THE STATE of ALASKA
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Health and Social Services

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February 23, 2022

Jamie Grant
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Re: Safety of clam consumption from Klag Bay, Alaska

Dear Ms. Grant:

Thank you for contacting the Environmental Public Health Program (EPHP) in the Section of Epidemiology regarding concerns about shellfish consumption in Klag Bay, Alaska. We examined the most recent data from the area that you recently provided us and have updated our previous health assessment below.

Background

In May 2020, Alaska Department of Environmental Conservation (ADEC) contacted the EPHP to help assess whether recreational and subsistence harvesting of shellfish in Klag Bay, Alaska poses any health risk from heavy metals at the site. The EPHP has provided health assessments in letter health consultations for two previous sampling events that occurred in 2014 (Appendix 2). This assessment is an update of those letter health consultations and is based on a June 2018 sampling event conducted by the Environmental Protection Agency (EPA).

In 1996, Klag Bay was placed on the EPA impaired water bodies Section 303(d) list due to contamination from tailings from the Chichagof Mine site that has impacted sediments and shellfish with heavy metals that include arsenic, cobalt, copper, lead, manganese, mercury, silver, and zinc. In May 2014, the EPHP provided ADEC with an assessment on the safety of eating shellfish from Klag Bay. Based on data from a report by the U.S. Fish and Wildlife Service (USFWS) titled *Mercury in Bald Eagle Blood and Marine Invertebrates from Klag Bay, Chichagof Island, Alaska* (USFWS, 2001), the EPHP concluded that the heavy metals concentrations in the shellfish should not harm people's health if they ate the clams and mussels.

In August 2014, ADEC conducted more sampling of mussels and clams in Klag Bay. In January 2015, ADEC asked that the EPHP update its assessment based on the new data. The EPHP provided ADEC with an updated letter health consultation in July 2015 that determined, once again, that eating clams and mussels from Klag Bay did not pose an appreciable health risk.

It should be noted that the State of Alaska advises that people not harvest shellfish from beaches that have not been tested for paralytic shellfish toxin (PST). PST can cause paralytic shellfish poisoning which can be lethal to an adult in an amount as small as 1 milligram of toxin (ADEC, 2021). Our health assessments for Klag Bay have solely analyzed heavy metals concentrations in clams at the site to determine whether these concentrations could harm people's health. We make no conclusions on the safety of consuming these clams from the perspective of PST.

The following assessment is based on the June 2018 sampling event conducted by the EPA, which included samples of softshell clams and littleneck clams that were tested for heavy metals.

Exposure and Health Evaluation

To re-evaluate the potential exposure to metals in clams from Klag Bay, we used data collected by the EPA from June 10 – 19, 2018 (EPA, 2019). We used 2013 subsistence harvest data collected by the Alaska Department of Fish and Game for Sitka, Alaska as an estimate of the average community traditional food consumption (ADFG, 2020; 2013 was the most recent year that harvest data for Sitka clams were available) (Appendix 1, Table 3). We used these data because there are no harvest or consumption data specifically for Klag Bay and Sitka is the nearest location with harvest data. In this update, we used the 95th percentile of subsistence user clam harvest per day as a conservative approach. We chose this method due to the small numbers of samples and the desire to be protective in our calculations.

Composite samples contained an unidentified number of individual clams from each location (decision units 6 through 12; please see EPA, 2019 for details on the decision units), for a total of seven different composite samples from seven different locations. Of these composite samples, six were softshell clam samples and one was littleneck clam.

Clams were depurated for at least 24 hours in ambient seawater to remove any sediment present in their stomachs before subsampling and analysis. Following depuration, the siphon skins were removed, and subsamples taken for metals analysis. The Oregon Health Authority has shown that most inorganic arsenic is found in the siphon skin of the clam (Oregon Health Authority, 2015).

Clams were analyzed for a suite of 16 different metals. As we discuss later, arsenic and cadmium were considered contaminants of concern in this assessment. The concentrations and calculated exposure doses for arsenic and cadmium are reported in Tables 1 and 2 in Appendix 1. For a full list of concentrations and calculated exposure doses for each contaminant considered in our analysis, please contact the Environmental Public Health Program.

Average concentrations of metals in soft shell clams were calculated using results from composite samples of clams (Table 1). In addition, risk was assessed using the maximum metals concentrations in the clam samples due to the small number of samples (Table 2). Both the average and maximum concentration scenarios were used for calculations to represent both a moderate amount of use for the site (average concentrations) and also to present a protective scenario for harvesters who may use the site more (maximum concentrations). The data were reported in dry weight and were converted to wet weight to assess risk as people generally do not consume dried clams. We used the average moisture content of the Klag Bay softshell clam samples of 88% for these calculations.

In this assessment, only health risks from eating softshell clams were calculated as there was only one sample of littleneck clams and metal concentrations in the littleneck clam were lower for most metals than in the softshell clam. Most importantly, in the one available sample, the inorganic arsenic content of the littleneck clam was an order of magnitude lower than in the softshell clams. We could not assess health risks of littleneck clams at Klag Bay based on only one sample. As will be discussed later in this document, inorganic arsenic is the metal that presents the most potential for health risk from consuming the clams.

Non-cancer Risks

For each metal, we calculated a daily exposure dose (*i.e.*, mass of metal ingested per body weight of person) for people consuming clams from Klag Bay using both the average concentrations and the maximum concentrations found in the samples of clams. We then compared the exposure doses to ATSDR's Minimal Risk Level (MRL), which is an estimate of the daily human exposure dose that is unlikely to cause non-cancer health effects. Where possible, MRLs are available for three specified exposure periods: Acute (14 days or less), intermediate (15 to 365 days), and chronic (more than 365 days). We calculated exposures for all three exposure periods when MRLs were available. MRLs for every contaminant are not available for all the exposure periods.

We then calculated a hazard quotient (HQ) to measure whether the food intake, combined with the contaminant concentration, could pose a non-cancer health risk. For a given substance, the HQ is the ratio of the site-specific exposure to the exposure that is not expected to result in adverse non-cancer health effects (Equation 1).

