Health Consultation

Evaluation of Selected Metals in Holmes Harbor Shellfish
Freeland, Island County, Washington

July 1, 2008

Prepared by:
Washington State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

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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.

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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/.

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Glossary

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.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
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.
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.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
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 Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on ATSDR's *minimal risk level* (MRL).

Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
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**].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
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.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
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.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
No apparent public health hazard	A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no 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.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
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.
Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The RMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
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].

Surface Water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].
Volatile organic compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Summary and Statement of Issues

The Washington State Department of Health (DOH) prepared this health consultation to evaluate whether chemical contaminants found in shellfish from Holmes Harbor pose a health hazard to people who consume shellfish from the area. The purpose of this health consultation is to fill a data gap identified in a previous health consultation. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Holmes Harbor is a horseshoe-shaped bay with approximately 13 miles of sheltered coastline (six miles long by about 0.75 to 1.75 miles wide) located on the southern part of Whidbey Island located in Washington's Puget Sound (see Figures 1 and 2). Land use along the shore of Holmes Harbor is primarily rural residential or low density residential with a small mixture of commercial, agricultural and industrial properties. The town of Freeland lies at the southern end of the bay. Approximately 878 people (see Figure 1) live within a one-mile radius of Freeland County Park because of its central location to the area under consideration.

The Washington State Department of Fish and Wildlife (WDFW) has indicated that prior to DOH closure in April 2006, greater than 4,500 recreational harvesters a year collected shellfish from the public tidelands at Freeland County Park [1]. A community group called Friends of Holmes Harbor (FOHH) is concerned that contamination from industrial activities near Freeland County Park might have contaminated Holmes Harbor's surface water and sediment, thus posing a risk to human health from consumption of intertidal shellfish harvested there. Before closure, WDFW seeded this area with Manila clams on a regular basis. In addition, there are native littleneck clams and butter clams present in much lower numbers.

Currently, the Freeland County Park beach of Holmes Harbor is classified as prohibited due to persistent elevated levels of fecal coliform bacteria. DOH Office of Shellfish and Water Protection (OFWP) is responsible for classifying recreational shellfish growing areas. Figure 2 shows a map of Holmes Harbor and its current classifications for shellfish growing and harvesting.

Sample Collection, preparation, and analysis

Three different regions were sampled by DOH representing three different segments of southern Holmes Harbor, Figure 3: (A) Freeland County Park beach growing area, (B) the area of beach along Nichols Brothers Boat Builders Incorporated (NBBBI), and (C) the area of beach west of NBBBI (see Figure 3, Photos 1 and 2). Table 1 shows the number of samples collected by species and sample location. All shellfish samples were collected during a low tidal cycle on May 18, 2007, as close to the water as practical. All clams taken for analysis were of legal size and all specimens were unbroken. Each sample of the primary species (Manila clams) consisted of 30 individual organisms of the same species. Each sample of the secondary species (Varnish clams) consisted of 15 individual organisms of the same species. Each sample was placed in zipper-locked plastic bags, given a unique identifier, placed on ice, and hand delivered to Severn

Trent Laboratories (STL) Seattle located in Fife. Samples were shucked, and then the tissues were homogenized and analyzed by STL. Tissues were analyzed for total arsenic, cadmium, chromium, copper, lead, nickel, zinc, and tributyltin. Manila clams were not collected at area C due to a rising tide and time constraints to get the samples to the lab. In addition, Varnish clams were taken as the secondary species because they were the only other species present in large quantity.

Table1. Sample summary of shellfish in Holmes Harbor, Freeland, Island County, Washington.

Sample species	Holmes Harbor		
	Number of samples		
	A	B	C
Manila clams	4	3	
Varnish clams	1		1

Results

Results of the shellfish analyses are presented in Tables 2 - 4. The mean and maximum concentrations for each species are shown in Table 4. There were no obvious differences in metal concentrations between sample locations where Manila clams were taken (Table 2). However, there may be differences in metal concentrations (cadmium, copper, lead, nickel, and zinc) between species (Table 2). Due to small sample size, variances in species differences were not calculated. When compared to the mean range for metals found in littleneck clams in the Puget Sound, the mean for Manila clams from southern Holmes Harbor (areas A, B and C) are within the Puget Sound range (Table 3), except for arsenic and cadmium which are higher.

