Health Consultation

EVALUATION OF PCBs, PBDEs AND SELECTED METALS
IN THE SPOKANE RIVER, INCLUDING LONG LAKE

SPOKANE, WASHINGTON

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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

EVALUATION OF PCBs, PBDEs AND SELECTED METALS IN THE SPOKANE RIVER, INCLUDING LONG LAKE

SPOKANE, WASHINGTON

Prepared By:

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

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation 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 hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH 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. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health advisor who prepared this document:

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For more information about ATSDR, contact the ATSDR Information Center at 1-888-422-8737 or visit the agency's Web site: www.atsdr.cdc.gov/.

Glossary

Acute	Occurring over a short time (less than 1 year)
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.
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison value	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 (for chemicals that are not radioactive)	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.
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Epidemiology	The study of the occurrence and causes of health effects in human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor (i.e., age, sex, occupation, economic status) is associated with the health effect.

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].
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.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Ingestion rate	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (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 Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
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.
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].
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.

Summary

This health consultation was prepared at the request of Washington State Department of Ecology (Ecology) and the Spokane Regional Health District (SRHD). The purpose of this health consultation is to evaluate recent Spokane River fish contaminant data and update recommendations for actions to ensure protection of the public's health. Generally, PCB levels were lower in 2005 than in 2001, except for largescale sucker (whole) and rainbow trout (fillet) in Mission Park. Ecology suggests that lower levels of PCBs in fish from Upriver Dam to the Idaho border correlate with cleanup actions in the Spokane River. To verify this observation, Ecology and DOH concur that further monitoring of the Spokane River is appropriate to confirm this apparent trend and before changing the original fish advisory. Advice for this area may change in the future if PCB levels drop below health concern levels. DOH emphasizes consuming fillets instead of whole fish in the Spokane River and cleaning all fish before eating.

The results of this evaluation indicate that exposure to PCBs through ingestion of Spokane River fish caught in the Spokane River fish represents *a public health hazard*. The potential for adverse health effects to result from eating Spokane River fish depends on several factors such as amount of fish consumed and fishing location. Extremely high levels of PBDEs were observed in mountain whitefish and rainbow trout (whole) between Ninemile Dam to Upriver Dam. Due to limited research on the possible consumer health risk from PBDEs, DOH concludes a *no apparent public health hazard* exists. However, concern remains about the effects of these compounds on humans and biota. *A public health hazard* exists for pregnant women and children who consume whole fish contaminated with lead from the Spokane River between the Upper Long Lake and the Idaho Border (Stateline). *No public health hazard* exists for adults exposed to lead who consume fillets from the Spokane River. Women who are pregnant or planning a pregnancy should follow the meal limit advice currently in place for PCBs, which will also be protective for PBDEs and lead.

DOH recommends against any consumption of fish between the Idaho border and Upriver Dam. For the reach between Upriver Dam and Ninemile Dam, DOH advises against eating more than one meal per month of any species. For the reach between Ninemile Dam and Long Lake Dam (Upper and Lower Long Lake) DOH advised that it is safe to eat fish in this location. Although some fish from this reach contain high levels of PCBs, DOH recommends as a prudent public health measure to clean and prepare fish to reduce exposure to PCBs and other contaminants that collect in the fat of fish.

Purpose

The Washington State Department of Health (DOH) prepared this health consultation at the request of Washington State Department of Ecology (Ecology) and the Spokane Regional Health District (SRHD). The purpose of this health consultation is to evaluate recent Spokane River fish contaminant data and update recommendations for actions to ensure protection of the public's health. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substance and Disease Registry (ATSDR).

Background and Statement of Issues

Previous evaluations of Spokane River fish data resulted in meal advisories for anglers and other consumers of fish from certain areas of the river. This consultation is in response to newly acquired data which provides for a more comprehensive evaluation of potential risk due to consumption of Spokane River fish. A brief history of past Spokane River evaluations follows.

In 1999 Ecology, DOH and SRHD issued a fish consumption advisory due to lead; the advisory was based on data collected in the same year. In August 2001, DOH completed an evaluation of cadmium, lead and zinc contamination in Spokane River fish. DOH concluded that *a public health hazard* existed for children and adults, specifically pregnant women, who were exposed to lead through consumption of whole fish from the Spokane River.[1] The 2001 report also concluded that there was *no apparent public health hazard* for children exposed to metals from consuming fish fillets from the Spokane River, but consumption of larger quantities of fish fillets than those assumed in the health-based assessment may have some health effects.[2]

The 1999 fish consumption advisory was later updated in March 2001 due to elevated PCB concentrations in Spokane River fish. The 2001 fish advisory based on a DOH report advised fishing enthusiasts that PCB concentrations in Spokane River fish were of concern. DOH concluded that exposure to PCBs through ingestion of Spokane River fish caught between the Washington/Idaho border and Ninemile Dam represented a *public health hazard* for persons who consumed fish from this area.[3,4] In July 2003, SRHD and DOH issued a fish advisory which recommends against any consumption of fish between the Idaho border and Upriver Dam. For the reach between Upriver Dam and Ninemile Dam, DOH advised against eating more than one meal per month of any species. Although fish downstream of Ninemile dam contained some PCBs, levels were lower relative to upstream portions, thus fish was safe to eat. Cleaning and preparation to reduce exposure to some contaminants was advised.[5]

More recently, DOH reviewed new data and evaluated health risks that may result from exposure to polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers flame retardants (PBDEs), and metals (arsenic, cadmium, lead, and zinc) through consumption of Spokane River fish.

Environmental Sampling Collection and Analysis

Fish sampling of the Spokane River dates back to 1992, and continued in 1993, 1994, 1999 and 2001 when Ecology sampled numerous fish species and analyzed them for metals and/or PCBs. In 2005, Ecology conducted a study to obtain up-to-date information on concentrations of PCBs, PBDEs, and selected metals (zinc, lead, cadmium, and arsenic) in several species of sport fish and bottom fish in the Spokane River. In 2005, Ecology sampled one to four fish species each from six reaches along the Spokane River: 1) Upper Long Lake, 2) Lower Long Lake, 3) Mission Park, 4) Ninemile Dam, 5) Plante Ferry, and 6) Idaho Stateline during August through November 2005. The six sampling locations correspond to three sections of the Spokane River (Figure 1). The first section of the river represents Long Lake (also known as Lake Spokane). This portion corresponds to the Spokane River from Long Lake Dam upstream to the confluence of the Little Spokane River. Ecology collected samples from the upper and lower portions of the Lake. The second portion of the river represents Ninemile Dam to Upriver Dam (including Mission Park and Ninemile locations). The third portion of the river represents the Upriver Dam to Idaho border (including Plante Ferry and the Idaho Stateline locations).

Rainbow trout, mountain whitefish, brown trout, smallmouth bass, largescale and bridgelip suckers were the fish species collected. Target species selected for analysis were based primarily on availability, desirability to anglers, and analysis in previous contaminant studies on the Spokane River.

PCB Aroclors (i.e., Aroclors 1016, -1221, -1232, -1242, 1248, -1254, -1260, -1262, and -1268) were analyzed using dual column gas chromatography electron conductivity detector (GC-ECD) in all species. These methods are modifications of EPA SW-846 methods 3540, 3620, 3665, and 8082. Aroclor results were summed to derive total PCBs.[a]

A subset of samples was analyzed for all 209 congeners. The sum of these congeners represents the total amount of PCBs. Blanks, surrogates, duplicates, matrix spiked samples and laboratory control samples were used for quality control (QC). All reported QC results had recoveries within acceptable limits. No PCBs were detected in method blanks.

[a] Half of the detection limit was used for non detects (NDs) and/or data with qualifiers U or UJ (U means that the analyte was not detected at or above the reported result, and UJ means that the analyte was not detected at or above the reported estimated result).

PBDE congeners (i.e., BDE-47, -49, -66, -71, -99, -100, -138, -153, -154, -183, -184, -191, and -209) were analyzed using gas chromatography mass spectrometry (GC/MS) by EPA method 8270. The total reported PBDE value represents the sum of all congeners. Laboratory control samples and internal standards were within acceptable recovery limits. All surrogate recoveries fell within acceptable QC recovery limits except in cases where dilutions resulted in concentrations below calibration range. No PBDEs were detected in method blanks.

Lead, cadmium, arsenic and zinc were analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP/MS) EPA method 200.8. All QC sample recoveries were within acceptable limits. No metals were detected in method blanks.

Results

A complete set of results is presented in Appendix A (Tables 1A through 6A). Table 1 presents the maximum value of arsenic (total and inorganic arsenic), cadmium, total PBDEs, lead, zinc, and total PCBs found in Spokane River fish compared to EPA's subsistence comparison values.[6]

Contaminant Screening

Fillet and whole body samples contaminant data were screened using values derived by DOH considered protective of subsistence fish consumers (Table 1). Comparison values were derived using high-end consumption rates presented in EPA's fish advisory guidance documents (Appendix B). Table 1 shows the maximum concentration of each contaminant measured in Spokane River fish compared to health-based subsistence consumer comparison values. The fact that a contaminant exceeds its health comparison value does not mean that a public health hazard exists but rather signifies the need to consider the chemical further.

When a chemical exceeds a health-based screening value (SV), additional evaluation of that chemical is necessary. Of all contaminants analyzed, only lead, total PCBs and total PBDEs had levels that exceeded EPA's subsistence comparison values. Therefore, lead, total PCBs and total PBDEs were further evaluated as contaminants of concern (COCs).

Historical Data vs. Current Data

Total PCBs (1994 to 2004) in Spokane River fish vs. current data (2005)

Recent and historical total PCB concentrations are reported as the sum of Aroclor mixtures. PCB levels are highest in whole body for largescale suckers at Mission Park location compared with fish fillets. PCB levels are also high in Upper and Lower Long Lake for largescale suckers.

Table 1. Summary of chemical contaminants in Spokane River fish 2005 compared to subsistence consumption screening values, Spokane, Washington.

Contaminant	Units	Max. (mg/kg)	EPA's Subsistence Comparison Value (mg/kg)	RfD (mg/kg/ day)	Contaminant of concern
Arsenic, total	ppm	0.39	NA	3.0E-04	No
Arsenic, inorganic 10% of total‡‡	ppm	0.039	0.147 (non-cancer)	3.0E-04	No
Cadmium	ppm	0.24	0.491	1.0E-03	No
Total PBDEs	ppm	4.7	9.7E-02	Variable* (used BDE-47)	**Yes**
Lead †	ppm	**6.7**	NA	NA	**Yes**
Zinc ‡	ppm	**165**	147.8	0.3	No
Total PCBs	ppm	**3.0**	9.83E-03	2.0E-05	**Yes**

NA – Not available
mg/kg = milligrams per kilograms; ppm = parts per million
BOLD Values exceed comparison value
* EPA's draft reference dose for four congeners of polybrominated diphenyl ethers: tetraBDE (BDE-47), pentaBDE (BDE-99), hexaBDE (BDE-153), and decaBDE (BDE-209) correspond to:

- BDE-47 reference dose (RfD) corresponds to 2.3 x 10^{-4} mg/kg-day or 0.2 ug/kg-day
- BDE-99 RfD corresponds to 1.3 x 10^{-4} mg/kg-day or 0.1 ug/kg-day
- BDE-153 RfD corresponds to 1.5 x 10^{-4} mg/kg-day or 0.2 ug/kg-day
- BDE-209 RfD corresponds to 0.007 mg/kg-day or 7 ug/kg-day

† IEUBK – The Integrated Exposure Uptake Biokinetic Model for Lead in Children is used to predict blood lead levels in children. EPA's adult exposure model to lead in soil was used to predict blood lead levels in adult workers and pregnant women associated with consumption of fish from the Spokane River (Appendix D).
‡ Zinc is an essential nutrient found in almost every cell. The Recommended Dietary Allowance (RDA), one of the Dietary Reference Intakes (DRIs), is the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals. For infants 0 to 6 months, the DRI is in the form of an Adequate Intake (AI), which is the mean intake of zinc in healthy, breastfed infants. The AI for zinc for infants from 0 through 6 months is 2.0 milligrams (mg) per day. The 2001 RDAs for zinc for infants 7 through 12 months, children and adults in mg per day are: 7 months through 3 years, the AI is 3.0 milligrams (mg) per day; 4 to 8 years 5 milligrams (mg) per day; 9 to 13 years is 8 milligrams (mg) per day; 14 and up is 13 milligrams (mg) per day. (Results of two national surveys, the National Health and Nutrition Examination Survey (NHANES III 1988-91)[7] and the Continuing Survey of Food Intakes of Individuals (1994 CSFII) [8] indicate that most infants, children, and adults consume recommended amounts of zinc).
‡‡ Cancer values for inorganic arsenic were not evaluated because there is not data for arsenic speciation in fish from Spokane River. The majority of arsenic in finfish is presumed to be organic arsenic, which is less toxic than inorganic forms.

