Health Consultation

INGESTION OF LAMPREY FOR THE CONFEDERATED TRIBES
OF SILETZ INDIANS

Lamprey caught at Willamette Falls
Oregon City, Clackamas County, Oregon

Part of

PORTLAND HARBOR
PORTLAND, MULTNOMAH COUNTY, OREGON

EPA FACILITY ID: ORSFN1002155

FEBRUARY 23, 2005

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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Prepared by:

Oregon Department of Human Services
Superfund Health Investigation and Education Program
Under a cooperative agreement with
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Background

The Confederated Tribes of the Siletz Indians (CTSI) requested that the Superfund Health Investigation and Education (SHINE) program of the Oregon Department of Human Services investigate the risk of ingesting lamprey. This health consultation focuses on the cancer and non-cancer risk potential associated with contaminants detected in lamprey collected at Willamette Falls. Contaminants of concern include organic and inorganic pollutants detected in lamprey tissue, such as organochlorine pesticides, polychlorinated biphenyls (PCBs), and arsenic.

The Pacific lamprey (*Lampetra tridentata*) is harvested in the lower Willamette River, at Willamette Falls in Clackamas County, Oregon. Juvenile lamprey (ammocetes) spend several years in freshwater rivers and tributaries before growing into adults. The main ammocete food sources are microscopic plants and animals obtained by filtering mud and water. This makes ammocetes particularly susceptible to any contaminants present in sediments. In the adult form, lamprey move into the ocean, where they live as parasites on larger fish before returning to fresh water to spawn [1]. Lamprey are not vertebrates with a bony spinal column — they instead have a cartilaginous structure known as a notochord. Lamprey are jawless animals that attach to other fish through horny teeth arranged in a circle. To facilitate this parasitic practice they secrete anticoagulant in their saliva to facilitate the bleeding of host fish.

Historically, CTSI members harvested lamprey directly from the Siletz River [2], but lamprey are no longer found there in sufficient quantities to harvest. To bring back their source of traditional food, the Siletz Indians have since the mid-1990s begun to collect lamprey at Willamette Falls. Several members of CTSI consider lamprey to be a delicacy, and they consume the meat in various gatherings, generally after smoking the fillet [2]. When adult lamprey return to Willamette Falls to spawn, they must travel through the Portland Harbor Superfund Site. SHINE has been involved with the public health assessment of Portland Harbor, including the issuance of fish advisories. On July 16, 2004, the Oregon Department of Human Services issued a fish advisory for a specific 6-mile area within Portland Harbor (www.healthoregon.org/fishadv). The advisory does not include migratory fish, such as lamprey. In May 2003, SHINE initiated an inter-agency study to determine the pollutant burden in migratory fish that migrate through Portland Harbor. The species analyzed were spring Chinook salmon, white sturgeon and pacific lamprey. Other agencies involved with this study included the Agency for Toxic Substances and Disease Registry (ATSDR), the U.S. Environmental Protection Agency (EPA), Oregon Department of Fish and Wildlife (ODFW), and the City of Portland. The results of this inter-agency effort were used to assess the potential risks of ingesting lamprey by members of CTSI.

Site Visit

On June 28, 2004, SHINE staff member Dave Stone accompanied members of the Siletz Tribe and their biologists to Willamette Falls to observe how the tribe harvests lamprey . A motorized boat guided the harvesters to rocky embankments below the falls so that lamprey could be collected among the rocks (Figure 1). The lamprey were placed in canvas sacks, and when the sacks were full the harvesters returned to the boat . Lamprey were counted and placed into coolers. Approximately 500 lamprey were collected on this trip. On July 6, 2004, approximately 500 more lamprey were collected for a total harvest of around 1,000 for the 2004 season [3].

Figure 1. The Confederated Tribes of Siletz Indians 2004 Lamprey: a) Willamette Falls, b) approaching the Falls, c) searching for lamprey among the rocks, and d) a cooler full of lamprey.