Table 2: Analytical results for sample taken from southern Holmes Harbor (areas A, B and C) in Freeland, Washington.

Manila	**Arsenic (ppm)**	**Cadmium (ppm)**	**Chromium (ppm)**	**Copper (ppm)**	**Lead (ppm)**	**Nickel (ppm)**	**Zinc (ppm)**
1	4.1	0.42	0.17	2.1	0.063	1.3	14
2	4.0	0.46	0.15	1.8	0.061	1.3	14
3	5.0	0.47	0.11	1.8	0.055	0.96	14
4	7.4	0.69	0.18	1.4	0.076	1.4	13
5	6.4	0.47	0.15	1.4	0.11	1.1	13
6	5.7	0.45	0.49	2.3	0.18	1.1	15
7	3.2	0.31	0.13	1.3	0.10	0.83	11
Varnish	**Arsenic (ppm)**	**Cadmium (ppm)**	**Chromium (ppm)**	**Copper (ppm)**	**Lead (ppm)**	**Nickel (ppm)**	**Zinc (ppm)**
1	4.5	0.052	0.21	7.0	0.16	0.65	43
2	3.6	0.068	0.17	6.0	0.59	0.33	38

PPM – parts per million

Table 3: Comparison of Manila clams mean, taken from southern Holmes Harbor (areas A, B and C) to the Puget Sound littleneck clam mean range, Washington.

	Arsenic (ppm)	**Cadmium (ppm)**	**Copper (ppm)**	**Lead (ppm)**	**Zinc (ppm)**
Puget Sound Mean Range	1.36 – 2.54	0.16 – 0.33	0.73 – 1.8	0.0 – 0.24	10.32 – 15.08
Holmes Harbor (areas A, B and C) Mean	5.1	0.47	1.7	0.09	13.4

PPM – parts per million

Discussion

Contaminants of Concern

Contaminants of concern (COC) in shellfish were determined by employing a screening process. Screening values (SV) were developed according to EPA guidance and were used to narrow the focus of evaluation to contaminants that are present at potential levels of public health concern [2]. Maximum shellfish contamination levels from each contaminant were screened against SV for cancer and non-cancer health effects (see Table 2 and Appendix A).

For chemicals that cause cancer, SVs represent levels that are calculated to increase an individuals risk of cancer by about one in one hundred thousand. With the exception of lead, SVs for chemicals that do not cause cancer represent levels that are not expected to cause any health problems. These types of SVs often form the basis for cleanup. In general, if a contaminant's maximum concentration is greater than its SV, then the contaminant is evaluated further. However, for lead the evaluation is based on the goal of keeping blood lead levels in most children below 10 micrograms per deciliter (μg/dl).

The contaminants of concern are highlighted in bold in Table 2 below. These contaminants will be evaluated in the following section. Other contaminants are not present at levels of concern and are not evaluated in this document.

Table 4: Mean and maximum metal concentrations found in shellfish and screening value used in evaluating shellfish from Holmes Harbor, Freeland, Island County, Washington.

Metals	Manila clams Concentration (ppm)		Varnish clams Concentration (ppm)		Screening Value Concentration (ppm)		Contaminant of concern
	Mean	Maximum	Mean	Maximum	Non Cancer	Cancer	
Total arsenic	5.1	7.4	4.05	4.5	NA	NA	NA
Inorganic arsenic 1 % of total	**0.051**	**0.074**	**0.041**	**0.045**	0.16	**0.00096**	**Yes**
Cadmium	0.47	**0.69**	0.06	0.068	**0.55**	NA*	**Yes**
Chromium	0.20	0.49	0.19	0.21	1.64	NA	No
Copper	1.7	2.3	6.5	7.0	21.9	NA	No
Lead	0.09	0.18	0.38	0.59	NA**	NA**	**Yes**
Nickel	1.14	1.4	0.49	0.65	10.9	NA	No
Zinc	13.4	15.0	40.5	43.0	164.3	NA	No
TBT	ND	ND	NA	NA	NA	NA	No

PPM – parts per million
NA- Not applicable
ND- Not detected
* Cadmium cancer risk is based on inhalation not ingestion.
**IEUBK - Integrated Exposure Uptake Biokinetic Model for lead in children is used to predict blood lead in children.

