ARCTOX: a pan-Arctic sampling network to track the mercury contamination of Arctic and sub-Arctic seabirds and marine food webs

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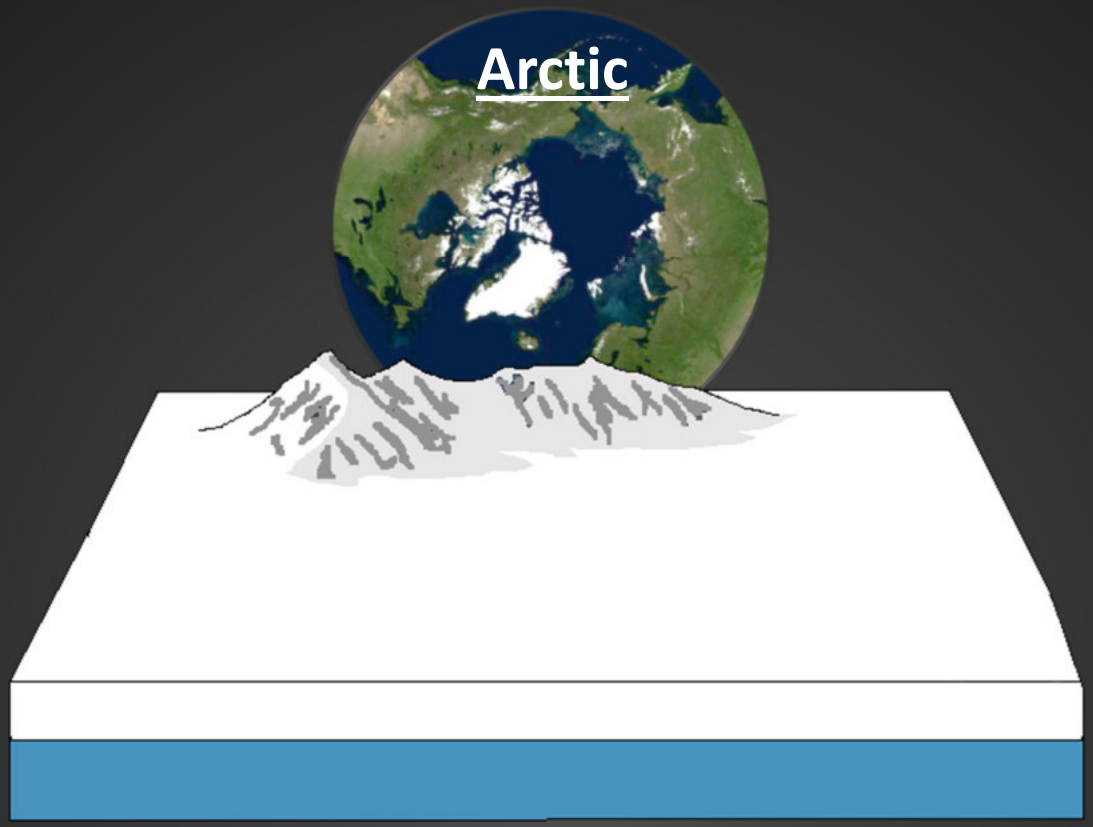
J. Fort, F. Amélineau, T. Anker-Nilssen, P. Bustamante,J.O. Bustnes, A. Cherenkov, J. Danielsen, S. Descamps, R. Dietz, K. Elliott, K.E. Erikstad, A. Ezhov, P. Fauchald, M. Gavrilo, G. Gilchrist, O. Gilg, D. Grémillet, E. Golubova, E.S Hansen, S.A. Hanssen, S. Hatch, M. Helberg, H.H. Helgason, N.P. Huffeldt, J.E. Jónsson, A. Kitaysky, Y. Krasnov, M. Langseth, S. Leclaire, T. Lindberg, S.H. Lorentsen, E. Lorentzen, M. Mallory, F. Merkel, B. Moe, W.A. Montevecchi, A. Mosbech, B. Olsen, R. Orben, I. Pratte, J. Provencher, S.B. Ragnarsdóttir, G.J. Robertson, K. Sagerup, V. Semashko, H. Strøm, G.H. Systad, A. Takahashi, G. Tertitski, P. Thompson, G.T. Hallgrímsso, E. Tolmacheva, A. Will, K. Wojczulanis-Jakubas

