

Health Consultation

MERCURY IN FISH FROM SILVER CREEK

Evaluation of Risk from Brown Trout Consumption

BLAINE COUNTY, IDAHO

FEBRUARY 8, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

Agency for Toxic Substances and Disease Registry

Division of Health Assessment and Consultation

Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

MERCURY IN FISH FROM SILVER CREEK

Evaluation of Risk from Brown Trout Consumption

BLAINE COUNTY, IDAHO

Prepared By:

Idaho Department Health
Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

The State of Idaho, Idaho Division of Health (IDOH), Bureau of Community and Environmental Health (BCEH) jointly prepared this public health consultation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to environmental contaminants. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The health consultation is an approach used by ATSDR and BCEH to respond to requests from agencies, organizations, and residents for health information on hazardous substances in the environment. The health consultation process evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

Summary

Background

In June 2007, the Nature Conservancy partnered with the US Geological Survey (USGS) to collect fish near the Nature Conservancy's property on Silver Creek and at a sportsman's access point near Picabo, Idaho. After collection, fish were tested for total mercury. Mercury levels in brown trout from Silver Creek ranged from 0.17 to 1.91 parts per million. In September 2007, BCEH was contacted by the Nature Conservancy and asked to evaluate the health risk that might be associated with eating fish from Silver Creek. As part of the cooperative agreement with ATSDR, BCEH prepared this health consultation to evaluate potential adverse health effects associated with consumption of fish from Silver Creek.

What is mercury and how can it affect my health?

Mercury is a grey-silver colored metal that is liquid at room temperature. Mercury occurs naturally in the environment and is distributed by both natural processes and human activities. The majority of mercury in fish is methylmercury, a form of mercury that is more toxic than other forms of mercury. Exposure to methylmercury is worse for young children than for adults because children are still developing and methylmercury easily passes into the developing brain and can cause damage to it. Critical periods of neonatal development and the early months after birth are times when the brain and nervous system are particularly sensitive to the harmful effects of methylmercury. Methylmercury can accumulate in fetal blood at concentrations higher than in the mother. Also, mothers who are exposed to methylmercury and breastfeed their infant may expose the child through breast milk.

Why do brown trout from Silver Creek have high levels of mercury?

The slow-moving water and rich nutrient levels of Silver Creek provide conditions that cause the conversion of mercury to methylmercury. Most of the mercury in fish is methylmercury which increases in larger animals as they eat smaller animals. Brown trout that eat other fish are more likely to have higher levels of mercury than fish such as rainbow trout that typically eat insects. It is not certain whether mercury levels in the Silver Creek area are caused only by the geology of the area, or whether mercury is also coming from air pollution that is carried there from far away.

What does BCEH recommend?

Fish are an excellent protein source and fish consumption is associated with reduced risk of coronary heart disease. The benefits of eating fish have been associated with omega-3 fatty acids found in fish. Saturated fats from other animal sources of protein are linked with increased cholesterol levels and risks of heart disease. Fish also provide a good source of some vitamins and minerals.

To get the benefits of eating fish while limiting any adverse health effects from the mercury in brown trout from Silver Creek, BCEH makes the following recommendations.

Recommendations:

BCEH will issue a fish advisory for brown trout caught in Silver Creek based on the evaluation in this health consultation. BCEH will work with the Idaho Department of Fish and Game to post and distribute the fish advisory. Efforts will also be made by BCEH to educate the fishing community on the health implications of fish consumption. The advisory will include the following:

1. Children (6 year old or younger) should not eat more than two 2.25-oz meals per month of brown trout from Silver Creek.
2. Pregnant women, including women planning to become pregnant, and nursing mothers, should not eat more than two 6-oz meals per month of brown trout from Silver Creek.
3. The general public should not eat more than seven 6-oz meals per month of brown trout from Silver Creek.
4. People should not eat other fish, including store-bought fish, in the same month if they eat up to the recommended limit of brown trout from Silver Creek, since all fish contain various levels of mercury. To find the level of mercury in common commercially available fish, please check the national fish advisory (<http://www.epa.gov/waterscience/fishadvice/advice.html>).
5. People should eat smaller, younger fish. Typically, the bigger or older the fish, the higher the mercury concentration in the fish fillet.