Chemical Specific Toxicity

Lead – *Occurrence, Health Concerns, and Risks*

Lead is a naturally occurring chemical element that is normally found in soil. In Washington, normal soil background concentrations rarely exceed 20 ppm [3]. However, the widespread use of certain products (such as leaded gasoline, lead-containing pesticides, and lead-based paint) and the emissions from certain industrial operations (such as smelters) has resulted in significantly higher levels of lead in soil in many areas of the state.

Elimination of lead in gasoline and solder used in food and beverage cans has greatly reduced exposure to lead. Currently, the main pathways of lead exposure in children are ingestion of paint chips, contaminated soil and house dust, and drinking water in homes with old plumbing.

Children less than seven years old are particularly vulnerable to the effects of lead. Compared to older children and adults, they tend to ingest more dust and soil, absorb significantly more of the lead that they swallow, and more of the lead that they absorb can enter their developing brain. Pregnant women and women of childbearing age should also be aware of lead in their environment because lead ingested by a mother can affect the unborn fetus.

Health effects

Exposure to lead can be monitored by measuring the level of lead in the blood. In general, blood lead rises 3-7 µg/dl for every 1,000 ppm increases in soil or dust concentration [4]. 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 micrograms of lead per deciliter of blood (µg/dl) [5]. However, there is growing evidence that damage to the central nervous system resulting in learning problems can occur at blood lead levels less than 10 µg/dl. About 2.2 percent of children in the U.S. have blood lead levels greater than 10 µg/dl.

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 [6].

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 [6]. 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 significant rise in blood lead level [7].

Arsenic

Arsenic is a naturally occurring element in the earth's soil. Background soil arsenic concentrations in Puget Sound Basin range from about 1.5 to 17.1 ppm [3]. However, the widespread use of arsenic-containing pesticides and the emissions from certain smelters has resulted in significantly higher levels of arsenic on many properties in the state. There are two forms of arsenic, organic and inorganic. The EPA established oral reference dose (RfD) for arsenic is 0.0003 mg/kg/day based on skin color changes and excessive growth of tissue (human data) [8]. EPA classifies the inorganic form of arsenic as a human carcinogen. The recent EPA IRIS review draft presented a cancer slope factor for combined lung and bladder cancer of 5.7 per mg/kg-day [9]. The slope factor calculated from the work by the National Research Council is about 21 per mg/kg/day [10]. These slope factors could be higher if the combined risk for all arsenic-associated cancers (bladder, lung, skin, kidney, liver, etc.) were evaluated. For this health consultation, DOH used a slope factor of 5.7 per mg/kg-day, which appears to reflect EPA's most recent assessment.

Studies have shown inorganic arsenic is much more harmful than organic arsenic; therefore, DOH will base this health evaluation on the levels of inorganic arsenic present in shellfish samples. Generally, inorganic arsenic in fish and shellfish normally ranged from about 1-20% of the total arsenic [8, 10, 11, 12]. Ecology's evaluation of shellfish in the Puget Sound indicated that less than 1% of the total arsenic found was in the inorganic form of arsenic [13]. For this health consultation, DOH assumed that 1% of the total arsenic detected was inorganic arsenic. Therefore, 1% of the concentration was used to calculate the estimated dose from exposure to inorganic arsenic in shellfish.

Cadmium

Cadmium is a naturally occurring element in the earth's crust. Cadmium is used mainly in batteries, pigments, metal coatings, and metal alloys. Cadmium is found in most foods at low levels, with the lowest levels found in fruits and the highest found in leafy vegetables and potatoes. Shellfish have higher cadmium levels (up to 1 ppm) than other types of fish or meat. Cadmium is stored in the liver and kidneys and slowly leaves the body in the urine and feces [14]. However, high levels of cadmium will cause kidney damage and bones to become fragile and break easily. Occupational exposure to inhaled cadmium is suspected to be a cause of lung cancer in workers, while animal studies have confirmed the ability of cadmium to cause lung tumors via the inhalation route. Studies of workers exposed to airborne cadmium also suggest a link with prostate cancer. The ability of cadmium to cause cancer via the oral route is disputed. The RfD for cadmium that is ingested with food is 0.001 mg/kg/day.

