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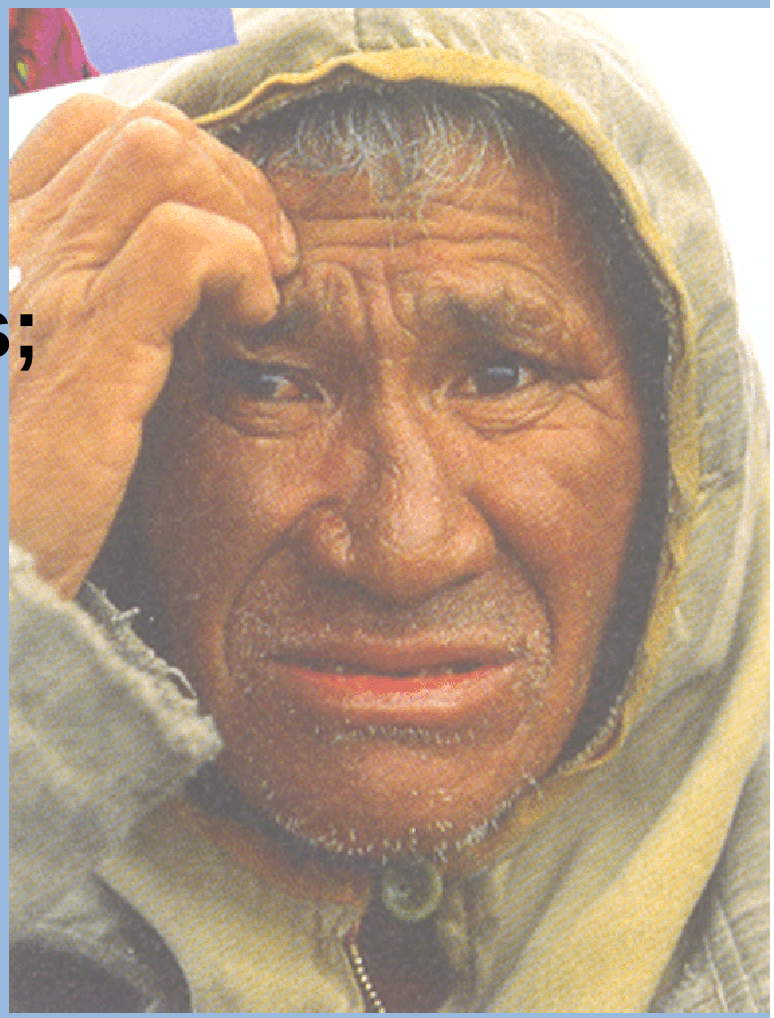
Arctic as the Sentinal for Environmental Processes and Effects; Results from AMAP



The 4th Norman workshop
Lyon, 17-18 March, 2008

Lars-Otto Reiersen
Executive Secretary

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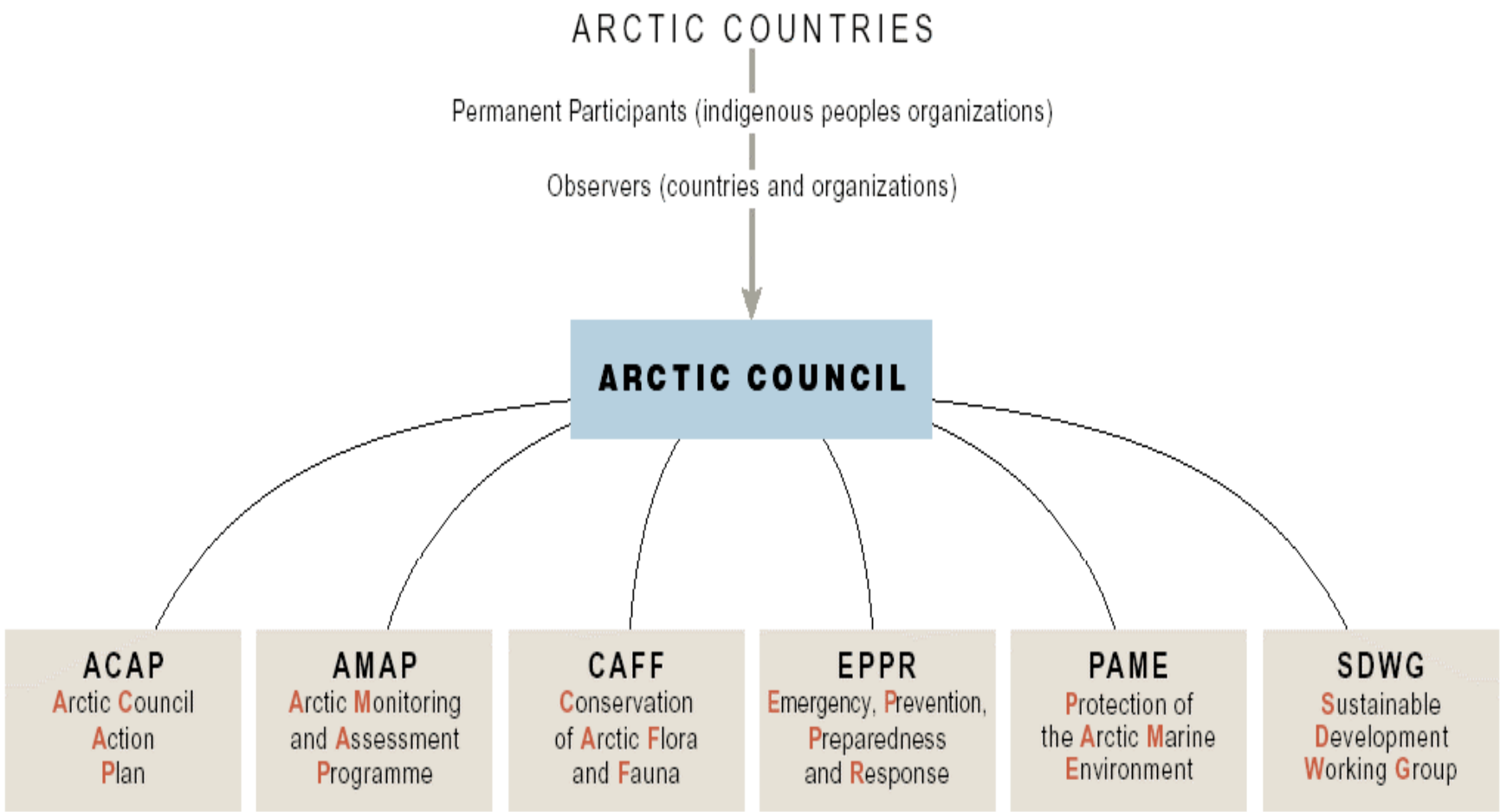

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HENRY HUNTINGTON

Iñupiat, Anaktuvuk Pass, Alaska.

GNWT/NWT ARCHIVES

Dene, Midway Lake, NWT, Canada.

STAFFAN WIDSTRAND

Saami, Kautokeino, Norway.

PTS PROJECT

Chukchi, Kanchalan, Russia.

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Monitoring and Assessment of levels, trends and effects of:

Persistent Organic Pollutants (POPs)
Heavy metals (Hq)
Radionuclides
Acidification & Arctic Haze
Petroleum hydrocarbons
Climate Change & UV.

Samples are collected from:

Air, Water, Snow, Ice & Sediments
Vegetation, Plankton, Invertebrates
Fish, Birds & Mammals
Humans

AMAP Assessment - leads

Acidification	Finland
Climate	USA & Norway
Human health	Denmark & Canada
Mercury	Denmark, Canada & Norway
Oil	Norway & USA
POPs	Canada & Sweden
Radionuclides	Russia & Norway

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AMAP Atmospheric programme for POPs

Media and Parameters

Media → / ↓Contaminant group		Air/Aerosol	Bulk precipitation	Throughfall	Snowpack	Frozen fog (rime), intensive	Glacial cores ❸
POPs (see Tables B.2 and B.3)	PAHs	E	E		ES ❶		R
	Planar-CB	R	R				E
	PCB	E	ES				E
	DDT/DDE/DDD	E	ES				E
	HCH	E	ES				E
	HCB	E	ES				E
	Chlordane	E	ES				E
	Dieldrin	E	ES				E
	Toxaphene	E	ES				E
	PCDD/PCDF	R					
	Annual Temporal Trend (POPs)	E					E ❸
Other persistent chemicals of potential concern (see Table B.2)	PCN	R (ss)					R (ss)
	CPs	R (ss)					R (ss)
	Current use pesticides	R (ss)	R (ss)				R (ss)
	Other persistent chemicals ❷	R (ss)	R (ss)				R (ss)

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AMAP Thematic Data Centres

•Atmospheric	NILU, Norway
•Marine	ICES, Denmark
•Terrestrial & Freshwater	UAF, USA
•Radioactivity	NRC, Norway
•Human	AMAP, Norway

•Provide access to data from recent monitoring and research

•Ensure that data are treated in a consistent manner, QA/QC

• Provide long-term secured archive of Arctic-relevant environmental data for use in future research and assessments.

AMAP Project Directory (www.amap.no)

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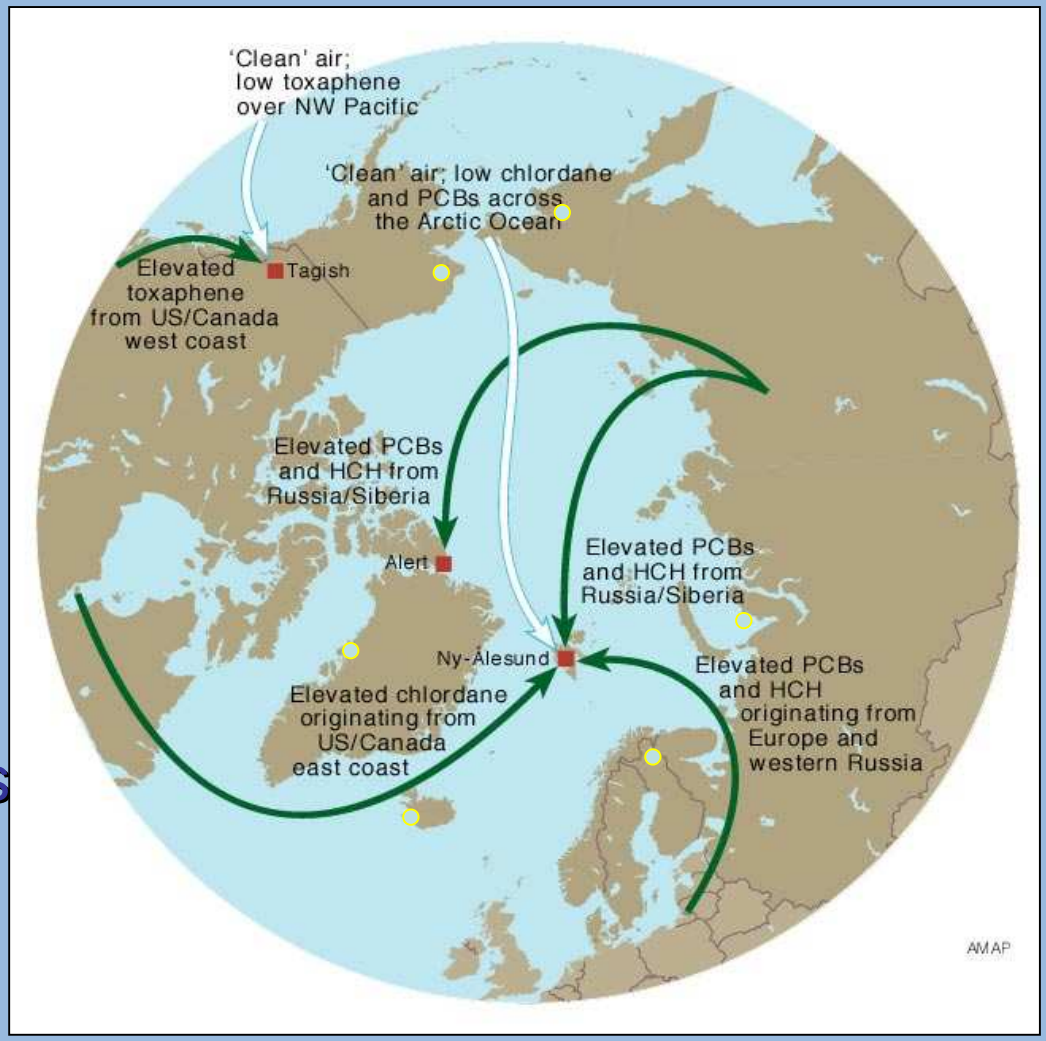
AMAP's geographical coverage

Persistent Organic Pollutants (POPs)

Mainly due to LRT, but also some regional use and releases of pesticides and industrial chemicals (e.g. PCB and HCB)



Riverine pathway

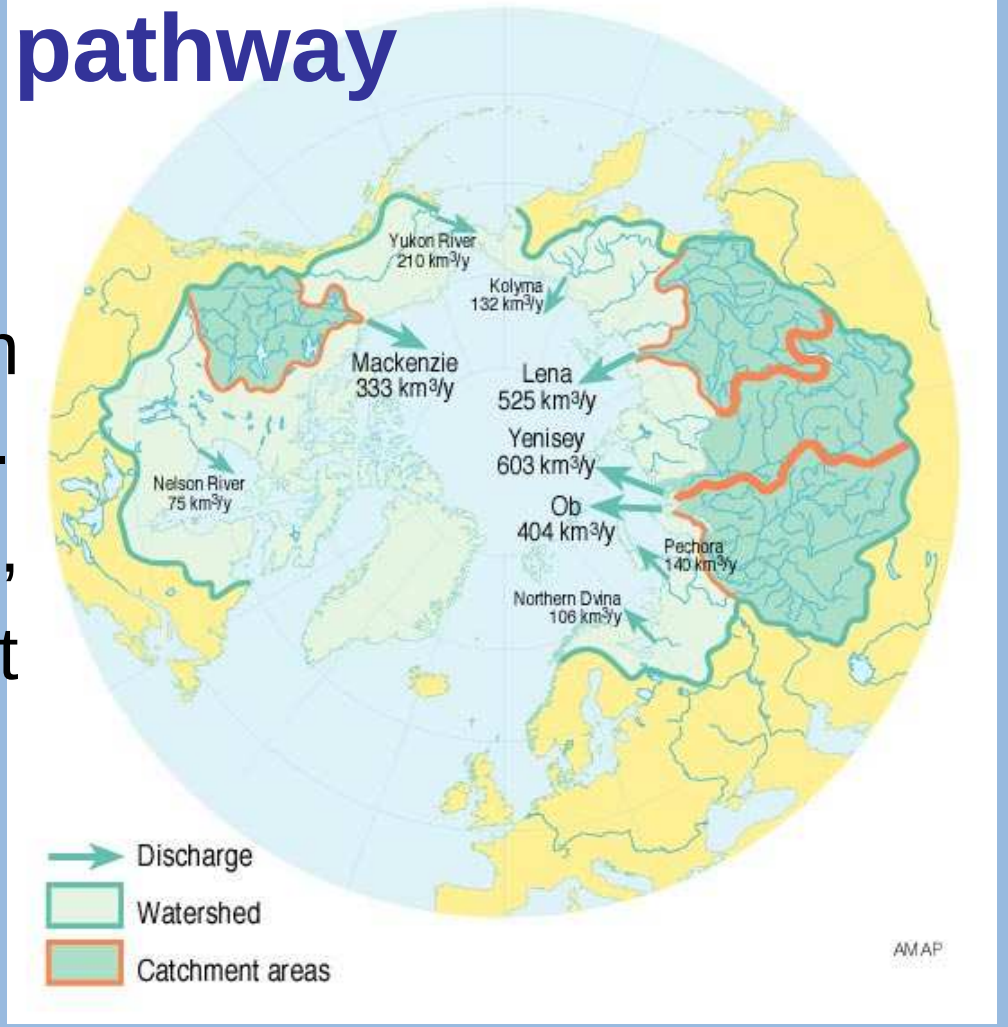
Main runoff in June

70 % of water from south of the Arctic.

Mainly due to LRT,

but also significant

local inputs.



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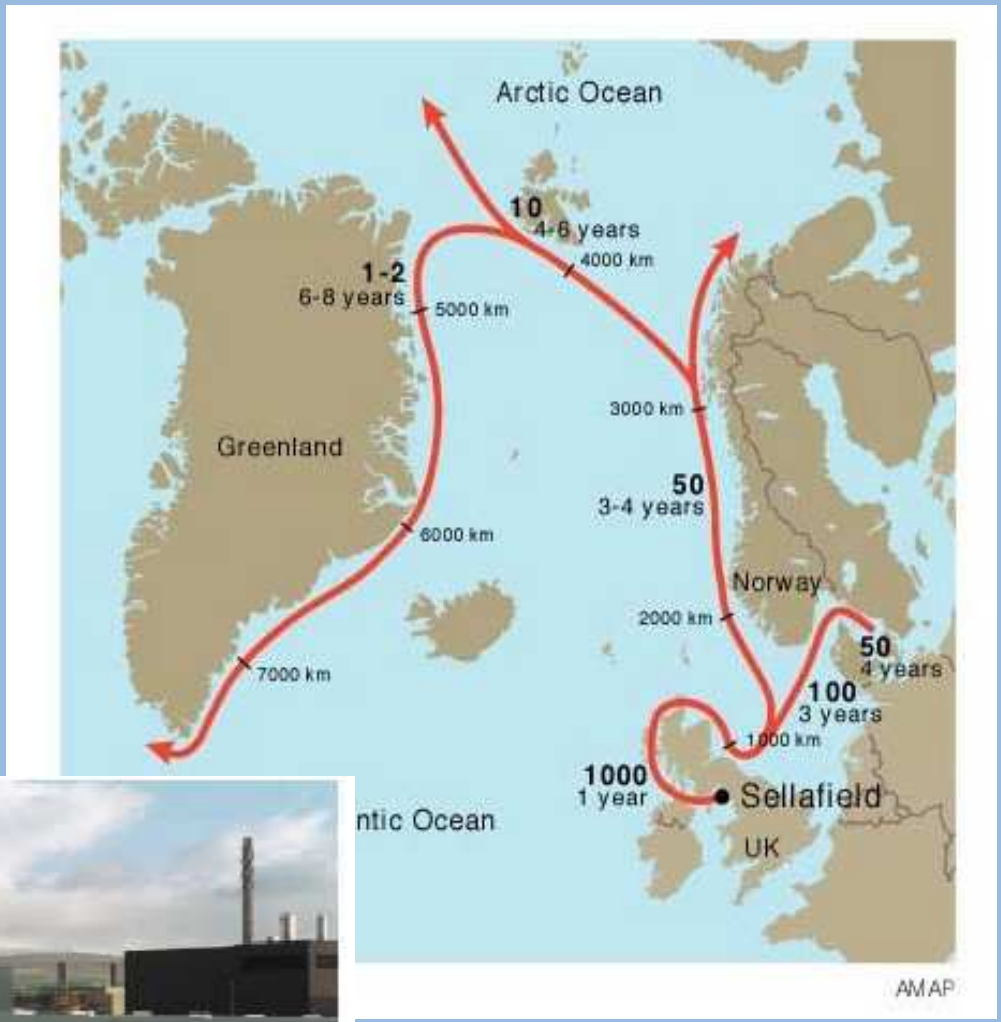
Marine pathway

Radionuclides

Mainly from storage and handling of spent nuclear fuel and waste, operation of nuclear power plants and vessels and military installations. Continued concern over previous releases from ‘old sins’



http://www.amap.no

Toxaphene Biomagnification

(Arctic Canada: after Bidleman et al 1989, Hargrave et al 1993)

Compartment	Concentration (wet weight)
Air	0.007 ppb
Snow	0.009 – 0.002 ppb
Seawater	0.0003 ppb
Zooplankton	3.6 ppb
Arctic cod muscle	14 – 46 ppb
Arctic char whole body	44 – 157 ppb
Ringed seal blubber	130 – 480 ppb
Beluga blubber	1380 – 5780 ppb
Narwhal blubber	2440 – 9160 ppb

Bioaccumulation, biomagnification and trophic level are critical factors in biotic tissue concentration of POPs

Air monitoring at Alert

Continuous measurement of POPs and mercury
Meteorological Service of Canada

Alert, Nunavut. *Defence R&D Canada/Janice Lang*

Zackenberg: Implementing the AMAP Programme

AMAP Arctic Monitoring and Assessment Programme

Appendix 3. MarineBasis in relation to AMAP's Effects Monitoring Programme (Climate Change effects)

Variable	Parameter subdivision	MarineBasis Sites	Level	Recommended by AMAP
Radiation	UV-B	2	Micro/Fjord	Yes
	Short wave	2	Micro/Fjord	Yes
	PAR	2	Micro/Fjord	Yes
Air pressure		1	Micro/Fjord	Yes
Wind	Speed	1	Micro/Fjord	Yes
	Direction	1	Micro/Fjord	Yes
Snow cover	Depth	3	Micro/Fjord	Yes
	Extent	3	Outer fjord	Yes
	Duration	3	Micro/Fjord	Yes
Ice cover	Depth	1	Micro/Fjord	Yes
	Extent	10	Outer and mid fjord	Yes
	Freeze time	1	–	Yes
	Thaw time	1	–	Yes
Current patterns	Vertical profiles	2	Micro/Outer and mid fjord	Yes
	Speed & direction	2	Micro/Outer and mid fjord	Yes
Nutrients	Vertical profiles & fluxes	2	Micro/	
Carbon and CO2	Vertical profiles & fluxes	2	Micro/	
Salinity and temperature profiles	Vertical profiles	2	Micro/	
Water table, tides	Depth	Irrelevant	–	
Plankton	Species composition, abundance, distribution	2	Micro/	
Primary production	Ice algae/phytoplank-ton/ underwater plants	2	Micro/	
Underwater plants/diatoms	Species composition, abundance, distribution	10	Outer	
Benthos	Species composition, abundance, distribution	10	Outer	
Walrus	Abundance	1	Outer	
Ringed seal	Change in food choice and condition	–	Outer	

Zackenberg: site of coordinated long-term Bio-, Geo-, Climate- and Marine monitoring

