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AMAP Arctic Monitoring and Assessment Programme

ARCTIC COUNCIL


AMAP 2018 - Biological Effects of Contaminants in Arctic Wildlife & Fish: An Introduction


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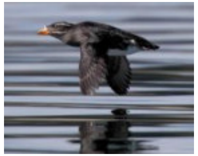
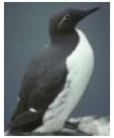
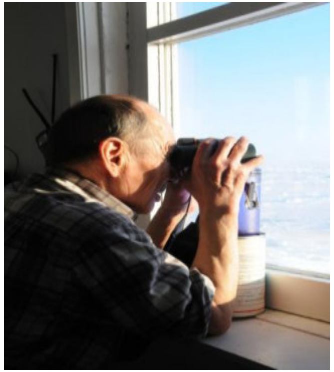





Arctic Biodiversity Congress,
Rovaniemi, Finland; Octpber 9-12, 2018

Acknowledgements



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Governments, northerners, communities, hunters and trappers associations, local hunters, field and laboratory workers and all those people from across the circumpolar Arctic who make everything we do possible

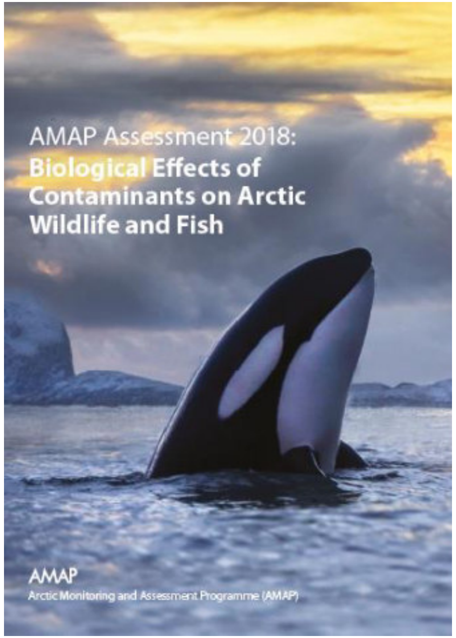
An Update on Effects Assessments

2009

covering knowledge on organohalogen effects from 2004 to 2009

2011

covering knowledge on mercury effects from 2004 to 2010



2018

covering knowledge on organohalogen and mercury effects from 2010 to 2016/2017

Key messages

https://www.amap.no/documents/doc/Biological-Effects-of-Contaminants-on-Arctic-Wildlife-and-Fish.-Key-Messages/1664

Technical report (pre-print watermarked)

https://www.amap.no/documents/doc/AMAP-Assessment-2018-Biological-Effects-of-Contaminants-on-Arctic-Wildlife-and-Fish-Pre-print/1663

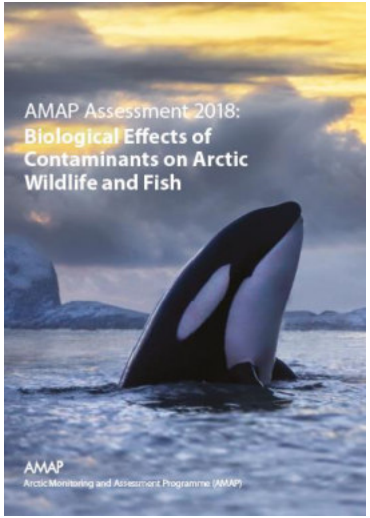
An assessment of the biological effects of organohalogen and mercury contaminants in Arctic wildlife and fish

UNEP Stockholm POPs Convention status

1. **PCBs** — polychlorinated biphenyls ← **Added 2001** (Annex A)
   mostly the sum of a varying number of congeners
2. **OCPs** — organochlorine pesticides
   hexachlorobenzene, hexachlorehexanes,
   chlordane-like compounds and ← **Added 2001** (Annex A)
   dichlorodiphenyltrichloroethane-like compounds
3. **FRs** — flame retardants
   mostly polybrominated diphenylethers (PBDEs) ← **Added 2009** (Annex A)
   and hexabromocyclododecane ← **Added 2013** (Annex A)
4. **PFASs** — poly- and per-fluoroalkyl substances
   mostly carboxylic acids, such as
   perfluorooctanesulfonate (PFOS), ← **Added 2009** (Annex B)
   perfluorohexane sulfonate (PFHxS), ← **2018** (under consideration for listing)
   perfluorooctanoic acid (PFOA) ← **2018** (under consideration for listing)
5. **Hg** — mercury - mostly total mercury (THg)

Scope of the 2018 Effects Assessment

An assessment of the biological effects of organohalogen and mercury exposure in [Arctic wildlife and fish]



1. marine mammals

2. terrestrial mammals

3. seabirds

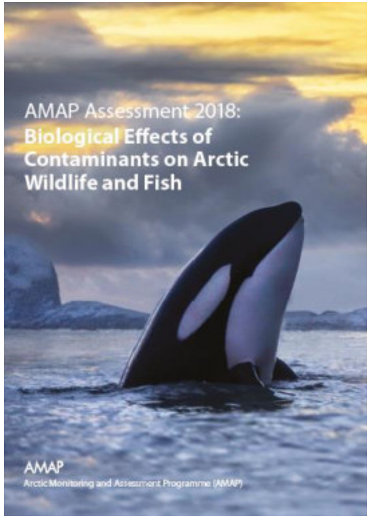
4. birds of prey

5. fish

Figure 1.1 Regions from which contaminant exposure and effect studies were available for the present assessment.

Regions from which contaminant exposure and effects studies were available

An assessment of the biological effects of organohalogen and mercury contaminants in Arctic wildlife and fish



1. **vitamin regulation and status***
   vitamines A, D, E, tocopherols, …
2. **enzyme activity***
   cytochrome P450s, …
3. oxidative stress
   reactive oxygen species
4. **hormone levels***
   thyroid and steroid hormones
5. reproduction
   egg shell thicknes, gonad size, …
6. DNA damage (genotoxicity)
   DNA strand breaks, telomer length, …
7. **immune system function***
   lymhocyte proliferation, interleukin expression, …
8. tissue pathology, skeleto- and histopathology
   liver and renal malformation, bone mineral density, …
9. neurotoxicity and behaviour
   cholinergic receptors, gamma-aminobutyric acid, …
10. bioenergetics
    basal metabliic rate, emaciation, …
11. blood clinical chemistry
    glucose, total proteins, alkaline phosphatase, …

All studies based on correlative relationships between POP tissue/blood & biomarker concentration –
Weight of Evidence only

***Indicates endpoints most commonly and consistently included in Arctic wildlife and fish studies since 2010.**

CAFF 11. OCT 2018

ECOTOXICOLOGY, WILDLIFE
MEDICINE AND HEALTH

DEPARTMENT OF BIOSCIENCE ROSKILDE
ARCTIC RESEARCH CENTRE
CENTER FOR ARCTIC HEALTH
AARHUS UNIVERSITY

CONTAMINANT EXPOSURE AND EFFECTS IN ARCTIC WILDLIFE

PHOTOS: RUNE DIETZ

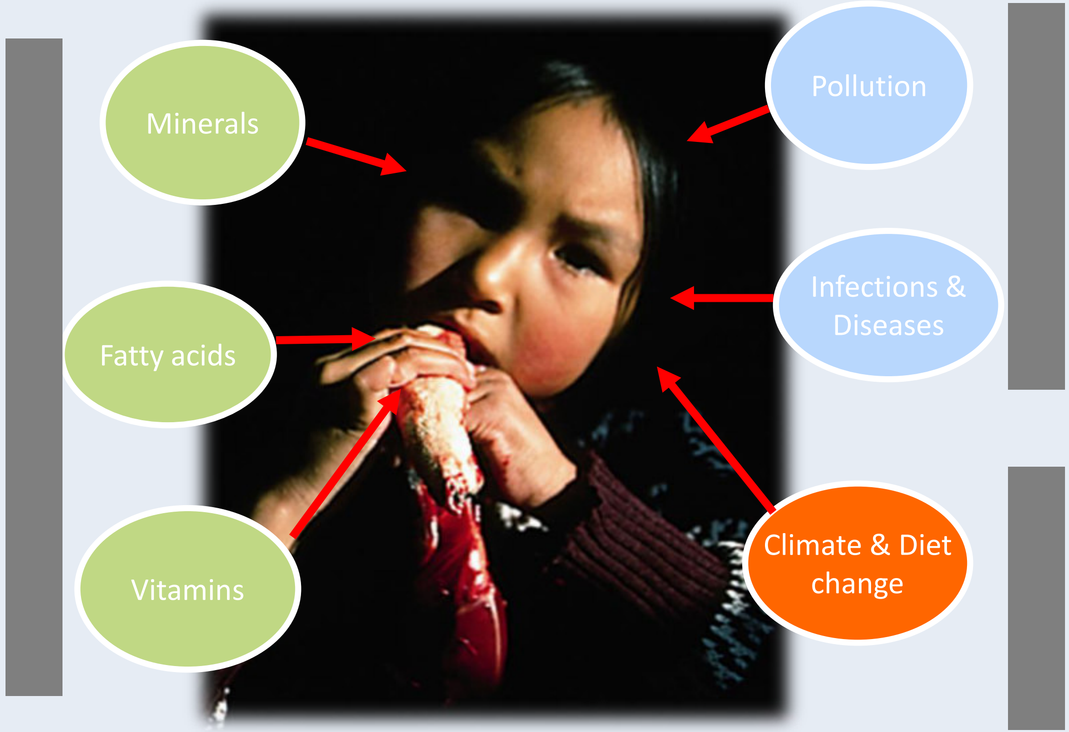
AMAP BACKGROUND: ONEHEALTH IN THE ARCTIC

Hg

PCB

resilience

AND fragility



POLAR BEARS

– ARE UNIQUE MONITORING ORGANIMS

Bioinformation
– reflecting the health of the environment

Pollution

Climate change

Diseases (zoonosis)

Bionics

… survival, culture and human health

GLOBAL IMPACT

- PUBLIC, SCIENCE & REGULATIONS

5.6 mill Google hits on "polar bear pollution"

… AND THE SAME FOR BIRDS

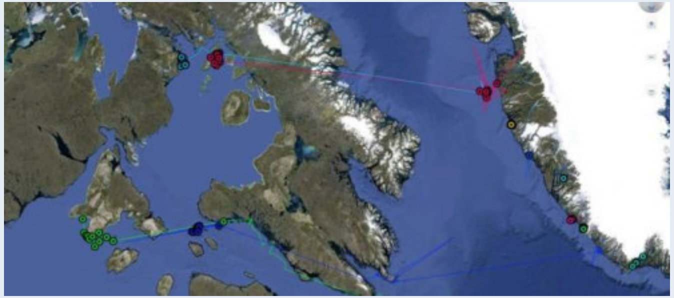
Pollution

Climate change

Diseases (zoonosis)

