

Summary of: ***Copper: Effects on Freshwater Food Chains and Salmon*** ***A literature review***

Highlights of a published scientific literature review of potential effects of increasing copper to salmon and their freshwater food chains.

Dr. Carol Ann Woody
Fisheries Research and Consulting

Sources of Copper

Copper occurs naturally in the environment at low levels. High levels are recorded for regions where hard rock and coal mining, smelting and refining occur and in areas near industrial and municipal waste sites.

The proposed Pebble mine would be a large-scale copper-gold-molybdenum mine with characteristics similar to other mines that increased copper and other pollutants harmful to fish in the surrounding environment and waters. The proposed Pebble site has sulfide rock that when exposed to air and water creates acid that can increase copper and other harmful pollutant concentrations downstream. Rain, which is acidic, can also mobilize and wash copper and other metals into salmon habitat from mining regions.

Copper and Salmon

While copper is a necessary trace element for all living organisms, hundreds of studies show that copper in small amounts can be lethal and have many sub-lethal effects that increase mortality rates and decrease fish survival and production. Salmon and their food sources can have a very low tolerance for this pollutant. The harmful effects of long-term, low-level exposure to copper may be difficult to detect compared to mass fish kills caused by a single toxic spill.

Copper can:

1. Impair a salmon's sense of smell.
Salmon use their keen sense of smell to identify predators, prey, kin, and mates. Mixing up any of these relationships could be detrimental or fatal to salmon.
2. Interfere with normal salmon migration.
If salmon cannot smell, or if the chemical signature changes in streams where salmon hatch, then fish will likely stray to and spawn in non-natal habitats to which they are not adapted. This could cause lower salmon survival and reduce the biodiversity that supports Bristol Bay fisheries.
3. Impair a salmon's ability to fight disease.
 - a. Copper is a biological stress agent which depresses immune system function. Fish, like humans, tend to get sick when stressed.
 - b. Copper can impair salmon's breathing and brain function.
 - c. Copper also disrupts osmoregulation in salmon, the process by which cells maintain fluid and electrolyte balance with their surroundings. This can stress salmon and make them more susceptible to disease.
4. Impair salmon's ability to sense vibrations in the water which helps them avoid predators.

5. Change salmon's enzyme activity, blood chemistry and metabolism, which can cause death and impair reproduction.
6. Delay or accelerate natural hatch rates, which can reduce salmon survival rates.
7. Kill or harm salmon food sources, including algae, zooplankton, aquatic insects and fish.

Copper and Other Toxins

Numerous elements, in addition to copper, such as zinc, cadmium, mercury, iron, lead, aluminum, and selenium are released at hard rock mining sites in a unique cocktail. The combined effect of exposure to copper and other metals, such as zinc, can be more deadly than exposure to copper alone.

1. Studies of the effects of these chemical cocktails show depressed immune systems in rainbow trout and other fish.
2. Federal and State water quality limits for metals do not take these effects into account.

Alaska's Water Quality Regulations, Copper and Salmon

The State of Alaska's water quality standard for protection of freshwater species, including salmon, is 9 micrograms of copper per liter or parts per billion (ppb). This is roughly equal to ¼ teaspoon in a 40,000 gallon swimming pool. The human drinking water standard for copper is 144 times higher than the level allowed for salmon, at 1,300 ppb. [Alaska Department of Environmental Conservation 18 AAC 2006.]

Harmful and even deadly effects of dissolved copper are documented throughout the food chain, from salmon to algae, at lower copper concentrations than the State of Alaska allows in waterways. For example:

1. Some algae, at the base of the salmon food chain, are harmed at 1/9th the level of copper allowed by the State of Alaska. Declines in algae translate to less food for sockeye.
2. Zooplankton, aquatic insects and other salmon prey are harmed within 48 hours at copper concentrations 1/3rd the allowed level.
3. Many species of freshwater plants and animals die within 96 hours at waterborne copper concentrations starting at just over ½ the allowed level. Studies have found that sensitive species of mollusks, crustaceans and fish can die at 1/26th the allowed level.
4. An increase of copper less than 1/3rd the allowed levels interferes with a juvenile coho's ability to smell. King salmon avoided waters with copper levels 1/12th the allowed level.

The State of Alaska uses a formula to calculate acceptable copper pollution levels that doesn't take into account many factors that affect toxicity to salmon, including age, size, and reproductive condition of fish, and water quality measures like temperature, pH, salinity, and dissolved particle concentrations.

This summary fact sheet is based on a paper prepared by Dr. Carol Ann Woody, founder of Fisheries Research and Consulting. Dr. Woody has a PhD in Fisheries Science from the University of Washington and over 20 years of Alaskan experience including 14 years researching salmon in both the Kvichak and Kasilof River watersheds of Alaska. She served as a technical expert for the US Geological Survey to other federal agencies for both the Galore Creek and Pebble mines and their implications to aquatic resources. She has published more than 25 scientific papers on salmon and a recent book on advances in sockeye salmon research. Dr. Woody is a past-President of the Alaska Chapter of the American Fisheries Society and currently serves on the Environmental Concerns Committee. She is adjunct faculty at the University of Alaska, Fairbanks, and the University of Idaho, Moscow.