Equation 1: Calculated Hazard Quotient (HQ):

HQ = Daily Dose of contaminant/MRL

Where,

Daily Dose = Amount of contaminant ingested (mg) daily on a chronic basis (one year or longer) per kilogram body weight (mg/kg/day)
MRL = Minimal Risk Level (mg/kg/day)

If the HQ equals 1 or less ($HQ \leq 1$), then no adverse health effects are expected. If the HQ is greater than 1 ($HQ > 1$), then adverse health effects are possible. It is important to note that an HQ greater than 1 does not necessarily mean that adverse health effects will occur. If the HQ is greater than 1 for a specific contaminant, that contaminant becomes a contaminant of concern (COC) and is evaluated further to determine whether health effects will occur.

We calculated possible daily exposure doses for both children and adults. We assumed children younger than two years of age did not eat clams. The contaminant concentrations, calculated exposure doses, MRLs, HQs, and cancer risks for contaminants of concern are listed in Table 1 and Table 2. The equation we used to calculate the exposure dose, as well as the assumptions we used for these calculations, are listed in Table 3. As shown in Table 1, no HQs for any of the contaminants of potential concern were greater than 1 when we used the mean metals concentrations found in the softshell clams. When we used the maximum concentrations of metals in clams, the hazard quotient was greater than 1 for two contaminants (1.4 for arsenic and 1.1 for cadmium) for children ages 2 years to 6 years old (Table 2).

Although the HQ is greater than 1 for arsenic for one age group, we do not expect that eating the clams will harm children's health. It is unlikely that children will eat the estimated quantity of clams (Table 3) with the maximum contamination, every day for four years which is what these calculations assume in order to be protective. For arsenic, the study that the chronic oral MRL was based on found the no observed-adverse-effect level (NOAEL), the highest dose of a contaminant in a study at which there was not an observed toxic or adverse effect, to be 0.0008 mg arsenic/kg body weight/day. To calculate the MRL, an uncertainty factor of 3 was applied to the NOAEL to account for variability in adverse responses among people (interhuman variability), which produced a MRL of 0.0003 mg/kg body weight/day (ATSDR, 2007). In this health assessment, the dose of inorganic arsenic for children ages 2 to 6 years old eating clams with the maximum amount of inorganic arsenic in all the samples was 0.00043 mg/kg body weight/day (Table 2). While this is slightly higher than the chronic oral MRL, it is below the NOAEL.

These calculations, coupled with the unlikelihood of children eating only clams with the maximum levels of contaminants, makes it unlikely that eating Klag Bay clams will harm the health of children ages 2 to 6 years old because of arsenic. It should also be noted that some areas of Southeast Alaska, as is also true in other parts of Alaska, have naturally occurring inorganic arsenic (background arsenic) (DNR, 2021). Background sediment samples taken from beaches near Klag Bay (5 miles and 2 miles away) contained naturally occurring arsenic (EPA, 2019). Hence, some of the arsenic found in the clams may be from naturally occurring arsenic and not necessarily from mining activities. Since background soft shell clam samples were not obtained for Klag Bay, it is not possible to know background levels of inorganic arsenic in the Klag Bay clam samples.

Though the HQ for cadmium is also greater than 1 for one age group, we do not expect that eating the clams will harm children's health due to the cadmium concentrations. For cadmium, the calculations that were used to produce the ATSDR chronic oral MRL also include uncertainty factors that are related to variability in adverse responses among people. The MRL for cadmium is based on a dietary intake and point-of-departure dose of 0.0003 mg/kg bw/day of cadmium, divided by an uncertainty factor of 3 (for interhuman variability), which produces a MRL of 0.0001 mg/kg body weight/day. The toxicity endpoint was the 95% lower confidence limit on a 10% excess risk of low molecular weight proteinuria, a biomarker of kidney function, by the age of 55 years after a lifetime of exposure (ATSDR, 2012). The calculated dose in this assessment for children ages 2 to 6 years old eating clams with the maximum amount of contamination was 0.0001 mg/kg body weight/day (Table 2) which is equal to the MRL and three-fold less than the level used for the toxicity endpoint for proteinuria. As we stated above, it is also unlikely that children will be eating the estimated quantity of clams every day for four years as is assumed in this assessment. For these reasons, we do not expect that the cadmium levels in the Klag Bay clams will harm the health of children ages 2 to 6 years old.

Cancer Risks

We calculated cancer risk for the levels of inorganic arsenic found in Klag Bay softshell clams. Studies have shown that ingestion of inorganic arsenic can increase the risk of skin, liver, bladder, and lung cancer. Inhalation of inorganic arsenic can cause increased risk of lung cancer. National and international agencies such as the EPA, the U.S. Department of Health and Human Services, and the International Agency for Research on Cancer have determined that inorganic arsenic is carcinogenic to humans (ATSDR, 2007).

To evaluate possible cancer risks, EPHP calculated the excess cancer risk that could be associated with the cumulative daily dose expected from exposure to arsenic over a lifetime. Daily exposure doses were multiplied by arsenic's cancer slope factor (CSF), an estimate of the risk of cancer associated with exposure to a carcinogenic or potentially carcinogenic substance. As opposed to non-cancer risk that may occur within hours to several years after repeated exposure to an agent, cancer risk is calculated based on multi-year exposure (40 years in this consultation for adults, and 19 years for children) (Tables 1 and 2).

CSFs are used to estimate the risk of cancer associated with exposure to a cancer-causing or potentially cancer-causing substance. EPHP calculated the possible cancer risks associated with arsenic at the site by using the following equation:

Equation 2: Calculated possible cancer risk:

*Calculated possible cancer risk (individual contaminant) = (D * CSF) * (ED / LY)*

Where,

D = Age-Specific Dose (mg/kg/day). Amount of contaminant ingested daily on a chronic basis per kilogram body weight.
CSF = Cancer Slope Factor ($(mg/kg/day)^{-1}$)
ED = Age-Specific Exposure Duration (years) (40 years for adults, 19 years for children in this consultation)
LY = Lifetime in Years (78 years)

The resulting risk of cancer is called an excess cancer risk because it is the risk of cancer above the already existing background risk of cancer. The risk could also be zero. Therefore, one interprets the excess cancer risk as being between 0 and some number for every defined number of people (usually for every 10,000, 100,000, or 1,000,000 people) who are exposed to a contaminant or contaminants over their lifetime (78 years). According to the American Cancer Society, the lifetime risk of cancer in the U.S. population is about 1 in every 2 men and 1 in every 3 women over a lifetime (ACS, 2021). The estimated cancer risk from the equation above is in addition to this background cancer risk.