Residents with further questions or concerns are encouraged to contact Dr. Kai Elgethun, BCEH at 208-334-5682 or elgethun@dhw.idaho.gov

Purpose and Statement of Issues

The Bureau of Community and Environmental Health (BCEH), Division of Health, Idaho Department of Health and Welfare (IDHW) has a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct public health assessments and consultations for hazardous waste sites in Idaho.

In June 2007, the Nature Conservancy partnered with the US Geological Survey (USGS) to collect fish near the Nature Conservancy's property on Silver Creek and at a sportsman's access point near Picabo, Idaho. After collection, the fish were tested for total mercury. In September 2007, BCEH was contacted by the Nature Conservancy and asked to evaluate the health risk that might be associated with eating fish from Silver Creek. As part of the cooperative agreement with ATSDR, BCEH prepared this health consultation to evaluate the potential adverse health effects associated with the consumption of brown trout from Silver Creek.

Site Description

Silver Creek is located in central Idaho at the base of the Picabo Hills. Silver Creek is spring-fed and meanders through mostly level terrain. The surrounding land use includes farm and ranch land, and the preserve area that is owned and maintained by the Nature Conservancy. Figure 1 depicts a map of the area.

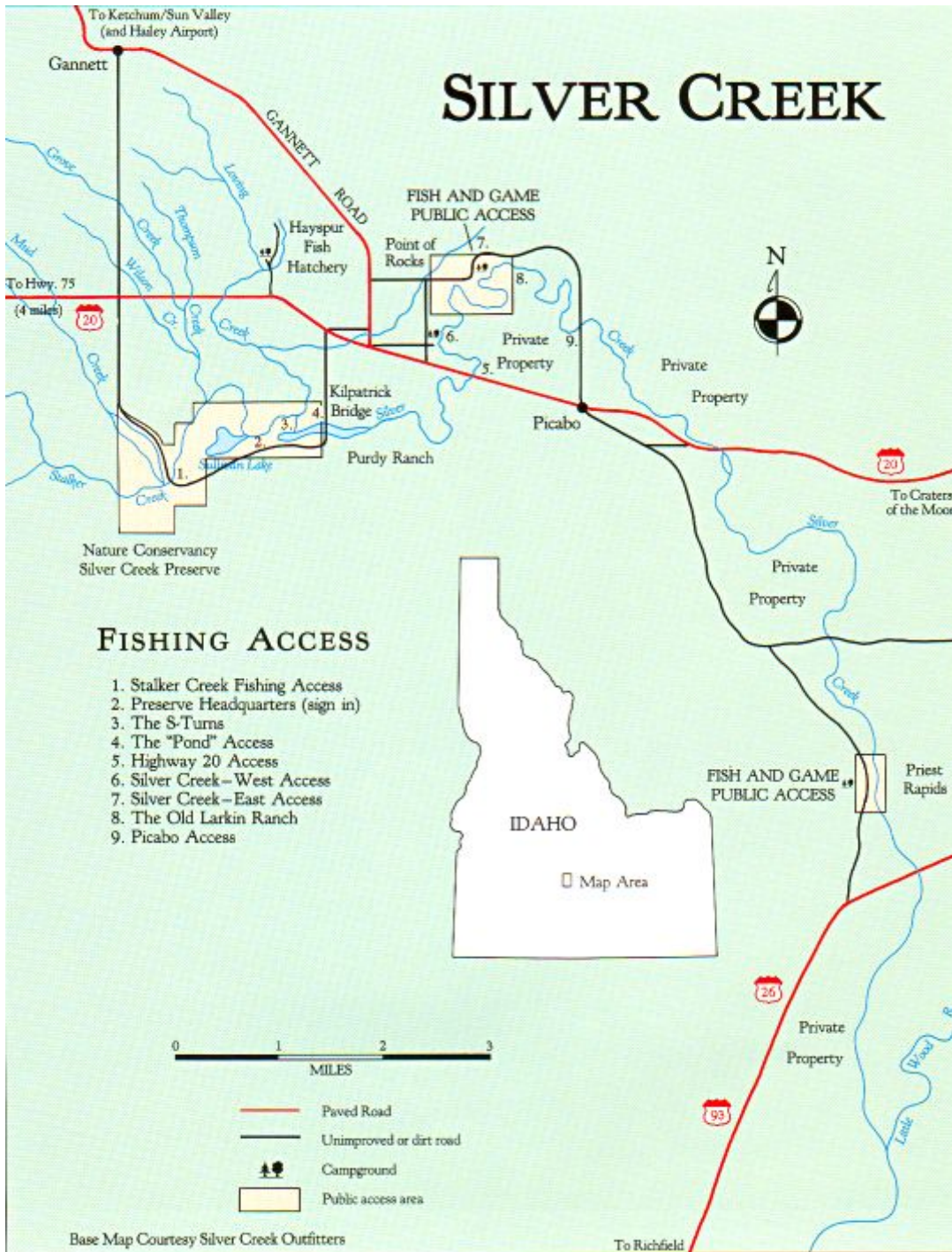


Figure 1: Map of the Silver Creek area (Credit: Silver Creek Outfitters).

Background

Sources of Mercury