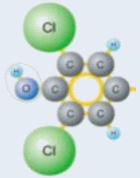
Bionics

… survival, culture and health

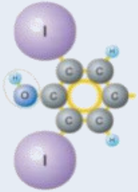


LONG-RANGE TRANSPORTED
TOXIC CHEMICALS

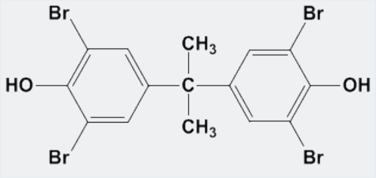
OH-PCB



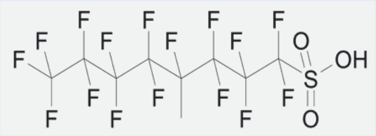
Thyroxin



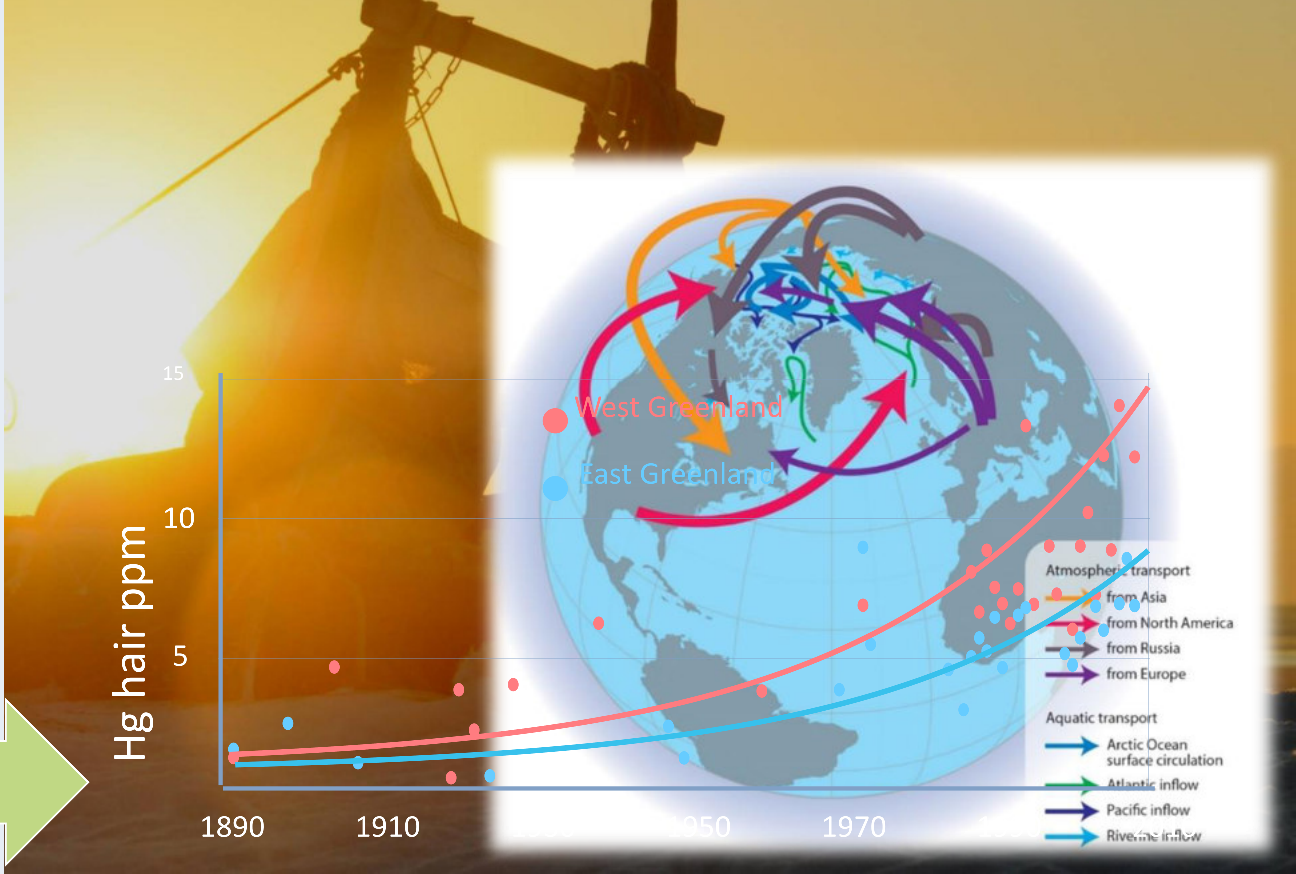
TBBP-A



PFAS



Me-Hg



PROBLEM: NEURO-ENDOCRINE DISRUPTION

Lactation transfer

THE LIST OF EFFECTS…

Endocrine glands

Sexual organs

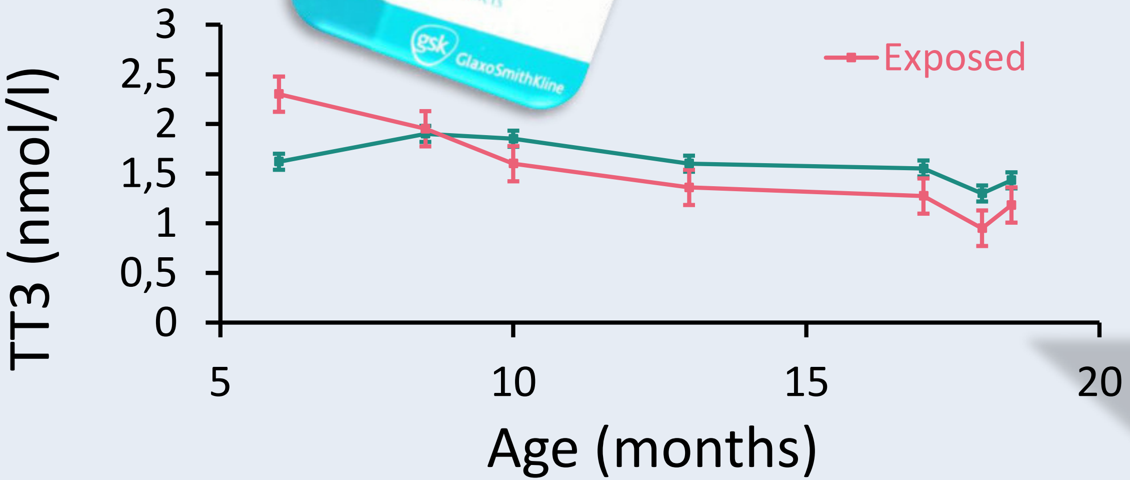
Liver and kidney

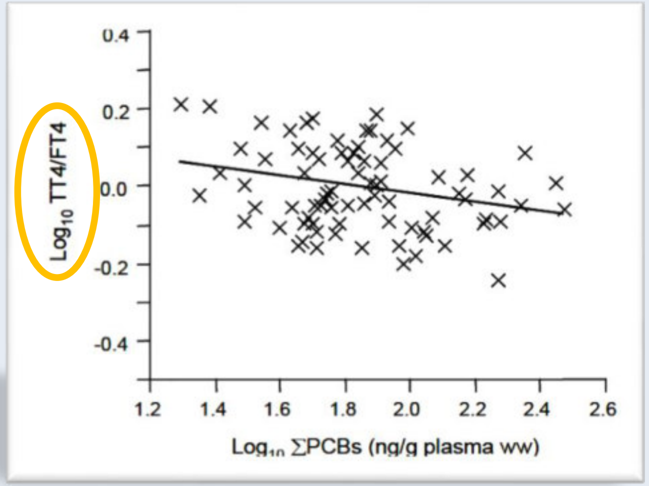
CNS

Immune system

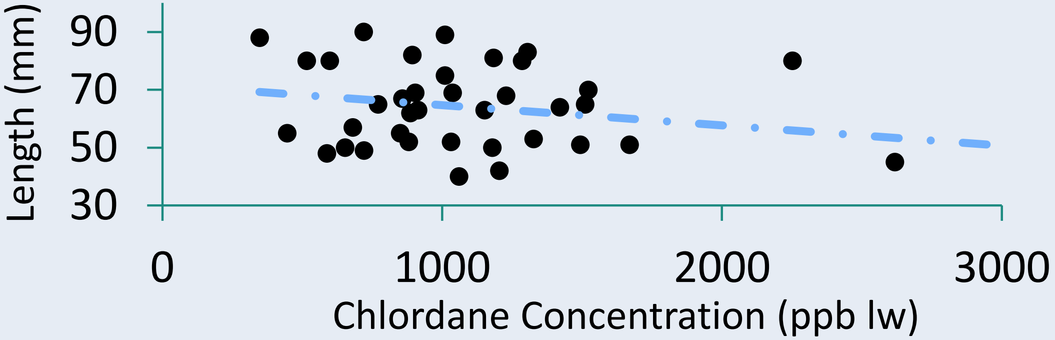
Bones

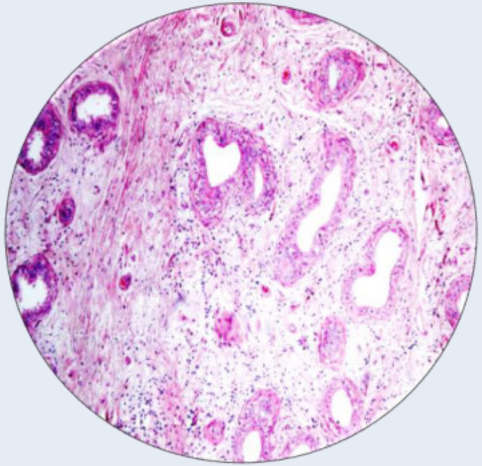
HYPOTHYROIDISM IN POLAR BEARS AND SLED DOGS

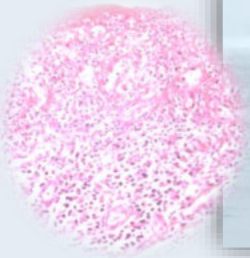




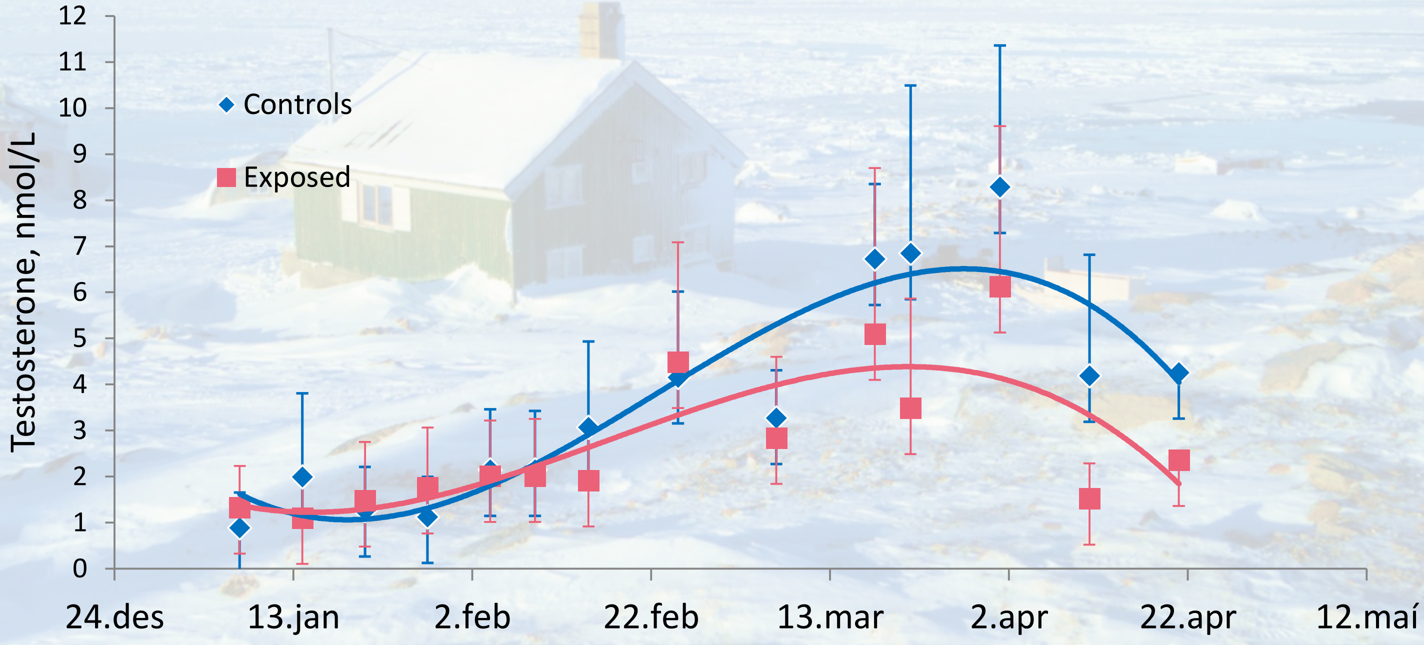
TESTICULAR DYSGENESIS SYNDROME: DO POLAR BEAR TESTICLES SHRINK?



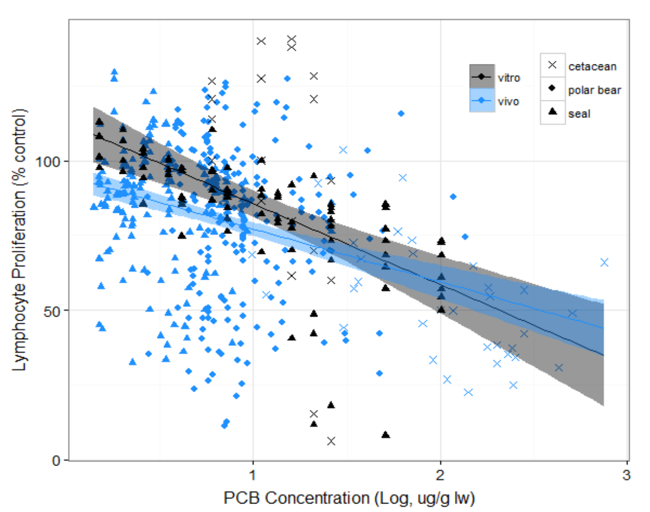


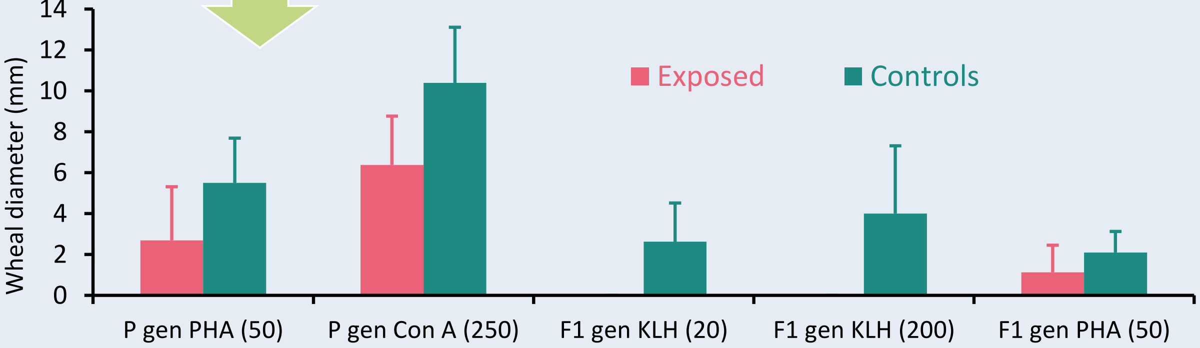


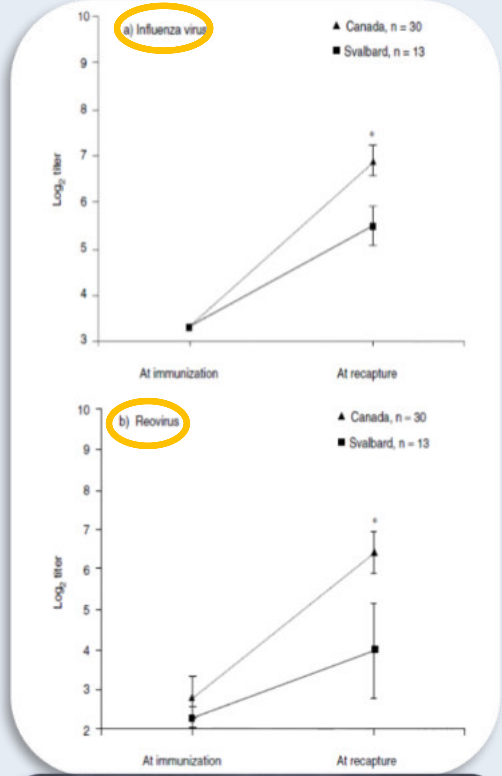
TESTOSTERONE PRODUCTION IN ARCTIC FOXES EXPOSED TO PCBs

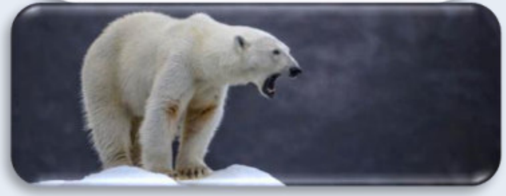


IMMUNE TOXICITY: SLED DOGS AND POLAR BEARS

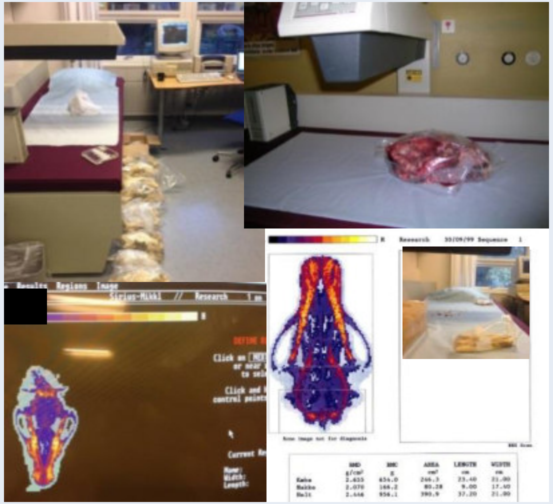


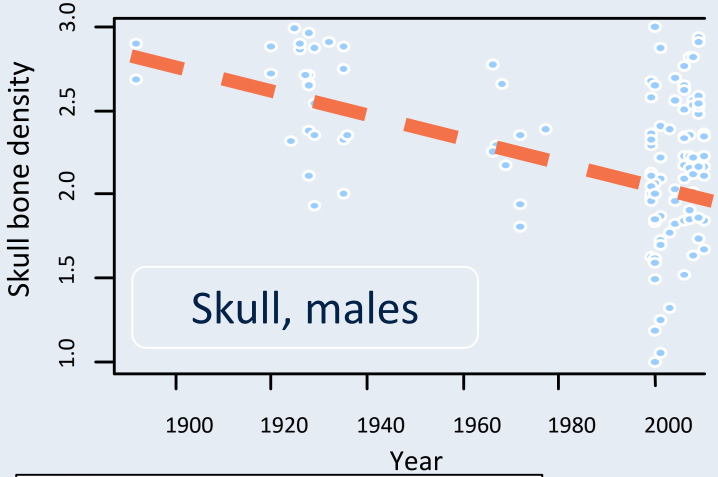


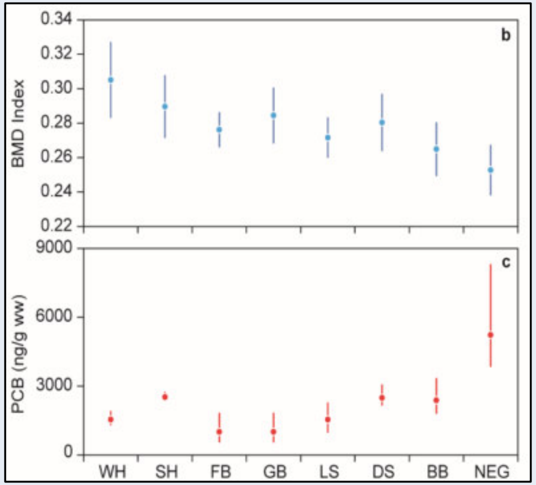


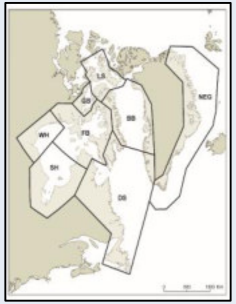


DO POLAR BEAR MALES HAVE OSTEOPOROSIS?