Demographics

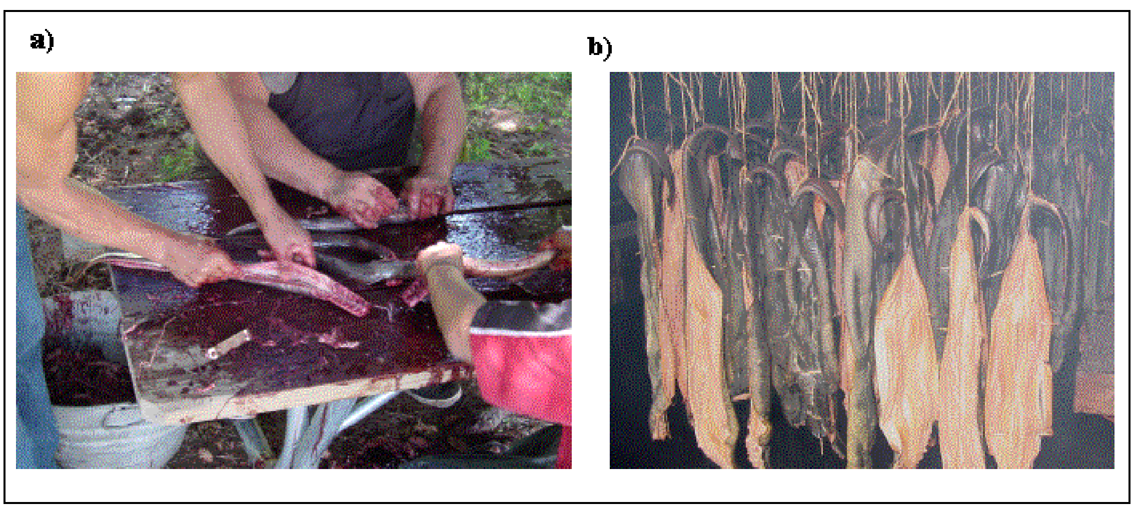
The Confederated Tribes of the Siletz Indians comprise 27 bands, ranging from Northern California to Southern Washington. In Lincoln County the Siletz manage a reservation of 3,666 acres. Federal recognition of the CTSI was reestablished in November 1977. The last enrollment counted 4,128 members of the Confederated Tribes of the Siletz Indians, many of whom live outside of Lincoln County. Exactly how many CTSI members consume lamprey from Willamette Falls is unknown.

Consumption

In 2004 approximately 1000 lamprey were harvested by the Siletz, which is a larger harvest compared with previous years. According to a biologist with CTSI 3**,** about 300 lamprey were distributed to 60 elder members in batches of five. Several hundred lamprey were consumed in cultural gatherings, including youth and elder cultural camps. Remaining lamprey were distributed to several families. Due to seasonal variability, lamprey are often consumed over brief periods during the summer; it is not uncommon for CTSI members to ingest several lamprey in one meal [4]. Using this information and after numerous discussions with CTSI members and their biologists, a consumption rate of 15 grams lamprey per day for adults and 6 grams lamprey per day for children was assumed for this study. If a cooked lamprey is assumed to weigh 8ounces, this would correspond to approximately 25 lamprey per year for adults and 10 lamprey per year for children. It should be noted that the current consumption of lamprey might be limited by declining lamprey populations, harvest restrictions, or by concerns over contamination levels in tissue [5].

The preferred method of cooking and preparing the lamprey is shown in Figure 2. The notochord and attached structures were removed, and during the smoking process the lamprey fillet is split open. The lamprey were hung by strings and smoked, similar to traditional methods. The fillets are often smoked over 2 or 3 days.

Figure 2. Harvested lamprey being a) filleted to remove the notochord and b) hung by strings during the smoking process.



Sampling Methods

Field Collection Methods

Pacific Lamprey analyzed for this health consultation were collected from the fish ladder at Willamette Falls on May 22, 2003 by U.S. Environmental Protection Agency (EPA) staff. The fish ladder was dewatered to facilitate collection. The lamprey were grouped into four composite samples consisting of approximately 30 adult lamprey in each composite (depending on weight), ranging in size from 24–30 inches long. Whole body samples were used in the composite samples.

Each sample was wrapped in clean, heavy-duty aluminum foil with dull side touching the fish and with labels attached. All of the lamprey collected for a composite sample were grouped and placed inside a labeled plastic bag. The EPA field crew immediately packed the bagged the fish samples on dry ice in clean ice chests to start cooling them down. The samples were completely frozen prior to shipping. The composite samples were shipped to Axys Analytical Laboratories. Upon receipt in the laboratory, lamprey were kept frozen at less than -20°C.

Whole body lamprey composites were analyzed for several organic and inorganic contaminants including metals, semi-volatile compounds, pesticides, dioxins, furans, and polychlorinated biphenyls (PCBs).