Mercury occurs naturally as a mineral and is distributed throughout the environment by both natural processes and human activities. The natural global bio-geochemical cycling of mercury is characterized by evaporation of mercury from soils and surface waters, followed by atmospheric transport, deposition of mercury back to land and surface water, and sorption of the compound to soil or sediment particulates. Mercury deposited on land and open water is in part re-volatilized back into the atmosphere. This emission, deposition, and re-volatilization create difficulties in tracing the movement of mercury to its sources. Major human activities which release mercury to the environment include mining and smelting; industrial processes involving the use of mercury, including chlor-alkali production facilities; combustion of fossil fuels, primarily coal; production of cement; medical and municipal waste incinerators; and industrial/commercial boilers (EPA 1996).

Who is at Risk?

Members of the general public with potentially high exposures to mercury include individuals who live in proximity to former mercury mining or production sites, secondary production (recycling) facilities, ore roasting plants for gold extraction, municipal or medical incinerators, or coal-fired power plants. Some people may be exposed to higher levels of mercury in the form of methylmercury if they have a diet high in fish, shellfish, or marine mammals that come from mercury-contaminated waters. Methylmercury accumulates up the food chain, so fish at the top of the food chain will have the most mercury in their tissue. Of these fish, the biggest fish will typically have the highest levels of mercury, as shown in Figure 2 (ATSDR 1999).