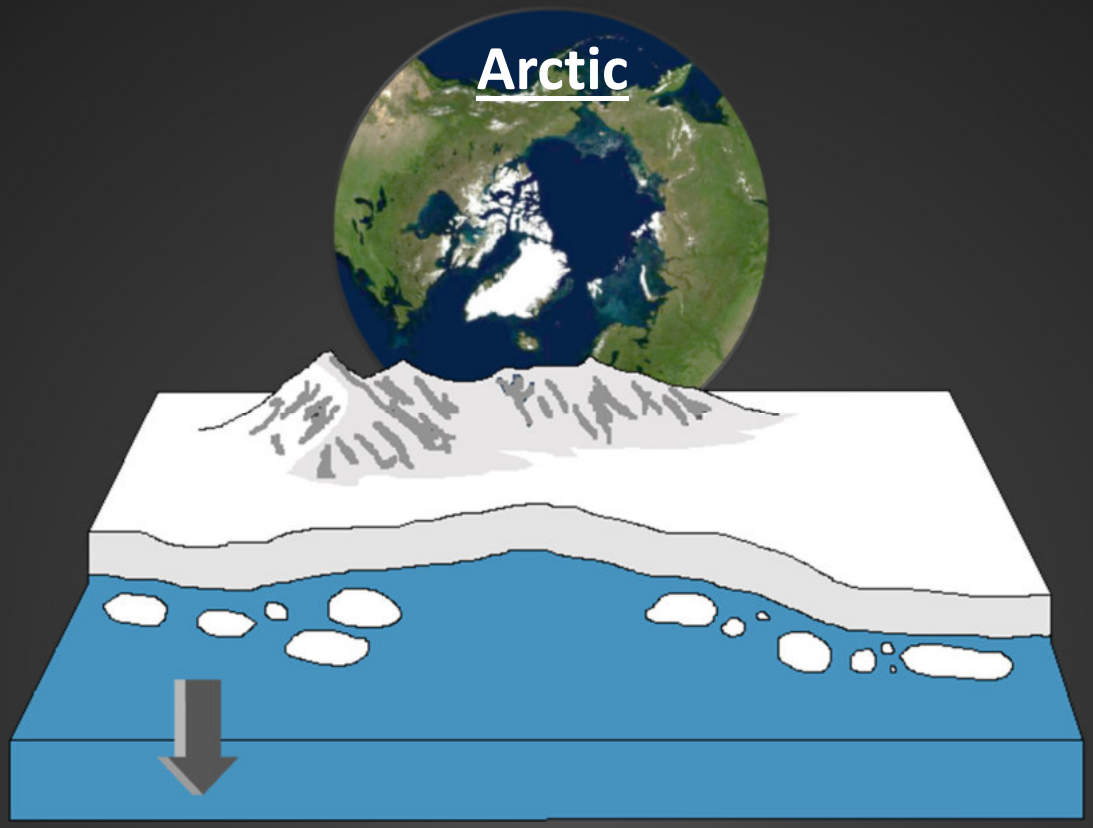
Arctic



accelerating environmental modifications

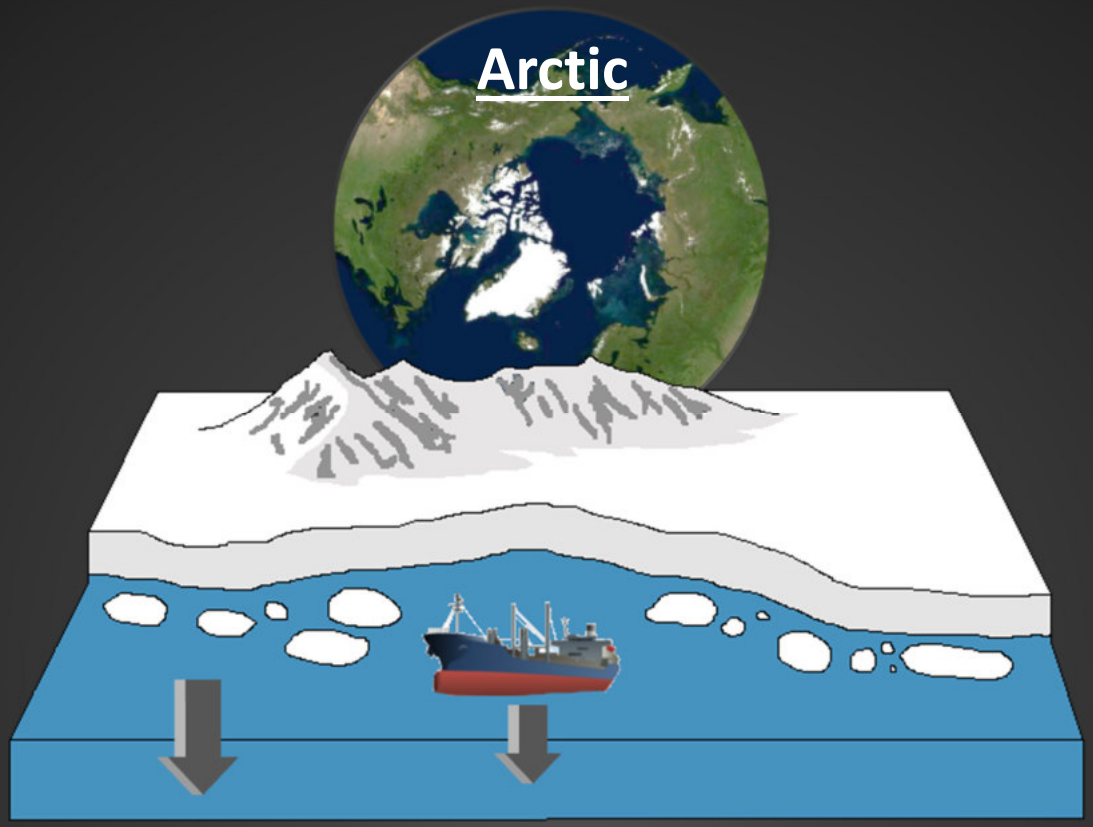
⬇

increasing environmental pollution



accelerating environmental modifications

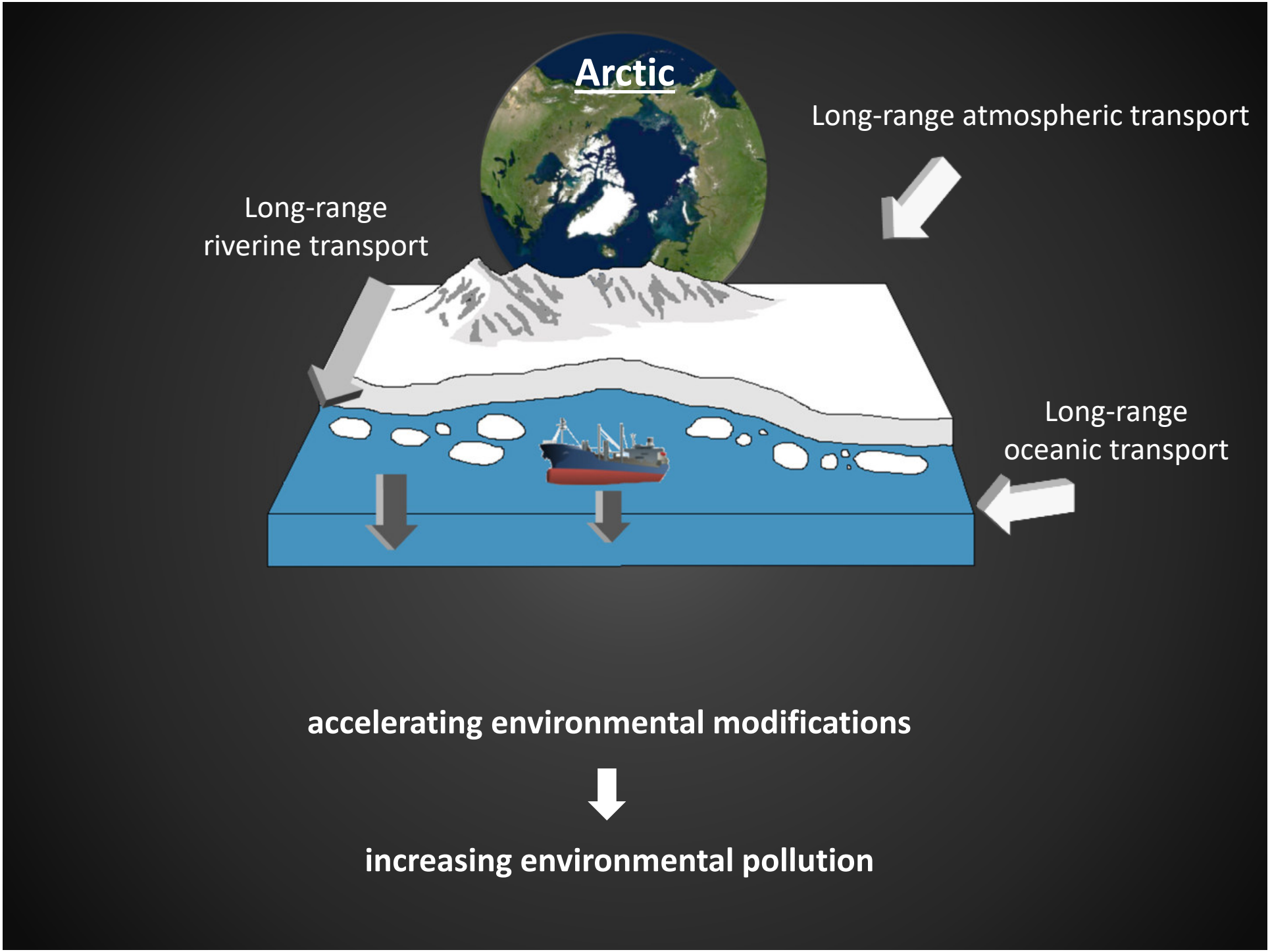
increasing environmental pollution

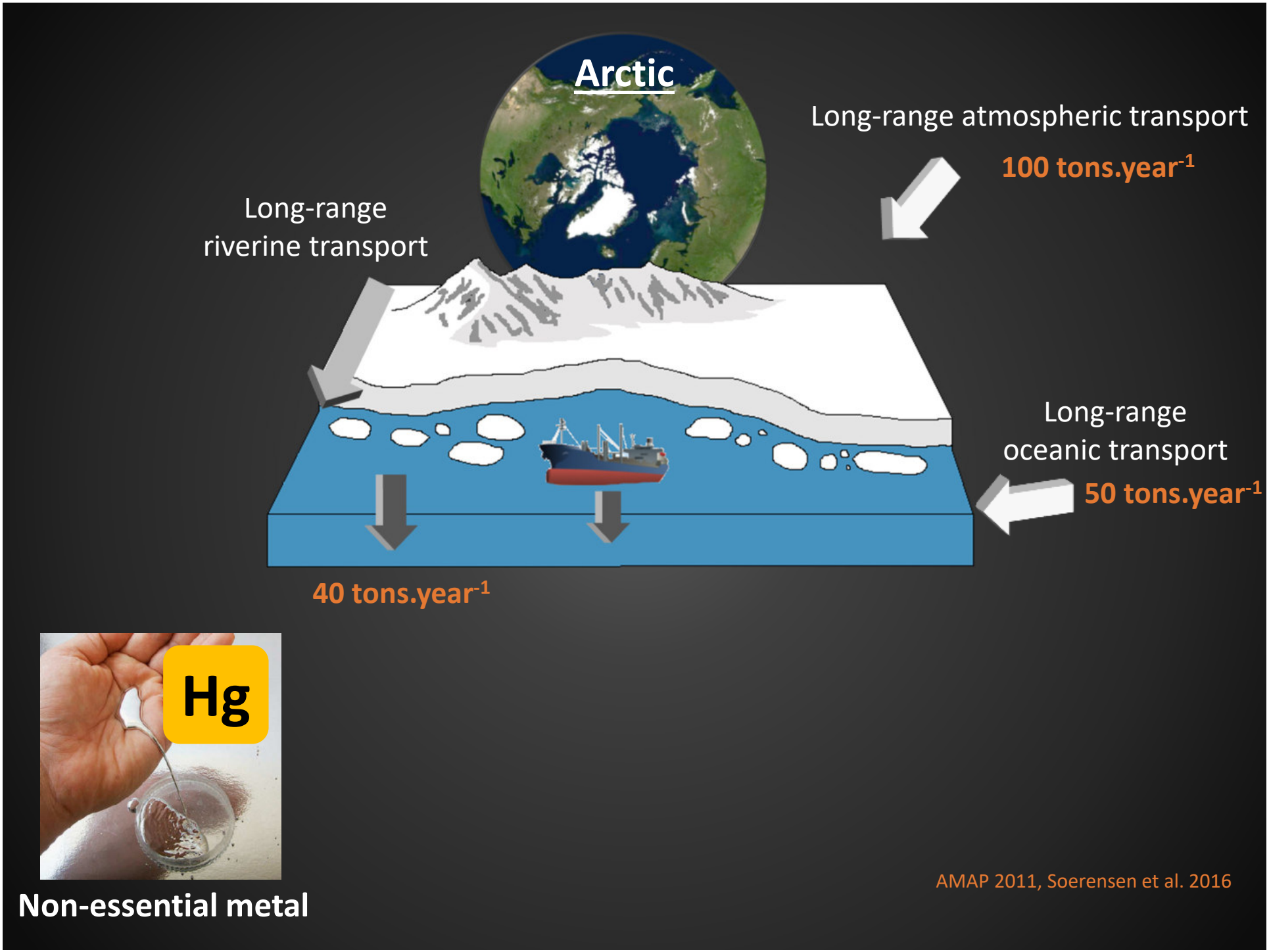


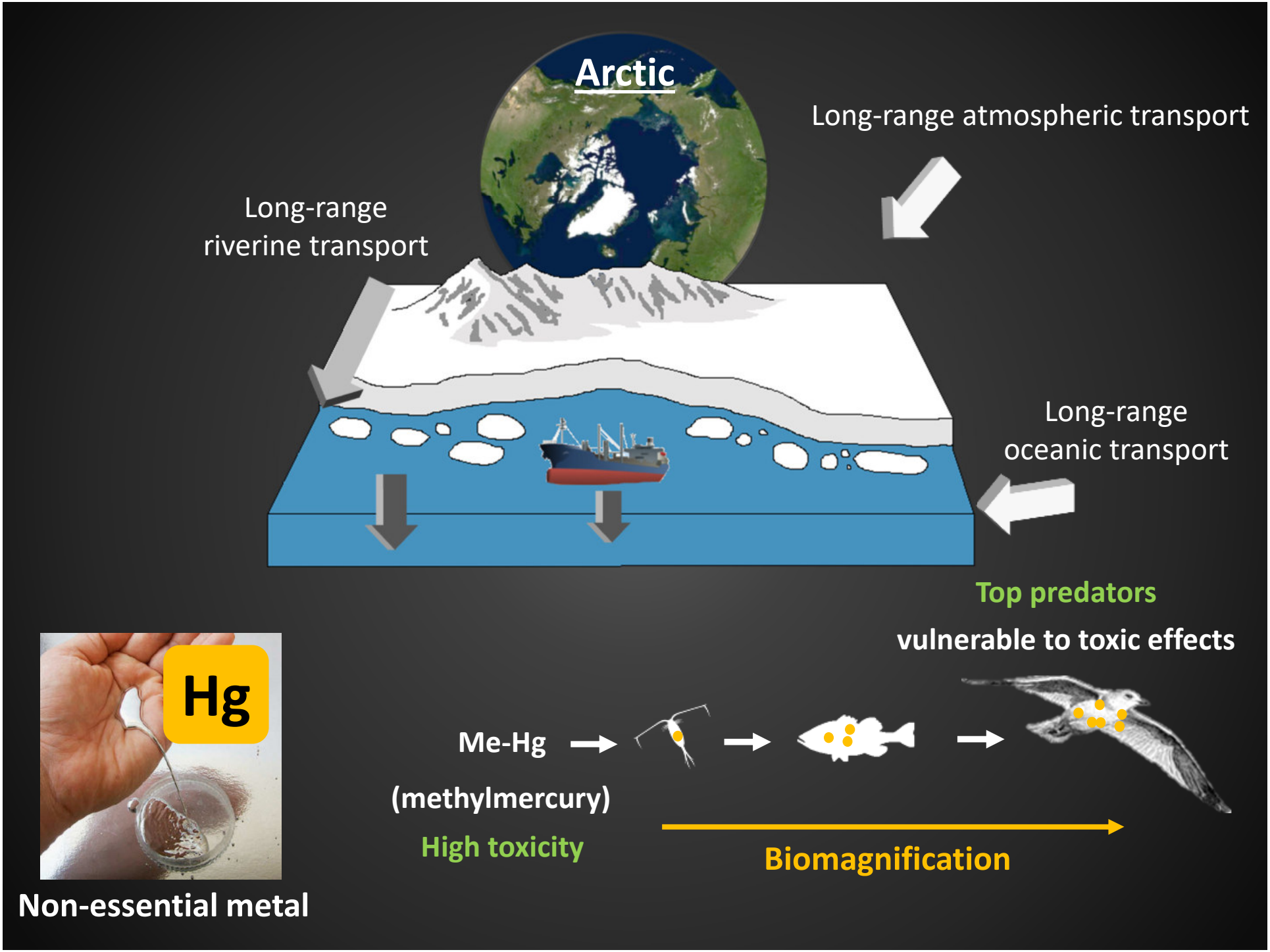
accelerating environmental modifications

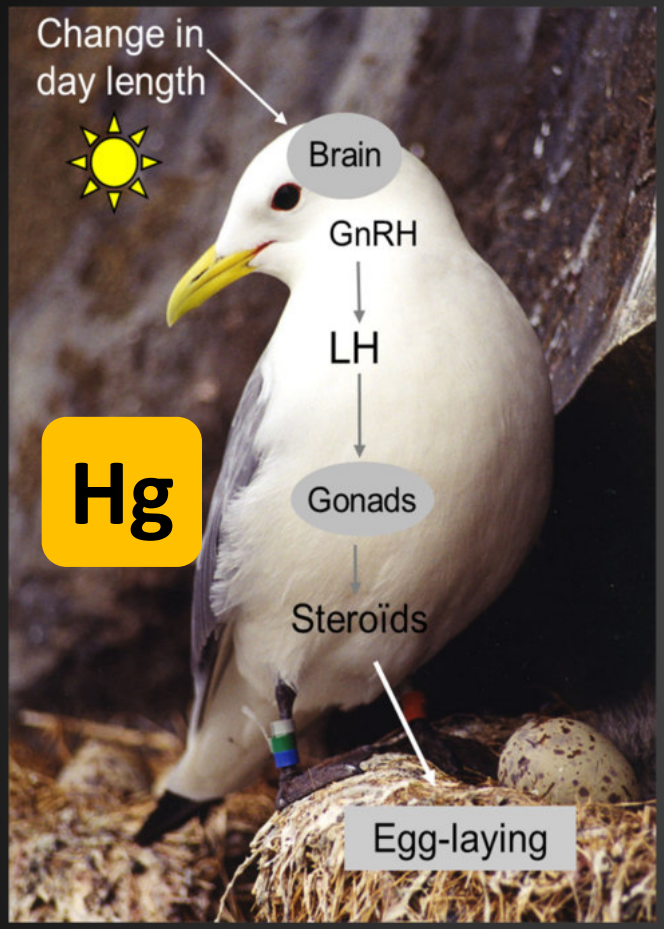
⬇

increasing environmental pollution

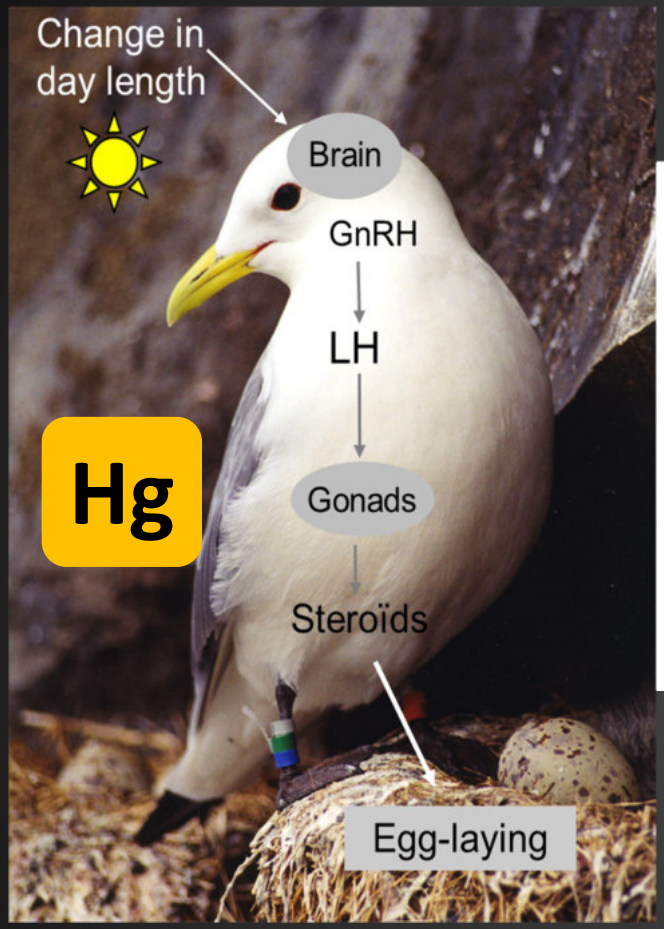

Arctic
Long-range atmospheric transport
Long-range
riverine transport
Long-range
oceanic transport
accelerating environmental modifications
increasing environmental pollution


Arctic
Long-range atmospheric transport
100 tons.year-1
Long-range
riverine transport
Long-range
oceanic transport
50 tons.year-1
40 tons.year-1
Hg
Non-essential metal
AMAP 2011, Soerensen et al. 2016

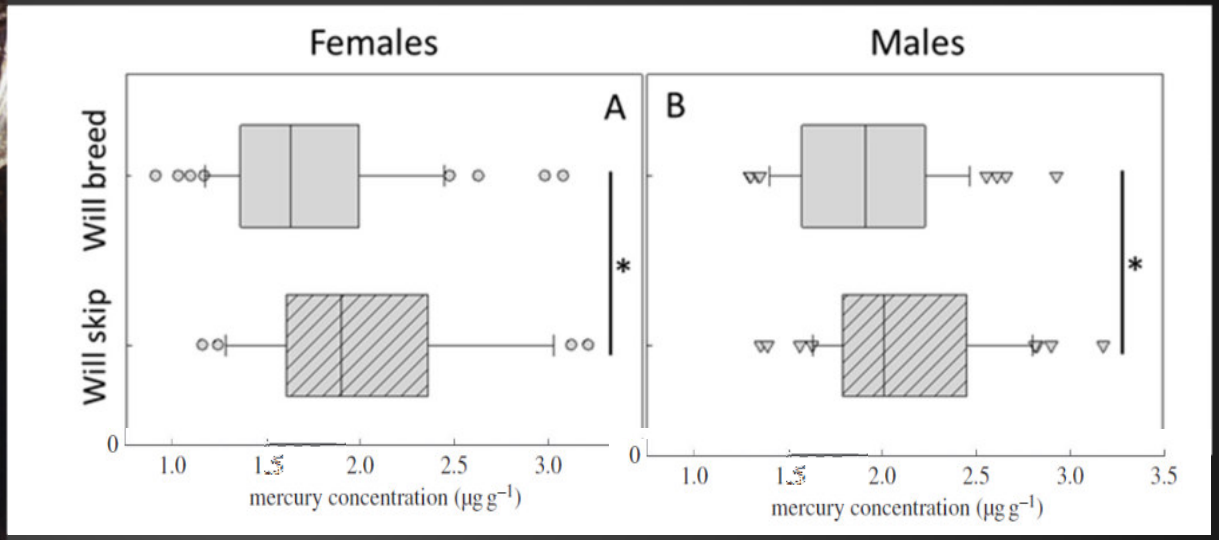

Arctic
Long-range atmospheric transport
Long-range riverine transport
Long-range oceanic transport
Top predators
vulnerable to toxic effects
Hg
Non-essential metal
Me-Hg
(methylmercury)
High toxicity
Biomagnification



Endocrine disruptor



Black-legged kittiwakes

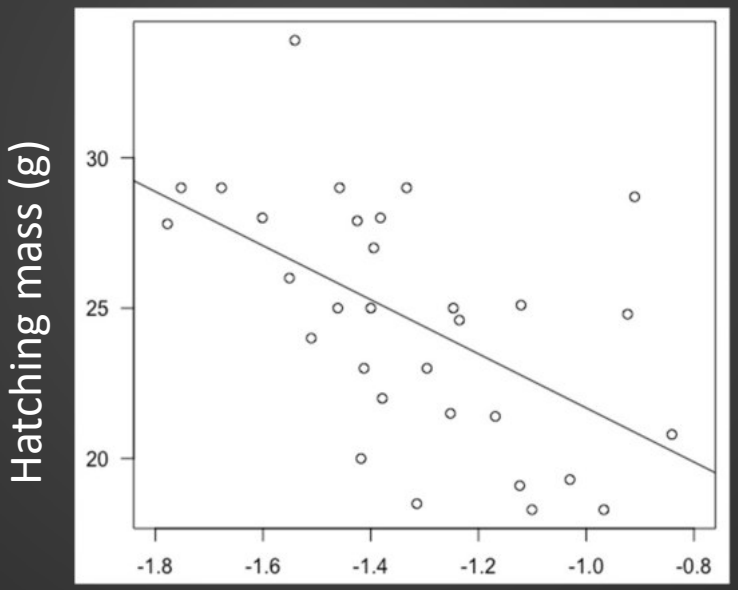


Tartu et al. 2013 *Biology Letters*

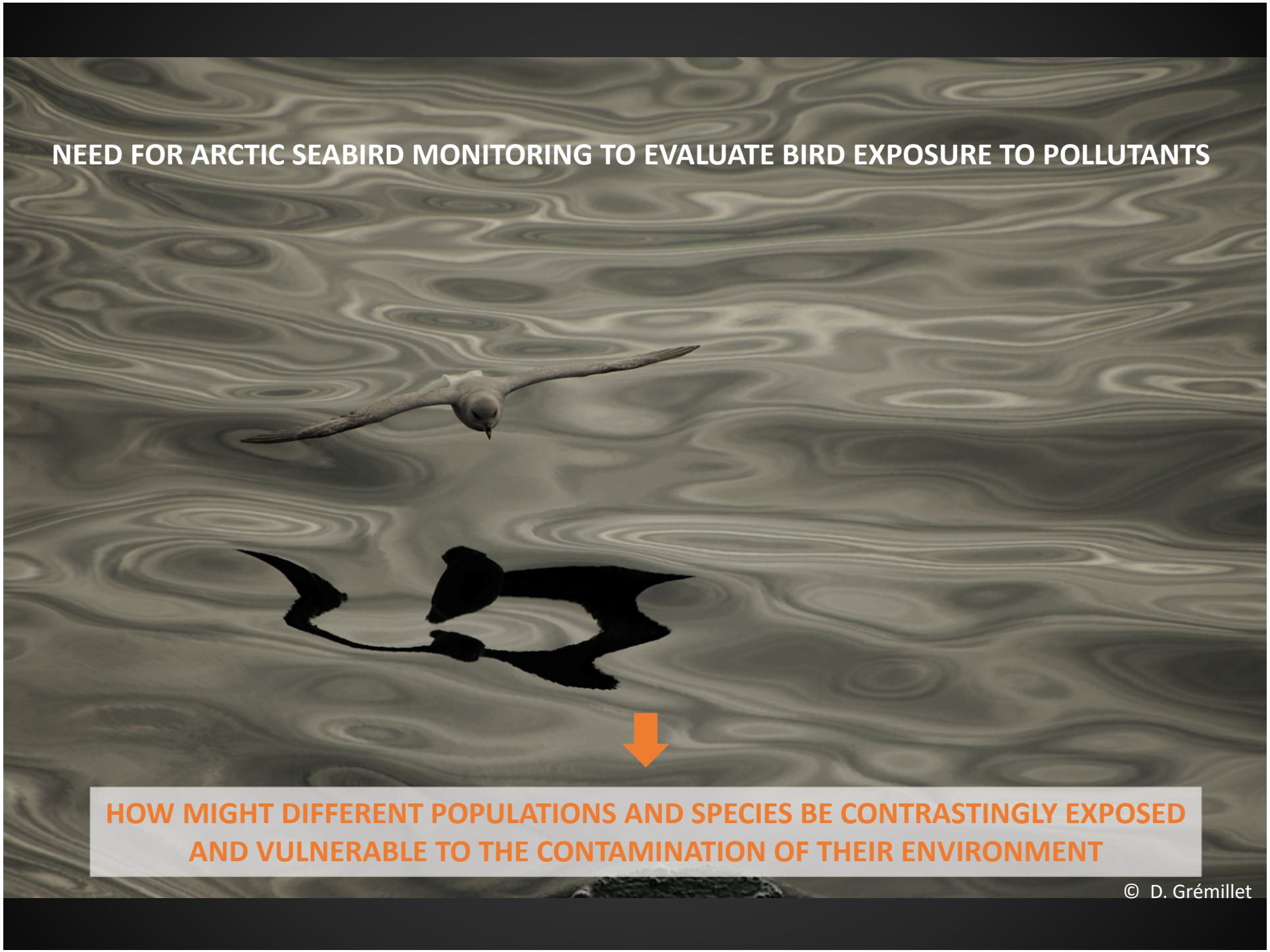
Endocrine disruptor

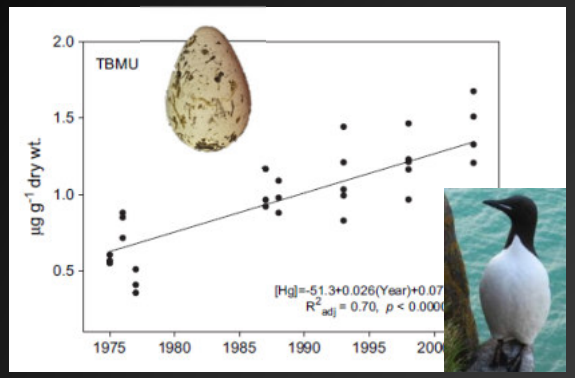
Hg concentrations excreted by females to their egg ↗