Evaluation Process

Exposure to contaminants through the ingestion of lamprey is considered a complete exposure pathway for CTSI members. ATSDR categorizes an exposure pathway as complete if five factors are present 6:

1. a source of contamination,
2. transportation through an environmental medium,
3. a point of exposure,
4. a route of human exposure, and
5. an exposed population.

The presence of a completed pathway indicates that human exposure to contaminants could have occurred in the past, could be occurring now, or could occur in the future.

In the public health assessment process, environmental data are screened using ATSDR environmental media evaluation guidelines (EMEGs). Because. EMEGs do not exist for fish tissue, SHINE used minimum risk levels (MRLs) and reference doses (RfDs) to calculate acceptable tissue levels for non-carcinogenic endpoints. These are the endpoints used in this consultation. The process to identify these levels is described in Appendix A. to determine acceptable tissue levels for carcinogenic endpoints, laboratory scientists used cancer slope factors and an acceptable lifetime excess cancer risk of one in 100,000 people exposed . The process used to determine non-carcinogenic and carcinogenic endpoints is described in detail in Appendix B. Contaminants detected above acceptable tissue concentrations for either carcinogenic or non-carcinogenic endpoints were further assessed for risk. The fact that a chemical exceeds its comparison value does not, however, indicate that adverse health effects are likely. Rather, it indicates that the contaminant is a candidate for further assessment.

Table 1 presents the average and maximum levels of chemical detected in lamprey tissue and their corresponding comparison values for carcinogenic and non-carcinogenic endpoints.

Table 1. Average and maximum levels of chemicals detected in lamprey tissue and comparison values for acceptable levels of contamination in fish.

Chemical	***Average Level Detected***	***Maximum Level Detected***	***Comparison Value (non-carcinogen)***		***Comparison Value (carcinogen)***
			Adult	***Child***	***Adult***
Inorganic Arsenic* (ug/kg†)	72	86	1400	750	31
Mercury (ug/kg)	138	168	467	250	---
Total DDTs‡ (ug/kg)	30.6	33.2	2333	1250	137.3
Chlordane (ug/kg)	7.0	7.6	2333	1250	133.3
Dieldrin (ug/kg)	5.5	6.2	233	125	2.92
Dioxin/furan TEQs§ (ug/kg)	0.0003	0.00033	---	----	0.00031
Total PCBs¶ (ug/kg)	44.8	48.6	93	50	23.3

*It was assumed that 10% of total arsenic was in the inorganic form
†ug/kg = parts per billion
‡Total DDTs = sum of all DDE, DDD and DDTs
§TEQ = Toxicity equivalent quotient
¶PCBs = Total PCB congeners

The average level of dieldrin, total PCBs and arsenic exceeded their comparison values for carcinogenic endpoints. PCB levels approached the comparison value for non-carcinogenic effects for children. Because these chemicals exceeded or approached their comparison values, they were assessed further in the Toxicological Profile section. The toxicity values used to assess the risk of exposure to dieldrin, total PCBs, and arsenic are presented in Table 2.

Toxicology Profile

Details on risk assessment calculations are provided in Appendix B. To be health protective, the maximum result of the four composites for an individual contaminant was assessed. The results analyzed in this consultation are for whole body, uncooked lamprey samples. The consumption of large amounts of lamprey over short periods of time can present an increased risk, compared with eating the same amount of lamprey over longer periods of time. Smoking the lamprey tends to reduce fat-soluble contaminants, such as dieldrin and PCBs Holding the fillet over high temperatures for long periods of time, allows the fats to drip off the carcass. In fact, smoking has been shown to be effective in removing 40% to over 50% of total PCBs in Great Lakes lake trout [7].

Table 2. Toxicity values used to determine risk levels for chemicals that exceeded comparison values in Table 1.

