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Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges

Working Group "Biodiversity and ecosystem services"

- **HIGH-ARCTIC 1997 – 2009**
- **Effects of climate warming on Arctic freshwater ecosystems**
- **Arctic-related activities of UNESCO´s „Man and Biosphere (MAB)" Programme**
- **Recommendations**

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RESEARCH COOPERATION

HIGH-ARCTIC 1997-2009

FISH FROM SENSITIVE ECOSYSTEMS AS BIOINDICATORS OF GLOBAL CLIMATE CHANGE

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HIGH-ARCTIC 1997 - 2009

Fish from sensitive ecosystems as bioindicators of global climate change

HIGH-ARCTIC, an ongoing multi-year study carried out in cooperation with various Canadian research facilities, is investigating the effects of short-term and long-term climate change on freshwater ecosystems in the Canadian High Arctic and in the Austrian Alps. High-mountain lakes and Arctic lakes are very similiar and extremely sensitive ecosystems, where even slight environmental changes (e.g. input of pollutants, climate change) may substantially affect ecosystem function.

Analyses of heavy metal concentrations (Cd, Hg..) and POPs in fish tissues

Analyses von biochemical stress indicators (glutathione, ascorbic acid) in fish

Paleolimnology: sediment cores as archives of climate and pollution

Population genetics

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Arctic char *Salvelinus alpinus*

HIGH-MOUNTAIN LAKES

Results from a study carried out in Arctic char from Austrian high mountain lakes

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Water temperature is the „driving force“ of metal accumulation in fish

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Rising lake temperatures after the ice break

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Increase of metabolic rates, increased oxygen demand

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Increased ventilation rates

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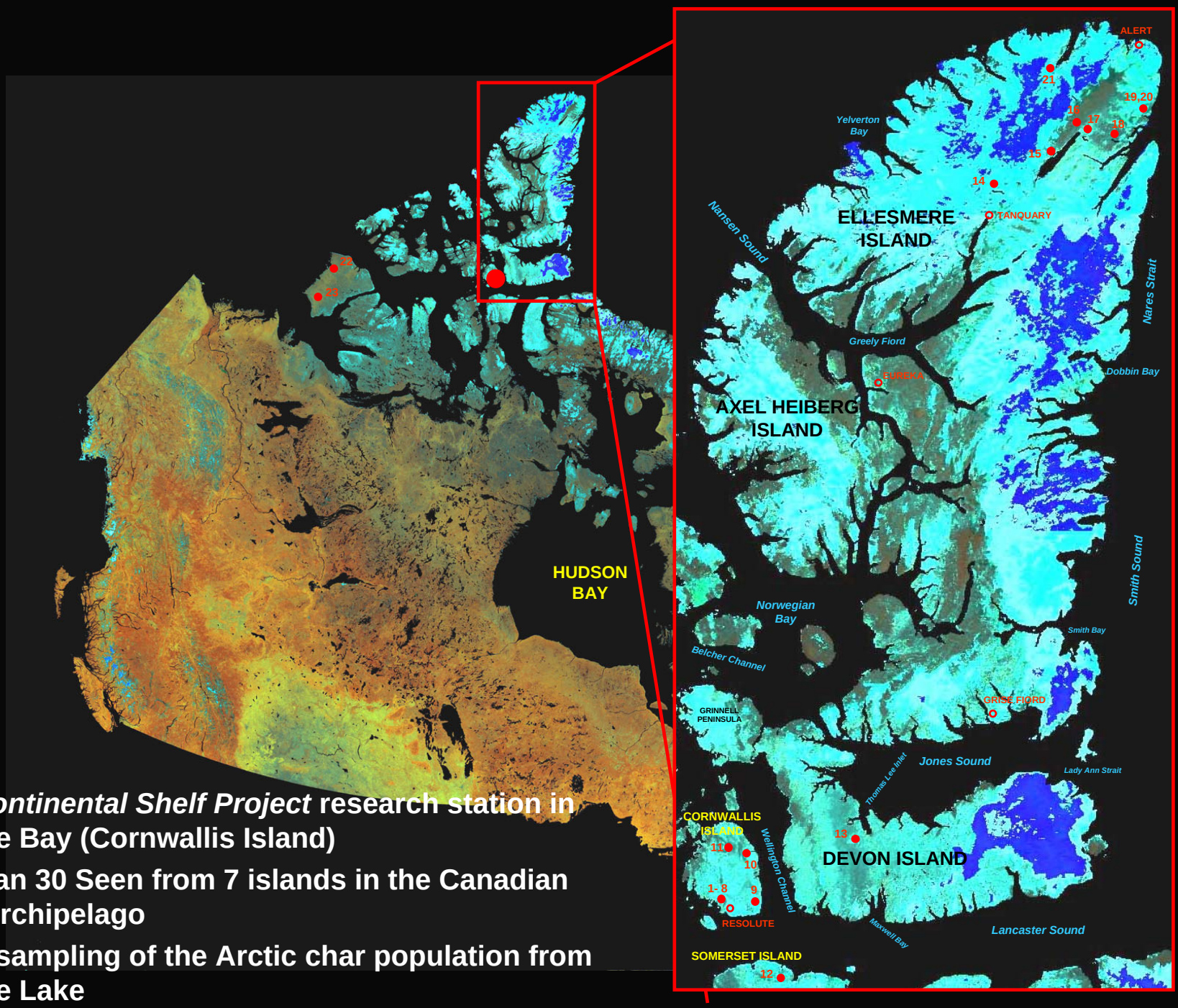
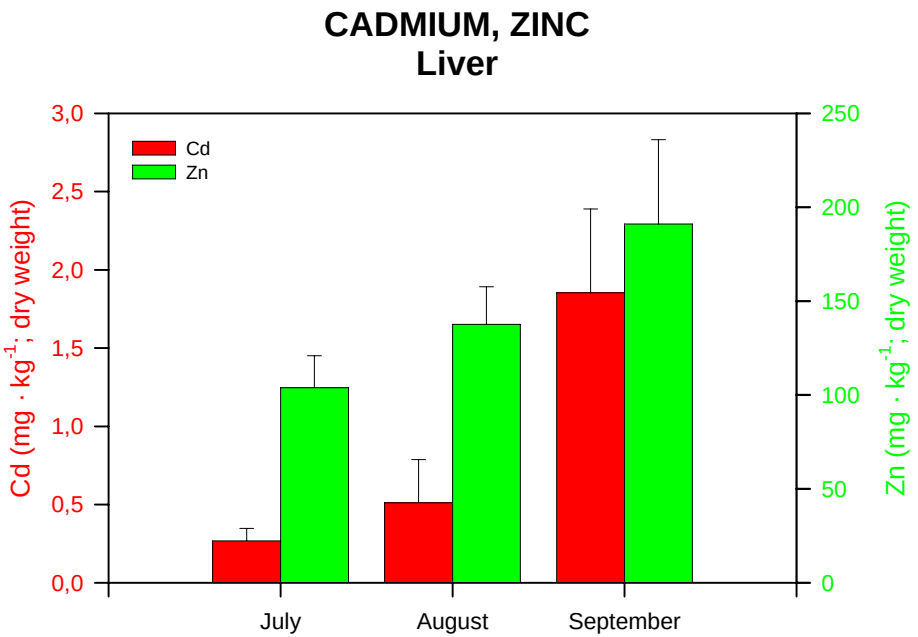
Increased uptake of dissolved metals



