What is this study about?

Mercury (Hg) is a toxic, global contaminant that threatens ecosystem and human health. Human activities have increased atmospheric concentrations 3-5 fold during the past 150 years. Airborne Hg enters environmental cycles in complex ways, resulting in the contamination of even remote places. The National Park Service (NPS) protects some of the most pristine and sensitive wilderness in North America. There is concern that atmospherically deposited Hg could threaten the ecological integrity of aquatic communities in the parks and the wildlife that depend on them. In this study, the NPS and U.S. Geological Survey examined Hg concentrations in more than 1,400 freshwater fish from 86 sites across 21 national parks in the western U.S., extending over a 4,000 km distance.

Do fish in parks contain mercury?

Yes - mercury was detected in all fish. Mercury concentrations in fish were generally low, but were elevated in some instances. Across all parks, sites, and species, fish mercury concentrations ranged from 9.9 to 1,109 ng/g wet weight (ww) with a mean of 77.7 ng/g ww. Fish mercury concentrations vary greatly both among and within parks, suggesting that patterns of mercury risk are driven by processes occurring at site-specific, local, and global scales.

Where and when were fish collected?

Fish were collected from mainly remote, high elevation waters in 2008–2012 by NPS personnel following standardized protocols. Whereas most of the sites were only sampled during one of four years, 10 lakes within four parks were sampled in two separate years in order to examine temporal variation within a subset of lakes. Over one-third of the total samples were collected from Rocky Mountain and Mount Rainier national parks (NPs; Figure 1). Samples were sent to U.S. Geological Survey (USGS), Forest and Rangeland Ecosystem Science Center, Contaminants Ecology Lab in Corvallis, OR, for mercury analysis of muscle tissue and data interpretation.

How do mercury levels in fish compare to health thresholds?

Across all fish sampled, only 5 percent of the fish had Hg concentrations exceeding the benchmark associated with toxic effects on fish. However, 35 percent of the fish sampled were above a benchmark for risk to sensitive fish-eating birds such as osprey. Four percent of sport fish exceeded the U.S. Environmental Protection Agency’s (EPA’s) human health criterion, a particular concern for children and women of child-bearing years. Capitol Reef, Lake Clark, Wrangell-St. Elias, and Zion national parks all contained sites in which the majority of fishes exceeded benchmarks for the protection of human and wildlife health (Figure 2).

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Figure 2. Total mercury in average fish muscle tissue (bars) and individual fish (circles), by species in wet weight (ww), compared to health benchmarks established for fish toxicity (325 ng/g ww), highly sensitive fish-eating birds (139 ng/g ww), and human consumers (300 ng/g ww; EPA criterion). Wildlife benchmarks were converted from a whole-body basis to the equivalent concentration in muscle tissue according to Peterson et al. 2007 (ES&T 41(1): 58-65). Parks are ordered by decreasing latitude (Top graph= NPS Intermountain Region; Bottom graph= NPS Alaska Region and NPS Pacific West Region) and park abbreviations can be referenced to park name in Table 1. *piscivores= fish-eating fish; *invertivores= invertebrate- or insect-eating fish. Data are plotted on a log₁₀ scale.

Table 1: Health Thresholds

<table>
<thead>
<tr>
<th>Species, Fish Type</th>
<th>Average Fish</th>
<th>Individual Fish</th>
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<tbody>
<tr>
<td>Brook Trout</td>
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<td>Rainbow Trout</td>
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<tr>
<td>Cutthroat Trout</td>
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<tr>
<td>Big piscivores</td>
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<tr>
<td>&quot;Other&quot; trout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big invertivores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little fish</td>
<td></td>
<td></td>
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</tbody>
</table>

Health Thresholds
- Fish: 325 ng/g
- Human: 300 ng/g
- Birds: 139 ng/g
How does size and species influence fish mercury concentrations?

Fish length can be used as a surrogate for age: the larger the fish, the older it is. Older fish are particularly at risk from Hg contamination given the increased susceptibility for bioaccumulation over a long time period. Further, the trophic level of fish and length of food chain can also influence Hg levels. For example, predatory fish are more likely to have elevated contaminant concentrations due to biomagnification within the food web. In this study, the standard length of fish ranged from 34–648 mm, representing 16 different species that occupy trophic positions ranging from forage (prey) fish to top predator. In order to account for the effects of size and species on fish Hg concentrations, we normalized the Hg concentrations, allowing for more meaningful spatial comparisons among parks. We classified fish species into three different size categories (50 mm, 200 mm, and 400 mm). The mean Hg concentrations of each fish size class differed among the parks. Hg concentrations in fish species assigned to the largest size class were highest at Wrangell-St. Elias NP. Within the mid-sized class, Yellowstone NP had the highest fish Hg concentrations. Among the smallest size class, fish Hg concentrations were highest at Zion NP. Interestingly, the mean values of the smallest fish class from Zion and Capitol Reef NPs are comparable to Hg levels in parks with the largest fish (Figure 3). This is noteworthy because it is expected that prey fish from the smallest fish class would not contain Hg concentrations at or near the magnitude of Hg concentrations in predatory fish from the largest fish class.

Figure 3. Size normalized least square (LS) mean total Hg concentration in fishes from 21 national parks in the western U.S. Blue bars are LS means for fish species normalized to 50 mm size, green bars are LS means for fish species normalized to 200 mm size, orange bars are LS means for fish species normalized to 400 mm size. Parks are ordered by decreasing latitude and park abbreviations can be referenced to park name in Table 1.
Where does mercury come from?

Although there are natural sources of mercury such as volcanoes, most of the Hg that affects parks comes from burning fossil fuels like coal in power plants. Waste incinerators, oil and gas wells, and mining operations are other human-caused sources of mercury. In the atmosphere, Hg travels long distances as tiny particles and gases. It settles to the ground by falling in rain and snow or landing as dust particles. In the environment and particularly in wetlands, Hg is transformed into a more toxic form, methylmercury, that can bioaccumulate and biomagnify in organisms.

What’s next?

Variation in site-specific fish Hg concentrations within individual parks suggests that more intensive sampling in some parks will be required to effectively characterize Hg contamination in western & Alaskan national parks. Future targeted research and monitoring across park habitats would help identify patterns of Hg distribution across the landscape and facilitate informed management decisions aimed at reducing the ecological risk posed by Hg contamination in sensitive ecosystems protected by the NPS.

For more information:


Websites: http://fresc.usgs.gov/ and www.nature.nps.gov/air/studies/ToxicEffects.cfm