Chick body condition ↘

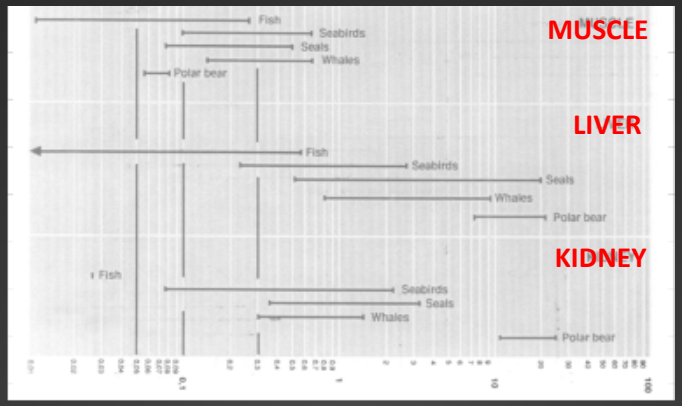


Kerric et al. in prep

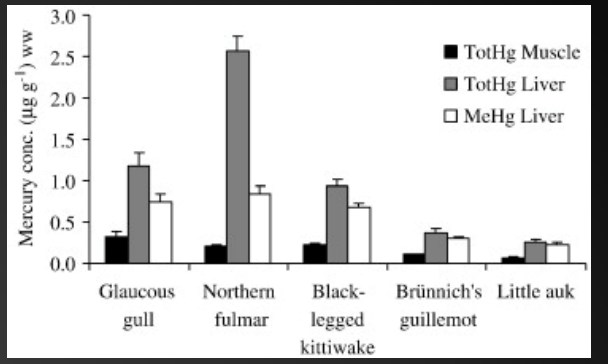

NEED FOR ARCTIC SEABIRD MONITORING TO EVALUATE BIRD EXPOSURE TO POLLUTANTS
HOW MIGHT DIFFERENT POPULATIONS AND SPECIES BE CONTRASTINGLY EXPOSED AND VULNERABLE TO THE CONTAMINATION OF THEIR ENVIRONMENT
© D. Grémillet