Generally, current PCB concentrations are lower in Spokane River fish from all areas of the river (except Mission Park) in relation to historical data (Tables 2a and 2b). Three matched data sets are available for the Mission Park site: rainbow trout fillets, mountain whitefish fillets, and whole suckers. According to Ecology, there is not a significant statistical change in the mean concentration of rainbow trout fillets (composites) at this sampling location in 2005 vs. 1999. On the other hand, the mean concentration in mountain whitefish fillets (composites) was slightly lower than in 1999, and the largescale sucker data suggest a consistent, substantial increase in total PCBs between 1994 and 2005.[9]

Although PCB levels changed from year to year, some locations exceeded 200 ug/kg in mountain whitefish fillets and whole body suckers (Mission Park and Upper and Lower Long Lake areas). This PCB level approximates a decision point above which DOH may recommend that people avoid eating fish from Spokane River.

Table 2a. Recent and historical average total PCB concentrations in fish tissue (fillet) collected in the Spokane River from 1994 to 2005, Washington.

Location	Species	Tissue type	N	C/I	Mean total PCBs ug/kg, wet weight (2005)	Historical samples mean total PCBs ug/kg, wet weight conducted from 1994 to 2001[a]			
						1994	1996	1999	2001
Plante Ferry	Rainbow Trout	Fillet	3	C	**55**	414	799	880	--
Mission Park	Rainbow Trout	Fillet	3	C	**153**	145	76	226	--
"	Mountain Whitefish	Fillet	3	C	**234**	568	381	339	--
Ninemile	Rainbow Trout	Fillet	3	C	**73**	371	76	143	--
"	Mountain Whitefish	Fillet	3	C	**139**	139	444	632	--
Upper Long Lake	Mountain Whitefish	Fillet	3	C	**43**	--	--	--	73
"	Brown Trout	Fillet	1	C	**130**	--	--	--	--
"	Smallmouth Bass	Fillet	1	C	**37**	--	--	--	--
Lower Long Lake	Mountain Whitefish	Fillet	6	I	**76**	113	--	--	--
"	Smallmouth Bass	Fillet	3	C	**67**	--	--	--	23

N = sample size
ug/kg = micrograms per kilograms
C = composites
I = individuals
[a] The 1994 to 2001 sampling studies often vary in sample size, and use of composite vs. individual fish samples, and in other ways.

Table 2b. Recent and historical average total PCB concentrations in fish tissue (whole) collected in the Spokane River from 1994 to 2005, Washington.

Location	Species	Tissue type	N	C/I	Mean total PCBs ug/kg, wet weight (2005)	Historical samples mean total PCBs ug/kg, wet weight collected from 1994 to 2004 [a]				
						1994	1996	1999	2001 and 2003	2004
Stateline	Largescale Sucker	Whole	3	C	**56**	--	--	120	--	100
Plante Ferry	Largescale Sucker	Whole	3	C	**122**	531	530	283	97*	--
Mission Park	Largescale Sucker	Whole	3	C	**1,823**	201	116	444	--	--
Ninemile	Bridgelip Sucker	Whole	3	C	**69**	--	345	680	--	--
Upper Long Lake	Largescale Sucker	Whole	3	C	**327**	--	--	--	265	--
Lower Long Lake	Largescale Sucker	Whole	3	C	**254**	820	--	--	357	--

N = sample size
ug/kg = micrograms per kilograms
C = composites
I = individuals
[a] The 1994 to 2004 sampling studies often vary in sample size, and use of composite vs. individual fish samples, and in other ways.
* Largescale sucker in Plante Ferry was sampled in 2003.

1999 historic sampling data for PBDEs

Only 2005 data were used in this evaluation. DOH did not use 1999 PBDE data because data were considered inappropriate for use in this health evaluation. The primary reason for not using the historical data is related to methodology issues. In 1999, gas chromatography, a traditional method for PCB analysis was used to analyze PBDE congeners in fish tissue. The gas chromatographic detector used in the analysis must be selective to PBDEs, because the presence of PCBs may interfere with the determination. Further, similarities between the physical properties of PBDEs and PCBs can make the determination of PBDEs in the presence of relatively high levels of PCBs problematic because separation of these types of compounds in environmental samples is difficult.[10] 2005 sampling data were analyzed using EPA's most recent analytical method which is specific for PBDE analysis making it inappropriate to compare trends for PBDEs. New analytical methods for the determination of PBDEs in environmental and human samples need further improvement because there are still limitations with the determination.

2005 PBDE data

DOH summarized 2005 sampling data for Spokane River fish (Appendix A, Table 2A). Mean total PBDE concentrations (sum of detected compounds) ranged from 30 – 1,059 ug/kg in sport fish fillets, 95 – 572 ug/kg in whole largescale sucker, and whole mountain whitefish and whole rainbow trout PBDE concentrations were 4,720 ug/kg and 2,043 ug/kg, respectively. The primary PBDEs detected were PBDE-47, -99, and -100, which comprised approximately 90% of the total. High levels of PBDEs were observed in fish from Ninemile, Mission Park Reach and in Upper Long Lake. Concentrations were lowest in Lower Long Lake. Mountain whitefish and rainbow trout fillets had the highest concentrations of PBDEs with concentrations of 1,059 and 418 ug/kg, respectively. Substantially elevated PBDE levels appear to extend up to the Idaho border. These results suggest that there is a major PBDE source in the Ninemile area and that there also may be significant sources in Idaho. Potential sources in the Spokane River near the city of Spokane include the Spokane wastewater treatment plant, which discharges just above the Ninemile reach, and stormwater runoff from the city of Spokane.[11]

2001 historic sampling data (statewide comparison) for PBDEs ranged from 1.4 ug/kg in whole rainbow trout from an undeveloped watershed to 1,250 ug/kg in whole mountain whitefish from the Spokane River. Fish from the Spokane River have the highest concentration of PBDEs found in Washington to date.[12] Total PBDEs in Spokane River fish fillets averaged 740 ug/kg, which is an order of magnitude higher than levels found in fish from other Washington rivers and lakes.[11]

Historical data on lead in Spokane River fish between 1999 and 2005

Comparison of historical lead data with 2005 samples is complicated by the different locations chosen for the 2005 sampling. Other issues include sampling size and use of composite vs. individual fish samples.

Lead concentrations in Stateline whole fish samples are clearly elevated (6.7 mg/kg). Lead levels in Spokane whole fish samples are very high compared to lead in fish from other parts of the state.[9]

Discussion

There is an existing fish advisory based solely on PCBs. 2005 data shows a decrease in PCB concentrations in fish (except Mission Park) and high levels of PBDEs and lead. DOH is re-evaluating these data to determine if the current advisory is protective of PCBs, PBDEs, and lead exposure. The goal of this evaluation is to determine whether the current fish advisory changes with the recent data. Thus, the most recent PCB, PBDE, and lead data are evaluated by DOH.

Exposure

The general population can be exposed to PCBs, PBDEs, and lead through several pathways (e.g., inhaling contaminated air, ingesting contaminated water, soil, and food). Of particular concern in this report is human exposure to contaminants of concern from consumption of fish.

Populations of Concern

Some groups may consume greater amounts of fish than others; for example, recreational anglers are the primary users of the Spokane River above the Long Lake Reservoir Dam. Current Spokane Indian reservation land is located on the lower section of the river.[13] Therefore, some Native American population may fish this and other portions of the river. Populations that eat fish from the Spokane River include sport fishermen as well as various ethnic groups (Slavic, Hispanic, Hmong, Vietnamese populations) that supplement meals with fish from the river. According to the Spokane River Toxins Survey, most fishing in the Spokane River occurs from Long Lake Dam to Lake Roosevelt area. Long Lake Dam to Lake Roosevelt is the most commonly visited section of the Spokane River.[14]

Non-cancer Hazard Evaluation

In order to evaluate the potential for *non-cancer* adverse health effects in children and adults that might result from exposure to contaminants in fish harvested from the study area, estimated doses for average consumers were calculated as shown in Appendix C. These estimated doses were compared to EPA's reference dose, or ATSDR's minimal risk level (MRL). These are doses below which non-cancer adverse health effects are not expected to occur (so called "safe" doses). They are derived from toxic effect levels obtained from human population and laboratory animal studies. These toxic effect levels are divided by multiple "safety factors" to give the lower, more protective RfD or MRL. A dose that exceeds the RfD or MRL indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded by the exposure dose. If the estimated exposure dose is only slightly above the RfD or MRL, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the RfD or MRL, the closer it will be to the toxic effect level.

In order to determine if an exposure dose represents a hazard of non-cancer human health effects, exposure doses are compared to the RfD (or MRL) to obtain a hazard quotient (HQ) where:

HQ = Estimated dose/RfD

This provides a convenient method to measure the relative health hazard associated with a dose. As the hazard quotient exceeds one and approaches an actual toxic effect level, the dose becomes more of a health concern.

The following health risk evaluation is based on exposure of recreational consumers. DOH calculated fish meal limits using the average fish ingestion rate of 42 g/day for recreational fishers, which are the main population of concern based on consumption of Spokane River fish (Appendix C, Table C1). By using the known concentration of a contaminant in a fish species, it is possible to calculate an allowable amount that can be eaten for that species without exceeding the reference dose (RfD) for that contaminant.

The RfD is defined as an exposure dose at or below which adverse non-cancer health effects are not likely. The RfD for PCBs (0.00002 mg/kg-day) is based on adverse immune system effects observed in exposed monkeys, but PCBs have also been shown to cause adverse developmental effects in children exposed in the womb.

Exceeding an RfD does not necessarily mean that adverse health effects will occur because numerous safety factors are applied to ensure the protection of public health. If a dose exceeds the RfD, it suggests only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which the RfD value is exceeded.

Non-cancer Hazards Associated with Exposure to PCBs and PBDEs

When the above approach is applied to consumption of Spokane River fish, recreational anglers consuming fish at an average of 42 g/day (~ 10 ounces or 1 meal per week) do exceed a hazard quotient of one for total PCBs for both fillet and whole body samples. The estimated exposure doses use conservative assumptions in the calculations – it assumes a fairly consistent exposure. Considering the exposure and toxicity data there is a potential for adverse non-cancer health effects that may result when an adult is exposed to contaminants from consumption of fish in the Spokane River (Appendix C, Table C3).

Appendix C shows exposure assumptions and dose calculations used to estimate PBDE dose from consuming Spokane River fish. An adult consuming mountain whitefish and rainbow trout (both fillet and whole body fish) from the Spokane River at average rates (~ 1 to 20 fish per year) exceed a hazard quotient of one for total PBDEs in the Ninemile location (Appendix C, Table C5). Human health effects from consuming fish with PBDEs are uncertain, but animal studies suggest that exposures to the developing fetus or infant may be a concern.

Lead Hazard Assessment

Health effects due to lead exposure were assessed for children and adults. Since the biokinetics of lead are different from many other chemicals, lead will be evaluated differently than for other chemicals such as PCBs and PBDEs.

To evaluate the potential for harm, public health agencies often use a computer model that can estimate blood lead levels in children younger than seven years of age who are exposed to lead-contaminated soil. This model (developed by EPA and called the Integrated Exposure Uptake Biokinetic Model, or IEUBK model) uses the concentration of lead in soil to predict blood lead levels in children.[15] It is intended to help evaluate the risk of lead poisoning for an average child who is exposed to lead in their environment.

Inputs to the IEUBK model include lead exposure through soil, house dust, air, diet, and water. The model predicts distributions of blood lead levels for children 84 months of age or younger.

Model Input Values

For the IEUBK model, EPA default values were used except lead fish consumption concentrations. To assess the lead hazard associated with fish consumption, the model requires information on the percentage of total meat consumption consisting of locally caught fish (i.e., average-end recreational estimate for a child, and high-end estimate for Native Americans) and the average lead concentration in fish tissue (Appendix E, Table E1).