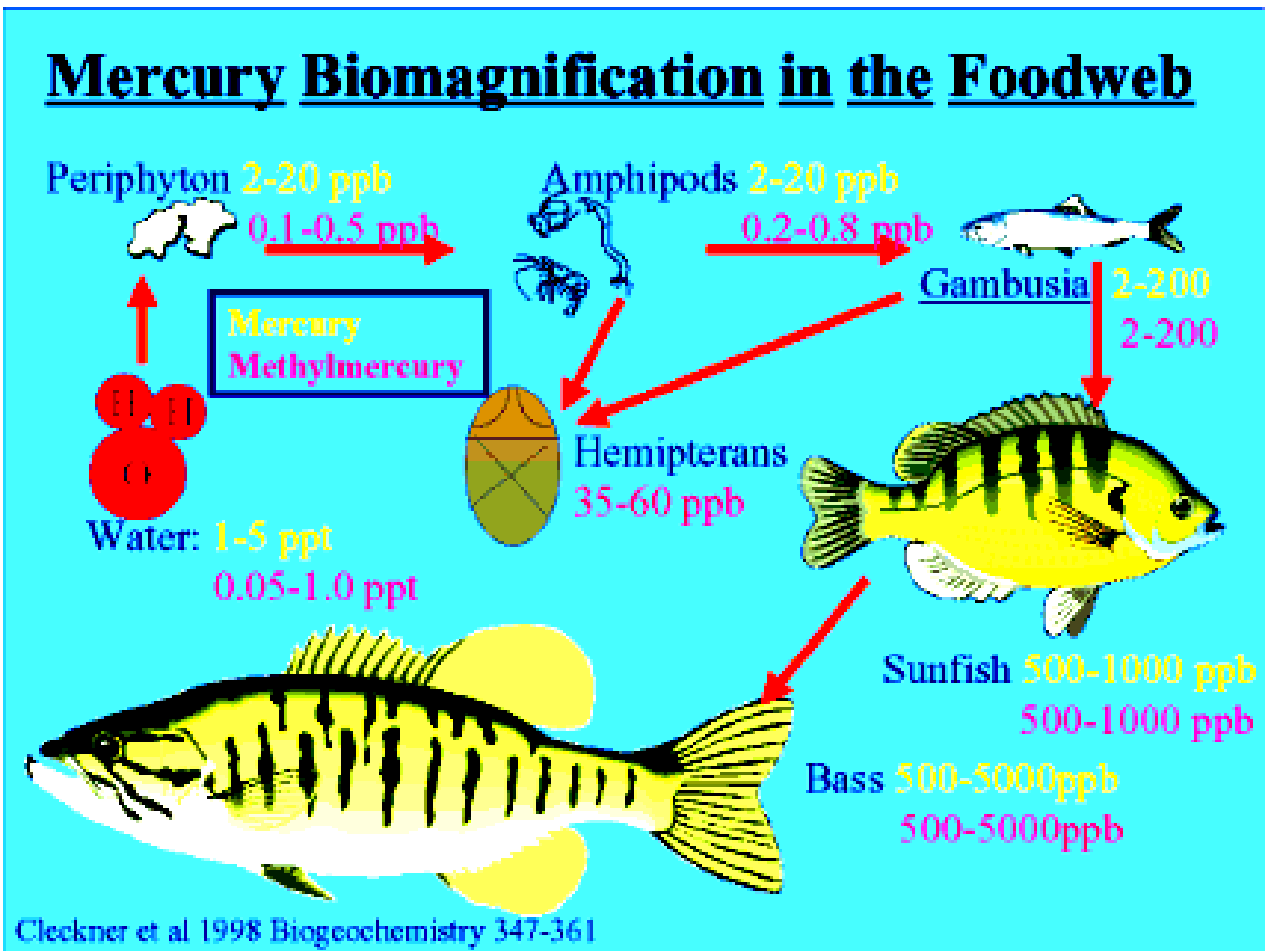


Figure 2: Drawing showing how piscivorous fish (fish that eat other fish) such as bass accumulate the most mercury in the aquatic food chain. Brown trout are also piscivorous.

Bioavailability

Methylmercury constitutes over 99% of the total mercury detected in fish muscle tissue (fillet), with no detection of inorganic or dimethylmercury (Grieb et al. 1990; Bloom 1992). BCEH conservatively assumed that the total mercury reported here (Table 1) is all methylmercury. Methylmercury is the form of mercury most easily absorbed through the gastrointestinal tract (about 95% absorbed). Again, to be conservative, BCEH also assumed that the bioavailability of total mercury in fish was 100%.

Exposure Pathway

To determine whether people are exposed to mercury, BCEH considered five elements: the source of contamination; the movement of the contaminants in soil, air or water; the point at which people can come in contact with the contaminants; the routes of exposure (such as eating contaminated fish); and the population that can potentially be exposed. All five elements must be present for an exposure pathway to be complete.

Exposure pathways are classified as a completed pathway, a potential pathway, or an eliminated pathway. If a pathway is complete, exposure is reasonably likely to have occurred in the past, is currently occurring, or is likely to occur in the future. If a potential pathway exists, exposure might have occurred, may be occurring, or may yet occur. A pathway is eliminated from further analysis when one of the five elements is missing and will never be present, or when no contaminant of concern can be identified.

Based on the exposure pathway analysis and environmental data, people are likely to be exposed to elevated levels of mercury through consumption of fish from Silver Creek. While some of the most popular parts of the creek are catch and release only, the Idaho Department of Fish and Game (IDFG) allows anglers to keep 2 fish per day from several sections of the creek. Thus, this constitutes a completed exposure pathway when the caught fish are eaten.

Health Comparison Values

ATSDR has developed a chronic oral minimal risk level (MRL) of 0.0003 milligram per kilogram of body weight per day (mg/kg/day) for methylmercury (ATSDR 1999). The U.S. Environmental Protection Agency (EPA) derived an oral reference dose (RfD) of 0.0001 mg/kg/day for methylmercury. In assessing risk, BCEH uses the MRL for the general population and the more protective RfD for women of reproductive age and children.