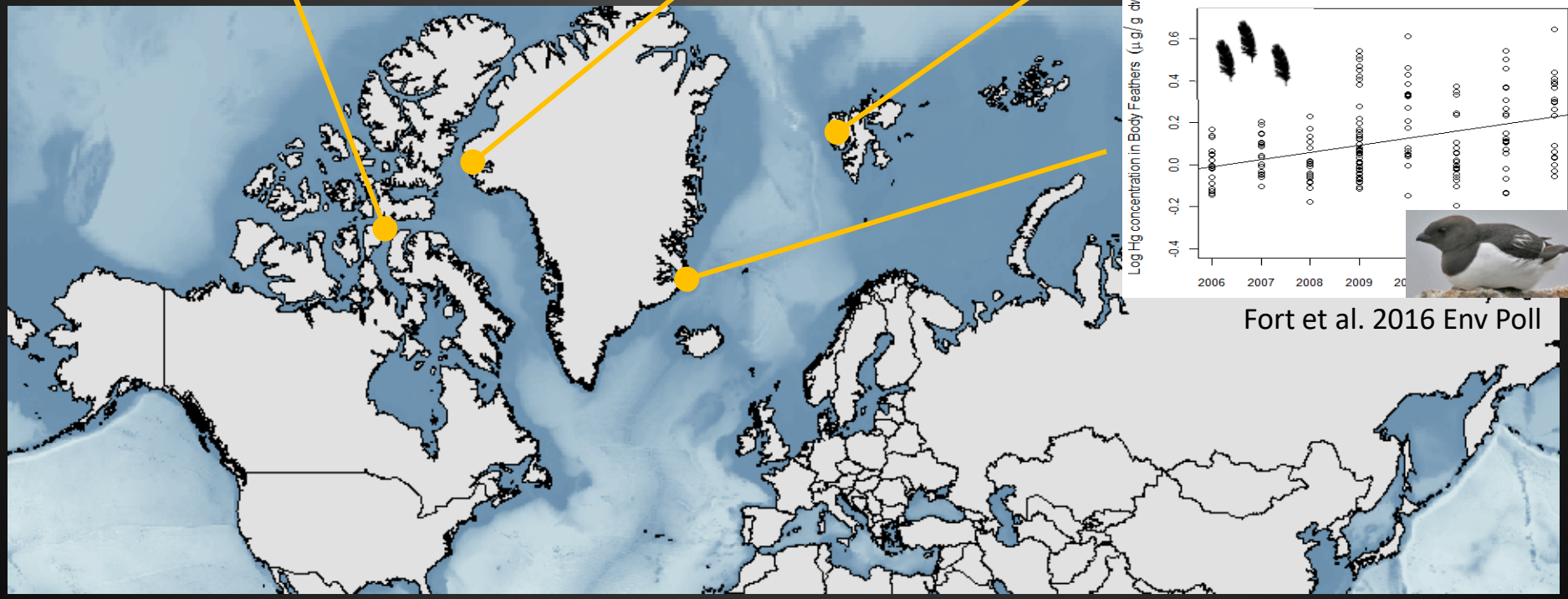
Braune 2007 Env Poll



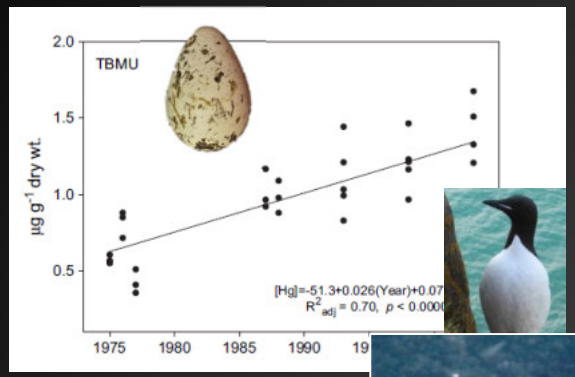
Dietz et al. 1996 STOTEN



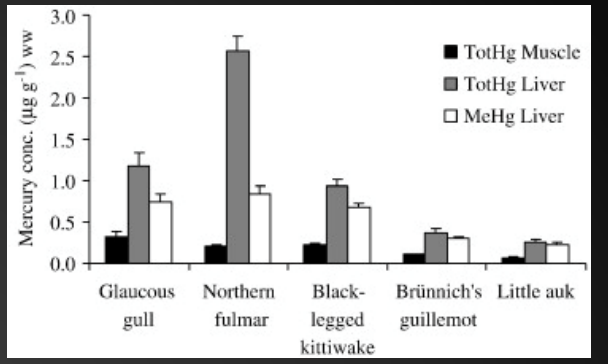
Jaeger et al. 2009 STOTEN



Fort et al. 2016 Env Poll

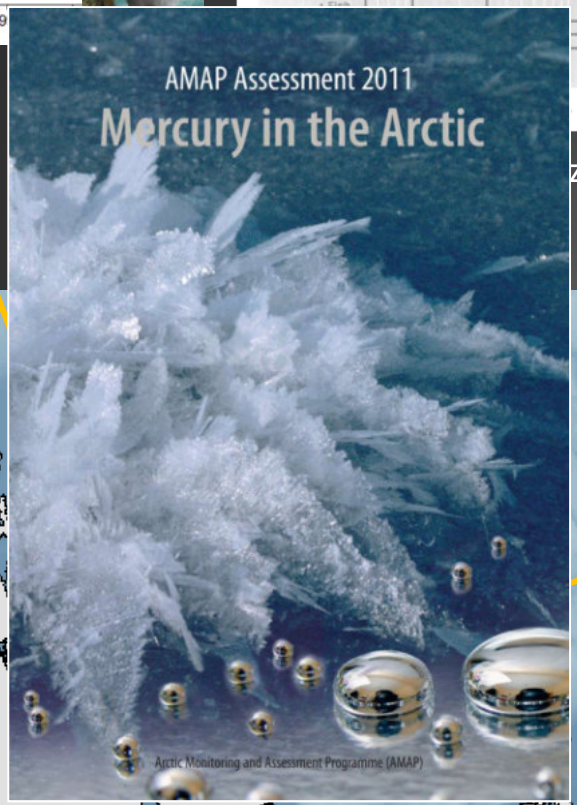


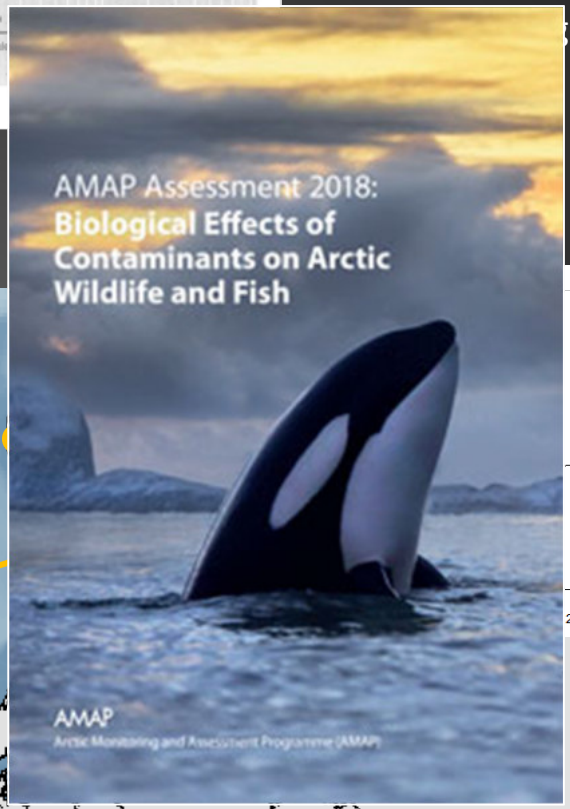
Braune 2007 Env Poll

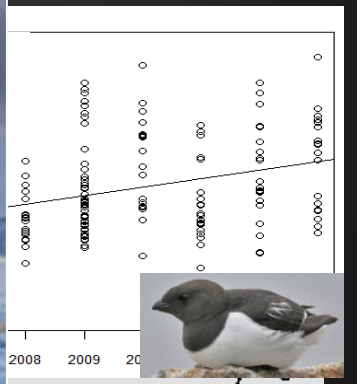


er et al. 2009 STOTEN

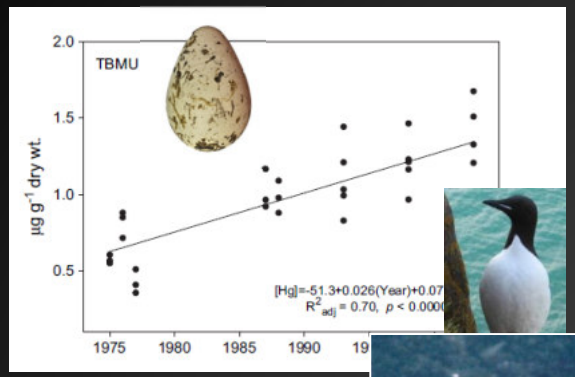
z et



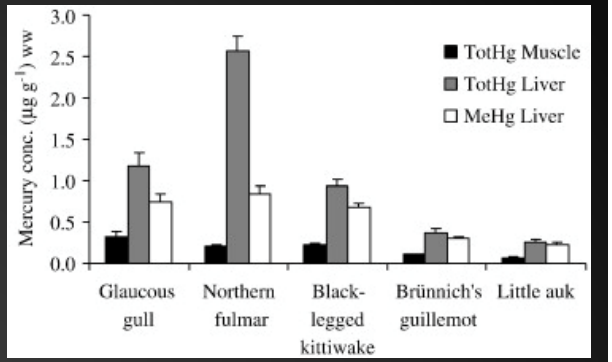




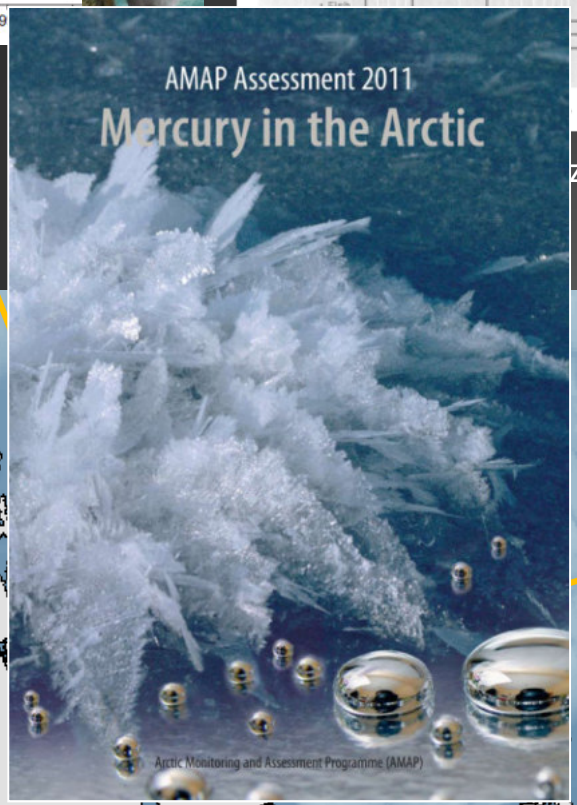
et al. 2016 Env Poll



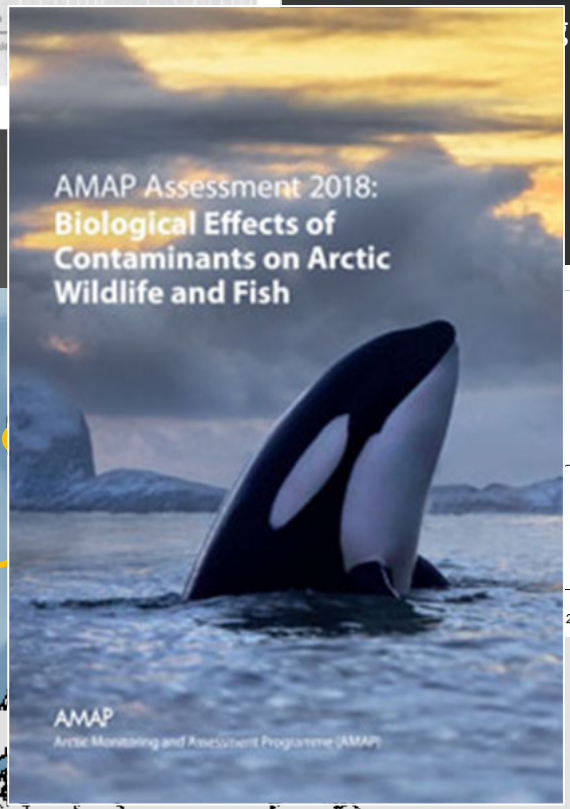
Braune 2007 Env Poll

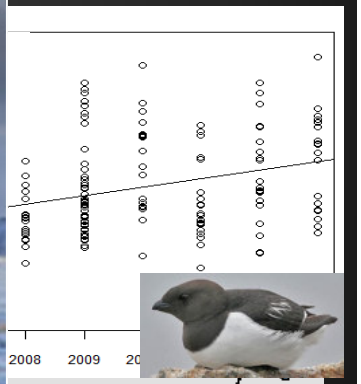


ger et al. 2009 STOTEN



z et



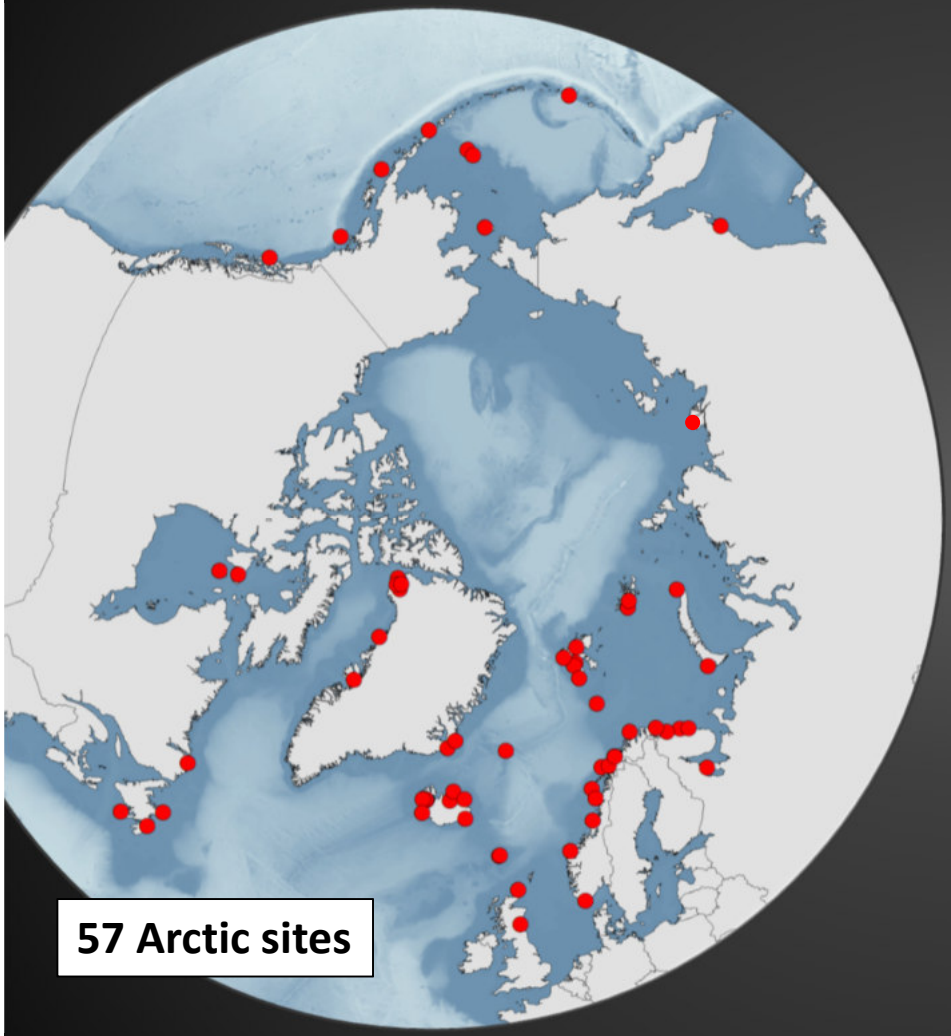


et al. 2016 Env Poll

COORDINATED PAN-ARCTIC / COMMUNITY STUDIES ARE MISSING

ARCTOX

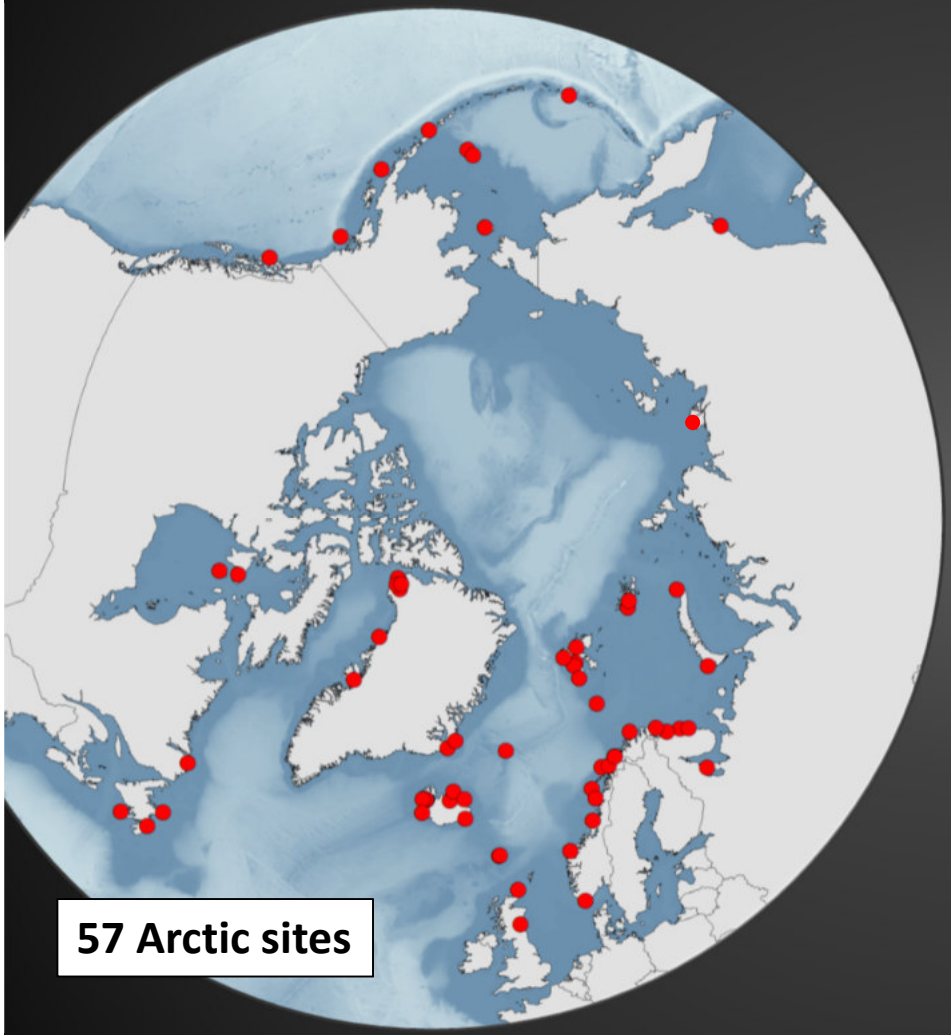
since 2015



57 Arctic sites

ARCTOX

since 2015

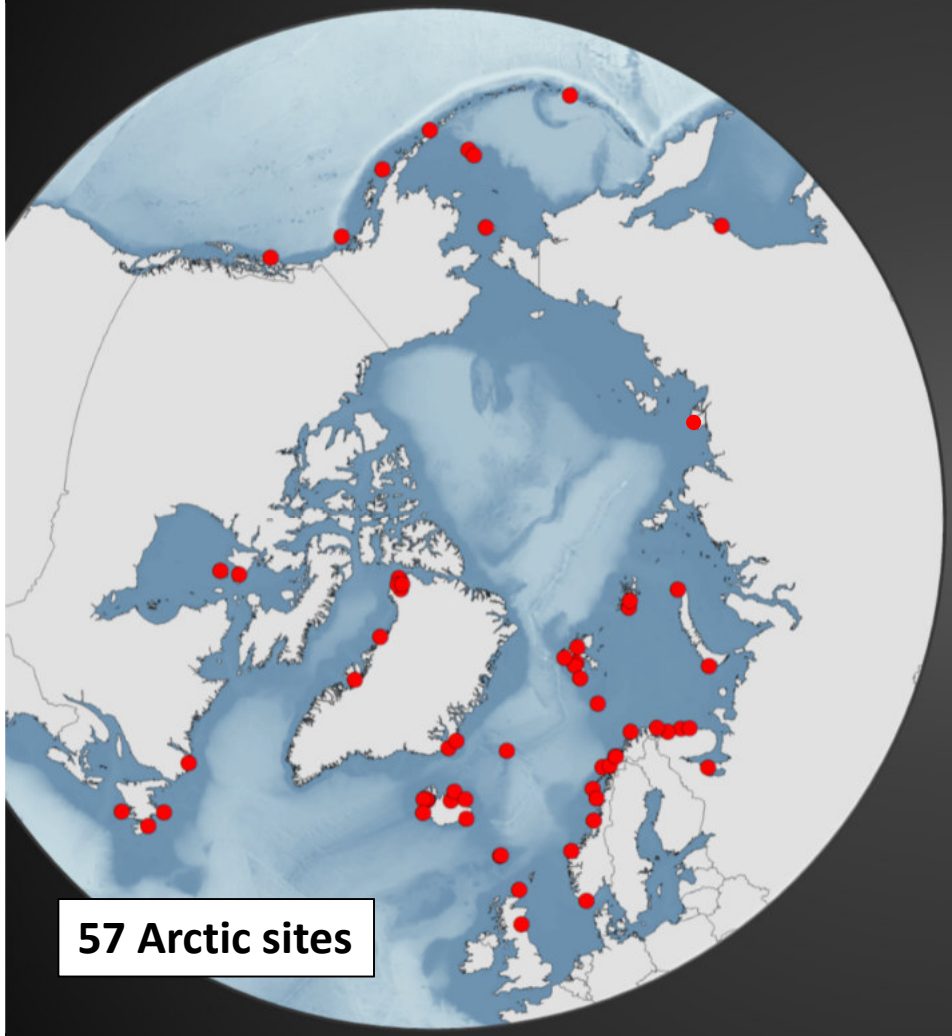


57 Arctic sites

20 seabird species

ARCTOX

since 2015



57 Arctic sites

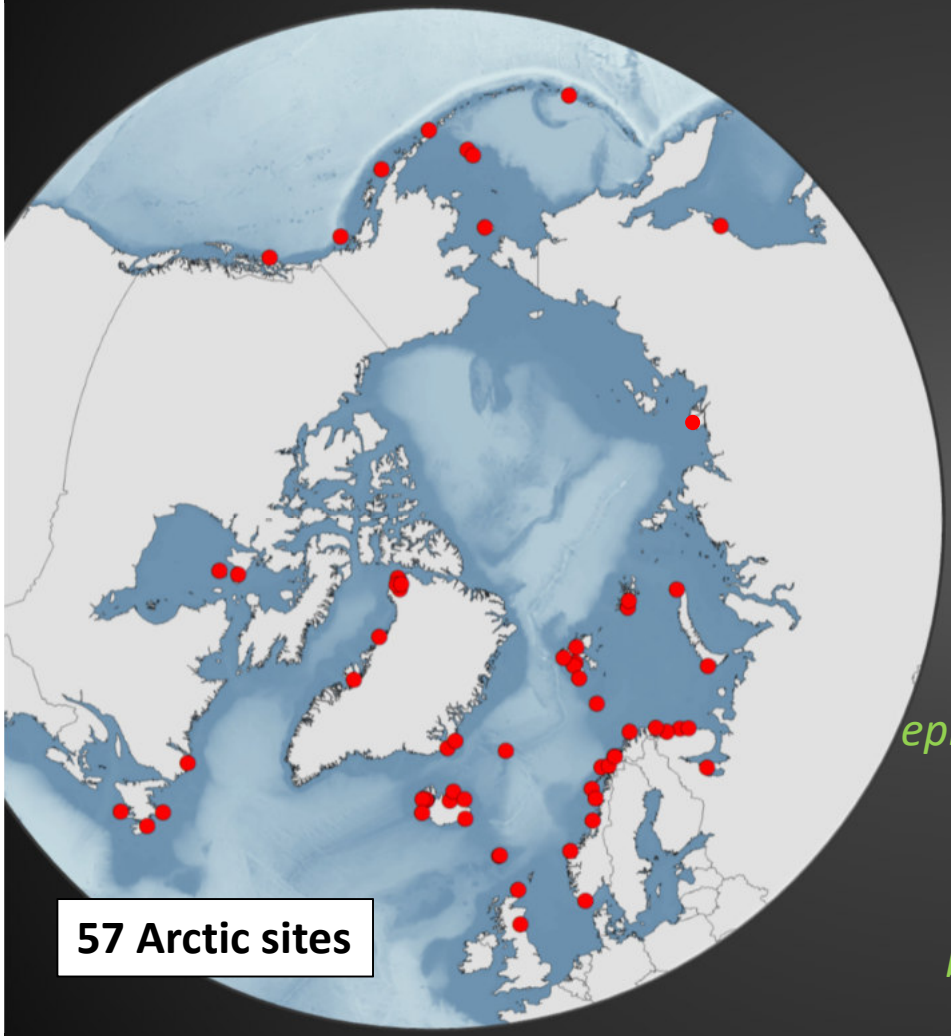
20 seabird species

bio-indicators of contamination of marine food webs

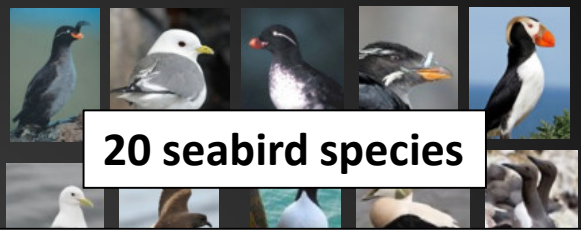
Elliott & Elliott (2013) Science

ARCTOX

since 2015

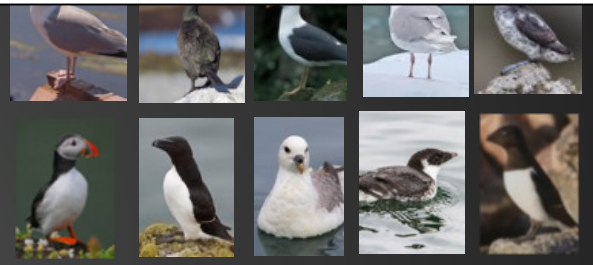


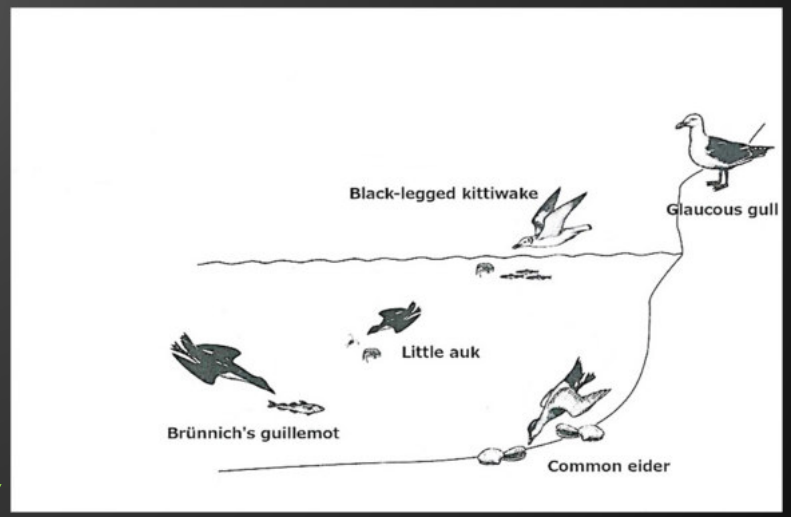
57 Arctic sites



20 seabird species

bio-indicators of contamination of marine food webs