Health Evaluation of Lead Exposure in Children

Metal concentrations in fillets tend to be lower than metal concentrations in whole fish. There are multiple reasons for whole fish having higher levels of lead contamination. Lead can accumulate in bones, scales and skin (by sticking on to the skin surface). Lead can also be introduced from mucus and organs. Depending on the trophic level of the fish, sediments can accumulate in the gullets that contain lead (suckers being a bottom feeder). However, because whole largescale sucker rather than the edible portion (fillets) were analyzed for suckers, the values reported are not appropriate for human health risk assessment. Nevertheless, in the event that largescale suckers are eaten whole, DOH has evaluated human health risk for whole fish.

Children that eat fish recreationally and/or Native American children consuming whole largescale sucker between Idaho Border and Ninemile stretch may be at risk of exceeding the EPA's target cleanup goal of having no more than 5 percent of the community with Blood Lead Levels (BLLs) above 10 µg/dL. However, it is highly unlikely that a child would consume only largescale suckers. In addition, the lead levels may have been biased higher due to whole fish analysis and sediments in the gullet of the fish.

Lead Hazard Assessment for Adults

The EPA's adult blood lead model is useful to predict blood lead levels in adults and their fetuses. The adult model uses well established default values and is completely different from the IEUBK model. The adult model considers lead exposure through the ingestion of soil and food. The dose of lead received through these pathways is then converted to a blood lead level by using the ratio of blood lead to lead dose. This ratio is called the Biokinetic Slope Factor (BKSF). The starting blood lead level, the blood level in the absence of lead exposure via food and soil ingestion pathways, is also part of this calculation. Appendix D shows the formulas and default values used to calculate blood lead levels in adults and pregnant women.

In order to protect the developing fetus, EPA has suggested that central tendency maternal blood lead levels need to be maintained at or below 2.8 ug/dL. Maintenance of the central tendency maternal blood level at or below 2.8 ug/dL should insure a low probability of fetal exposure to blood levels of greater than 10 ug/dL. 10 ug/dL is the same health protective value used for assessment of lead for children in the IEUBK model.

Health Evaluation of Lead Exposure in Adults

DOH predicted blood lead levels for recreational anglers of the Spokane River (Appendix D, Table D2). Two health endpoints are of concern, fetal protection for pregnant women and hypertension for all adults. The cutoff point for fetal protection is 2.8 ug lead/dL blood, while the cutoff for adults is 10 ug lead/dL blood. Blood lead levels exceeding the fetal protection endpoint are **bolded**. Recreational anglers consuming **whole** largescale sucker may be at risk of exceeding the fetal protection endpoint.

In general, 2005 data demonstrate a substantial increase in whole fish mean lead concentrations. Although lead levels in some fish may pose a risk to the fetuses of pregnant women, PCBs are still the dominating risk driver except at Stateline location. Since DOH recommends no fish consumption at this site, any advice provided for fish consumption based on PCBs will also be protective of excessive lead exposure.

Evaluating Cancer Risk

Cancer risk is estimated by calculating a dose similar to that described in the previous section and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice suggests that there is no “safe dose” of a carcinogen and that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates are, therefore, not yes/no answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries associated risk. Validity of the “no safe dose” assumption for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. More recent guidelines on cancer risk from EPA reflect the existence of thresholds for some carcinogens. However, EPA still assumes no threshold unless sufficient data indicate otherwise. This consultation assumes that there is no threshold for carcinogenicity.

Cancer Risk = Estimated Dose x Cancer Slope Factor

Cancer risk is expressed as a probability. For instance, a cancer risk of 1×10^{-5} can be interpreted to mean that a person's overall risk of obtaining cancer increases by 0.00001, or if 100,000 people were exposed, there might be one extra cancer in that population above normal cancer rates. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population. Cancer risks quantified in this document are an upper-bound theoretical estimate. Actual risks are likely to be much lower.

Cancer Risk Attributed to Exposure to PCBs

When the above approach is applied to consumption of fish from the Spokane River, lifetime increased cancer risks range from 1.2×10^{-4} to 7.9×10^{-5} for a recreational angler eating fillets and 1.3×10^{-4} to 6.3×10^{-5} for adults eating whole body fish (Appendix C, Table C4). The cancer risk for a recreational angler consuming mountain whitefish fillet at the Spokane River between Ninemile Dam to Upriver Dam would be 1.9E-04. These risks do exceed the range of cancer risks considered acceptable by EPA (1×10^{-4} to 1×10^{-6}).

Determining Allowable Consumption Rates

Because some consumers may eat Spokane River fish at a rate that may increase health risk from exposure to certain chemicals (i.e., PCBs, PBDEs and lead), DOH calculated meal limits for these contaminants in fish sampled from Spokane River based on the recreational anglers average consumption rate of 42 g/day.

A. PCBs

DOH calculated eight-ounce fish meal limits per month using 2005 fish tissue data (PCB Aroclors) based on the formula in Appendix B. Calculated meal limits range from less than one meal to 4 meals per month in fillet and whole body samples for all locations (Table 3).

Fillet samples for smallmouth bass and mountain whitefish at Upper Long Lake have the highest calculated meal limits at 4 eight-ounce meals limit per month. Whole body samples for largescale suckers at most locations resulted in lowest calculated meal limits per month, ranging from less than one meal to 3 meals per month. Largescale suckers at Stateline and bridgelip suckers at Ninemile have the highest calculated meal limits per month for these species (3 to 2 meals per month, respectively).

Recommended meal limits are designed to protect a 60-kg adult eating an eight-ounce fish meal. Meal sizes for people weighing more or less than 60 kg may increase or decrease proportionally. DOH does not typically recommend fish consumption at meal limits lower than one meal per month.

Table 3. Calculated meal limits (per month) for fish sampled from Spokane River, Spokane, Washington.

Location	Species	Total mean PCBs ug/kg, wet weight	Calculated meal limit (meal per month)
Fillet samples			
Plante Ferry	Rainbow Trout	**55**	3
Mission Park	Rainbow Trout	**153**	1
"	Mountain Whitefish	**234**	1
Ninemile	Rainbow Trout	**73**	2
"	Mountain Whitefish	**139**	1
Upper Long Lake	Mountain Whitefish	**43**	4
"	Brown Trout	**130**	1
"	Smallmouth Bass	**37**	4
Lower Long Lake	Mountain Whitefish	**76**	2
"	Smallmouth Bass	**67**	2
Whole body samples			
Stateline	Largescale Sucker	**56**	3
Plante Ferry	Largescale Sucker	**122**	1
Mission Park	Largescale Sucker	**1,823**	0
Ninemile	Bridgelip Sucker	**69**	2
Upper Long Lake	Largescale Sucker	**327**	1
Lower Long Lake	Largescale Sucker	**254**	1

ug/kg = micrograms per kilograms

B. PBDEs

PBDEs are chemicals added to plastics and fabrics to prevent them from catching on fire or burning when exposed to flame or high heat. Levels of PBDEs have increased rapidly in soil, air and wildlife and have been detected in a variety of human tissues and in other organisms. The health impacts of PBDEs have not been studied in people. Information on the possible health effects of PBDEs comes from studies conducted in laboratory animals. These animal studies indicate that the developing fetus and infants are the most sensitive to the potential toxic effects of PBDEs. Some of the effects of PBDEs observed in animals include changes in brain development leading to altered behavior, learning and memory later in life. PBDE exposure is also associated with decreases in thyroid hormones and changes in the development of reproductive effects. Chemicals like PBDEs and PCBs are bioaccumulative, meaning they can stay in our bodies for a very long time.

Identifying sources of PBDE exposure in the general population continues to be an area of active research. Early studies indicate that food is likely the main source of exposure to PBDEs. Although structural similarities between PBDEs and PCBs suggest that food would likely be the main source of exposure to PBDEs since food is the primary source of human exposure to PCBs,[16,17] recent studies indicate that indoor dust is the main source of exposure to PBDEs especially in children.[18,19]

Meal Limits Based Solely on PBDEs

DOH calculated meal limits per month for total PBDEs in fish sampled from Spokane River (Table 4). Overall, calculated meals ranged from 1.5 to 54 meals per month in fillet samples and less than one to 17 meals per month in whole body samples at all sample locations. Ninemile location had the lowest calculated meal per month for both fillet and whole body samples, followed by Mission Park only for mountain whitefish fillet. Mountain whitefish and rainbow trout (fillet samples) at Ninemile location had the lowest calculated meal limit at 1.5 and 4 meals per month, respectively. Mountain whitefish and rainbow trout (whole body samples) at Ninemile location resulted in calculated meal limits of less than one meal per month; largescale sucker and bridgelip sucker (whole body samples) in the Upper Long Lake and Ninemile, respectively had a calculated meal limit of 3 meals per month. Recommended meal limits derived from these calculations are designed to protect a 60-kg woman eating an eight-ounce fish meal. Meal sizes for people weighing more than 60 kg would increase or decrease proportionally. DOH does not typically recommend fish consumption at meal limits lower than one meal per month. Women who are pregnant or planning a pregnancy should follow the meal limit advice currently in place for PCBs, which will also be protective for PBDEs.

C. Lead

Appendix D, Table D3 shows calculated meal limits per month for lead in fish sampled from Spokane River. By using a maximum value of 6.7 ug/g of fish lead concentration an adult intake of lead from fish consumption will exhibit blood lead levels greater than 10 ug/dL and 2.8 ug/dL, which are the cutoff points for adult and fetal protection, respectively.

Calculated meal limits range from less than one to 8 meals per month in whole fish from Stateline to Lower Long Lake (Table D3). Largescale suckers from Stateline to Ninemile resulted in lowest calculated meal limits per month, ranging from less than one meal to 1 meal per month for pregnant women. Due to the fact that the meal limit for a pregnant woman protects against fetal exposure to lead, a child eating at the same rate as a pregnant woman would also be protected.

Table 4. Calculated meal limits (per month) based on PBDE levels in fish sampled from Spokane River, Spokane, Washington.

Location	Species	Mean PBDE congeners ug/kg, wet weight				Mean Total PBDEs (ug/kg) †	Calculated meal limits (meals per month) based on Total PBDEs*
FILLET SAMPLES		**BDE-47**	**BDE-99**	**BDE-100**	**BDE-153**		
Plante Ferry	Rainbow Trout	35	39	9.4	2.4	90	18
Mission Park	Rainbow Trout	12	11	3.9	0.9	30	54
"	Mountain Whitefish	144	172	31	4.9	368	4
Ninemile	Rainbow Trout	182	172	39	7.5	418	4
"	Mountain Whitefish	443	449	111	17	1,059	2
Upper Long Lake	Mountain Whitefish	76	69	19	2.7	175	9
"	Brown Trout	86	41	16.8	2.2	159	10
"	Smallmouth Bass	26	8.9	3.9	0.5	42	38
Lower Long Lake	Mountain Whitefish	54	45	13.7	2.9	122	13
"	Smallmouth Bass	29	14	6.2	1.1	57	28
WHOLE BODY SAMPLES							
Stateline	Largescale Sucker	156	0.6	26	5.9	198	8
Plante Ferry	Largescale Sucker	125	0.4	20.5	2.5	154	10
Mission Park	Largescale Sucker	74	0.4	12	1.2	95	17
Ninemile	Bridgelip Sucker	423	2.8	64	13	522	3
"	Rainbow Trout	934	882	182	45	2,043	1
"	Mountain Whitefish	1,932	2,164	537	88	4,720	0
Upper Long Lake	Largescale Sucker	471	0.4	72	5.1	572	3
Lower Long Lake	Largescale Sucker	162	0.5	22.1	2.2	198	8

* Used EPA's draft BDE-47 to calculate meal limit for total PBDEs.
† Mean total PBDEs equals the sum of all congeners
ug/kg = micrograms per kilograms

Comparing Calculated Meal limits (Past and Present)

A. PCBs

Historical and current data for PCBs (1994, 1996, 1999, 2001, 2003, 2004, and 2005) indicate a decline in the PCB levels of Spokane River fish.[3] However, this trend was not consistent for each species of fish at every location and is not considered a strong trend when results of recent sampling are considered. It appears that PCB levels from the Idaho border to Upriver Dam drop significantly with the recent sampling data. The decline in PCBs may be a direct result of Ecology initiatives to reduce point sources.[20] To confirm this apparent trend, Ecology will continue to monitor the Spokane River before the existing fish advisory is revised.