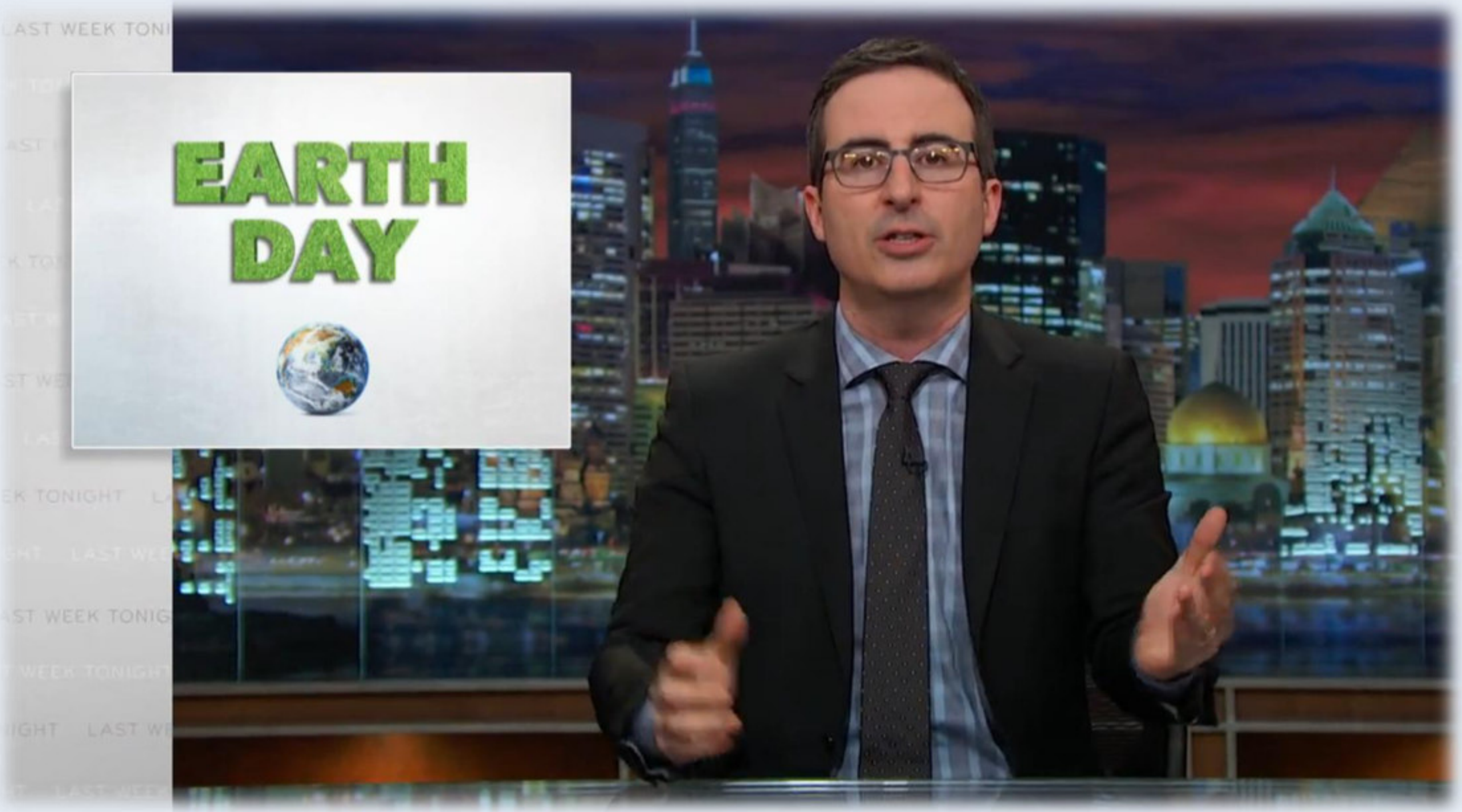




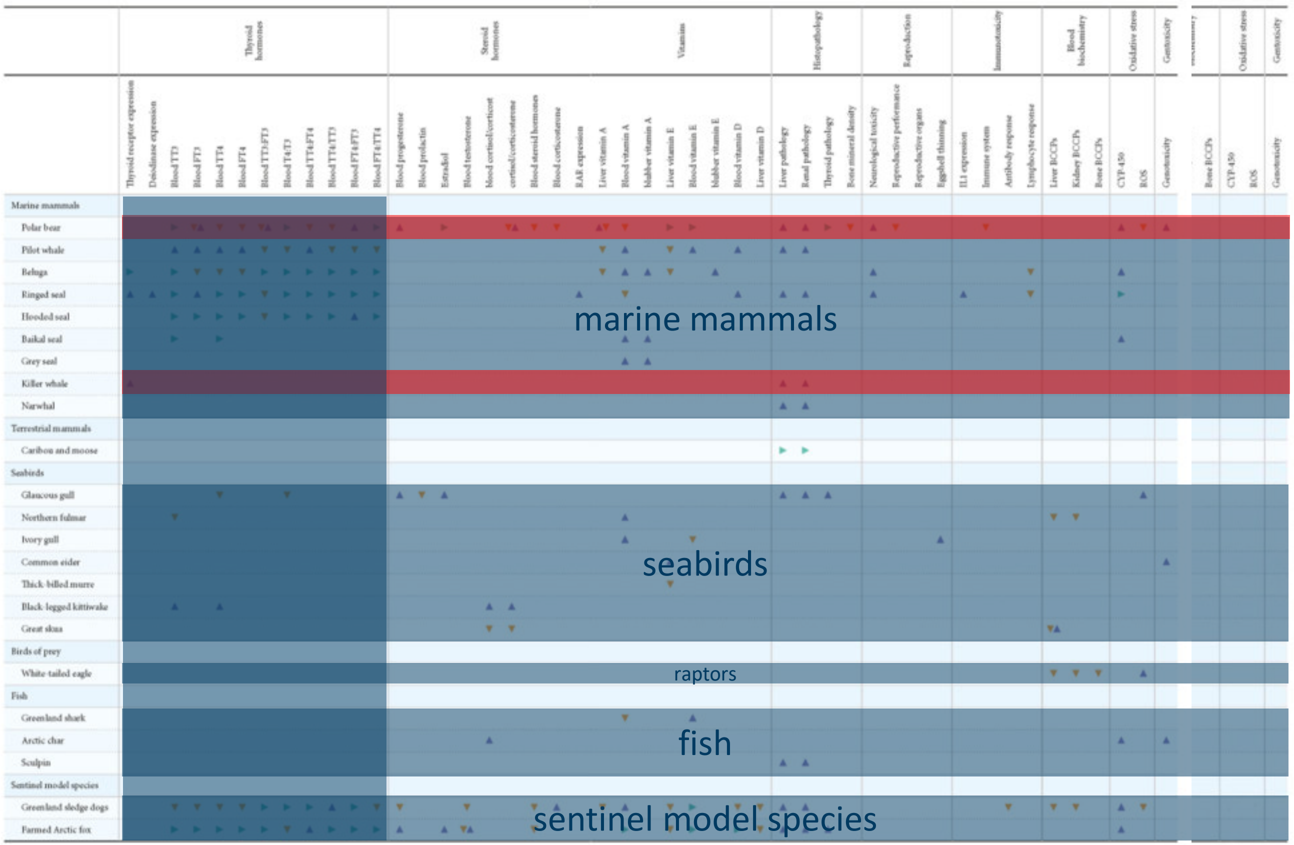
Bacula

The females are resilient

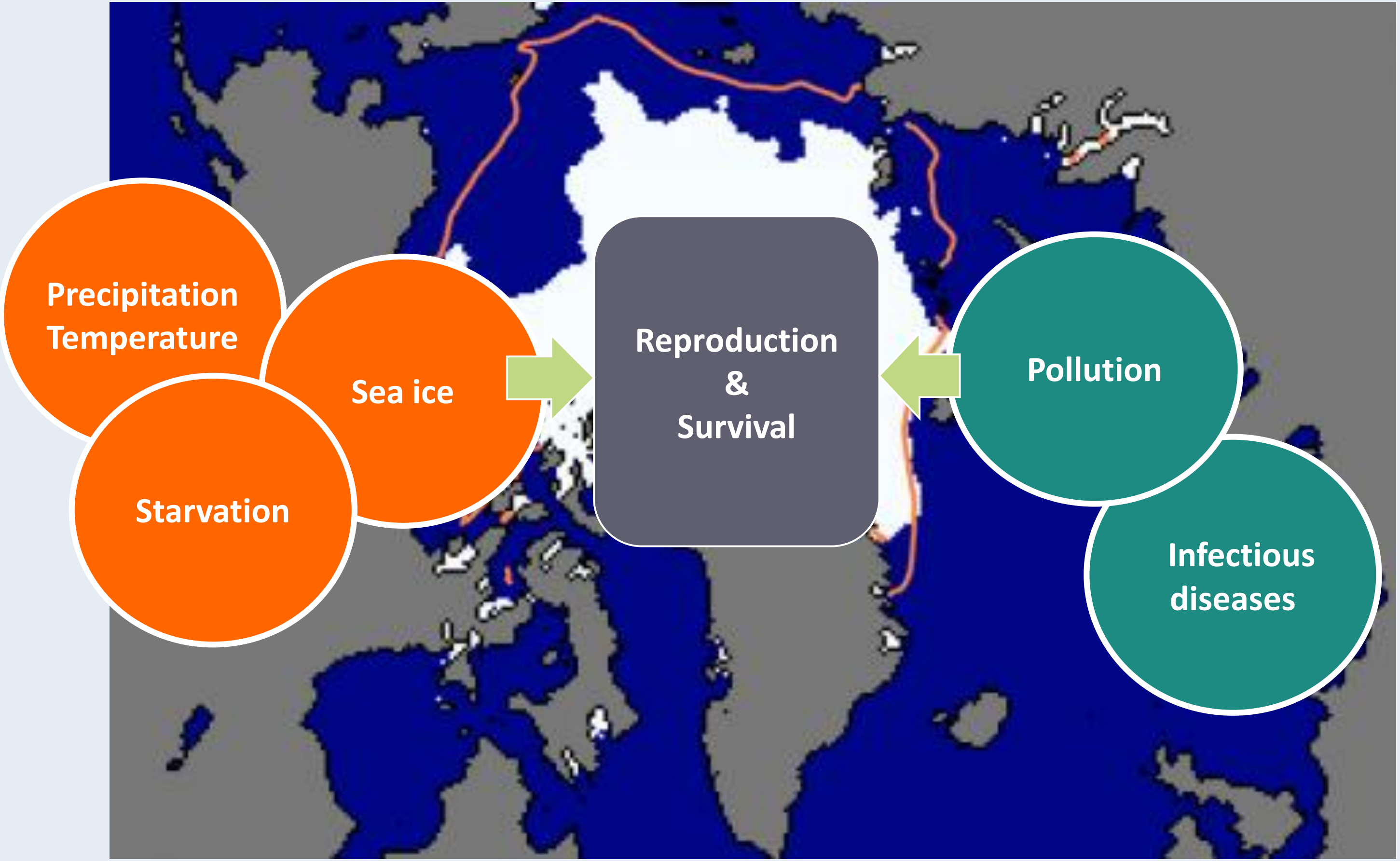
UNINTENDED BUT IMPORTANT OUTREACH (LAST WEEK TONIGHT SHOW)



TAKE A LOOK AT THE NEW ASSESSMENT!



AND KEEP AND EYE ON THE OTHER STRESSORS!!



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AMAP 2018:
Risk Evaluation of PCBs and Hg in Marine and Terrestrial Mammals and Birds

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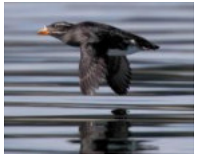
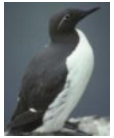
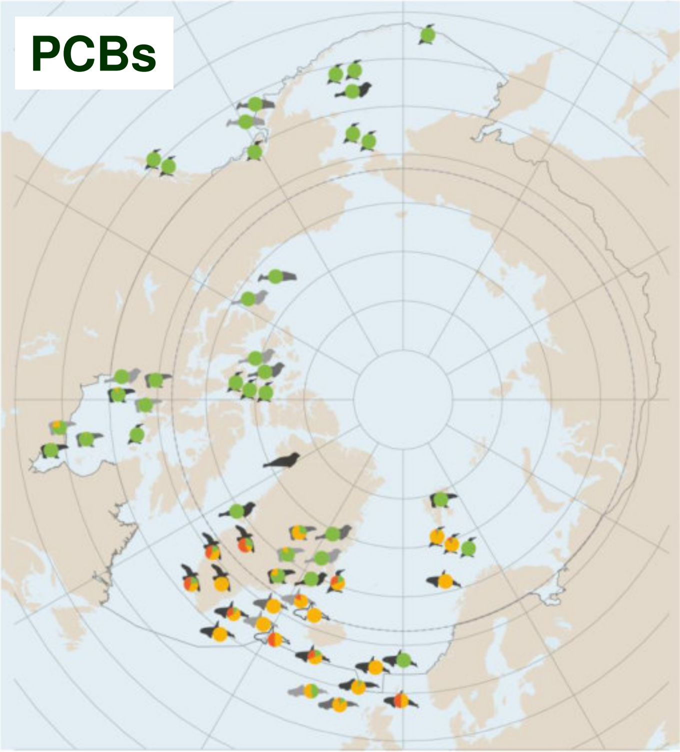




Arctic Biodiversity Congress,
Rovaniemi, Finland; Octpber 9-12, 2018

Risk Quotients (RQs) for Effects (on Immune and Hormone Levels) by PCBs in Marine Mammals/Seabirds and THg in Marine Mammals



RQ
<1
1-10
10-100

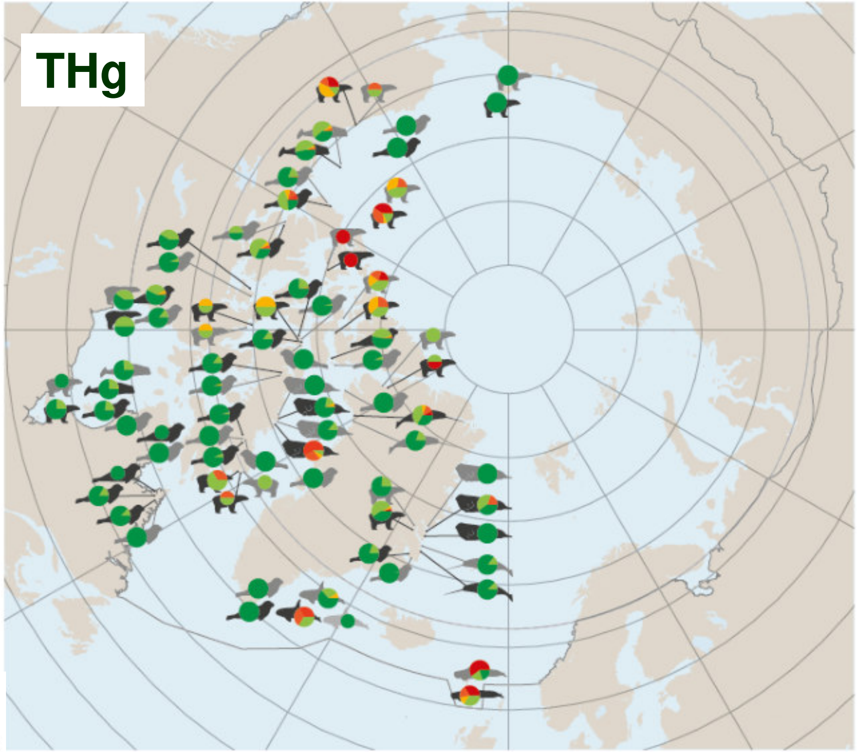
Age/sex
Adult female
Adult male
Subadults
Fetus

Species
Polar bear
Killer whale
Beluga
Pilot whale
Ringed seal
Seabirds









Hg-mediated risk
Severe risk
High risk
Moderate risk
Low risk
No risk

Maturity stage
Fetus
Juvenile
Adult

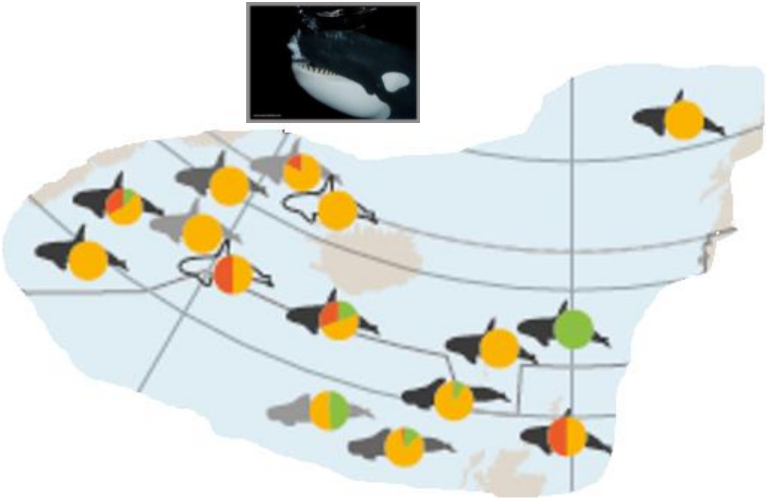
Species
Polar bear
Killer whale
Beluga
Pilot whale
Ringed seal
Narwhal
Harp/Hooded/
Bearded seal

