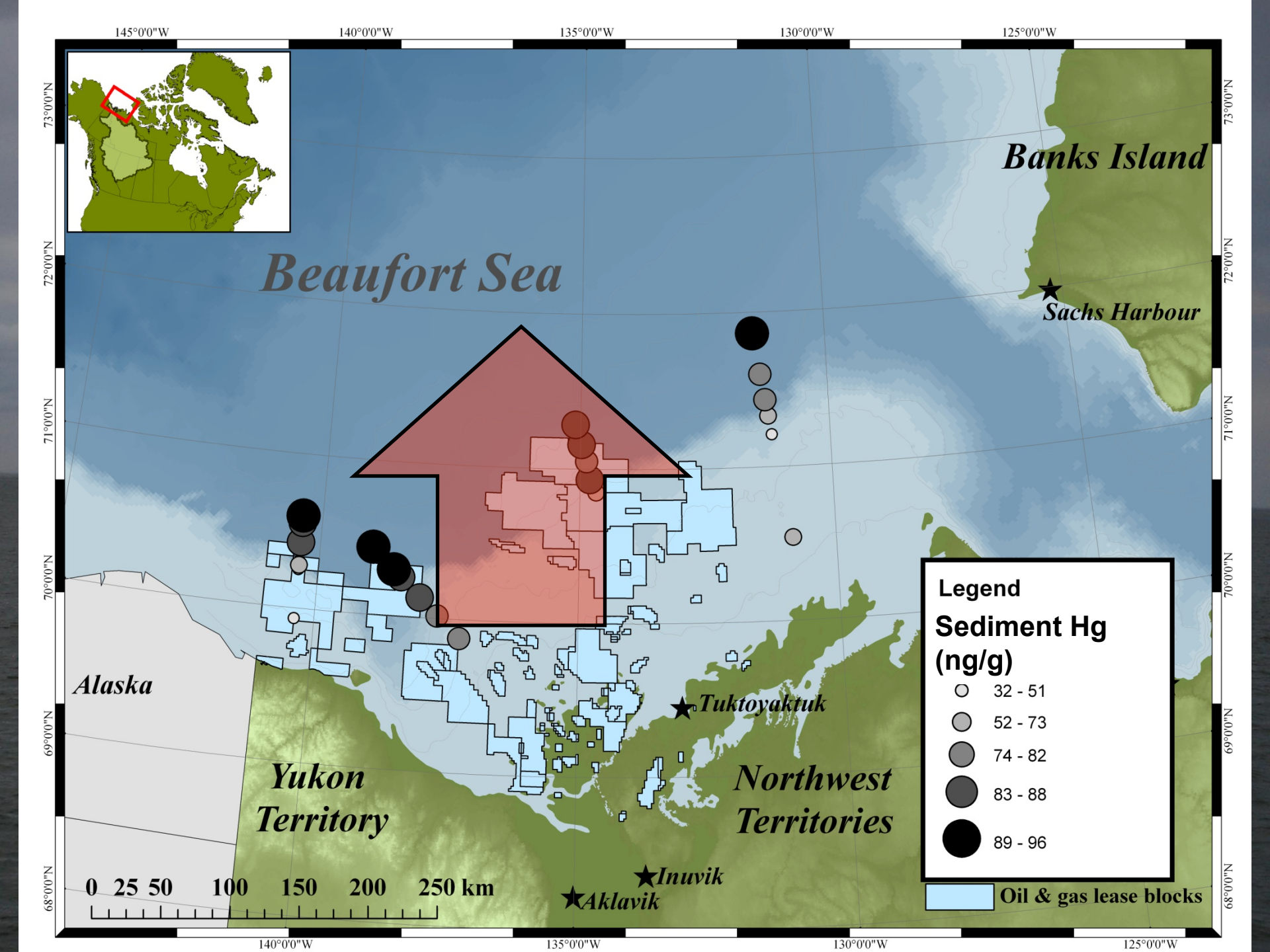

Paraeuchaeta
Banks Island
Sachs Harbour
Beaufort Sea
Alaska
Yukon Territory
Tuktoyaktuk
Northwest Territories
Inuvik
Aklavik
0 25 50 100 150 200 km
Legend
Zooplankton Hg (mg/kg)
Paraeuchaeta
0.046 - 0.090
0.091 - 0.120
0.121 - 0.150
0.151 - 0.180
0.181 - 0.210
Oil & gas lease blocks
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N