Evaluating non-cancer hazards

Exposure assumptions for estimating contaminant doses from shellfish exposure are found in Appendix B, Tables B1 – B2. In order to evaluate the potential for non-cancer adverse health effects that may result from exposure to contaminated media (i.e., air, water, soil, and sediment), a dose is estimated for each contaminant of concern. These doses are calculated for situations (scenarios) in which shellfish harvesters might be exposed to the contaminated shellfish. The estimated dose for each contaminant under each scenario is then compared to EPA's oral reference dose (RfD). RfDs 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 can be either the lowest-observed adverse effect level (LOAEL) or a no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that does not result in any observed adverse health effects.

Because of uncertainty in these data, the toxic effect level is divided by "safety factors" to produce the lower and more protective RfD. If a dose exceeds the RfD, this 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. If the estimated exposure dose is only slightly above the RfD, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the RfD, the closer it will be to the actual toxic effect level. This comparison is called a hazard quotient (HQ) and is given by the equation below:

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

Two scenarios were use to estimate exposure to contaminants in shellfish: general population and high-end shellfish consumers (i.e., Tulalip tribal members). Estimated exposure doses, exposure assumptions, and hazard quotients are presented in Appendix B for COCs (arsenic and cadmium) found in shellfish. Based on exposure estimates quantified in Appendix B, calculated hazard quotients were less than one for all scenarios. This means that the general population and high-end consumers (adults and children) are not likely to experience adverse non-cancer health effects from exposure to arsenic and cadmium in shellfish (see Appendix B, Table B3).

Evaluating exposure to lead

The biokinetics of lead is different from most toxicants because it is stored in bone and remains in the body long after it is ingested. Children's exposure to lead is evaluated through the use of the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) developed by the EPA. The IEUBK predicts blood lead levels in a distribution of exposed children based on the amount of lead that is in environmental media (e.g. shellfish) [15]. It is important to note that the IEUBK model is not expected to accurately predict the blood lead level of a child (or a small group of children) at a specific point in time. In part, this is because a child (or group of children) may behave differently, and therefore have different amounts of exposure to contaminated soil and dust, than the average group of children used by the model to calculate blood lead levels. For example, the model does not take into account reductions in exposure that could result from community education programs. Despite this limitation, the IEUBK model is a useful tool to help prevent lead poisoning because of the information it can provide about the hazards of environmental lead exposure. For children who are regularly exposed to lead-contaminated shellfish, the IEUBK model can estimate the percentage of young children who are likely to have blood lead concentrations that exceed a level that may be associated with health problems (usually 10 μg/dl).

Shellfish lead concentrations and estimated blood lead levels

The IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they eat lead contaminated shellfish. Exposure assumptions for estimating blood lead levels are found in Appendix C, Table C1. Default parameters were used for all other model inputs [15]. Exposure were based on a general population scenario of children eating 0.57 g/day or Tribal high-end consumer scenario of children eating 9 g/day of shellfish containing the average or maximum concentration of lead. Based on these scenarios, the model indicates no children would exceed the EPA's criteria of no more than 5% of the community with BLLs above 10 μg/dL (see Appendix C, Table C1).

The adult lead model was used to estimate the percentage of fetus' that would have elevated blood lead levels if women frequently ate lead contaminated shellfish. Exposure assumptions for estimating blood lead from shellfish exposure are found in Appendix C, Table C2. Exposures were based on a general population scenario of adults eating 17.5 g/day or a Tribal high-end consumer scenario of adults eating 93.5 g/day of shellfish containing the average or maximum concentration of lead. Based on these scenarios, the model indicates only Tribal high-end consumers (mothers) eating varnish clams at the maximum concentration would have greater than 5 % probability of carrying a fetus with blood lead levels greater than 10 μg/dl (see Appendix C, Table C2). This scenario is unlikely because varnish clams are not typically targeted for harvest and consumption.

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose similar to that described above and multiplying it by a cancer potency factor, also known as the cancer slope factor (CSF). 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.

Cancer Risk

Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		# of Excess Cancers
low	is approximately equal to	1 in 10,000
very low	is approximately equal to	1 in 100,000
slight	is approximately equal to	1 in 1,000,000
insignificant	is less than	1 in 1,000,000

Current regulatory practice suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will result in 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 an associated risk. The 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 potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise [16].