Sample size
n<5
n>5

Risk Quotients (RQs) for Effects (on Immune system and reproduction) by PCBs in Marine Mammals and seabirds

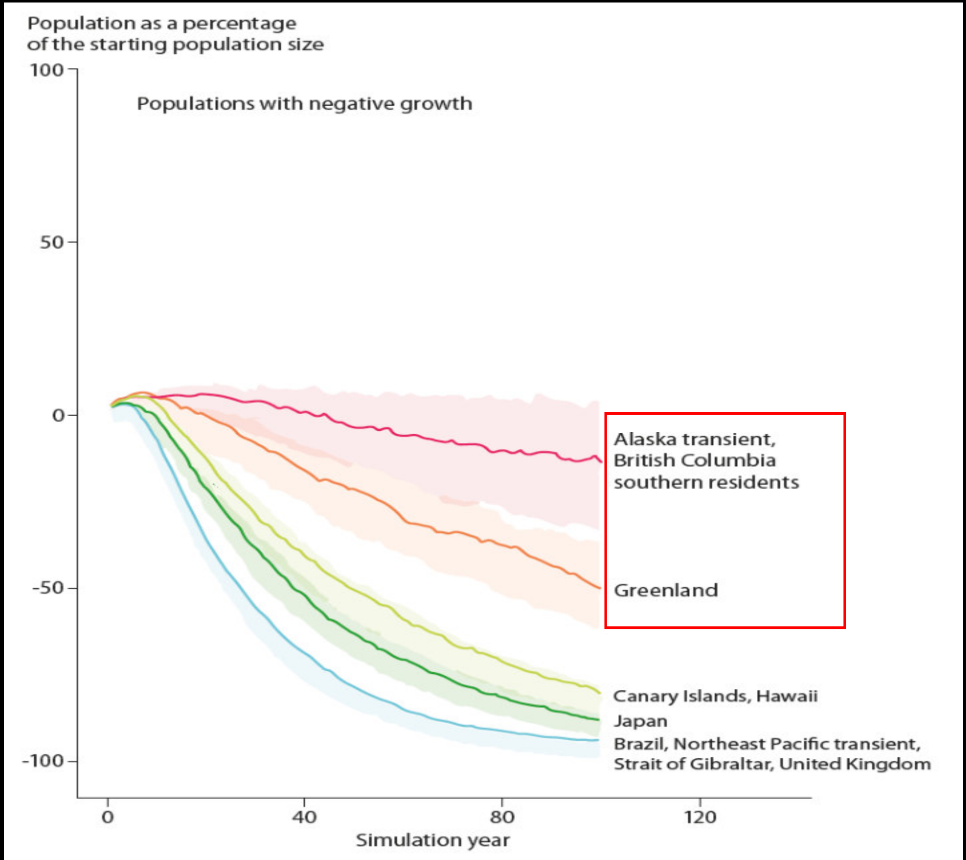
Species	Region	Years	Age/sex	RQs, %		
				<1	1–10	10–100
Toothed whales						
Killer whale	East Greenland	2012–2013	Ad Female	0	83	17
	East Greenland	2012–2013	Ad Male	0	100	0
	East Greenland	2012–2013	Sub-adult	0	100	0
	East Greenland	2012–2013	Fetus	0	100	0
	East Greenland	2013	Ad Male	0	100	0
	East Greenland	2012–2014	Ad Female	0	100	0
	East Greenland	2012–2014	Sub-adult	11	56	33
	East Greenland	2012–2014	Fetus	50	50	0
	Iceland	2003–2013		19	50	31
	Faroe Islands	2008		0	100	0
	Faroe Islands	2008	Ad and Sub-adult Female	100	0	0
	Shetland	2013		0	50	50
	Northern Norway	2002		0	100	0
Pilot whale	Faroe Islands	2001–2012	Immature	9	90	1
		2001–2007	Adult male	14	82	4
		2001–2011	Adult female	48	52	0

North Atlantic toothed whales killer whales and pilot whales



RQ	PCB Conc (µg/g lw)	Color
<1	<10 ppm	
1-10	10-100 ppm	
10-100	100-1000 ppm	

Population effects on killer whales



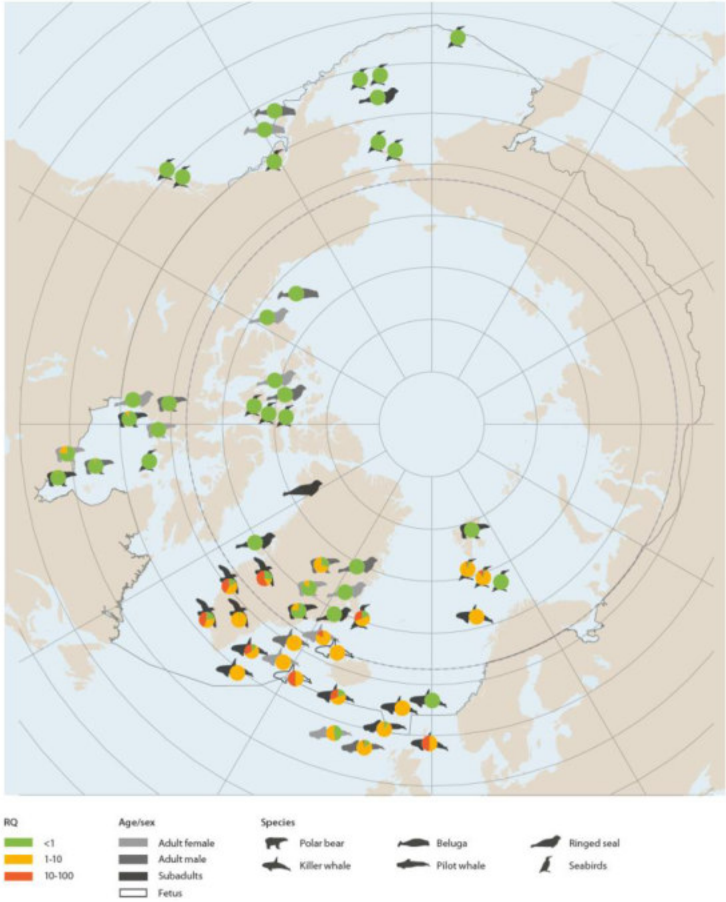
The good

the bad and

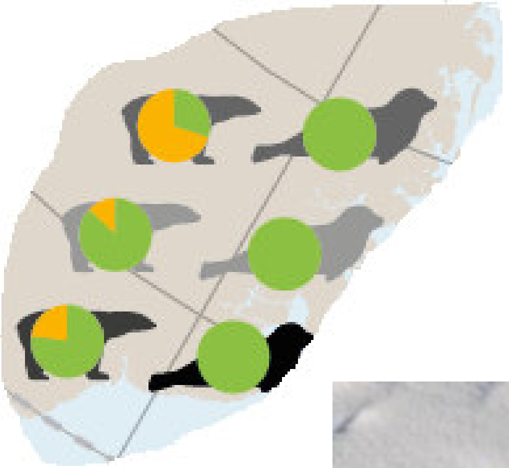
the ugly

Desforges et al. 2018 Science 361: 1373–1376

Risk Quotients (RQs) for Effects (on Immune system and reproduction) by PCBs in Marine Mammals and seabirds

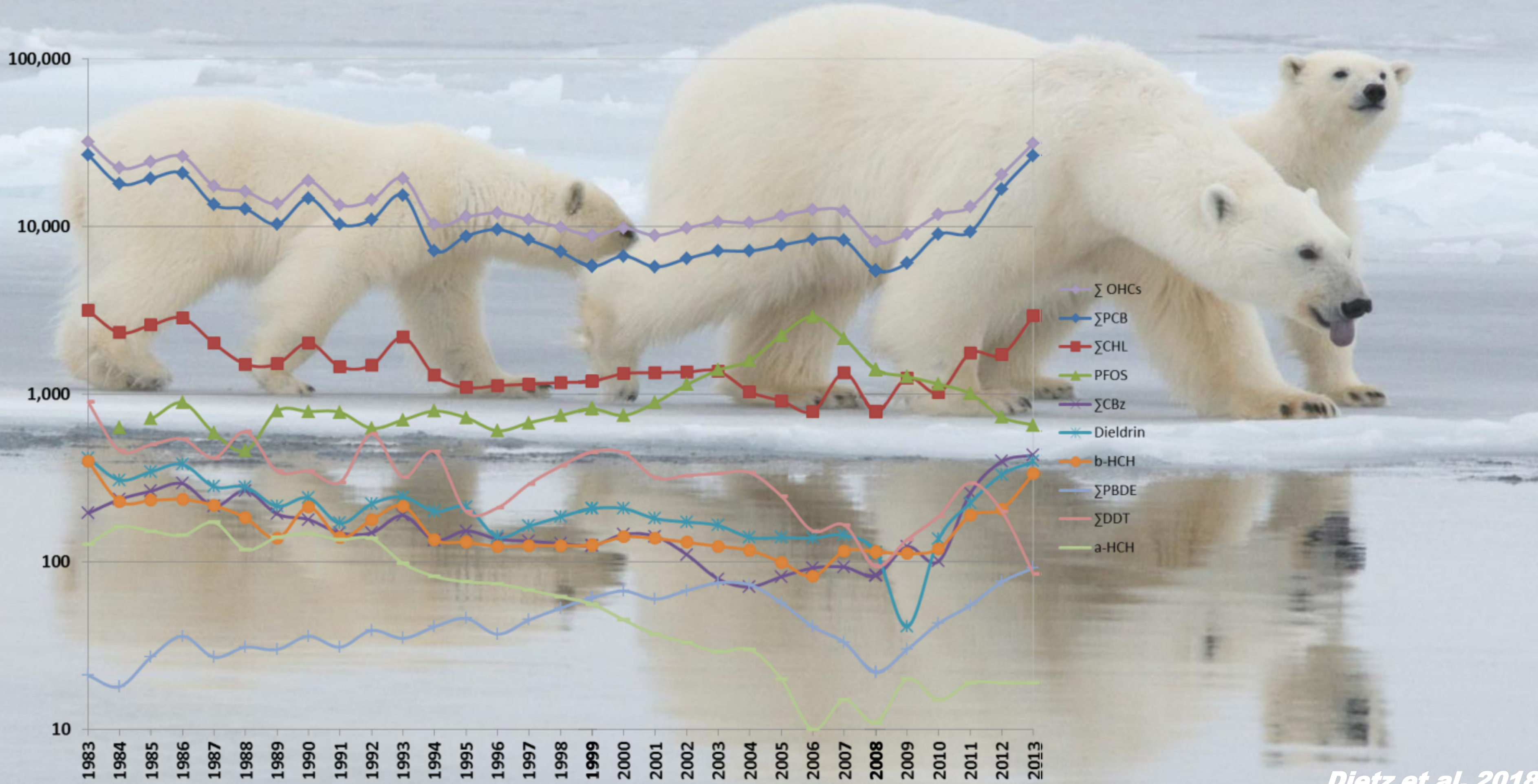


East Greenland polar bears



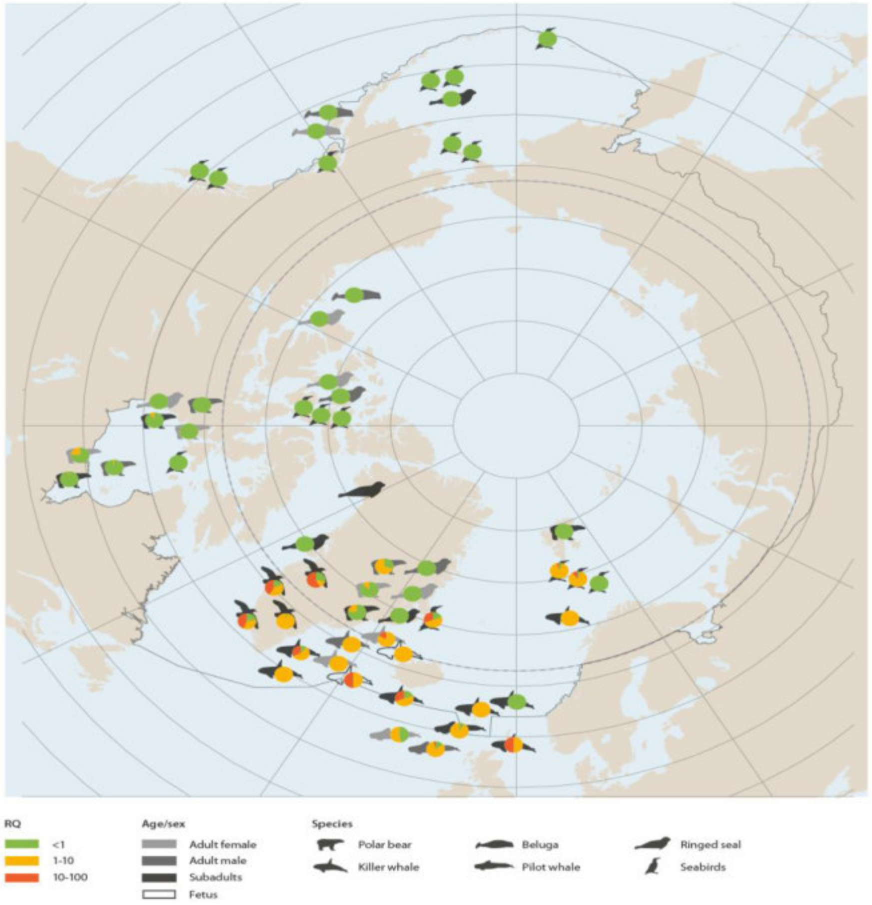
RQ	PCB Conc (µg/g lw)	Color
<1	<10 ppm	
1-10	10-100 ppm	
10-100	100-1000 ppm	

Risk qoutients over time in East Greenland juvenile bears



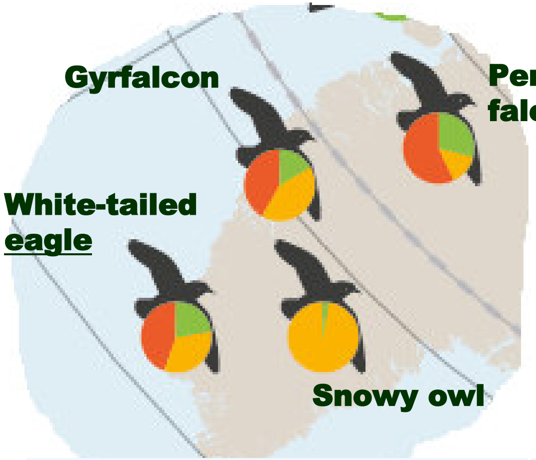
Dietz et al. 2018

Risk Quotients (RQs) for Effects (on Immune system and reproduction) by PCBs in Marine Mammals and seabirds



Greenland birds of prey

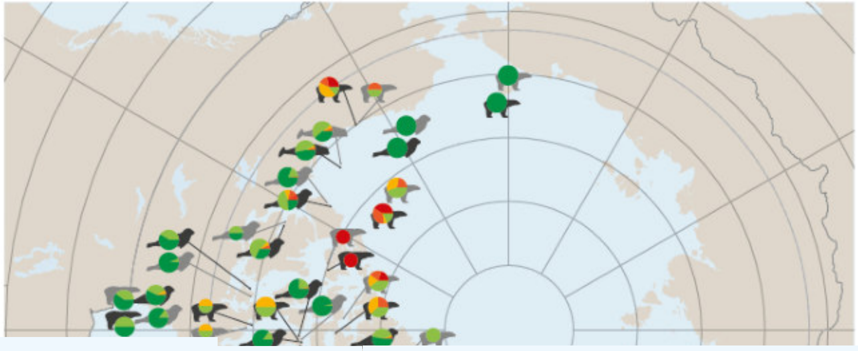
White tailed eagles, gyrfalcon, peregrin falcons and snowy owl



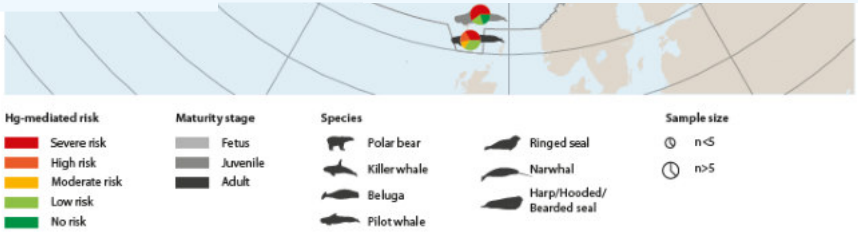
RQ	PCB Conc (µg/g lw)	Color
<1	<10 ppm	
1-10	10-100 ppm	
10-100	100-1000 ppm	

