Environment and Climate Change Canada / Environnement et Changement climatique Canada

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AMAP Arctic Monitoring and Assessment Programme

ARCTIC COUNCIL

AMAP 2018: Key Findings from Biological Effects of Chemical Pollutants on Species/Ecosystem Risks and Advice for Future Monitoring and Research (for the CBMP)

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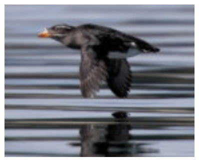
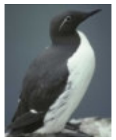




Arctic Biodiversity Congress,
Rovaniemi, Finland; Octpber 9-12, 2018

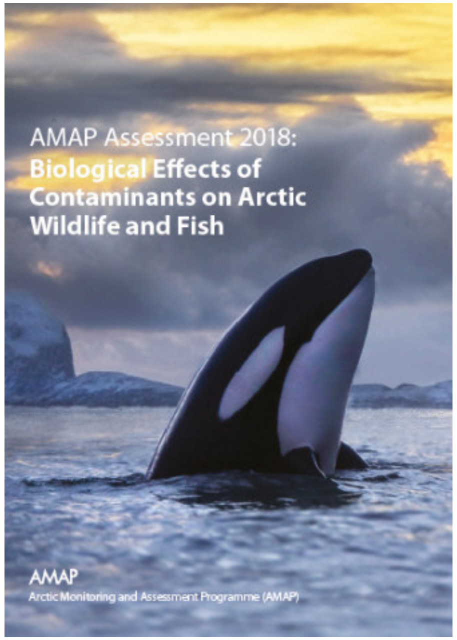
An Update on Effects Assessments

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

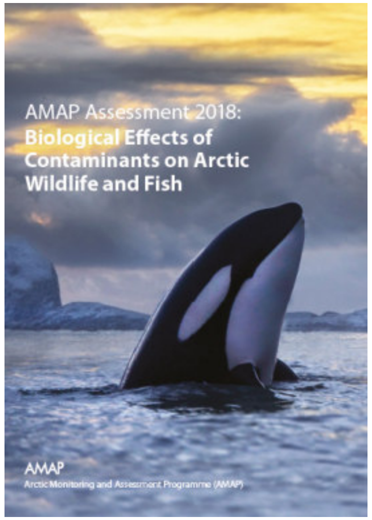
https://www.amap.no/documents/doc/Biological-Effects-of-Contaminants-on-Arctic-Wildlife-and-Fish.-Key-Messages/1664

Technical report (pre-print watermarked)

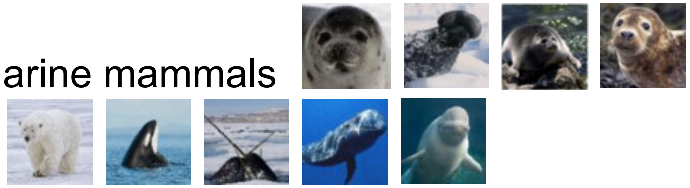
https://www.amap.no/documents/doc/AMAP-Assessment-2018-Biological-Effects-of-Contaminants-on-Arctic-Wildlife-and-Fish-Pre-print/1663

