Environmental Contaminants and Climate Change in Alaska

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Abstract: Climate change is a global pollution issue, caused by anthropogenic greenhouse gases and aerosols, primarily CO_2, CH_4, carbon particles ("black" carbon) and N_2O. It will alter contaminant effects on Service-managed resources in Alaska by: 1) Influencing contaminant fate and transport, as chemicals more readily partition to air under warmer temperatures, which may increase the amount of atmospheric transport to the Arctic via poleward movement of warm air, and projected precipitation increases will scour these contaminants from the atmosphere, depositing them within watersheds; 2) Releasing contaminants from abiotic media through enhanced coastal and river erosion, more frequent and intense wildfires (releasing mercury), glacial melt surrendering pollutants deposited decades ago, and melting permafrost liberating toxins sequestered in ice; 3) Increased natural resource development and new shipping routes from projected sea ice losses and warmer Arctic temperatures, raising the risk of oil or hazardous materials spills in Alaska's sensitive habitats; 4) Altering metabolism, uptake, cycling, and toxicity of pollutants such as mercury, which generally increase with temperature and heat stress. Collectively, these findings suggest that projected temperature increases will enhance contaminant influx to and within Alaskan ecosystems, particularly aquatic systems, and by stressing organisms increase their susceptibility to contaminant impacts. The Environmental Contaminants Program will support the Service's collective efforts to address this daunting challenge by continuing to implement our core mission of evaluating and remediating contaminants exposure and effects on trust resources, and by working with others on oil spill preparation and response, eroding landfills, contaminated sites, and contaminants in subsistence foods.

Oiled birds from the Selendang Ayu spill, 2004

Loss of sea ice will allow **increased shipping** and industrial activity in Arctic marine waters (ACIAC 2008, MacDonald et al. 2005), along with contaminants like **tributyl tin** in marine antifouling paints. The increased likelihood of **oil spills** may be the worst effect (MacDonald et al. 2005, Kraemer et al. 2005), especially since spills in broken ice conditions can't be efficiently cleaned up using traditional methods like skimming (e.g., SL Ross et al. 1998). Reduced marine ice cover will **increase ocean-atmosphere gas exchange** and therefore deposition of contaminants like **PCBs and toxaphene**, which are still loading into the Arctic Ocean via the atmosphere (AMAP 2003).

References are listed on back of handouts.

Coastal and riverine erosion, surface water encroachment, and loss of permafrost may cause release of pollutants from **contaminated sites** like landfills, drilling mud pits, sewage lagoons, tailing ponds, and oil-contaminated sites (AMAP 2003). In particular, **shoreline erosion** has and will continue to impact **fuel delivery, storage, and pipeline systems** in Alaska. Dendritic drainage patterns that will allow more efficient transport of contaminants into ponds and lakes and possibly re-mobilize contaminants entrained in tundra soils (MacDonald et al. 2005).

Eroding landfill, Beaufort Sea shore, Arctic National Wildlife Refuge

Modeling predicts **increases in mean annual river discharge** of about 20% for the Yenisei, Lena, Mackenzie Rivers (MacDonald et al. 2005) and other large Arctic rivers. Contaminant loads are correlated and will also increase, including **mercury** (studied in the MacKenzie River; Leitch et al. 2007) and other contaminants (Carroll et al. 2008, Zhulidov et al. 2000).

Lower Marsh Fork River, Arctic National Wildlife Refuge

Melting glaciers (Hinzman et al. 2005) can release contaminants accumulated during years of deposition (Blais et al. 1998). **Glacial streams contain unusually high proportions of persistent organic pollutants in solution**, because of the low organic matter content and therefore low potential adsorption to suspended sediments. Contaminants in solution are much more **bioavailable** than adsorbed contaminants (Blais et al. 2001).