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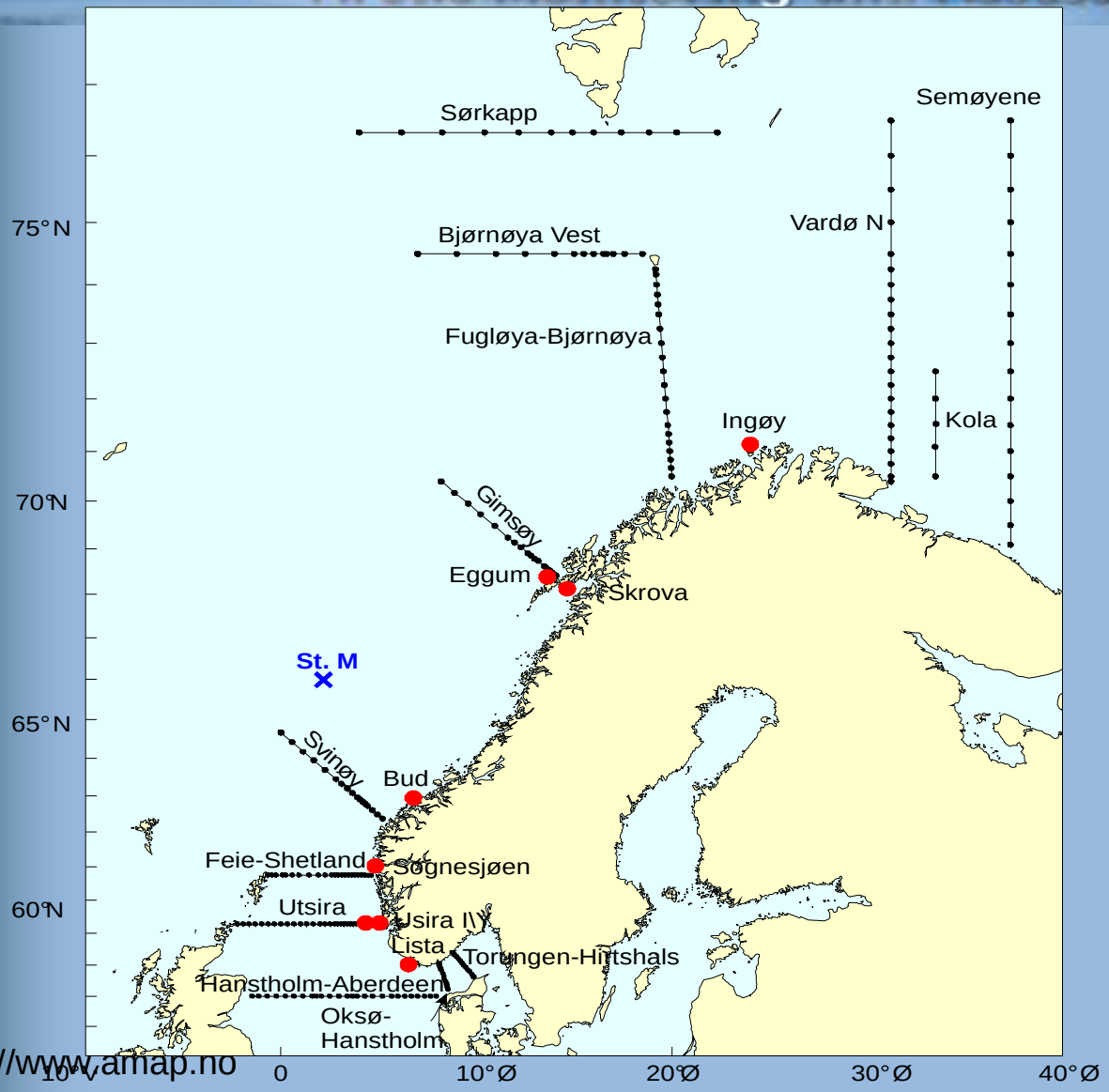

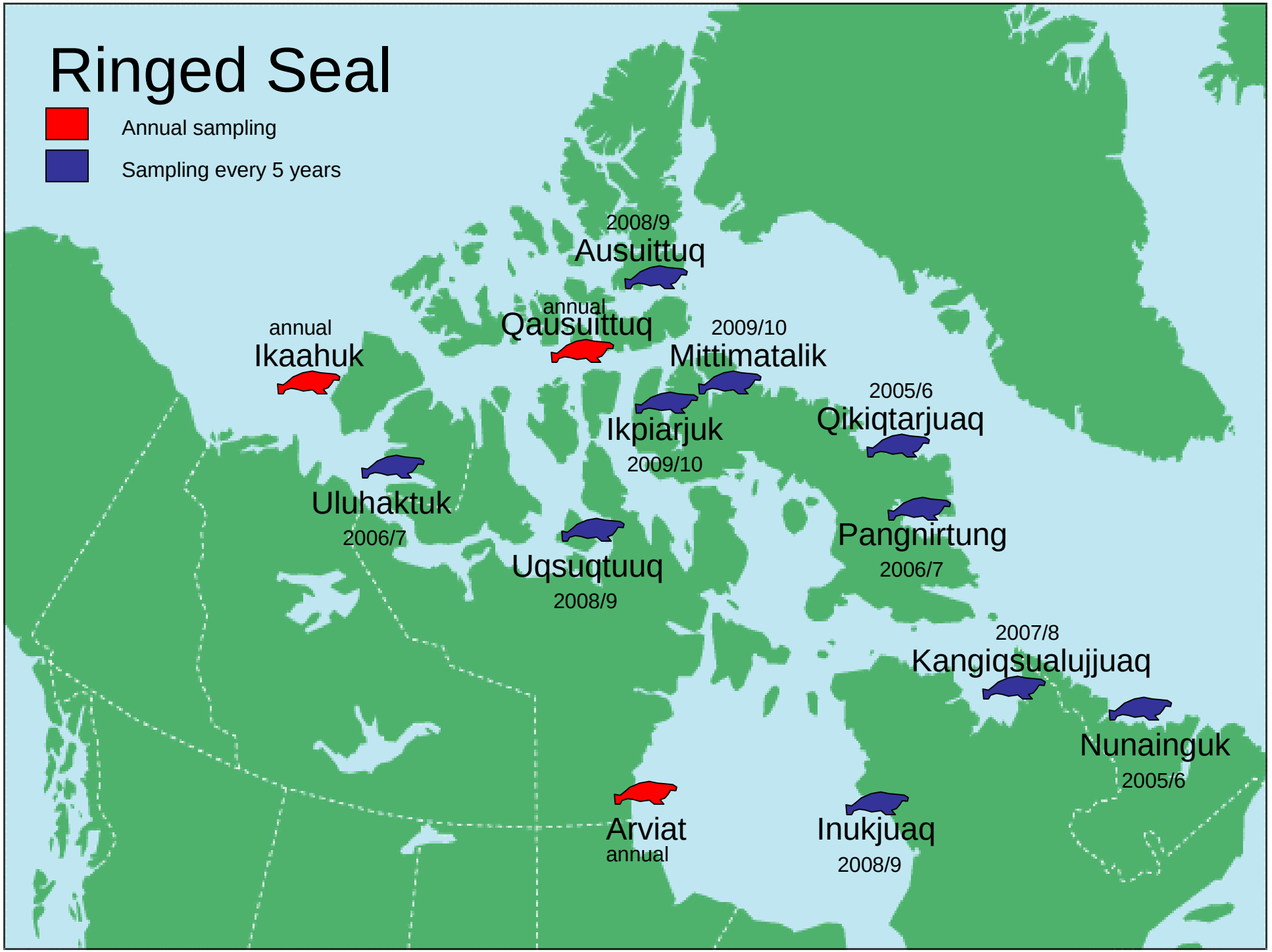
Ringed Seal
Annual sampling
Sampling every 5 years
2008/9
Ausuittuq
annual
Qausuittuq
annual
Ikaahuk
2009/10
Mittimatalik
2005/6
Qikiqtarjuaq
Ikpiarjuk
2009/10
Uluhaktuk
2006/7
Pangnirtung
2006/7
Uqsuqtuuq
2008/9
2007/8
Kangiqsualujjuaq
Nunainguk
2005/6
Arviat
annual
Inukjuaq
2008/9

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CCGS AMUNDSEN

CANADIAN RESEARCH ICEBREAKER

www.amundsen.quebec-ocean.ulaval.ca

The CCGS *Amundsen*: a Canadian research icebreaker for international collaboration in the study of the changing Arctic

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

Pêches et Océans Canada | Fisheries and Oceans Canada
Garde côtière | Coast Guard

UNIVERSITÉ LAVAL

Canada

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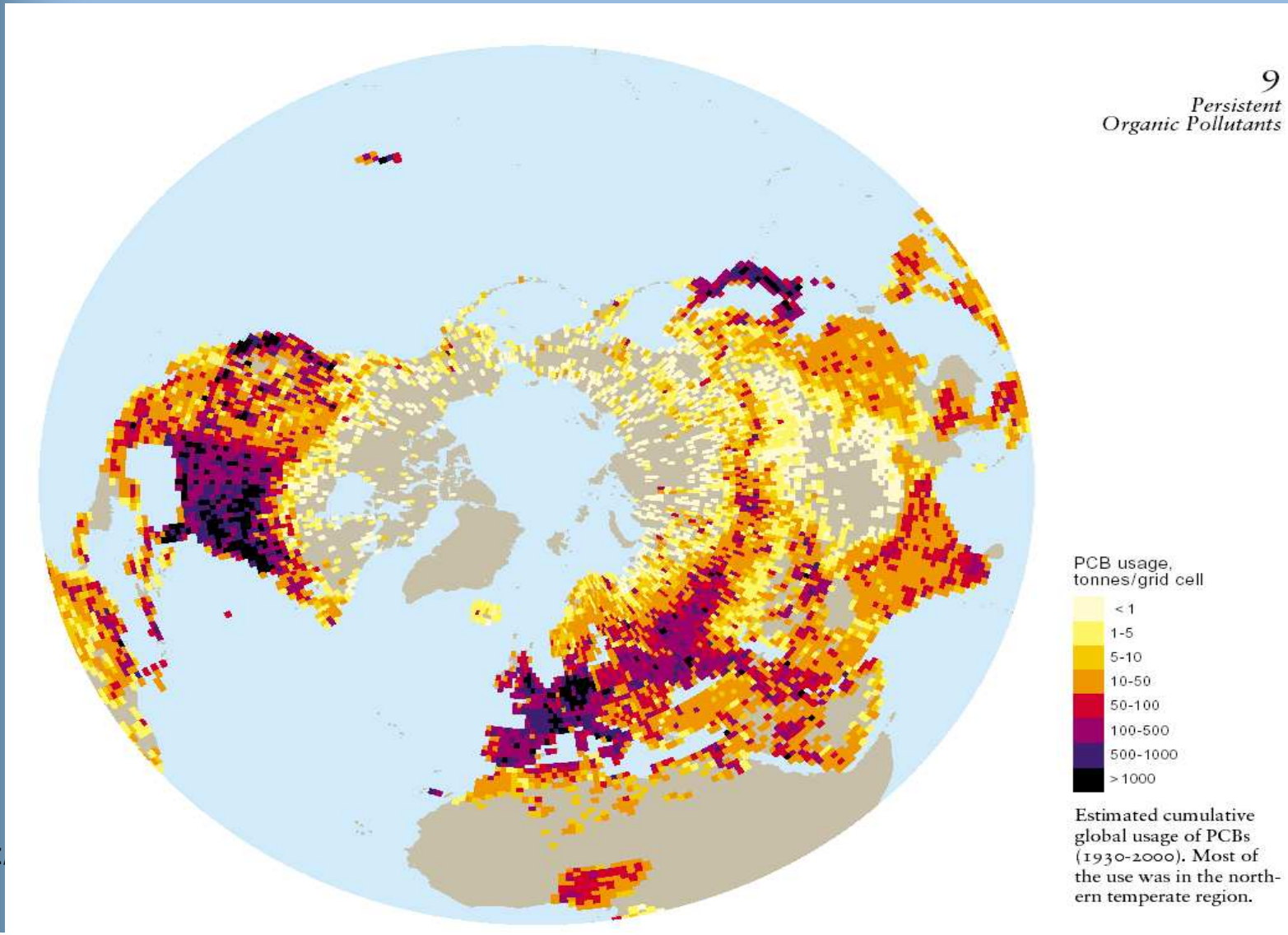
Sources of PCB



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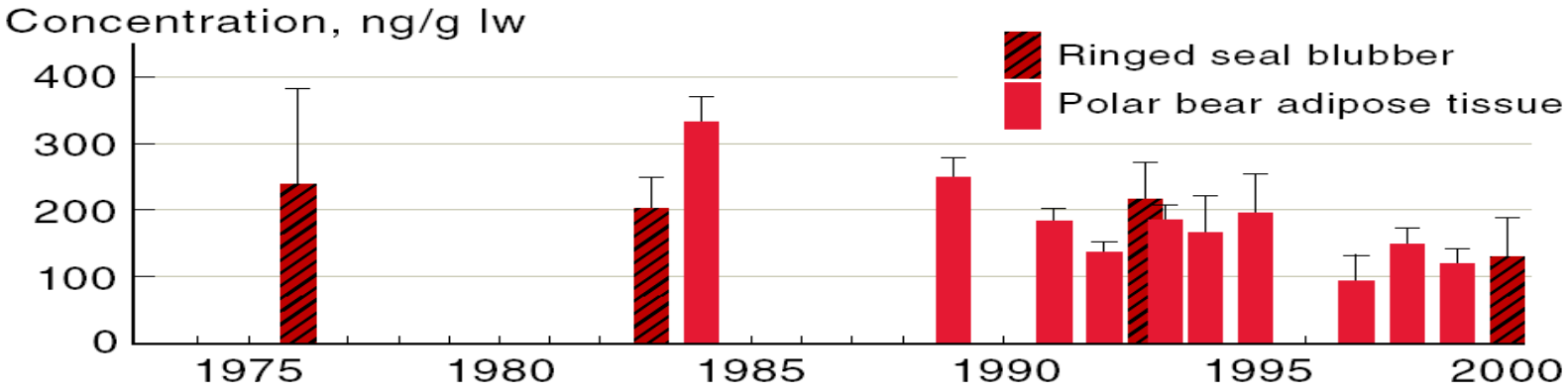
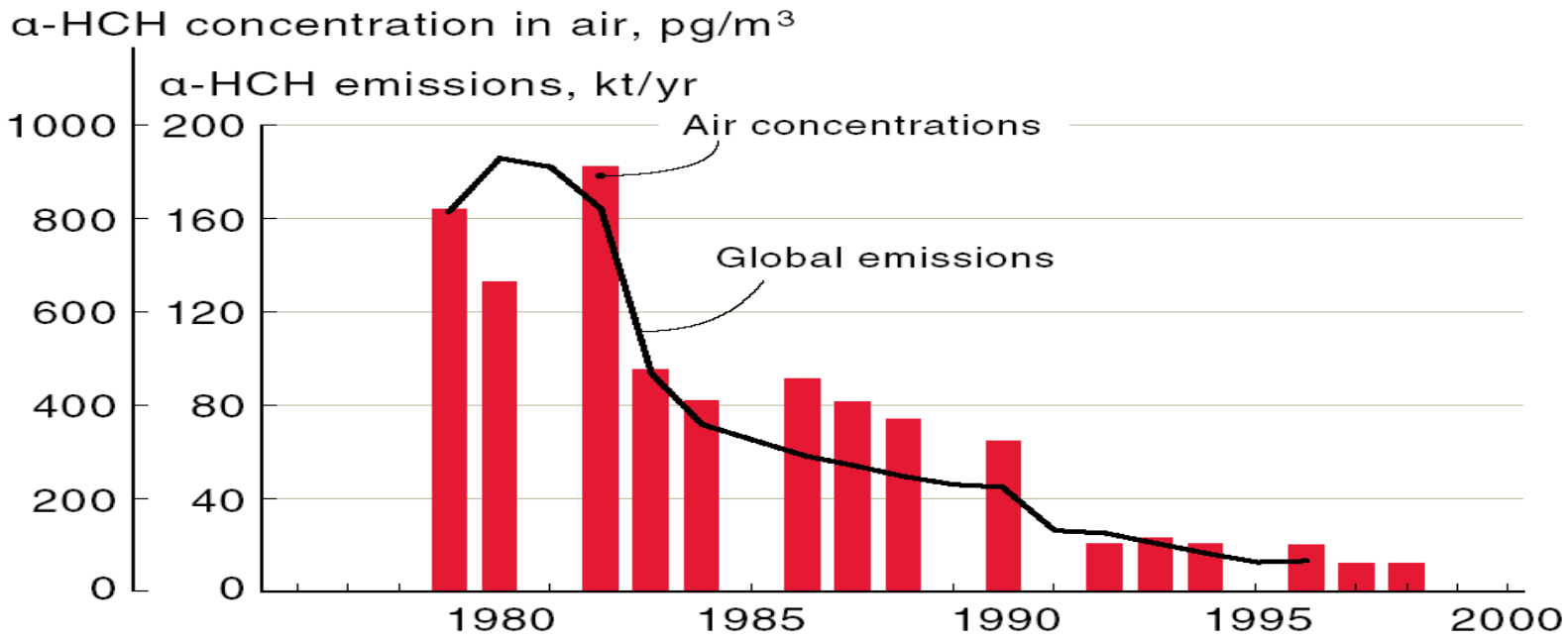
HCH, Global emissions & Conc. in Air & Marine Mammals





http://v

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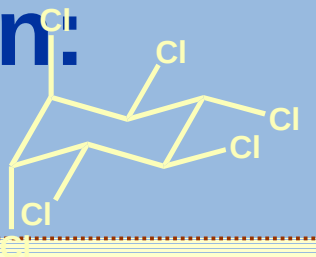
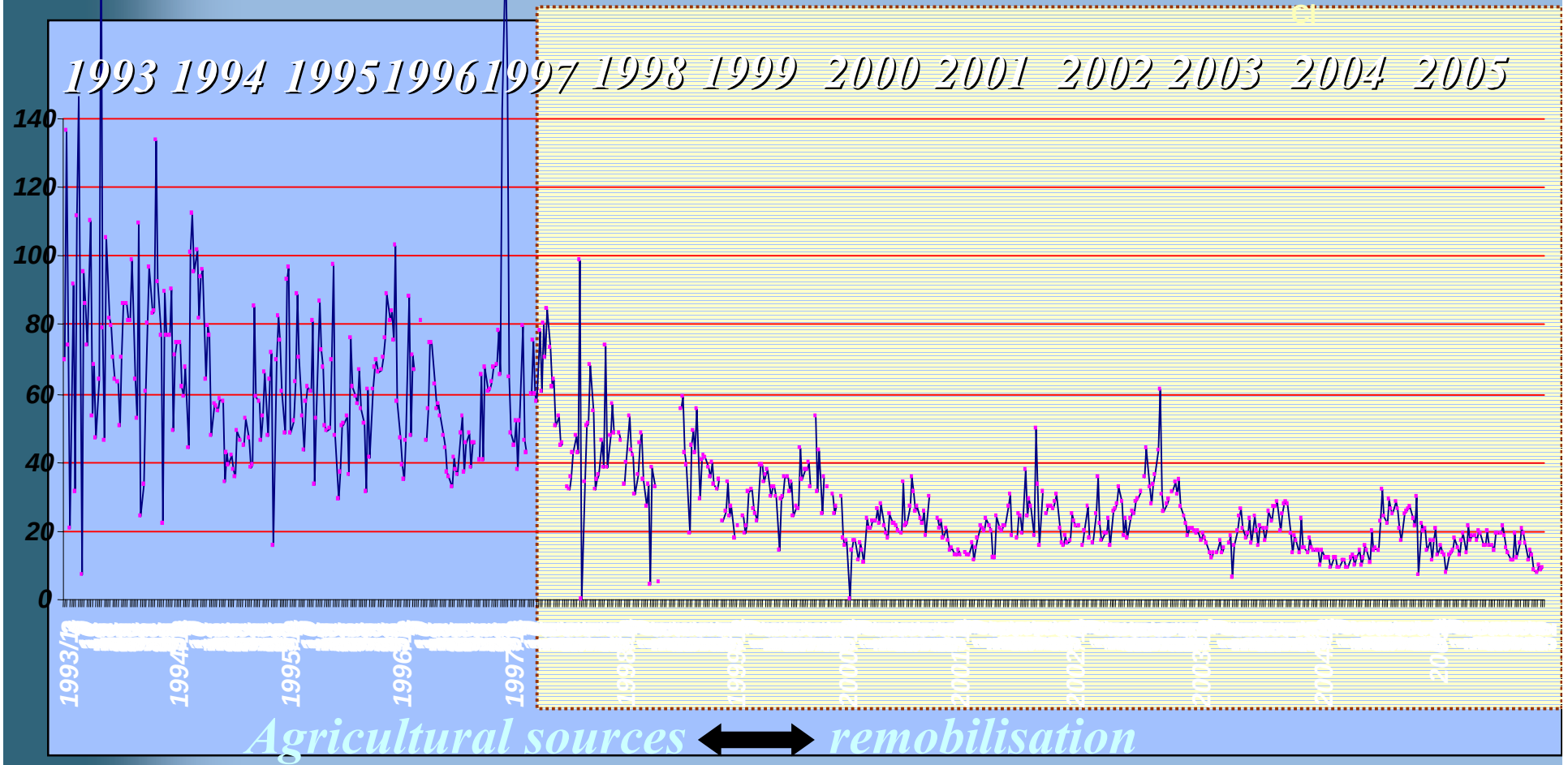
Zeppelin station: Source evaluation: α-HCH distribution