If the cancer risk equals 1 in 10,000 exposed or less (e.g., 1 in 100,000 or 1 in a 1,000,000) then the cancer risk is considered acceptable by the Environmental Protection Agency. If the cancer risk is greater than 1 in 10,000 exposed (e.g., 1 in 1,000 or 1 in a 100) then that population may be at increased cancer risk. It is important to note that a cancer risk greater than 1 in 10,000 does not necessarily mean that adverse health effects like cancer will occur. In this analysis, we found that cancer risk from arsenic for adults eating softshell clams with the average amount of metals contamination from Klag Bay was 8 in 100,000 and cancer risk for children was lower at 6 in 100,000. Both of these cancer risks are considered in the acceptable range by the Environmental Protection Agency. These risks assume that adults are eating clams from Klag Bay for 40 years and children are eating clams from the site for 19 years (Table 1). Cancer risk for both adults and children eating clams with the maximum concentration of arsenic seen in the clam samples was 1 in 10,000 (Table 2). While this cancer risk is higher than the risk from eating clams with average concentrations of contaminants, the cancer risk from eating clams with the maximum amount of contamination seen in the samples from Klag Bay is still in the acceptable range.

Conclusions

Based on our calculations using existing contaminant data, the EPHP concludes that eating clams from Klag Bay poses no apparent public health hazard. However, because of the limited availability of clams during the sampling (EPA, 2019) and because we do not have harvest or consumption data from Klag Bay, there is uncertainty in this assessment. Representatives from the Sitka Tribe indicated that Sitka lies 60 miles south of Klag Bay and can be a difficult trip on open ocean (personal communication). They also indicated that Klag Bay is not a frequent subsistence site. The site is harvested opportunistically at times, but not consistently or heavily. Even if more clams were available from Klag Bay, the assumed consumption rate and metals concentrations in clam tissue do not indicate that eating the clams would harm a person’s health. In addition, harvest data may not be representative of actual consumption. Current harvest and consumption rates for Klag Bay would allow us to more accurately calculate the risk of consuming clams from Klag Bay. However, the State of Alaska recommends that people not harvest shellfish from beaches that have not been tested for PST.

Uncertainties

1. The clam consumption rates are based on historic harvest data from Sitka, and therefore our calculations may not reflect current use of Klag Bay for clamming. Klag Bay is a challenging site to reach by boat. Because of this, the consumption rates of clams from Klag Bay that were used in this analysis are likely an overestimate. The risk calculations based on these estimates are protective of the clamming population.

2. We assumed that children under 11 years of age consumed half of an adult portion of clams. Some children may eat more or less than this, so the risk conclusions may differ from this assessment depending on a child's individual serving size.
3. In Southeast Alaska, naturally occurring arsenic (background arsenic) is present in some areas. Hence, some of the arsenic found in the softshell clams in Klag Bay may be from naturally occurring arsenic and not all from human activity such as mining. The background softshell clam samples (*i.e.*, the comparison samples) in this study were from Salt Chuck Mine and not Klag Bay. No background data is available from Klag Bay. The background data is from a different location and the softshell clam samples from Salt Chuck Mine were analyzed with their siphon skins on, whereas the clams that this assessment is based on were analyzed with their siphon skins removed. As mentioned earlier, arsenic can accumulate in the siphon skin of softshell calms, potentially biasing arsenic concentrations higher in those samples than in samples that were analyzed without the siphon skin (EPA, 2019). For these reasons, the background arsenic data may not be accurate for Klag Bay.
4. Since softshell clams have higher concentrations of inorganic arsenic than other shellfish species, our analysis of the risk of eating softshell clams from Klag Bay is likely an overestimate of risk for other clam species.
5. Our health assessment is based on a small sample size of six composite samples. The contaminant concentrations in these samples may not represent the concentrations in all Klag Bay clams. Our assessment would be strengthened by a larger number of samples.

Recommendations

EPHP recommends that:

1. DEC continue to monitor clam contaminant concentrations at Klag Bay, as warranted, to characterize the extent of contamination at the site.
2. As time and resources allow, consider obtaining clam harvest data specific to Klag Bay. These data would enable us to form a health assessment that is more reflective of actual harvest size from Klag Bay.
3. As time and resources allow, consider further sampling of clams at Klag Bay. Data from a larger number of clams may help address some of the uncertainties of our assessment. Additionally, the collection of background clam samples from the Klag Bay area may help characterize background arsenic levels specific to the area.
4. It is important that people who eat softshell clams from Klag Bay remove the siphon skins before they consume the clam. This is because most of the inorganic arsenic in the clam is found in the siphon skin. However, it is important to note that the State of Alaska does not recommend harvesting shellfish from beaches that have not been tested for PST.

Please feel free to contact us with any questions that you may have.

Sincerely,

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Disclaimer: This report was supported by funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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Appendix 1

Tables

Table 1. Klag Bay Clams Calculated Dose, Hazard Quotient, and Cancer Risk Using Mean Contaminant Concentrations

1a. Chronic Exposure Timeframe – Mean metals concentrations

Exposure Group	Chronic Dose (mg/kg/day)	Chronic Hazard Quotient	Cancer Risk	ED (yrs)
Inorganic Arsenic (Concentration: 0.4236 mg/kg; Chronic MRL: 0.0003 mg/kg/day; CSF: 1.5 (mg/kg/day)$^{-1}$)				
2 to < 6 years	0.00024	0.81	5.7E-5 β	4
6 to < 11 years	0.00013	0.44		5
11 to < 16 years	0.00015	0.48		5
16 to < 21 years	0.00012	0.38		5
Total exposure duration for child cancer risk				19
Adult	0.00010	0.34	7.9E-5 β	40
Cadmium (Concentration: 0.15 mg/kg; Chronic MRL: 0.0001 mg/kg/day; CSF: NA[1])				
2 to < 6 years	8.6E-05	0.86	NC	4
6 to < 11 years	4.7E-05	0.47		5
11 to < 16 years	5.1E-05	0.51		5
16 to < 21 years	4.1E-05	0.41		5
Total exposure duration for child cancer risk				19
Adult	3.7E-05	0.37	NC	40

[1] Carcinogen; No cancer slope factor (CSF)
β Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation

CSF = Cancer slope factor
ED = Exposure duration
Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 1b. Intermediate Exposure Timeframe – Mean metals concentrations