- *Polar Continental Shelf Project* research station in Resolute Bay (Cornwallis Island)
- More than 30 Seen from 7 islands in the Canadian Arctic Archipelago
- Annual sampling of the Arctic char population from Resolute Lake

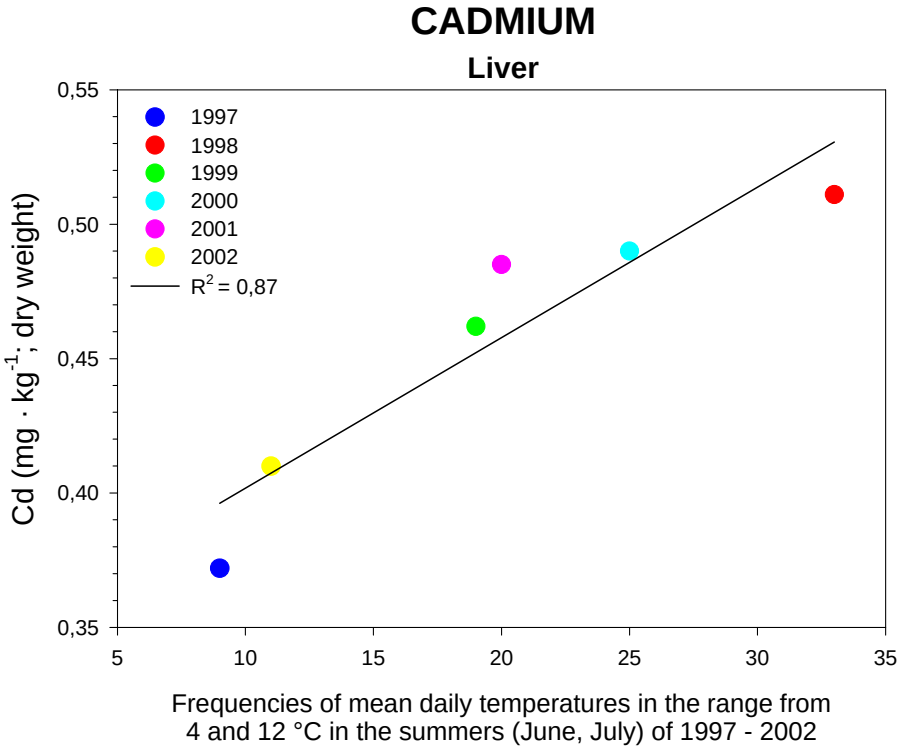
COMPARISON HIGH-MOUNTAIN / ARCTIC LAKES



Seasonal variation of Cd- and Zn-concentrations in the liver of Arctic char from Resolute Lake