Zooplankton Hg trends

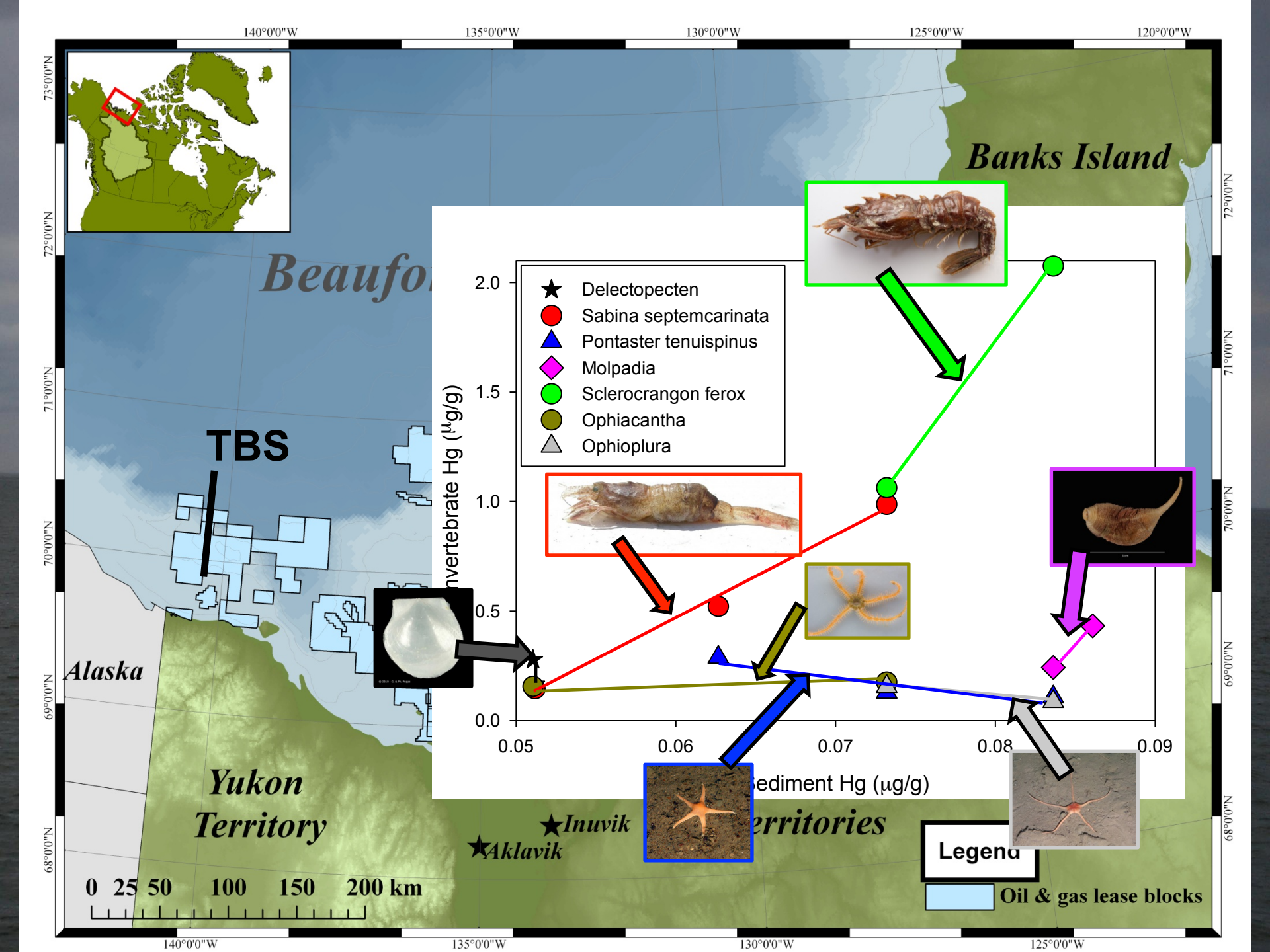




Sediment Mercury (Hg)


145°0'0"W
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
73°0'0"N
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N
Banks Island
Beaufort Sea
Sachs Harbour
Alaska
Tuktoyaktuk
Yukon Territory
Northwest Territories
Inuvik
Aklavik
0 25 50 100 150 200 250 km
Legend
Sediment Hg (ng/g)
32 - 51
52 - 73
74 - 82
83 - 88
89 - 96
Oil & gas lease blocks


Benthic
invertebrates


140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
120°0'0"W
73°0'0"N
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N
Banks Island
Beaufo
TBS
Alaska
Yukon Territory
Inuvik
Aklavik
erritories
0 25 50 100 150 200 km
Delectopecten
Sabina septemcarinata
Pontaster tenuispinus
Molpadia
Sclerocrangon ferox
Ophiacantha
Ophioplura
nvertebrate Hg (µg/g)
2.0
1.5
1.0
0.5
0.0
0.05
0.06
0.07
0.08
0.09
ediment Hg (µg/g)
Legend
Oil & gas lease blocks


Hydrocarbons

Hydrocarbons in the environment

Petrogenic (oil-based)

- Compounds come from coal, oil, peat
- Erosion (coal, peat)
- Seeps (oil)
- Spills and leaks (shipping, drilling platforms)

Pyrogenic (fire-based)

- Compounds come from combustion
- Burning of fossil fuels (coal, oil), such as vehicles and generators
- Burning of biomass (crops, forests)

Hydrocarbons have “fingerprints”

- Each source (e.g., oil, coal, combustion) has a distinct fingerprint
- Each site also has a “fingerprint” from all possible sources to that site
- Possible to distinguish between (petro vs. pyro) and among (e.g., petro vs. petro) sources