epipelagic

pelagic

benthic

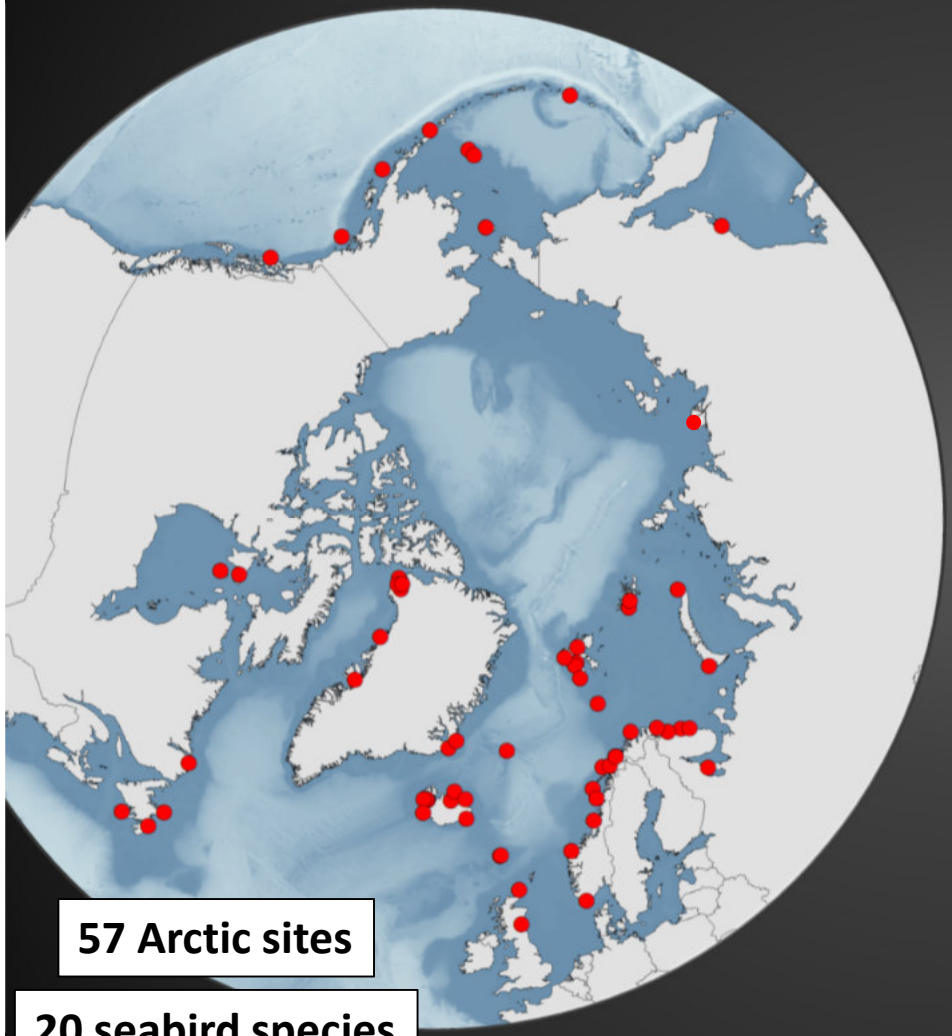
oceanic

coastal

terrestrial

ARCTOX

2015-2017



57 Arctic sites

20 seabird species

5837 individuals sampled

blood samples

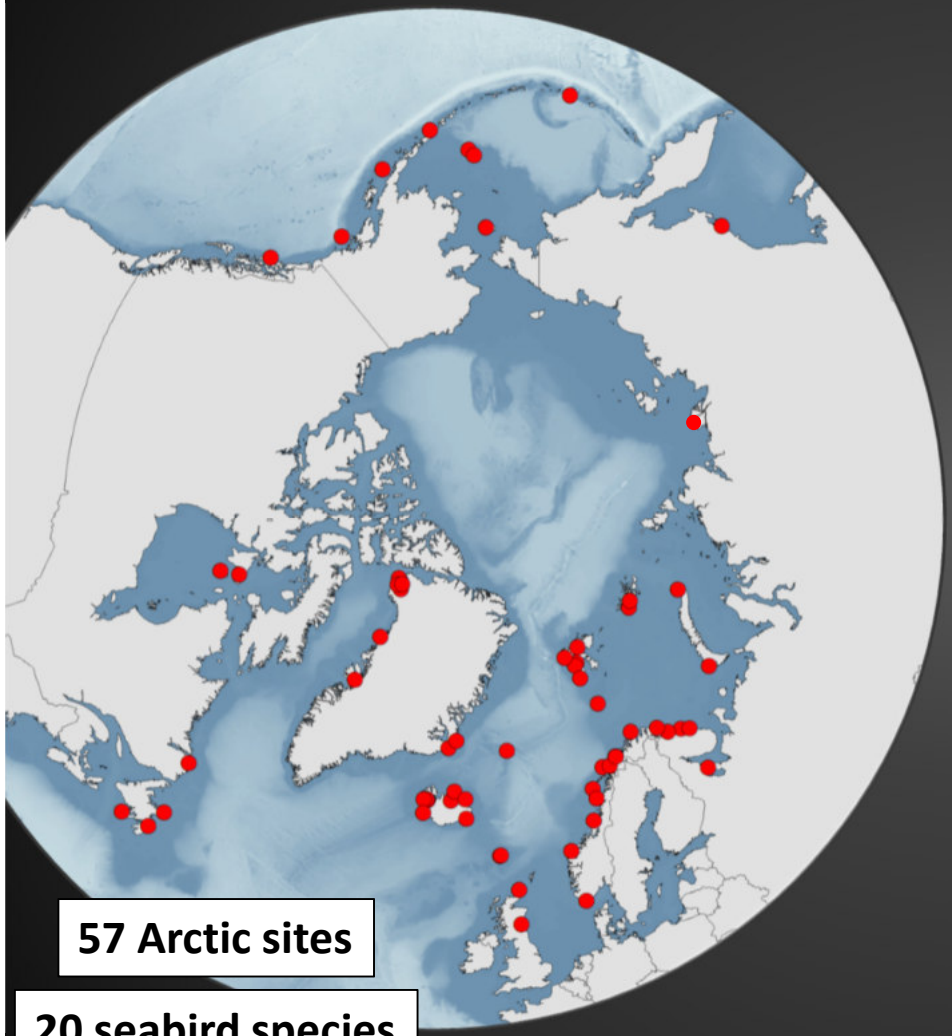
breeding (Arctic) contamination

feather samples

wintering (non-Arctic) contamination

ARCTOX

2015-2017



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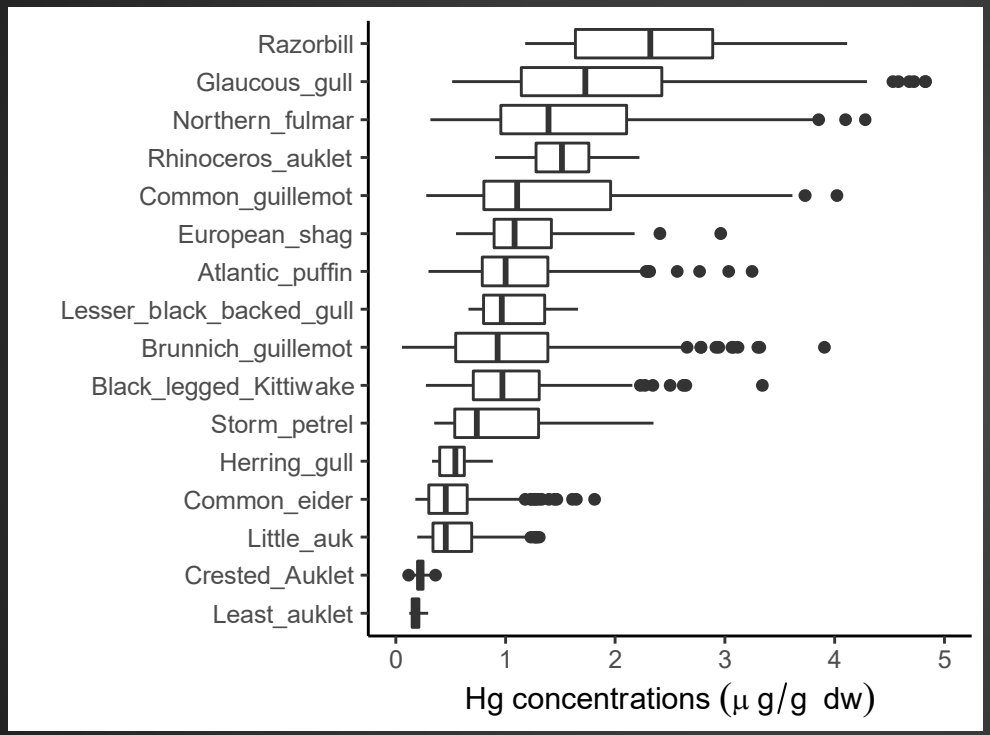
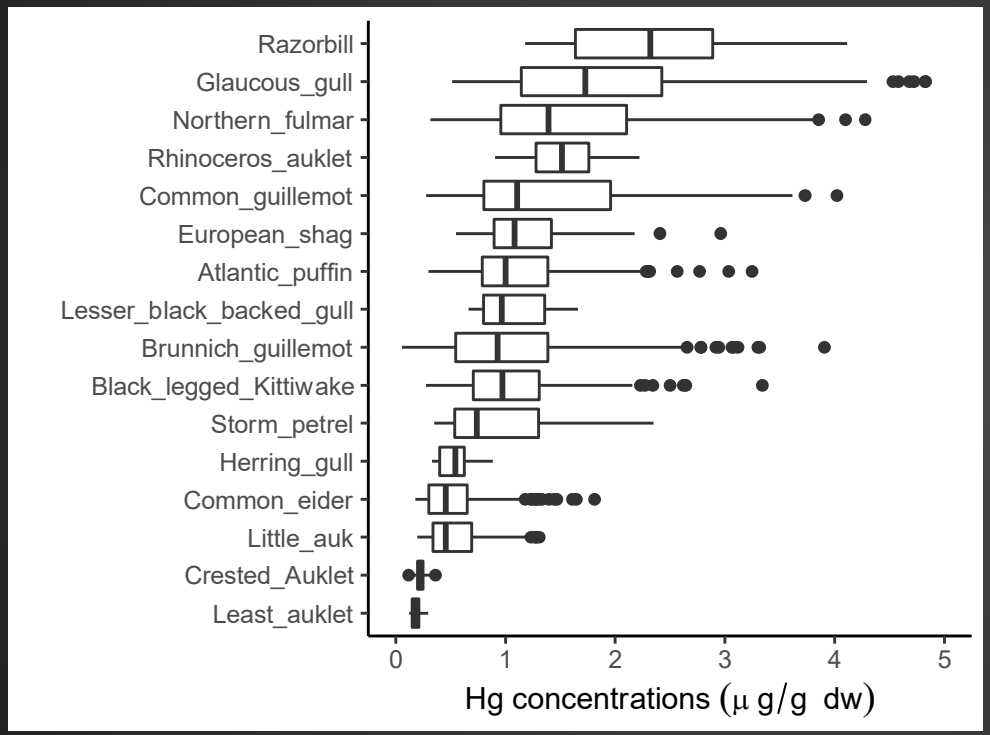

Razorbill
Glaucous_gull
Northern_fulmar
Rhinoceros_auklet
Common_guillemot
European_shag
Atlantic_puffin
Lesser_black_backed_gull
Brunnich_guillemot
Black_legged_Kittiwake
Storm_petrel
Herring_gull
Common_eider
Little_auk
Crested_Auklet
Least_auklet
0
1
2
3
4
5
Hg concentrations (μ g/g dw)


Razorbill
Glaucous_gull
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0
1
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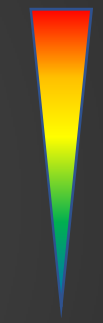
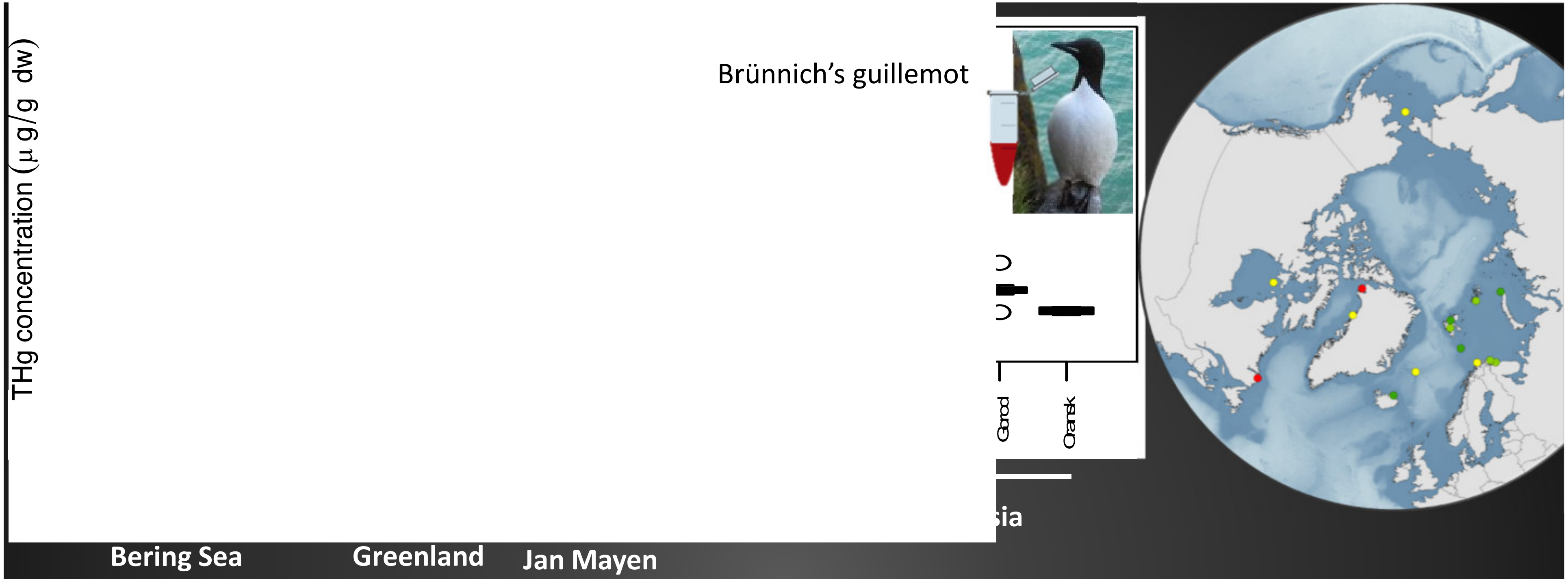
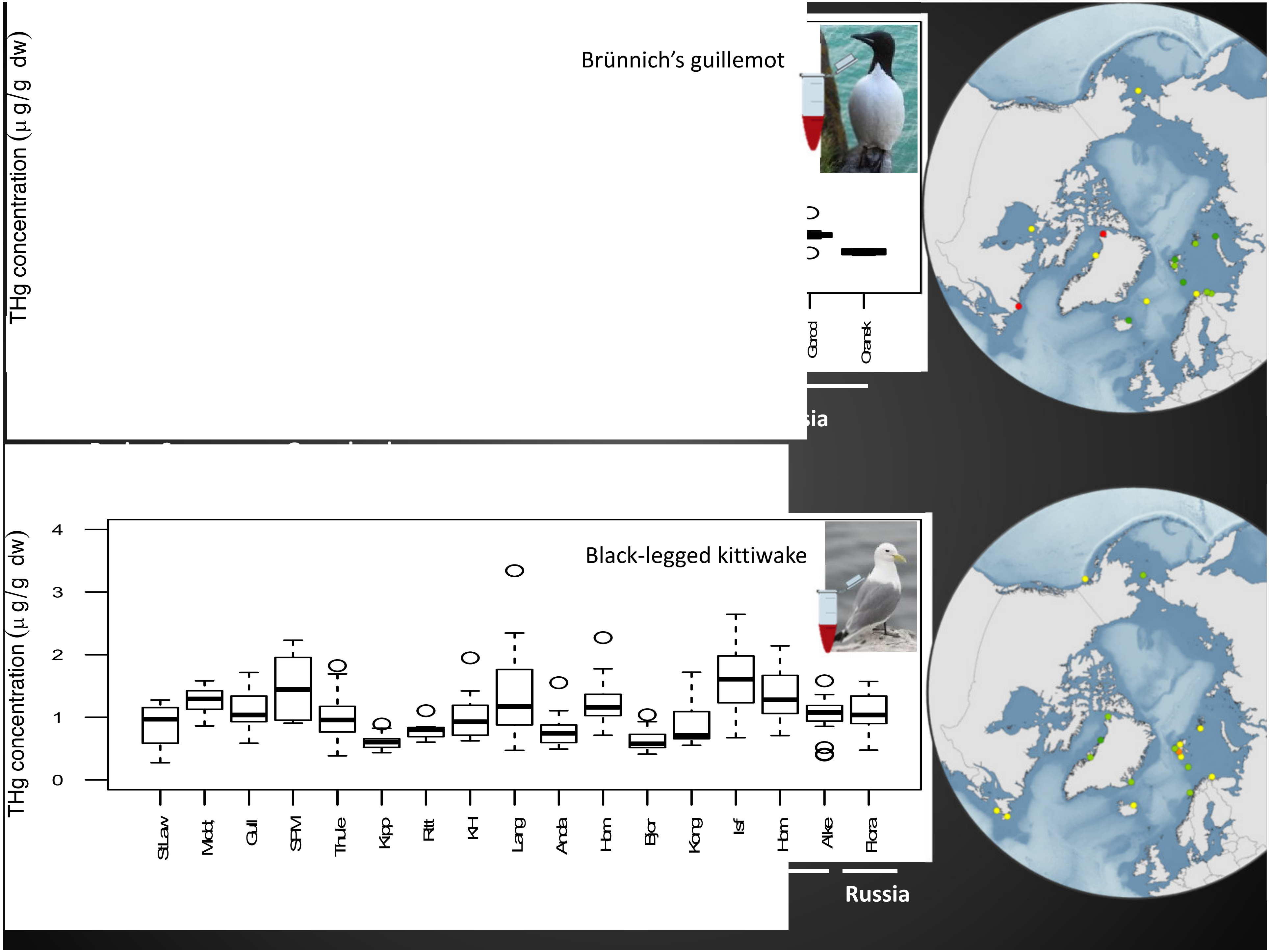
Hg concentrations (μ g/g dw)



Hg


THg concentration (µ g/g dw)
Brünnich's guillemot
Bering Sea
Greenland
Jan Mayen



THg concentration (µ g/g dw)
Brünnich's guillemot
Gorod
Oransk
sia
THg concentration (µ g/g dw)
Black-legged kittiwake
0
1
2
3
4
StLaw
Midd
Gull
SPM
Thule
Kipp
Ritt
KH
Lang
Anda
Hom
Bjor
Kong
Isf
Hom
Alke
Flora
Russia

What risks?