Contaminant	*Cancer Slope Factor /Source*	*Non-cancer toxicity value (mg/kg/day)/Source*
Arsenic	1.5/IRIS*	0.0003/ MRL†
PCBs	2.0/IRIS	0.00002/ MRL
Dieldrin	16/IRIS	0.00005/ MRL
*IRIS = EPA's integrated risk information system †MRL = Minimum Risk Level (ATSDR)		

Dieldrin

Dieldrin is an organochlorine insecticide manufactured in the United States until 1989. Dieldrin continues to enter the waterways through atmospheric deposition and soil run-off, where it can eventually accumulate in wildlife tissue. Dieldrin is a lipid-soluble compound and is ultimately stored in fat and fatty tissues such as the brain and liver.
At high exposure doses, dieldrin stimulates the nervous system and can lead to convulsions, respiratory paralysis, and even death. The amount of dieldrin necessary to develop these effects is, however, much greater than one would expect to ingest by eating fish. Other potential effects of dieldrin exposure at high doses include irritability, excitability, deficits in immune system performance, effects on the kidneys, and negative impacts on the cardiovascular system [8]
A minimum risk level (MRL) of 0.00005 mg/kg/day was developed for chronic exposure to dieldrin, based on adverse effects on the liver in studies on rats. Liver effects have also been noted in chronic exposure studies in animals and in occupational exposures to humans 8. The estimated exposure dose to dieldrin from the ingestion of lamprey is 0.0000013 mg/kg/day for adults, and 0.0000025 mg/kg/day for children. This corresponds to 38 times less than the MRL for adults and 20 times less than the MRL for children. Consequently, no adverse, non-carcinogenic health outcomes would be anticipated for exposure to dieldrin through the ingestion of lamprey.
The data on the carcinogenic potential of dieldrin is conflicting. Animal studies have demonstrated that dieldrin is carcinogenic to mice, but the relevance of this particular chemical to humans is unclear. In a study in Europe, dieldrin was the only organochlorine compound associated with a significant increase in breast cancer [9]. Blood levels of dieldrin above 57.6 ng/g (nanograms per gram or parts per billion) were associated with a reduction in overall survival in women with breast cancer [10]. A study in Missouri failed to find an association between serum levels of dieldrin and breast cancer in women [11]. The International Agency for Research on Cancer (IARC) categorized dieldrin as unclassifiable as to human carcinogenic potential. The Environmental Protection Agency (EPA) has classified dieldrin as a probable human carcinogen. Using an exposure dose of 0.0000013 mg dieldrin/kg/day for adults ingesting lamprey, the excess lifetime cancer risk would equal an additional 2 in 100,000 people exposed. SHINE considers a risk of

greater than 1 in 10,000 people exposed to constitute a significant elevation in excess cancer.

Polychlorinated Biphenyls (PCBs)

Manufactured in the United States until 1977, PCBs consist of 209 structurally related compounds called congeners. They were sold under the commercial name of Aroclor for use as hydraulic and lubricating oils, in transformers, in fluorescent lighting, insulating materials, plasticizers, and many other applications. PCBs are highly persistent in the environment. In addition, PCBs are known to bioaccumulate in fish; shellfish and seafood constitute the highest dietary exposure to these toxins.

PCBs can affect thyroid hormone production [12] and associated loss of hearing as a result of lower thyroid hormone levels [13], based on studies in rats. In addition, PCBs can affect immune system performance and liver function [14].

Several studies have examined the effect of PCBs on cognitive development, intelligence, and behavior on children exposed to contaminated fish in the womb [15,16]. Two large studies, the Michigan Maternal Cohort study [17,18,19] and the Oswego Cohort study [20], suggest that neuromuscular and neurobehavioral deficits in children are associated with exposure in the womb as a result of maternal consumption of contaminated fish. In one study, babies born to women who consumed high amounts of contaminated fish demonstrated an association between levels of higher chlorinated PCBs in cord blood and poor performance on neurobehavioral assessment scales [21].

Using data on immunological effects in adult monkeys, a minimum risk level (MRL) of 0.00002 mg/kg/day was developed for PCBs . The estimated exposure to PCBs from the ingestion of lamprey is 0.00001 mg/kg/day for adults and 0.00002 mg/kg/day for children. This corresponds to half of the minimum risk level (MRL) for adults, and it is equal to the MRL for children. Given these results, SHINE recommends that members of CTSI should follow these consumption guidelines for the ingestion of lamprey:

- Women of child-bearing age, especially pregnant and nursing women, children under six and people with liver or immunological problem should consume no more than one 6-ounce meal of lamprey per month.
- Other CTSI members can ingest up to three 8-ounce meals of lamprey per month as indicated in the Oregon-wide fish consumption advisory issued by the Oregon Department of Human Services. This limit is especially important to women of child-bearing age and to young children, given the potential for developmental effects outlined above.