Exposure Group	Intermediate Dose (mg/kg/day)	Intermediate Hazard Quotient
Inorganic Arsenic (Concentration: 0.4236 mg/kg; Intermediate MRL: NA)		
2 to < 6 years	0.00024	NC
6 to < 11 years	0.00013	NC
11 to < 16 years	0.00015	NC
16 to < 21 years	0.00012	NC
Adult	0.00010	NC
Cadmium (Concentration: 0.15 mg/kg; Intermediate MRL: 0.0005 mg/kg/day)		
2 to < 6 years	8.6E-05	0.17
6 to < 11 years	4.7E-05	0.094
11 to < 16 years	5.1E-05	0.10
16 to < 21 years	4.1E-05	0.082
Adult	3.7E-05	0.073

ED = Exposure duration
Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 1c. Acute Exposure Timeframe – Mean metals concentrations

Exposure Group	Acute Dose (mg/kg/day)	Acute Hazard Quotient
Inorganic Arsenic (EPC: 0.4236 mg/kg; Acute MRL: 0.005 mg/kg/day)		
2 to < 6 years	0.00024	0.049
6 to < 11 years	0.00013	0.027
11 to < 16 years	0.00015	0.029
16 to < 21 years	0.00012	0.023
Adult	0.00010	0.021
Cadmium (EPC: 0.15 mg/kg; Acute MRL: NA)		
2 to < 6 years	8.6E-05	NC
6 to < 11 years	4.7E-05	NC
11 to < 16 years	5.1E-05	NC
16 to < 21 years	4.1E-05	NC
Adult	3.7E-05	NC

ED = Exposure duration
Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 2. Klag Bay Clams Maximum Contaminant Concentrations, Dose, Hazard Quotient, and Cancer Risk

Table 2a. Chronic Exposure Timeframe – Maximum metals concentrations

Exposure Group	Chronic Dose (mg/kg/day)	Chronic Hazard Quotient	Cancer Risk	ED (yrs)
Inorganic Arsenic (Concentration: 0.74936 mg/kg; Chronic MRL: 0.0003 mg/kg/day; CSF: 1.5 $(mg/kg/day)^{-1}$)				
2 to < 6 years	0.00043	1.4 α	1.0E-4 β	4
6 to < 11 years	0.00024	0.79		5
11 to < 16 years	0.00026	0.86		5
16 to < 21 years	0.00020	0.68		5
Total exposure duration for child cancer risk				19
Adult	0.00018	0.61	1.4E-4 β	40
Cadmium (Concentration: 0.19 mg/kg; Chronic MRL: 0.0001 mg/kg/day; CSF: NA[1])				
2 to < 6 years	0.00011	1.1 α	NC	4
6 to < 11 years	6.0E-05	0.60		5
11 to < 16 years	6.5E-05	0.65		5
16 to < 21 years	5.2E-05	0.52		5
Total exposure duration for child cancer risk				19
Adult	4.6E-05	0.46	NC	40

[1] Carcinogen; No cancer slope factor (CSF)
α Hazard Quotients are greater than 1. The health assessor should conduct further toxicological evaluation.
β Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation

CSF = Cancer slope factor
ED = Exposure duration
Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 2b. Intermediate Exposure Timeframe – Maximum metals concentrations

Exposure Group	Intermediate Dose (mg/kg/day)	Intermediate Hazard Quotient
Inorganic Arsenic (Concentration: 0.74936 mg/kg; Intermediate MRL: NA)		
2 to < 6 years	0.00043	NC
6 to < 11 years	0.00024	NC
11 to < 16 years	0.00026	NC
16 to < 21 years	0.00020	NC
Adult	0.00018	NC
Cadmium (Concentration: 0.19 mg/kg; Intermediate MRL: 0.0005 mg/kg/day)		
2 to < 6 years	0.00011	0.22
6 to < 11 years	6.0E-05	0.12
11 to < 16 years	6.5E-05	0.13
16 to < 21 years	5.2E-05	0.10
Adult	4.6E-05	0.093

ED = Exposure duration
Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 2c. Acute Exposure Timeframe – Maximum metals concentrations

Exposure Group	Acute Dose (mg/kg/day)	Acute Hazard Quotient
Inorganic Arsenic (Concentration: 0.74936 mg/kg; Acute MRL: 0.005 mg/kg/day)		
2 to < 6 years	0.00043	0.086
6 to < 11 years	0.00024	0.047
11 to < 16 years	0.00026	0.051
16 to < 21 years	0.00020	0.041
Adult	0.00018	0.037
Cadmium (Concentration: 0.19 mg/kg; Acute MRL: NA)		
2 to < 6 years	0.00011	NC
6 to < 11 years	6.0E-05	NC
11 to < 16 years	6.5E-05	NC
16 to < 21 years	5.2E-05	NC
Adult	4.6E-05	NC

Concentration = Exposure point concentration
MRL = Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level
NC = Not calculated
Mg/kg/day = milligrams per kilogram per day

Table 3. Equation for the ingestion of clams exposure pathway

Exposure Pathway: Ingestion of Clams or Mussels **Equation: Dose (mg/kg/day) = (C x IR x AF) / BW** Source: ATSDR, 2005				
Parameter	**Parameter Definition**	**Units**	**Value**	**Reference/ Reason**
C	Contaminant Concentration	mg contaminant/kg clam (mg/kg)	Tables 1 and 2 - Concentration	EPA, 2019
IR	Intake Rate of clams and/or mussels	kg clams/day (kg/day)	Sitka harvest data: Clams: 2×10^{-2} <11 years old: 1×10^{-2}	ADFG, 2020
AF	Bioavailability Factor*	Unitless	1	Dose is compared to MRL. No additional bioavailability considerations
BW	Body Weight	kg	Adult = 80 Child (2-21 yrs) = 17.4 to 71.6	ATSDR, 2014

mg/kg/day = milligrams per kilogram body weight per day, kg = kilogram

*The bioavailability factor represents, as a percent, the total amount of a substance ingested, inhaled, or contacted that actually enters the bloodstream and is available to possibly harm a person. Typically, the bioavailability factor is assumed to be 1 (100%) for screening purposes. That is, all of a substance to which a person is exposed is assumed to be absorbed.

Appendix 2

Letter Health Consultations

THE STATE of ALASKA
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May 5, 2014

Sally Schlichting
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Re: Safety of clam and mussel consumption in Klag Bay, Alaska

Dear Ms. Schlichting:

Thank you for contacting the Environmental Public Health Program (EPHP) in the Section of Epidemiology regarding concerns about shellfish consumption in Klag Bay, Alaska. We examined data that were available from past studies of the area and describe our health assessment below.