Petrogenic

Pyrogenic

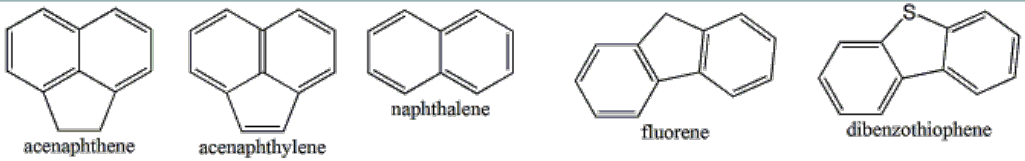
2-ring

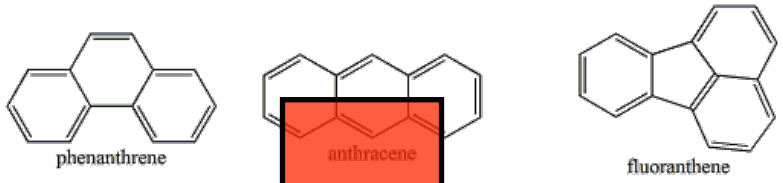
3-ring

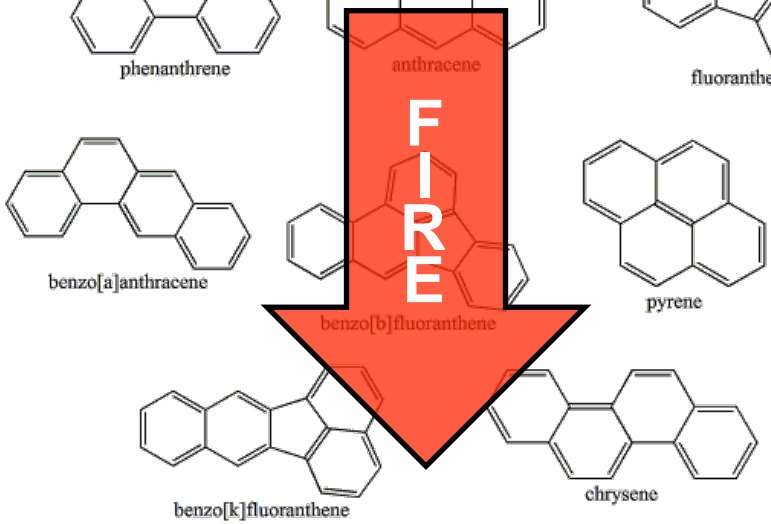
4-ring

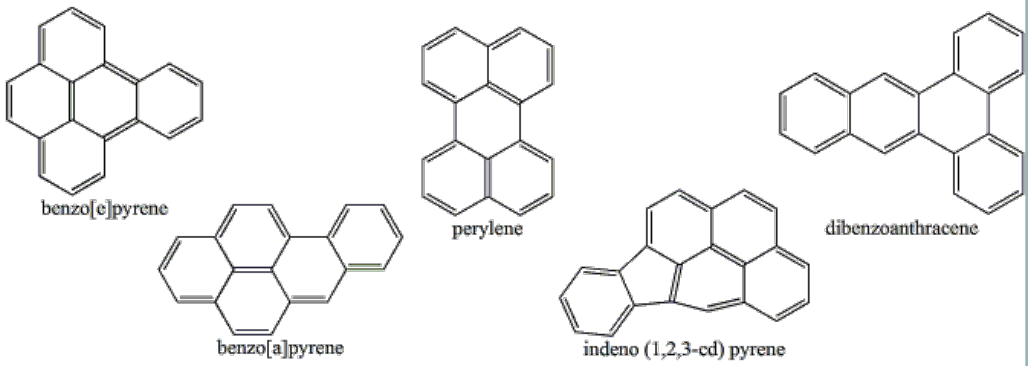
5-ring

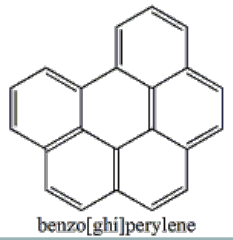
6-ring











Petrogenic

Pyrogenic

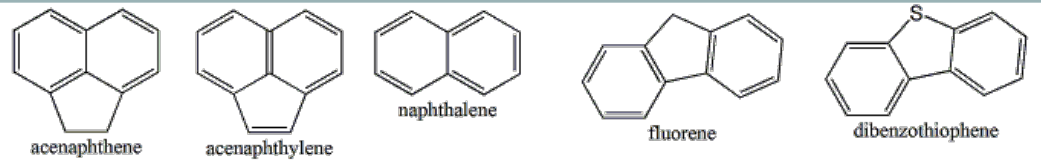
2-ring

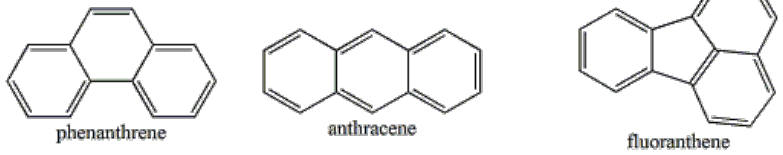