Old vs. Current Fish Consumption Advisory Guidance

The risk evaluation based on exposure to PCBs in Spokane River fish in 2001 indicated that recreational fishers are at risk for both non-cancer and cancer toxicity endpoints depending upon their consumption rate. This conclusion for cancer toxicity endpoint is consistent with the evaluation of 2005 sampling data (Table, 5). Recent calculated meal limits per month show a similar trend when compared to old fish consumption advisories. Therefore, the new calculated meal results support the current consumption advisory for Spokane River.

Lake Spokane (Upper and Lower Long Lake) tissue samples revealed higher levels of PCBs in largescale suckers (whole) compared to smallmouth bass and mountain whitefish (fillet) (Table 5). Calculated meal limits for Long Lake range from 1-3 meals per month, yet past guidance stated it was safe to eat fish. Although fish downstream of Lake Spokane contained some PCBs, levels were lower relative to upstream portions, thus DOH recommended that it was safe to eat fish in that location. Cleaning and preparation to reduce exposure to some contaminants was advised.

Levels of PCBs in edible tissue in most fish species are close to average in Upper and Lower Long Lake compared to other waterbodies in Washington State (i.e., mountain whitefish fillet averages about 43 ug/kg, brown trout fillet 130 ug/kg and smallmouth bass 37 ug/kg). 2003 results in most rivers and lakes average fish concentrations between 5 and 40 ug/kg. Largescale suckers are highest in Long Lake (above 200 ug/kg) compared to other fish in other waterbodies in Washington.[21]

It is clear that consumption of rainbow trout (fillet) above the Upriver Dam will result in a higher dose of PCBs than from trout below the dam. Rainbow trout levels were significantly lower in 2005 between the Upriver Dam to Idaho Border. As mentioned earlier, this decline might be the result of cleanup work conducted in the upper river corridor by Ecology in 2003 and 2004.

B. PBDEs

Calculated meal limits are lower in rainbow trout and mountain whitefish (whole) between Ninemile Dam to Upriver Dam (Table 6). Currently, there is no fish consumption advisory in Washington State based on PBDE levels. Choosing fish low in PCBs and mercury and preparing fish and meats in ways that reduces fat will also reduce the levels of PBDEs.

C. Lead

In 2001, no restrictions were proposed based on calculated meal limits for pregnant women and adults.[22] Calculated meal limits for lead indicate that pregnant women may be at risk of exceeding fetal protection endpoint from consuming whole largescale and bridgelip sucker between the Stateline and Ninemile reach (Appendix D, Table D3). As mentioned previously any advice provided for fish consumption based on PCBs will also be protective of excessive lead exposure.

Table 5. Comparison of 2005 PCB data vs. 2001 PCB sampling data, Spokane River, Washington.

New Calculations (Based on current data)				**Old Guidance** (Based on former data)			
Species	**N**[a]	**Mean PCB Conc. (ug/kg ww)**	**Meals/ month**	**N**[b]	**Mean PCB Conc. (ug/kg ww)**	**Meals/ month**	**Health advisory recommendation**
Lake Spokane (Upper and Lower Long Lake)							
Largescale sucker (whole)	6	290	1	NA*	311	1	Safe to Eat Fish
Largescale sucker (fillet)	NA	NA	NA	19	101	2	
Brown Trout (fillet)	1	130	1	NA	NA	NA	
Smallmouth Bass (fillet)	4	52	3	10	37	4	
Mountain Whitefish (fillet)	9	59	3	6	73	2	
Ninemile Dam to Upriver Dam							
Bridgelip Sucker (whole)	3	69	2	NA	NA	NA	Eat no more than 1 Meal of Any Kind of Fish
Rainbow Trout (fillet)	6	113	1	12	169	1	
Largescale Sucker (whole)	3	1,823	0	NA	NA	NA	
Largescale Sucker (fillet)	NA	NA	NA	10	169	1	
Mountain Whitefish (fillet)	6	186	1	10	491	0	
Upriver Dam to Idaho Border							
Rainbow Trout (fillet)	3	55	3	10	494†	0	Do not Eat Any Fish
Largescale Sucker (whole)	6	89	2	NA	NA	NA	
Largescale Sucker (fillet)	NA	NA	NA	10	125	1	

N = sample size
ww = Wet Weight
ug/kg = micrograms per kilograms
NA Not available
[a] Composites of 4-5 individual fish each, except Long Lake mountain whitefish which were analyzed individually.
[b] Whole body samples are composites of five fish, fillets are individual fish.
* Whole body samples for Largescale sucker were analyzed from individual fish.
† Used the mean average between both means (880 and 108 ppb wet weight)

Table 6. New meal calculations based on PBDE 2005 sampling data, Spokane River, Washington.

New PBDE meal calculations (Based on current data)			
Species	**N** [a]	**Total mean PBDE Conc. (ug/kg ww)**	**Meals/Month***
Lake Spokane (Upper and Lower Long Lake)			
Largescale sucker (whole)	6	385	4
Brown Trout (fillet)	1	159	10
Smallmouth Bass (fillet)	4	50	32
Mountain Whitefish (fillet)	6	149	11
Ninemile Dam to Upriver Dam			
Bridgelip Sucker (whole)	3	522	3
Rainbow Trout (fillet)	6	418 (max.)	4
Rainbow Trout (whole)	3	2,043	1
Largescale Sucker (whole)	3	95	17
Mountain Whitefish (fillet)	6	714	2
Mountain Whitefish (whole)	3	4,720	0
Upriver Dam to Idaho Border			
Rainbow Trout (fillet)	3	90	18
Largescale Sucker (whole)	6	176	9

N = sample size
ww = Wet Weight
ug/kg = micrograms per kilograms
[a] Composites of 4-5 individual fish, except lower Long Lake mountain whitefish which were analyzed individually.
* Used EPA's draft BDE-47 reference dose to calculate meal per month.

Table 7. PCB and PBDE 2005 sampling data, Spokane River, Washington.

PCB sampling data				**PBDE sampling data**			**Health advisory**
Species	**N** [a]	**Mean PCB Conc. (ug/kg ww)**	**Meals/ month**	**N**	**Mean PBDE Conc. (ug/kg ww)**	**Meals/ month**	**Recommendation for both PCBs & PBDEs**
Lake Spokane (Upper and Lower Long Lake)							
Largescale sucker (whole)	6	290	1	6	385	4	Safe to Eat Fish
Brown Trout (fillet)	1	130	1	1	159	10	
Smallmouth Bass (fillet)	4	52	3	4	50	32	
Mountain Whitefish (fillet)	9	59	3	6	149	11	
Ninemile Dam to Upriver Dam							
Bridgelip Sucker (whole)	3	69	2	3	522	3	Eat no more than 1 Meal of Any Kind of Fish
Rainbow Trout (fillet)	6	113	1	6	418 *	4	
Rainbow Trout (whole)	NA	NA	NA	3	2,043	1	
Largescale Sucker (whole)	3	1,823	0	3	95	17	
Mountain whitefish (fillet)	6	186	1	6	714	2	
Mountain Whitefish (whole)	NA	NA	NA	3	4,720	0	
Upriver Dam to Idaho Border							
Rainbow Trout (fillet)	3	55	3	3	90	18	Do not Eat Any Fish
Largescale Sucker (whole)	6	89	2	6	176	9	

N = sample size
ww = Wet Weight; ug/kg= micrograms per kilograms
* Used the highest mean concentration found at Ninemile in rainbow trout fillet.
[a] Composites of 4-5 individual fish each, except Lake Spokane mountain whitefish which was analyzed individually.

Benefits of Fish Consumption

Recent studies have attempted to quantify risks of eating contaminated fish with benefits associated with their ingestion. [23,24,25,26,27,28,29] Further work is expected on this subject as more reports on fish contaminant levels and human health become available. At present, fish are known to be an excellent protein source that is low in saturated fats, rich in vitamin D and omega-3 fatty acids and other vitamins and minerals.

The primary health benefits of eating fish are well documented and relate to the reduction of cardiovascular disease [30,31,32,33,34,35,36] and positive pregnancy outcome.[37,38,39,40,41,42,43 44,45] Limited data show a link between fish consumption and a decrease in development of some cancers.[46] Eating fish has also been associated with impacts on brain function, including protection against cognitive decline.[46] Cardiovascular disease, cancer, and cognitive decline are serious health problems that affect large portions of the U.S. population. Health benefits of eating fish are associated with low levels of saturated versus unsaturated fats. Saturated fats are linked with increased cholesterol levels and risk of heart disease while unsaturated fats (e.g., omega-3 polyunsaturated fatty acid) are an essential nutrient. Replacing fish in the diet with other sources of protein may reduce exposure to contaminants but could result in increased risk for certain diseases. For example, replacing fish with red meat could increase the risk of cardiovascular disease since red meat has higher levels of saturated fat and cholesterol.

Advisories can be protective (while acknowledging the benefits of eating fish) by recommending decreased consumption of fish known to have high contaminant concentrations in favor of fish that are lower in contaminants. DOH supports the American Heart Association and the U.S. Food and Drug Administration recommendation of at least 12 ounces (about 3 – 4 servings) of fish per week as part of a healthy diet.

Health benefits of eating fish deserve particular consideration when dealing with groups that consume fish for subsistence. Removal of fish from the diet of subsistence consumers may have serious health, social and economic consequences. Such populations are encouraged to consume a variety of fish species, to fish from locations with low contamination, and to follow recommended preparation and cooking methods.

Communicating Risk vs. Benefits

All fish contain some level of persistent and bioaccumulative contaminants. A strict risk assessment approach would provide a meal limit, no matter how large or small, for every fish species. While meal limit calculations are a useful and necessary component of providing advice about eating fish, such messages should not stand alone. DOH considers the health benefits of eating fish to be an important part of consumption advice provided to the public. Since methods are not currently available to quantify these benefits with respect to risk, DOH chooses to promote consumption of fish that are lowest in contaminants. This approach moves away from setting strict limits and moves toward encouraging consumers to eat fish but to be smart about their choices.

EPA has recently revised estimates of per capita seafood consumption and found that the average fish consumption rate in the US is 20 g/day for all respondents (including non-consumers) for anadromous and resident finfish and shellfish from fresh, estuarine, and marine environments.[47] This equates to 2-3 eight ounce meals per month, which is much lower than the American Heart Association's (AHA) recommendation of at least two fish meals per week. The goal of DOH fish advice is to encourage Washingtonians to eat two fish meals per week (roughly 50 – 65 g/day) while following localized fish advisories and general fish consumption guidance (such as limiting consumption of species high in mercury and/or PCBs).

Some considerations in risk communication include the importance of gender, age, body weight, genetics and culture. Pregnant women and women of child-bearing age are an important population to advice about potential risk of mercury and PCBs in fish because of ongoing neurological development of the fetus. In addition, children often consume larger meals, pound per pound, than adults and so receive a higher dose of contaminants. This consideration applies to adults of various body weights as well; those of higher body weight can eat larger portions while those of lower body weight should eat smaller portions (advice in this report is based on an assumed bodyweight of 60 kg).

It is also important to understand the importance of fish in different cultures and how health messages may need to be adapted culturally. Connecting with culturally diverse communities often requires outreach that goes beyond traditional governmental methods of communicating such as meetings sponsored by agencies, informational mailings and press releases. Some communities prefer visual and verbal communications, for example, use of local access cable. Meeting with community groups on their own terms demonstrates sincerity and can build trust. Accurate translation of printed material is essential.

DOH believes that recent news articles about limits may scare people from consuming fish and prevent some members of the public from getting the benefits of good fish choices. The public should understand that removing fish from the diet will not eliminate exposure to contaminants and that other sources of protein, such as beef, chicken and dairy products also contain persistent bioaccumulative toxins (PBTs). The best approach is to eat fish but to be smart about fish choices.

Child Health Considerations

DOH and ATSDR recognize that infants and children may be more vulnerable to chemical exposures than adults when faced with contamination of air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are smaller and receive higher doses of chemical exposure per body weight.
- Children's developing body systems are more vulnerable to toxic exposures, especially during critical growth stages in which permanent damage may be incurred.

PCBs and PBDEs are the main contaminants of public health concern found in Spokane River. These chemicals can cause adverse developmental effects in children exposed in the womb. For this reason, it is important for pregnant women and women considering pregnancy to pay special attention to the recommendations of this health consultation.

