Contaminants and Climate Change: New Challenges for Alaska

Alaska Climate & Human Health - Ecosystem Impacts to Health Interagency Work Group

May 26, 2011

Overview

- Alaska and Arctic
- Physical Changes
- Ecological Impacts
- Multiple Stressors
- Subsistence Resources
- Monitoring Change

Alaska and Arctic

Warming has resulted in:

- Extensive melting of glaciers
- Thawing of permafrost
- Reduction in Arctic Ocean sea ice extent
- Increases in precipitation (but varies)
- Decrease in the duration of snow cover
- Longer ice free season on lakes
- Altered food webs

Alaska and Arctic

Most climate-related contaminants research to date has focused on the Arctic and northern regions given these profound changes

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Physical Changes

- Temperature
- Sea Ice
- Glacial Melt
- Erosion
- Storms
- Sea Level Rise
- Permafrost Melt
- Precipitation
- Wildfires

Physical Changes - Temperature

- Warmer temperatures: Chemicals move more readily from soil to air
- Projected release of more contaminants from lower latitude source area soils (industrial sites, agricultural areas, etc.)
- Deposition in colder areas (“cold condensation”)
- Increased amount of atmospheric transport to the cold regions like the Arctic

Physical Changes - Temperature

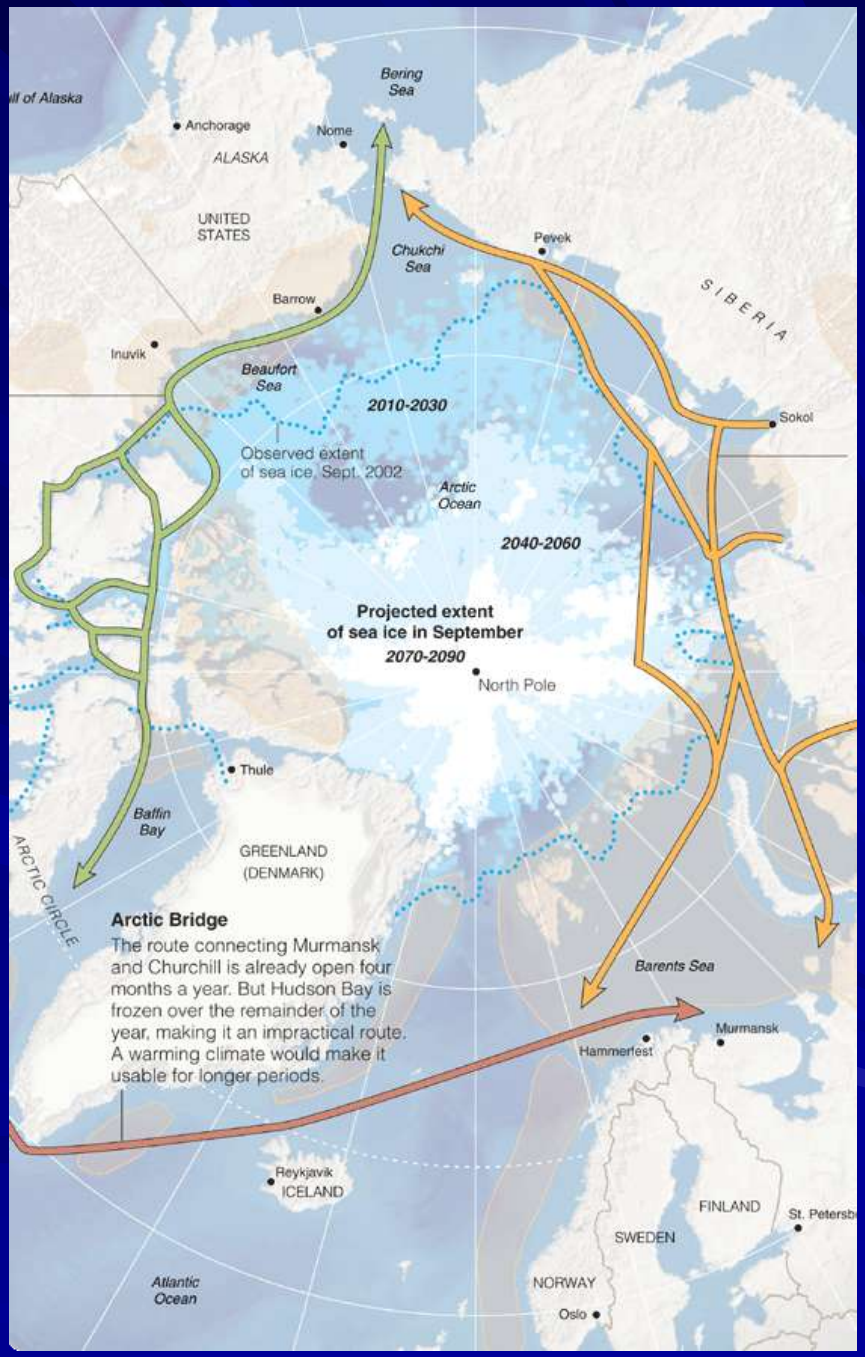
- Fish increase metabolism and ventilation with temperature: increased uptake of pollutants
- Some pollutants more toxic at higher temperatures
- Exposure to some contaminants can lower temperature tolerance in fish