Species	Region	Years	RQs, % <1	RQs, % 1–10	RQs, % 10–100
Birds of prey					
White-tailed eagle	Southwest Greenland	2002–2013	22	33	44
Gyrfalcon	West Greenland	2001–2012	15	38	38
Perigrine falcon	West Greenland	2001–2012	29	14	57
Snowy owl	Greenland	2001–2008	83	17	0

Effects categories from THg in Marine Mammals
Killer whales and pilot whales

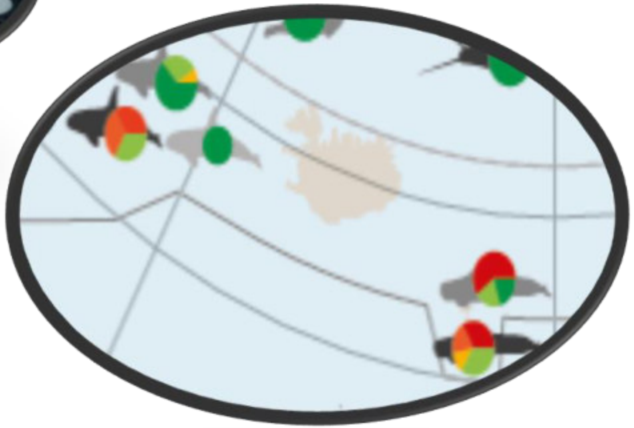


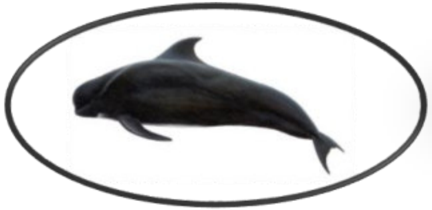
Pilot whale *Globicephala* spp.	Juvenile	20	20	0	0	60
	Adult	0	34	13	20	33
Killer whale *Orcinus orca*	Foetus	100	0	0	0	0
	Juvenile	63.6	27.3	9.1	0	0
	Adult	0	33	0	33	33



THg

Risk category	PCB Conc (µg/g lw)	Color
Severe Risk	≥ 126 ppm	
High risk	83-126 ppm	
Moderate risk	64-83 ppm	
Low risk	16-64 ppm	
No risk	≤ 16 ppm	



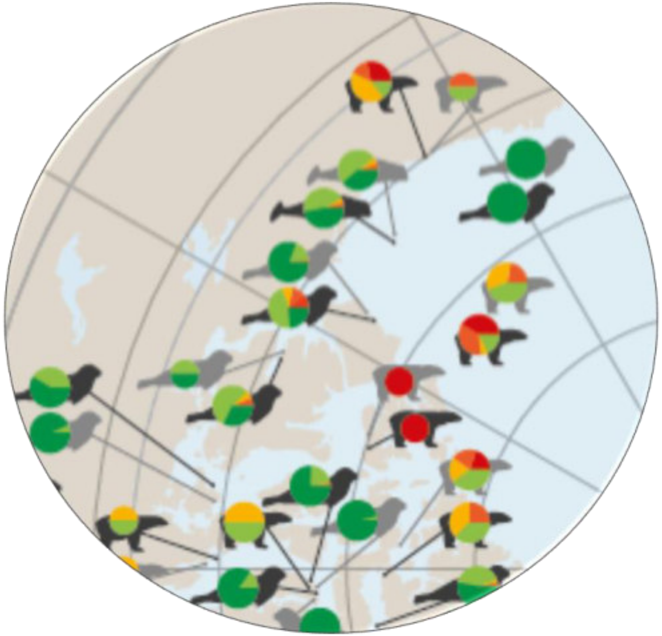


Effects categories from THg in Marine Mammals
Polar bear

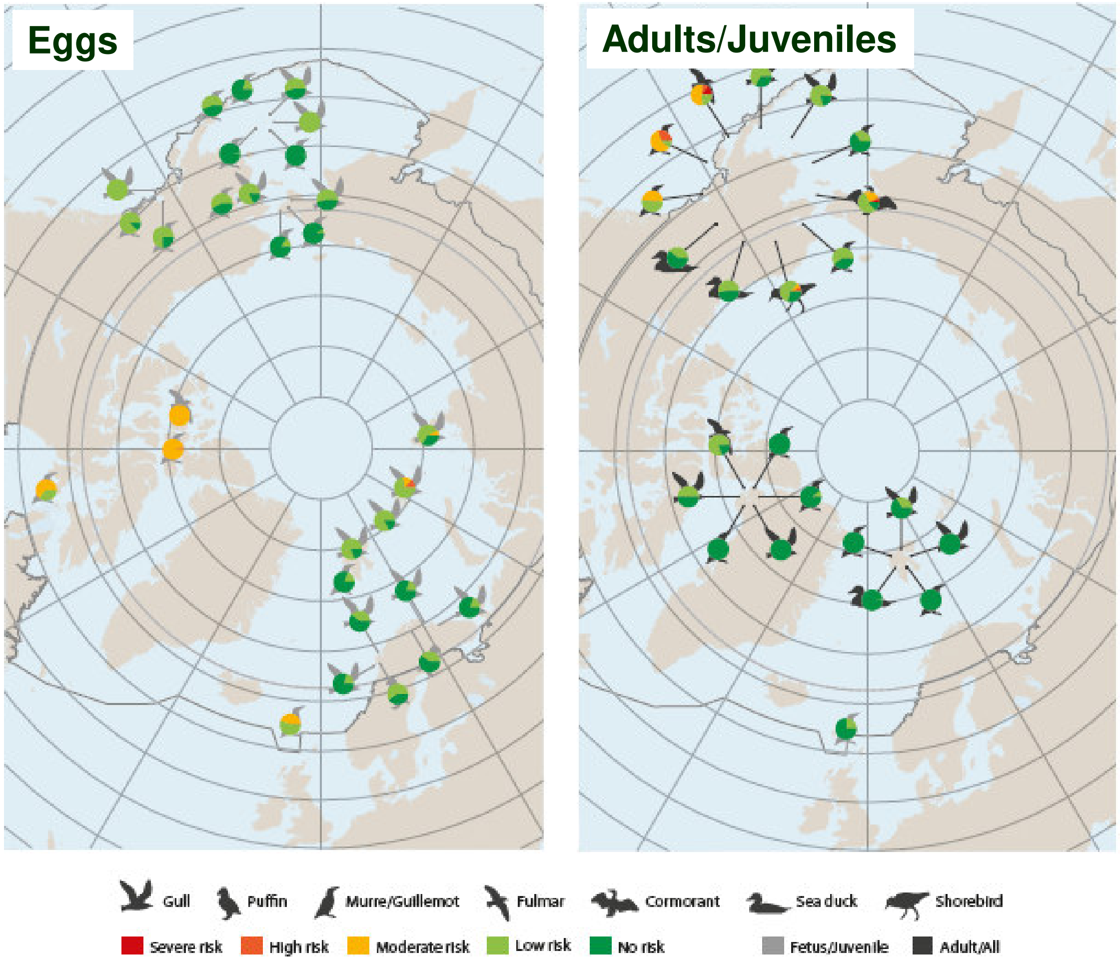
Region	Maturity	Risk category				
		<16	16–64	64–83	83–126	≥126
		No effect	Low risk	Moderate risk	High risk	Severe risk
Baffin Bay	Juvemile	33	50	17	0	0
	Adult	0	67	0	33	0
Chuckchi Sea	Juvemile	100	0	0	0	0
	Adult	100	0	0	0	0
Davis Strait	All	0	83	0	17	0
Gulf of Boothia	All	0	50	50	0	0
Lancaster/Jones Sound	Juvenile	0	40	20	20	20
	Adult	0	38	38	25	0
Northern Beaufort Sea	Juvenile	0	44	33	22	0
	Adult	0	18	6	35	41
Southern Beaufort Sea	Adult	0	14	43	14	29
Southern Hudson Bay	Adult	75	25	0	0	0
Western Hudson Bay	Juvenile	60	40	0	0	0
	Adult	50	50	0	0	0
Ittoqqortoormiit	Juvenile	76	24	0	0	0
	Adult	40	52	3	2	3

THg

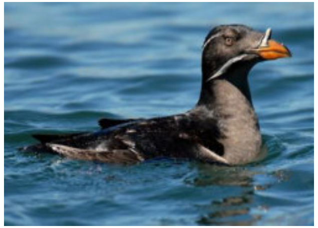
Risk category	PCB Conc (µg/g lw)	Color
Severe Risk	≥ 126 ppm	
High risk	83-126 ppm	
Moderate risk	64-83 ppm	
Low risk	16-64 ppm	
No risk	≤ 16 ppm	

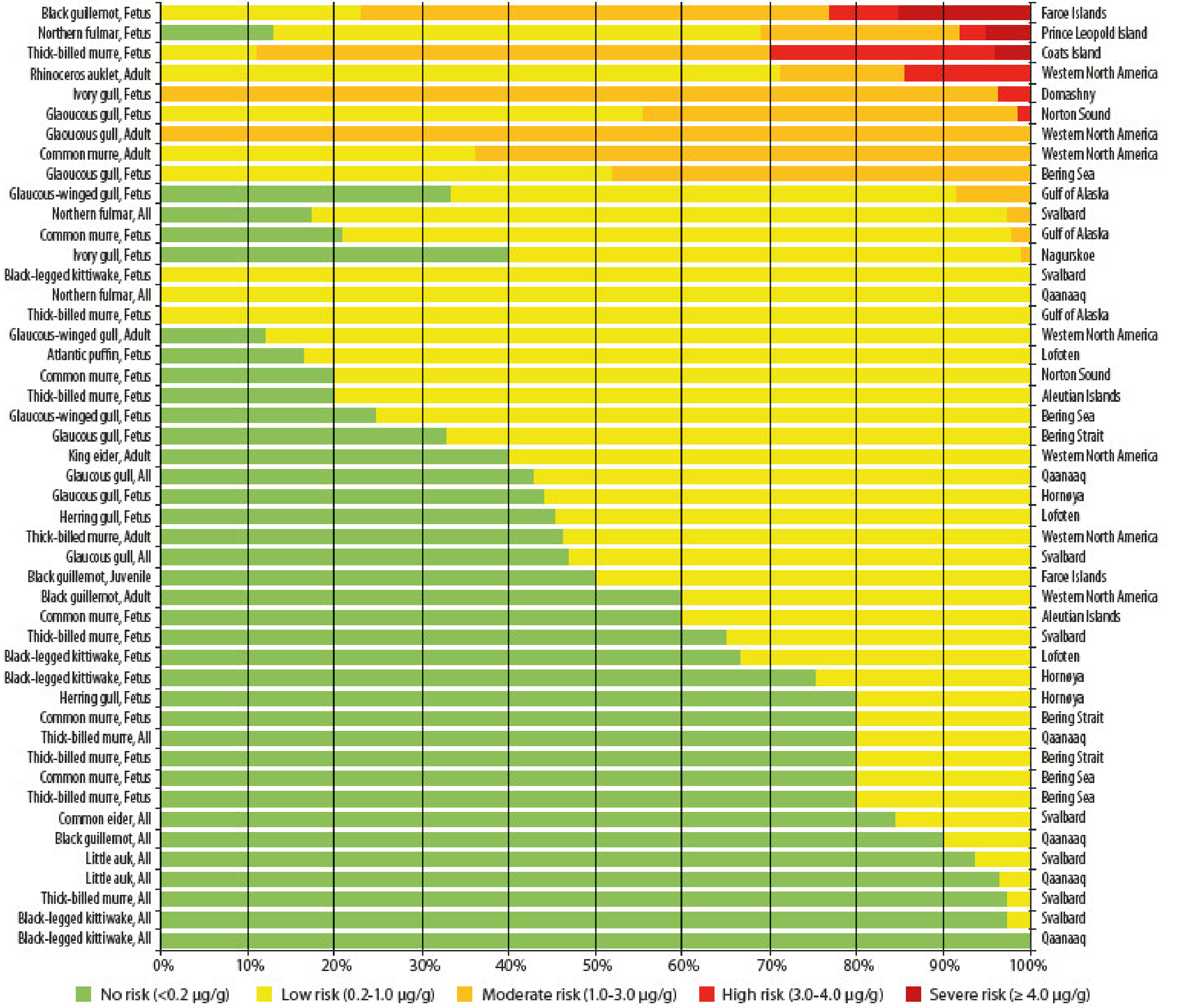


Risk Quotients (RQs) for THg-Mediated Effects on in Seabirds

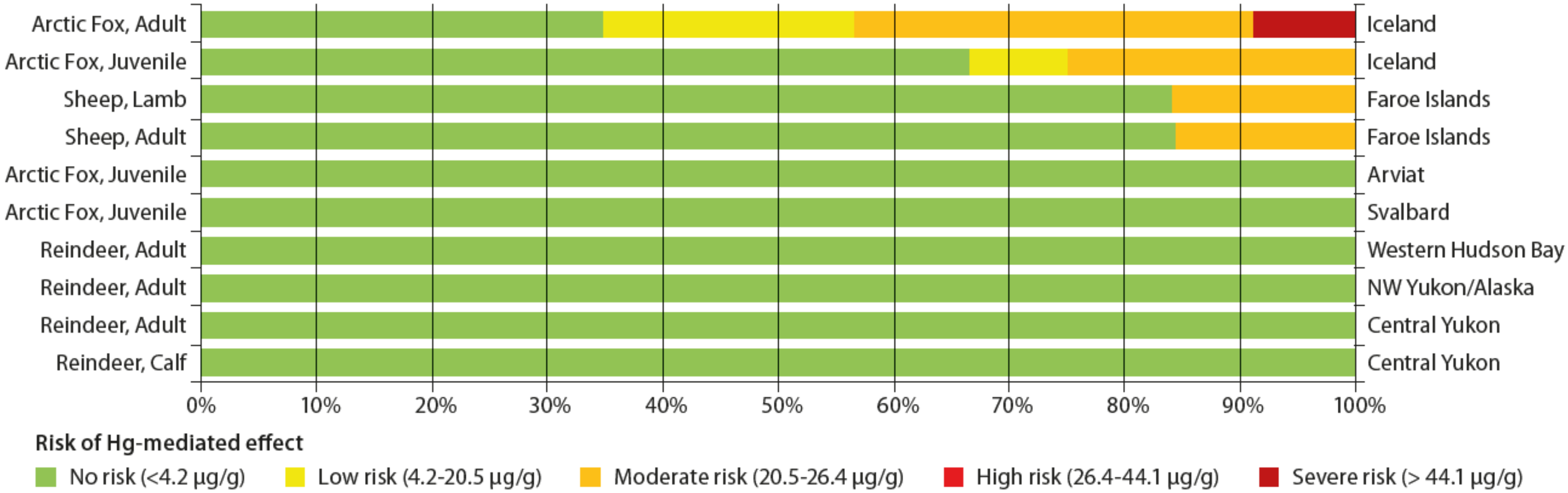


Effects categories from THg-Mediated effects on in Seabirds





Terrestrial mammals



Environment and Climate Change Canada   Environnement et Changement climatique Canada

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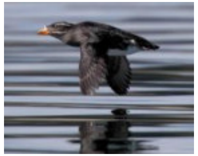
AMAP Arctic Monitoring and Assessment Programme

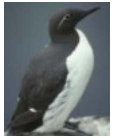
ARCTIC COUNCIL

AMAP 2018:
Contaminant Exposure, Pathways and Effects in a Changing Arctic

Rune Dietz[1], Robert J. Letcher[2], Igor Eulaers[1], Jean-Pierre Desforges[1], Christian Sonne[1]

[1] *Department of Environmental Science, Arctic Research Centre, Aarhus University, Roskilde, Denmark*
[2] *Ecotoxicology and Wildlife Health Division, Environment and Climate Change Canada, National Wildlife Research Centre, Carleton University, Ottawa, Ontario, Canada*