Scope of the 2018 Effects Assessment

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

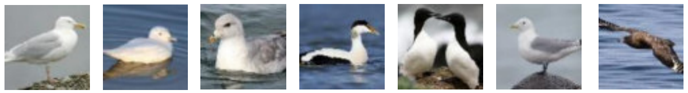


1. marine mammals



2. terrestrial mammals

3. seabirds



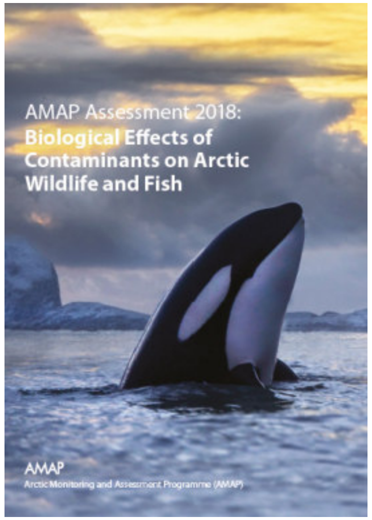
4. birds of prey

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

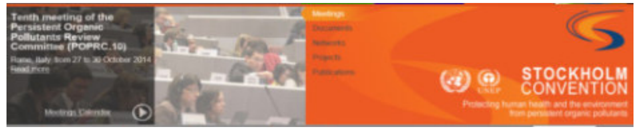
5. fish

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

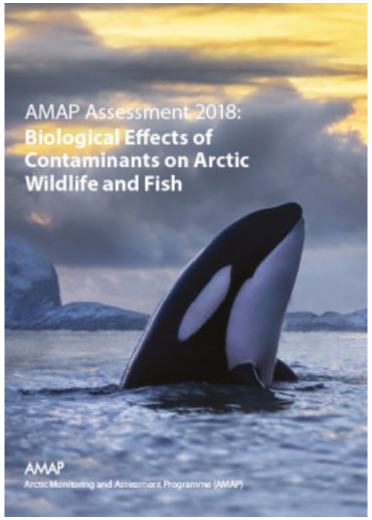


UNEP Stockholm POPs Convention status



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
   perfluorooctanesulfonic (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)