Physical Changes - Sea Ice

- Sea ice can act like a “cap”
  - Trapping some contaminants in the water
  - Preventing other contaminants in air from reaching water
- Sea ice changes should alter these relationships
- Some contaminants will increase, others decrease

Sea Ice Loss - Shipping

- Projected new routes – Canada and Russia
- Oil spill threat
- Arctic Council report completed in 2008
- Current Arctic spill response plans: onshore emphasis



Sea Ice Loss - Development

Arctic predicted to be more accessible in next decade

- Growth as a major energy development arena
- Other resource extraction
- Tourism (e.g. cruise ships)

Sea Ice Loss – Spill Risk

- Large spills in the Arctic could be devastating
- Beaufort, Chukchi & Bering Seas – important habitat for polar bears, walrus, sea ducks, loons
- Spills in broken ice: Skimming and other traditional cleanup methods have low efficiency

Physical Changes – Glacial Melt

- Glaciers accumulated contaminants during peak pollution emission period (1950s – 1970s)
- Italy: Sharp increase in DDT (a pesticide) observed in two glacier-fed Italian lakes
- DDT concentrations in fish exceeded human consumption

Photo: Hans van Zutphen

Physical Changes – Glacial Melt

Summary of two other European studies:

- **Transport of dioxins, PCBs, DDT to glacial-fed lakes equal or exceed 1960-1970s levels: DDT up to 5x higher than former "peak"**
- **Macroinvertebrates in glacial streams generally had higher contaminants concentrations than non-glacial streams in same watershed**

Photo by Hans van Zutphen

Physical Changes - Glacial Melt

- Implications for Alaska unknown
- Same process should occur in AK, but our glaciers may be less polluted than the Alps?