Mercury is toxic and increasing in Arctic biota. Continuing use of coal and other fossil fuels, especially in Asia (Pacyna et al. 2006), physical factors such as ice cover, permafrost melting and organic carbon cycling, and abiotic factors such as increasing primary productivity may be driving increased mercury in Arctic biota (MacDonald et a. 2005), including in fish used for subsistence (Carrie et al. 2010) and in freshwater ecosystems (Chetelat and Amyot 2009). Mercury becomes toxic and bioavailable through **methylation** in wetlands (Lindberg et al. 2002, Loseto et al. 2004, MacDonald et al. 2005) – something that will increase with more **flooding** (ACIA 2005). Simple erosion can increase mercury concentrations in waters, such as those draining from peat bogs (Jörnhagena et al. 2007). **Mercury** is also released from peat soils during **fires in boreal and tundra ecosystems**, which modeling suggests will increase (ACIA 2005, Turetsky et al. 2006), along with mercury concentrations in fish after fires (Kelly et al. 2006).

Literature Cited:

ACIA. 2005. Arctic Climate Impact Assessment. Cambridge University Press. 1042 pp.

ACIAC. 2008. Alaska Climate Impact Assessment Commission. Final Commission Report. Alaska State Legislature. 124 pp.

AMAP, 2003. AMAP Assessment 2002: The Influence of Global Change on contaminant pathways to, within, and from the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xi+65 pp.

Blais, J.M., D.W. Schindler, D.C.G. Muir, L.E. Kimpe, D.B. Donald and B. Rosenberg, 1998. Accumulation of persistent organochlorine compounds in mountains of western Canada. Nature (395): 585–588.

Blais, J.M., D.W. Schindler, D.C.G. Muir, M. Sharp, D. Donald, M. Lafrenière, E. Braekevelt and W.M.J. Strachan. 2001. Melting Glaciers: A major source of persistent organochlorines to subalpine Bow Lake in Banff National Park, Canada. Ambio (30): 410-415.

CCAAG. 2008. Climate Change Adaptation Advisory Group. Alaska Climate Change Strategy: Public Infrastructure. Materials prepared for CCAAG meeting, May 16, 2008. http://www.akclimatechange.us/ewebeditpro/items/O97F17336.pdf

Carrie, J., F. Wang, H. Sanei, R.W. MacDonald, P.M. Outridge, and G.A. Stern. 2010. Increasing contaminant burdens in an Arctic fish, Burbot (*Lota lota*), in a warming climate. Environ. Sci. Technol. 44:316-322.

Carroll, J., V. Savinov, T. Savinova, S. Dahle, R. McCrea, and D.C.G. Muir. 2008. PCBs, PBDEs and pesticides released to the Arctic Ocean by the Russian Rivers Ob and Yenisei. Environmental Science and Technology (42): 69–74.

Chetelat, J. and M. Amyot. 2009. Elevated methylmercury in High Arctic Daphnia and the role of productivity in controlling their distribution. Global Change Biol. 15:706-718.

Hinzman, L.D., N.D. Bette, W.R. Bolton, F.S. Chapin, M. B. Dyurgerov, C.L. Fastie, B. Griffith, R.D. Hollister, A. Hope, H.P. Huntington, A.M. Jensen, G.J. Jia, T. Jorgenson, D.L. Kane, D.R. Klein, G. Kofinas, A.H. Lynch, A.H. Lloyd, A. D. McGuire, F.E. Nelson, W.C. Oechel, T.E. Osterkamp, C.H. Racine, V.E. Romanovsky, R.S. Stone, D.A. Stow, M. Strum, C.E. Tweedie, G.L. Vourlitis, M.D. Walker, D.A. Walker, P.J. Webber, J.M. Welker, K.S. Winker, and K. Yoshikawa. 2005. Evidence and implications of recent climate change in northern Alaska and other Arctic regions. Climatic Change (72): 251–298.

Kelly, E.N., D.W. Schindler, V.L. St. Louis, D.B. Donald, and K.E. Vladicka. 2006. Forest fire increases mercury accumulation by fishes via food web restructuring and increased mercury inputs. Proceedings of the National Academy of Sciences (103): 19380–19385.

Kraemer L.D., J.E. Berner, and C.M. Furgal. 2005. The potential impact of climate on human exposure to contaminants in the Arctic. International Journal of Circumpolar Health (64): 498-508.