Increase of metal concentration in fish liver tissue over the summer

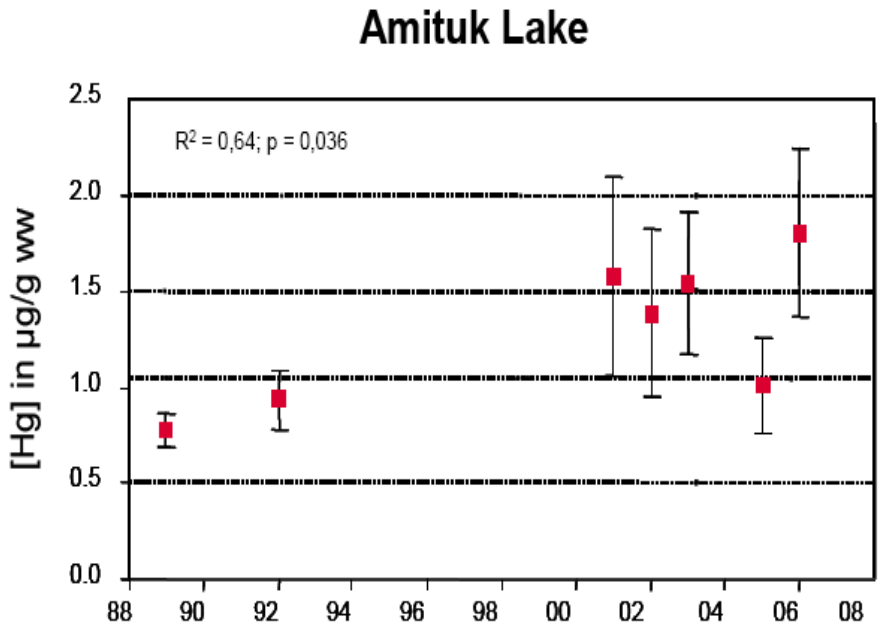
LONG-TERM TREND



Correlation between of Cd concentrations in the liver of Arctic char from a Canadian Arctic lake and ambient summer temperatures (Köck et al. 2004).

Positive correlation between metal accumulation and summer temperatures

MERCURY



Mercury concentrations in landlocked char (modified after Muir et al. 2008)

Inorganic Hg is transformed into the highly toxic methyl-Hg (the most common Hg form in fish) by microbioal activity in watershed, wetlands and littoral zones of the lakes during the short Arctic summer (Loseto et al 2004).

Increase of ambient temperature will increase microbial activity and thus Hg methylation rates. Furthermore, thawing of permafrost soils will increase the size of wetlands and thus area of microbial action.

Hg concentrations increase with trophic positioning in the food web, with top predators having the highest body burdens of any species in a lake.

HIGH-ARCTIC-SUMMARY

- **Predictive relationships between lake temperature and metal uptake were similar for high Arctic lakes and previously studied Austrian high mountain lakes, thus confirming water temperature to be a driving force of metal accumulation in char from these sensitive ecosystems.**
- **Results indicate metal accumulation and level of stress to be higher the warmer the summers are in the Canadian Arctic.**
- **Increase of temperatures and/or higher frequencies of atypically warm summers could be a serious threat to Arctic char populations in high latitude lakes.**
- **Rising temperatures will increase bioavailability of metals (in part. mercury) in high-mountain and polar lakes.**
- **Increasing metal contamination may affect food security.**

EFFECTS OF CLIMATE WARMING ON ARCTIC LAKES

Physical and chemical changes of freshwater ecosystems (e.g. flow of nutrients, sediments, contaminants)

Increase of precipitation is likely to increase deposition of Hg and POPs

Remobilization of contaminants due to accelerated thawing of glaciers and permafrost soils