What risks?

Ackerman et al 2016

Toxicity thresholds

< 1	1 - 5	5 - 14	14 - 19	>19	µg/g dw
no risk	low risk	moderate risk	high risk	severe risk	

What risks?

Ackerman et al 2016

Toxicity thresholds

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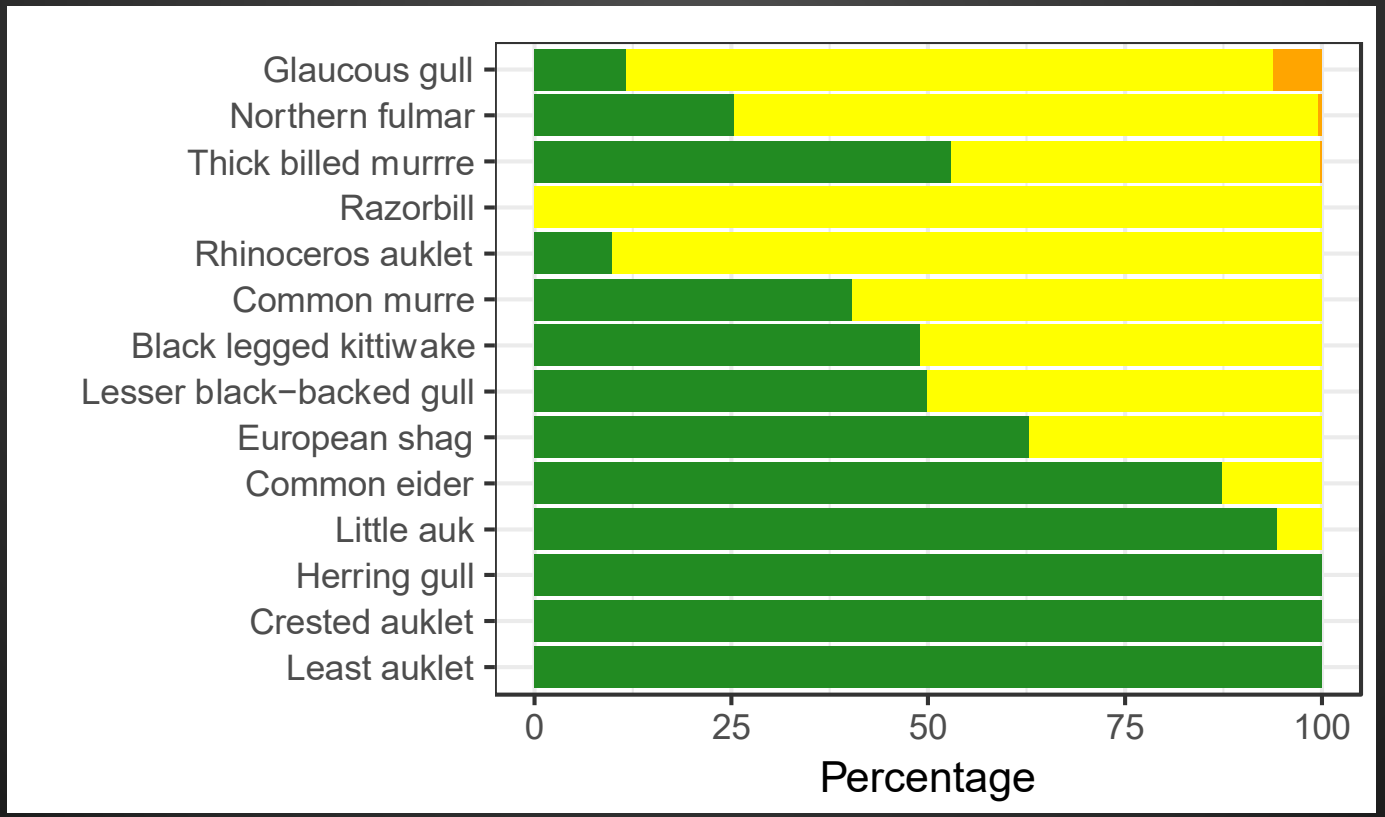
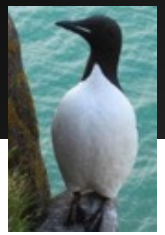
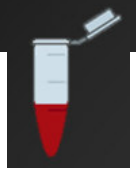




Brünnich's guillemot



What risks?

THg concentration (µg/g dw)

Bering Sea **Greenland** **Jan Mayen**

Brünnich's guillemot

What risks?

THg concentration (µg/g dw)

Bering Sea

Greenland

Jan Mayen

alter hormones and reproductive behaviour (Tartu et al. 2013)

alter gene expression (Gibson et al. 2014)

Brünnich's guillemot

What risks?

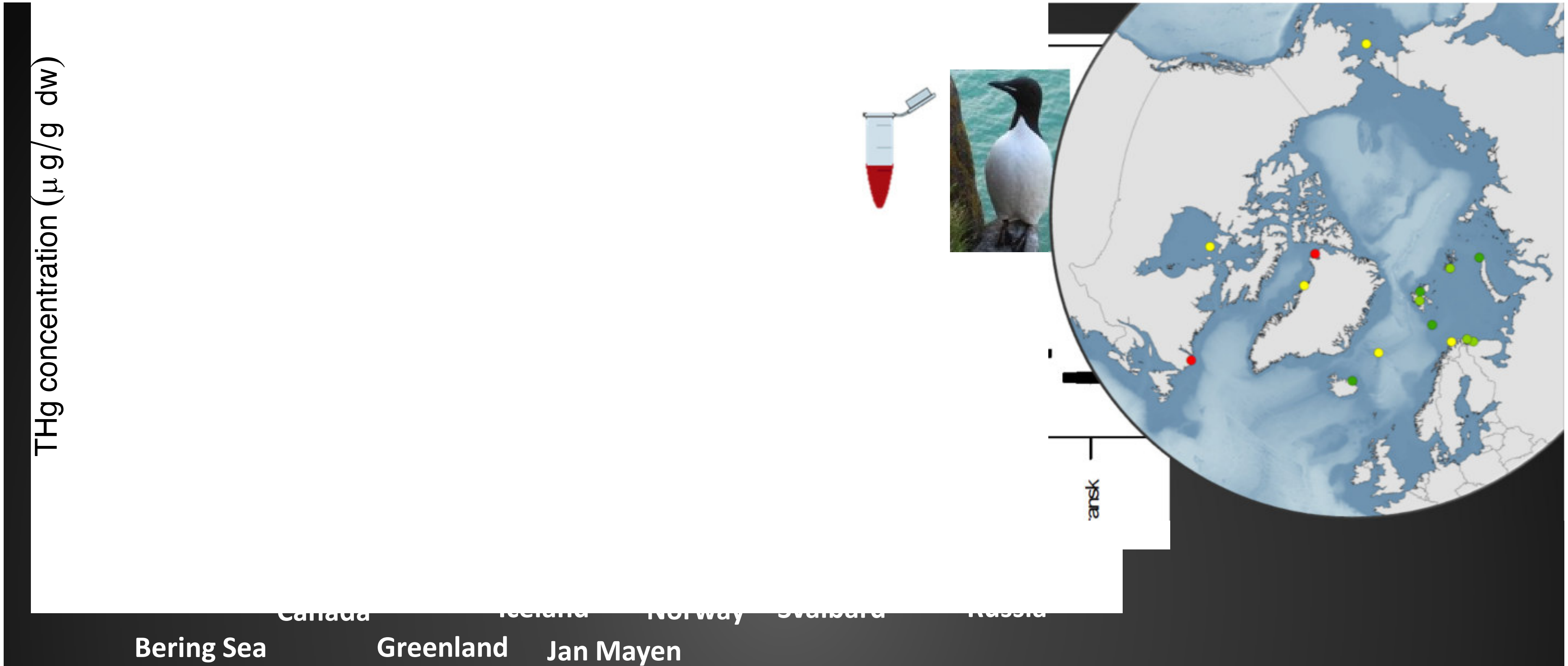
THg concentration (µg/g dw)

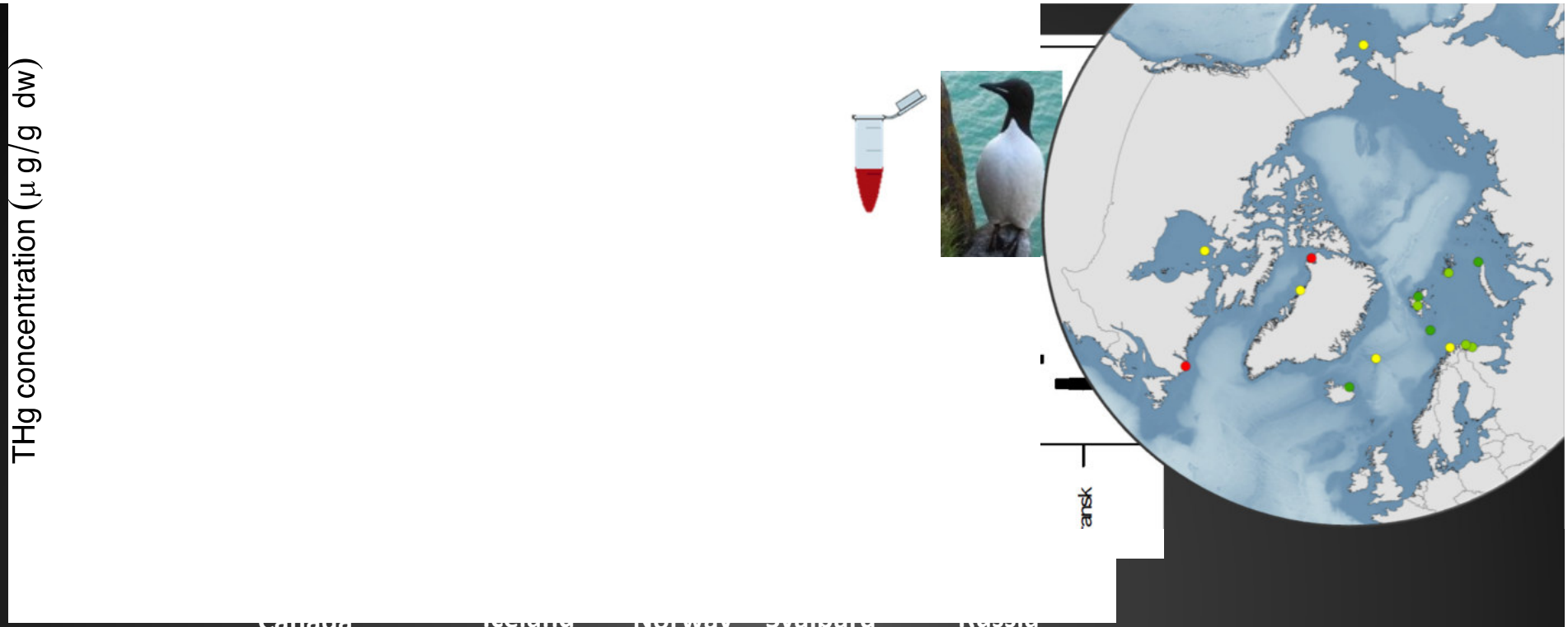
alter hormones and reproductive behaviour (Tartu et al. 2013)

alter gene expression (Gibson et al. 2014)

Bering Sea **Greenland** **Jan Mayen**

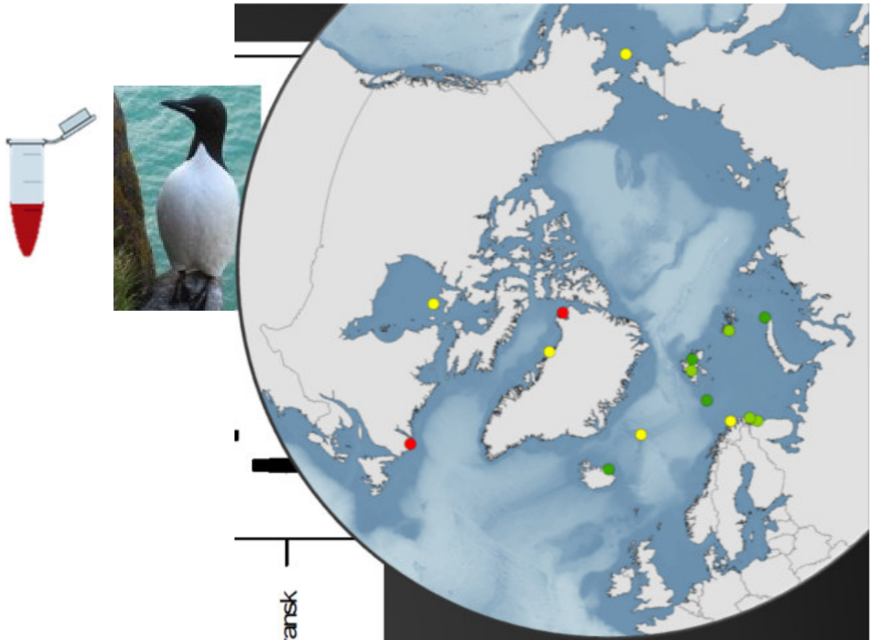
Importance to monitor Hg exposure of Arctic seabird populations at the large scale


THg concentration (μ g/g dw)
ansk
Bering Sea
Greenland
Jan Mayen



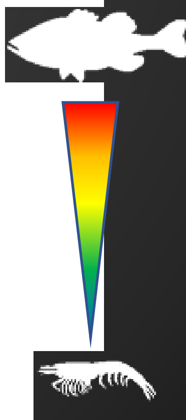
Can we use seabirds as bioindicators to infer the spatial distribution of Hg in Arctic marine food webs?