Arctic Biodiversity Congress,
Rovaniemi, Finland; Octpber 9-12, 2018

A rapidly multi-facetted changing environment

shipping

nutrition and foraging

infectious diseases

habitat change

tourism

pollutant exposure

hunt and harvest

climate change

A rapidly multi-facetted changing environment

THE GOOD

- neurology and behaviour
- homeostasis
- clinical health
- reproduction

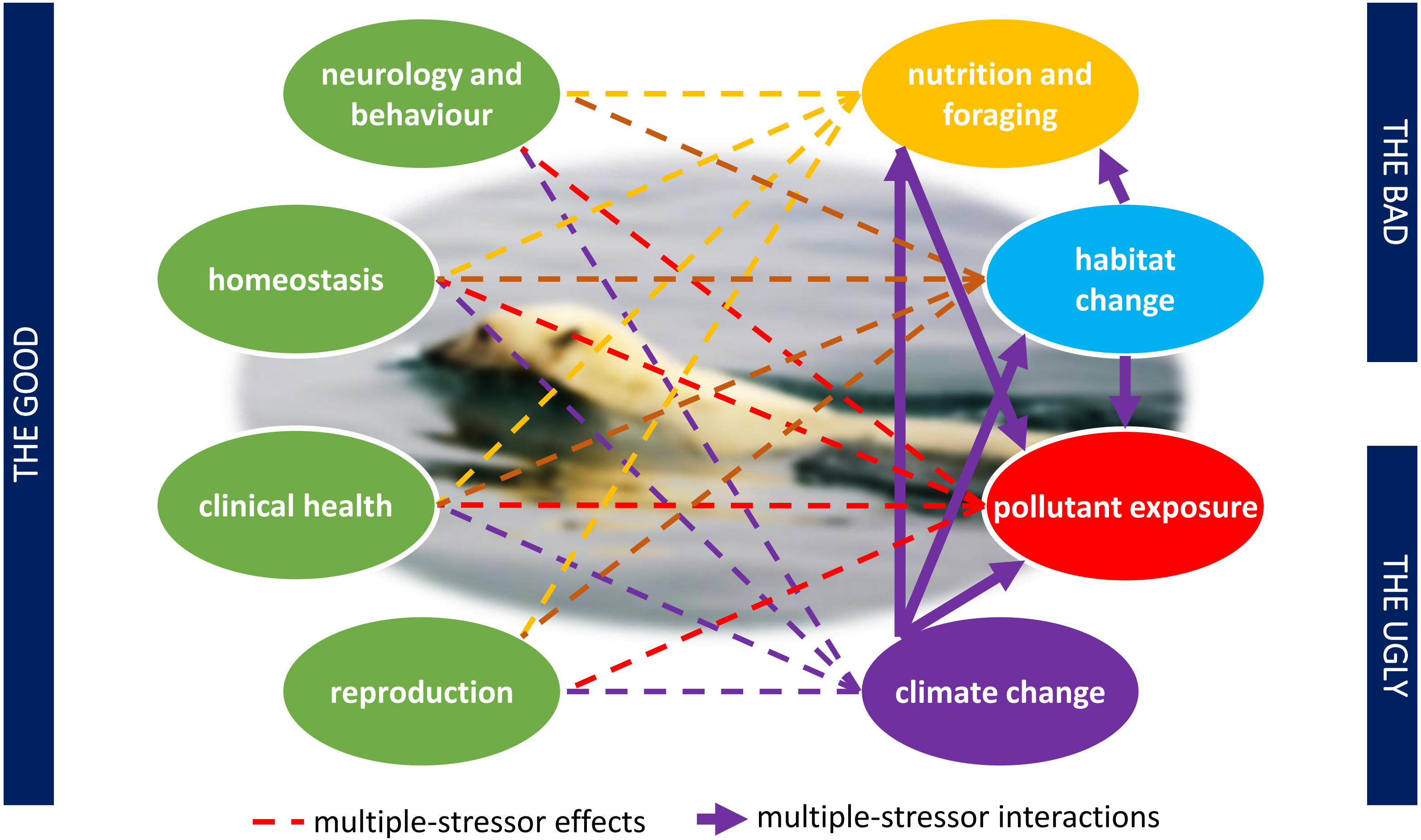
THE BAD

- nutrition and foraging
- habitat change

THE UGLY

- pollutant exposure
- climate change

When Arctic ecotoxicology becomes multiple-stressor ecology



A changing climate affects:

1. environmental pathways of contaminants
2. habitat properties resulting in changing exposure
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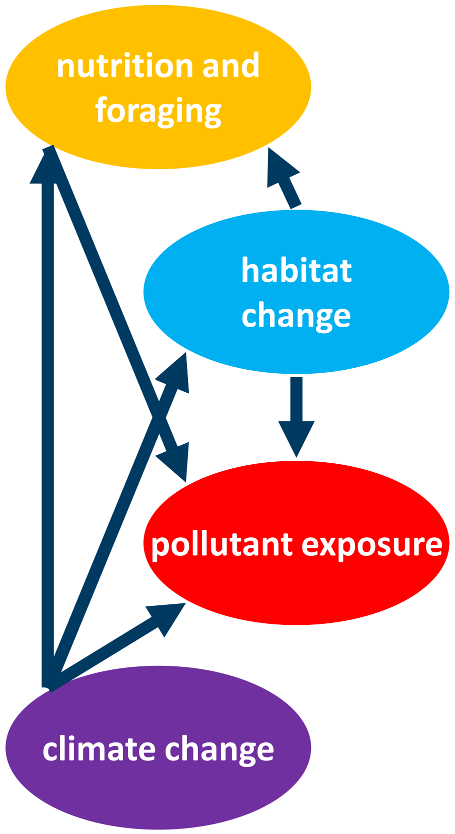

Modes of action of climate forcing on contaminant pathways and exposure

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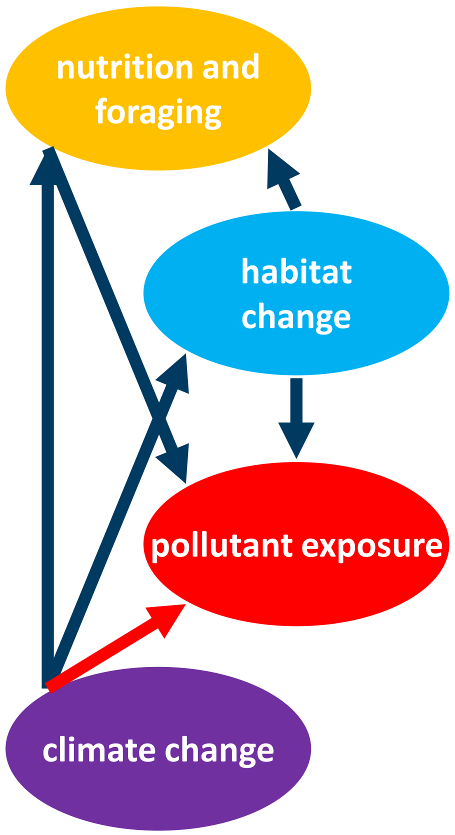
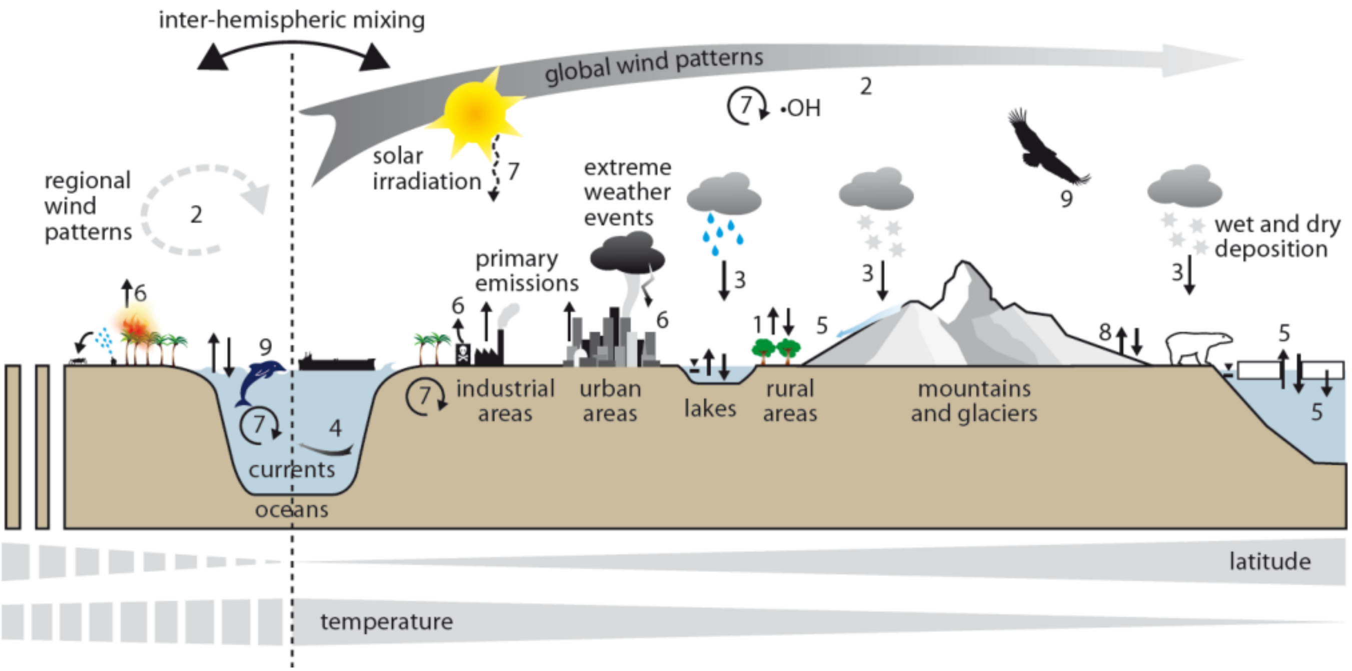


Changing environmental pathways of contaminants



1. secondary revolatisation
2. atmospheric dynamics
3. precipitation

4. ocean currents
5. melting of ice caps
6. extreme event frequency

7. degradation + transformation
8. environmental partitioning
9. biotic transport

UNEP/AMAP. 2011. Report of the UNEP/AMAP Expert Group

Modes of action of climate forcing on contaminant pathways and exposure

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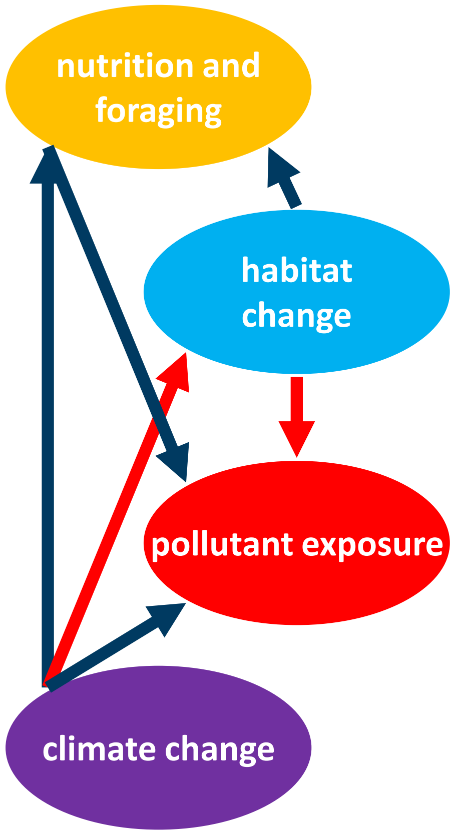
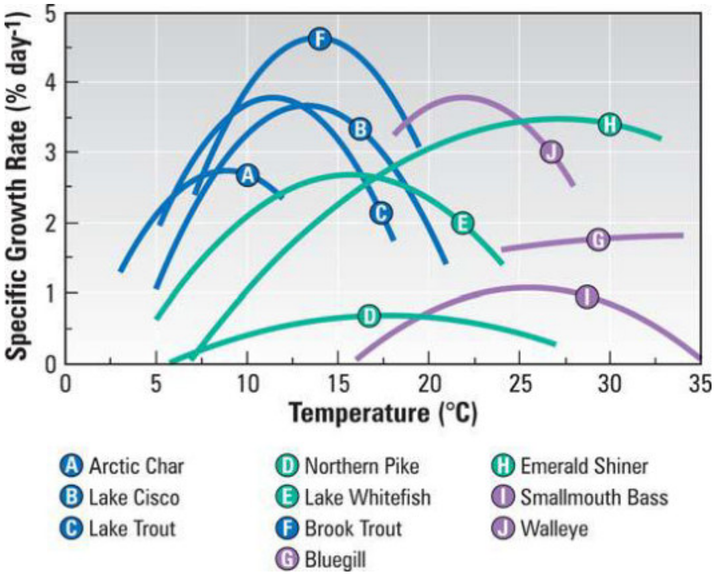
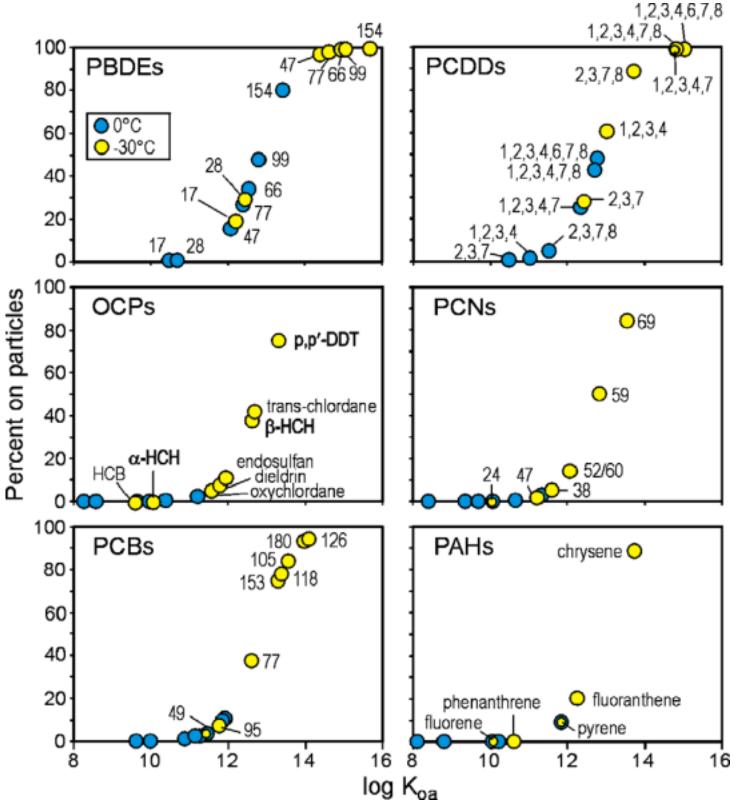