Background

In February, 2013, the Alaska Department of Environmental Conservation (DEC) contacted the Environmental Public Health Program (EPHP) to help assess whether recreational and subsistence harvesting of seafood in Klag Bay, Alaska poses any health risk. The Sitka Tribe of Alaska contacted DEC with this inquiry. The Alaska Division of Water has declared Klag Bay to be impaired due to contamination from tailings from the Chichagof Mine site that has impacted sediments and possibly shellfish with heavy metals. There are currently signs in Klag Bay to alert users about possible risks of consumption of seafood from Klag Bay.

Exposure and Health Evaluation

To evaluate the potential exposure to metals in clams and mussels in Klag Bay, we used data from a report by the U.S. Fish and Wildlife Service (USFWS) titled *Mercury in Bald Eagle Blood and Marine Invertebrates from Klag Bay, Chichagof Island, Alaska* (USFWS, 2001). We used subsistence harvest data for Sitka, Alaska available from the Alaska Department of Fish and Game (ADFG, 2014) as an estimation of community traditional food consumption. The data are summarized in Table 1 (Appendix) and our calculated exposures to the metals present at the site are summarized in Table 2 (Appendix).

Average concentrations for both clams and mussels were calculated using the samples analyzed for each metal in each species (clams and mussels) in the USFWS report (Table 1, Appendix). The USFWS collected four composite clam and three composite blue mussel samples from three locations within Klag Bay.

To calculate a daily exposure dose for people harvesting clams and mussels at Klag Bay we used the average contaminant concentrations from each species for each metal. We then added the exposures for clams and mussels and compared the cumulative (added) exposure of both species to the respective comparison value (CV) for each contaminant. These CVs are set by federal or state agencies for each contaminant to protect human health (Table 2, Appendix). When a person's exposure level to a contaminant is higher than the contaminant's CV, that contaminant becomes a "contaminant of concern," or COC. When a person's exposure level is lower than the contaminant's CV, the exposure is not expected to result in adverse health effects and we do not look at the contaminant further. It is important to note that a COC does not mean that we expect to see harmful effects from exposure to that contaminant. Rather, it simply flags the contaminant for closer evaluation to determine whether health effects may occur

We calculated possible exposure doses for a child that is 1 year to 6 years old and for an adult to determine if age is a factor in health risks from contaminants at Klag Bay. The calculated exposure doses and their comparison to CVs are shown in Table 2. The equations we used to calculate the exposure dose for each pathway, as well as the assumptions we used for these calculations, are listed in Table 3 in the Appendix. Based on our calculations, age is not a factor in health risks from contaminants in Klag Bay as the risks were identical for both adults and children.

We also used a calculation called the hazard quotient (HQ) to measure whether the food intake, combined with the contaminant level, could pose a health risk. The HQ is the ratio of the potential exposure to a substance at the level that is not expected to result in adverse health effects (Equation 1).

<u>Equation 1: Calculated Hazard Quotient (HQ):</u>

HQ = (Chronic Daily Dose of contaminant)/CV

Where,

> Chronic Daily Dose = Amount of contaminant ingested daily on a chronic basis per kilogram body weight
> CV = Contaminant's comparison value

If the HQ equals 1 or less ($HQ \leq 1$), then no adverse health effects are expected. If the HQ is greater than 1 ($HQ > 1$), then adverse health effects are possible. It is important to note that an HQ greater than 1 does not necessarily mean that adverse health effects will occur.

To calculate the risk of exposure to lead, we used the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (EPA, 2010). We used the default parameters in the model except that we used lead contamination levels found in clams and mussels from Klag Bay for the diet lead intake parameter. The model suggested that eating clams and mussels from Klag Bay would have negligible impact on blood lead levels.

As Table 2 illustrates, no HQs for any of the contaminants of potential concern were greater than 1. Given the data that we have, there appears to be no health risk in eating shellfish from Klag Bay. However, because of the age of the data and the fact that the harvest data we used for our calculations are from Sitka and not Klag Bay, there is uncertainty in this assessment. Representatives from the Sitka Tribe indicated that Sitka lies 60 miles south of Klag Bay and can be a difficult trip on open ocean (personal communication, February 24th, 2013). They also indicated that Klag Bay is not a frequent subsistence site, but is sometime harvested opportunistically. More recent contamination data as well as harvest and consumption rates for Klag Bay would allow us to more accurately calculate the risk of consuming shellfish from Klag Bay.

In addition to shellfish data, we also reviewed data on concentrations of metals in salmon harvested from Klag Bay. These samples were collected in 2010 and analyzed by the DEC Fish Monitoring Program that provided the data. Based on the Alaska Fish Consumption Guidelines published by the Alaska Division of Public, metals concentrations in salmon from Klag Bay do not present a health concern.

Conclusions

The EPHP concludes that based on existing contaminant data, eating clams and mussels from Klag Bay does not pose a health risk. Given that the data used for our calculations are from the year 2001 and the consumption rates are based on historic harvest data from Sitka, Alaska, our calculations may not reflect current conditions.

Recommendations

EPHP recommends that more recent shellfish contaminant concentration data be collected along with consumption data for Klag Bay so that a more accurate health assessment can be conducted.

Please feel free to contact us with any questions that you may have.

Sincerely,

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Disclaimer: This report was supported by funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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National Academy of Sciences. Institute of Medicine. Food and Nutrition Board. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc.

US FWS, 2001. Mercury in bald eagle blood and marine invertebrates from Klag Bay, Chichagof Island, Alaska.

Appendix

Table 1. Average Metals Concentrations from Clams and Mussels in Klag Bay

Analyte	Clams (mg/kg)	Mussels (mg/kg)
Aluminum	38.20	186.33
Arsenic	1.61	1.84
Boron	2.23	4.47
Barium	1.62	1.25
Beryllium	0.01	0.02
Cadmium	0.18	0.55
Chromium	0.76	2.24
Copper	1.51	1.53
Iron	95.95	433.67
Mercury	0.09	0.06
Magnesium	727.25	1075.33
Manganese	1.97	4.70
Molybdenum	0.12	0.09
Nickel	0.32	1.53
Lead	0.38	0.69
Selenium	0.39	0.50
Strontium	7.56	18.87
Vanadium	0.53	0.96
Zinc	17.53	16.30
Methylmercury	0.05	0.04

mg/kg = milligram per kilogram

Table 2. Calculated exposure doses from consumption of Klag Bay clams and mussels.