ATSDR's MRL is based on the Seychelles Child Development Study of over 700 mother-infant pairs in the Seychelles Islands. This population eats a large quantity and variety of fish, with 12 fish meals/week being typical. Developing fetuses were exposed *in utero* through maternal fish ingestion during pregnancy. Newborn children continued to be exposed during breastfeeding and after their shift to a fish diet (ATSDR 1999). In the 66-month evaluation period of the Seychelles study, several developmental tests were conducted. None of these indicated adverse effects of methylmercury exposure. The study also mentioned positive benefits of the fish diet. ATSDR derived a no-observed-adverse-effect level (NOAEL) of 0.0013 mg/kg/day from the highest exposure group in this study. The MRL was derived by applying an uncertainty factor of 3 for human variability and a modifying factor of 1.5 to account for the specific findings in the Faroe Islands study (ATSDR 1999).

EPA's methylmercury RfD is based on a benchmark dose analysis of developmental and neurological impairment. The RfD and the MRL differ by a factor of three, but they are in the same concentration range. Although derived by different methods, the RfD and the MRL are both relevant to Silver Creek, especially given concerns about preventing adverse fetal and infant exposures to methylmercury.

Sampling

Sampling was conducted by the USGS in June of 2007. Ten individual fish were collected at each of two locations: inside the Nature Conservancy's preserve, and downstream at the sportsman's access near Picabo. The latter site is an area where catch-

and-keep fishing is allowed. The preserve and many other areas of the creek are catch-and-release only. Fish were filleted and transported on ice to the USGS Mercury Lab in Middleton, Wisconsin.

Analysis

Analysis was performed at the USGS Mercury Lab in Middleton, Wisconsin, using EPA method 7473. This method involves the thermal decomposition and amalgamation of the tissue sample followed by detection of mercury using atomic absorption spectrophotometry.

Results

Table 1 summarizes the fish mercury data received by BCEH from the Nature Conservancy. A geometric mean is used to express average values. The geometric mean is more representative of the central tendency of the data than the conventional arithmetic mean (which is what most people think of as the average). For all 20 fish, the range and geometric mean with and without the highest data point is shown to illustrate whether or not a single high value is elevating the mean. While the highest value (1.91 mg/kg wet weight) was significantly higher than other values, it affected the mean by less than 10%.

Table 1: Mercury content in tissue of Silver Creek Brown Trout Sampled June 2007 (n=20 individual fish)

	Mercury (mg/kg wet weight)		Length (inches)		Weight (pounds)	
	Range	Geometric Mean	Range	Geometric Mean	Range	Geometric Mean
Whole dataset	0.17-1.91	0.48	12.01-22.91	16.67	0.58-4.40	1.50
Without highest datapoint	0.17-1.10	0.44	12.01-20.51	16.39	0.58-2.70	1.42
Nature Conservancy	0.17-1.91	0.56	12.80-20.47	16.86	0.73-2.70	1.53
Bridge Near Picabo	0.19-1.10	0.41	12.01-22.51	16.48	0.58-4.40	1.48

Exposure Assumptions

Based on the Idaho Fish Consumption Advisory Project (IFCAP) protocol (BCEH 2004), BCEH applied a body weight of 44 pounds (20kg) for children six and younger, 154 pounds (70 kg) for women (including women planning to become pregnant, and nursing mothers), and 176 pounds (80kg) for the general public. The meal size of uncooked fish fillet used was 4 ounce (oz) for children and 8 oz for adults (Table 2).

Table 2: General Risk Assessment Assumptions for Estimation of Mercury Exposure Doses

Population		Children ^a	Pregnant Women ^b	General Public
Body Weight ^c	(kg)	20	70	80
	(lbs)	44	154	176
Meal Size Uncooked ^d (cooked weight)		4 (2.25)	8 (6)	8 (6)

a: children 6 years old or younger

b: pregnant women, women planning to become pregnant, and nursing mothers

c: adjusted from Idaho Behavioral Risk Factors (BVRHS 2001)

d: ounces, 1 oz = 0.0283 kg; 4 oz = 0.1134 kg; 8 oz = 0.2268 kg

Dose Calculations

BCEH used the following equation to calculate the exposure dose of mercury from eating fish for each ingestion category:

$$EED = \frac{Conc \times IR}{BW}$$

Where,

EED: Estimated Exposure Dose (mg/kg/day)

Conc: Geometric Mean of Mercury Concentration in Fish (mg/kg)

IR: Ingestion Rate of Fish (kg/day)

BW: Body Weight (kg)

Child Health Considerations

Children differ from adults in their physiology (e.g., respiratory rates relative to body weight), pharmacokinetics (i.e., distribution, absorption, metabolism, and excretion of chemicals), and pharmacodynamics (i.e., susceptibility of an organ to the exposure).