Changing habitat comes along with changing contaminant exposure

changing biological process



changing environmental chemistry



Macdonald et al. 2005. Sci. Total Environ. 342
Rejst et al. 2006. Ambio 35

Modes of action of climate forcing on contaminant pathways and exposure

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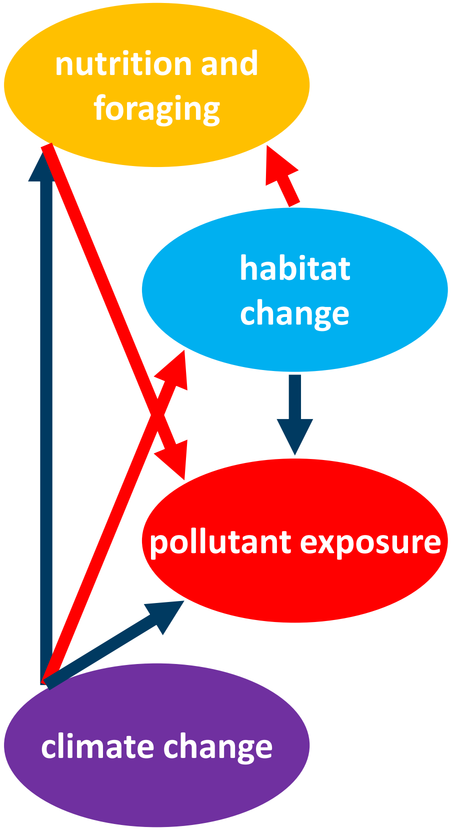
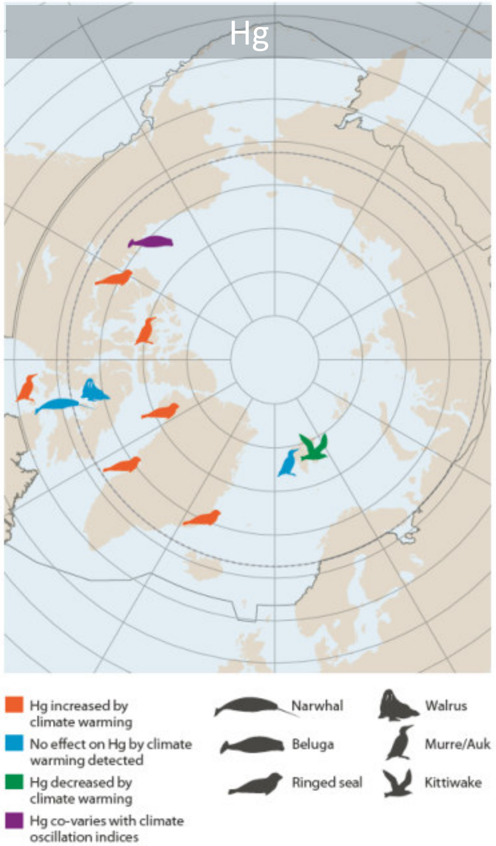
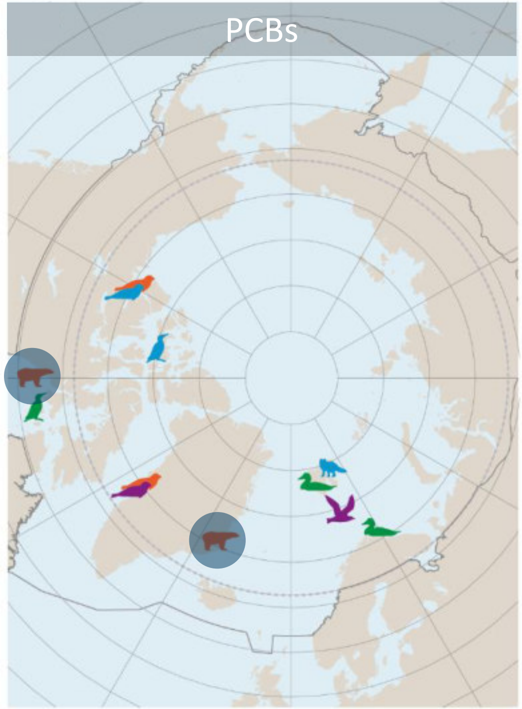


Changing habitats comes with changing dietary pathways of contaminants

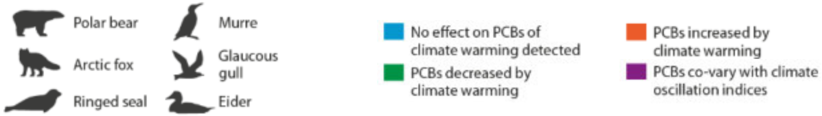


Changing habitats comes with changing dietary pathways of contaminants

species-specific case studies



Study species	Year	Location	Climate metric	Ecological change/variation	PCB/Hg Influence	PCB/Hg Variation/change	Reference
PCBs							
Terrestrial mammals							
Arctic fox	1997–2013	Svalbard	Sea-ice extent	Diet (marine vs terrestrial)	ΣPCB	↔	Andersen et al. 2015
Marine mammals							
Ringed seal	1993–2008	Eastern Amundsen Gulf	Sea ice break-up date	Prey availability or type	CB31, CB52, CB101, CB118, CB138, CB153, CB180	↑ in years of earlier break-up	Gaden et al. 2012
	1993–2008	Eastern Amundsen Gulf	Sea ice break-up date	Prey availability or type	CB28, CB105, CB156	↔	Gaden et al. 2012
	1994–2010	West Greenland	Arctic Oscillation, Ocean temperature, Salinity, Sea-ice cover	Prey availability or type	CB153 CB52, CB153	↑ in years of ↓ ice ↑ with ↑ AO or ↑ salinity (related to abiotic inputs)	Rigét et al. 2013
Polar bear	1991–2007	Western Hudson Bay	Sea ice break-up date	Diet (subarctic vs Arctic seals)	ΣPCB	↑ instead of ↓ trend	McKinney et al. 2009
	1984–2011	East Greenland	North Atlantic Oscillation	Diet (subarctic vs Arctic seals)	ΣPCB, CB170/CB190, CB180, CB153	Not significantly slower rate of ↓ trend	McKinney et al. 2013
Marine birds							
Glaucous gull	1997–2006	Bjørnøya	Arctic Oscillation	Possibly foraging region, diet or condition	ΣPCB	↑ in colder years (↓ AO), but ↑ if warmer the previous year (↑ AO), (possibly related to ↑ transport)	Bustnes et al. 2010
Common eider	2005–2009	Northern Norway and Svalbard	Air temperature	Body mass loss / lipid mobilization during fasting	CB153	↑ in circulating levels in colder years and in colder region (Svalbard)	Bustnes et al. 2012
Thick-billed murre	1975–2013	Canadian High Arctic			ΣPCB[illegible]		Braune et al. 2015
	1993–2013	Northern Hudson Bay	Sea-ice conditions	Diet (subarctic vs Arctic fish)	ΣPCB[illegible]	Faster rate of ↓ trend	Braune et al. 2015

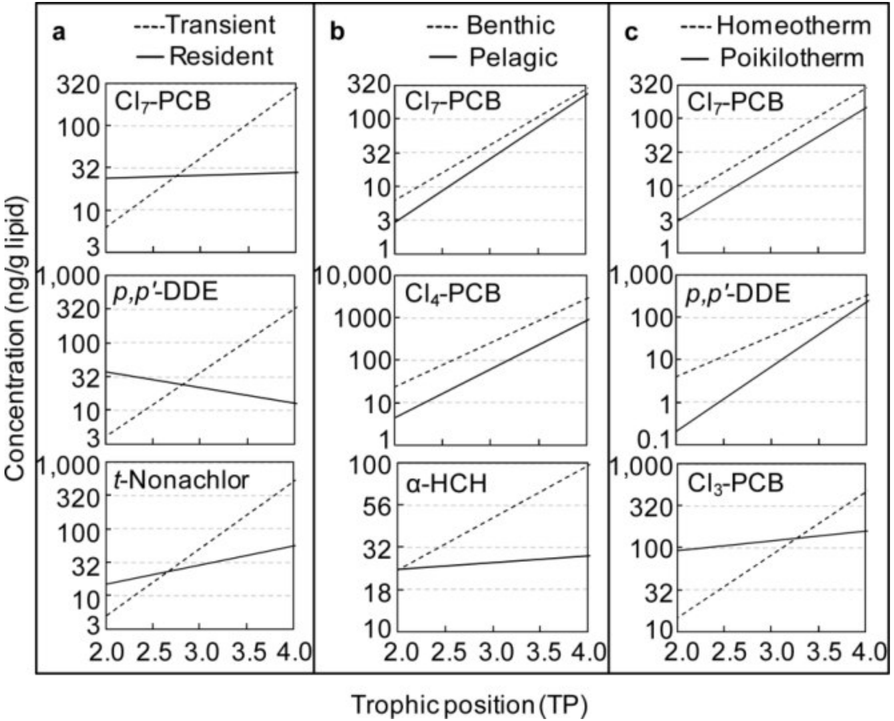


species-specific case studies

McKinney et al. 2009. Environ. Sci. Technol. 43
McKinney et al. 2013. Glob. Change Biol. 19

Changing habitats comes with changing dietary pathways of contaminants

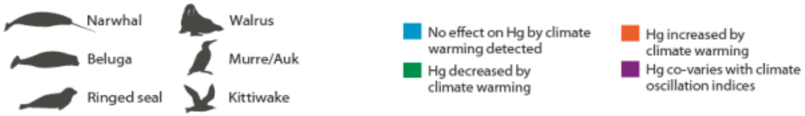
Food web case studies



McKinney et al. 2012. Environ Sci. Technol. 46

Changing habitats comes with changing dietary pathways of contaminants

Study species	Year	Location	Climate metric	Ecological change/variation	PCB/Hg Influence	PCB/Hg Variation/change	Reference
Hg							
Marine mammals							
Ringed seal	1994–2010	Central West, North West, and East Greenland	Arctic Oscillation, Ocean temperature, Salinity, Sea-ice cover	Prey availability or type	Total Hg	↑ in years of ↓ ice and/or ↑ AO (also possibly related to abiotic inputs)	Rigét et al. 2012
	1973–2007	Eastern Amundsen Gulf	Ice-free season length	Diet (Arctic cod amount and age classes)	Total Hg	↑ in both long and short ice-free seasons	Gaden et al. 2009
Atlantic walrus	1982–2008	Foxe Basin	North Atlantic Oscillation	None reported	Total Hg	↔	Gaden and Stern 2010
Beluga	1981–2012	Beaufort Sea	Arctic Oscillation, Pacific Decadal Oscillation, Sea-ice minimum	Unclear (possibly food web structure)	Total Hg	Variable, parallels PDO with 8-year time lag	Loseto et al. 2015
	1984–2008	Hudson Bay	North Atlantic Oscillation	Foraging region or diet	Total Hg	↓ parallels $\delta^{13}C$ ↓ in females	Gaden and Stern 2010
Narwhal	1993–2001	Foxe Basin	North Atlantic Oscillation	None reported	Total Hg	↔	Gaden and Stern 2010
Marine birds							
Black-legged kittiwake	2008–2009	Svalbard	Sea-ice cover	Diet (subarctic vs Arctic fish)	Total Hg	↓ in years of ↓ ice	Øverjordet et al. 2015
Little auk	2008–2009	Svalbard	None identified	None reported	Total Hg	↔	
Thick-billed murre	1975–2013	Canadian High Arctic	None identified	Diet (fish vs invertebrates)	Total Hg	Faster rate of ↑ trend	Braune et al. 2014
	1993–2013	Northern Hudson Bay	Sea-ice conditions	Diet (subarctic vs Arctic fish)	Total Hg	No trend instead of ↑ trend	Braune et al. 2014



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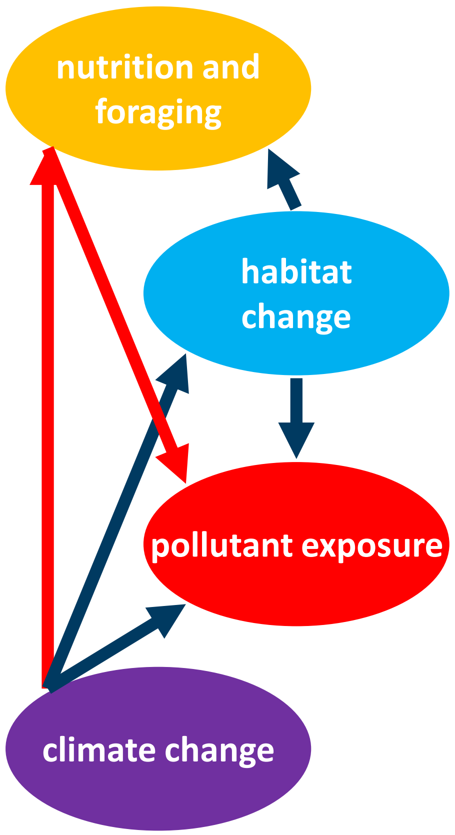
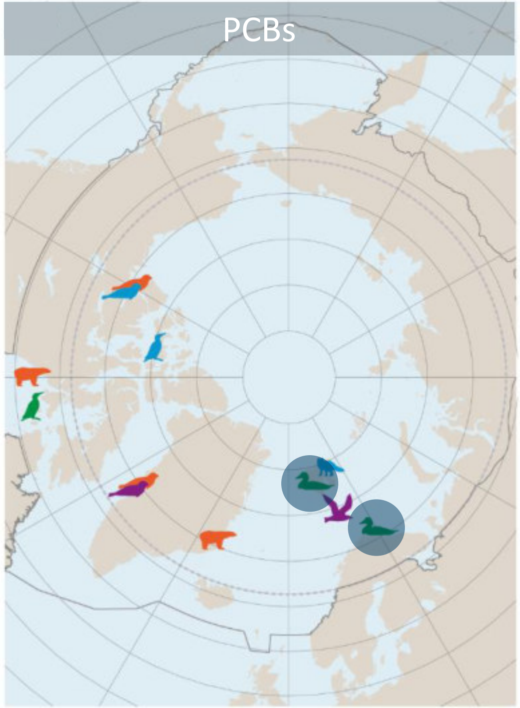


species-specific case studies



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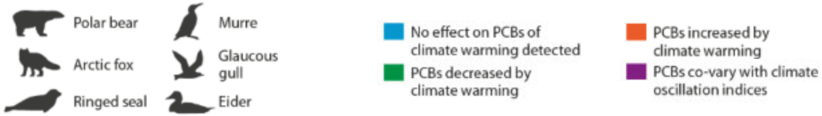
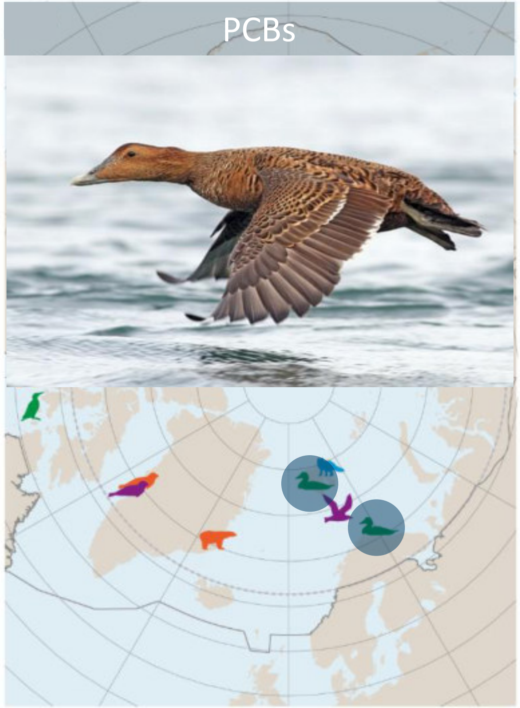
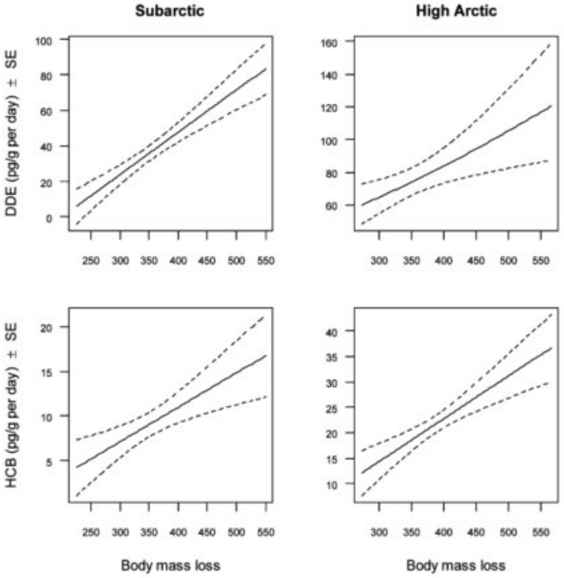