	Ingestion Dose Clams (mg/kg/d)	Ingestion Dose Mussels (mg/kg/d)	Comparison Value (CV)	CV Source	Hazard Quotient
Aluminum	0.003	0.0002	1.0	ATSDR chronic MRL	0.003
Arsenic	1.2×10^{-5}	1.7×10^{-6}	0.0003	ATSDR chronic MRL	0.04
Boron	0.0002	4.2×10^{-6}	0.2	ATSDR chronic MRL	0.001
Barium	0.0001	1.2×10^{-6}	0.2	ATSDR chronic MRL	0.001
Beryllium	1.0×10^{-6}	1.4×10^{-8}	0.002	ATSDR chronic MRL	0.001
Cadmium	1.3×10^{-5}	5.2×10^{-7}	0.0001	ATSDR chronic MRL	0.1
Chromium †	5.5×10^{-5}	2.1×10^{-6}	1.5	EPA RfD	0.000
Copper	0.0001	1.4×10^{-6}	0.12	NAS IOM Tolerable Upper Intake Level	0.001
Iron	0.007	0.0004	0.64	NAS IOM Tolerable Upper Intake Level	0.01
Mercury	6.5×10^{-6}	5.6×10^{-8}	0.0004	Alaska Division of Public Health	0.02
Magnesium	0.05	0.001	5.0	NAS IOM Tolerable Upper Intake Level	0.01
Manganese	0.0001	4.4×10^{-6}	0.16	NAS IOM Tolerable Upper Intake Level	0.001
Molybdenum	8.5×10^{-6}	8.4×10^{-8}	0.029	NAS IOM Tolerable Upper Intake Level	0.0003
Nickel	2.3×10^{-5}	1.4×10^{-6}	0.014	NAS IOM Tolerable Upper Intake Level	0.002
Lead	2.7×10^{-5}	6.5×10^{-7}	NA*	NA*	NA*
Selenium	2.8×10^{-5}	4.7×10^{-7}	0.005	ATSDR chronic MRL	0.006
Strontium	0.0005	1.8×10^{-5}	0.6	EPA RfD	0.001
Vanadium	3.9×10^{-5}	9.0×10^{-7}	0.005	EPA RfD	0.008
Zinc	0.001	1.5×10^{-5}	0.3	ATSDR chronic MRL	0.004
Methylmercury	3.7×10^{-6}	3.5×10^{-8}	0.0003	ATSDR chronic MRL	0.01

mg/kg/d = milligram per kilogram of body weight per day.

† We have assumed all chromium to be trivalent chromium. If sediment and water at Klag Bay contains hexavalent chromium, this chromium will be rapidly reduced to trivalent chromium once in contact with clam tissue or plant tissue, as hexavalent chromium is highly reactive and will generally be reduced in the presence of organic matter and cellular molecules. The National Academy of Sciences Institute of Medicine also states that hexavalent chromium is generally not found in food (NAS, 2001).

* We calculated potential lead exposure by using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 2010). All inputs were the default model parameter except diet where we input clam and mussel consumption for Klag Bay (0.00003 mg Pb/kg).We do not have a CV for lead. The CDC uses a reference value of 5 µg/dL for children and 10 µg/dL for adults. Based on the IEUBK model, consumption of clams and mussels from Klag Bay would not add to health risk for blood lead levels.

Table 3. Equation for the ingestion of clams and mussels exposure pathway.

Exposure Pathway: Ingestion of Clams or Mussels **Equation*: Dose (mg/kg/day) = (C x IR x AF) / BW** Source: ATSDR, 2005				
Parameter	**Parameter Definition**	**Units**	**Value**	**Reference/ Reason**
C	Contaminant Concentration	mg contaminant/kg clam or mussel (mg/kg)	Table 1	USFS, 2001
IR	Intake Rate of clams or vegetation	kg clams or vegetation/day (kg/day)	Sitka harvest data	ADFG, 2014
AF	Bioavailability Factor**	Unitless	1	Dose is compared to CV. No additional bioavailability considerations
BW	Body Weight	kg	Adult = 80 Child (1-6 yrs) = 16	Adult and Child, ATSDR, 2005

mg/kg/day = milligrams per kilogram body weight per day, kg = kilogram

*For children, the dose, D, was multiplied by a body weight multiplier, $Multiplier_{BW}$:
$Multiplier_{BW}$ (unitless) = Child Body Weight (kg)/ Adult Body Weight (kg) (EPA, 2000);

**The bioavailability factor represents, as a percent, the total amount of a substance ingested, inhaled, or contacted that actually enters the bloodstream and is available to possibly harm a person. Typically, the bioavailability factor is assumed to be 1 (100%) for screening purposes. That is, all of a substance to which a person is exposed is assumed to be absorbed.

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July 9, 2015

Danielle Duncan
Alaska Department of Environmental Conservation
Contaminated Sites Program
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Re: Safety of clam and mussel consumption from Klag Bay, Alaska

Dear Ms. Duncan:

Thank you for contacting the Environmental Public Health Program (EPHP) in the Section of Epidemiology regarding concerns about shellfish consumption in Klag Bay, Alaska. We examined data from the area that you recently provided us and describe our health assessment below.

Background

In February 2014, the Alaska Department of Environmental Conservation (ADEC) contacted the EPHP to help assess whether recreational and subsistence harvesting of seafood in Klag Bay, Alaska poses any health risk. The Sitka Tribe of Alaska contacted ADEC with this inquiry. The Alaska Division of Water has declared Klag Bay to be impaired due to contamination from tailings from the Chichagof Mine site that has impacted sediments and possibly shellfish with heavy metals. There are currently signs in Klag Bay to alert users about possible risks of seafood consumption from the area.

In May 2014, the EPHP provided ADEC with an assessment on the safety of eating shellfish from Klag Bay. Based on data from a report by the U.S. Fish and Wildlife Service (USFWS) titled *Mercury in Bald Eagle Blood and Marine Invertebrates from Klag Bay, Chichagof Island, Alaska* (USFWS, 2001), the EPHP concluded that eating clams and mussels from Klag Bay does not pose an appreciable health risk.

In August 2014, ADEC conducted more sampling of mussels and clams in Klag Bay. In January 2015, ADEC asked that the EPHP update its assessment based on the new data. This assessment is based solely on data collected in August 2014.