This document describes cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight and no significant increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands exposed over a lifetime and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers cancer risk insignificant when the estimate results in less than one cancer per one million exposed over a lifetime. 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 is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes; not all are fatal. Approximately 1/4 to 1/3 of people living in the United States will develop cancer at some point in their lives [17].

Cancer risk from exposure to shellfish was calculated for arsenic only (see Appendix B, Table B4). While the average or background total arsenic level for littleneck clams in the Puget Sound is about 1.9 ppm, the average found in this study is about 5.1 ppm (Appendix B, Tables B5 and B6). Therefore, lifetime cancer risk will be increased about three times as compared to the rest of the Puget Sound. The lifetime increase of cancer risk associated with exposure to arsenic (assuming 1% of total arsenic is inorganic arsenic) in shellfish at this site is low to slight (3.21×10^{-4}) or (3 in 10,000) to (6.95×10^{-6}) or (7 in 1,000,000).

No cancer risk was calculated for cadmium because cancer caused via the oral route by cadmium is disputed. In addition, the CSF for cadmium is for cadmium via the inhalation route, which is not a likely exposure route in this case.

Children’s Health Concerns

ATSDR recognizes that infants and children may be more vulnerable to 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.

Special consideration was given to children's exposure to contaminants in this health consultation by evaluating children's exposure to lead in shellfish separate from adults acknowledging that children are more susceptible to lead's toxicity than adults.

Conclusions

1. Exposure to arsenic, cadmium and lead in Holmes Harbor shellfish represents *no apparent public health hazard.*

    i. Maximum arsenic concentration would result in a lifetime cancer risk for high-end (subsistence) consumers of greater than 1 in 10,000, assuming all shellfish consumed contains the maximum level of arsenic and are from this area only. However, it is unlikely that 100% of a subsistence consumer's (86.9 g/day) clams would be harvested from the Holmes Harbor recreational area. While the average or background total arsenic level for littleneck clams in the Puget Sound is about 1.9 ppm, the average found in this study is about 5.1 ppm (Appendix B, Table B5 and B6). Therefore, lifetime cancer risk will be increased about three times as compared to the rest of the Puget Sound.

    ii. Adults and children consuming shellfish from Holmes Harbor that contain the maximum reported lead concentration (0.59 ppm) are not likely to have elevated blood lead levels. On the other hand, fetuses of subsistence consumers (86.9 g/day) consuming Varnish clams would exceed the EPA's criteria of no more than 5% of the community with BLLs above 10 µg/dL. However, it is unlikely a subsistence clam consumer (i.e., eating 86.9 g/day) would be consuming only Varnish clams harvested from the Holmes Harbor recreational area.

    Shellfish consumers from the general population and high-end consumers of shellfish from Holmes Harbor are not likely to experience non-cancer health effects.

Recommendations

1. The Department of Health's Office of Shellfish and Water Protection (OSWP) formerly the Office of Food Safety and Shellfish Programs (OFSS) and Island County should use this health consultation to guide their decision for recreational harvesting of shellfish in the Holmes Harbor recreational area.

2. DOH recommends additional sampling in Holmes Harbor due to the higher than normal level of arsenic found in the clams.

a. To verify the high arsenic concentration is restricted to the southern end of the harbor, collect shellfish outside the original sample area.

b. Split samples, depurate half of the clam samples for 24 hours prior to shucking and note changes in arsenic concentration if any.

Public Health Action Plan

Actions completed

1. OSWP conducted a shoreline survey, which resulted in closure of the growing and harvesting area of Freeland County Park due to high bacterial counts from the discharge points of concern along the Freeland County Park and NBBBI.

2. Sampling and analysis of clams for inorganic contaminants has been conducted to determine whether chemical contaminants are present at levels of health concern.