3-ring

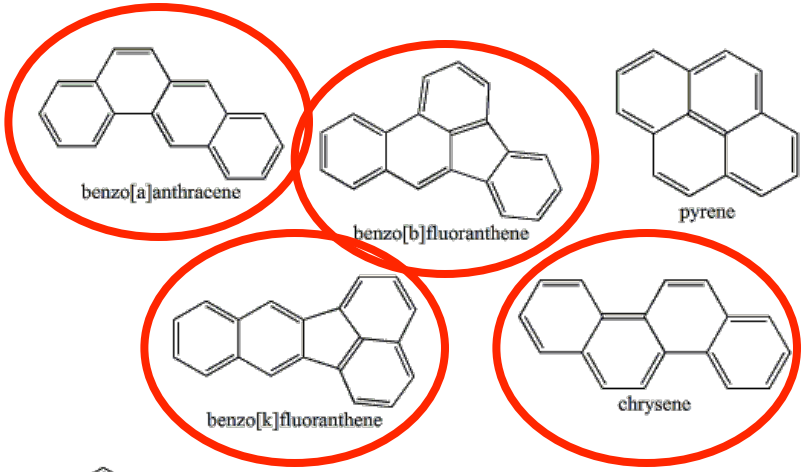
4-ring

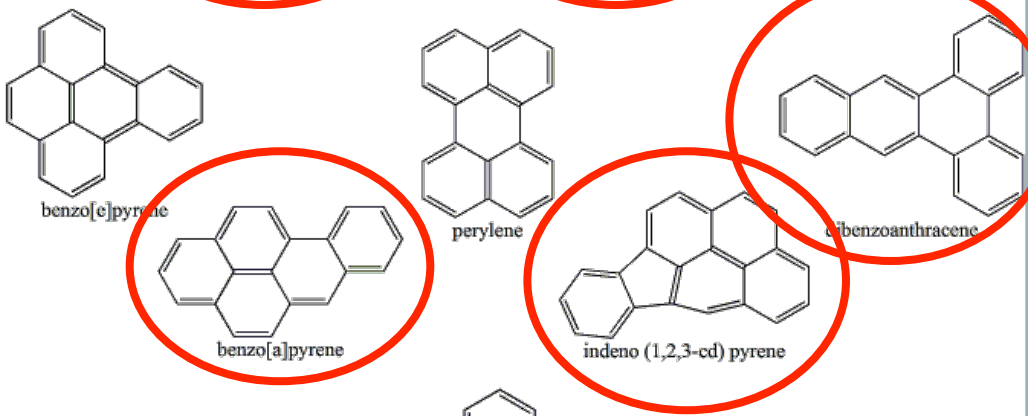
5-ring

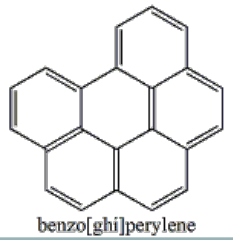
6-ring











Petrogenic

Pyrogenic

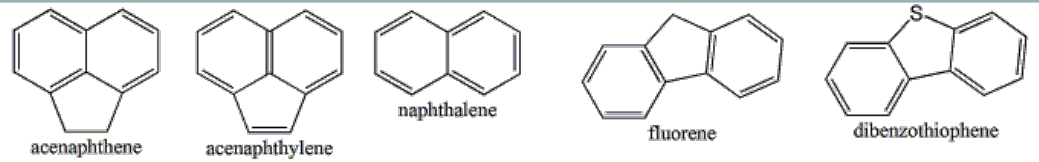
2-ring

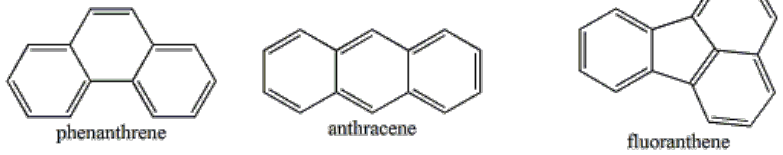
3-ring

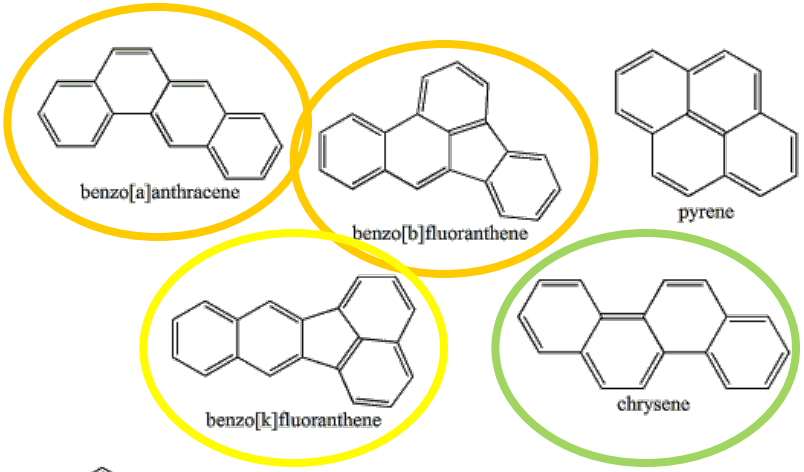
4-ring

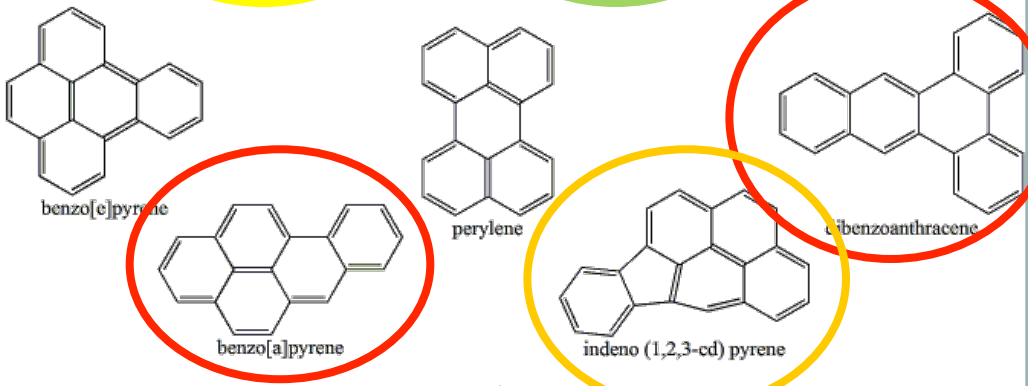