Exposure and Health Evaluation

To re-evaluate the potential exposure to metals in clams and mussels in Klag Bay, we used data collected by ADEC on August 26, 2014 (ADEC, 2014). We used subsistence harvest data for Sitka, Alaska for the year 1996 available from the Alaska Department of Fish and Game (ADFG, 2014) as an estimate of the average community traditional food consumption. The year 1996 was the most recent year that consumption data for Sitka clams and mussels were available. Since, in this update, clams and mussels were analyzed together, we added the clam and mussel consumption rates for Sitka. When clams and mussels were analyzed separately, neither clams nor mussels had a distinctly higher concentration. The metal concentration data are summarized in Table 1 (Appendix) and our calculated exposures to the metals present at the site are summarized in Table 2 (Appendix). Average concentrations for clams and mussels were calculated using metal analyses results in composite samples of clams and mussels (ADEC, 2014) (Table 1, Appendix).

For each metal, we calculated a daily exposure dose (*i.e.*, mass of metal ingested per body weight of person) for people consuming clams and mussels from Klag Bay using the average concentrations found in the composite samples of clams and mussels. We then compared these exposure levels to the respective comparison value (CV) for each metal. These CVs are set by federal or state agencies for each contaminant to protect human health against non-cancer health effects (Table 2, Appendix). When a person's exposure concentration to a contaminant is higher than the contaminant's CV, that contaminant becomes a "contaminant of concern," or COC. When a person's exposure concentration is lower than the contaminant's CV, the exposure is not expected to result in adverse health effects and we do not look at the contaminant further. It is important to note that a COC does not mean that we expect to see harmful effects from exposure to that contaminant. Rather, it simply flags the contaminant for closer evaluation to determine whether health effects may occur

We calculated possible daily exposure doses for a child that is 2 years to 6 years old and for an adult to determine if age is a factor in health risks from contaminants at Klag Bay. The calculated exposure doses and their comparison to CVs are shown in Table 2. The equations we used to calculate the exposure dose for each pathway, as well as the assumptions we used for these calculations, are listed in Table 3 in the Appendix. We used a body weight multiplier to calculate consumption rates for children (EPA, 2000). It is common to assume that consumption is proportional to body weight for any age. Using this assumption results in the same exposure risk for both children and adults. Based on this assumption, age was not a factor in the magnitude of exposure to contaminants in Klag Bay and the risks were identical for both adults and children.

We also used a calculation called the hazard quotient (HQ) to measure whether the food intake, combined with the contaminant concentration, could pose a non-cancer health risk. For a given substance, the HQ is the ratio of the potential exposure to the exposure that is not expected to result in adverse non-cancer health effects (Equation 1).

<u>Equation 1: Calculated Hazard Quotient (HQ):</u>

HQ = (Chronic Daily Dose of contaminant)/CV

Where,

> Chronic Daily Dose = Amount of contaminant ingested daily on a chronic basis (one year or longer) per kilogram body weight (mg/kg/d)
> CV = Contaminant's comparison value (mg/kg/d)

If the HQ equals 1 or less ($HQ \leq 1$), then no adverse health effects are expected. If the HQ is greater than 1 ($HQ > 1$), then adverse health effects are possible. It is important to note that an HQ greater than 1 does not necessarily mean that adverse health effects will occur.

To calculate the risk of exposure to lead, the Agency for Toxic Substances and Disease Registry (ATSDR) assisted us in using a model that is under development by EPA for transient exposure to lead. We used this model instead of the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children because the IEUBK model assumes consumption of food for at least one day per week for three months. According to the Sitka Tribe, Klag Bay is a remote site that is rarely used for clamming or collecting mussels (Sitka Tribe, 2015). We therefore considered that it was unlikely that people consumed shellfish from Klag Bay often enough to meet the consumption requirements of the IEUBK model. We based consumption rates on harvest data from Sitka, Alaska (Table 3). Since Klag Bay is not easily accessible to Sitka residents and the Bay is not used as a primary clam source for Sitka residents, we assumed consumption rates for Klag Bay to be half of the Sitka harvest value.

We assumed that lead exposure would primarily be from clams and mussels and we used lead contamination concentrations found in clams and mussels from Klag Bay for the lead intake (Table 1). We assumed no lead exposure from soil or sediment. For reference, the average lead concentration in clam

s and mussels in Klag Bay is lower than the FDA action level of lead in clams of 1.7 parts per million, although it is higher than most shellfish tested by ADEC's Fish Monitoring Program (ADEC, 2015).

The EPA model suggested that under various consumption scenarios (1 meal per week, 2 meals per week, 1 meal per month, 1 meal per year), children between the ages of 1 year and 7 years old would have blood lead levels well below 5 µg/dL (ATSDR, 2015). Tables 4 and 5 illustrate the model parameters and results. The exposure risk for adults is much lower than that for children and is not discussed here.

As shown in Table 2, no HQs for any of the contaminants of potential concern were greater than 1. Given the data that we have, there appears to be minimal health risk in eating shellfish from Klag Bay. However, because of the limited availability of clams and mussels during the sampling and because the harvest data we used for our calculations are from Sitka and not Klag Bay, there is uncertainty in this assessment. Representatives from the Sitka Tribe indicated that Sitka lies 60 miles south of Klag Bay and can be a difficult trip on open ocean (personal communication, February 24, 2014). They also indicated that Klag Bay is not a frequent subsistence site, but is sometimes harvested opportunistically. In addition, harvest data may not be representative of actual consumption. Current harvest and consumption rates for Klag Bay would allow us to more accurately calculate the risk of consuming shellfish from Klag Bay.

In addition to shellfish data, we also reviewed data on concentrations of metals in salmon harvested from Klag Bay. The Sitka Tribe reports that salmon is the most harvested fish from Klag Bay (Sitka Tribe, 2015). These samples were collected in 2010 and analyzed by the ADEC Fish Monitoring Program that provided the data. Based on the Alaska Fish Consumption Guidelines published by the Alaska Division of Public Health, metals concentrations in salmon from Klag Bay do not present a health concern.

Uncertainties

1. The clam and mussel consumption rates are based on historic harvest data from Sitka, and therefore our calculations may not reflect current use of Klag Bay for clamming. This assessment also assumes that no population other than Sitka uses the Bay for clamming and no other population consumes more than the estimate in this assessment.
2. We assumed that the amount of metal ingested from shellfish consumption per body weight (*i.e.*, dose) would be the same at any age.
3. The model we used to estimate exposure to lead is under development at EPA and therefore may require further refinement to accurately simulate blood lead levels from lead exposure.
4. We only considered heavy metal exposure sources from shellfish. Other non-Klag Bay sources of lead may contribute to a blood lead level.