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

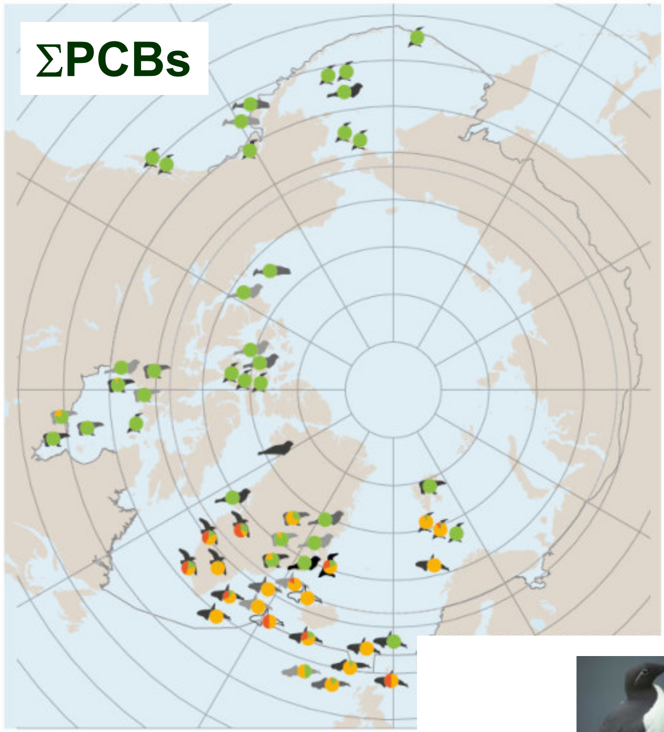


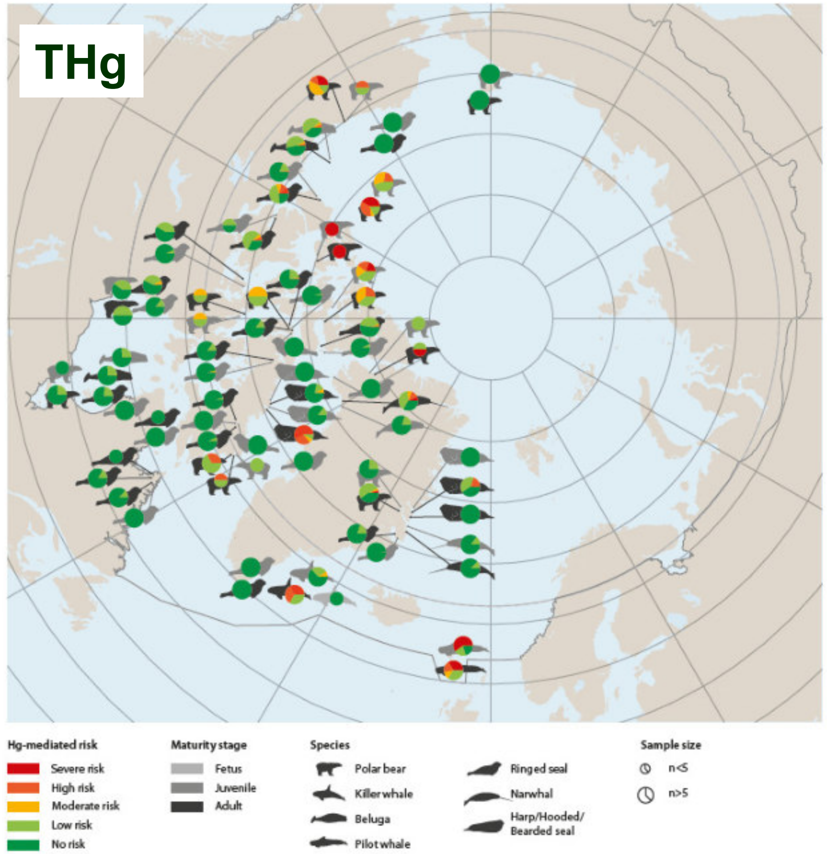
All studies based on correlative relationships between POP tissue/blood & biomarker concentration –
Weight of Evidence only