Physical Changes -Erosion

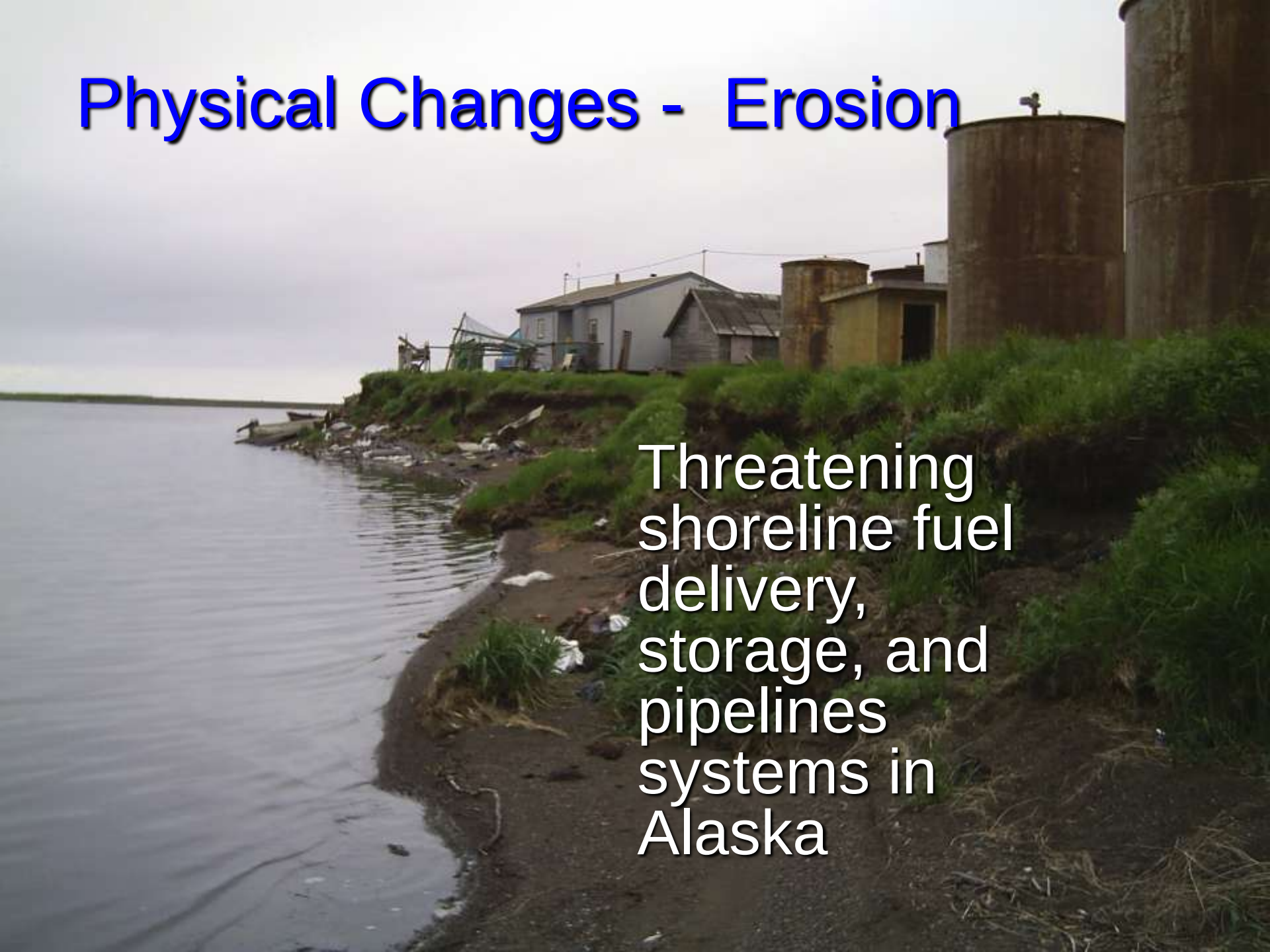
- Increased storm energy
- Seasonal loss of “protective” shore-fast ice
- Permafrost loss: less soil stability

Physical Changes -Erosion

- Formerly Used Defense Sites eroding into marine waters

- BLM removing drilling mud pits on Alaska's North Slope

Physical Changes - Erosion



Threatening shoreline fuel delivery, storage, and pipelines systems in Alaska

Physical Changes -Storms

- September 2007 storm threatened bulk fuel storage tanks in Kivalina, AK, mobilizing spill response assets

Physical Changes - Sea Level Rise

- Sea level rise is predicted to affect coastal regions throughout U.S.
- Alaska has nearly 47,000 miles of coastline (half US total)
- Ice melt and thermal expansion
- Flooding threat to contaminated sites and landfills

Physical Changes - Permafrost Melt

Loss of “containment”

- Sewage lagoons
- Dumps
- Tailings ponds
- Contaminated sites

Physical Changes - Permafrost Melt

- Permafrost thawing in a Swedish peat bog mobilized mercury during subsidence and flooding
- Transport of mercury to nearby lake exceeded inputs from atmospheric deposition
- Authors predict increased mercury levels in freshwater ecosystems within the Arctic but more study needed