Conc.: pg/m³



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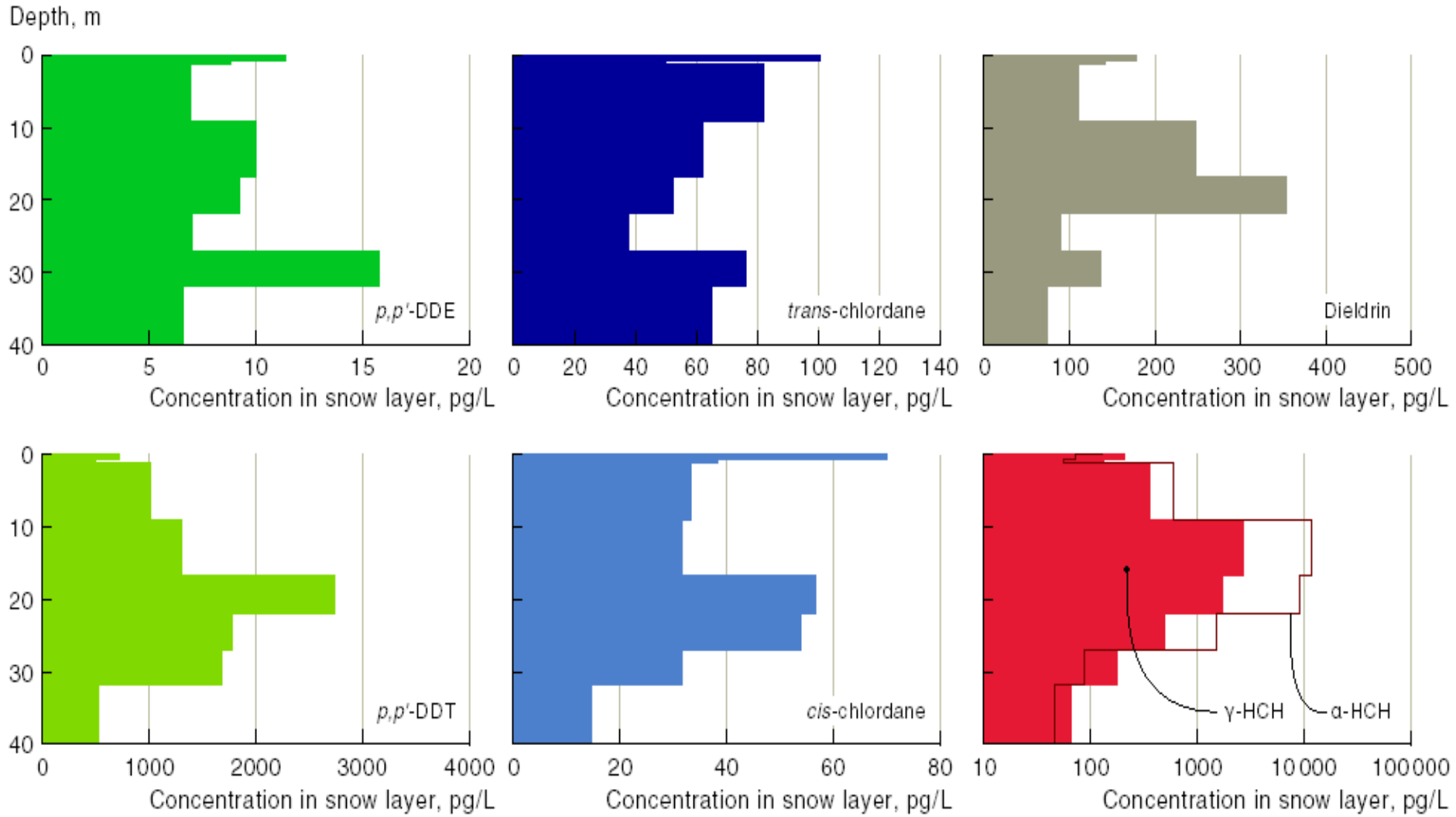
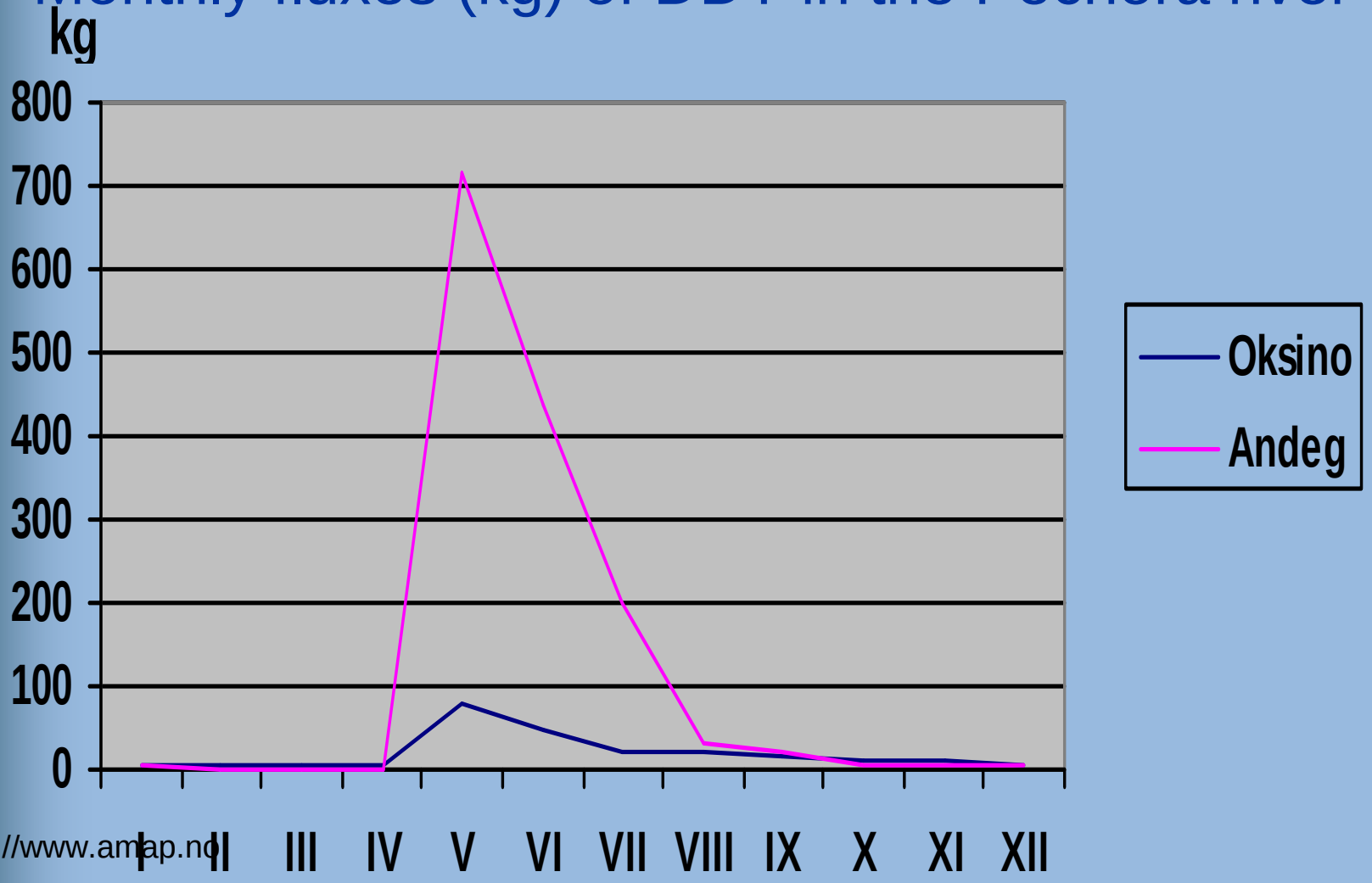
OCs in Snow cores from Svalbard



Monthly fluxes (kg) of DDT in the Pechora river



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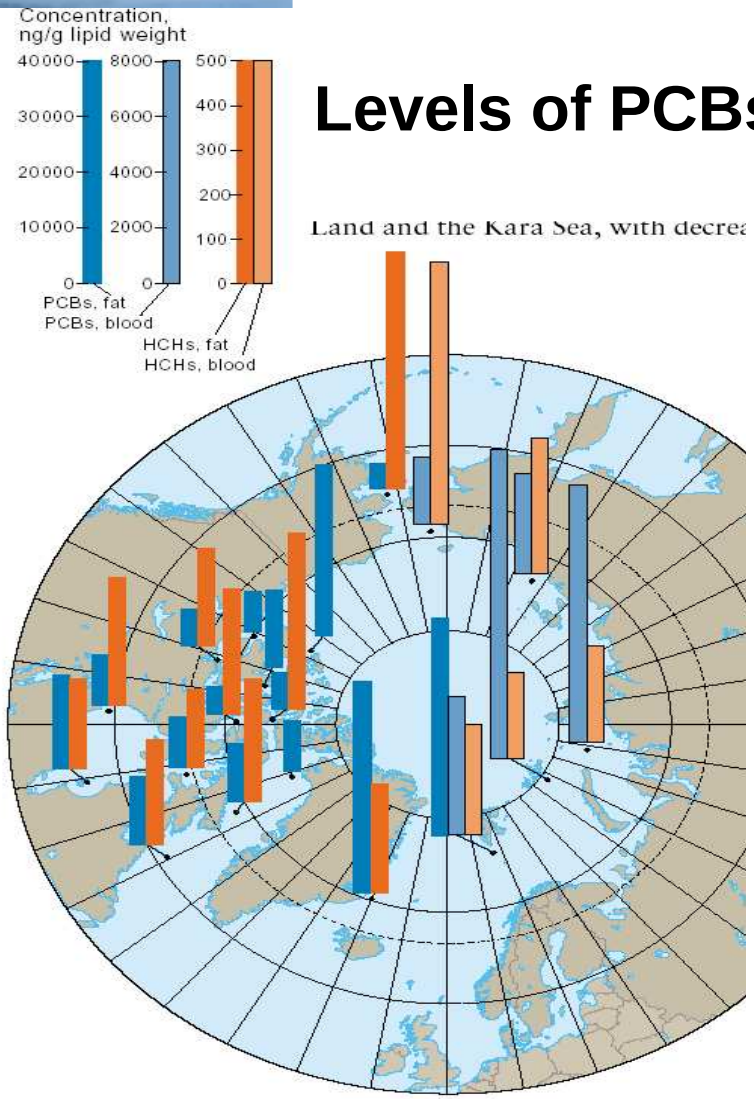
Levels of PCBs and HCHs in Polar Bears



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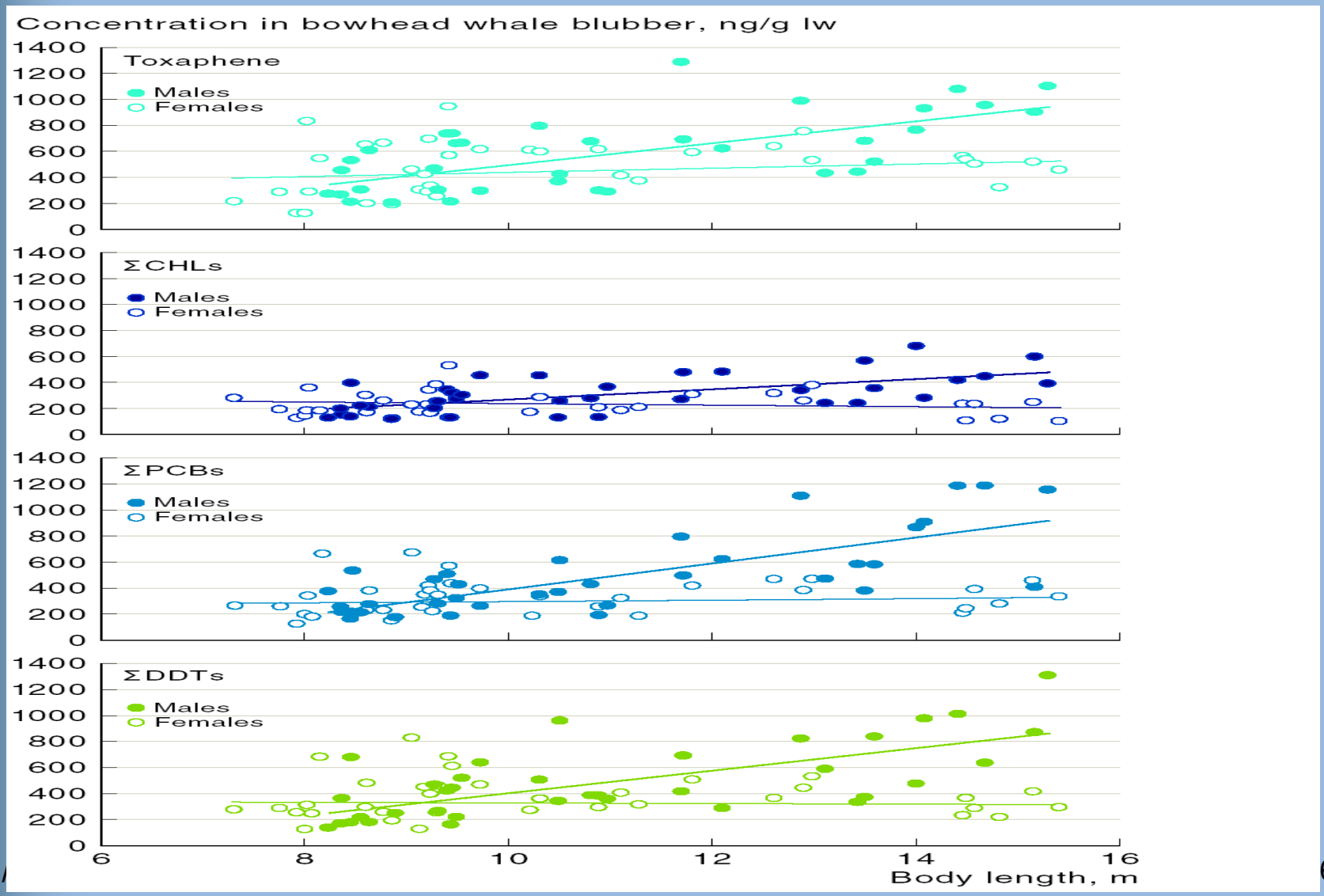
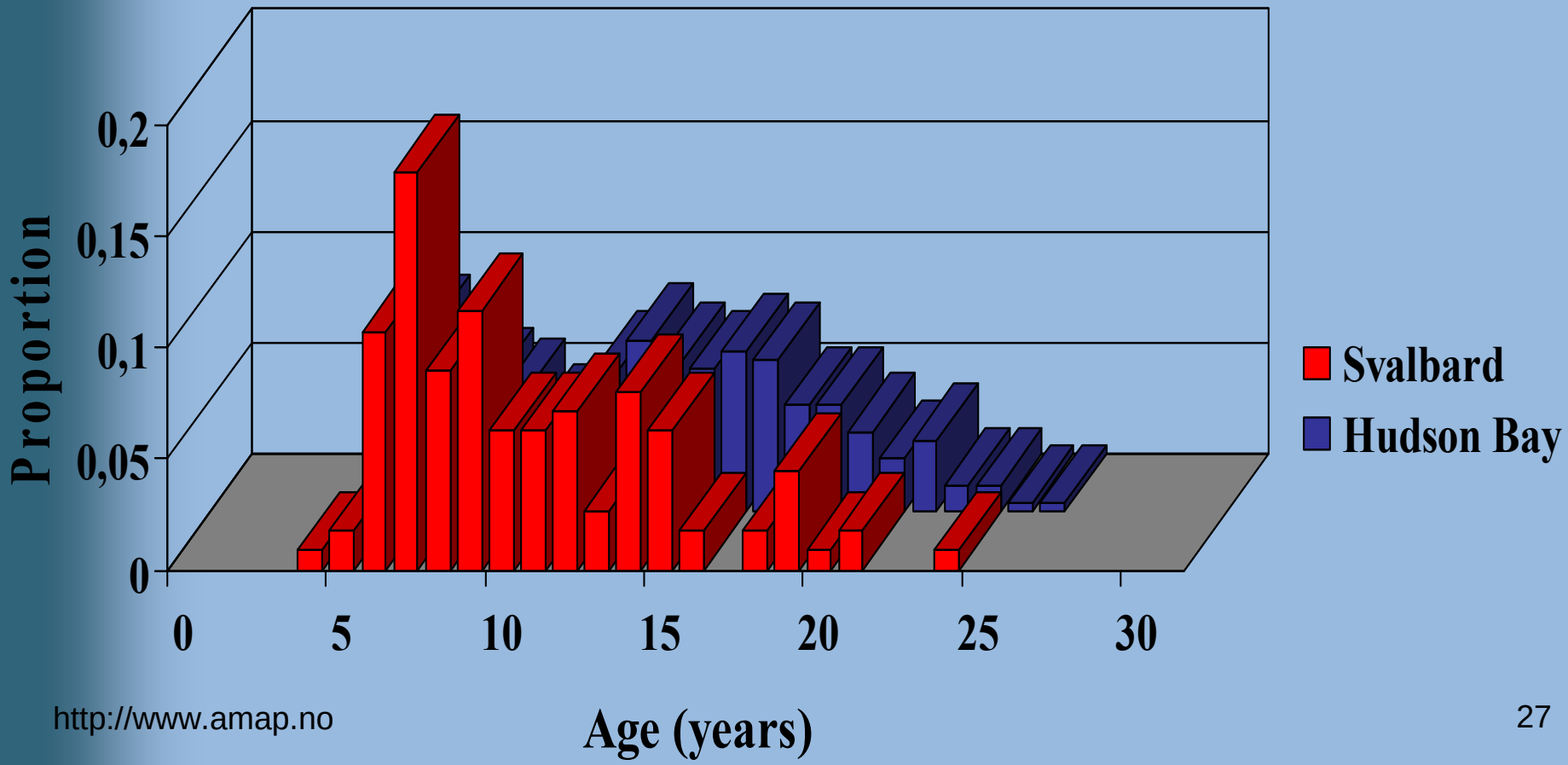


Age of female polar bears with cubs



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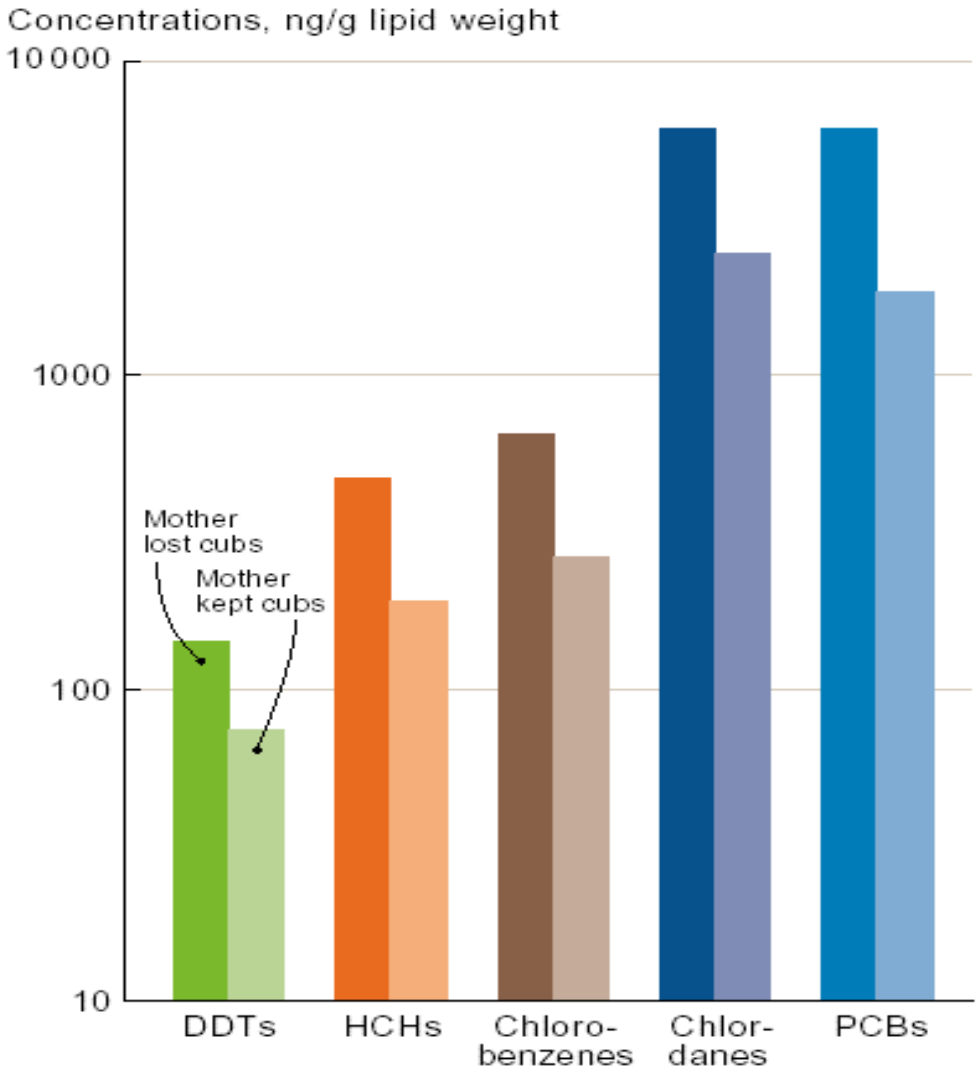
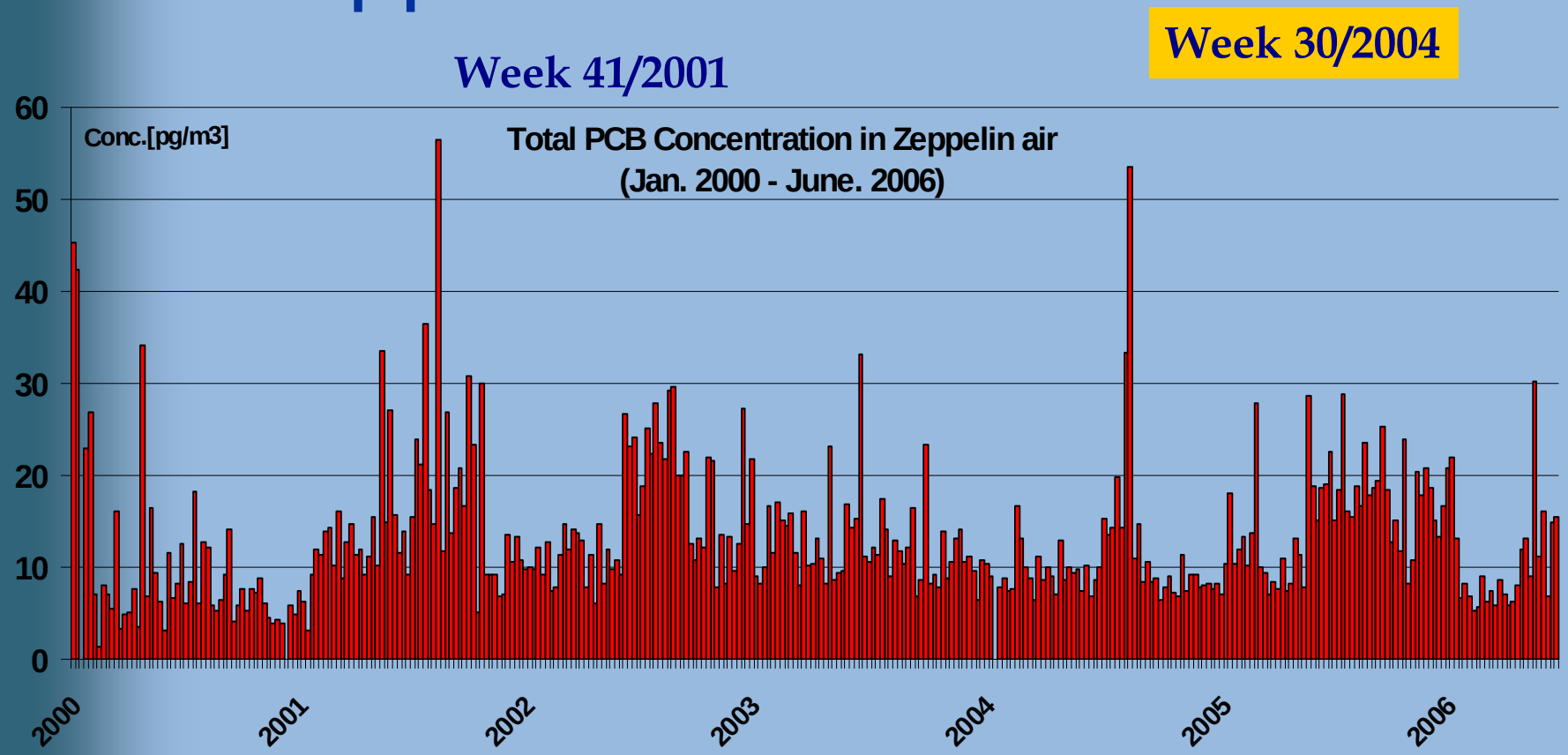
Effects of POPs on Reproduction of Polar Bears