Therefore, it is always important to address chemical exposures of this sensitive population. Infants and children may be more vulnerable to the toxic effects of chemicals for the following reasons:

- 1) children are more likely to play outdoors, put hands in their mouths, and bring food into contaminated areas;
- 2) children are closer to the ground (shorter), resulting in a greater likelihood of breathing and absorbing contaminants in dust, soil, and heavy vapors near the ground;

- 3) children weigh less, resulting in higher doses of chemical exposure per body weight; and
- 4) children's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages.

Critical periods of neonatal development and the early months after birth are times that are particularly sensitive to the harmful effects of methylmercury on the nervous system. Exposure to methylmercury is more dangerous for young children than for adults because methylmercury more easily passes into the developing brain of young children and may interfere with the development process (ATSDR 1999). Methylmercury can accumulate in fetal blood at concentrations higher than those in the mother. Mothers who are exposed to methylmercury and breastfeed their infant may also expose the child through breast milk. Abnormal heart rhythms have been seen in children who ate grains contaminated with very high levels of methylmercury. Methylmercury that enters the body can also be converted to inorganic mercury and result in kidney damage.

Consumption Advisory For Brown Trout From Silver Creek

Fish are an excellent protein source and fish consumption is associated with reduced risk of coronary heart disease. The benefits of eating fish have been associated with omega-3 fatty acids found in fish. Saturated fats from other animal sources of protein are linked with increased cholesterol levels and risks of heart disease. Fish also provide a good source of some vitamins and minerals.

To get the benefits of eating fish while limiting any adverse health effects from the mercury contamination in fish from Silver Creek, BCEH calculated the recommended meals per month people can safely eat using the following equation.

$$\text{Meals / Month} = \frac{\frac{\text{RfD} \times \text{BW}}{\text{Conc}} \times 30.44 \text{days / mo}}{\text{MS}}$$

where,

RfD: Reference Dose for methylmercury (0.0001 mg/kg/day)

BW: Body Weight (kg)

Conc: Fish tissue mercury concentration (mg/kg)

days/mo: Days per month

MS: Meal Size (kg)

The calculated limited meals for children, pregnant women and general public are listed in Table 3. Children (6 years old or younger) should eat no more than two 2.25-oz meals per month of brown trout from Silver Creek. Pregnant women (as well as women planning to become pregnant, and nursing mothers) should eat no more than two 6-oz meals per month of brown trout from Silver Creek. The general public should eat no more than seven 6-oz meals per month of brown trout from Silver Creek.

**Table 3: Limited Fish Meals for Silver Creek Brown Trout Sampled June 2007
(n=20 individual fish)**

	Mercury Concentration (mg/kg) (wet weight)		Limited Meals per Month		
	Range	Geometric Mean	Children ^a	Pregnant Women ^b	General Public ^c
Whole dataset	0.17-1.91	0.48	2	2	7
Without highest datapoint (1.91)	0.17-1.10	0.44	2	2	7.5

a: children 6 years old or younger (body weight of 20 kg or 44 lbs)

b: pregnant women, women planning to become pregnant, and nursing mothers (body weight of 70 kg or 154 lbs)

c: body weight of 80 kg or 176 lbs

Meal Size (cooked): 2.25-oz for children, 6-oz for adults.

Conclusions

1. A *public health hazard* exists for children and pregnant women who eat more than two meals per month of brown trout from Silver Creek.
2. A *public health hazard* also exists for others in the general public who eat more than seven meals per month of brown trout from Silver Creek.