Physical Changes - Precipitation

- Modeling predicts that precipitation will increase in parts of the Arctic, making it a much wetter environment (other areas will be drier)
- Implications for contaminant deposition: many contaminants are scavenged from atmosphere and deposited via rain, snow

Physical Changes - Precipitation

- High concentrations of mercury in marine mammals and other biota from Mackenzie River Delta and Beaufort Sea
- Mercury concentrations positively correlated with river flow – increased flows attributed to greater precipitation and climate change
- Authors: Mackenzie River mercury inputs expected to increase with continued warming

Physical Changes – Flooding

- Ontario: Experimental flooding of boreal wetland
- Wetland changed from a carbon sink to carbon source (decomposing vegetation)
- Microbial methylation of mercury – 39x increase
- Methyl mercury increased in vegetation, invertebrates, fish

Physical Changes - Wildfires

- Arctic Climate Impact Assessment report: Modeling suggests that a warming climate will lead to more and larger fires

- Warmer and wetter scenarios produced more very large fires compared to the warmer and drier scenarios

USFWS photo

Physical Changes - Wildfires

- Mercury sequestered in cold, wet peat soils was released during fires in Canadian boreal forests
- Growing threat to aquatic habitats and northern food chains

Physical Changes - Wildfires

- Estimated mercury emissions from wildfires in Alaska & lower 48 States from 2002-2006:
  - Averaged 44 metric tons/yr
  - Equivalent to 30% of mercury releases documented in EPA's 2002 National Emissions Inventory
- Alaska results were more variable – high fire years vs. low fire years
- Increased uptake of mercury in fish within fire affected watersheds

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Ecological Changes

- Canadians studied mercury & PCBs in burbot for 21+ years
- Atmospheric levels stable or declining
- Burbot liver: mercury increased = 2x, DDT = 3x, one type of PCB (congener) = 6x
- Authors: Higher algal productivity “scavenged” contaminants from water column

Ecological Changes

- Canadian Arctic lakes – *Daphnia* dominated systems: 5x more mercury vs. copepod communities
- *Daphnia* related to algal productivity and growth
- Authors predict expansion of *Daphnia* dominated lakes with climate change (more mercury)
- Mercury accumulates up food chains

Ecological Changes

- Husdon Bay Polar Bears - Feeding ecology from 1991-2007. Stable isotopes and fatty acids – dietary change
- Timing of sea ice breakup explained 84% of variation in stable isotope changes
- Shift from bearded seal (pack ice) to harbor and harp seals (open water habitat)
- Most contaminants increased but DDT decreased
- Key concept: Changing diet influences contaminants exposure

Ecological Changes - Biotransport

- Transport marine contaminants to freshwater systems in Canadian Arctic
- Climate induced increase of fulmar population
- Increases in nutrients, chlorophyll, benthic insects, PCBs, cadmium in nearby freshwater ponds

Ecological Changes - Biotransport

- PCBs and DDT transported by salmon: much lower concentrations in Arctic grayling from salmon-free lake vs. salmon-enriched lake
- PCBs in Alaska and Canada sediment samples: correlated with salmon spawning density
- Climate-related changes to spawning salmon populations: nutrient and contaminant implications

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Multiple Stressors

- Many persistent organic pollutants: stored in fat
- Food or temperature stress: fish and wildlife draw on fat reserves, releasing pollutants into blood
- Blood-circulating contaminants are more biologically available

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Subsistence Resources

Given observed and projected changes:

Likely that <u>some</u> subsistence resources will be affected

Subsistence Resources

Fish and Wildlife Service: Impacts to species (resource availability)

State of Alaska & other public health officials: Consumption advice

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Monitoring Change

Documenting climate-influenced changes in contaminants exposure to fish, wildlife, habitats and consumers will require long-term monitoring

Conclusions

- Climate change may influence virtually <u>all</u> aspects of contaminant release, transport, uptake, and toxicity
- Change: already being observed in the North
- Subsistence resources: may be affected
- We won’t understand the type and degree of change without contaminants monitoring
- There <u>will</u> be surprises !!!

Questions?

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