Summary and Conclusions

Summary

PCB and PBDE Sampling Data

DOH compared 2005 vs. 2001 PCB sampling data for all species of fish at all sampling locations of the Spokane River. The following summarizes the most important findings (Tables 5 and 7):

- PCBs in fish tissue from Ninemile Dam to Upriver Dam declined in rainbow trout fillets and mountain whitefish fillets (2005 vs. 2001). These were the only two species collected in both years available and appropriate for comparison in this river section.
- PCBs in rainbow trout fillets from Upriver Dam to the Idaho border were markedly lower in 2005 compared to levels in 2001. Largescale sucker fillet data were not available for comparison.
- Concentrations for both PBDEs and PCBs were highest in fish from Mission Park and Ninemile sampling sites.

Generally, PCB levels were lower in 2005 than in 2001, except for largescale sucker (whole) and rainbow trout (fillet) in Mission Park. Ecology suggests that lower levels of PCBs in fish from Upriver Dam to the Idaho border correlates with cleanup actions in the Spokane River. To verify this observation, Ecology and DOH concur that further monitoring of the Spokane River is advised to confirm this apparent trend and before changing the original fish advisory. Advice for this area may change in the future if PCB levels drop below health concern levels. DOH emphasizes consuming fillets instead of whole fish from the Spokane River and cleaning all fish before eating.

The following summarizes PBDE data in the Spokane River (Table 6 and 7):

- Overall, PBDE concentrations were extremely high (ranged from 65 to 1,222 ug/kg in fillet samples and 34 to 4,900 ug/kg in whole body samples) in fish from the Spokane River relative to other fish in Washington State and in the country.
- Highest values were observed in rainbow trout and mountain white fish (whole) in the area between Ninemile Dam and Upriver Dam. Fillet samples of rainbow trout and mountain whitefish also had high PBDE values.
- PBDEs were relatively lower in fish (fillet) from Lake Spokane and from Upriver Dam to the Idaho border.
- PBDEs were relatively high in largescale sucker (whole) from Lake Spokane (Upper Long Lake).

PBDEs are an emerging contaminant, and human health effects from consuming fish with PBDEs are not well characterized due to limited research. Thus, concern remains about consuming fish with high PBDE levels.

Conclusions

- Exposure to PCBs through ingestion of Spokane River fish caught in the Spokane River represents *a public health hazard*. The potential for adverse health effects to result from eating Spokane River fish depends on several factors such as amount of fish consumed and fishing location.

    - Consumption of rainbow trout and mountain white fish in Ninemile Dam to Upriver Dam is a *public health hazard*.

    - Recent samples of resident fish in the Spokane River showed levels of PCBs that are lower than previous samples except for mountain whitefish and rainbow trout fillets and largescale suckers in whole body samples at Mission Park.

    - Eating frequent meals of trout and mountain whitefish that live in the Spokane River may cause health problems, particularly to children, infants and pregnant women. PCBs in these fish may affect the immune system and cause learning problems in children exposed in the womb.

- Extremely high levels of PBDEs were observed in mountain whitefish and rainbow trout (whole) between Ninemile Dam to Upriver Dam. Due to limited research on the possible consumer health risk from PBDEs, DOH concludes a *no* *apparent public health hazard* exists. However, concern remains about the effects of these compounds on humans and biota.

- It is important to consider PBDEs for future health advisories since there may be potential health risks associated with fish consumption.

- *A public health hazard* exists for pregnant women and children who consume whole fish contaminated with lead from the Spokane River between the Upper Long Lake and the Idaho Border (Stateline). *No public health hazard* exists for adults exposed to lead who consume fillets from the Spokane River.

Recommendations

1. The 2003 fish advisory for the Spokane River should remain in place based on recent PCB data. Consistent with and in addition to the advisory:

    - DOH recommends against any consumption of fish between the Idaho border and Upriver Dam. For the reach between Upriver Dam and Ninemile Dam, DOH advises against eating more than one meal per month of any species. For the reach between Ninemile Dam and Long Lake (Upper and Lower Long Lake) DOH advised that it is safe to eat fish.
    - In order to reduce exposure from PCBs in all trout and mountain whitefish, DOH recommends eating fillet instead of whole fish, removing the skin and cleaning all fish. Further, DOH recommends let fat drip off and prepare by grilling, broiling or baking.
    - DOH recommends continuing monitoring for PBDEs in the Spokane River.
    - DOH recommends addressing PBDEs in the Spokane River Fish Meal Advisory.
    - Although a substantial decrease in PCB levels was observed at some locations, DOH recommends continued PCB monitoring to confirm the downward trend before modifying the current health advisory.
    - DOH recommends additional fish tissue sampling for both fillet and whole body samples at sites where contaminants exceeded health comparison values.

2. Future updates of the Spokane River fish advisory should be based on long-term fish tissue monitoring trends.

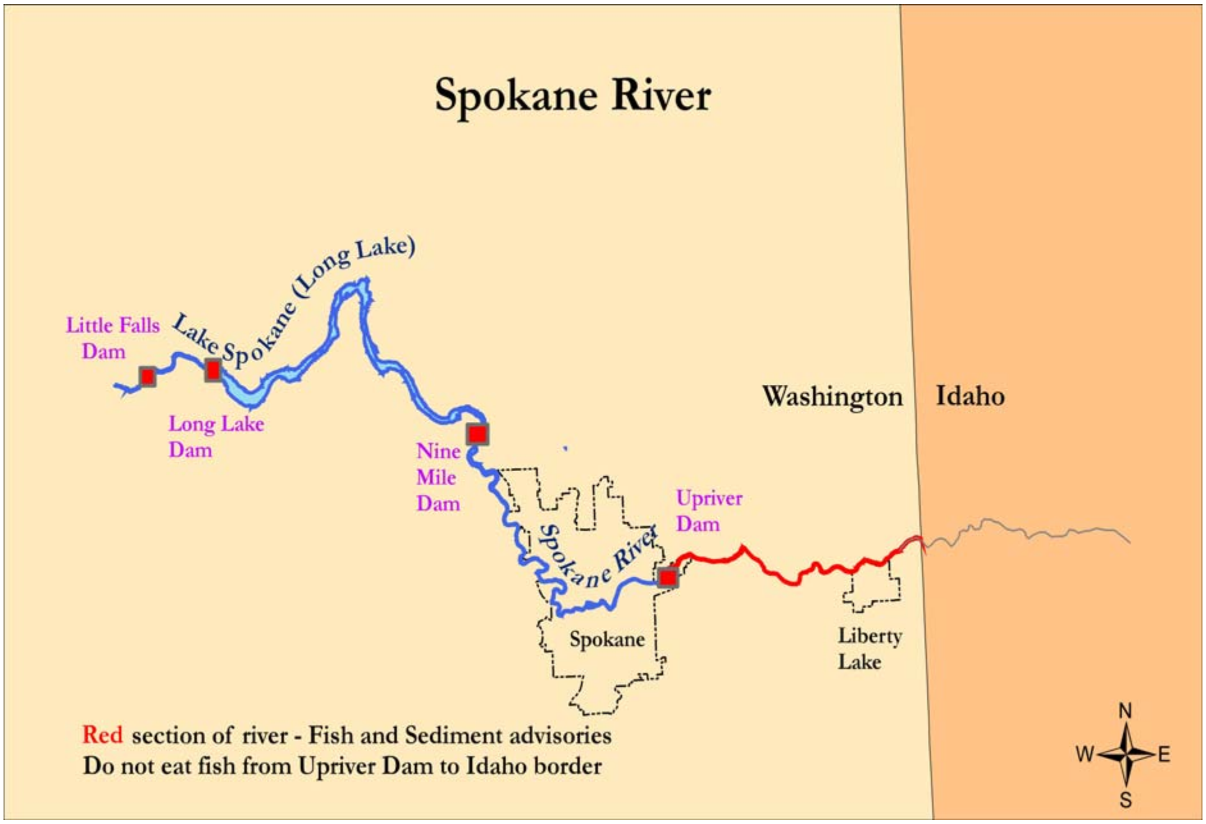

Figure 1. Spokane River map, Spokane, Washington.

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Appendix A

Sample Results

Table 1A. Summary of total PCB concentrations measured in Spokane River fish collected in 2005, Spokane, Washington.

Location	Species	Tissue type	N*	C/I	Total mean PCBs ug/g (ppm), wet weight	Range (ug/kg)	EPA non-carcinogens [6] Subsistence CVs (mg/kg)
Plante Ferry	Rainbow Trout	Fillet	3	C	**0.055**	48 – 68	9.83E-03
Mission Park	Rainbow Trout	Fillet	3	C	**0.153**	118 – 220	
"	Mountain Whitefish	Fillet	3	C	**0.234**	203 – 280	
Ninemile	Rainbow Trout	Fillet	3	C	**0.073**	46 – 94	
"	Mountain Whitefish	Fillet	3	C	**0.139**	86 – 172	
Upper Long Lake	Mountain Whitefish	Fillet	3	C	**0.043**	36 – 55	
"	Brown Trout	Fillet	1	C	**0.130**	- -	
"	Smallmouth Bass	Fillet	1	C	**0.037**	- -	
Lower Long Lake	Mountain Whitefish	Fillet	6	I	**0.076**	<9.6 – 190	
"	Smallmouth Bass	Fillet	3	C	**0.067**	49 – 82	
Stateline	Largescale Sucker	Whole	3	C	**0.056**	16 – 77	
Plante Ferry	Largescale Sucker	Whole	3	C	**0.122**	91 – 180	
Mission Park	Largescale Sucker	Whole	3	C	**1.8**	1,100 – 3,000	
Ninemile	Bridgelip Sucker	Whole	3	C	**0.069**	52 – 94	
Upper Long Lake	Largescale Sucker	Whole	3	C	**0.327**	160 – 510	
Lower Long Lake	Largescale Sucker	Whole	3	C	**0.254**	109 – 396	

N = sample size
ppm = parts per million; ug/g = micrograms per gram; ug/kg = micrograms per kilogram
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.

Table 2A. Summary of total PBDE concentrations measured in Spokane River fish collected in 2005, Spokane, Washington.

Location	Species	Tissue type	N*	C/I	Mean total PBDEs ug/kg, wet weight	Range	EPA's Subsistence comparison value (ug/kg)
Plante Ferry	Rainbow Trout	Fillet	3	C	90	65 – 107	96.9
Mission Park	Rainbow Trout	Fillet	3	C	30	27 – 32	
"	Mountain Whitefish	Fillet	3	C	368	355 – 391	
Ninemile	Rainbow Trout	Fillet	3	C	418	292 – 564	
"	Mountain Whitefish	Fillet	3	C	1,059	905 – 1,222	
Upper Long Lake	Mountain Whitefish	Fillet	3	C	175	161 – 198	
"	Brown Trout	Fillet	1	C	159	- -	
"	Smallmouth Bass	Fillet	1	C	42	- -	
Lower Long Lake	Mountain Whitefish	Fillet	6	I	122	56 – 228	
"	Smallmouth Bass	Fillet	3	C	57	34 – 92	
Stateline	Largescale Sucker	Whole	3	C	198	169 – 214	
Plante Ferry	Largescale Sucker	Whole	3	C	154	84 – 252	
Mission Park	Largescale Sucker	Whole	3	C	95	90 – 98	
Ninemile	Bridgelip Sucker	Whole	3	C	522	334 – 708	
"	Rainbow Trout	Whole	3	C	2,043	- -	
"	Mountain Whitefish	Whole	3	C	4,720	- -	
Upper Long Lake	Largescale Sucker	Whole	3	C	572	459 – 718	
Lower Long Lake	Largescale Sucker	Whole	3	C	198	90 – 357	

N = sample size
ug/kg = micrograms per kilogram
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.
- - Not available

Table 3A. Summary of lead concentrations in Spokane River fish compared to subsistence consumption screening values. Spokane, Washington.