Polychlorinated biphenyls (PCB) in Zeppelin air



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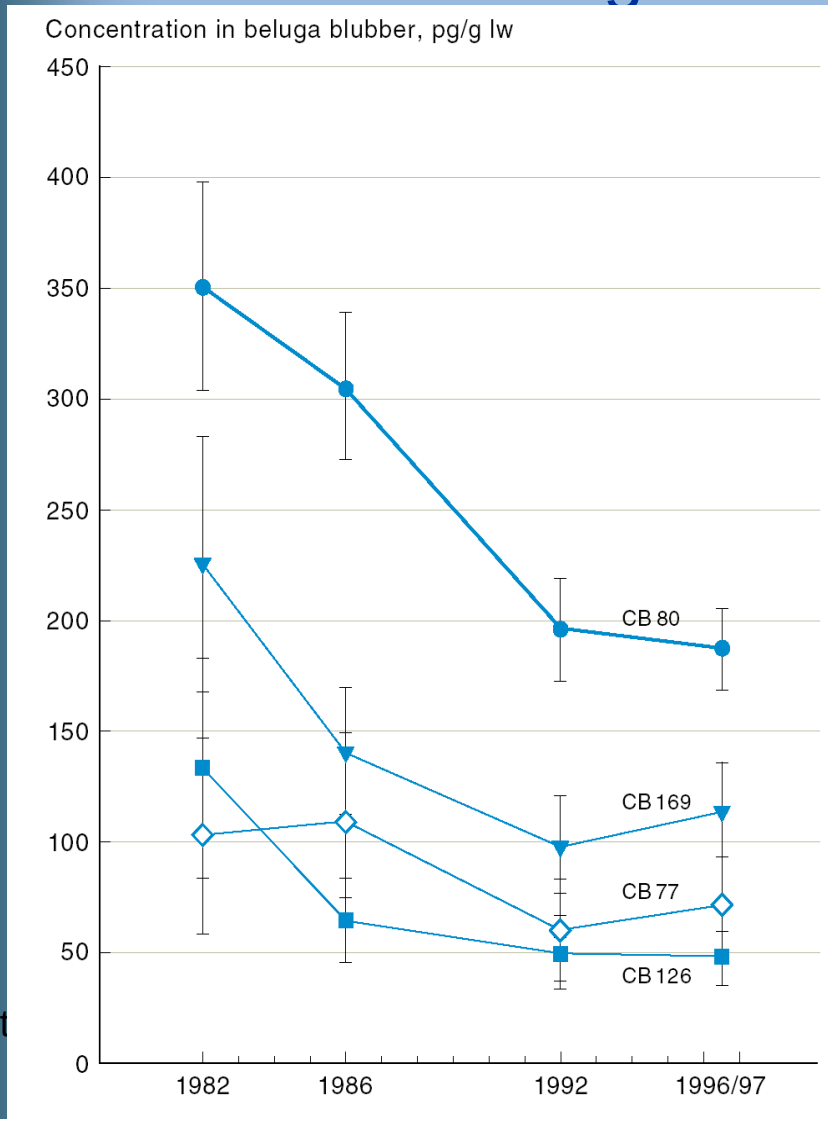
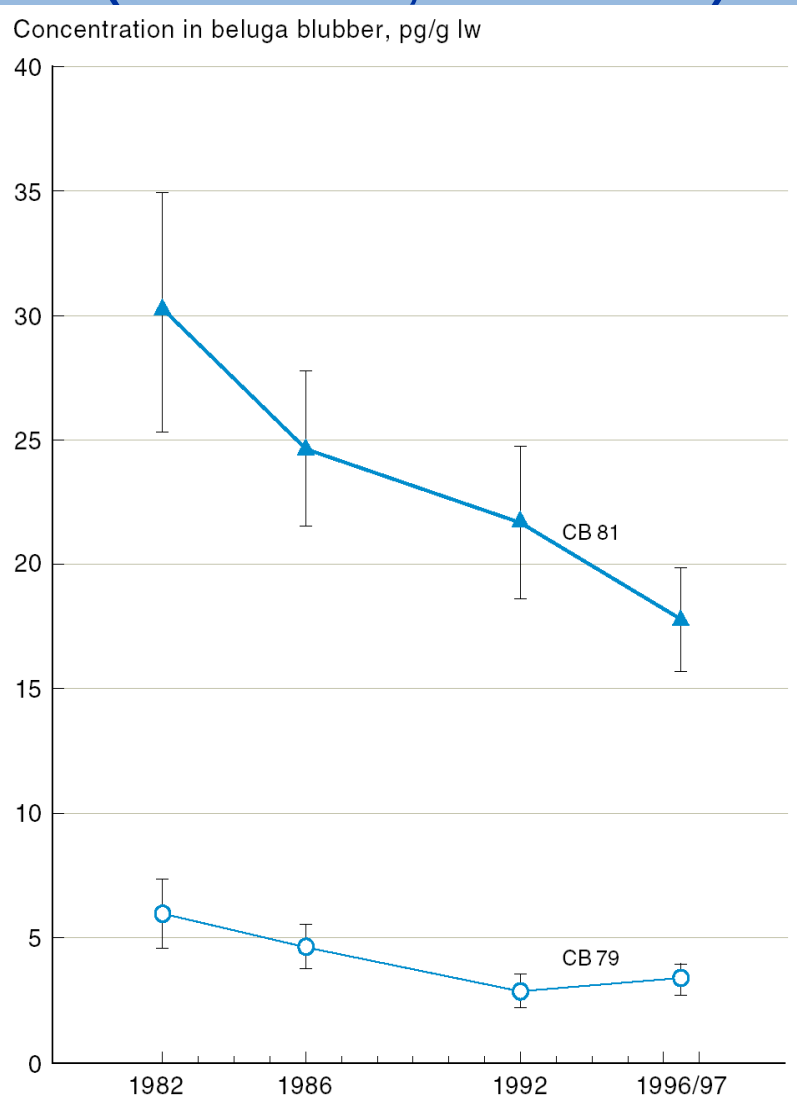
PCBs in Beluga blubber (Nunavut, Canada)





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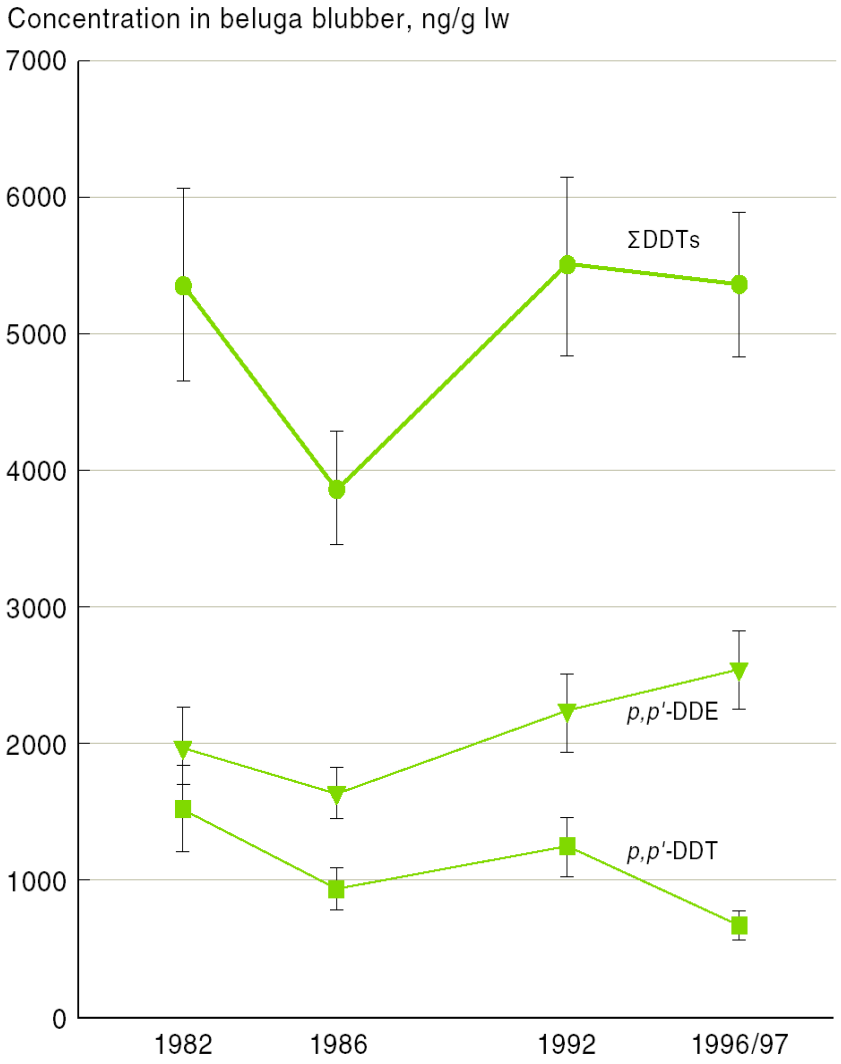
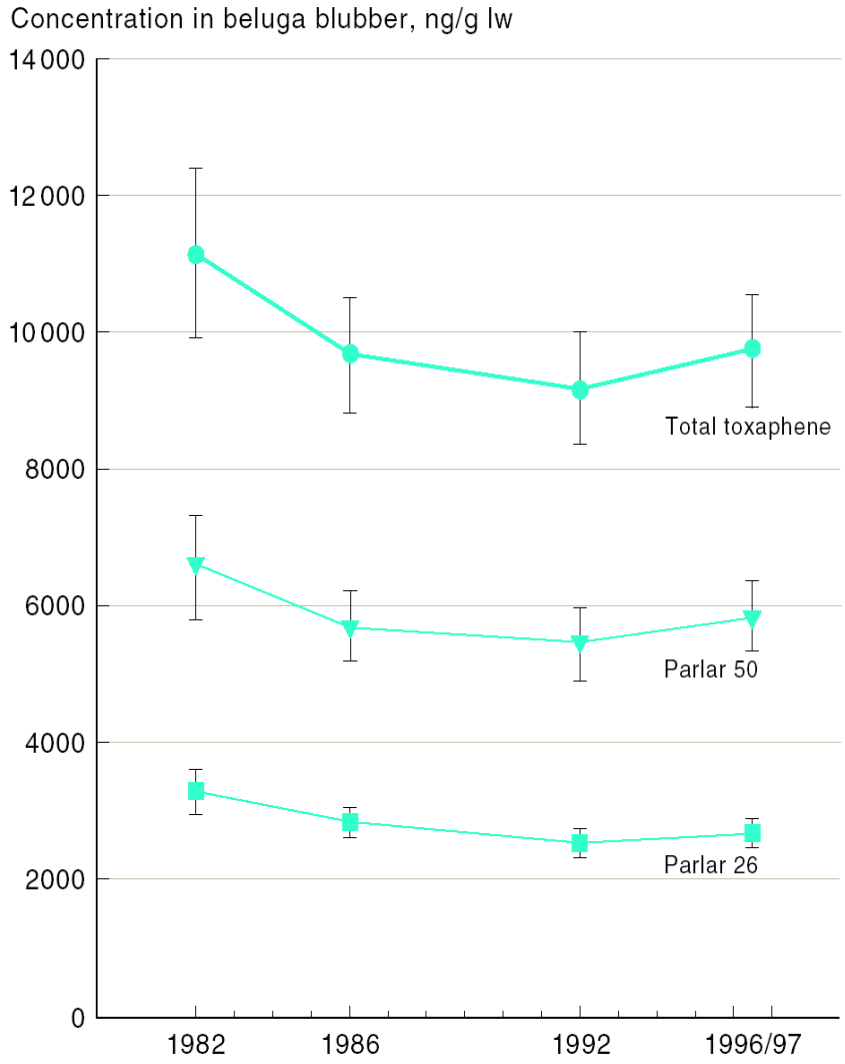
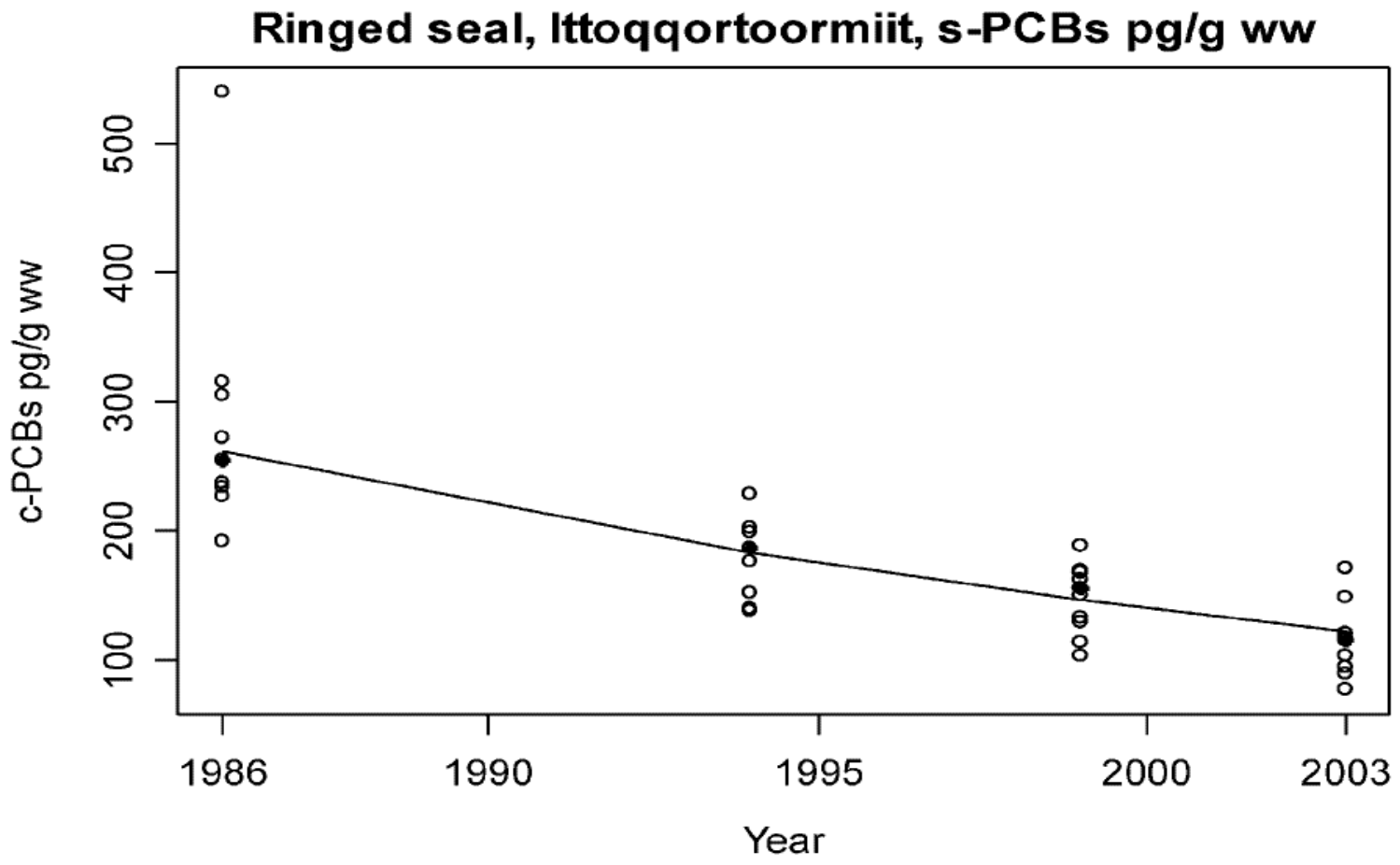
DDTs & Toxaphene in Beluga blubber







Riget et al. 2005. Mar. Poll. Bull. 2005 (50) 1523-1529.

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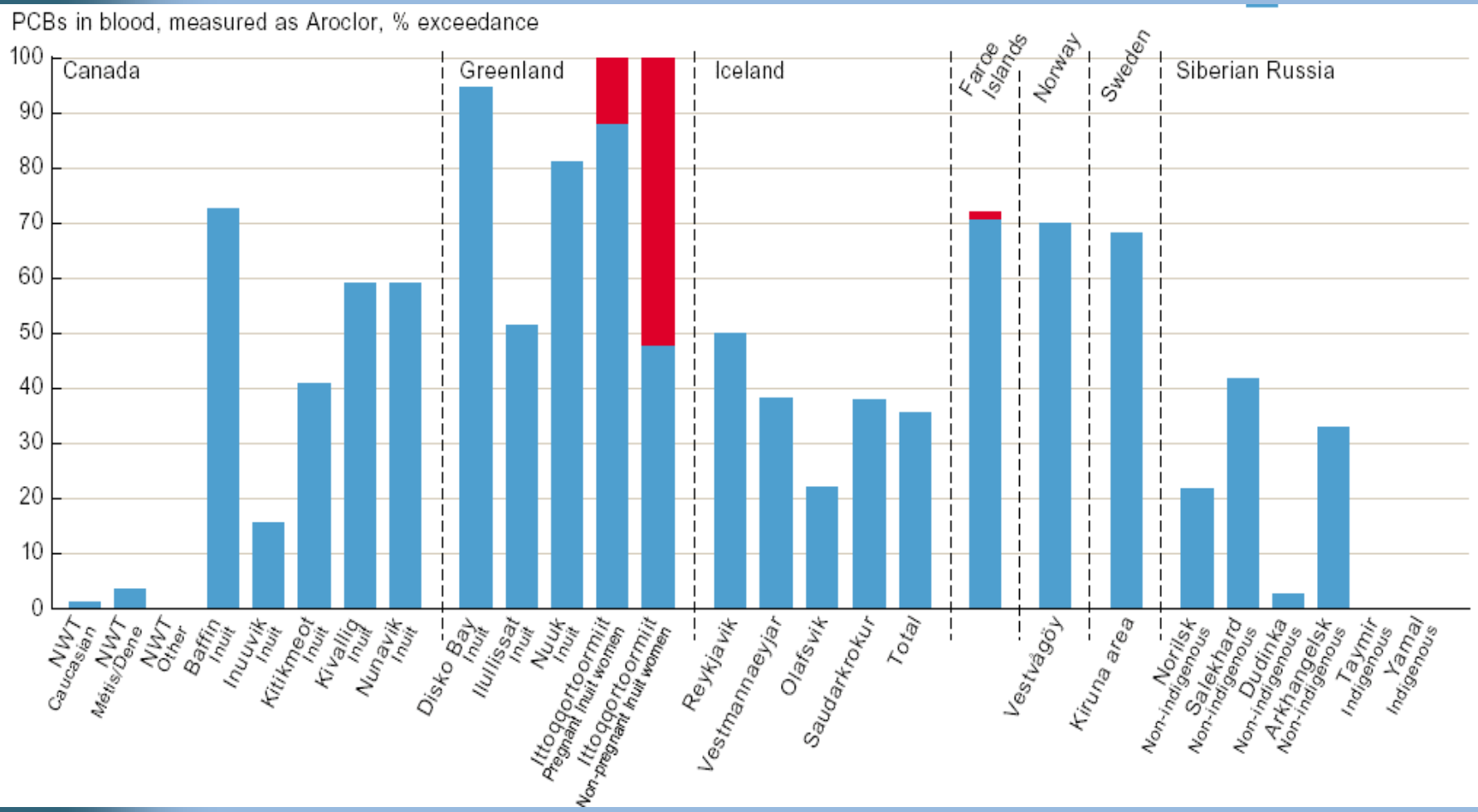
PCB in Human Blood



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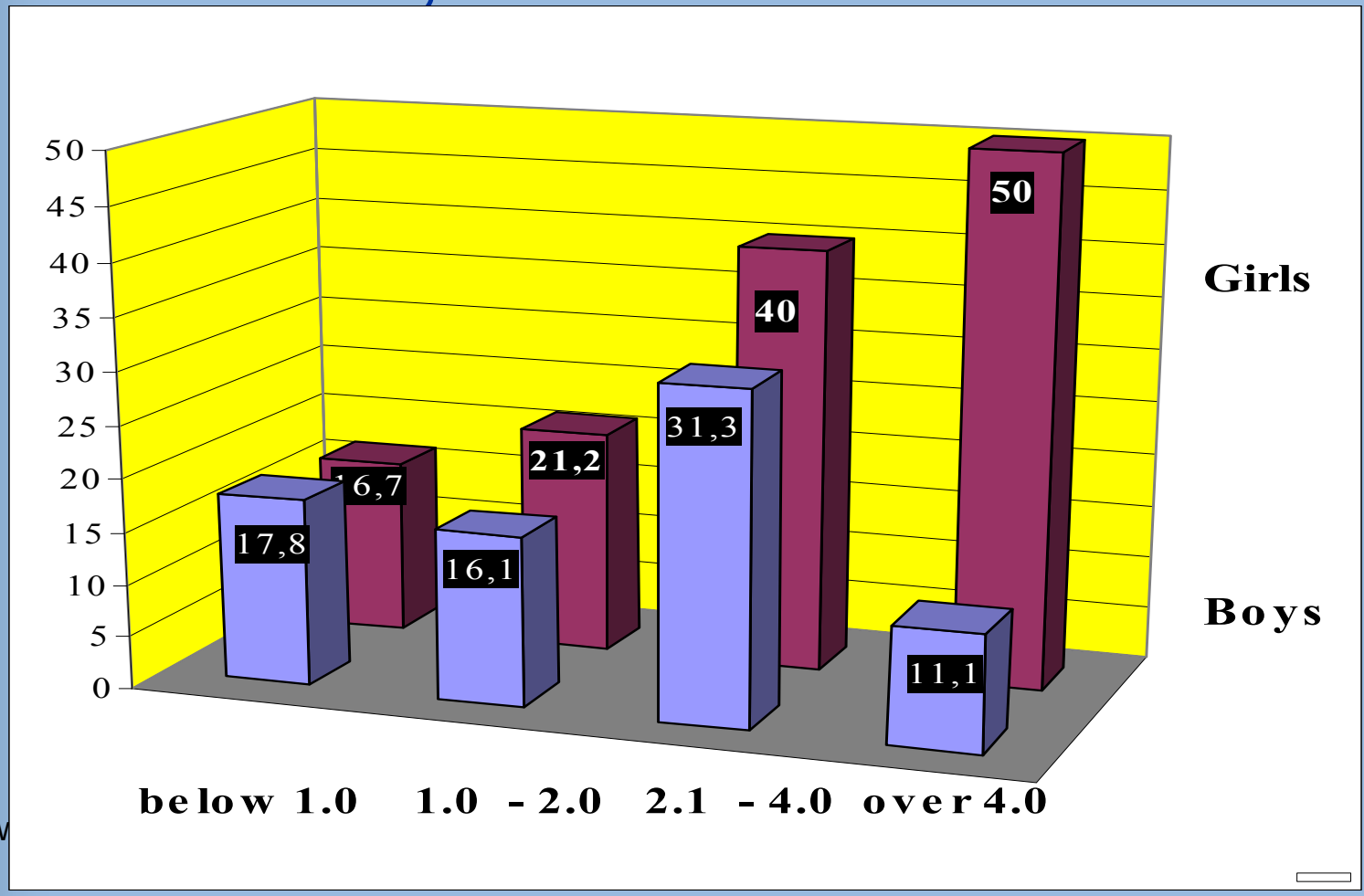
Mean POP concentrations in fresh (frozen) and cooked local foods, ng/g ww (AMAP 2004, the PTS study)

