Mercurial tuna: Study explores sources of mercury to ocean fish

March 2 2010

With concern over mercury contamination of tuna on the rise and growing information about the health effects of eating contaminated fish, scientists would like to know exactly where the pollutant is coming from and how it's getting into open-ocean fish species.

A new study published in the journal Environmental Science *& Technology* uses chemical signatures of nitrogen, carbon and mercury to get at the question. The work also paves the way to new means of tracking sources of mercury poisoning in people.

The study, by researchers at the University of Michigan, Harvard School of Public Health, the Louisiana Universities Marine Consortium and the National Institute of Nutrition and Seafood Research in Norway, appears in the journal's March 1, 2010 issue.

Mercury is a naturally occurring element, but some 2,000 tons of it enter the global environment each year from human-generated sources such as coal-burning power plants, incinerators and chlorine-producing plants. Deposited onto land or into water, mercury is picked up by microorganisms, which convert some of it to methylmercury, a highly toxic form that builds up in fish and the animals---and people---that eat them.

The primary way people in the United States are exposed to methylmercury is by eating fish and shellfish. Health effects include damage to the central nervous system, heart and immune system, and the developing brains of young and unborn children are especially vulnerable.

In the current study, the researchers wanted to know if tuna and other open-ocean fish pick up methylmercury by eating contaminated fish that live closer to shore or by some other means. They studied 11 species of fish, including red snapper, speckled trout, Spanish mackerel and two species of tuna. Seven of the species studied live in the shallow, coastal waters of the Gulf of Mexico; the two tuna species live far out in the ocean and are highly migratory; the remaining two species spend parts of their lives in both habitats.

It's no mystery how the coastal fish acquire methylmercury, said Joel Blum, who is the John D. MacArthur Professor of Geological Sciences at U-M. "We know that there's a lot of mercury pollution in the coastal zone. A large amount of mercury comes down the Mississippi River, and there's also air pollution and deposition of mercury from the highly industrialized coastal Gulf region." In this environment, methylation occurs in the low-oxygen conditions of the lower water column and sediments, and the methylmercury wends its way up the food web, becoming more concentrated at each step along the way.

"It's much less clear how methylmercury gets into open-ocean fish species, some of which don't come anywhere close to shore but can still have very high levels," said the study's lead author, David Senn, formerly of the Harvard School of Public Health, and now a senior researcher at the Swiss Federal Institute of Aquatic Science and Technology. Scientists have proposed three possibilities.

One is that open-ocean fish visit coastal areas to feed, picking up methylmercury from the coastal food web. Another possibility is that small organisms that acquire methylmercury in coastal regions are washed out to sea, where they enter the open-ocean food web. In the third scenario, mercury is directly deposited into the open ocean, where it undergoes methylation.

By looking at three chemical signatures in the fish---nitrogen isotopes, carbon isotopes and mercury isotopes--- Senn, Blum and colleagues learned that coastal fish and open-ocean fish are feeding from two separate food webs.

"That rules out the first explanation, that these tuna were getting their methylmercury by feeding off coastal fish," Senn said.

"We think it's unlikely that the mercury is being methylated in coastal sediments and then washed out to the open ocean, so the most likely alternative is that there is deposition and methylation of mercury in the open ocean," Blum said. The finding runs counter to the long-held view that the open ocean is too oxygen-rich to support methylation, but it is consistent with recent studies suggesting more methylation may be occurring in that environment than was previously thought.

"It turns out there are probably low-oxygen microenvironments on tiny particles of organic matter, where methylation may be able to occur," Blum said.

One of the biggest differences the researchers found between coastal and open-ocean fish was in their mercury "fingerprint." The fingerprint is the result of a natural phenomenon called isotopic fractionation, in which different isotopes of mercury react to form new compounds at slightly different rates. In one type of isotopic fractionation, mass-dependent fractionation (MDF), the differing rates depend on the masses of the isotopes. In mass-independent fractionation (MIF), the behavior of the isotopes depends not on their absolute masses but on whether their masses are odd or even.

The researchers found that open-ocean fish have a much stronger MIF fingerprint than do coastal fish, a discovery that opens the door to new ways of analyzing human exposure to mercury.

"We can do an isotopic analysis of the mercury in your hair, and by looking at this mass-independent signal, tell you how much of the mercury is coming from inorganic sources, such as exposure to mercury gas or amalgams in your dental fillings, versus how much is coming from the fish that you eat," Blum said. "We think this could become a widespread technique for identifying sources of mercury contamination."

More information: Environmental Science & Technology: pubs.acs.org/journal/esthag

Provided by University of Michigan

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