Location	Species	Tissue type	N *	C/I	Lead mg/kg, wet weight		Range	Subsistence CVs (mg/kg)	
					Mean	Max.		lower-end	higher-end
Plante Ferry	Rainbow Trout	Fillet	3	C	0.12	**0.14**	<0.10 – 0.14	0.07[a]	0.27[b]
Mission Park	Rainbow Trout	Fillet	3	C	<0.10	**0.14**	<0.10 – 0.14		
"	Mountain Whitefish	Fillet	3	C	<0.10	**0.19**	<0.10 – 0.19		
Ninemile	Rainbow Trout	Fillet	3	C	<0.10	**0.26**	<0.10 – 0.26		
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10	<0.10 (all)		
Upper Long Lake	Mountain Whitefish	Fillet	3	C	<0.10	<0.10	<0.10 (all)		
"	Brown Trout	Fillet	1	C	<0.10	--	- -		
"	Smallmouth Bass	Fillet	1	C	<0.10	--	- -		
Lower Long Lake	Mountain Whitefish	Fillet	6	I	<0.10	<0.10	<0.10 (all)		
"	Smallmouth Bass	Fillet	3	C	<0.10	<0.10	<0.10 (all)		
Stateline	Largescale Sucker	Whole	3	C	4.2	**6.7**	2.6 – 6.7		
Plante Ferry	Largescale Sucker	Whole	3	C	2.9	**3.2**	2.6 – 3.2		
Mission Park	Largescale Sucker	Whole	3	C	3.5	**4.2**	2.8 – 4.2		
Ninemile	Bridgelip Sucker	Whole	3	C	2.9	**3.1**	2.6 – 3.1		
Upper Long Lake	Largescale Sucker	Whole	3	C	0.80	**1.2**	0.6 – 1.2		
Lower Long Lake	Largescale Sucker	Whole	3	C	0.33	**0.57**	0.14 – 0.57		

N = sample size
mg/kg = milligrams per kilograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.
NA – Not available
BOLD Values exceed comparison value
[a] assumes 50% of meat portion of diet is fish
[b] assumes 12% of meat portion of diet is fish

Table 4A. Summary of cadmium concentrations measured in Spokane River fish collected in 2005, Spokane, Washington.

Location	Species	Tissue type	N*	C/I	Mean total Cadmium ug/kg, wet weight	Range	EPA non-carcinogens [6] Subsistence CVs (mg/kg)
Plante Ferry	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	0.491
Mission Park	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 (all)	
Ninemile	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 (all)	
Upper Long Lake	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 (all)	
"	Brown Trout	Fillet	1	C	<0.10	- -	
"	Smallmouth Bass	Fillet	1	C	<0.10	- -	
Lower Long Lake	Mountain Whitefish	Fillet	6	I	<0.10	<0.10 (all)	
"	Smallmouth Bass	Fillet	3	C	<0.10	<0.10 (all)	
Stateline	Largescale Sucker	Whole	3	C	0.20	0.20 – 0.24	
Plante Ferry	Largescale Sucker	Whole	3	C	0.20	0.17 – 0.24	
Mission Park	Largescale Sucker	Whole	3	C	0.18	0.16 – 0.20	
Ninemile	Bridgelip Sucker	Whole	3	C	0.15	0.13 – 0.18	
Upper Long Lake	Largescale Sucker	Whole	3	C	<0.10	<0.10 (all)	
Lower Long Lake	Largescale Sucker	Whole	3	C	<0.10	<0.10 (all)	

N = sample size
ug/kg = micrograms per kilograms; mg/kg = milligrams per kilograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.

Table 5A. Summary of arsenic concentrations measured in Spokane River fish collected in 2005, Spokane, Washington.

Location	Species	Tissue type	N*	C/I	Mean total Arsenic ug/kg, wet weight	Range	EPA's Subsistence Comparison Value (mg/kg)
Plante Ferry	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	0.147
Mission Park	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 (all)	
Ninemile	Rainbow Trout	Fillet	3	C	<0.10	<0.10 (all)	
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 (all)	
Upper Long Lake	Mountain Whitefish	Fillet	3	C	<0.10	<0.10 – 0.12	
"	Brown Trout	Fillet	1	C	0.10	- -	
"	Smallmouth Bass	Fillet	1	C	0.11	- -	
Lower Long Lake	Mountain Whitefish	Fillet	6	I	0.31	0.23 – 0.38	
"	Smallmouth Bass	Fillet	3	C	0.13	0.10 – 0.16	
Stateline	Largescale Sucker	Whole	3	C	0.20	0.16 – 0.24	
Plante Ferry	Largescale Sucker	Whole	3	C	0.26	0.18 – 0.34	
Mission Park	Largescale Sucker	Whole	3	C	0.26	0.16 – 0.33	
Ninemile	Bridgelip Sucker	Whole	3	C	0.35	0.28 – 0.39	
Upper Long Lake	Largescale Sucker	Whole	3	C	0.15	0.11 – 0.20	
Lower Long Lake	Largescale Sucker	Whole	3	C	0.22	0.18 – 0.26	

N = sample size
ug/kg = micrograms per kilograms; mg/kg = milligrams per kilograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.

Table 6A. Summary of zinc concentrations measured in Spokane River fish collected in 2005, Spokane, Washington.

Location	Species	Tissue type	N*	C/I	Mean total Zinc mg/kg, wet weight	Range	EPA's non-carcinogens Subsistence Comparison Value (mg/kg)
Plante Ferry	Rainbow Trout	Fillet	3	C	15	12 – 17	147.8
Mission Park	Rainbow Trout	Fillet	3	C	12	9.9 – 14	
"	Mountain Whitefish	Fillet	3	C	13	13 – 14	
Ninemile	Rainbow Trout	Fillet	3	C	10	8 – 12	
"	Mountain Whitefish	Fillet	3	C	12	11 – 13	
Upper Long Lake	Mountain Whitefish	Fillet	3	C	12	9.3 – 16	
"	Brown Trout	Fillet	1	C	6.0	- -	
"	Smallmouth Bass	Fillet	1	C	7.8	- -	
Lower Long Lake	Mountain Whitefish	Fillet	6	I	7.1	6.3 – 8.3	
"	Smallmouth Bass	Fillet	3	C	8.3	7.8 – 8.8	
Stateline	Largescale Sucker	Whole	3	C	114	87 – 165	
Plante Ferry	Largescale Sucker	Whole	3	C	79	71 – 93	
Mission Park	Largescale Sucker	Whole	3	C	56	54 – 58	
Ninemile	Bridgelip Sucker	Whole	3	C	72	57 – 89	
Upper Long Lake	Largescale Sucker	Whole	3	C	41	25 – 62	
Lower Long Lake	Largescale Sucker	Whole	3	C	24	18 – 31	

N = sample size
mg/kg = milligrams per kilograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.

Appendix B

Contaminant Screening Process

The information in this section describes how contaminants of concern in fish were chosen from a set of many contaminants. A contaminant's maximum fish concentration was compared to a screening value (comparison value), and if the contaminant's concentration was greater than that value, it was considered further.

Comparison values were calculated using chronic EPA's reference doses (RfDs) and cancer slope factors (CSFs). RfDs represent an estimate of daily human exposure to a contaminant below which non-cancer adverse health effects are unlikely.

This screening method ensured consideration of contaminants that may be of concern for shellfish consumers. The equations below show how comparison values were calculated for both non-cancer and cancer endpoints associated with consumption of shellfish.

$$CV_{\text{non-cancer}} = \frac{RfD * BW}{SIR * CF}$$

$$CV_{\text{cancer}} = \frac{\text{Risk Level} * BW}{SIR * CF * CPF}$$

Where CV for non-cancer:

RfD = oral reference dose (mg/kg-day).
BW = mean body weight of the general population or subpopulation of concern (kg).
SIR = mean daily consumption rate of the species of interest by the general population or subpopulation of concern averaged over a 70-yr lifetime (kg/d).
CF = conversion factor (kg/g)
CPF = cancer potency factor

Where CV for cancer:

Risk Level = an assigned level of maximum acceptable individual lifetime risk (e.g., RL = 10^{-5} for a level of risk not to exceed one excess case of cancer per 100,000 individuals exposed over a 70-yr lifetime.

Table B1. Parameters used to calculate comparison values used in the Spokane fish contaminant screening process, Spokane River, Spokane, Washington.

Abbreviation	Parameter	Units	Value	Comments
CV	Comparison Value	mg/kg	Calculated	
RfD	Reference Dose	mg/kg-day	Chemical Specific	EPA
SIR	Fish Ingestion Rate	g/day	142.4	EPA fish consumption advisory guidance [6]
BW	Bodyweight	kg	70 & 60	Adult & adult pregnant women
			15	Child
CF	Conversion Factor	kg/g	0.001	kilograms per gram
AT	Averaging Time	Days	25550	Days in 75 year lifetime
EF	Exposure Frequency	Days	365	Days per year
ED	Exposure Duration	Years	70 (adult)	Years consuming fish
			5 (child)	
Risk Level	Lifetime cancer risk	Unitless	$1x10^{-5}$	
CPF	Cancer Potency Factor	kg-day/mg	Chemical Specific	EPA

Developing Comparison Values for Lead in Spokane River Fish

Since the biokinetics of lead are different from many chemicals, a different approach was used for deriving comparison values for lead. DOH used the IEUBK model with the following assumptions to determine a level of lead in fish that would be protective of a child who eats fish at a subsistence rate.

Table B2. Assumptions (other than default) used in the IEUBK to determine comparison value for lead in fish.

Parameter	Value	Units	Notes
Fish Concentration	6.7 (the maximum value from whole body sample)	ppm	Solve for value that results in > 5% of 12-24 month old children with blood lead levels greater than 10 ug/dl
Percentage meat intake that is fish [a]	50 and 12	percent	Solve for value that results in > 5% of 12-24 month old children with blood lead levels greater than 10 ug/dl
Lower end consumption rate	0.07 [b]	ppm	Solve for value that results in > 5% of 12-24 month old children with blood lead levels greater than 10 ug/dl
Higher end consumption rate	0.27 [c]	ppm	Solve for value that results in > 5% of 12-24 month old children with blood lead levels greater than 10 ug/dl

[a] assumes that a child's total meat intake is 93.5 g/day
[b] assumes that 50% of meat portion of diet is fish
[c] assumes that 12 % of meat portion of diet is fish

Appendix C

Exposure dose calculations and assumptions

Average and upper-bound general population exposure scenarios were evaluated for consumption of fish from Spokane River. Exposure assumptions given in Table C1 below were used with the following equations estimate contaminant doses associated with fish consumption.

$$Dose_{(non\text{-}cancer\ (mg/kg\text{-}day)} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times ED}{BW \times AT_{non\text{-}cancer}}$$

$$Dose_{(cancer\ (mg/kg\text{-}day)} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times ED}{BW \times AT_{cancer}}$$

Table C1. Exposure assumptions for deriving health-based comparison values

Parameter	Value	Unit	Comments
Concentration (C)	Variable	ug/kg	Maximum detected value.
Conversion Factor$_1$ (CF_1)	0.001	mg/ug	Converts contaminant concentration from micrograms (ug) to milligrams (mg)
Ingestion Rate (IR) – Subsistence	42 g/day	g/kg/day	Average recreational anglers (42 g/day) [48,49]
Conversion Factor$_2$ (CF_1)	0.001	mg/ug	Converts contaminant concentration from micrograms (ug) to milligrams (mg)
Conversion Factor$_2$ (CF_2)	0.001	kg/g	Converts mass of fish from grams (g) to kilograms (kg)
Exposure Frequency (EF)	365	days/year	Assumes daily exposure consistent with units of ingestion rate given in g/day
Exposure Duration (ED)	30 (adult) 5 (child)	years	Number of years eating fish
Averaging Time$_{non\text{-}cancer}$ (AT)	10950	days	30 years
Averaging Time$_{cancer}$ (AT)	25550	days	70 years
Oral Reference Dose (RfD)	Contaminant-specific	mg/kg/day	Source: ATSDR, EPA, IRIS
Cancer Risk	1x 10-5	unitless	Target Cancer Risk
Cancer Slope Factor (CSF)	Contaminant-specific	mg/kg-day-1	Source: EPA

Calculating eight-ounce fish meal limits

The equation used to calculate a safe consumption rate is shown below.

$$\text{8-ounce fish meals per month} = \frac{\text{RfD x (Days/Month) x BW}}{\text{Meals size x C}}$$

Table C2. Exposure parameters for calculating 8-ounce fish meal limits

Parameter	Value**	Units	Source
Reference dose	0.00002* for PCBs, BDE-47 (0.00023), BDE-99 (0.00013), BDE-153 (0.00015), BDE-209 (0.007)	mg/kg-day	EPA Iris [50] EPA draft [51]
Days per month	30.4	days per month	
Body weight	60 (adult pregnant women) and 70	kg	EPA exposure factors handbook
Concentration	Mean concentration specific to fish species	mg/kg	2005 Aroclor and PBDE data
Meal size	0.227	kg	Kg per 8 oz.