THg concentration (µg/g dw)



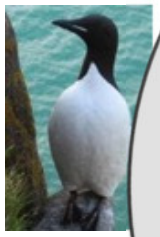
$\delta^{15}N$ (per mil)

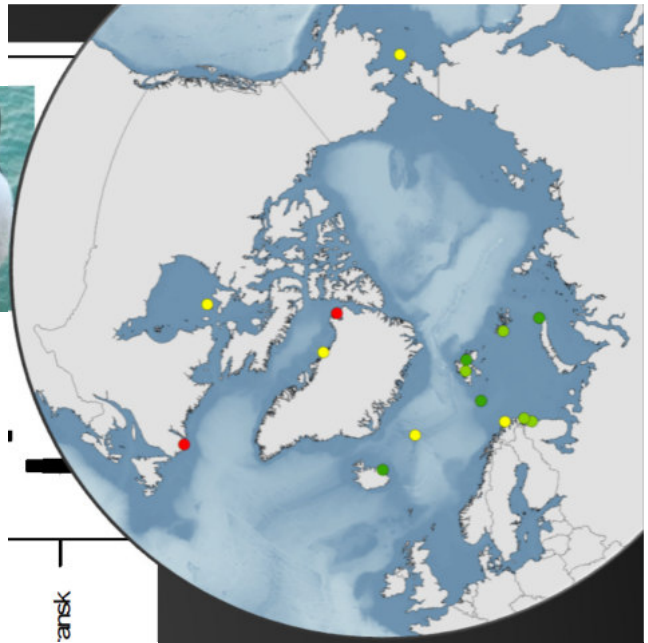
BIRD DIET

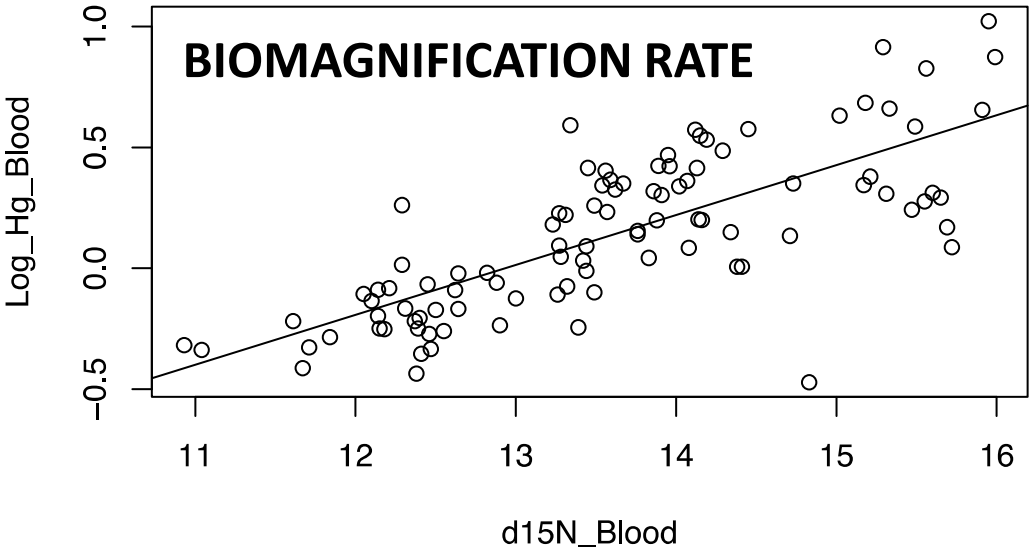


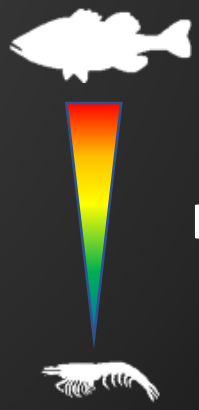
Hg

THg concentration (µg/g dw)

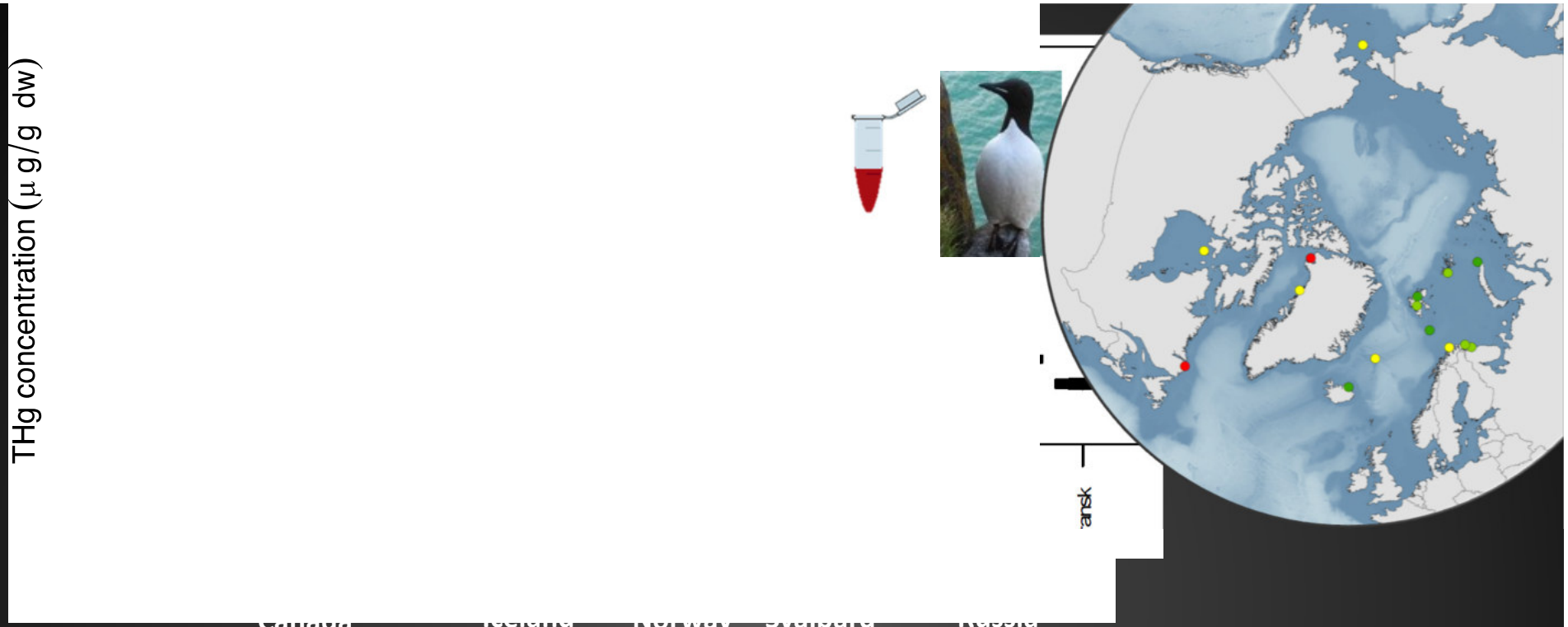








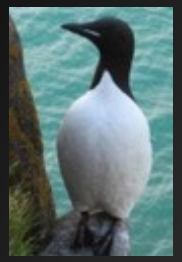
Hg



$$Hg_{adjusted} = Hg_{measured} * A\ (\delta^{15}N_{average} - \delta^{15}N_{measured})$$

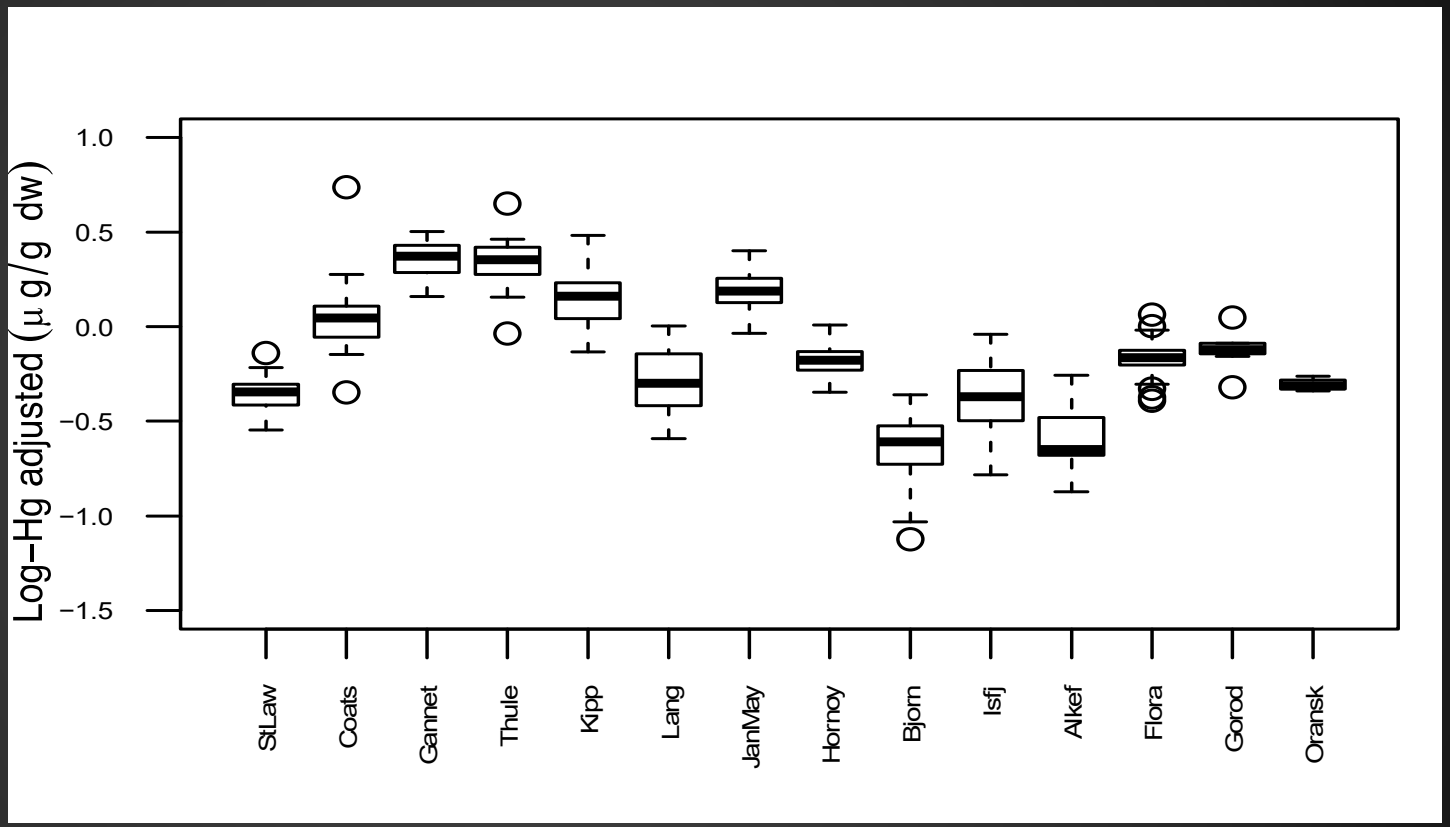
A = regression coefficient for Hg - $\delta^{15}N_{measured}$ relationships for each site

Burgess et al. 2013. *Env. Poll.*



Brünnich's guillemot

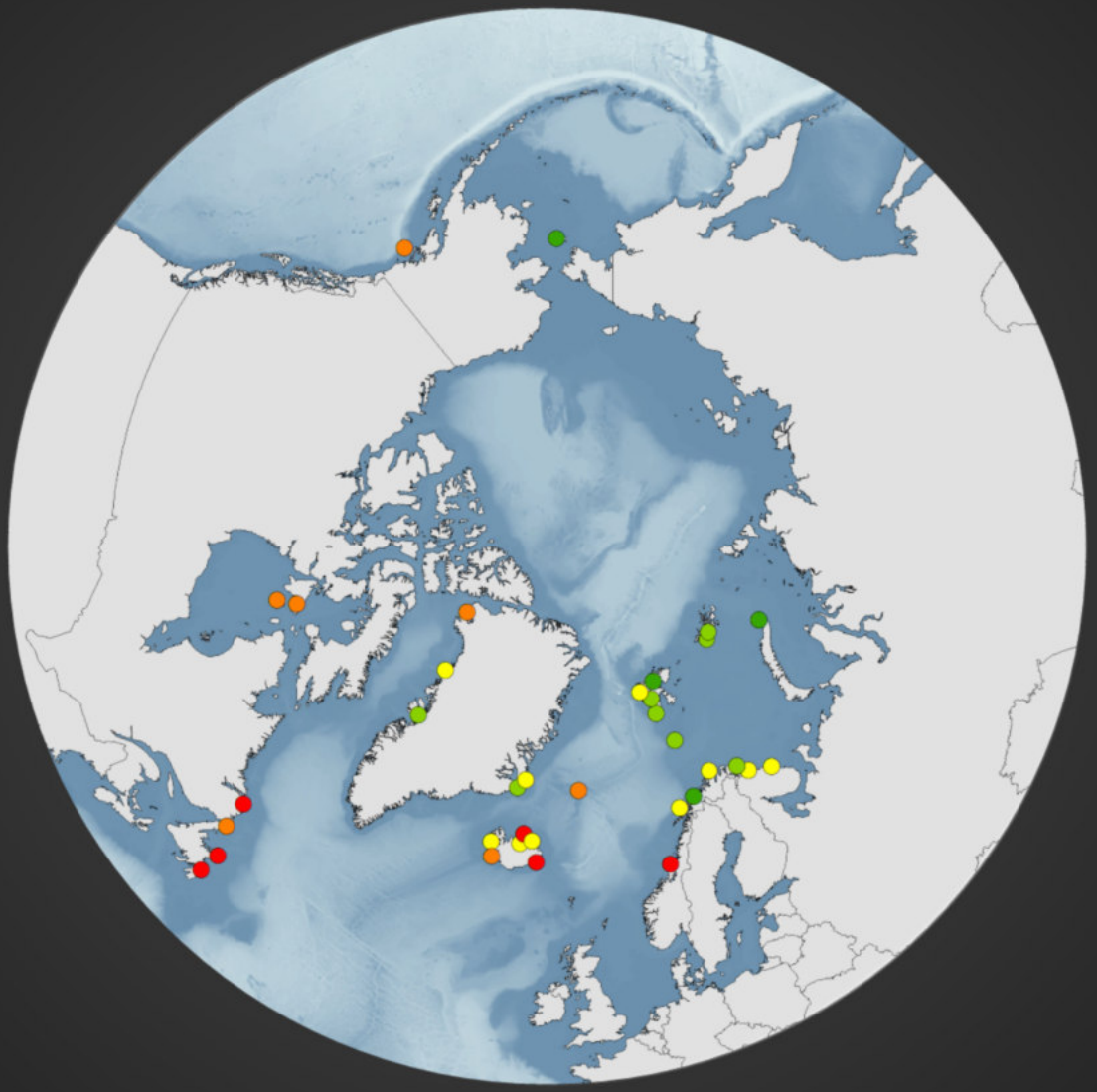
Hg adjusted



Bering Sea **Canada** **Greenland** **Iceland** **Jan Mayen** **Norway** **Svalbard** **Russia**