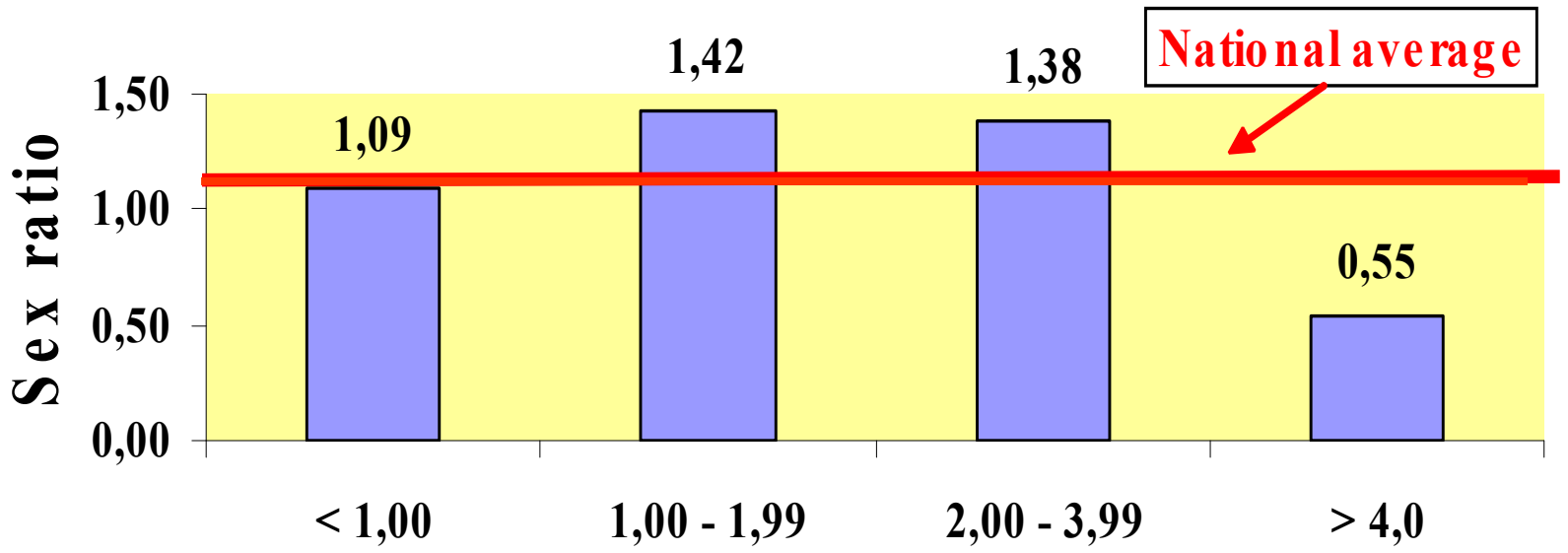
Foods	State of food	Concentrations of selected POPs			
		Total PCBs	HCB	ΣHCHs	Σ DDTs
Bearded seal, meat	Fresh	9.42	0.24	0.55	4.0
	Boiled	1.89	0.25	0.25	0.91
Whale, mantak	Fresh	22.63	0.71	2.29	7.50
	Boiled	10.03	n.d	0.58	3.29
Walrus, meat	Fresh	3.1	0.20	0.17	0.30
	Fermented [1]	623	0.16	0.73	7.76
Ringed seal, meat	Fresh	14.6	0.39	0.77	3.19
	Boiled	6.85	0.13	0.12	1.01
Arctic char	Fresh	9.79	0.12	1.00	0.99
	Marinated	3.83	0.13	n.d	0.80
	Dry-cured	20.12	0.52	2.43	1.68

Frantz Josef Land PCB and oil study, Graham-Bell Island, 2004

Proportion of reduced birth weight newborns (below 3000 g) by total PCB concentrations in maternal serum, %



Sex ratio of newborns (boys/girls) by PCB concentrations measured in maternal blood, µg/L



New Concerns

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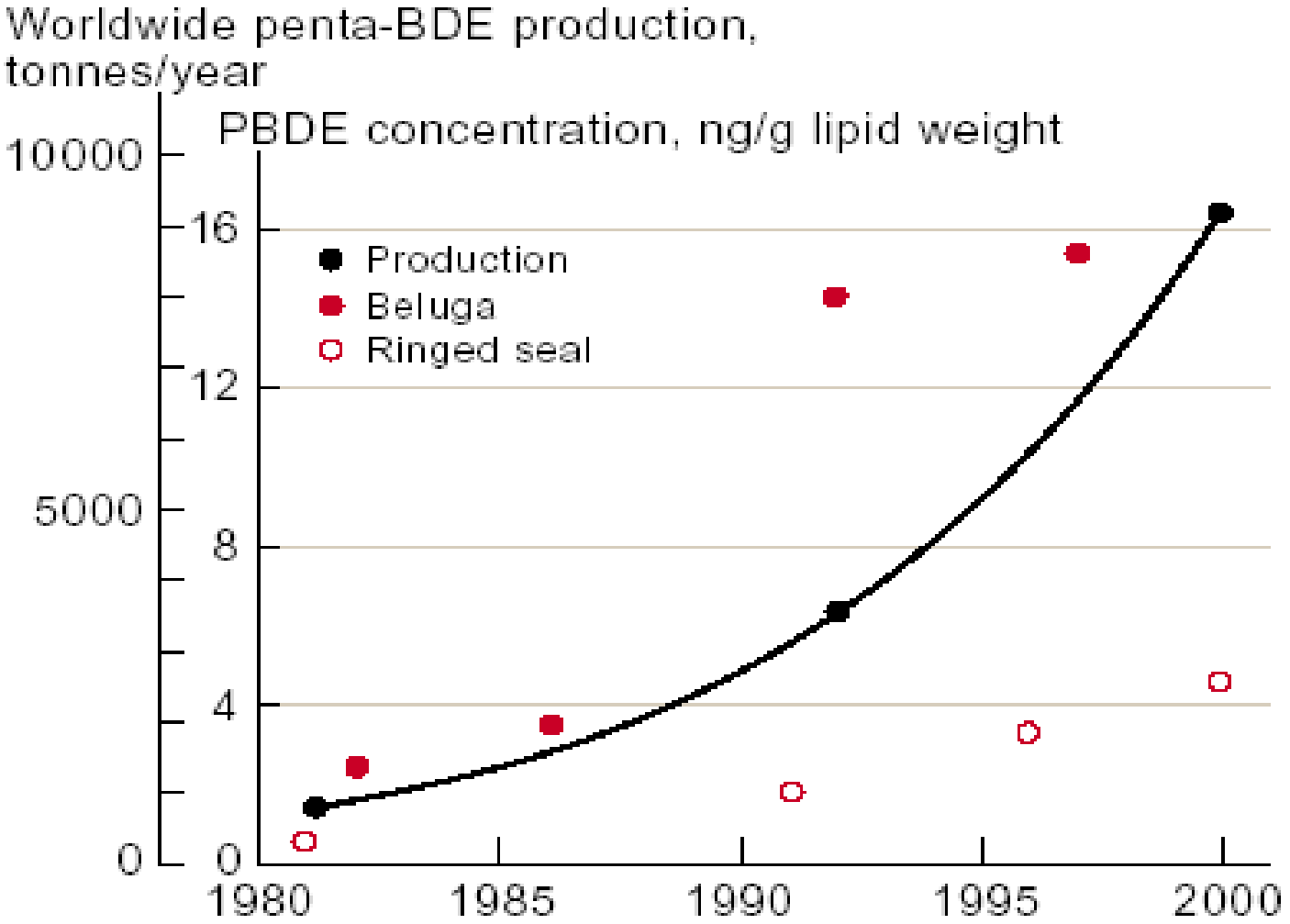
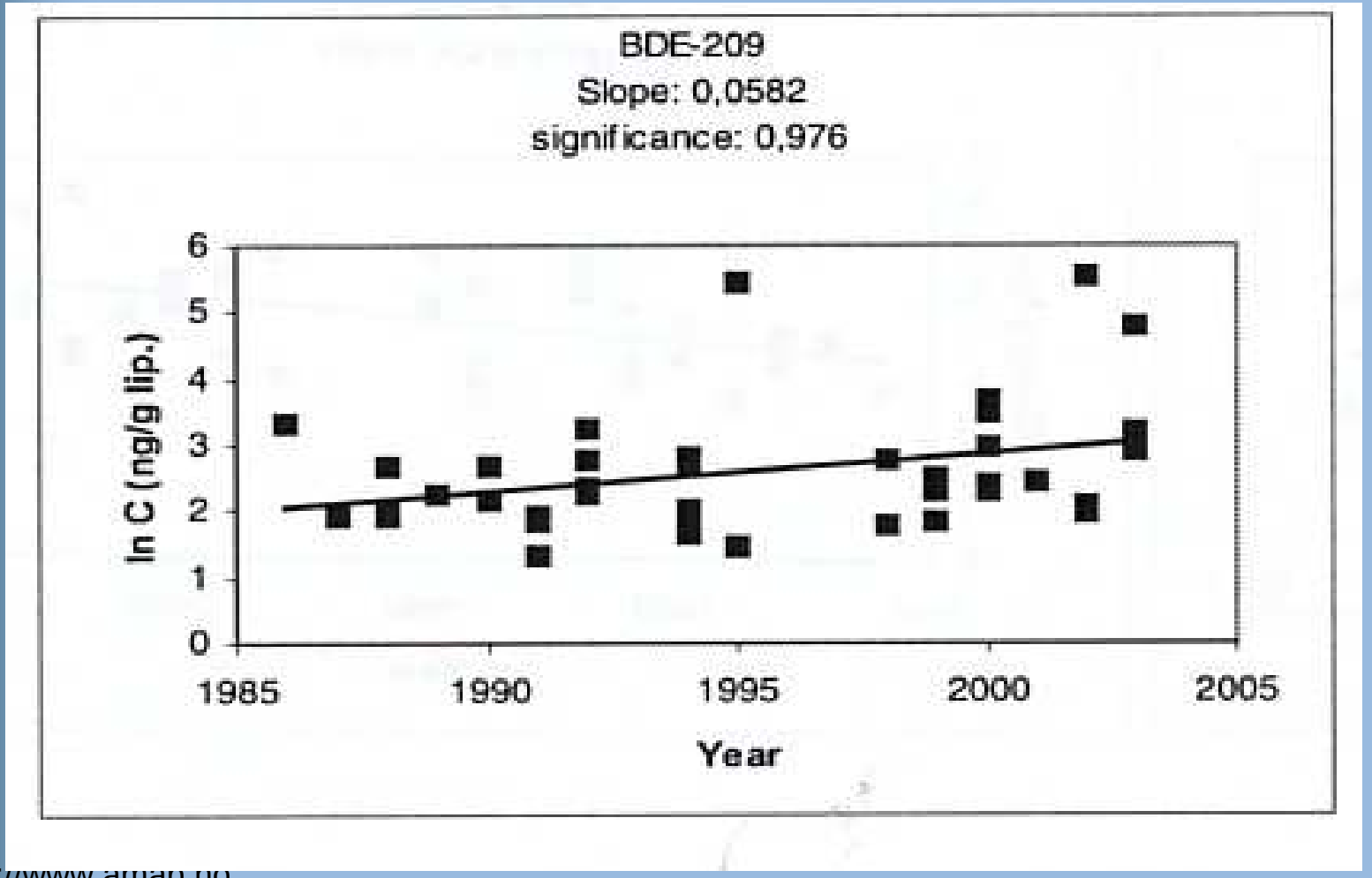


Temporal trend of DecaBDE in Greenland peregrine falcon eggs



Vorkamp et al., 2005, ES&T 39:8199

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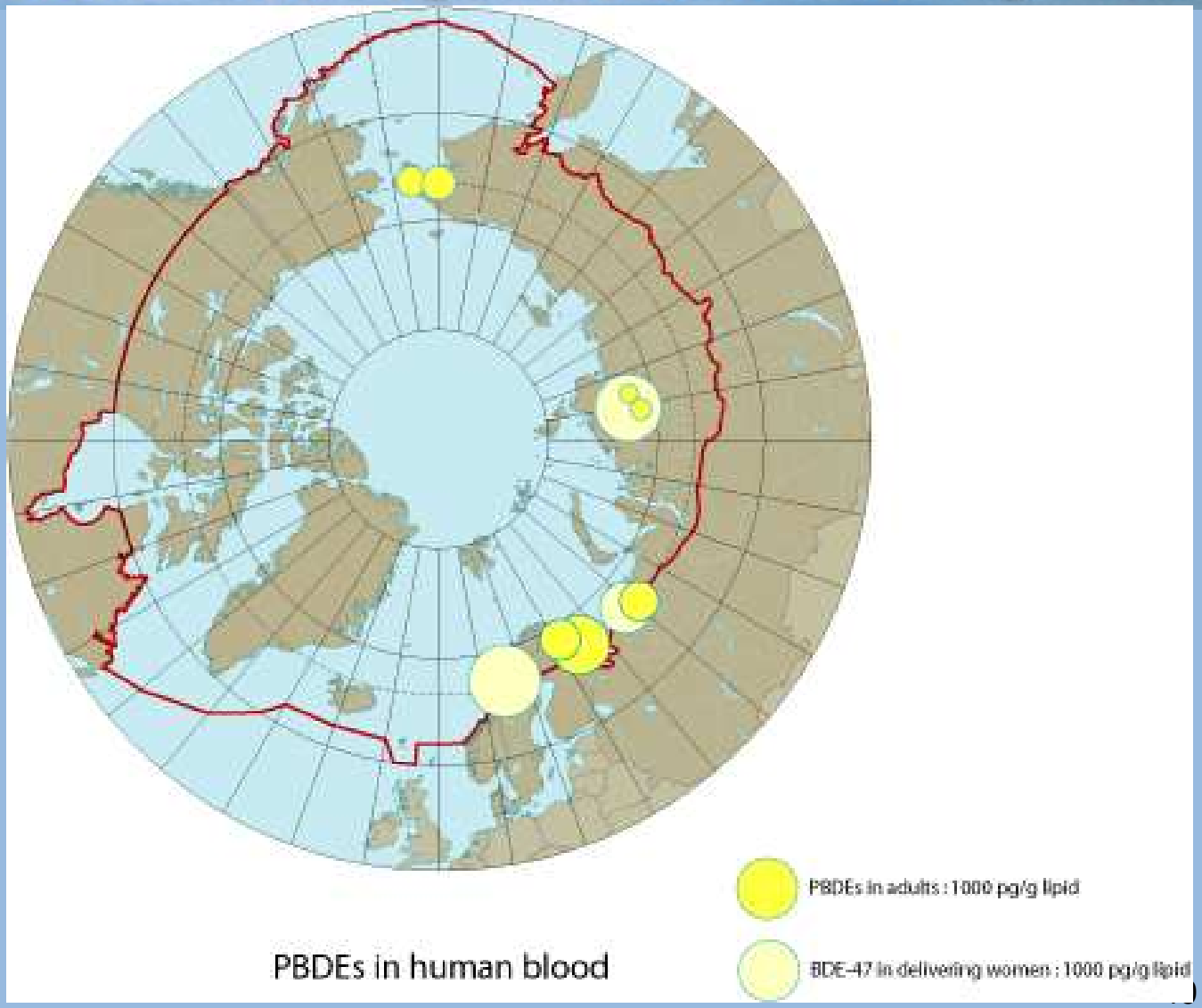


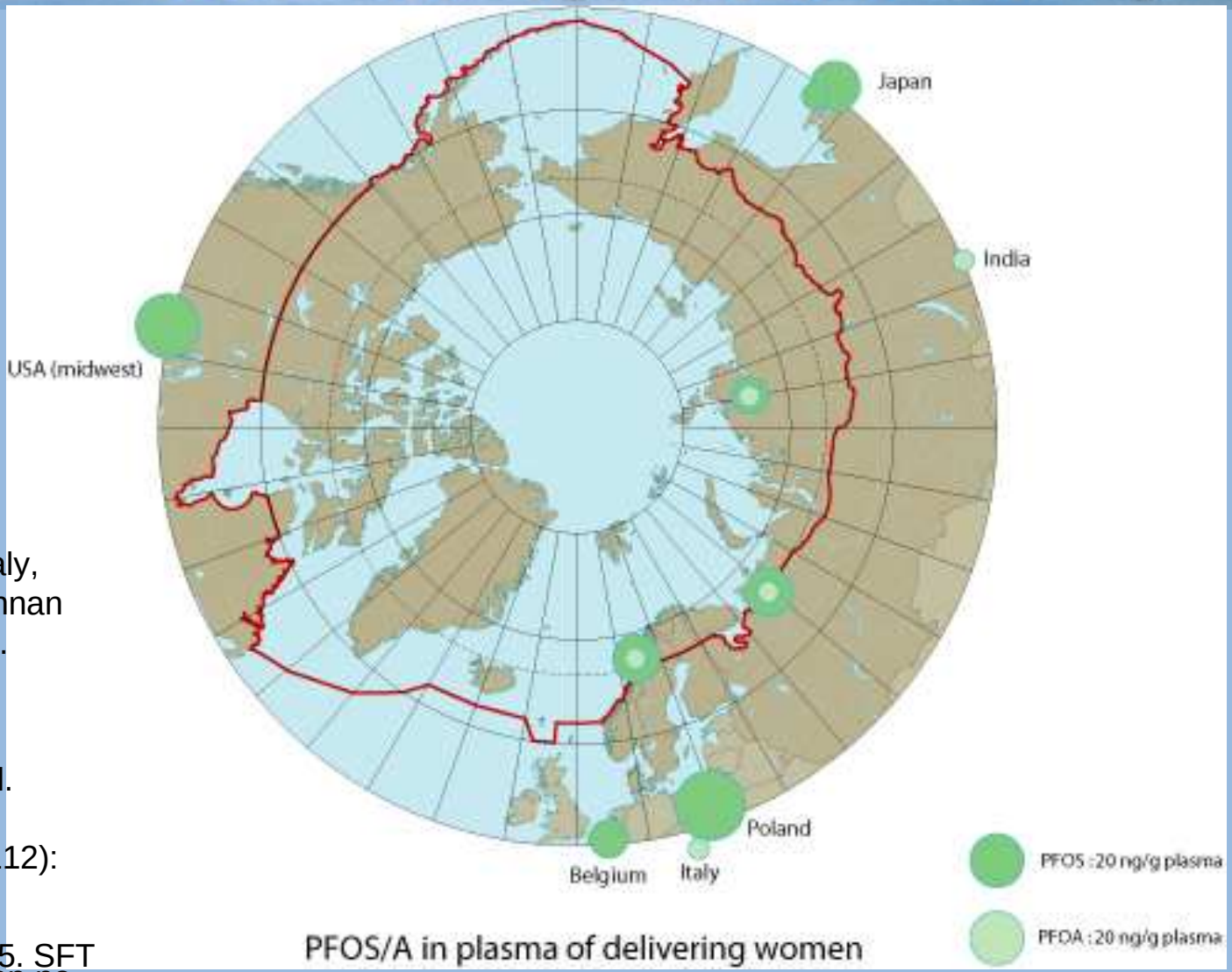
PBDEs in human blood

Data Sources

PBDEs: AMAP, 2004. AMAP Report 2004:2 and Konoplev et al, 2006 (Dioxin 2006)

BDE-47: SFT, 2005. SFT Report 930-2005.

http://www.amap.no



Data Sources

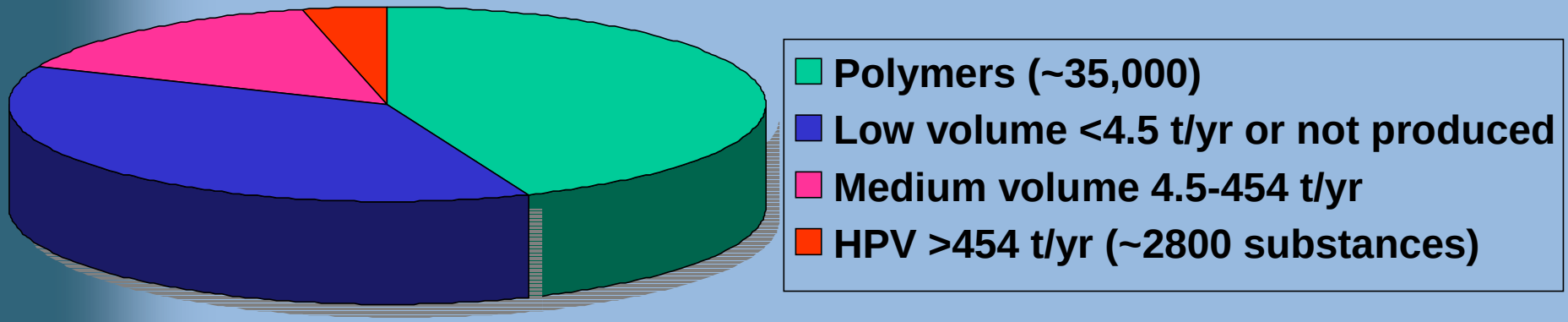
Belgium, India, Italy, Poland, USA: Kannan et al. Environ. Sci. Technol. 2004 (38),4489-4495