* RfD corresponds to Aroclor 1254

** Exposure parameters are defined in Table C1.

Table C3. Non-cancer hazards associated with exposure to PCBs in Spokane River, Spokane, Washington.

Location	Species	Tissue type	N	C/I	Total mean PCBs ug/kg (ppb), wet weight	RfD (mg/kg/day)	Adult Hazard Quotient Average Recreational anglers
Plante Ferry	Rainbow Trout	Fillet	3	C	55	2.0E-05*	**1.7**
Mission Park	Rainbow Trout	Fillet	3	C	153		**4.6**
"	Mountain Whitefish	Fillet	3	C	234		**7.0**
Ninemile	Rainbow Trout	Fillet	3	C	73		**2.2**
"	Mountain Whitefish	Fillet	3	C	139		**4.2**
Upper Long Lake	Mountain Whitefish	Fillet	3	C	43		**1.3**
"	Brown Trout	Fillet	1	C	130		**3.9**
"	Smallmouth Bass	Fillet	1	C	37		**1.1**
Lower Long Lake	Mountain Whitefish	Fillet	6	I	76		**2.3**
"	Smallmouth Bass	Fillet	3	C	67		**2.0**
Stateline	Largescale Sucker	Whole	3	C	56		**1.7**
Plante Ferry	Largescale Sucker	Whole	3	C	122		**3.7**
Mission Park	Largescale Sucker	Whole	3	C	1,823		**54.7**
Ninemile	Bridgelip Sucker	Whole	3	C	69		**2.1**
Upper Long Lake	Largescale Sucker	Whole	3	C	327		**9.8**
Lower Long Lake	Largescale Sucker	Whole	3	C	254		**7.6**

N = sample size
ug/kg = micrograms per kilograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.
* EPA RfD for Aroclor 1254

Table C4. Cancer hazards associated with exposure to PCBs in Spokane River, Spokane, Washington.

Location	**Species**	**Tissue type**	**N**	**C/I**	**Total mean PCBs ug/g (ppm), wet weight**	**CSF (mg/kg/day)**	**Adult Cancer Risk Average Recreational anglers**
Plante Ferry	Rainbow Trout	Fillet	3	C	55	2.0	**2.8E-05**
Mission Park	Rainbow Trout	Fillet	3	C	153		**7.9E-05**
"	Mountain Whitefish	Fillet	3	C	234		**1.2E-04**
Ninemile	Rainbow Trout	Fillet	3	C	73		**3.8E-05**
"	Mountain Whitefish	Fillet	3	C	139		**7.1E-05**
Upper Long Lake	Mountain Whitefish	Fillet	3	C	43		**2.2E-05**
"	Brown Trout	Fillet	1	C	130		**6.7E-05**
"	Smallmouth Bass	Fillet	1	C	37		**1.9E-05**
Lower Long Lake	Mountain Whitefish	Fillet	6	I	76		**3.9E-05**
"	Smallmouth Bass	Fillet	3	C	67		**3.4E-05**
Stateline	Largescale Sucker	Whole	3	C	56		**2.9E-05**
Plante Ferry	Largescale Sucker	Whole	3	C	122		**6.3E-05**
Mission Park	Largescale Sucker	Whole	3	C	1,823		**9.3E-04**
Ninemile	Bridgelip Sucker	Whole	3	C	69		**3.5E-05**
Upper Long Lake	Largescale Sucker	Whole	3	C	327		**1.7E-04**
Lower Long Lake	Largescale Sucker	Whole	3	C	254		**1.3E-04**

N = sample size
ug/g = micrograms per grams
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.

Table C5. Non-cancer hazards associated with exposure to PBDEs in fish sampled from Spokane River - Spokane, Washington.

Chemical	Mean Concentration (ug/kg)		RfD (mg/kg/day)	Adult Hazard Quotient	
				Recreational anglers (0.7 g/kg/day)	Recreational anglers (0.7 g/kg/day)
Fillet	**RBT (Ninemile)***	**MWF (Ninemile)**		**RBT**	**MWF**
BDEs - 47	182	443	0.00023	0.6	1.3
BDEs - 99	172	449	0.00013	0.9	2.4
BDEs - 100	39	111	0.00013	0.2	0.6
BDEs - 153	7.5	17	0.00015	< 0.1	0.1
Total Hazard Index				**1.7**	**4.4**
Whole body	**RBT (Ninemile)**	**MWF (Ninemile)**		**RBT**	**MWF**
BDEs - 47	934	1,932	0.00023	2.8	5.9
BDEs - 99	882	2,164	0.00013	4.7	11.7
BDEs - 100	182	537	0.00013	1.0	2.9
BDEs - 153	45	88	0.00015	0.2	0.4
Total Hazard Index				**8.7**	**20.9**

MWF: Mountain whitefish
RBT: Rainbow trout
* Ninemile stretch has the highest concentrations of PBDEs. Other sites are not shown.

Appendix D

Adult Lead Model

Equation 1 shows the formula for the analysis of the lead hazard associated with adult consumption of fish from the Spokane River. For bioavailable fraction of lead in fish (AFF), a protective estimate of 12% would be appropriate.[52,53]

Equation 1:

$$\mathbf{PbB}_{\mathbf{adult}} = (PbF*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S.D}) + PbB_0$$

$$\mathbf{PbB}_{\mathbf{fetal,\ 0.95}} = PbB_{adult} * (GSDi^{1.645}*R)$$

PbB_{adult} = Adult blood lead concentration in the absence of other lead exposure.

BKSF = slope factor relating the (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake (ug/dl blood lead increase per ug/day lead uptake).

PbF = Fish lead concentration (ug/g) (appropriate average concentration).

IR_f = Fish ingestion rate, including soil-derived dust (mg/day) (central tendency estimate).

AFs = Absolute gastrointestinal absorption factor for ingested lead in fish (dimensionless).

EFs = Exposure frequency for ingestion of fish (days of exposure during the averaging period); may be taken as days per year in continuing long term exposures.

AT = Averaging time, the total period during which exposure may occur. In this evaluation, an averaging time of 365 days was used.

PbB_0 = Baseline blood lead (ug/dL)

R = Fetal/maternal PbB ratio

Table D1. Adult lead model exposure parameters values

Exposure Variable	PbB Equation[1] 1*	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario Using Equation 1 GSDi = Hom
PbS	X	Fish lead concentration	ug/g or ppm	6.7
$R_{fetal/maternal}$	X	Fetal/maternal PbB ratio	--	0.9
BKSF	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	X	Geometric standard deviation PbB	--	2.1
PbB_0	X	Baseline PbB	ug/dL	1.5
IR_S	X	Fish ingestion rate	g/day	42.000
IR_{S+D}		Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S		Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}		Mass fraction of soil in dust	--	--
$AF_{S, D}$	X	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	X	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S, D}$	X	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**		**ug/dL**	**15.0**
$PbB_{fetal, 0.95}$	**95th percentile PbB among fetuses of adult workers**		**ug/dL**	**45.8**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**		**ug/dL**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**		**%**	**65.7%**

Hom = homogenous population
X = Variables used for equation one

Table D2. Predicted blood lead results for adult and 95th percentile PbB among fetuses of adults Spokane River, Washington.

Location	Species	Tissue type	N	C/I	Maximum Lead concentration mg/kg, wet weight	Predicted blood lead levels	
						PbB adult ug/dL	PbB fetal, 0.95 ug/dL
Plante Ferry	Rainbow Trout	Fillet	3	C	0.14	1.8	5.4
Mission Park	Rainbow Trout	Fillet	3	C	0.14	1.8	5.4
"	Mountain Whitefish	Fillet	3	C	0.19	1.9	5.7
Ninemile	Rainbow Trout	Fillet	3	C	0.26	2.0	6.2
"	Mountain Whitefish	Fillet	3	C	<0.10	<0.10	<0.10
Upper Long Lake	Mountain Whitefish	Fillet	3	C	<0.10	<0.10	<0.10
"	Brown Trout	Fillet	1	C	--	--	--
"	Smallmouth Bass	Fillet	1	C	--	--	--
Lower Long Lake	Mountain Whitefish	Fillet	6	I	<0.10	<0.10	<0.10
"	Smallmouth Bass	Fillet	3	C	<0.10	<0.10	<0.10
Stateline	Largescale Sucker	Whole	3	C	6.7	**15**	**45.8**
Plante Ferry	Largescale Sucker	Whole	3	C	3.2	8.0	**24.3**
Mission Park	Largescale Sucker	Whole	3	C	4.2	**10**	**30.4**
Ninemile	Bridgelip Sucker	Whole	3	C	3.1	7.7	**23.6**
Upper Long Lake	Largescale Sucker	Whole	3	C	1.2	3.9	**12.0**
Lower Long Lake	Largescale Sucker	Whole	3	C	0.57	2.6	8.1

N = sample size
mg/kg = milligrams per killograms
C = composites
I = individuals
*Composites of 4-5 individual fish each, except Lower Long Lake mountain whitefish which were analyzed individually.
Bold values exceed the target blood lead level of concern of 10 ug/dL.

Table D3. Maximum whole fish meals for pregnant women and adults, Spokane River, Washington.

Location	Species	Maximum Pb concentration mg/kg, (ww)	8 ounce meals per month (7.5 g/day)*	
			Pregnant women	Adults
Stateline	Largescale Sucker	6.7	0	3
Plante Ferry	Largescale Sucker	3.2	1	7
Mission Park	Largescale Sucker	4.2	1	5
Ninemile	Bridgelip Sucker	3.1	1	8
Upper Long Lake	Largescale Sucker	1.2	4	19
Lower Long Lake	Largescale Sucker	0.57	8	40

ww = Wet weight
g/day = grams per day
* Follow exposure parameters on Table C2 and Table D1 to calculate eight-ounce fish meal limits. Use exposure parameters on table D1 and change the fish concentration value, so that the results per number of meals equals below 10 ug/dL of blood lead.

Appendix E

Lead Exposure Fish ingestion scenario used in the IEUBK model

This section provides inputs for the IEUBK model. The following inputs to the model were used to account for the average fish ingestion lead exposures on Spokane River fish, Washington.

Consumption rates: Recreational (Rec.) child – 7 g/day and Native American fish consumption rates for a child – 16.2 g/day. IEUBK model assumes that a child's total meat intake is 93.5 g/day. EPA's target cleanup goal of having no more than 5 percent of the community with BLLs above 10 µg/dL. Default assumptions were used unless noted.

Table E1. Input parameter values used for the IEUBK model

Input parameter	Comments	Units mg/kg or (ppm)
Value soil lead concentration		200
House dust lead concentration		200
Locally caught fish as percentage of meat consumed	Child recreational	7.5 %
	Native American fish consumption rates (CRIFTC study) [54]	16 %
Mean lead concentration for different locations		Variable

mg/kg = milligrams per kilograms

Table E2. Blood lead values determine using the IEUBK model for lead in whole fish at Spokane River, Washington.

Location	Average fish Concentration (ppm)		Percent meat intake as fish (%)		Blood Lead level in percent above 10 ug/dl Age range 0 - 84 months			
					LSS		BLS	
	Largescale sucker (LSS)	Bridgelip sucker (BLS)	Rec Child	Native American Child (Nam)	Rec Child	Nam Child	Rec Child	Nam Child
Stateline	4.2	NA	7.5	16	**26**	**59**	NA	NA
Plante Ferry	2.9	NA			**16**	**41**	NA	NA
Mission Park	3.5	NA			**20**	**50**	**NA**	**NA**
Ninemile	NA	2.9			NA	NA	**16**	**41**
Upper Long Lake	0.8	NA			3.5	7.7	NA	NA
Lower Long Lake	0.33	NA			1.9	3.1	NA	NA

Whole fish
Rec Child = recreational child
Nam = Native American child
NA – not available
Bold values exceed the target blood lead level of concern of 10 ug/dL

Appendix E: Chemical Specific Information and Toxicity

Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are persistent environmental contaminants that are ubiquitous in the environment due to intensive industrial use. PCBs were used as commercial mixtures (Aroclors) that contain up to 209 different chlorinated biphenyl congeners which are structurally similar compounds that vary in toxicity. A smaller subset of 50 to 60 congeners is commonly found in Aroclor mixtures.[55] Each congener has a biphenyl ring structure but differs in the number and arrangement of chlorine atoms substituted around the biphenyl ring. The name Aroclor 1254, for example, means that the molecule contains 12 carbon atoms (the first 2 digits) and approximately 54% chlorine by weight (second 2 digits).[56] Each mixture (1016, 1242, 1254, and 1260) contained many different PCB congeners. PCBs are lipid soluble and very stable; their stability depends on the number of chlorine atoms and their position on the biphenyl molecule. PCBs' lipophilic character and resistance to metabolism enhances concentration in the food web and exposure to humans and wildlife.
In 1971, the sole U.S. producer of PCBs (Monsanto Chemical Company) voluntarily stopped open-ended uses of PCBs and in 1977 ceased their production. Because PCBs do not burn easily and are good insulators, they were commonly used as lubricants and coolants in capacitors, transformers, and other electrical equipment. Old capacitors and transformers that contain PCBs are still in operation. Over the years, PCBs have been spilled, illegally disposed, and leaked into the environment from transformers and other electrical equipment. PCBs in the environment have decreased since the 1970s but are still detectable in our air, water, soil, food, and in our bodies.