IARC and EPA have classified PCBs as probable human carcinogens, primarily on sufficient evidence of carcinogenicity in animals. The cancer most commonly linked to PCB exposure is liver cancer. This association has been made in occupational studies [22,23] and in the *Yusho* contaminated rice oil incident [24]. In a study of Swedish fishermen eating fish contaminated with PCBs, mortality from liver cancer did not increase [25]. Still, assuming an exposure dose of 0.00001 mg PCBs/kg/day for adults ingesting lamprey, the excess lifetime cancer risk would equal an additional 2 in 100,000 people exposed. Although this estimate does not represent a significant elevation in excess cancers — especially in context of current cancer incidence rates [26] — SHINE considers a risk of greater than one in 10,000 people exposed to constitute a significant elevation in excess cancer.

Arsenic

Arsenic is a naturally occurring element found throughout the environment. Arsenic has been used in many products, especially as a wood preservative. Other uses include pesticide formulations, alloys for lead-acid batteries, and semiconductors. The largest source of arsenic in the typical diet is through the ingestion of fish and shellfish [27,28]. Furthermore, marine organisms have the ability to accumulate any arsenic present in seawater and in food items, as opposed to just from local pollution sources [29]. Most studies indicate that about 90% of the arsenic found in fish and shellfish is organic arsenic, which is much less toxic than inorganic arsenic [30]. Thus, for this health consultation, it was assumed that 10% of the total arsenic detected in lamprey tissue was in the inorganic form. This is similar to the approach used for the Portland Harbor Superfund site investigation.

Numerous health effects have been attributed to arsenic, ranging from irritation of the gastrointestinal tract to damage to the cardiovascular and nervous systems. One of the principal effects of chronic exposure to arsenic is a pattern of skin changes characterized by the darkening of skin and by the appearance of small bumps on one's palms, soles, and torso [30]. These skin changes could ultimately lead to skin cancer.

ATSDR developed a minimum risk level (MRL) of 0.0003 mg/kg/day the for chronic oral exposure to arsenic, based on skin lesions detected in farmers exposed to high levels of arsenic in well water on Taiwan. By contrast, the estimated exposure dose from the ingestion of lamprey is 0.00002 mg/kg/day for adults and 0.000034 mg/kg/day for children. These exposure doses are approximately 15 times less than the MRL for adults and 10 times less than the MRL for children. Given these calculations, no adverse non-carcinogenic health effects would be anticipated.

Beyond skin cancers as a result of arsenic, other cancers that have been associated with the ingestion of arsenic include liver, bladder, kidney, prostate, and lung cancer [30]. The International Agency for Research on Cancer, the National Toxicology Program, and the Environmental Protection Agency classify inorganic arsenic as a known human carcinogen. The excess lifetime cancer risk to adults would equal an additional 3 in 100,000 people exposed. Again, SHINE considers a risk of greater than one in 10,000 people exposed to constitute a significant elevation in excess cancer.

Child Health Considerations

SHINE recognizes that infants and children might be more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, SHINE is committed to evaluating their special interests at the site.

- Infants and children are more susceptible to the adverse effects of developmental contaminants such as mercury, pesticides and PCBs

- Children are smaller, resulting in higher doses of chemical exposure per body weight and exposure at a young age will increase the amount of time that a chemical can exert a toxic effect.
- Infants and young children have different absorption, excretion and detoxification capabilities than adults which may make them more susceptible.
- Infants and children have proportionally larger livers and brains – fatty organs in which PCBs and other organic contaminates preferentially accumulate.
- Infants and children have longer remaining lifespan in which the expression of toxicity can occur (especially cancer).

SHINE will continue to evaluate the risks of ingesting contaminated seafood, and especially evaluate for CTSI members the risks to identifiable subpopulations such as infants, children, and developing fetus, as new data become available.

Conclusions

1. The childhood exposure scenario approached the minimum risk level for non-carcinogenic effects associated with PCBs. This indicates that women of child-bearing age, especially pregnant and nursing women, children under 6 years of age, and people with liver or immunological problem should consume no more than one 6-ounce meal of lamprey per month.
2. Dieldrin, PCBs, and arsenic exceeded their comparison values for carcinogenic endpoints, based on conservative screening assumptions. None of these chemicals, however, were above the levels SHINE considers significant for a cancer risk-based public health hazard.
3. Several contaminants were detected in the tissue of Pacific lamprey collected at Willamette Falls. These chemicals, especially PCBs and other fat-soluble compounds known to accumulate in the food chain, are commonly detected in fresh and marine water animals.