Conclusions

The EPHP concludes that based on existing contaminant data, eating clams and mussels from Klag Bay does not pose an appreciable risk to public health. This is because there were few clam samples available from Klag Bay for harvesting (ADEC, 2015) which does not provide an ample number of shellfish for the Sitka population. Moreover, even if more clams were available from Klag Bay, the assumed consumption rate and available lead concentrations in clam tissue do not indicate an exceedance of CDC blood lead reference concentrations.

Recommendations

EPHP recommends that:

1. Seafood from Klag Bay could be a healthful part of a balanced diet.
2. As time and resources allow, clam and mussel harvest data from Klag Bay could be collected. These data would enable us to form a health assessment that is more reflective of conditions in Klag Bay.
3. DEC continue to monitor clam and mussel contaminant concentrations at Klag Bay, as necessary, to characterize the extent of seafood contamination at the site.

Please feel free to contact us with any questions that you may have.

Sincerely,

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Appendix

Table 1. Average Metals Concentrations from Clams and Mussels in Klag Bay (ADEC, 2014)

Analyte	Clams and Mussels (mg/kg)
Arsenic	8.68
Cadmium	0.34
Copper	1.20
Mercury	0.09
Lead	0.97
Selenium	1.51

mg/kg = milligram per kilogram

Table 2. Calculated exposure doses from consumption of Klag Bay clams and mussels.

	Ingestion Dose Clams and Mussels (mg/kg/d)[#]	Comparison Value (CV) (mg/kg/d)	CV Source	Hazard Quotient
Arsenic	6.4E-05	0.0003	ATSDR chronic MRL	0.21
Cadmium	2.5E-05	0.0001	ATSDR chronic MRL	0.25
Copper	8.8E-05	0.12	National Academy of Sciences Institute of Medicine Tolerable Upper Intake Level	0.00
Mercury	6.3E-06	0.00056	Alaska Division of Public Health	0.01
Lead	7.1E-05	NA*	NA*	NA*
Selenium	1.1E-04	0.005	ATSDR chronic MRL	0.02

mg/kg/d = milligram per kilogram of body weight per day.

[#] Please refer to Table 2 for the dose calculation equation for both adults and children. The ingested dose per body weight is the same for adults and children.

* We calculated potential lead exposure by using a model for transient lead exposure that is under development by the EPA. All inputs were the default model parameters except diet, where we input the average lead concentration for clams and mussels in Klag Bay (0.97 mg/kg). We do not have a CV for lead. The CDC uses a reference value of 5 µg/dL for children and 10 µg/dL for adults. Based on this new EPA model, consumption of clams and mussels from Klag Bay would not add an appreciable health risk for blood lead levels.

Table 3. Equation for the ingestion of clams and mussels exposure pathway.

Exposure Pathway: Ingestion of Clams or Mussels **Equation*: Dose (mg/kg/day) = (C x IR x AF) / BW** Source: ATSDR, 2005				
Parameter	**Parameter Definition**	**Units**	**Value**	**Reference/ Reason**
C	Contaminant Concentration	mg contaminant/kg clam or mussel (mg/kg)	Table 1	ADEC, 2014
IR	Intake Rate of clams and/or mussels	kg clams and/or mussels/day (kg/day)	Sitka harvest data: Clams: 5.8×10^{-3} Mussels: 1.0×10^{-4}	ADFG, 2014
AF	Bioavailability Factor**	Unitless	1	Dose is compared to CV. No additional bioavailability considerations
BW	Body Weight	kg	Adult = 80 Child (2-6 yrs) = 17.4	Adult and Child, ATSDR, 2014

mg/kg/day = milligrams per kilogram body weight per day, kg = kilogram

*For children, the dose, D, was multiplied by a body weight multiplier, $Multiplier_{BW}$:
$Multiplier_{BW}$ (unitless) = Child Body Weight (kg)/ Adult Body Weight (kg) (EPA, 2000);

**The bioavailability factor represents, as a percent, the total amount of a substance ingested, inhaled, or contacted that actually enters the bloodstream and is available to possibly harm a person. Typically, the bioavailability factor is assumed to be 1 (100%) for screening purposes. That is, all of a substance to which a person is exposed is assumed to be absorbed.

Table 4. Model scenarios and parameters for transient lead exposure (ATSDR, 2015)

	Exposure Scenario 1	Exposure Scenario 2	Exposure Scenario 3	Exposure Scenario 4
Exposure Dose (ug/clam meal)	5.723	5.723	5.723	5.723
Contaminant Concentration (mg Pb/kg clam)	0.97	0.97	0.97	0.97
Intake Rate (kg clams/clam meal)	0.0059	0.0059	0.0059	0.0059
Frequency of Exposure	1 meal/week	2 meals/ week	1 meal/month	1 meal/year
Duration of Exposure	Age 1 - 7	Age 1 - 7	Age 1 - 7	Age 1 - 7
Relative Bioavailability	Model defaults	Model defaults	Model defaults	Model defaults

	Exposure Scenario 5	Exposure Scenario 6	Exposure Scenario 7	Exposure Scenario 8
Exposure Dose (ug/clam meal)	1.245	1.245	1.245	1.245
Contaminant Concentration (mg Pb/kg clam)	0.97	0.97	0.97	0.97
Intake Rate (kg clams/clam meal)	0.0013	0.0013	0.0013	0.0013
Frequency of Exposure	1 meal/week	2 meals/ week	1 meal/month	1 meal/year
Duration of Exposure	Age 1 - 7	Age 1 - 7	Age 1 - 7	Age 1 - 7
Relative Bioavailability	Model defaults	Model defaults	Model defaults	Model defaults

Table 5. Blood lead levels (BLLs) predicted by the EPA model under various scenarios (ATSDR, 2015)*

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
YEAR	BLL(ug/dL)							
1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2	0.17	0.26	0.06	0.01	0.05	0.07	0.02	0.01
3	0.15	0.30	0.04	0.01	0.04	0.07	0.01	0.01
4	0.13	0.25	0.03	0.01	0.03	0.06	0.01	0.01
5	0.10	0.20	0.02	0.01	0.03	0.05	0.01	0.01
6	0.09	0.17	0.02	0.01	0.02	0.04	0.01	0.00
7	0.08	0.15	0.02	0.00	0.02	0.04	0.01	0.00

*Scenarios are described in Table 4.