5-ring

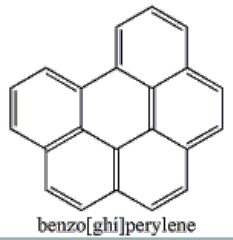
6-ring



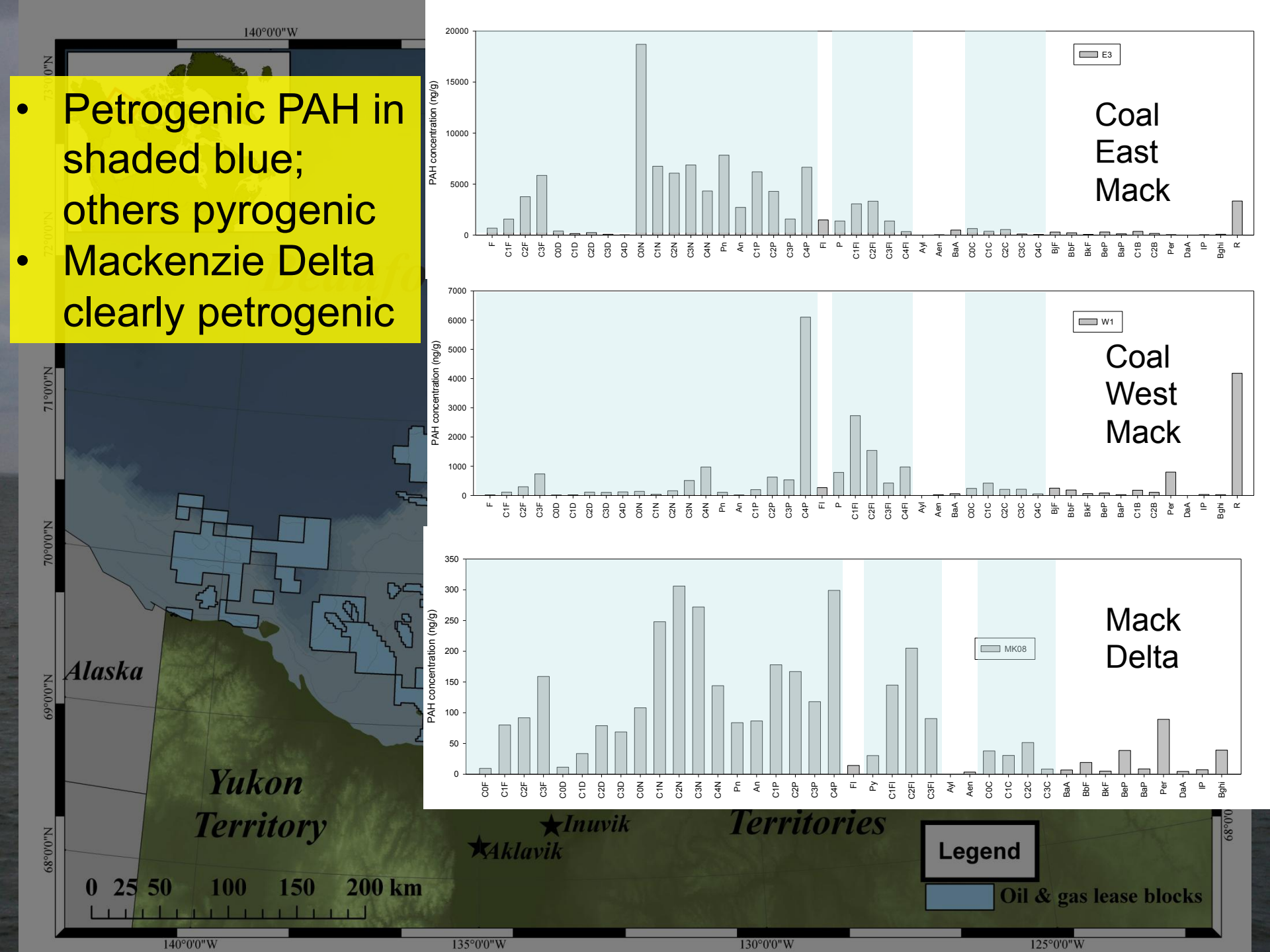


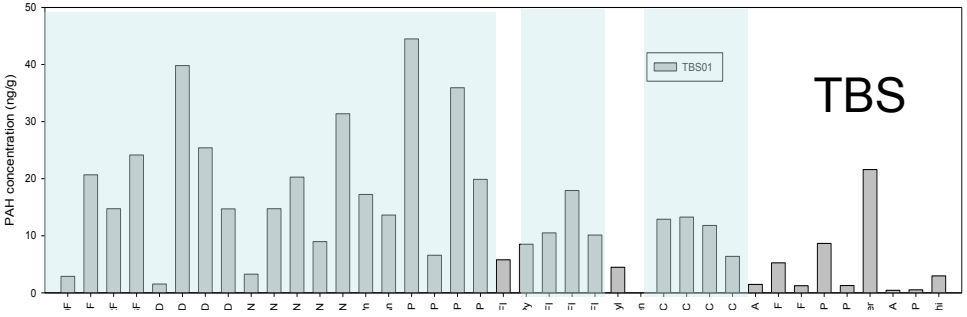


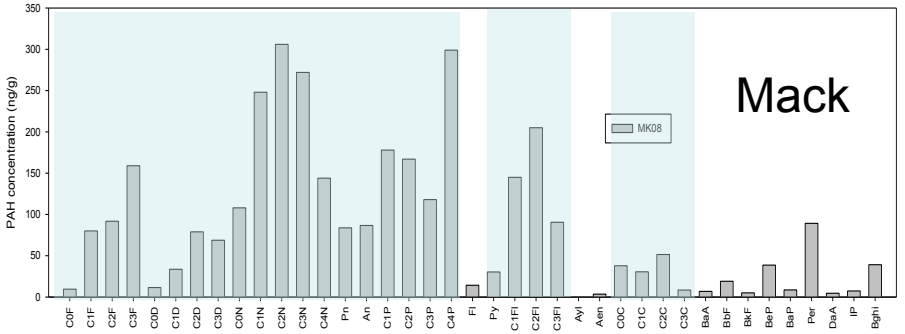


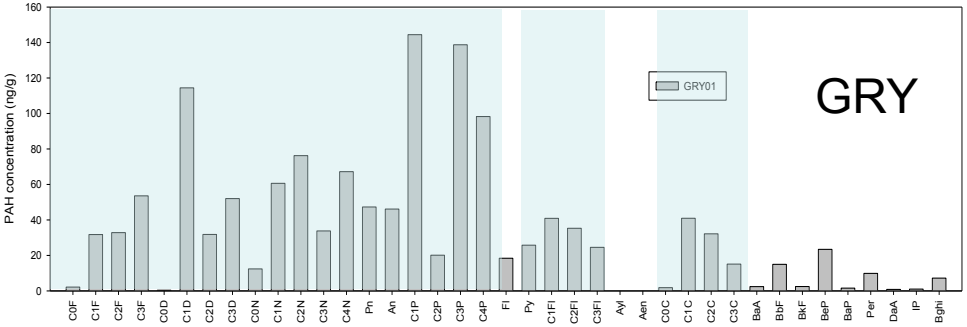


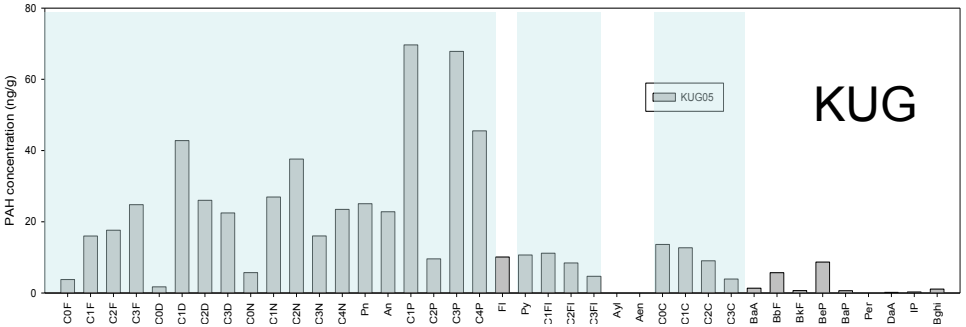
- Petrogenic PAH in shaded blue; others pyrogenic
- Mackenzie Delta clearly petrogenic