3. Clam inorganic contaminant data has been evaluated by DOH and presented within this health consultation.

4. Previous health consultation available at: (http://www.doh.wa.gov/ehp/oehas/publications_pdf/HealthConsults/holmesharbor_freeland_Island_9-30-06.pdf)

Action Planned

DOH will send copies of the health consultation to concerned parties and provide hard copies to this repository: Freeland Library - 5495 Harbor Ave, Freeland, WA 98249 (360) 331-7323

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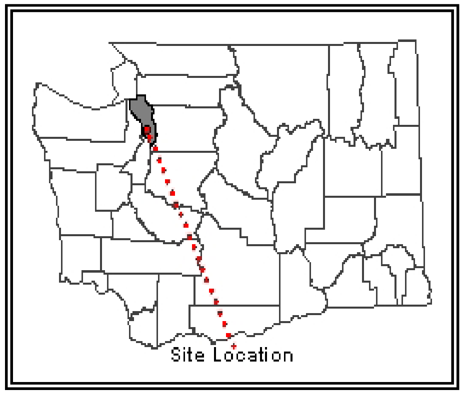
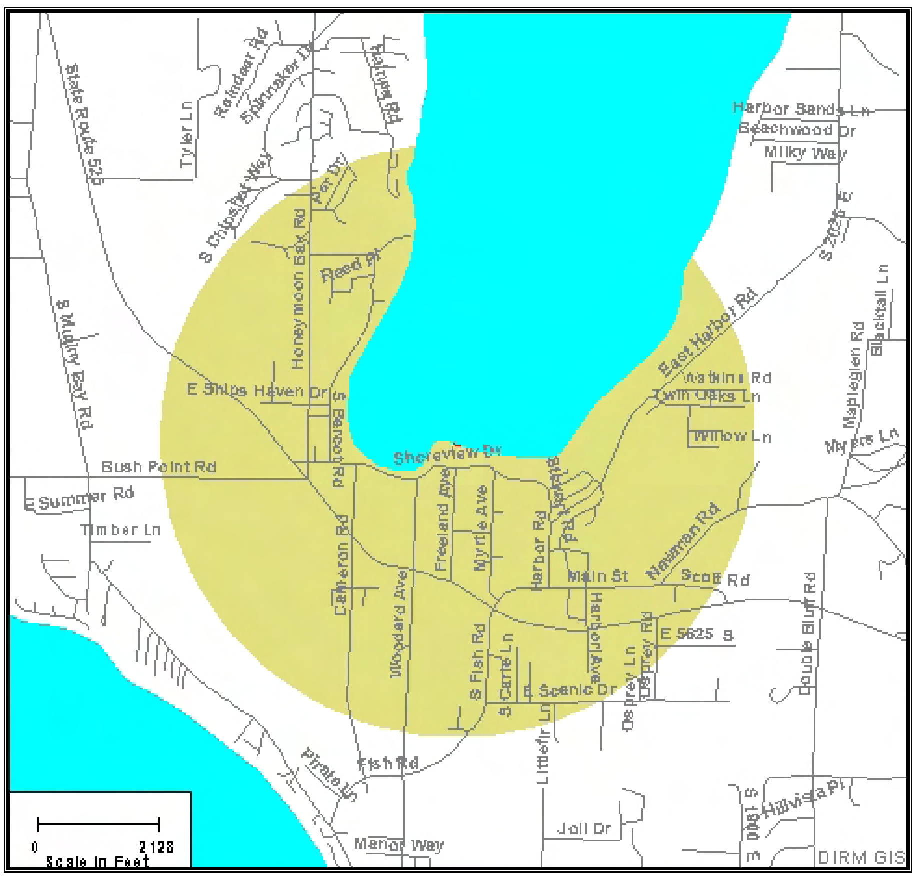
Figure 1. Demographic Statistics Within One Mile of the Site* - South end of Holmes Harbor, Island County.

Total Population	**878**
White	**830**
Black	**3**
American Indian, Eskimo, Aleut	**8**
Asian or Pacific Islander	**9**
Other Race	**3**
Hispanic Origin	**25**
Children Aged 6 and Younger	**66**
Adults Aged 65 and Older	**132**
Females Aged 15 - 44	**166**
Total Aged over 18	**679**
Total Aged under 18	**200**
Total Housing Units	**432**





*** Calculated using the area proportion technique. Source: 2000 U.S. CENSUS**

Figure 2. Holmes Harbor, Southwest Whidbey Island Shellfish Growing area, Island County Washington State

Figure 3. Holmes Harbor, Southwest Whidbey Island sample collection location, Island County Washington State

Appendix A

Screening Value Calculations

For Non-cancer Health Effects

SV = [(MRL or RfD)*BW]/CR * CF

SV = Screening value (mg/kg or ppm)
MRL = Minimal risk level (mg/kg/day)
RfD = Reference dose (mg/kg/day)
BW = Mean body weight (kg)
CR = Tulalip Tribe adult 95th percentile shellfish daily consumption rate (g/day)
CF = Conversion factor (kg/g)
CPF = Cancer Potency Factor

BW = 70kg
CR = 127.82 g/day
CF = 0.001

If maximum concentration is greater than screening value, further evaluation is required.