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, …

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

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



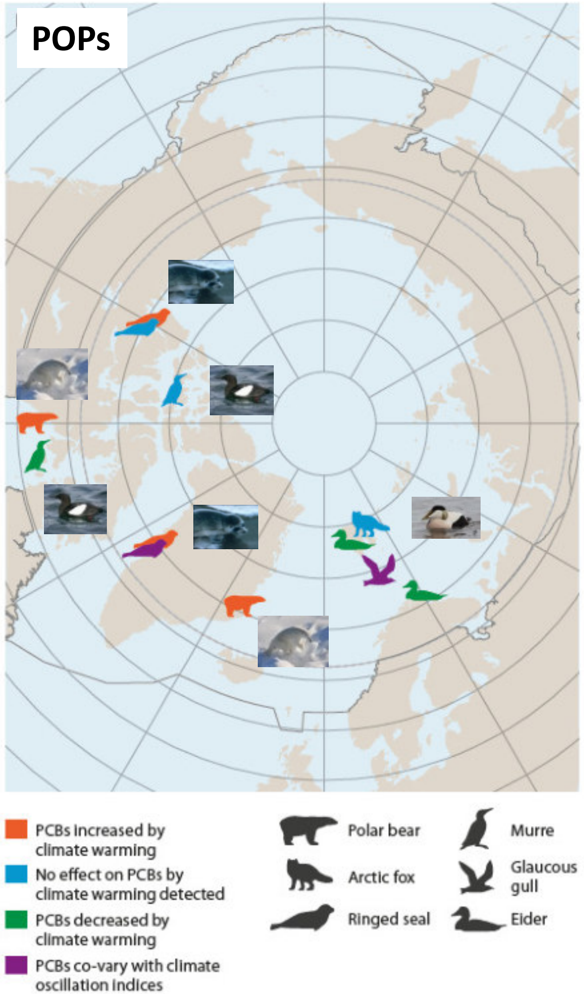


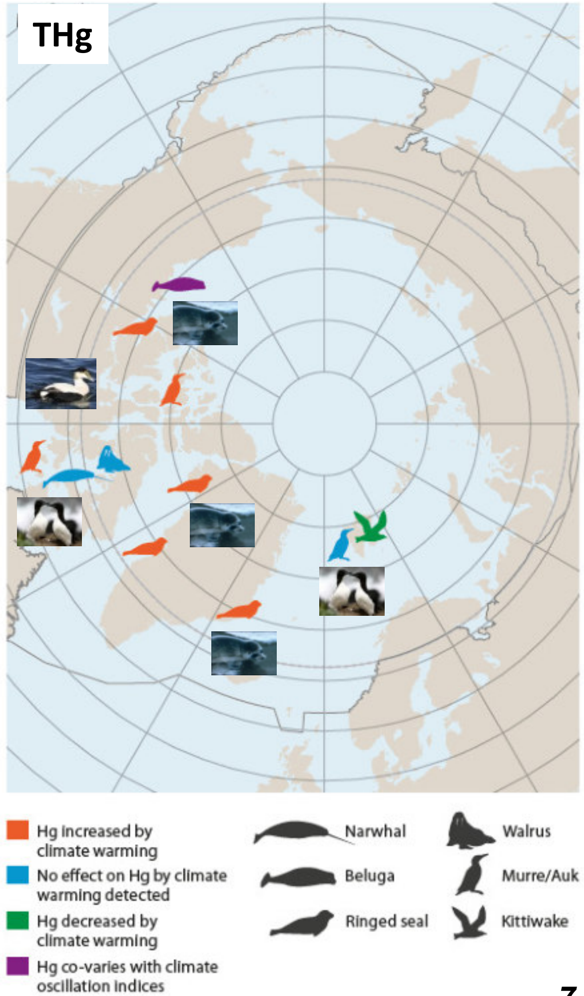
Risk Quotients (RQs)

- < 1
- 1 – 10
- 10 - 100

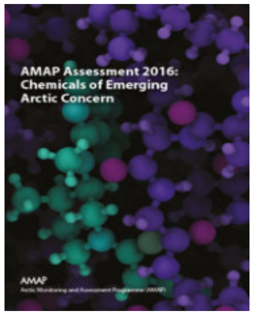
- ΣPCB-immune and -hormone effects
- ΣPCB loads used a conservatively determined **critical body residue of 10 µg /g lipid weight of PCBs**

Locations and Effects Studies Reporting Linkages Between Global Climate Change-Induced Ecological Impacts and POP and Hg Pathways



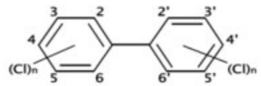


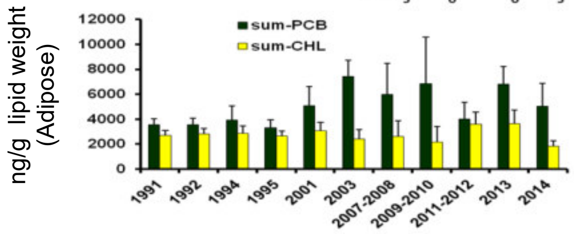
KEY MESSAGES:
New and Lasting Impacts of Chemical Exposures in Arctic Wildlife and Fish



