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Background paper on the potential impacts of heavy metals in aquatic environments

Summary: Heavy metals, often at very low concentrations, are naturally occurring elements in the terrestrial environment. While some heavy metals may be relatively inert at low levels in aquatic environments, human activities can concentrate heavy metals in aquatic systems at levels hundreds to thousands of times the natural background rates resulting in adverse effects to aquatic organisms including commercially, recreationally, culturally and ecologically important fishes (e.g., salmon, steelhead, sturgeon, lamprey). To reduce the adverse impacts of heavy metals on aquatic environments, we recommend 1) minimizing the use of heavy metal-containing materials in products that have the potential to enter waterways, 2) utilizing best management practices in construction, manufacturing and urban planning, and 3) educating people on the risks of heavy metal contamination.

Heavy metals including mercury, arsenic, copper, cadmium, lead, and zinc are naturally occurring elements in the terrestrial environment. In some instances, these metals leach into surface or ground water from surrounding geology and natural events such as volcanic activity, landslides, and flooding. Heavy metals can also enter the aquatic environment, sometimes at high concentrations, through a variety of human activities including industrial manufacturing, coal combustion, construction, hard rock mining, landfills, pesticides, fertilizers, and mineral processing. Urban environments can also concentrate and deliver heavy metals to adjacent aquatic environments from chemicals found in or produced by automobiles (e.g., brake pads and exhaust emissions). Urban area storm drains are a primary conduit for delivering heavy metals to the aquatic environment. Other delivery mechanisms include acid deposition, effluent discharge, and incidental spills. Human activities can concentrate heavy metals in aquatic systems at hundreds to thousands of times the natural background rates, often with deleterious effects. Some heavy metals such as lead may be relatively inert in the aquatic environment (except when consumed by waterfowl or other aquatic and terrestrial species).

Many heavy metals can adversely affect fish and other aquatic organisms when they enter waterways. Elements such as mercury and arsenic are more bioactive in the aquatic environment than lead and are therefore more likely to harm fish and other aquatic organisms. Heavy metals enter the bodies of fish and interfere with a number of essential processes such as respiration, fitness, migration, and reproduction (e.g., see Peterson et al. 2002 and 2007) and have been implicated in interfering with salmon homing and migration in urban areas near Washington's Puget Sound (Baldwin et al. 2003, Sandahl et al. 2007). Although high levels of certain heavy metals can cause direct fish mortality, lower levels can cause chronic exposure effects that result in reduced performance, survival, and reproductive success. For example, trace concentrations of mercury, zinc, and other metals reduce the swimming rate of fish larvae, thus reducing their ability to escape predation (AFS 2010). These impacts to individual fishes and other aquatic organisms can produce population-level changes over time, potentially depleting local fish populations and affecting commercial, recreational and cultural fisheries and ecosystem services.

Bioaccumulation of heavy metals in fish also can have far-reaching impacts on other animals found in the aquatic and riparian environment (e.g., fish-eating birds and mammals) and can threaten human health. The classic Japanese "Minamata disease" associated with human consumption of fish and shellfish laden with high concentrations of mercury demonstrates the human health risks of heavy metals in aquatic ecosystems (AFS 2010). The Oregon Department of Environmental Quality under direction of the US Environmental Protection Agency has established water quality standards to protect aquatic life and limit human exposure (ORS Chapter 468b, OAR 340). Numerous restrictions on human consumption of fish are in place in Oregon. On February 25, 2010, health advisories were posted warning humans against eating fish from the Willamette River's Columbia Slough (Oregonian 2010) because of heavy metal and polychlorinated biphenyls (PCBs) bioaccumulation. Over 10 other state water bodies also have currently posted health advisories for heavy metals or PCBs.

Heavy metal impacts to aquatic systems in Oregon and the Pacific Northwest also include impacts from human generated copper to threatened salmon species, and acid mine discharge. Copper potentially derived from automobile brake pads, herbicides, and pesticides was found to significantly affect coho salmon, a species threatened with extinction throughout its range in Oregon, in California at levels as low as two parts per billion (Baldwin et al. 2003). These are much lower concentrations than are currently accepted for human consumption. Impacts from heavy metals associated with acid mine drainage in a copper mine near the California border have eliminated fish species from a coldwater tributary to the Applegate River (ITSI 2011). Toxic metals contamination has eliminated coho and steelhead from 18 miles of Silver Butte Creek because of toxic metals contamination from the Formosa mine near Roseburg (Woody et al. 2010).

In order to reduce impacts from heavy metals to the aquatic environment and its associated fish and wildlife species we recommend minimizing the use of heavy metal-containing materials that have a mechanism for entering and reacting with the aquatic environment. Further, we recommend using best management practices during construction, mining, mineral processing, manufacturing, and urban planning of storm drainage systems to minimize heavy metal discharge into aquatic environments. Finally, we recommend educating the public and industry on the potential risk of allowing heavy metals to enter aquatic environments. Safeguards should be put in place to prevent members of the public or industry from knowingly polluting waters with heavy metals.

References:

AFS [American Fisheries Society]. 2010. Policy paper #6. Effects of toxic substances in surface waters. http://www.fisheries.org/afs/docs/policy_6f.pdf

Baldwin, DH, JF Sandahl, JS Labenia, and NL Schloz. 2003. Sublethal effects of copper on coho salmon: impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. *Environmental Toxicology and Chemistry*. 10:2266–2274. http://onlinelibrary.wiley.com/doi/10.1897/02-428/abstract

Goddard, CI, NJ Leonard, DL Stang, PJ Wingate, BA Rattner, JC Franson, and SR Sheffield. 2008. Management concerns about known and potential impacts of lead use in shooting and in fishing activities. *Fisheries* 33: 228-236. http://www.informaworld.com/smpp/content~db=all~content=a932084613~frm=titlelink

Oregonian. 2010. 25 February. Warning: fish from Columbia Slough tainted with PCBs, heavy metals. http://www.oregonlive.com/environment/index.ssf/2010/02/warning_fish_from_columbia_slo.html

Peterson, SA, AT Herlihy, RM Hughes, KL Motter, and JM Robbins. 2002. Level and extent of mercury contamination in Oregon, USA, lotic fish. *Environmental Toxicology and Chemistry* 21:2157-2164. http://onlinelibrary.wiley.com/doi/10.1002/etc.5620211019/abstract

Peterson, SA., J Van Sickle, AT Herlihy, and RM Hughes. 2007. Mercury concentration in fish from streams and rivers throughout the western United States. *Environmental Science and Technology* 41:58-65. http://pubs.acs.org/doi/abs/10.1021/es061070u

Sandahl, JF, DH Baldwin, JJ Jenkins and NL Schlotz. 2007. A sensory system at the interface between urban stormwater runoff and salmon survival. *Environmental Science and Technology* 41:2998-3004. http://pubs.acs.org/doi/abs/10.1021/es062287r

ITSI [Innovative Technical Solutions Inc.]. 2011. Technical Memorandum Results of October 2010 Sampling. Blue Ledge Mine, Rogue River National Forest, Siskiyou County, California. EPA Contract No. EP-S9-08-03, Task Order 0048. http://1.usa.gov/fiTJjU

Woody, CA, RM Hughes, EJ Wagner, TP Quinn, LH Roulsen, LM Martin, and K Griswold. 2010. The U.S. General Mining Law of 1872: change is overdue. *Fisheries* 35:321-333. http://www.informaworld.com/smpp/content~db=all~content=a932084177~frm=titlelink