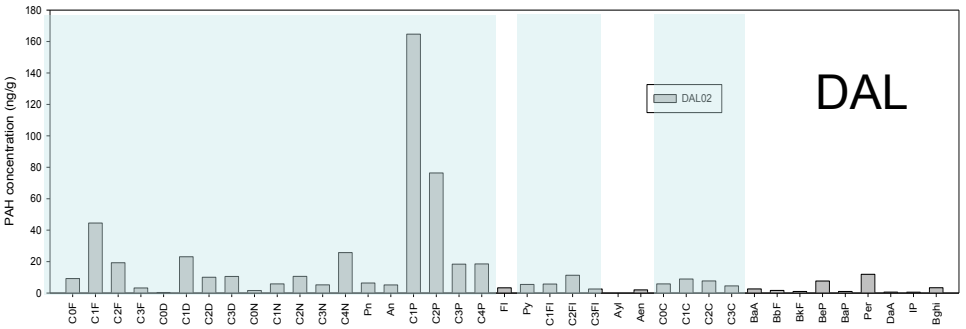




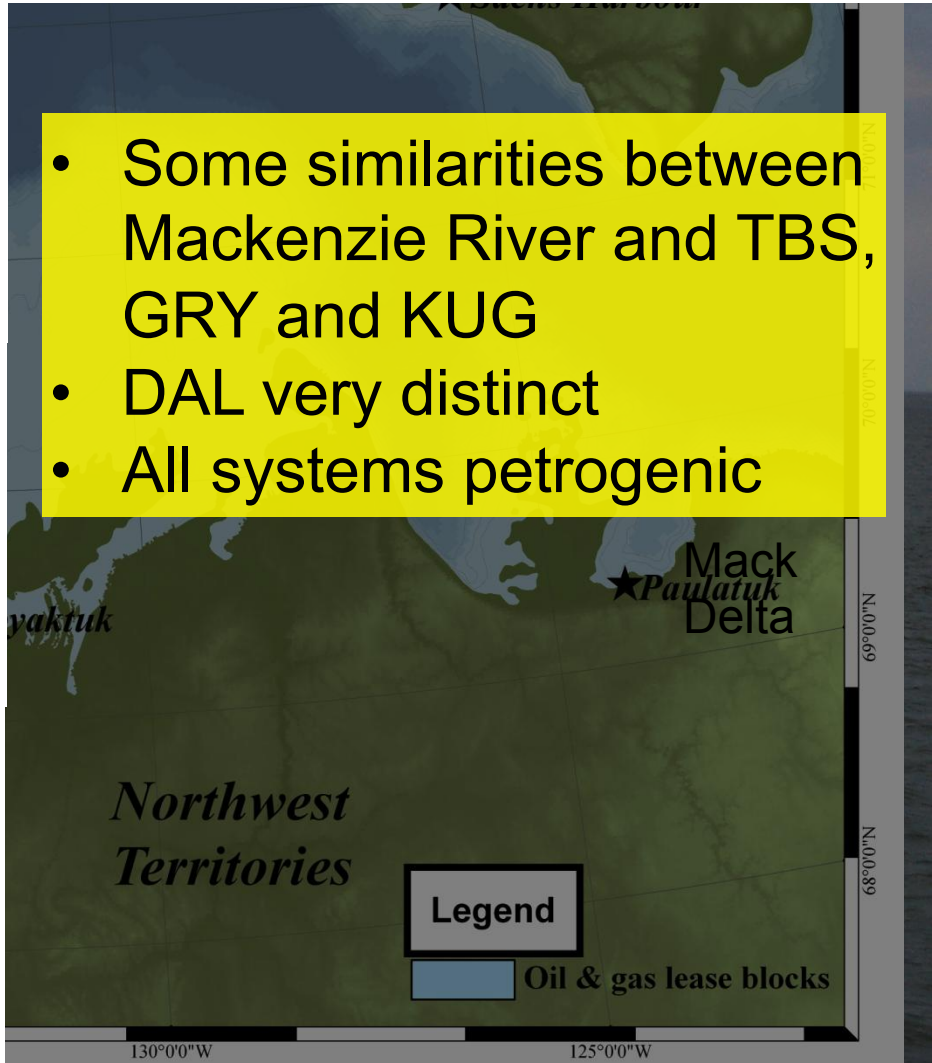


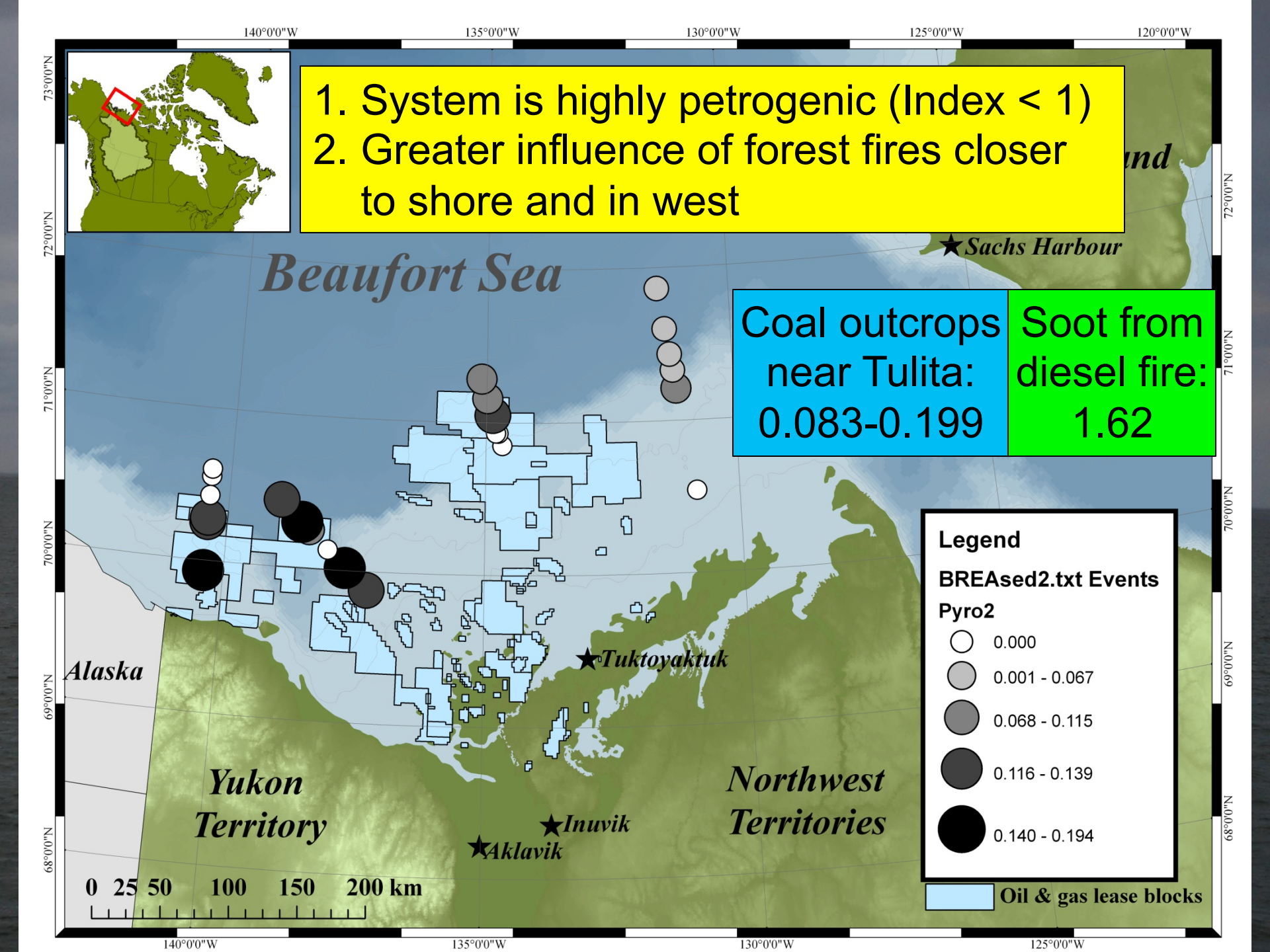






- Some similarities between Mackenzie River and TBS, GRY and KUG
- DAL very distinct
- All systems petrogenic



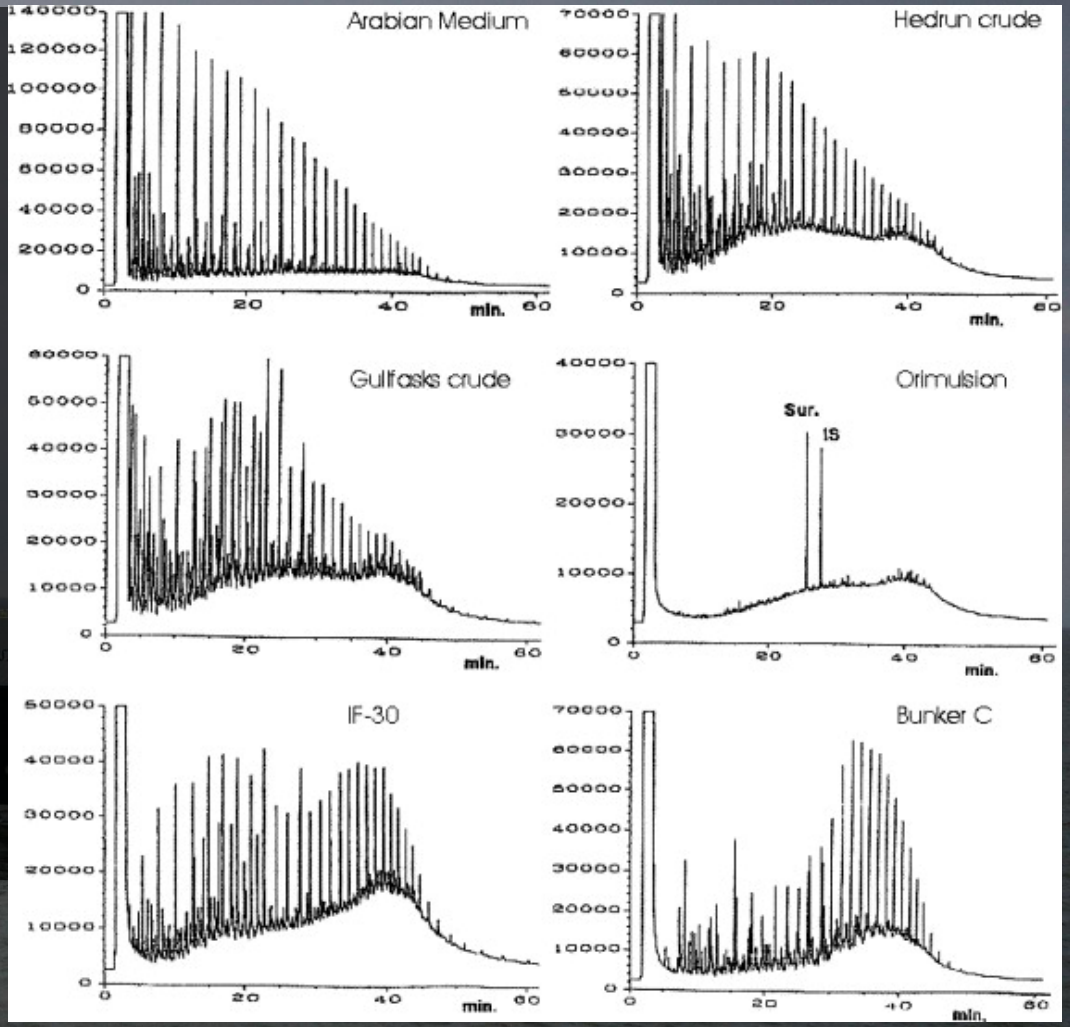

1. System is highly petrogenic (Index < 1)
2. Greater influence of forest fires closer to shore and in west
Coal outcrops near Tulita: 0.083-0.199
Soot from diesel fire: 1.62
Beaufort Sea
Sachs Harbour
Tuktoyaktuk
Inuvik
Aklavik
Alaska
Yukon Territory
Northwest Territories
Legend
BREAsed2.txt Events
Pyro2
0.000
0.001 - 0.067
0.068 - 0.115
0.116 - 0.139
0.140 - 0.194
Oil & gas lease blocks
0 25 50 100 150 200 km
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
120°0'0"W
73°0'0"N
72°0'0"N
71°0'0"N
70°0'0"N
69°0'0"N
68°0'0"N