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

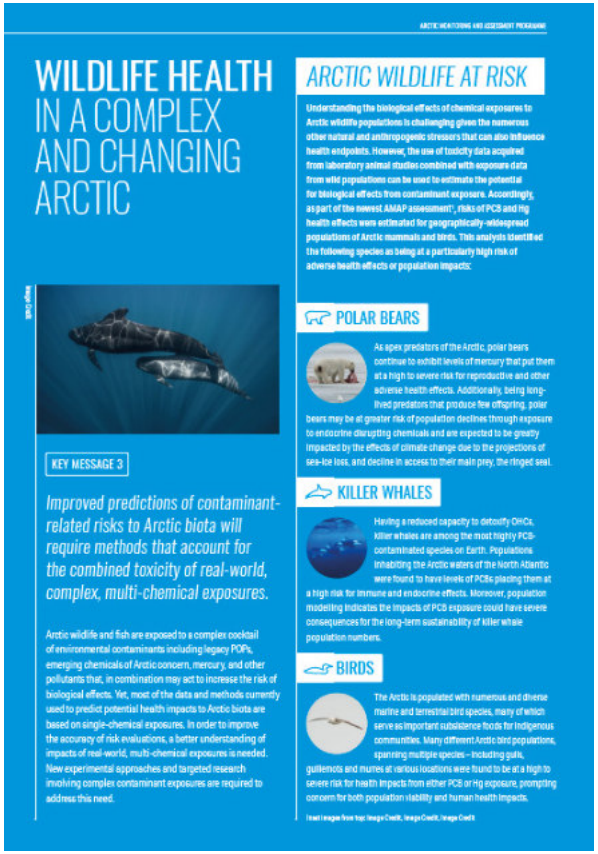




New and Lasting Impacts of Chemical Exposures in Arctic Wildlife and Fish

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

- **Populations of polar bears, killer whales and seabirds** (e.g. thick-billed murrres) presently at highest risk



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.

Confounding Factors and POP/Metal Trends and Effects in Wildlife

Biological Factors

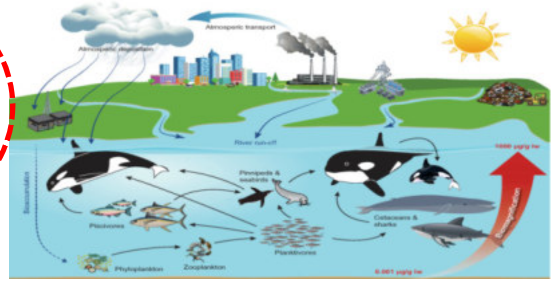
- lipid content
- sex
- age
- season
- reproductive status
- **metabolism**

Abiotic Factors

- global emissions
- long-range transport
- POP properties
- **Local sources**
- **climate change / warming**

Changing Ecological Factors

- **diet**
- **food web**
- **BIODIVERSITY**

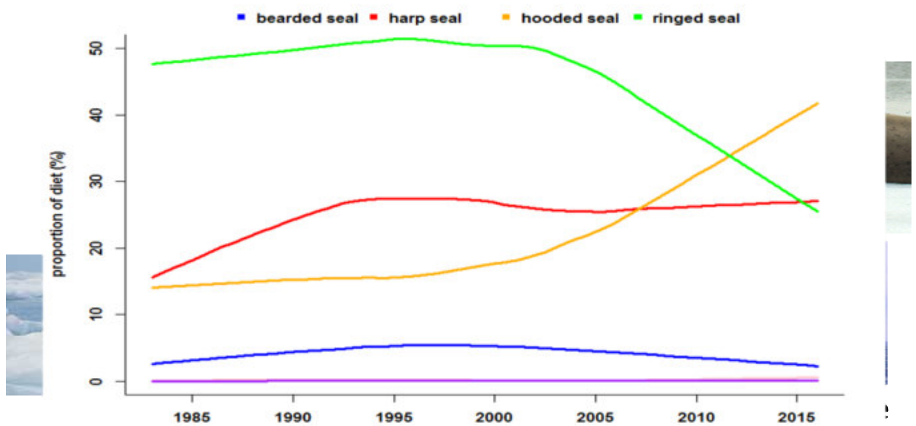


Ringed Seal

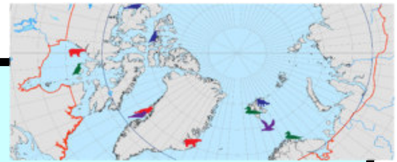
Harp Seal

Hooded Seal

East Greenland polar bear change in food over time extrapolated from Fatty Acids profiles

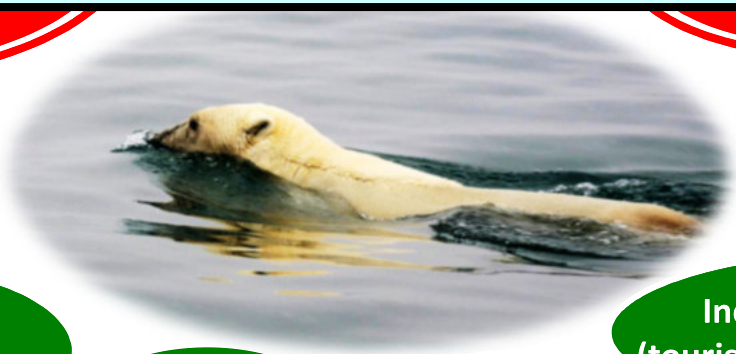


Wildlife Health in a Complex & Changing Arctic



Key Message #4:
The impact of contaminant exposure in Arctic biota needs to be considered in combination with other natural and anthropogenic stressors

and other effects



Habitat degradation (oil spills, noise pollution)