Increase of Hg methylation rates

Increase of metal accumulation in freshwater fish

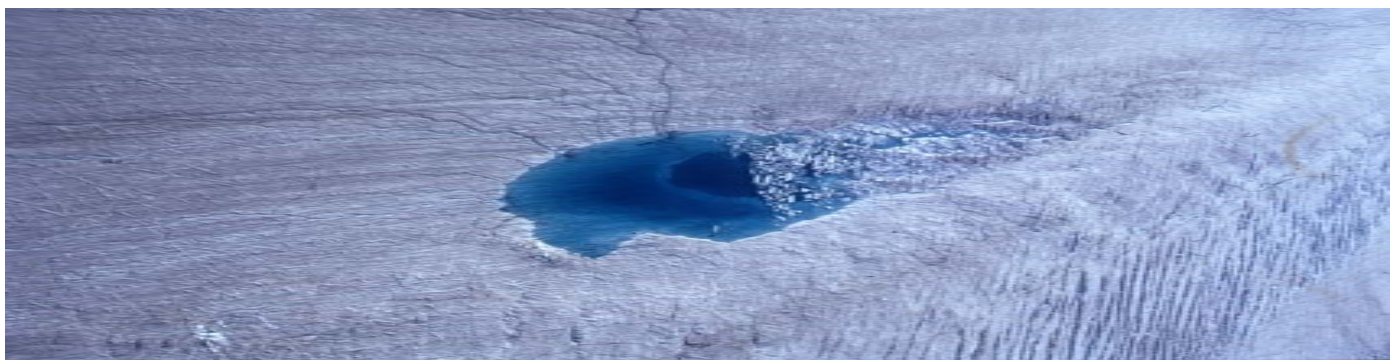
Risk of increasing contamination (in part. mercury) for humans

Effects on biodiversity: animal species shifts

- **increasing water temperatures will allow fish species from the South to move in; negative effects on stability of fish populations**

Northward migration of bird species (out-compete of autochthonous species, import of parasites and diseases, changes in lake water chemistry)

From: Köck et al. 2004, ACIA, Muir et al. 2008, Gantner et al. 2009



HISTORY OF MAB-RELATED ACTIVITIES IN THE ARCTIC

Many thanks to Fred Roots (Canada) who provided me with lots of information!

September 1980: UNESCO-sponsored conference in Edmonton (Canada) entitled “Renewable Resources and the Economy/Environment of the North“.
- Representatives from all northern countries (including USSR) except Iceland.
- Conclusion that "the MAB approach was very much needed".
- Recommendations were made to develop an international MAB northern activity.

September 1981: 7th session of the MAB-ICC established the UNESCO MAB “Northern Sciences Network (NSN)“ with six country members.
- The emphasis was on the sciences (including human sciences).
- it was to be a network, not a programme on its own. In that way, the new activity was not to be a direct drain on UNESCO headquarters funds or staff.
- The NSN did not raise funds for research, but only provided communication.
- For two decades, NSN was a busy and on the whole successful activity.

1984: Formation of a Circumpolar Biosphere Reserves Working Group
- provided recommendations and suggestions to the respective national MAB committees to establish a Biosphere Reserve in its arctic territory.

1990: NSN inaugurated the International Tundra Experiment (ITEX), a cooperative international research project to study the response of typical wide-ranging tundra vegetation to natural and induced changes in climate.
- ITEX is generally regarded as one of the MAB associated scientific activities.

1994: In preparation for the BR Conference in Seville, the NSN produced a discussion paper on how the BR concept could apply to polar areas.
- Due to the shortness of time and the excessive number of papers received the discussion of BRs in polar areas would be dropped.

2001: International interest in and support for NSN dried up.

HISTORY OF MAB-RELATED ACTIVITIES IN THE ARCTIC

***Status quo*: only five BRs are existing in Arctic regions**

Taimyrsky Biosphere Reserve, Laplandskiy Biosphere Reserve (Russian Federation)
North East Greenland Biosphere Reserve (Denmark)
Lake Torne Biosphere Reserve (Sweden)
Lake Torne Biosphere Reserve (USA)

No vigorous MAB-related activity in the Arctic, except possibly in the Taimyrsky BR.

Reasons for the low number:

• the concept of a modern "Seville style" MAB BR with its triple integrated functions of conservation, economic and social development, and scientific research, and the typical "zoning" structure, is in most cases not appropriate for the Arctic region.

• local people are not convinced that the concept would be of benefit to them

• the zoning and human use structure needed for a successful BR does not make sense locally

• bureaucratic/policy obstacles

• source of continuing funding has not been found.

Recommendations:

MAB BRs are excellent places for long-term monitoring and excellent learning sites for adaptation and mitigation processes. Thus it would be highly desirable to establish a circumpolar BR network.

Comparative research in high-mountain BRs and protected areas (BRs, world heritage sites, national parks) in Arctic regions should be facilitated and intensified.

Intensified monitoring of contaminants (in part. mercury) in the Arctic ecosystem an in the food web

NSN has not been disbanded, it is just dormant. An updated version, specifically designed to carry on with Human/Biosphere issues and researches in the light of the IPY results might be worth proposing.

Many thanks for your interest!

And thanks to:

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Austrian Academy of Sciences

University of Innsbruck

Polar Continental Shelf Project

Parks Canada

Northern Contaminants Programme