The breakdown of PCBs in water, sediment, and soil occurs over many years and is often incomplete. Lower chlorinated PCBs are more easily broken down in the environment, while adsorption of PCBs generally increases as chlorination of the compound increases. The highly chlorinated Aroclors (1248, 1254, and 1260) resist both chemical and biological degradation in the environment. Microbial degradation of highly chlorinated Aroclors to lower chlorinated biphenyls has been reported under anaerobic conditions, as has the mineralization of biphenyl and lower chlorinated biphenyls by aerobic microorganisms. Although they are slow processes, volatilization and biodegradation are the major pathways of removal of PCBs from water and soil,[56] and volatilization is more significant for lower chlorinated congeners. In water, photolysis appears to be the only viable chemical degradation process. The chemical composition of the original Aroclor mixtures released to the environment changes over time since the individual congeners degrade and partition at different rates.[56]

Many PCB congeners persist in ambient air, water, marine sediments, and soil at low levels throughout the world. The half-life of PCBs (the time it takes for one-half of the PCBs to breakdown) in the air is 10 days or more, depending on the type of PCB. PCBs in the air can be carried long distances and may be deposited onto land or water. Once in water, most PCBs tend to adsorb to organic particles and sediments. The rate and extent of degradation is a function of temperature and the degree to which PCBs are bound to organic material and hence unavailable for degradation.

In Spokane River and other water bodies, sediment-associated PCBs are accumulated in the bodies of aquatic organisms, which are in turn consumed by creatures higher in the food web. Fish, birds, and mammals tend to accumulate certain congeners over time in their fatty tissue. Concentrations of PCBs can reach levels hundreds of thousand times higher than the levels in water. Bioconcentration is the uptake of a chemical from water alone, while bioaccumulation is the result of combined uptake via food, sediment, and water. These processes can lead to high levels in the fat of predatory animals.[56] Also, PCBs can biomagnify in fresh and saltwater ecosystems. Humans may be exposed to detectable quantities of PCBs when they eat fish, use fish oils in cooking, or consume meat, milk or cheese; the half life of PCBs in humans is estimated to be 2 – 6 years.[57]

Toxicity

Toxic responses to PCBs include dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development, and endocrine functions. Several epidemiological studies indicate that consumption of background levels of PCBs may cause slight but measurable impairments in physical growth and learning behavior in children while others have not. Some PCB congeners have a structure and biological activity that is similar to dioxin.

Dioxins are a family of chemicals produced by incomplete burning of organic material through natural and industrial processes.[58] Like PCBs, dioxins (and a very similar family of chemicals called furans) are persistent in the environment and have been shown to be toxic through a particular mechanism shared by certain PCB congeners. Toxic equivalency factors (TEFs) are used to account for the potential of these PCB congeners to exert dioxin-like toxicity. TEFs are available for twelve dioxin-like PCB congeners.[59] The larger the TEF, the more toxic the PCB congener is. Each congener is multiplied by its TEF to give the dioxin toxic equivalent value (TEQ). The TEQs for each congener are then summed to give the overall PCB-TEQ. TEFs for each congener are based on the toxicity of one well studied dioxin congener known as 2,3,7,8-tetrachlorodibenzo-p-dioxin.

EPA has determined that PCBs are probable human carcinogens and assigned them the cancer weight-of-evidence classification B2 based on animal studies. Human studies are being updated; current available evidence is inadequate but suggestive regarding cancer to humans. The upper-bound cancer slope factor for PCBs is 2.0 $(mg/kg/day)^{-1}$.

Part of the uncertainty in assessing PCB effects from consuming fish is that PCB congeners selectively bioaccumulate in fish in different patterns than found in commercial mixtures of PCBs or in the environment.[60] Another issue is how to combine cancer risks computed using PCB cancer potency factors based on Aroclors with cancer risks computed using TEFs for dioxin-like PCBs. The congener mix encountered by a fetus during pregnancy and via nursing may be quite different than congener patterns initially released into the environment. Since PCB congeners differ in their potency and in the specific ways they interact with biological systems, health criteria based on data from Aroclor mixtures fed to animals (e.g., the EPA RfD) may not account for biodegradation or selective accumulation by an organism. EPA has addressed this uncertainty by a policy decision to use an upper bound, health-protective estimate of the PCB cancer potency factor when computing cancer risks for PCBs found in fish tissue.[61,62]

DOH recently conducted a thorough review of the scientific literature on PCB toxicity in an attempt to set a state standard for PCB exposure through consumption of fish and shellfish. DOH concluded that ATSDR's MRL of 0.02 ug/kg/day for chronic-duration oral exposure to PCBs would be protective of the most sensitive population (fetus) for the most sensitive endpoints reviewed (immune and developmental). The intermediate oral MRL is based on a lowest observed adverse effect level (LOAEL) of 0.005 mg/kg-day for immunological effects seen in adult monkeys' exposure to Aroclor 1254.[56] EPA verified an oral reference dose (RfD) of 0.02 ug/kg-day for Aroclor 1254,[63] based on dermal/ocular and immunological effects in monkeys.

Polybrominated diphenyl ethers (PBDEs)

A new area of concern for human health is the widespread environmental presence of polybrominated diphenyl ethers (PBDEs), which are flame retardants used in a variety of consumer and industrial products. Puget Sound Assessment and Monitoring Program (PSAMP) has begun collecting fish tissue data for this analyte.[64] PBDEs were recently identified as bioaccumulative in the environment and have been detected in a variety of human tissues and in other organisms. Given the long life of many PBDE products and the length of time they remain in the environment, exposure can continue for years after their production. Washington State has developed a draft chemical action plan to identify efforts the state may take to reduce threats posed by some PBDEs.[65]

Information on possible health impacts of PBDEs comes primarily from animal toxicity studies.[66] In general, specific PBDE congeners found in penta-PBDE commercial products are more toxic than octa-PBDE and deca-PBDE. Deca-PBDE breaks down to penta-PBDE. The most sensitive toxic effect associated with penta-PBDE congeners appears to be developmental neurotoxicity, although penta-PBDE may also impact thyroid and other hormone systems. Octa-PBDE showed fetal toxicity and liver changes in rat and rabbit studies. Dietary intake of deca-PBDE was associated with liver, pancreas and thyroid tumors at very high doses in rodent studies. Washington State's PBDE chemical action plan states that human health risks are associated with PBDE exposure, although pathways and levels that may result in harm are not clearly understood. While consumption of food, including fish, may be an important exposure pathway for these chemicals, the indoor environment poses a unique exposure pathway for PBDEs unlike pathways for other persistent bioaccumulative toxins.

Five congeners (PBDE-47, -99, -100, -153, and -154) predominate in human tissues, usually accounting for more than 90 percent of the total PBDE body burden in most individuals not occupationally exposed. PBDE-47, -99, and -100 are present in the penta-BDE technical mixture, whereas PBDE-153 and -154 are constituents of both the penta-BDE and octa-BDE technical mixtures. Growing evidence suggests that the more highly brominated congeners of the deca-BDE technical mixture break down in the environment (e.g., lose bromine atoms through sunlight degradation and biotic metabolism) and subsequently form lower brominated PBDE congeners commonly found in humans.[67,68]

Current PBDE toxicity values as provided by EPA do not indicate the need to provide fish consumption advice based on this contaminant (RfDs = 1x 10^{-3} mg/kg-day for decabromodiphenyl ether, 3 x10^{-3} mg/kg-day for octabromodiphenyl ether, and 2 x10^{-3} mg/kg-day for pentabromodiphenyl ether) (mg/kg = ppm). Unfortunately, toxicity data for PBDEs are limited. EPA is currently updating critical toxicity values for PBDEs that consider recent animal studies showing similar adverse neurodevelopmental effects as observed with mercury and PCBs. The U.S. EPA is conducting a peer review of the scientific basis supporting the human health hazard and dose-response assessments of four congeners of polybrominated diphenyl ethers: tetraBDE (BDE-47), pentaBDE (BDE-99), hexaBDE (BDE-153), and decaBDE (BDE-209), that will appear on the Integrated Risk Information System (IRIS) database. Peer review is meant to ensure that science is used credibly and appropriately in derivation of the dose-response assessments and toxicological characterization.[69] Based on recent research in animals (rats), EPA's new reference dose values are as follows:

- BDE-47 reference dose (RfD) corresponds to 2.3 x 10^{-4} mg/kg-day or 0.2 ug/kg-day
- BDE-99 RfD corresponds to 1.3 x 10^{-4} mg/kg-day or 0.1 ug/kg-day
- BDE-153 RfD corresponds to 1.5 x 10^{-4} mg/kg-day or 0.2 ug/kg-day
- BDE-209 RfD corresponds to 0.007 mg/kg-day or 7 ug/kg-day

Lead

Lead is a naturally-occurring element. The widespread use of certain products (such as leaded gasoline, lead-containing pesticides, and lead-based paint) and the emissions from certain industrial operations have resulted in substantially higher levels of lead in many areas of the state.

Elimination of lead in gasoline and solder used in food and beverage cans has greatly reduced people's exposure to lead. Currently, the main pathways for lead exposure in children are ingestion of chips and dust from leaded paint, contaminated soil and house dust, and drinking water in homes that have plumbing materials containing lead.

Children six years old and younger are particularly vulnerable to the effects of lead. Compared with older children and adults, they tend to ingest more dust and soil and absorb more of the lead they swallow. Because children's brains are developing rapidly, they may be more sensitive to the neurological effects of lead than adults. Pregnant women and women of childbearing age should also be aware of lead in their environment because an expectant mother's exposure to lead can harm her fetus.

Lead poisoning can affect almost every system of the body and often occurs with no obvious or distinctive symptoms. Depending on the amount of exposure a child has, lead can cause behavior and learning problems, central nervous system damage, kidney damage, reduced growth, hearing impairment, and anemia.

Exposure to lead can be monitored by measuring the level of lead in the blood. For children, the Centers for Disease Control and Prevention (CDC) has defined an elevated blood lead level (BLL) as greater than or equal to 10 µg/dL (10 µg/dL is defined as a toxicological level of concern by the CDC). However, evidence is growing that damage to the central nervous system resulting in learning problems can occur at blood lead levels less than 10 µg/dL. Deficits in cognitive and academic skills associated with lead exposure occur at blood lead concentrations lower than 5 µg/dL. About 2.2 % of children in the United States have blood lead levels greater than 10 µg/dL.

In adults, lead can cause health problems such as high blood pressure, kidney damage, nerve disorders, memory and concentration problems, difficulties during pregnancy, digestive problems, and pain in the muscles and joints. These have usually been associated with blood lead levels greater than 30 µg/dL.

Because of chemical similarities to calcium, lead can be stored in bone for many years. Even after exposure to environmental lead has been reduced, lead stored in bone can be released back into the blood where it can have harmful effects. Normally this release occurs relatively slowly. However, certain conditions, such as pregnancy, lactation, menopause, and hyperthyroidism can cause more rapid release of the lead, which could lead to a substantial rise in blood lead level.

Certification

The Washington State Department of Health prepared this evaluation of PCBs, PBDEs and selected metals in the Spokane River, including Long Lake Spokane, Washington Public Health consultation 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 were initiated. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

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