Recommendations

SHINE recommends that members of CTSI should follow these consumption guidelines:

- Women of child-bearing age, especially pregnant women and nursing mothers, children under 6 years of age, and people with liver or immunological problems, should consume no more than one 6-ounce meal of lamprey per month.
- The Oregon Department of Human Services has recommended that CTSI members can ingest up to three 8-ounce meals of lamprey per month.

Exposure to organic contaminants, such as pesticides, dioxins, and PCBs can be further reduced through cooking methods such as smoking. Discarding the organs and head, as well as cooking over long periods of time thus allowing the fats to drip off, will also assist in reducing exposure to these contaminants.

Public Health Action Plan

The Public Health Action Plan for the site contains a description of actions that have been or will be taken by SHINE at this site. The purpose of the Public Health Action Plan is to ensure that this health consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of SHINE to follow up on this plan to ensure that it is implemented.

Public health actions that have been taken include:

- SHINE staff presentation and participation with an environmental health training session at the Chemawa Indian School on March 15, 2004.
- Funding the Confederated Tribes of Siletz Indians with a mini-grant designed to create and distribute information focused on fish health issues.
- Assistance with development of a fish consumption brochure and coloring book specific to tribal anglers in the Pacific Northwest.
- Participation in a meeting with CTSI legal, environmental, cultural, and medical staff on September 7, 2004, to discuss fish-health issues.

The public health actions to be implemented include:

- SHINE and ATSDR will continue to provide assistance to CTSI in interpreting fish tissue contamination levels and their implications for human health.
- SHINE, EPA, ODEQ, ATSDR, and local public health agencies will continue to respond to the community’s concerns and questions.

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A. Appendix A. Evaluation Process

Screening Process

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (e.g., soil, water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone could inhale or ingest each day. Because comparison values such as environmental medial evaluation guidelines (EMEGs) and cancer risk evaluation guidelines (CREGs) are not available for fish tissue, minimum risk levels (MRLs) and references doses (RfDs) were used as surrogates for other comparison values.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on valid toxicological studies for a chemical, with appropriate safety factors included. They are also based on the assumption that small children and adults are exposed every day. Cancer levels are the media concentrations at which there could be a 1 in 100,000 excess cancer risk for daily exposure for 70 years. For chemicals for which both cancer and non-cancer numbers exist, to be protective of human health, the lower level is used. Also, exceeding a CV does not mean that health effects will occur — it just means that more evaluation is needed.

Evaluation of Public Health Implications

Estimation of Exposure Dose

The next step is to take those contaminants above the CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Child and adult exposure doses are calculated for the site-specific exposure scenario, using assumptions outlined in Appendix B. The exposure dose is the amount of a contaminant that gets into a person's body.

Non-cancer Health Effects

The calculated exposure doses are then compared to an appropriate health guideline for that chemical. Health guideline values are considered safe doses; that is, health effects are unlikely below this level. The health guideline value is based on valid toxicological studies for a chemical — with appropriate safety factors built in — to account for human variation, for animal-to-human differences, for the use of the lowest adverse effect level, or for a combination of all three. For non-cancer health effects, the following health guideline values were used:

Minimal Risk Level (MRLs) - developed by ATSDR
An estimate of daily human exposure — by a specified route and length of time — to a dose of chemical that is likely to be without a measurable risk of adverse, non-cancerous effects. An MRL should not be used as a predictor of adverse health effects. A list of MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

Reference Dose (RfD) - developed by EPA
An estimate, with safety factors built in, of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. The RfDs can be found at http://www.epa.gov/iris/.
If the estimated exposure dose for a chemical is less than the comparison value, then the exposure is unlikely to cause a non-carcinogenic health effect in that specific situation. If the exposure dose for a chemical is greater than the health guideline, then the exposure dose is compared to known toxicological values for that chemical and is discussed in more detail in the public health consultation or assessment. These toxicological values are doses derived from human and animal studies summarized in the ATSDR toxicological profiles. A direct comparison of site-specific exposure and doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely.