Habitat loss (declining sea ice)

Infections & diseases

Invasive species

Increasing human activity (tourism, shipping, oil exploration)

Changes in food abundance (shifting prey abundance and movements)

Relevance to Arctic Biodiversity:

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

Thank you / Qujannamiik

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

Confounding Factors and POP/Metal Trends and Effects in Wildlife

Biological Factors

- lipid content
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- age
- season
- reproductive status
- **metabolism**

Abiotic Factors

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- **diet**
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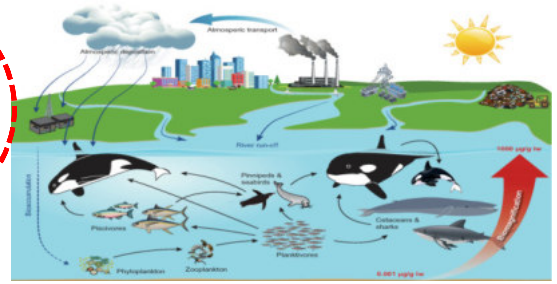
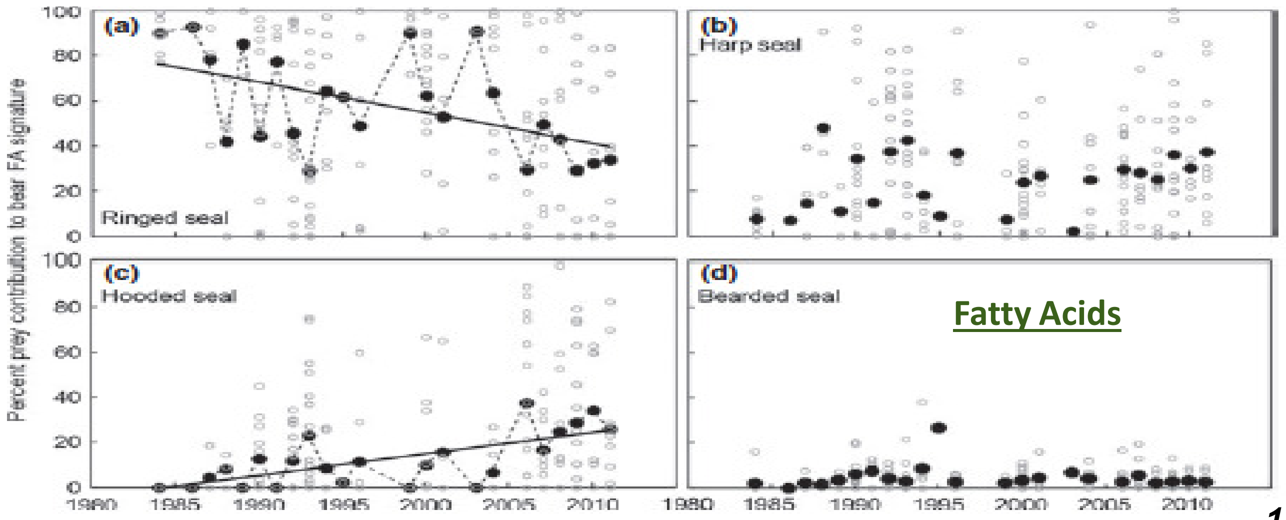
- **BIODIVERSITY**



Ringed Seal

Hooded Seal

Temporal % diet change for East Greenland polar bears (1980-2011)



(McKinney, Iverson, Fisk, Sonne, Riget, Letcher *et al*. **2013**. *Global Change Biol.* 19: 2360-2372)