Biochemical effects and metabolite analysis (Tomy)

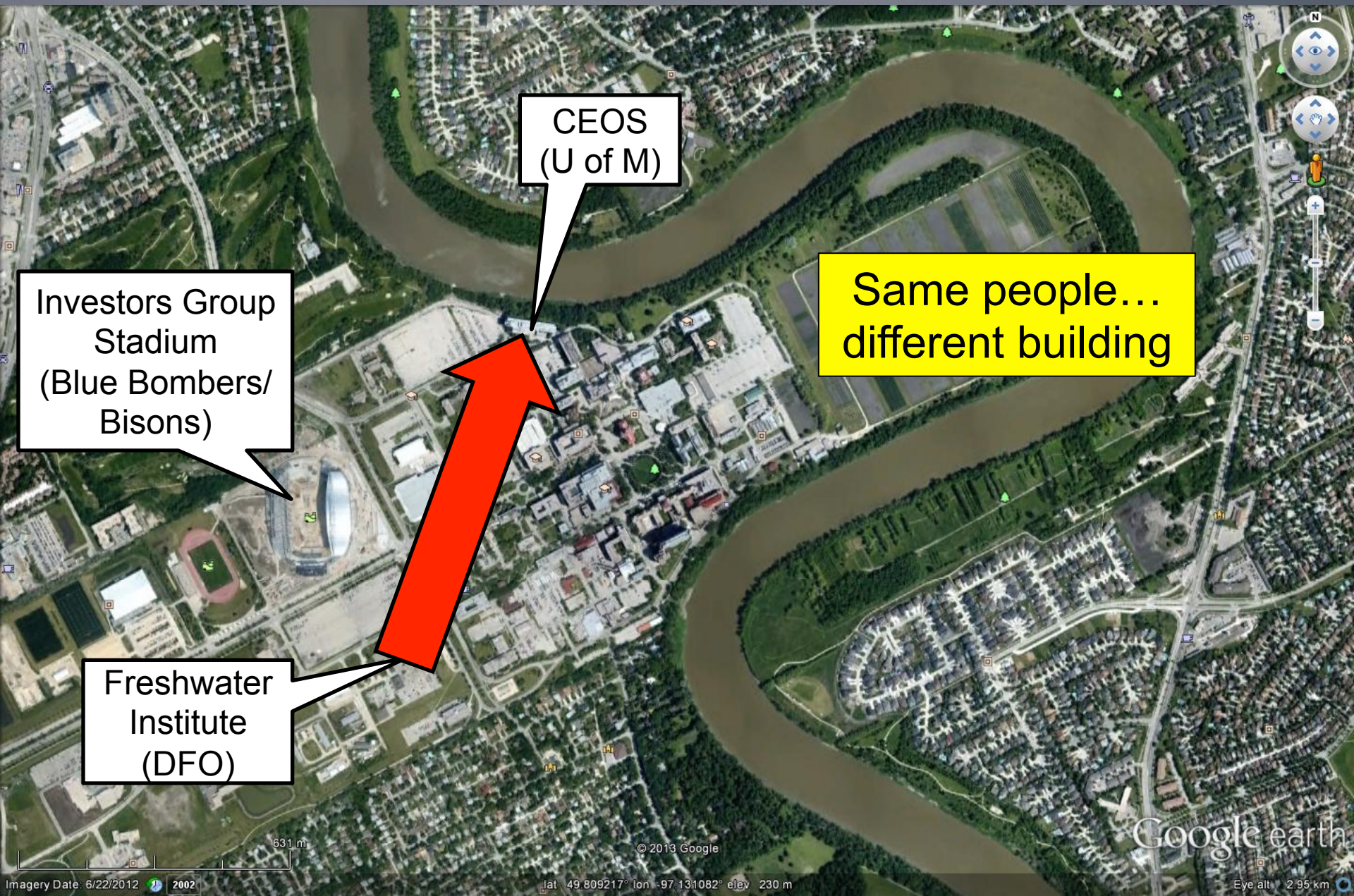
- 60 arctic cod samples were selected for analysis
- Livers from each fish have been removed
- Individual liver samples are being extracted and analysed for:
  - Vitamin A and E
  - Deiodinase activity (conversion of T4 to T3)
- PAH-metabolites are also being analysed in the liver using HPLC-fluorescence
- Results are expected by April 2013

Hydrocarbon fingerprints: Alkanes

- Samples for surface sediments run, analysis underway
- Very helpful to distinguish sources (e.g., terrestrial plants vs. marine algae; different oils/lubes)
- Paired with PAH, can help identify source of compounds (or spill) conclusively



Contaminants Group is Moving!



➢ New 16.8M Nellie Cournoyea Arctic Research Facility

What's next?

- Metadata to Polar Data Catalogue
  - Submitted early Feb., and on-going
- Generate maps, tables of distributions & concentrations
- Combine chemical & physical oceanographic data with zooplankton and fish data to help explain contaminant trends
- Determine sources of HC biomarkers at each site
- Papers in peer-reviewed journals

Acknowledgements

- BREA
- ESRF
- ArcticNet
- U. Manitoba
- DFO
- Captain and crew of M/V Frosti
- Numerous science crew, including Andy Majewski, Wojciech Walkusz, Sheila Atchison, Shannon McPhee

Questions?

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gary.stern@dfo-mpo.gc.ca
or Jesse Carrie @
carrie@cc.umanitoba.ca