Risk of Carcinogenic Effects

The estimated risk of developing cancer from exposure to the contaminants was calculated by multiplying the site-specific adult exposure dose by EPA's corresponding Cancer Slope Factor (see http://www.epa.gov/iris/). The results estimate the maximum increase in risk of developing cancer after 70 years of exposure to the contaminant. The actual risk of cancer is probably lower than the calculated number, and could be zero. Because of uncertainties involved in estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data. Therefore, the carcinogenic risk is described in words (i.e., qualitatively) rather than as only a numerical risk estimate. A numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures must be given careful consideration in evaluating the assumptions and variables relating to both toxicity and exposure.

B. Appendix B. Comparison Values and Risk Assessment Process

Calculation of Acceptable Fish Tissue Levels (Comparison Values):
The first step in calculatating the risk posed by ingesting lamprey is to develop comparison values to screen contaminants.
Comparison values are calculated using the formulas below.

$$CV_{cancer} = \frac{10^{-5} \times BW}{SF \times IR \times CF} \qquad CV_{non-cancer} = \frac{RfD\ or\ MRL \times BW}{IR \times CF}$$

Carcinogenic endpoints are assessed for adults only, assuming 70 years of exposure. This scenario is protective of childhood exposure because it projects the risk of cancer over a 70-year span. Non-carcinogenic endpoints are assessed for both children and adults. A high-end ingestion rate (IR) is assumed to be 15 grams/day for adults and 6 grams/day for children. It is assumed that a cooked lamprey fillet weights 8 oz (227 grams). This corresponds to an ingestion rate of approximately 25 lamprey and 10 lamprey per year for adults and children, respectively. An acceptable lifetime cancer risk of 1 in 100000 people exposed and a hazard quotient less than or equal to one is used as the criteria for acceptable risk (hazard quotient is defined as the exposure concentration divided by the MRL or RfD). The conversion factor (CF) used in the equations above is 0.001 — to convert from grams to kilograms. A body weight (BW) of 70 kg is used for adults and 15 kg for children. Slope factors (SF), minimum risk levels (MRLs) and reference doses (RfDs) are described in Appendix A.

Exposure Calculations:

The exposure dose (i.e. the amount of a substance that one contacts per kg of body weight per day) is calculated below.

$$Dose_{(non-cancer,\ mg/kg/day)} = \frac{C \times C_1 \times IR \times C_2 \times EF \times ED}{BW \times AT_{cancer}}$$

$$Dose_{(non-cancer,\ mg/kg/day)} = \frac{C \times C_1 \times IR \times C_2 \times EF \times ED}{BW \times AT_{non-cancer}}$$

Where,

Parameter	***Group***		***Units***	***Comments***
	Adult	***Child***		
Concentration (C)	---	---	µg/kg	Concentration of chemical in lamprey whole body samples
Conversion Factor (C_1)	0.001	0.001	mg/µg	Converts fish concentration (µg) to mg
Ingestion Rate (IR)	15	6.0	g/day	Based on conversations with members of the Siletz
Conversion Factor (C_2)	0.001	0.001	kg/g	Converts g → kg
Exposure Frequency (EF)	365	365	days/ year	Assumes daily exposure
Exposure Duration (ED)	70	70	years	Estimated residence time spent eating lamprey
Averaging Time (AT)	25550	25550	days	Number of days in 70 years
Body weight (BW)	70	15	kg	Assumed weight of adult and child

Evaluating Non-cancer Risk:

The following section describes how risk is assessed from the exposure doses calculated above. For non-cancer health effects, a comparison is made between the exposure concentrations (mg/kg/day) and the ATSDR's MRL or the EPA's RfD. If the estimated exposure concentration is above the MRL or RfD, the potential for adverse health effects needs to be further assessed. The higher the exposure concentration is above the MRL or RfD, the more risk is present. This comparison is called a hazard quotient (HQ) and is expressed as:

$$HQ = \frac{Exposure\ concentration\,(mg/kg/day)}{MRL\ or\ RFD}$$

Evaluating Cancer Risk:

Some chemicals are considered carcinogenic, or cancer-causing. Cancer risk is assessed by determining a dose (as detailed above) and multiplying this dose by a cancer slope factor for that chemical (see Appendix A). From these calculations, an estimate of the number of excess lifetime cancer risk to an exposed individual can be derived. This approach has a large degree of uncertainty. Cancer can occur different reasons, many of which are not linked to environmental contaminants. In the United States, approximately one-quarter to one-third of the population will be diagnosed with some form of cancer [26].