Define the pan-Arctic distribution of Hg in marine food webs

Adj-Hg

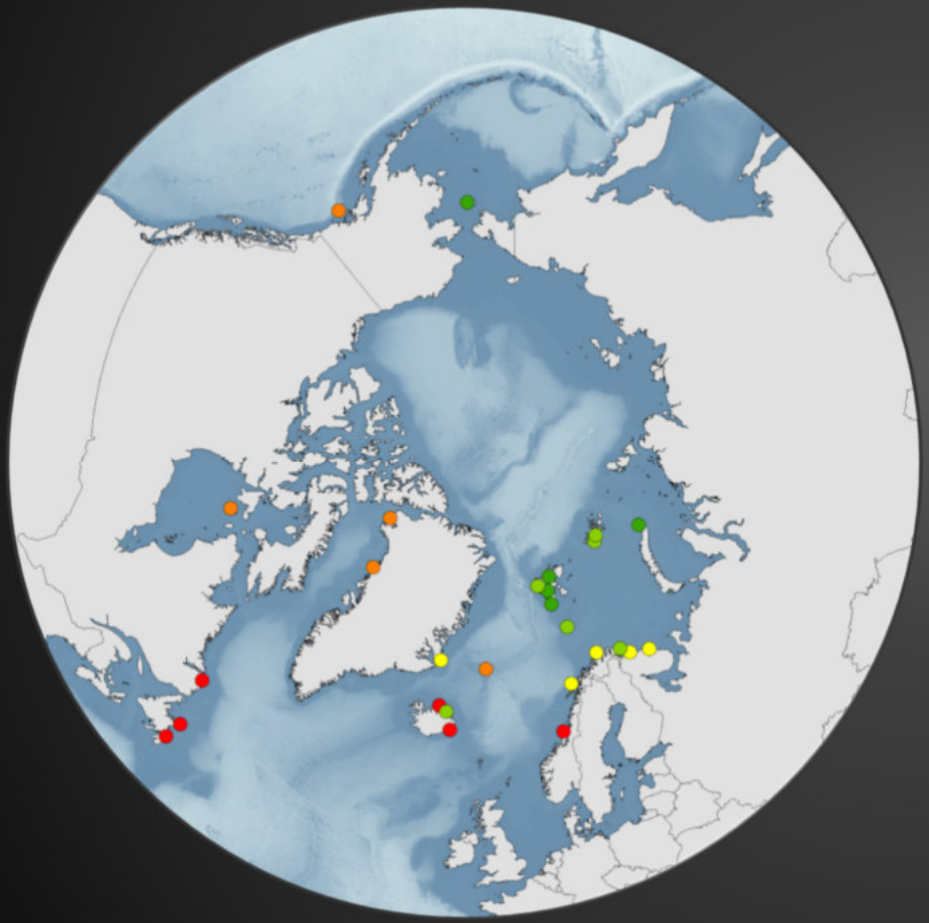


Highlight hotspots of Hg

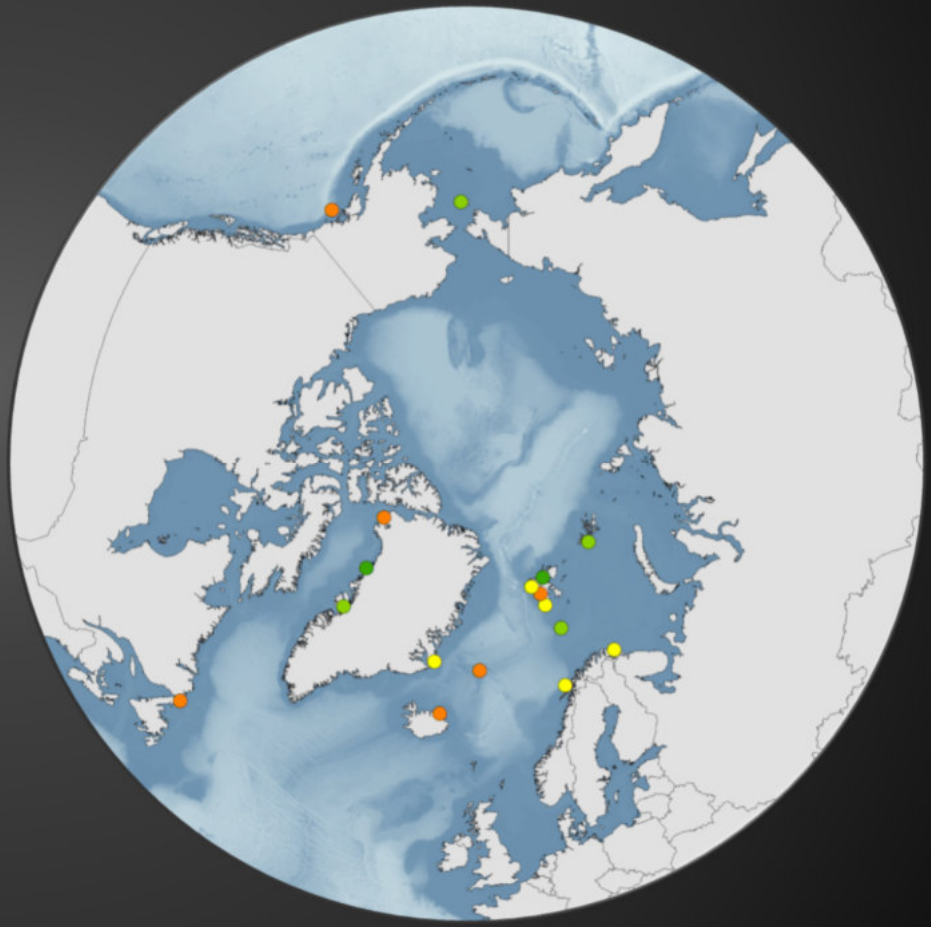
Fort et al. in prep

Define the pan-Arctic distribution of Hg in marine food webs

Pelagic divers



Surface feeders



Fort et al. in prep

Conclusion

Importance of a coordinated large-scale monitoring of the seabird community

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Determine the most exposed species and populations in a perspective of conservation of these vulnerable species in a context of rapid environmental modifications

Although Arctic seabirds are at low risk, some populations/species are above toxicity thresholds

Conclusion

Importance of a coordinated large-scale monitoring of the seabird community

Determine the most exposed species and populations in a perspective of conservation of these vulnerable species in a context of rapid environmental modifications

Although Arctic seabirds are at low risk, some populations/species are above toxicity thresholds

Define hotspots of mercury in the Arctic and sub-Arctic marine food webs

Canada and Iceland show the highest levels of Hg while Svalbard and the western Russian Arctic have the lowest concentrations

Next steps?

Next steps?

1/ Seabirds can also be highly exposed to Hg during the non-breeding season

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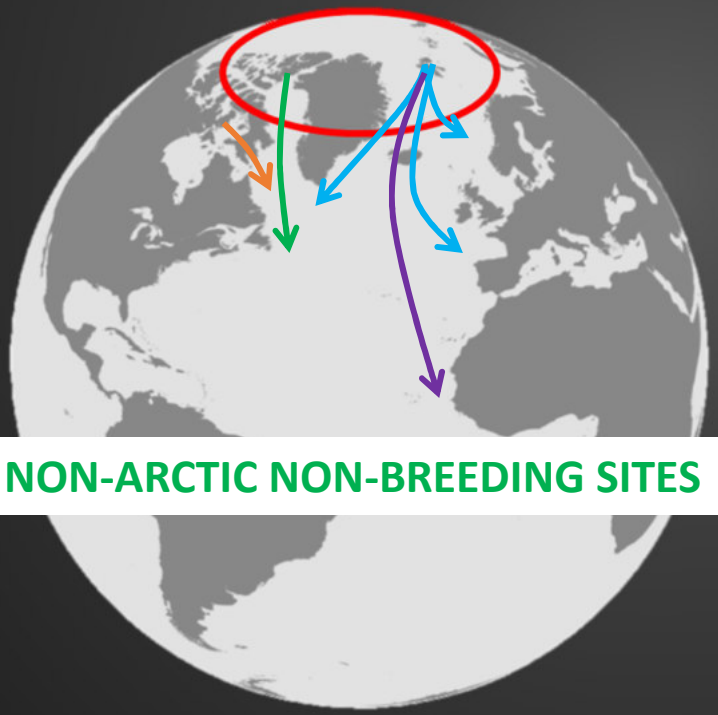
ARCTIC BREEDING SITES



?

Hg

NON-ARCTIC NON-BREEDING SITES

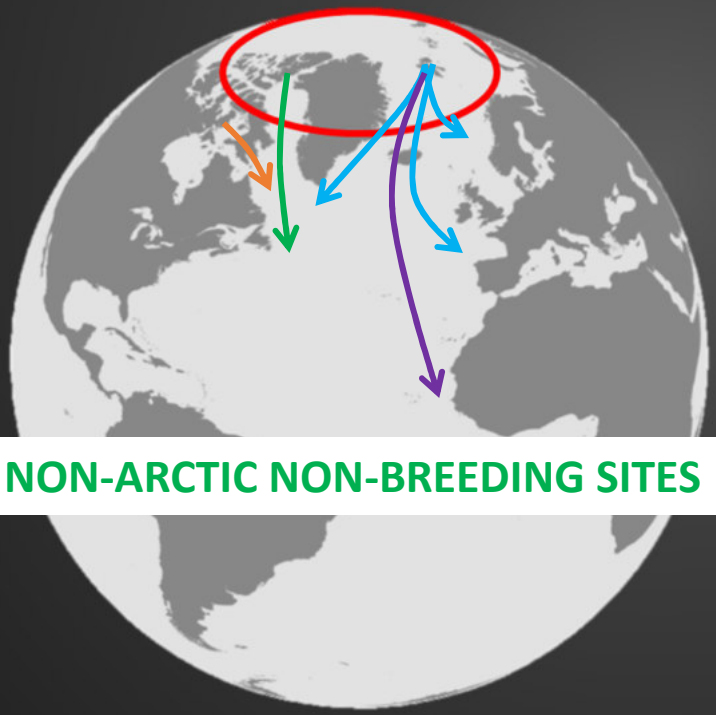
Next steps?

1/ Seabirds can also be highly exposed to Hg during the non-breeding season

ARCTIC BREEDING SITES

?

Hg



NON-ARCTIC NON-BREEDING SITES

feather samples

Non-breeding contamination

+

Individual non-breeding distribution

Next steps?

1/ Seabirds can also be highly exposed to Hg during the non-breeding season

2/ Use this unique network to monitor temporal changes of Hg in Arctic seabirds and marine food webs at the pan-Arctic scale

Next steps for ARCTOX?

1/ Seabirds can also be highly exposed to Hg during the non-breeding season

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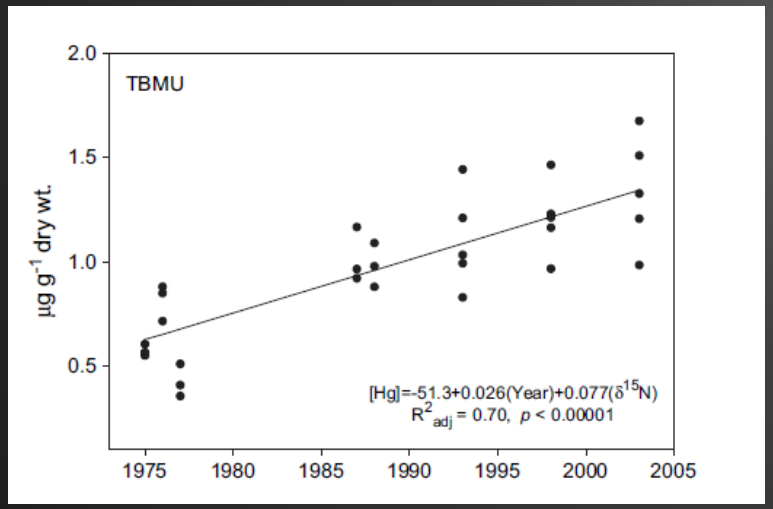
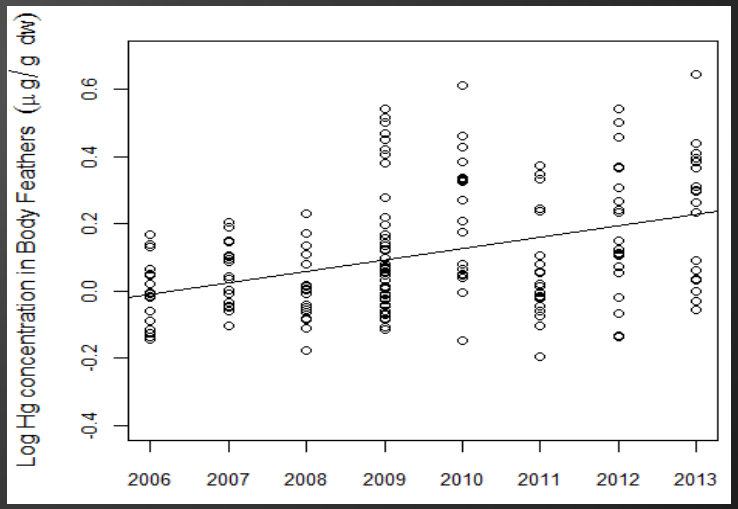


Braune 2007 Env Poll

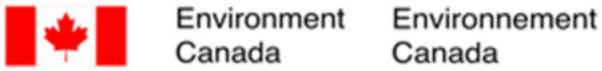


Fort et al. 2016 Env Poll

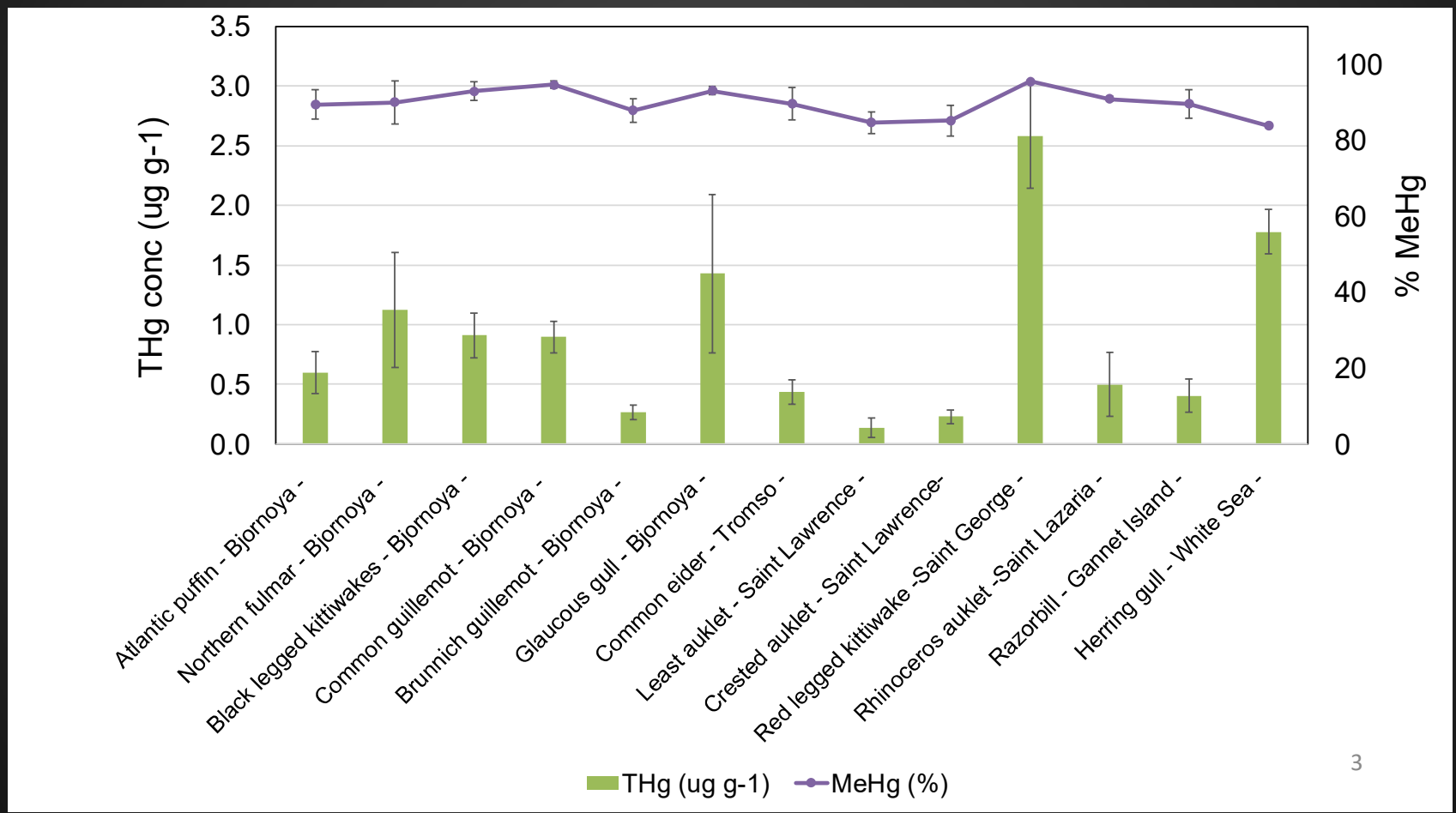
Brünnich's guillemot – Canadian Arctic

Little auks – East Greenland

THANK YOU FOR YOUR ATTENTION!



Hg speciation



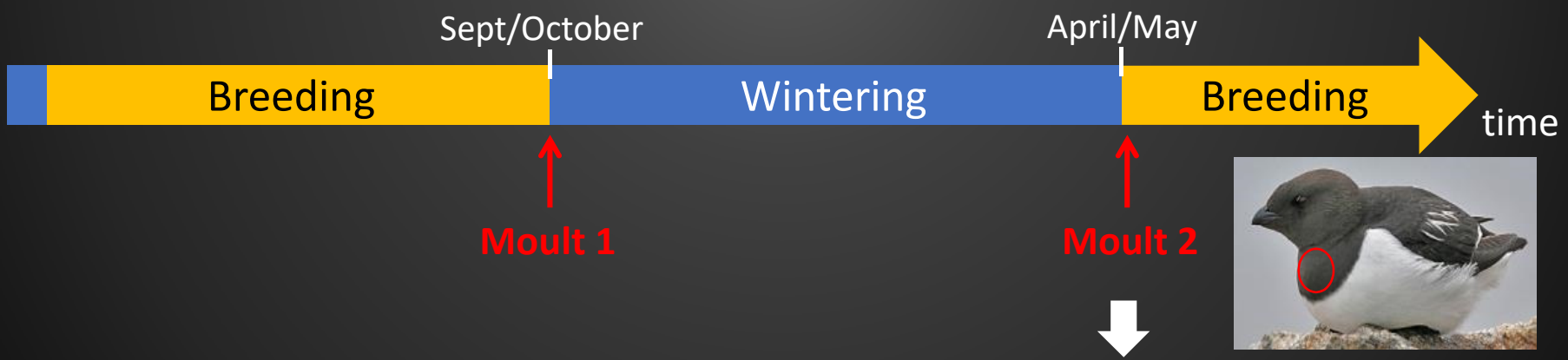
Hg accumulates in body tissues over time

(bioaccumulation process)

Feather moult = mechanism by which accumulated Hg is excreted

Hg in feathers reflect levels accumulated since the last moulting sequence

(Thompson et al. 1998)



Hg accumulated over the wintering period

Next steps for ARCTOX?

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3/ Further understand the risks associated with this Hg contamination

Se-Hg
=
protection against
Me-Hg toxicity

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