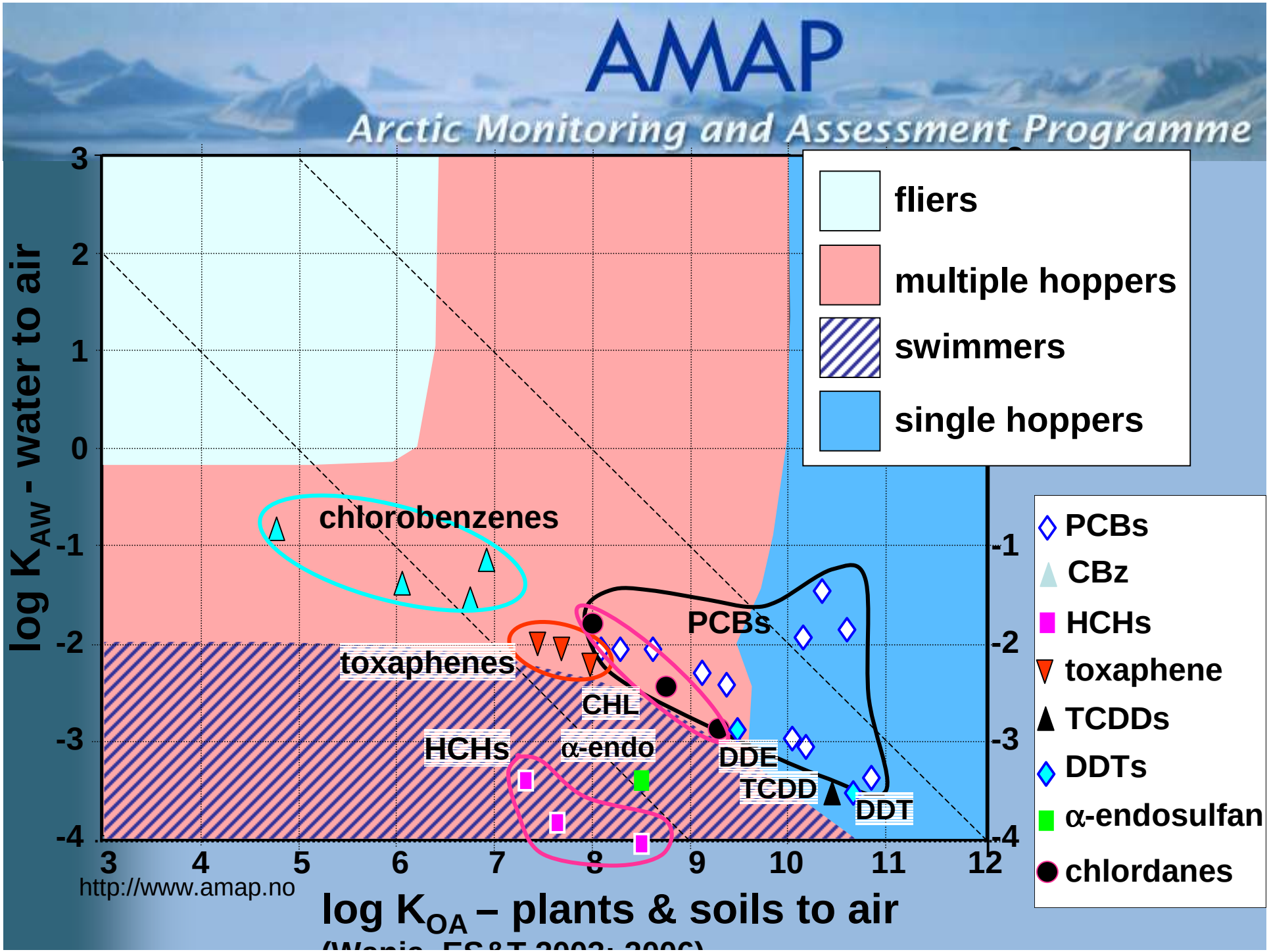
Japan: Inoue et al. Environ. Health Perspect. 2004 (112): 1204-1207

Russia: SFT, 2005. SFT Report 930-2005

1. Breakdown of the Chemicals in commerce – USA

2. "Industrial" Chemicals in commerce – US TSCA inventory




AMAP
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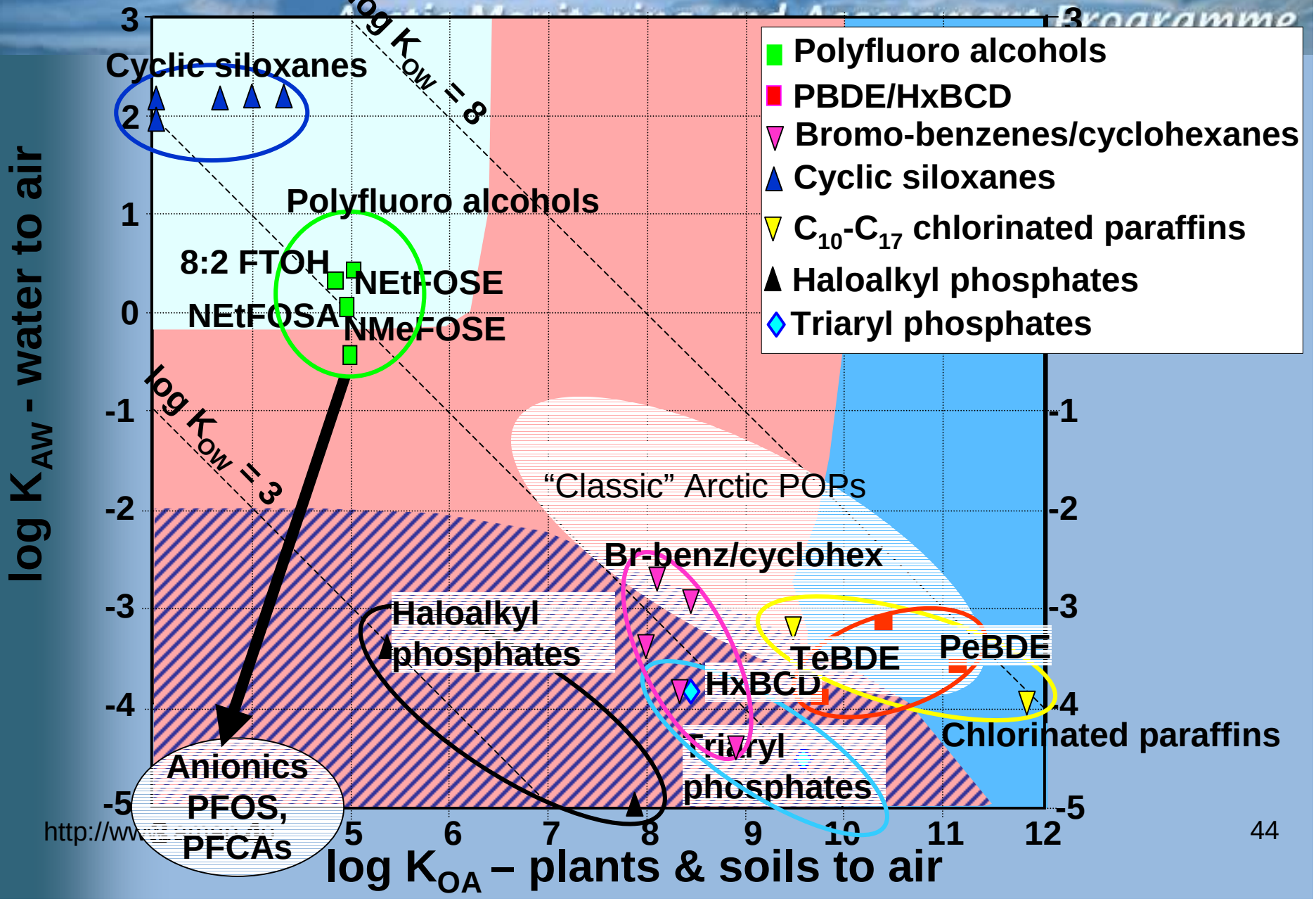
fliers
multiple hoppers
swimmers
single hoppers
chlorobenzenes
toxaphenes
HCHs
CHL
α-endo
PCBs
DDE
TCDD
DDT
PCBs
CBz
HCHs
toxaphene
TCDDs
DDTs
α-endosulfan
chlordanes
log K_AW - water to air
log K_OA – plants & soils to air
3
2
1
0
-1
-2
-3
-4
3
4
5
6
7
8
9
10
11
12
http://www.amap.no


log K_{OW} = 8
log K_{OW} = 3
Cyclic siloxanes
Polyfluoro alcohols
8:2 FTOH
NEtFOSE
NEtFOSA
NMeFOSE
"Classic" Arctic POPs
Br-benz/cyclohex
Haloalkyl phosphates
TeBDE
PeBDE
HxBCD
Triaryl phosphates
Chlorinated paraffins
Anionics PFOS, PFCAs
Polyfluoro alcohols
PBDE/HxBCD
Bromo-benzenes/cyclohexanes
Cyclic siloxanes
C_{10}-C_{17} chlorinated paraffins
Haloalkyl phosphates
Triaryl phosphates
log K_{AW} - water to air
log K_{OA} – plants & soils to air
3
2
1
0
-1
-2
-3
-4
-5
5
6
7
8
9
10
11
12

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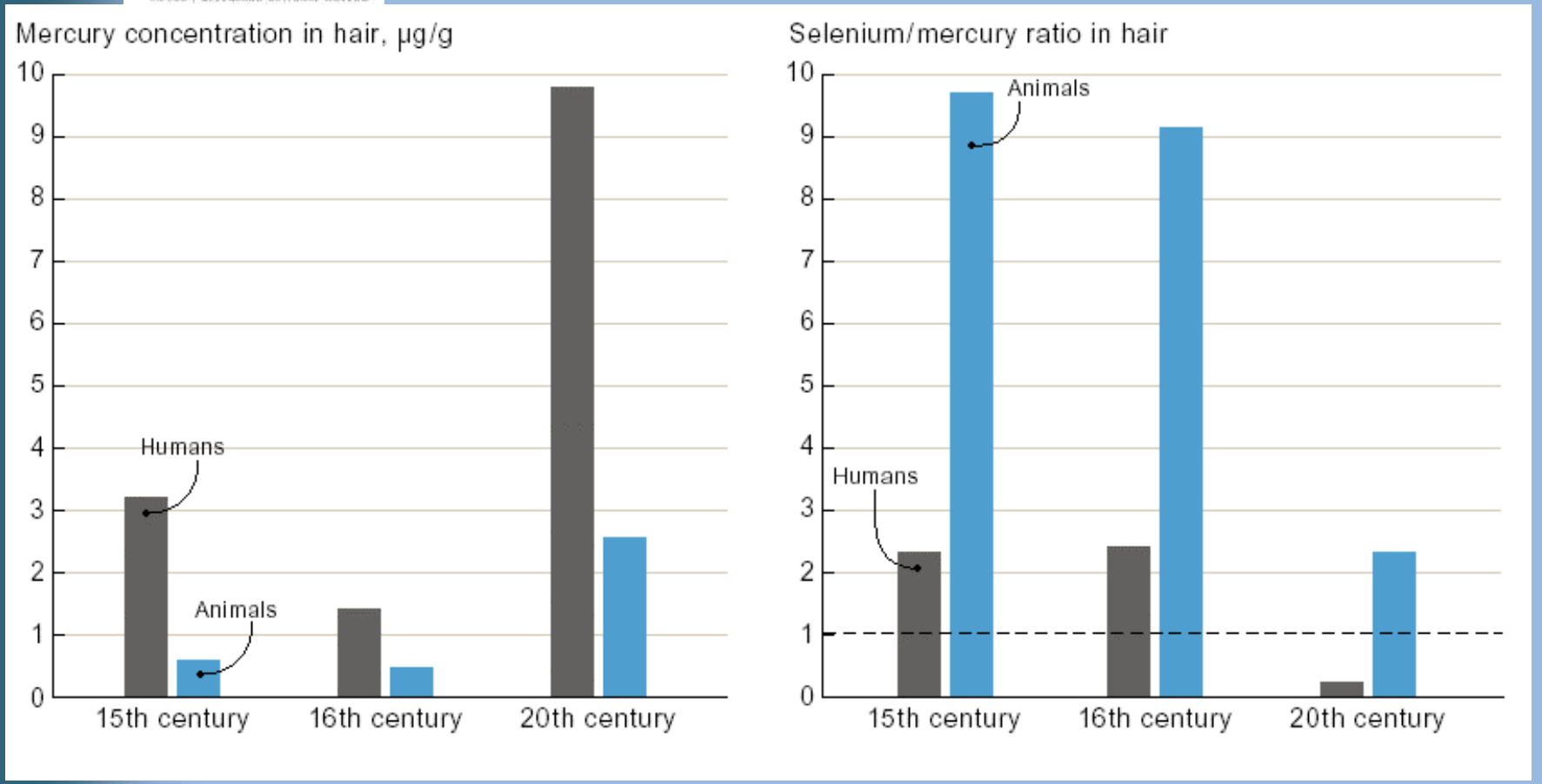
Time Trends, Mercury and Selenium in Hair from Humans and Seals in Greenland



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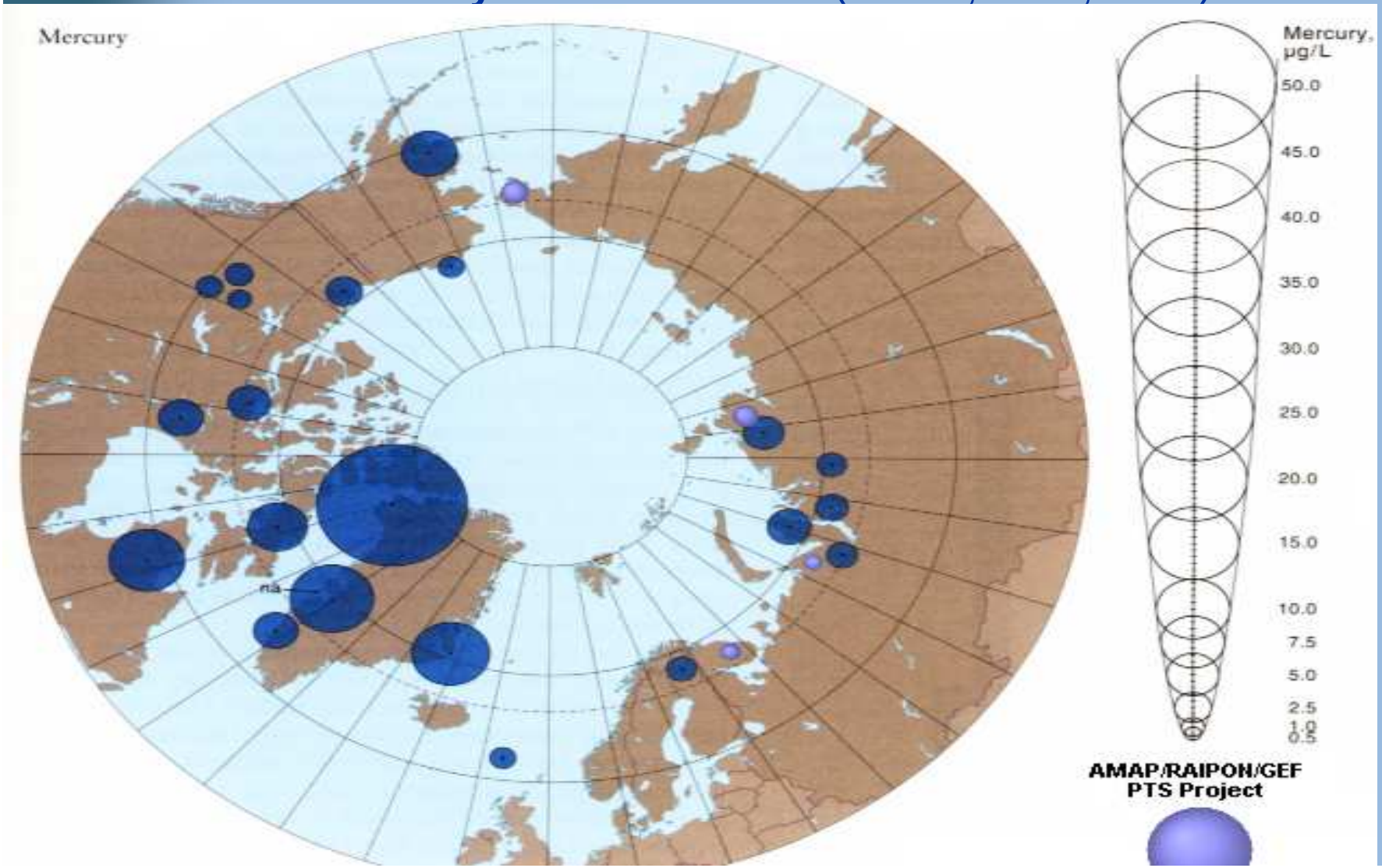
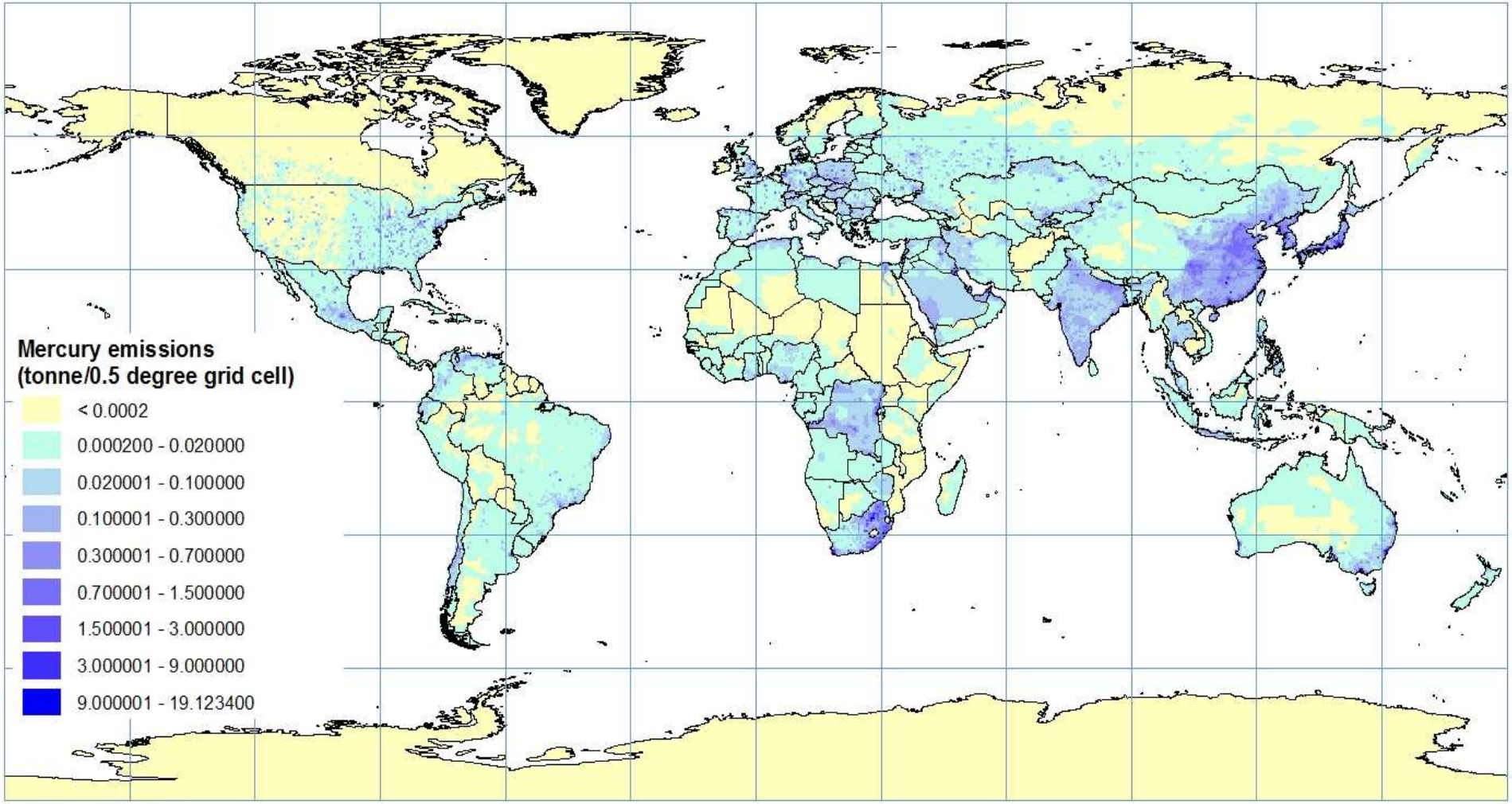
Mercury in maternal blood (AMAP, 2003, 2004)



Conclusions from studies on MeHg

- Neurobehavioral effects most clearly on attention, memory and language, but also visuospatial and motor functions
- Cardiovascular effects, increased blood pressure
- Prenatal generally more toxic than early postnatal exposure
- Preliminary results from age 14 years suggest that effects are permanent
- Food advice has reduced intake and levels

Mercury Emissions, 2000
diffuse + point sources

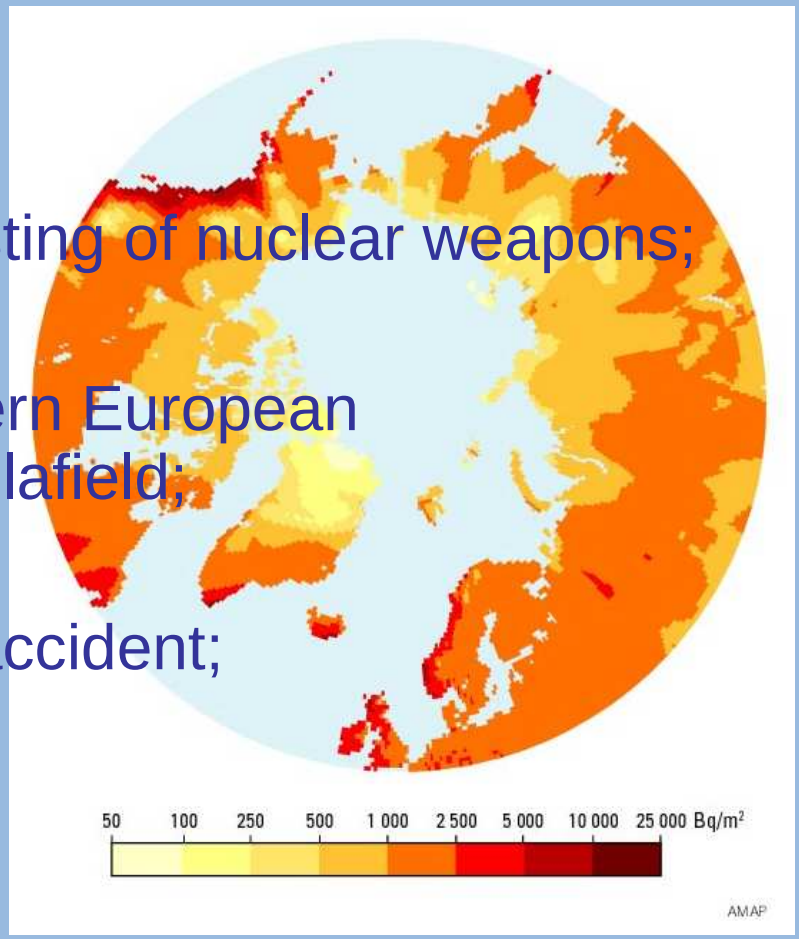


no projection (geographic)