For Cancer Health Effects

Cadmium cancer risk is based on inhalation and not ingestion therefore; cadmium would not be evaluated for cancer risk.

SV = (Risk Level * BW) / (CR * CF * CPF)

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 in 100,000 individual exposed over a 70 yr lifetime.

If maximum concentration is greater than screening value, further evaluation is required.

Appendix B

This section provides calculated exposure doses and assumptions used for exposure to chemicals in shellfish from Holmes Harbor. These exposure scenarios were developed to model exposures that might occur. These scenarios were devised to represent exposures to the general population and the Tulalip Tribe. The following exposure parameters and dose equations were used to estimate exposure doses from ingestion with chemicals in fish.

Ingestion Route

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

$$\text{Cancer Risk} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Table B1. Exposure Assumptions used in exposure evaluation to contaminants in shellfish samples taken from Holmes Harbor, Freeland, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	ug/kg	Average detected value
Conversion Factor (CF_1)	0.001	mg/ug	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Conversion Factor (CF_2)	0.001	kg/g	Converts mass of fish from grams (g) to kilograms (kg)
Ingestion Rate (IR)	0.57		Body weight-adjusted consumption rates to account for children eating nearly 1.6 times as much fish per body weight as do adults (see table B2)
Ingestion Rate (IR)	9		90th percentile Tulalip Tribe child
Ingestion Rate (IR)	0.81	g/day	Body weight-adjusted consumption rates to account for an older child eating 0.81 times as much fish per body weight as do adults (see table B2)
Ingestion Rate (IR)	50.9		Based on 90th percentile Tulalip Tribe adult - older child eating at the same ingestion rate as an adult (body weight adjusted consumption rate)
Ingestion Rate (IR)	1.7		Average general population adult
Ingestion Rate (IR)	86.9		90th percentile Tulalip Tribe adult
Exposure Frequency (EF)	365	Days/year	Assumes daily exposure
Exposure Duration (ED)	6	years	Number of years at one residence (child)
Exposure Duration (ED)	30		Number of years at one residence (adult)
Body weight (BW)	15	kg	Mean body weight child
Body weight (BW)	70		Mean body weight adult
Averaging $\text{Time}_{\text{non-cancer}}$ (AT)	Variable	days	Equal to Exposure Duration
Averaging $\text{Time}_{\text{cancer}}$ (AT)	25550	days	70 years
Cancer Potency Factor (CPF)	Variable	mg/kg-day^{-1}	Source: EPA – Chemical specific

Table B2. Derivation of child and older child shellfish consumption rates for the general U.S. population.

Row	Parameter	Adult	Older Child (6-17 yrs)	Child (0-5 yrs)
1	Reported All Fish Consumption Rate-gram fish per kg bodyweight per day (g/kg/day)	0.277	0.225	0.433
2	Ratio to Adult All Fish Consumption Rate	1	0.81	1.6
3	Reported Shellfish Consumption (g/day)	1.70 (average)	Not Reported	Not Reported
4	Average Body Weight (kg)	70	41	15
5	Ratio to Adult BW	1	0.59	0.21
6	Adjusted Shellfish Consumption Rates (g/day) = Row 2 x Row 3 x Row 5	1.70 (average)	0.81 (average)	0.57 (average)

Table B3. Exposure dose and non-cancer risk from ingesting shellfish at the maximum concentration of contaminant from Holmes Harbor, Freeland, Washington.