Recommendations

BCEH will issue a fish advisory for brown trout caught in Silver Creek based on the evaluation in this health consultation. BCEH will work with the Idaho Department of Fish and Game to post and distribute the fish advisory. Efforts will also be made by BCEH to educate the fishing community on the health implications of fish consumption. The advisory will include the following:

1. Children (6 year old or younger) should not eat more than two 2.25-oz meals per month of brown trout from Silver Creek.
2. Pregnant women, including women planning to become pregnant, and nursing mothers, should not eat more than two 6-oz meals per month of brown trout from Silver Creek.
3. General public should not eat more than seven 6-oz meals per month of brown trout from Silver Creek.
4. Do not eat other fish including commercial fish in the same month if you eat up to the recommended limit of brown trout from Silver Creek, since all fish contain various levels of mercury. To find the level of mercury in common commercially available fish, please check the national fish advisory (<http://www.epa.gov/waterscience/fishadvice/advice.html>).
5. People should eat smaller, younger fish. Typically, the bigger or older the fish, the higher the mercury concentration in the fish fillet.

Public Health Advice/Public Health Action Plan

BCEH will work with the Idaho Fish Consumption Advisory Project to issue a fish advisory for Silver Creek.

BCEH will work with the Idaho Department of Fish and Game and the Nature Conservancy to make anglers aware of the advisory.

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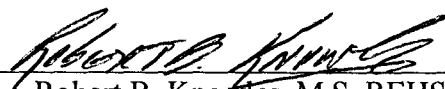
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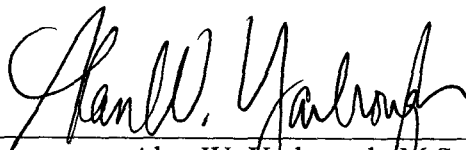
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Certification

This health consultation, **Mercury in Fish from Silver Creek--Evaluation of Risk from Brown Trout Consumption**, was prepared by the Idaho Division of Health (IDOH), Bureau of Community and Environmental Health (BCEH), under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.



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Appendix A: Glossary

Acute Occurring over a short time.

Agency for Toxic Substances and Disease Registry (ATSDR)

The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.

BCEH Bureau of Community & Environmental Health, a bureau within IDOH.

Chronic Occurring over a long time (more than 1 year).

Comparison value (CV)

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Contaminant

A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dose

The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

EPA The U.S. Environmental Protection Agency.

Exposure

Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute**], of intermediate duration [**intermediate**], or long-term [**chronic**].

Fish Consumption Advisory

Guidelines for how many meals per month people can eat fish that contain certain contaminants. Issued by IDHW in consultation with members of the IFCAP.

FDA The U.S. Food and Drug Administration.

Hazardous substance

Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.

IDEQ The Idaho Department of Environmental Quality.

IDFG The Idaho Department of Fish and Game.

IDHW The Idaho Department of Health & Welfare.

IDOH The Idaho Division of Health, a division within IDHW.

IFCAP

The Idaho Fish Consumption Advisory Project. Members of this project group include representatives from IDEQ, ISDA, IDFG, USGS, and the Idaho Governor's Office. This group reviews fish mercury data and decides if a fish consumption advisory should be issued by IDHW.

Indeterminate public health hazard

The category used in ATSDR's health consultation documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Ingestion rate

The amount of an environmental medium which could be ingested typically on a daily basis. Units for ingestion rate are usually liter/day for water, and mg/day for soil.

ISDA The Idaho State Department of Agriculture.

Lowest Observed Adverse Effect Level (LOAEL) The lowest tested dose of a substance that has been reported to cause measurable adverse health effects in people or animals.

Media

Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

No apparent public health hazard

A category used in ATSDR's health consultation reports for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No Observed Adverse Effect Level (NOAEL)

The highest tested dose of a substance that has been reported to have no measurable adverse health effects on people or animals.

No public health hazard

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Oral Reference Dose (RfD)

An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.

Organic

Compounds composed of carbon, including materials such as solvents, oils, and pesticides which are not easily dissolved in water.

Public Health Hazard

A category used in ATSDR's health consultation reports for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances that could result in harmful health effects.

Route of exposure

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor

A number that is used to account for uncertainty in the data and/or severity of the health effect when calculating an oral RfD or other level or dose to which humans can safely be exposed. Safety factors generally range from 1-100.

USGS The United States Geological Survey.