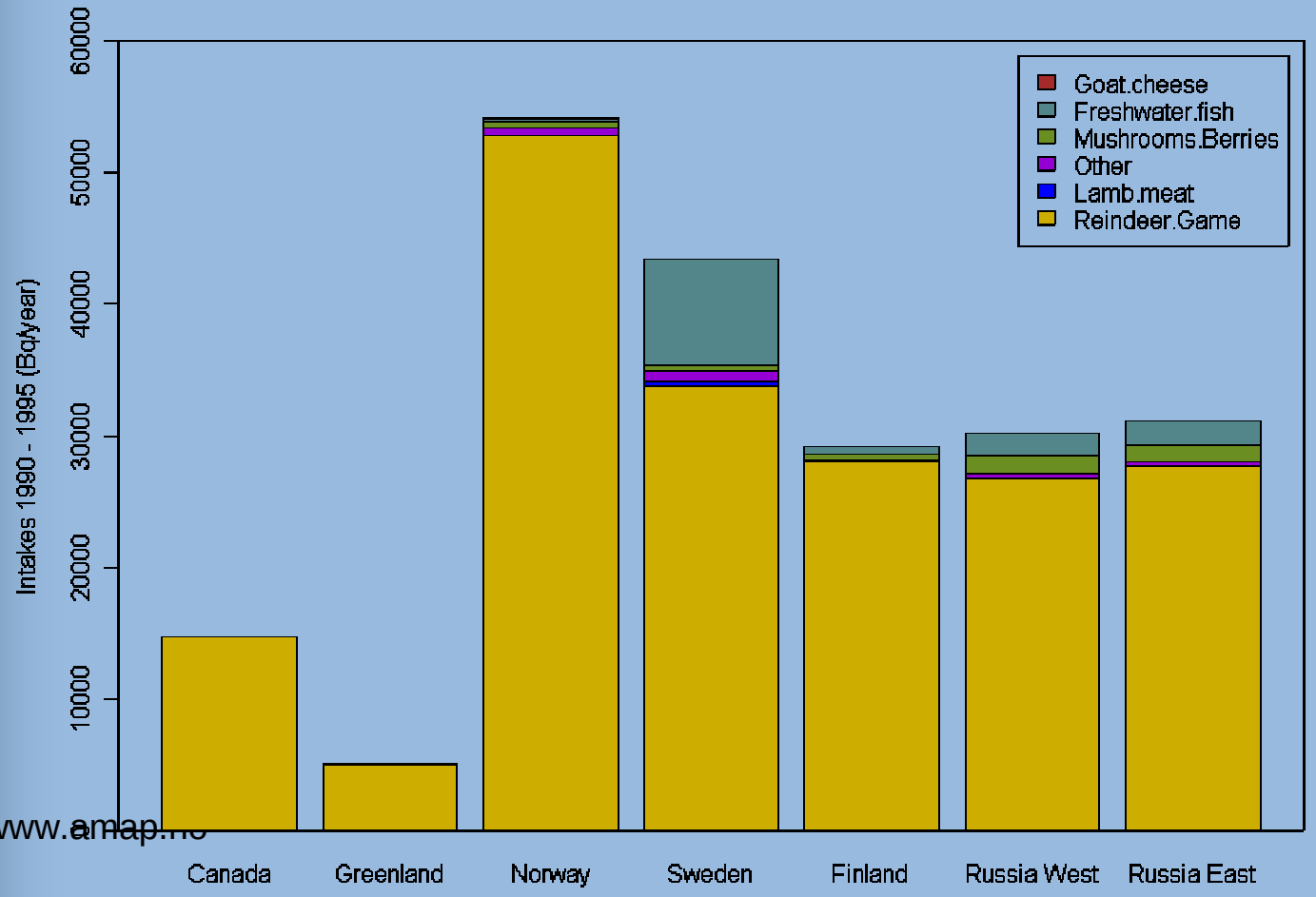
Global Emissions Inventory Activity (GEIA)
S. Wilson (AMAP), F. Steenhuisen (Arctic Centre, RuG), J. Pacyna (NILU)

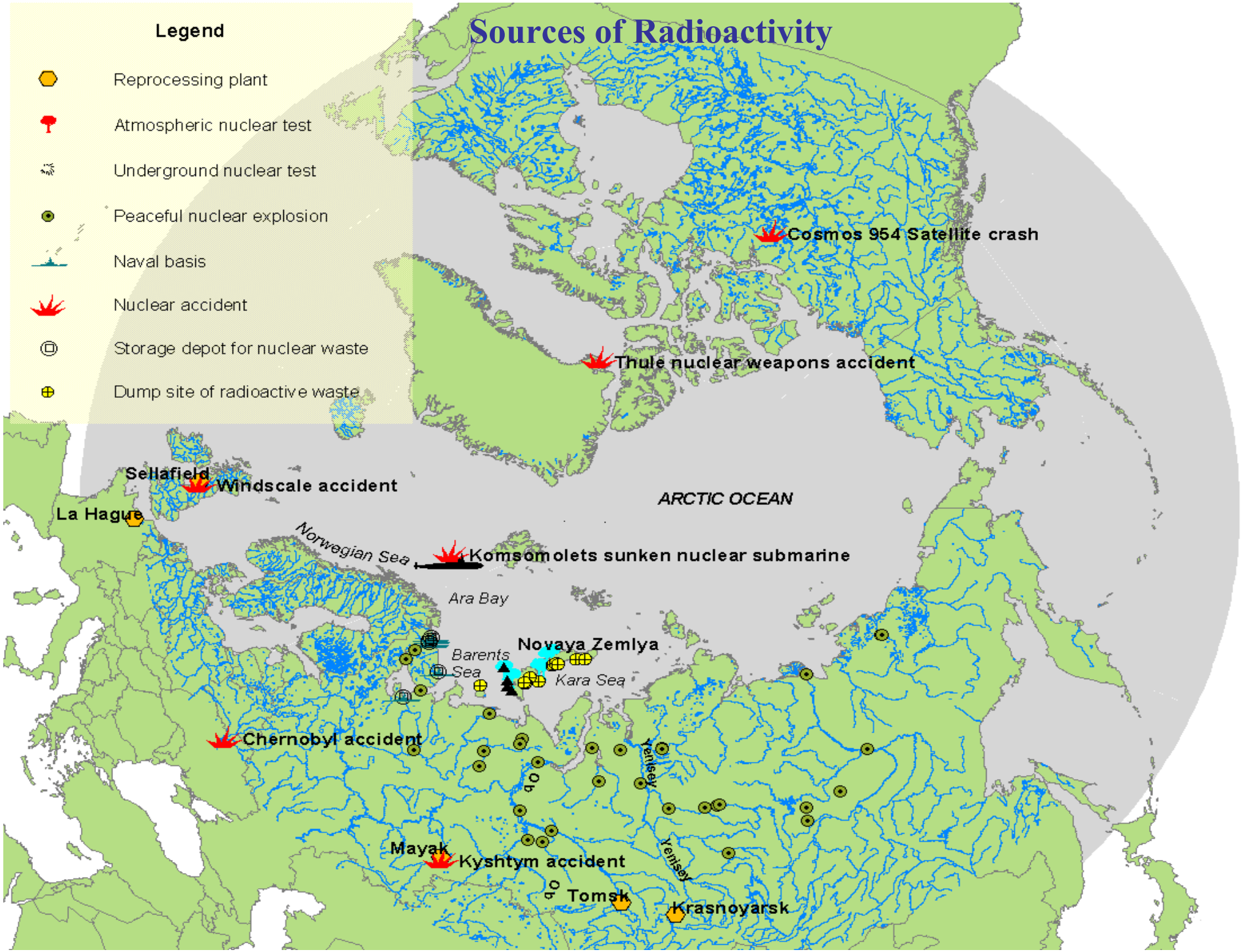
Three major sources have contributed to the widespread radioactive contamination of the Arctic area:

- Fallout from atmospheric testing of nuclear weapons;
- Routine releases from western European reprocessing plants, e.g. Sellafield;
- Fallout from the Chernobyl accident;



Humans - Intake of radionuclides – selected groups




Sources of Radioactivity
Legend
Reprocessing plant
Atmospheric nuclear test
Underground nuclear test
Peaceful nuclear explosion
Naval basis
Nuclear accident
Storage depot for nuclear waste
Dump site of radioactive waste
Cosmos 954 Satellite crash
Thule nuclear weapons accident
Sellafield
Windscale accident
La Hague
ARCTIC OCEAN
Norwegian Sea
Komsomolets sunken nuclear submarine
Ara Bay
Novaya Zemlya
Barents Sea
Kara Sea
Chernobyl accident
Ob
Yenisey
Mayak
Kyshtym accident
Tomsk
Krasnoyarsk

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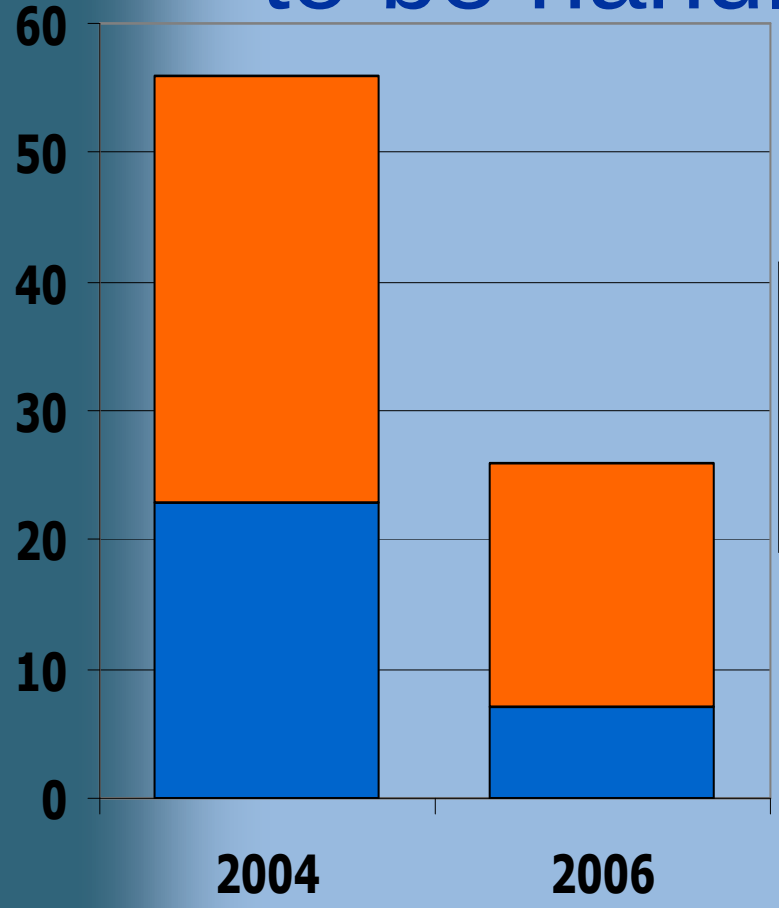
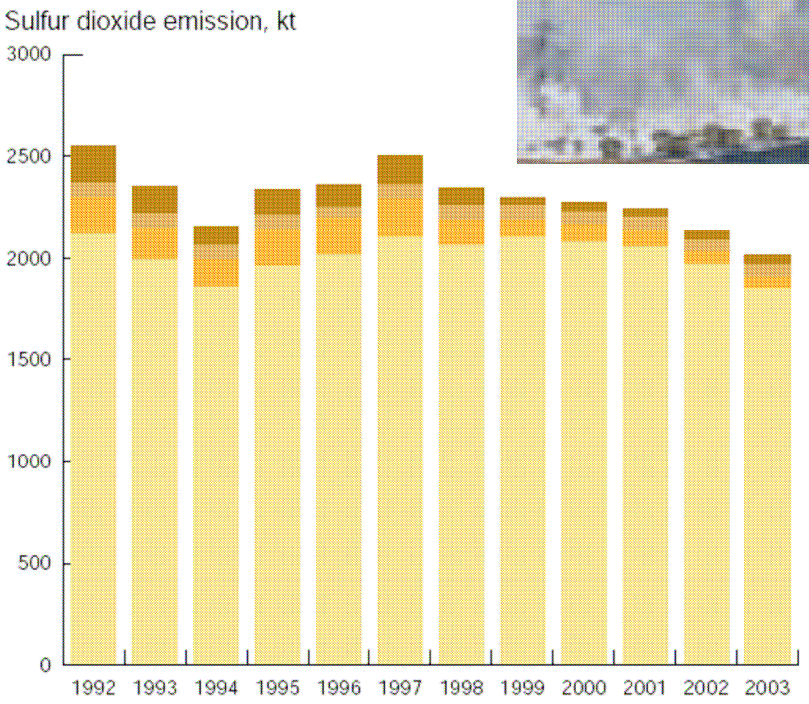
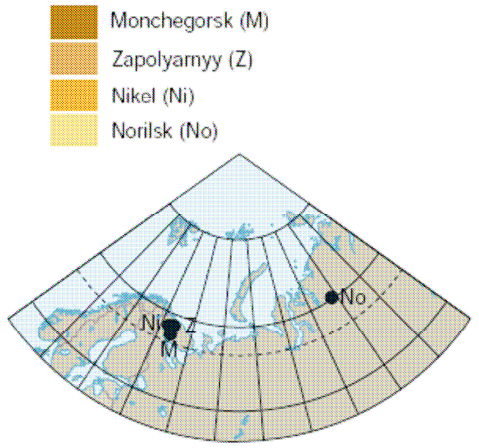
Decommissioned submarines to be handled



Approximately 200 submarines taken out of service

Declines in smelter emissions





Although they remain the dominant source of sulfur dioxide (SO_2) emissions within the Arctic, SO_2 emissions from the smelters in Arctic Russia decreased by about 21% between 1992 and 2003. The greatest reductions in SO_2 emissions have occurred on the Kola Peninsula. At Nikel, emissions decreased by around 68% between 1990 (when emissions peaked) and 2003, with even bigger reductions at Monchegorsk where emissions decreased by around 82% over this period. Emissions reductions at Norilsk have been much less, decreasing by about 16% between 1990 and 2003.

ARCTIC MONITORING AND ASSESSMENT PROGRAMME

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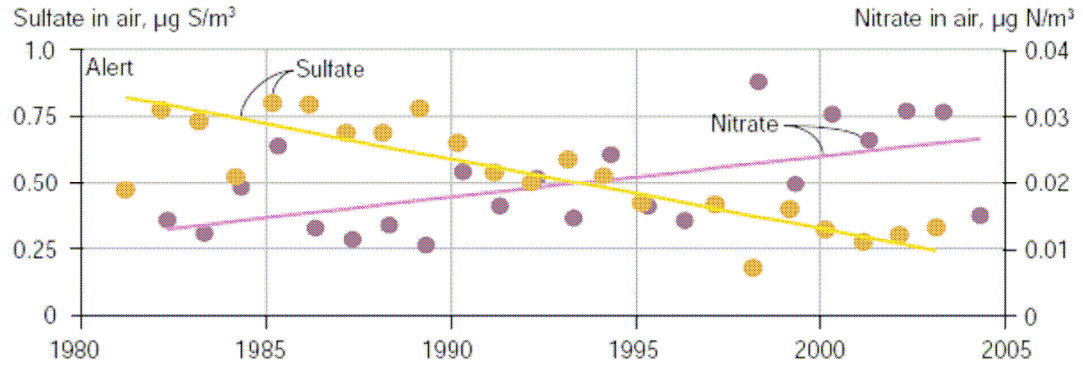
Recent trends in Arctic haze

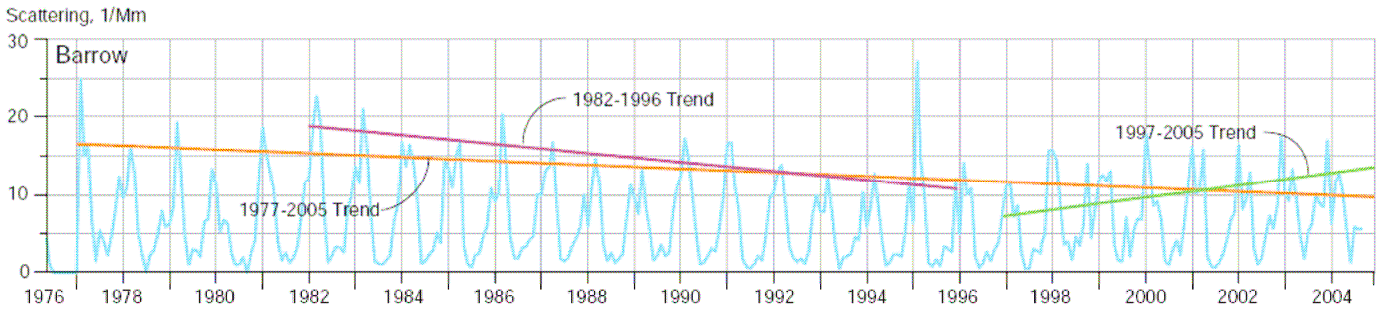
Arctic Monitoring and Assessment Programme

Recent trends in sulfate and nitrate have decoupled



Long-term trends in sulfate and nitrate in air at Alert, Ellesmere Island, northern Canada, based on averaged values for April.

Light scattering and absorption appear to be increasing



Light scattering measured at Barrow, Alaska, showing peaks during spring when haze levels are at their highest. The long-term decreasing trend in spring-time light scattering masks a more recent increase since the end of the 1990s. The cause of this recent increase is not yet known.

Human health

BRYAN & CHERRY ALEXANDER

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Workers in smelters are exposed to high levels of sulfur dioxide. However, studies have not found any significant health effects associated with smelter emissions in the general population in areas close to the smelters.

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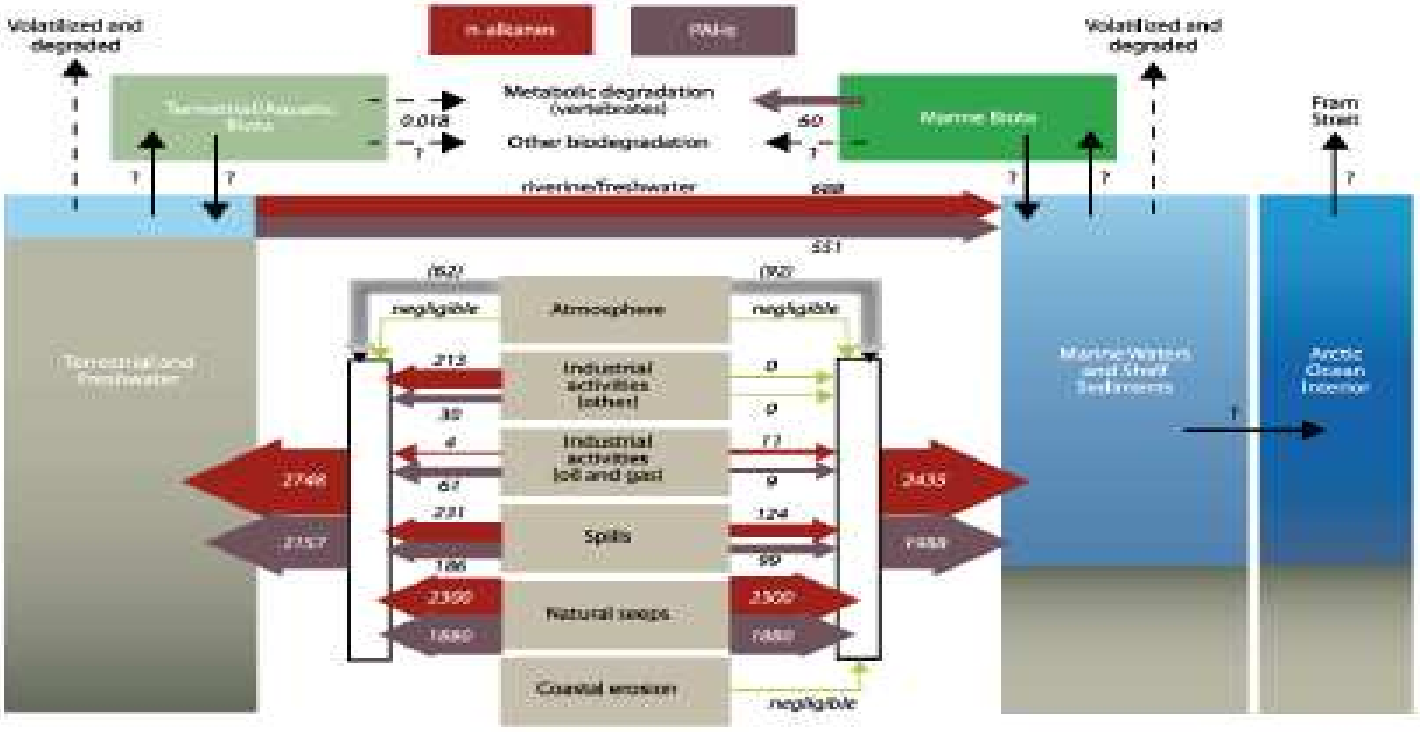
Arctic Petroleum budget



Schematic diagram of the petroleum hydrocarbon budget of the Arctic. Inputs via the atmosphere are primarily non-petrogenic.

Due to lack of information concerning some parts of the budget a number of assumptions had to be made. Future work will hopefully fill some of these knowledge gaps and allow this budget to be improved in the future.

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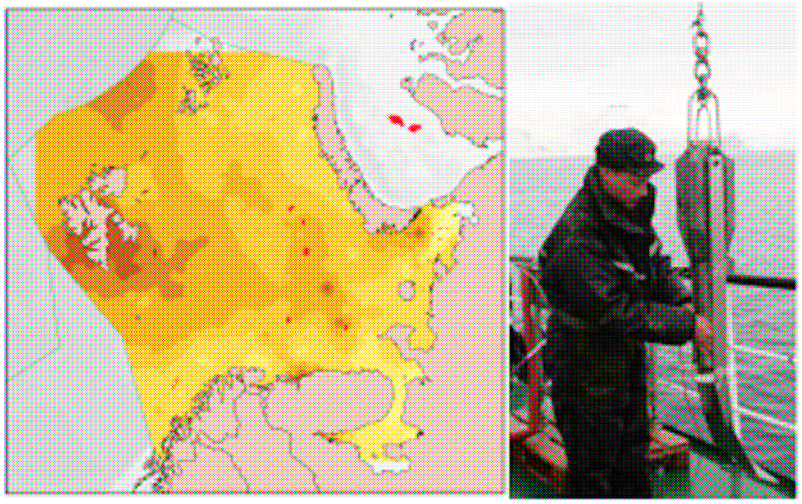
PAH in marine sediments

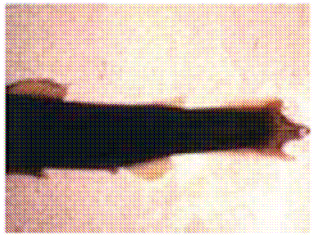


PAHs (ng/g dry weight) in bottom sediments of the Barents Sea.