IAQAB 2008. International Air Quality Advisory Board Expert Consultation Meeting. September 9-10, 2008, National Park Service Regional Office, Anchorage, Alaska. Draft meeting summary. 25 pp.

IPCC. 2007. Intergovernmental Panel on Climate Change. Climate Change 2007: Synthesis Report. 52 pp.

Jörnhagena, L., N. C. Oslerb, and F. Samuelssona. 2007. Effects of climate change: mercury loss from a thawing and eroding palsa mire. Internet-published manuscript, Umeå University in Kiruna, Sweden. http://www.kiruna.umu.se/utbildning/alpingeoekologi/Mercury_report(2007).pdf

Law, K.S., and A. Stohl. 2007. Arctic air pollution: Origins and impacts. Science (315): 1537-1540.

Leitch, D.R., J. Carrie, D. Lean, R.W. Macdonald, G.A. Stern, F. Wang. 2007. The delivery of mercury to the Beaufort Sea of the Arctic Ocean by the Mackenzie River. Science of the Total Environment (373): 178-195.

Lindberg, S.E., S. Brooks, C.J. Lin, K.J. Scott, M.S. Landis, R.K. Stevens, M. Goodsite, A. Richter. 2002. Dynamic oxidation of gaseous mercury in the Arctic troposphere at polar sunrise. Environmental Science and Technology (36): 1245-1256

Loseto, L.L, S.D. Sicliano, and D.R.S. Lean. 2004. Methylmercury production in high Arctic wetlands. Environmental Toxicology and Chemistry (23): 17–23

Macdonald, R. 2005. Climate change, risks and contaminants: A perspective from studying the Arctic. Human and Ecological Risk Assessment (11): 1099-1104.

Macdonald, R.W., T. Harner, J. Fyfe, T.F. Biddleman, J.P. Stow. 2005. Recent climate change in the Arctic and its impacts on contaminant pathways and interpretation of temporal trend data. Science of the Total Environment (342): 5-86.

Pacyna, E.G., J.M. Pacyna, F. Steenhuisen, and S. Wilson. 2006. Global anthropogenic mercury emission inventory for 2000. Atmospheric Environment (40): 4048-4063.

Patra, R.W., J. C. Chapman, E.P. Lim, and P.C. Gehrke. 2007. The effects of three organic chemicals on the upper thermal tolerances of four freshwater fishes. Environmental Toxicology and Chemistry (26): 1454–1459.

Schiedek, D., B. Sundelin, J.W. Readman, and R. W. Macdonald. 2007. Interactions between climate change and contaminants. Marine Pollution Bulletin (54):1845–1856.

SL Ross Environmental Research, DF Dickens and Associates, and Vaudrey and Associates. 1998. Evaluation of cleanup capabilities for large blowout spills in the Alaskan Beaufort Sea during periods of broken ice. Prepared for Alaska Clean Seas, Anchorage, AK, and Department of the Interior, Mineral Management Service, Anchorage, AK. 222 pp.

Streets, D.G., J. Hao, Y. Wu, J. Jiang, M. Chan, H. Tian and X. Feng. 2005. Anthropogenic mercury emissions in China. Atmospheric Environment (39): 7789-7806.

Turetsky, M.R., J.W. Harden, H.R. Friedli, M. Flannigan, N. Payne, J. Crock, L Radke. 2006. Wildlifes threaten mercury stocks in northern soils. Geophysical Research Letters (33): L16043.1-L16043

Wiedinmeyer, C., and H. Friedli. 2007. Mercury emission estimates from fires: An initial inventory for the United States. Environmental Science and Technology (41): 8092-8098.

Zhulidov, A.V., J.V. Headley, D.F. Pavlov, R.D. Robarts, L.G. Korotova, Y.Y. Vinnikov, O.V. Zhulidova. 2000. Riverine fluxes of the persistent organochlorine pesticides hexachlorcyclohexane and DDT in the Russian Federation. Chemoshpere (41): 829-841.