By Tasha Eichenseher

Only if you are a young coho salmon, or similar aquatic species.

A new study published in the latest edition of *Ecological Applications* reports that small amounts of copper in water can deaden a salmon's sense of smell, which normally alerts the fish to the presence of predators.

When olfactory systems are fully functional, the fish will detect a compound called *Schreckstoff*—German for "scary stuff." *Schreckstoff* wafts from nearby fish that have been attacked and it cues yet-unharmed fish to stay still and on guard.

Young coho salmon swirl in the Columbia River, Oregon. Photograph by Robert Sisson.

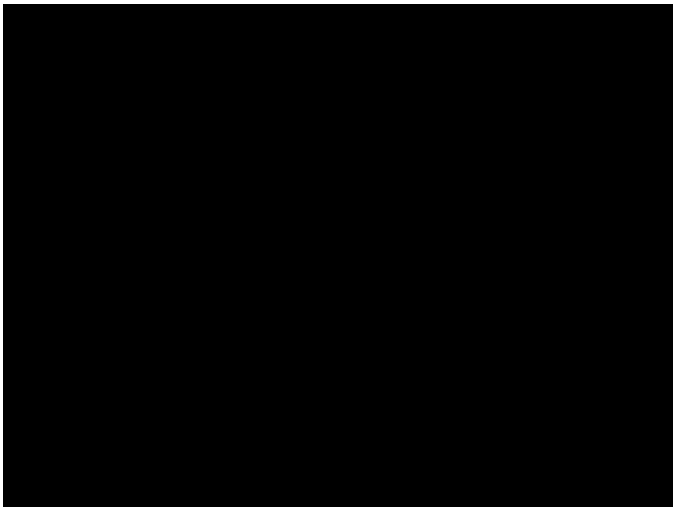
Previous studies had already established that copper affects a fish's sense of smell, and that a dulled sense of smell changes a fish's behavior.

But Washington State University (WSU) postdoctoral research associate Jenifer McIntyre and her colleagues put two and two together. They exposed juvenile coho salmon to copper and pitted them against cutthroat trout, a common coho predator.

Watch this video of what happens when coho salmon—some that are exposed to copper and others that aren't—are warned of an approaching predator (10 micrograms/L = 10 parts per billion).

Just a minute amount of copper—five parts per billion—in a four-foot-diameter and approximately 12-inch deep tank was enough to kill a coho's nasal sensory system. The fish kept swimming and were attacked within eight seconds. (You can think of five parts per billion as five drops of water among a billion drops of water.) Copper-free fish remained quiet and weren't discovered by predators for at least an average of 30 seconds.

This video shows cutthroat (in red) plying waters that contain an unaltered and motionless coho (in yellow). The other smaller gray dots are rocks.



(See photos of the "13 Scariest Freshwater Animals.")

Daily Dose of Copper

Fish, just like humans, require some copper. For us, a daily dose of 1.5 to three milligrams per day should be enough to help you avoid copper deficiency, according to the Mayo Clinic website. The naturally occurring metal helps your body make red blood cells and collagen and maintain nerve cells and your immune system, according to the University of Maryland Medical Center.

Oysters, shellfish, liver, whole grains, dark leafy vegetables, nuts, and chocolate are all good sources.

The U.S. Environmental Protection Agency, which has regulated copper levels in drinking water since 1974, warns that exposure to more than 1,300 parts per billion of copper can result in gastrointestinal distress, and liver or kidney damage. Most human exposure to copper comes from corroded pipes and plumbing fixtures.

Non-aquatic species, including humans, can also experience disruptions in chemosensory function, including smell, when they inhale too much copper, said WSU's McIntyre. But it is much less likely that they'd be exposed to neurotoxic concentrations. "This has been studied in rodents and observed (rarely) in metal smelter workers," she said. "Fish and invertebrates are more vulnerable because if it is in the water, they are exposed."

McIntyre adds: "Fish have many of the same physiological requirements as humans, hence the use of models such as zebrafish in medical research."

Fish food generally contains in the range of one to five milligrams of copper per kilogram of dry food.

Copper Mining

Copper isn't uncommon in the environment, but scientists have detected increased levels in regions that have been developed for housing or commercial buildings, according to McIntyre. And they are concerned about large-scale copper mining.

Much of the copper that ends up in urban waterways is dust from vehicle brake linings that rain washes from roads and parking lots. Other sources include pesticides, building and plumbing materials, and protective boat coatings, according to WSU. That said, storm runoff usually contains organic material that binds to copper and makes it less available to aquatic species.

(More about urban stormwater management in *National Geographic News*: "Philadelphia Cleans Up Storm Water With Innovative Program.")

It is mining operations that expose waterways, and fish, to vast amounts of the raw metal.

"My scenarios are potentially more like a hard-rock copper mining situation than storm water runoff," McIntyre noted in a WSU press release. The University warns that large copper mining operations, such as Alaska's proposed Pebble Mine near Bristol Bay would produce tens of billions of pounds of copper that could affect a nearby sockeye salmon fishery—the largest in the world.

(Read more about Bristol Bay in *National Geographic* magazine.)

McIntyre points to a *Marine Environment Research* study of leachate from the abandoned Britannia Mines in British Columbia that reported copper concentrations of five to 1000 parts per billion in a nearby creek.

"Many risks to sustainable salmon populations are worrisome," said McIntyre, whose study was funded by the National Oceanic and Atmospheric Administration's Coastal Storms Program. "In mathematical modeling exercises using the neurobehavioral toxicity described in my paper, a theoretical salmon population exposed to two parts per billion of bioavailable copper in simulated storm pulses experienced a significant decline in population growth rate."

So, remember to eat your copper, but don't inhale too much and try to keep it out of nearby rivers and lakes.