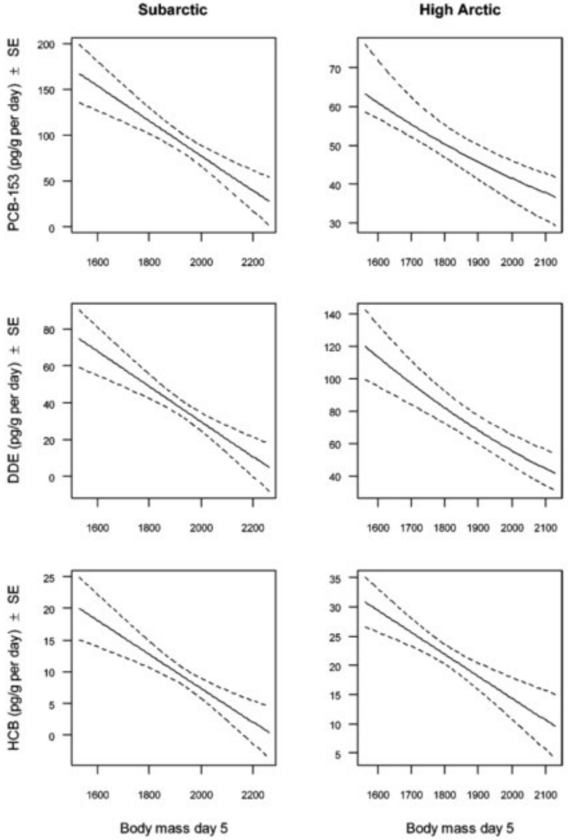
Effects of climate change on POPs exposure



fasting during breeding



condition at onset of breeding



Bustnes et al. 2012. Environ. Sci. Technol. 46

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AMAP 2018:

Highlights Findings, Key Messages & Priority Data and Knowledge Needs in the Future

Rune Dietz[1], Robert J. Letcher[2], Igor Eulaers[1], Jean-Pierre Desforges[1], Christian Sonne[1]

[1] *Department of Environmental Science, Arctic Research Centre, Aarhus University, Roskilde, Denmark*

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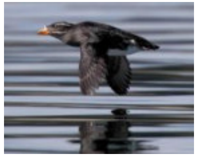
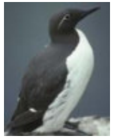
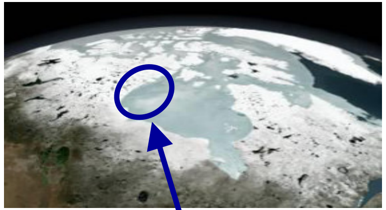
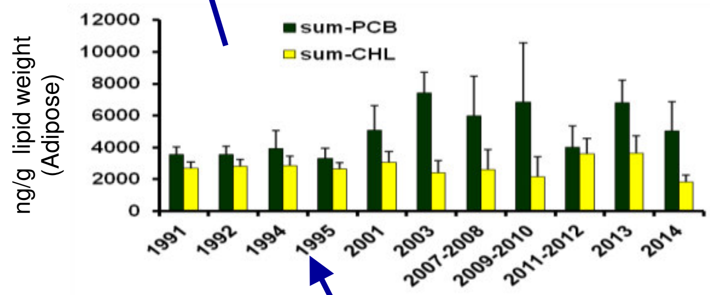


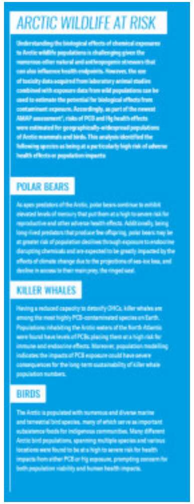


Arctic Biodiversity Congress,
Rovaniemi, Finland; Octpber 9-12, 2018

Some Highlight Findings (as of 2017)







- **Legacy chemicals (e.g. PCB, Hg) remain of high concern to Arctic biota**, and effects data has been reported for mainly these substances
- Depending on the species/population/tissue contaminant burdens, **exposure levels in key Arctic biota** (marine and terrestrial mammals, birds and fish) **can exceed putative risk threshold levels estimated** for non-target species and species from outside the Arctic
- **Populations of polar bears, killer whales and seabirds** (e.g. thick-billed murrres) presently at highest risk
- Based on PCB concentrations (as the dominant effect contributor for reproductive, immune and/or carcinogenic effects) and a conservative critical body residue for PCBs of 10 µg/g lw, risk quotients (RQ) were calculated and reported for the entire Arctic region and bordering waters
- RQs make it possible to summarize the cumulative effects of environmental contaminant mixtures for which critical body burdens can be estimated

KEY MESSAGES:
New and Lasting Impacts of Chemical Exposures in Arctic Wildlife and Fish

Key Message #1:

Legacy chemicals (e.g. PCBs) and mercury continue to pose a significant concern for Arctic biota

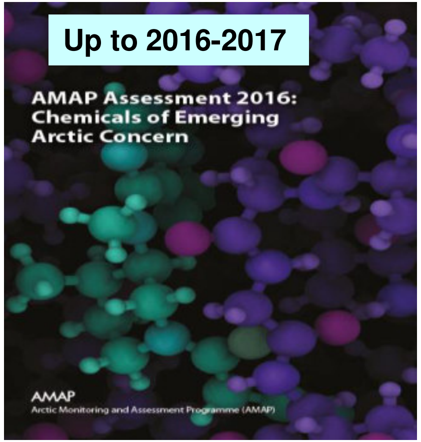
Key Message #2:

The suite of environmental contaminants found in many Arctic apex predators is expanding and may require new investigations of their potential biological effects

AMAP
Arctic Monitoring and Assessment Programme

Chemicals of Emerging Arctic Concern (CEACs)

Air, water, sediment, biota, wildlife



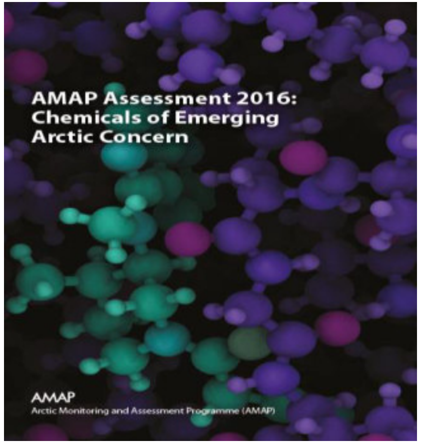
(Released Jan. 2018)

- **Per-/polyfluoroalkyl substances** (PFASs)
- **Brominated flame retardants** (BFRs) (incl. BDE-209)
- **New BFRs** (e.g. DBDPE, BTBPE)
- **Chlorinated FRs** (Dechlorane Plus and other Dechloranes)
- **Organophosphate esters** (OPEs, 20 types
- **Phthalates**
- **Short-chain chlorinated paraffins** (SCCPs)
- **Siloxanes**
- **Pharmaceuticals and personal care products** (PPCPs)
- **Polychlorinated naphthalenes** (PCNs)
- **Hexachlorobutadiene** (HCBD)
- **Current-use pesticides** (CUPs, 16 types)
- **Pentachlorophenol** (PCP) / **pentachloroanisole** (PCA
- **Organotins**
- **Polyaromatic hydrocarbons** (PAHs, 16 types)
- **"New" unintentionally generated PCBs**
- **Halogenated natural products** (HNPs)
- **Marine plastics and microplastics**

> 150 individual and 18 groups of substances

Chemicals of Emerging Arctic Concern (CEACs)

2010 - 2017



(Released Jan. 2018)

Biological and toxicological effects of CEACs – Chapter 3

- Up until 2017, at present there is essentially a total knowledge gap on CEAC linked biological or toxicological effects in Arctic biota

- Important recent reviews have been published recently on the (environmental) toxicology (in non-Arctic species) of the CEAC classes:
  - **Per-/polyfluoroalkyl substances** (PFASs)
  - **Brominated flame retardants** (BFRs)
  - **Chlorinated FRs** (Dechlorane Plus and other Dechloranes)
  - **Organophosphate esters** (OPEs)
  - **Phthalates**
  - **Siloxanes**
  - **Pharmaceuticals and personal care products** (PPCPs)
  - **Polychlorinated naphthalenes** (PCNs)
  - **Organotins**
  - **Polyaromatic hydrocarbons** (PAHs, 16 types)
  - **Marine plastics and microplastics**

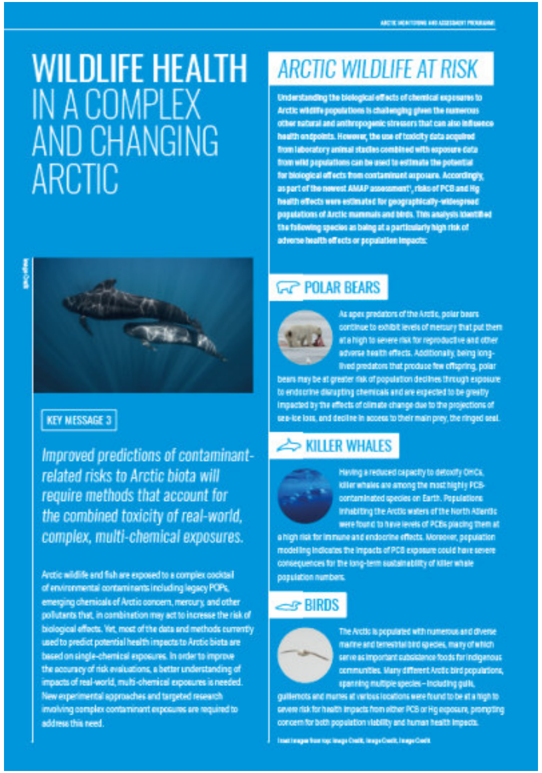
These non-Arctic species reviews showed information suggestive of mechanisms and modes of action and adverse outcome pathways of effects and impacts for Arctic biota

KEY MESSAGES: New and Lasting Impacts of Chemical Exposures in Arctic Wildlife and Fish

<u>Key Message #3:</u>

Improved predictions of contaminant-related risks to Arctic biota will require methods that account for the combined toxicity of real-world, complex, multi-chemical exposures

Also, changes in food web structure relationships e.g. changes and degradation of <u>Arctic biodiversity</u>



ARCTIC MONITORING AND ASSESSMENT PROGRAMME

WILDLIFE HEALTH IN A COMPLEX AND CHANGING ARCTIC

KEY MESSAGE 3

Improved predictions of contaminant-related risks to Arctic biota will require methods that account for the combined toxicity of real-world, complex, multi-chemical exposures.

Arctic wildlife and fish are exposed to a complex cocktail of environmental contaminants including legacy POPs, emerging chemicals of Arctic concern, mercury, and other pollutants that, in combination may act to increase the risk of biological effects. Yet, most of the data and methods currently used to predict potential health impacts to Arctic biota are based on single-chemical exposures. In order to improve the accuracy of risk evaluations, a better understanding of impacts of real-world, multi-chemical exposures is needed. New experimental approaches and targeted research involving complex contaminant exposures are required to address this need.

ARCTIC WILDLIFE AT RISK

Understanding the biological effects of chemical exposures to Arctic wildlife populations is challenging given the numerous other natural and anthropogenic stressors that can also influence health endpoints. However, the use of toxicity data acquired from laboratory animal studies combined with exposure data from wild populations can be used to estimate the potential for biological effects from contaminant exposure. Accordingly, as part of the newest AMAP assessment[1], risks of PCB and Hg health effects were estimated for geographically-widespread populations of Arctic mammals and birds. This analysis identified the following species as being at a particularly high risk of adverse health effects or population impacts:

POLAR BEARS

As apex predators of the Arctic, polar bears continue to exhibit levels of mercury that put them at a high to severe risk for reproductive and other adverse health effects. Additionally, being long-lived predators that produce few offspring, polar bears may be at greater risk of population declines through exposure to endocrine disrupting chemicals and are expected to be greatly impacted by the effects of climate change due to the projections of sea-ice loss, and decline in access to their main prey, the ringed seal.

KILLER WHALES

Having a reduced capacity to detoxify OHCs, killer whales are among the most highly PCB-contaminated species on Earth. Populations inhabiting the Arctic waters of the North Atlantic were found to have levels of PCBs placing them at a high risk for immune and endocrine effects. Moreover, population modelling indicates the impacts of PCB exposure could have severe consequences for the long-term sustainability of killer whale population numbers.

BIRDS

The Arctic is populated with numerous and diverse marine and terrestrial bird species, many of which serve as important subsistence foods for indigenous communities. Many different Arctic bird populations, spanning multiple species – including gulls, guillemots and murres at various locations were found to be at a high to severe risk for health impacts from either PCB or Hg exposure, prompting concern for both population viability and human health impacts.

Inset images from top: Image Credit, Image Credit, Image Credit

AMAP

KEY MESSAGE 4

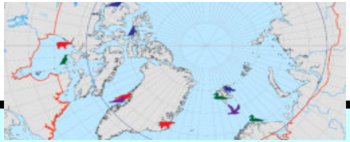
The impact of contaminant exposure in Arctic biota needs to be considered in combination with other natural and anthropogenic stressors.

In addition to being exposed to a complex mixture of environmental contaminants, Arctic biota are subject to numerous natural and anthropogenic stressors including, but not limited to, climate change, hunting pressure, invasive species, emerging pathogens, and changes in food web dynamics. The added influence of these environmental factors, on top of existing chemical exposures, may significantly increase the risk of health effects and population impacts. This observation highlights the need for cross-disciplinary studies that include observations of indigenous knowledge holders, environmental data, and the development of new tools, such as computer models, to integrate data collected from the field into a larger, holistic picture of Arctic wildlife health.

THE IMPACT OF MULTIPLE STRESSORS IN A CHANGING ARCTIC

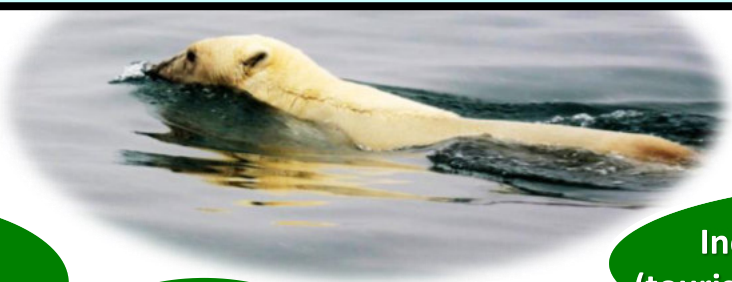
Risks to wildlife populations are often based on oversimplified scenarios where predicted impacts are estimated based on exposure to a single chemical or stressor. In reality, wildlife are exposed to a diverse and highly complex and interwoven series of natural and anthropogenic stressors that may act cumulatively to impact wildlife health. New approaches that approximate these 'real world' exposures as closely as possible would enable the ability to more accurately predict and anticipate population- and ecosystem-level effects in a rapidly changing Arctic environment.

KEY MESSAGES: Wildlife Health in a Complex & Changing Arctic



Key Message #4:

Impact of contaminant exposure in Arctic biota needs to be considered in combination with other natural and anthropogenic stressors (including changes in biodiversity)



Habitat degradation (oil spills, noise pollution)

Changes in food abundance (shifting prey abundance and movements)

Habitat loss (declining sea ice)

Increasing human activity (tourism, shipping, oil exploration)

Infections & diseases

Invasive species

Relevance to Arctic Biodiversity:

Work by AMAP on biological effects of contaminant on Arctic wildlife complements CAFF work on species trends, changes and biodiversity

Knowledge Gaps and Future Research Priorities

Spatiotemporal aspects of contaminants

1. **Lack of geographic data** for the Russian, Fennoscandian and Alaskan regions
2. We need **panArctic harmonisation** in terms of sampling frequency, season and foci species
3. We need closer investigation of **hotspot, reference and 'unique' regions**

Contaminant –specific focus

1. Problems to pinpoint **individual contaminant versus cocktail effects**
2. We need to keep focus on **existing high levels of legacy contaminants**
3. We need (more) physicochemical and industrial data for **emerging contaminants**

Biota considerations

1. Lack of focus on **marine-terrestrial and wildlife-human coupling**
2. We need **maturity- and sex specific toxicity**, supported by sufficient sample sizes
3. Assessments needed in relation to **spatial & temporal variation in dietary exposure pathways**
4. We need better understanding of the role of **invasive and biovector species** in a changing Arctic

Health effects

1. Lack of **toxicity thresholds** adapted to specific health endpoints, species and contaminants
2. We need better **identification of cumulative and interactive effect** thresholds
3. We need to **scale-up individual effects to the population level**
4. Prediction of effects of **complex contaminant mixtures within a multi-stressor framework** (e.g. infectious and zoonotic diseases)
5. **OneHealth concept;** information integration of assessments from wildlife & human health studies

Thank you / Qujannamiik

Panel Discussion

Panel:
Rune Dietz, Igor Eulaers, Robert Letcher, Christian Sonne, Pal Weihe

Charge Questions:

How do we obtain more precise effect levels to proxy population health, and how do we better obtain population effect assessments?

How do contaminants and environmental change synergise, and how does contaminant exposure affect Arctic biodiversity?