Fine structure and hot spots shown on interpolated maps, such as this, should be viewed with caution, however the general trends, such as the high concentrations around Svalbard are clear.

Oil introduced into the environment, especially as a result of spills, has potential to cause harmful effects to Arctic biota. Low levels of petroleum hydrocarbons found in most Arctic areas are unlikely to cause toxic effects – but concerns remain in more polluted areas.

Toxicological effects	Significance of levels of petroleum hydrocarbons in the Arctic, and significance of cold on toxicological effects. Toxicological impacts on people.
Oil spills	Impacts of spills on land, including a description of the 1994 Komi Republic pipeline rupture. Effects of marine spills, including those from subarctic spills such as the Exxon Valdez. Potential for impacts from arctic spills.

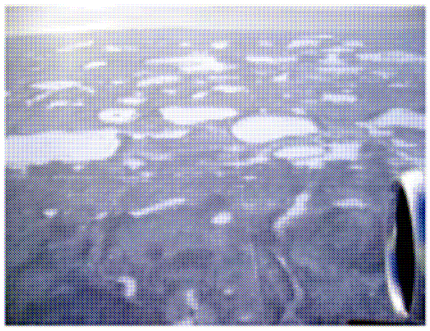


Key Finding #4. On land, physical disturbance is the largest effect

Exploration, construction, and infrastructure have damaged some areas of tundra and other terrestrial ecosystems. Oil spills have also had local impacts. Over time, the impacts associated with new developments have decreased as industry practices have improved and regulations have become more stringent. Ice roads eliminate lasting transportation corridors. Directional drilling reduces the number of platforms used. Effects, however, can be cumulative and last for decades.

Oil spills continue to pose a threat to local ecosystems.

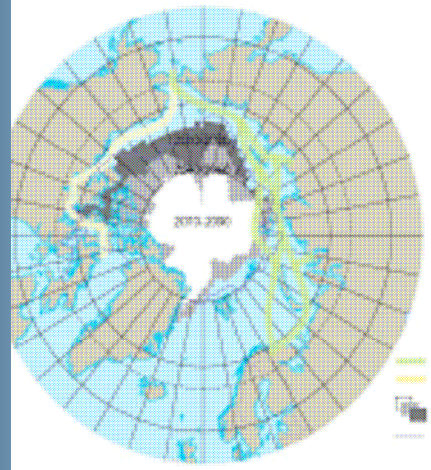
Seismic surveys can leave scars on the tundra that persist for decades.



Modern practices, such as the use of ice roads can reduce impacts, but only during certain seasons.

Key Finding #5. In marine environments, oil spills are the largest threat

To date, no major oil spills have occurred in arctic seas. Experiences from elsewhere, including the subarctic, show that the environmental consequences could be severe. A spill that occurred in a time and place that animals were aggregated could be especially disastrous. The frequency of large spills is low, but the overall risk increases with increased activity.



Sea-ice melting as a result of climate change is expected to increase shipping transport of oil in Arctic seas.

The *Exxon Valdez* spill (below) demonstrated the potential effects of a major spill in conditions typical of subarctic areas.

Although no large spills have occurred in the Arctic so far, even small spills (right) can have devastating effects on local aggregations of animals and birds.

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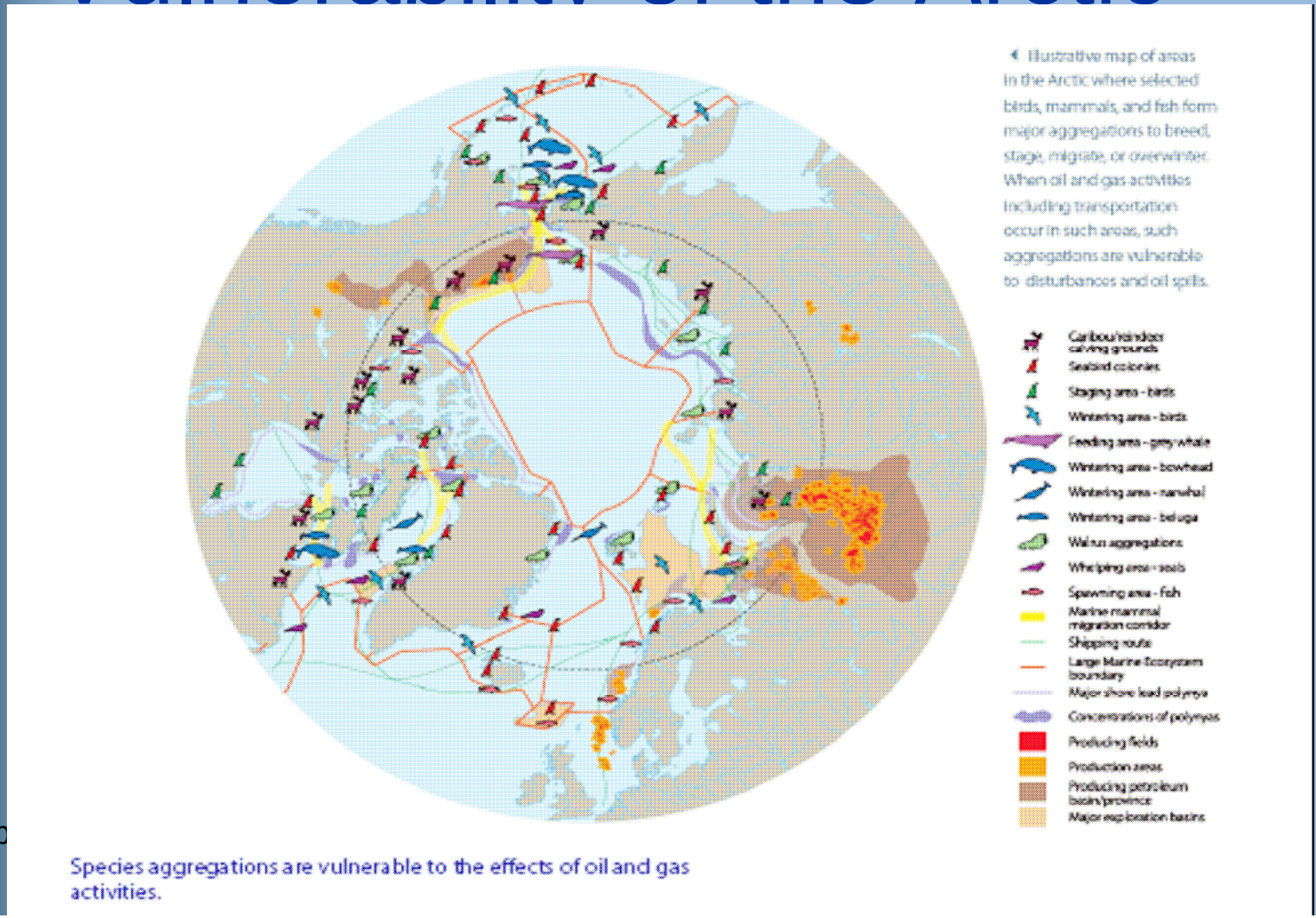
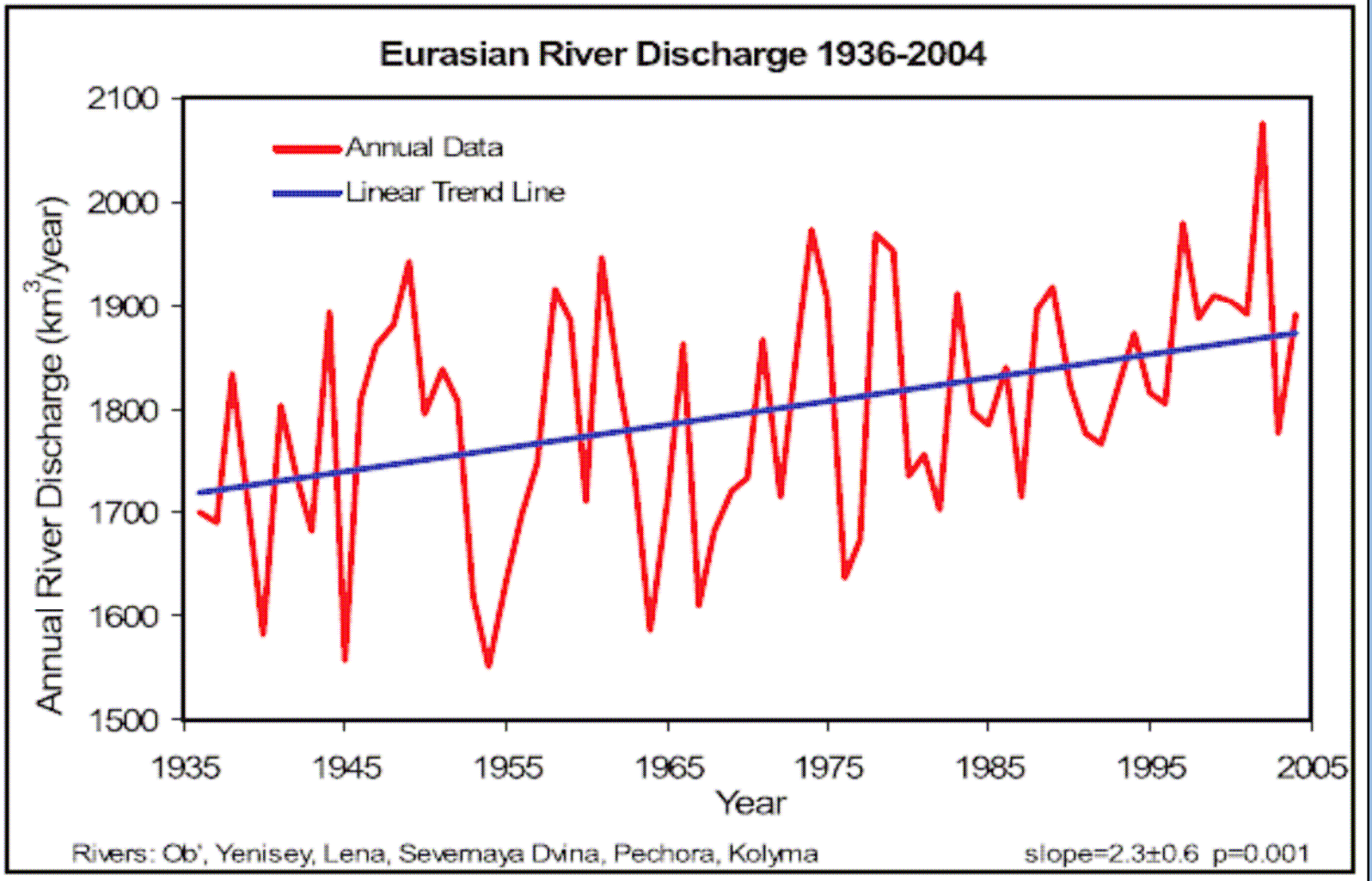
Vulnerability of the Arctic



Species aggregations are vulnerable to the effects of oil and gas activities.


Eurasian River Discharge 1936-2004
Annual Data
Linear Trend Line
Annual River Discharge (km3/year)
2100
2000
1900
1800
1700
1600
1500
1935
1945
1955
1965
1975
1985
1995
2005
Year
Rivers: Ob', Yenisey, Lena, Severnaya Dvina, Pechora, Kolyma
slope=2.3±0.6 p=0.001

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Some Arctic peoples are at threat !

Stockholm convention

Global Monitoring for POPs in air and human tissue (blood or milk)

First report in 2009 to be based on:

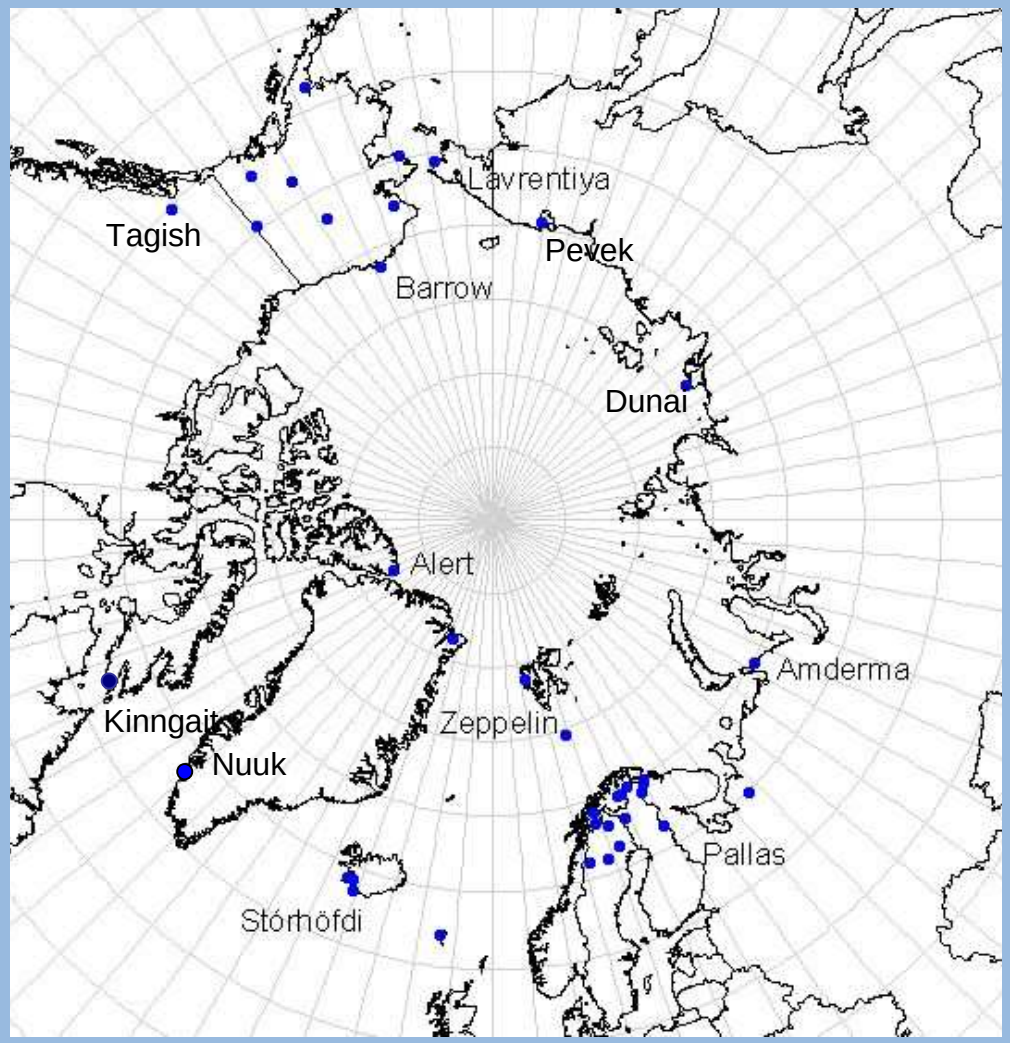
- Existing monitoring programmes (e.g. AMAP, EMEP & WHO) to perform Regional assessments and global overviews

Harmonized methodologies
QA/QC requirements
A Tired system

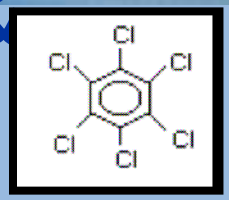
Open for new and simple methodologies, e.g. passive sampler

Background air monitoring sites in the Arctic

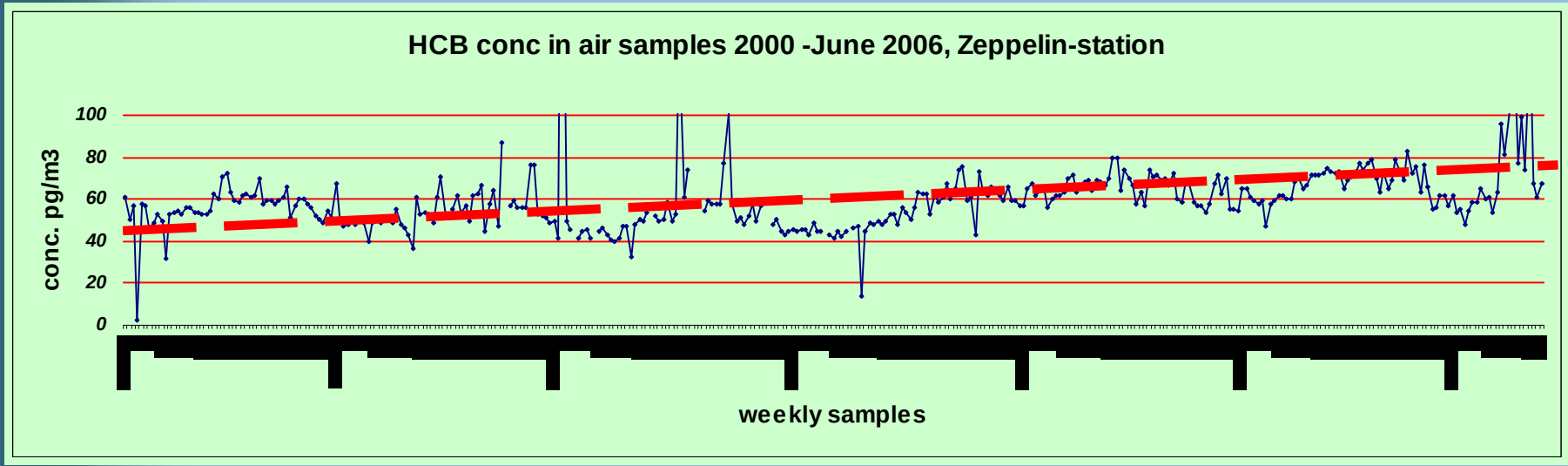
- AMAP air monitoring sites
- Key AMAP air monitoring sites where POPs monitoring is performed
- AMAP POPs monitoring sites operated under temporary funding arrangements
- POPs monitoring sites where operations have ceased
- NILU



Combined effects, Climate & Hexachlorobenzene (HCB)



2000 2001 2002 2003 2004 2005 2006



Indication for climate change induced increase of evaporation from the sea surface ?

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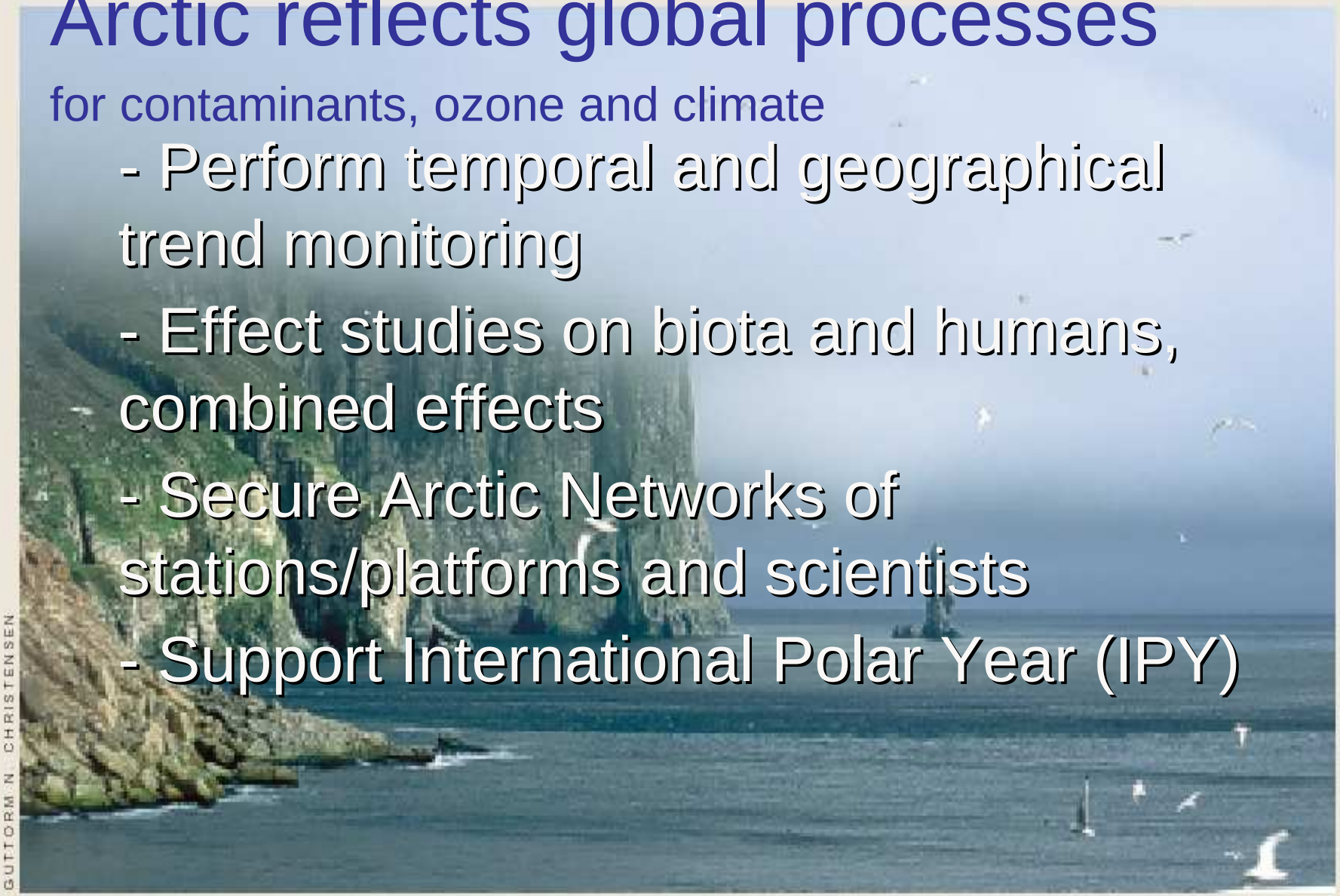
Arctic reflects global processes

for contaminants, ozone and climate

- Perform temporal and geographical trend monitoring
- Effect studies on biota and humans, combined effects
- Secure Arctic Networks of stations/platforms and scientists
- Support International Polar Year (IPY)



Classic monitoring of the Arctic

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I smell……