Contaminant	Maximum Concentration (ppm)		Estimated Dose (mg/kg/day)		RfD (mg/kg/day)	Hazard quotient Average population	Hazard quotient 90th percentile Tulalip Tribe
			Average population	90th percentile Tulalip Tribe			
Arsenic	0.074	Child	2.81E-6	4.44E-5	3.00E-4	0.01	0.15
		Older child	1.46E-6	9.19E-5		0.005	0.31
		Adult	1.80E-6	9.19E-5		0.006	0.31
Cadmium	0.69	Child	2.62E-5	4.14E-4	1.00E-3	0.03	0.41
		Older child	1.36E-5	8.57E-4		0.01	0.86
		Adult	1.68E-5	8.56E-4		0.02	0.86

PPM – parts per million

Table B4. Cancer risk from ingesting Manila clam at the maximum total arsenic concentration obtained from southern Holmes Harbor (Areas A and B), Freeland, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor (mg/kg-day^{-1})		Increased Cancer Risk		Total Cancer Risk Average population	Total Cancer Risk 90th percentile Tulalip Tribe
				Average population	90th percentile Tulalip Tribe		
Arsenic	0.074	5.7	Child	1.37E-6	2.17E-5	6.95E-6	3.21E-4
			Older child	1.19E-6	7.48E-5		
			Adult	4.39E-6	2.24E-4		

PPM – parts per million

Table B5. Cancer risk from ingesting Manila clams at average total arsenic concentration obtained from southern Holmes Harbor (Areas A and B), Washington.

Contaminant	Holmes Harbor average Concentration (ppm)	Cancer Potency Factor (mg/kg-day^{-1})		Increased Cancer Risk	Total Cancer Risk 90th percentile Tulalip Tribe
Arsenic	0.051	5.7	Child	1.50E-5	2.21E-4
			Older child	5.16E-5	
			Adult	1.55E-5	

PPM – parts per million

Table B6. Cancer risk from ingesting littleneck clams at average arsenic concentration from Puget Sound, Washington.

Contaminant	Puget Sound average Concentration (ppm)	Cancer Potency Factor (mg/kg-day^{-1})		Increased Cancer Risk	Total Cancer Risk 90th percentile Tulalip Tribe
Arsenic	0.019	5.7	Child	5.57E-6	8.24E-5
			Older child	1.92E-5	
			Adult	5.76E-5	

PPM – parts per million

Appendix C

Lead exposure shellfish 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 shellfish ingestion lead exposure on Holmes Harbor, Washington. Consumption rates: General population (Gen.) child – 0.57 g/day: Tulalip Tribe (Sub) Child – 9 g/day.
IEUBK model assumes that a child's total meat intake is 93.5 g/day. EPA's target cleanup goal is no more than 5 % of the community with BLLs above 10 µg/dL. Default assumptions were used unless noted.

Table C1. Blood lead values determined using the IEUBK model for lead in shellfish from Holmes Harbor, Freeland, Washington.

Clam Species	Average Concentration (ppm)		Percent meat intake as shellfish (%)		Blood Lead level in percent above 10ug/dl Age range 0 - 84 months			
					Mean		Max	
	Mean	Max	Gen Child	Sub Child	Gen Child	Sub Child	Gen Child	Sub Child
Manila	0.09	0.18	0.61	9.6	1.21	1.4	1.22	1.7
Varnish	0.38	0.59			1.26	2.4	1.29	3.3

PPM – parts per million

Lead exposure shellfish ingestion scenario used in the Adult lead model

This section provides inputs for the Adult lead model. The following inputs to the model were used to account for the average fish ingestion lead exposure on Holmes Harbor, Washington. Consumption rates: General population (Gen.) 1.7 g/day: Tulalip Tribe (Sub) 86.9 g/day EPA's target cleanup goal is no more than 5 % of the community with BLLs above 10 µg/dL. Default assumptions were used unless noted.

Table C2. Blood lead values determined using the Adult lead model for lead in shellfish from Holmes Harbor, Washington.

Clam Species	Average Concentration (ppm)		Average Mother Blood Lead concentration in ug/dl Fetus Blood Lead in percent above 10ug/dl				
				Mean		Max	
	Mean	Max		Gen	Sub	Gen	Sub
Manila	0.09	0.18	mother	1.5	1.9	1.5	2.3
			fetus	0.4	0.8	0.4	1.6
Varnish	0.38	0.59	mother	1.5	3.1	1.5	4.0
			fetus	0.4	4.2	0.4	**8.2**

PPM – parts per million

Photo 1. Southern Shore of Holmes Harbor during normal tide

Photo 2. Southwestern Shore of Holmes Harbor during low tide

Certification

This Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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